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Annual World Bank Conference on
Development Economics
Global

Rethinking Infrastructure for Development

Edited by

François Bourguignon
and Boris Pleskovic



THE GOVERNMENT OF JAPAN

Rethinking Infrastructure for Development

Annual World Bank Conference
on Development Economics—Global
2007

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and Boris Pleskovic



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About This Book

The Annual World Bank Conference on Development Economics is a forum for discussion and debate of important policy issues facing developing countries. The conferences emphasize the contribution that empirical economic research can make to understanding development processes and to formulating sound development policies. Conference papers are written by researchers in and outside the World Bank. The conference series was started in 1989. Conference papers are reviewed by the editors and are also subject to internal and external peer review. Some papers were revised after the conference, to reflect the comments made by discussants or from the floor, while most discussants' comments were not revised. As a result, discussants' comments may refer to elements of the paper that no longer exist in their original form. Participants' affiliations identified in this volume are as of the time of the conference, May 29–30, 2006.

The planning and organization of the May 2006 conference was a joint effort by the Government of Japan and the World Bank. We would especially like to thank Kiyoto Ido, Director General, International Finance Division, Ministry of Finance, Japan, for overall guidance. We gratefully acknowledge timely and valuable contributions made by all the members of the steering committee, Aehyung Kim, and several anonymous reviewers. We wish to thank Jean-Christophe Bas for general coordination of the conference. We would also like to thank conference coordinators Mika Iwasaki, Leita Jones, Anna Kuznicka, and Gaetano Vivo, whose excellent organizational skills helped to ensure a successful conference. Finally, we thank the editorial staff for pulling this volume together, especially Aziz Gokdemir, Stuart K. Tucker, and Nora Ridolfi from the Office of the Publisher.



Introduction

FRANÇOIS BOURGUIGNON AND BORIS PLESKOVIC

The Annual Bank Conference on Development Economics (ABCDE) is one of the best-known conferences for the presentation and discussion of new knowledge on development. It is an opportunity for many of the world's finest development thinkers to present their ideas.

The 2007 ABCDE—held in Tokyo on May 29–30, 2006, and cosponsored by the Government of Japan—was devoted to “Rethinking Infrastructure for Development.” The conference opened with remarks by Sadakazu Tanigaki, Japan’s Minister of Finance, and Paul Wolfowitz, President of the World Bank. Their remarks were followed by keynote addresses by Donald Kaberuka, President of the African Development Bank; Sadako Ogata, President of Japan International Cooperation Agency (JICA); and Joseph Stiglitz, University Professor at Columbia University. Six papers were presented addressing the issues of infrastructure for growth, sustainable development and infrastructure, rural infrastructure and agricultural development, and infrastructure and regional cooperation. François Bourguignon, Chief Economist and Senior Vice President of the World Bank, delivered closing remarks.

Opening Addresses

Sadakazu Tanigaki notes that there are many reasons why rethinking infrastructure for development is the theme of this year’s ABCDE. One of them is Japan’s reliance on Bank lending for infrastructure for reconstruction and its experience with Bank technical assistance, which introduced new technologies to Japan.

Tanigaki states that there has been a major shift in thinking about who should play the central role in providing infrastructure. In the 1990s, it was thought that private capital should be a main source of infrastructure investment, even in developing

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countries. Today the need for public sector involvement has once again been recognized. The concept of public-private partnership has been reintroduced and developed on the basis of experience and lessons learned. Greater emphasis is now placed on institutional and policy reform, including service delivery and environmental and social safeguard policies. Infrastructure is also needed to achieve the Millennium Development Goals (MDGs); as Tanigaki notes, children need lights to study, and patients need roads to get to a hospital.

A new perspective for infrastructure is needed that takes into account lessons learned and changes in the external environment. Tanigaki hopes that the ABCDE will be a source of cutting-edge knowledge on infrastructure, both theoretical and practical, and that this knowledge will provide Japan, a major donor in infrastructure, with new insights into the subject.

Tanigaki notes the importance of each of the four themes of this year's ABCDE. He concludes that hosting the ABCDE in Tokyo provides an opportunity not only to deepen discussions on infrastructure but also to provide a vehicle for strengthening the relationship between the Bank and Japan in research and analysis, a relationship that should help spur sustainable growth and reduce poverty in developing countries.

Paul Wolfowitz notes that the Government of Japan has been a strong supporter of infrastructure projects in developing countries. He outlines current and future infrastructure needs for increasing access to basic energy, water, and sanitation services. Wolfowitz notes that over the next 25 years, 2 billion people will be born, most of them in developing countries, who will need access to energy, water, and sanitation services. In 2007 more of the world's people will live in urban areas than in rural areas—the first time in history this has been the case. In the next 30 years, the urban population in developing countries will double, creating enormous challenges for meeting basic infrastructure needs while preserving the environment.

Wolfowitz singles out Africa, where the poor are disproportionately affected by the shortage of modern energy services and where infrastructure is critical to increasing growth and meeting the MDGs. Africans lose 40 billion productive working hours each year carrying water. Although large-scale infrastructure for energy generation and transmission is fundamental to Africa's development, most poverty reduction strategies do not target these projects toward the poor. Many East Asian countries have achieved remarkable results in spurring growth through improved infrastructure. Understanding how to reproduce these successes in other countries is one of the reasons for this conference.

Wolfowitz discusses the Bank's two-pillar strategy for "rethinking" infrastructure. As part of the first pillar, over the next year or two, the Bank plans to lend about \$9–\$10 billion a year, almost 40 percent of the Bank's total lending, with special attention devoted to Africa. The second pillar focuses on harnessing the Bank's knowledge and technical expertise to more effectively mobilize other investments and to help create the right economic, financial, and regulatory environment for infrastructure investment. This strategy includes working with countries to promote sensible economic policies.

According to Wolfowitz, the approach to infrastructure must focus not only on economic growth or human growth but also on smart growth to make a difference in people's lives. Experience points to a compelling need to consider responses along the full public-private spectrum. It is necessary, for example, to get tough—and stay tough—on corruption. Wolfowitz concludes with the hope that the conference will reveal lessons learned and help promote new thinking about infrastructure, with the goal of achieving successful development.

Keynote Addresses

Donald Kaberuka notes that the theme of the conference—“Rethinking Infrastructure for Development”—is of particular importance to the African Development Bank and its regional member countries. Kaberuka acknowledges the changing view within multilateral development banks and recipient countries that the financing of infrastructure is at the center of enhancing economic growth and meeting the MDGs.

Kaberuka argues that poor infrastructure has constrained the integration of Africa into the global trading environment. He gives several examples of inadequate infrastructure and notes the large gap between Africa and the rest of the world in all types of infrastructure services. There is also a limited interconnectivity between African countries, which negatively affects regional economic integration and private sector investment. The markets of African economies are small and the cost of doing business high. The financing of infrastructure needs to be scaled up to accelerate economic growth and make Africa more competitive in the global economic environment.

Aid to Africa largely overlooked infrastructure in favor of the social sectors over the past decade. Recent positive economic and political developments in Africa strongly support the case for reversing this trend. Kaberuka argues that the most pressing challenges in financing infrastructure in Africa is to leverage private and public resources more efficiently and to reduce inefficiencies, such as tied aid. He notes private sector investment in telecommunications, air, railways, and power but argues that more needs to be done to increase such participation. Kaberuka concludes that money alone is not enough in rethinking infrastructure: an improved policy and regulatory environment and greater transparency are needed.

Sadako Ogata notes that 60 years ago, much of Japan was destroyed and many of its people lived in poverty. The International Bank for Reconstruction and Development (IBRD) played a major role in rebuilding Japan. The first Bank loans were used to build hydroelectric power plants; these projects were followed by heavy-industry plants and highways crisscrossing the country. The Bank also provided assistance in building Japan's high-speed bullet train.

As a result of its own reconstruction experience, Japan concentrated on infrastructure development and technical assistance as it began to aid other Asian countries. As many Asian countries have achieved remarkable economic growth, Japan has extended its official development assistance globally and is now increasingly engaged in Africa.

According to Ogata, extending infrastructure assistance requires new approaches. To tackle global challenges, there is a need to introduce infrastructure assistance backed by social and economic development that enables people. JICA has introduced a “human security” approach in its development assistance, an approach that ensures that its assistance is community based, comprehensive, and cross-sectoral. A community-based approach involves local residents and leaders. A comprehensive approach ensures the full use of physical infrastructure facilities. It supports their full maintenance and utilization, including through provision of service delivery mechanisms. A cross-sectoral approach recognizes that linking diverse development sectors into an overall program has proven extremely difficult. JICA is currently undertaking cross-sectional infrastructure development in Africa, focused on cross-border road construction.

By 2008 JICA will be the largest bilateral development agency in the world—and the world’s second-largest development agency after the World Bank. With an annual budget estimated at about \$9 billion, it will become a unique aid agency, providing technical assistance, grant aid, and official development assistance (ODA) loans in an integrated manner. JICA’s reorganization represents a major challenge for everyone involved in the reshaping of Japan’s ODA. Ogata emphasizes that during this time of rapid change in global development economics, innovative ideas and programs as well as financial resources are needed to tackle the problems of developing countries. In conclusion, she asks for the support of and collaboration with the World Bank and other international organizations, governments, and nongovernmental agencies at the conference in order to help improve the well-being of millions of the world’s poorest people.

Joseph Stiglitz and **Andrew Charlton** note that aid for trade has been attracting increased attention, as donors recognize that increased aid flows may have unintended negative effects on developing countries, such as real exchange rate appreciation. In such cases, attention should focus on counterbalancing programs, including trade development, trade facilitation, and other programs that increase competitiveness in developing countries.

Aid for trade is also receiving attention because of disappointment with the Washington Consensus. The old trade framework assumed that trade liberalization would automatically lead to increased trade, which would spur faster growth and development that benefited everyone. Subsequent research has produced a new trade policy framework that has questioned these assumptions.

Aid for trade focuses mainly on ensuring that trade liberalization leads to increased trade. Stiglitz and Charlton argue that trade has failed to increase in developing countries (whose share of world trade has been falling over the past 20 years) because of the absence of export infrastructure, other internal barriers to trade, and supply constraints. Experience has repeatedly shown that without adequate roads, efficient ports, and the technical capability to produce and distribute goods of sufficient quality, new trading opportunities are meaningless for the poorest countries. They add that without access to credit, it will be difficult for new enterprises to form or old enterprises to expand to take advantage of new opportunities; without the necessary infrastructure, internal barriers to trade will remain high.

Countries face large adjustment costs as a result of liberalization, as resources are moved from one sector to another in the process of reform. The costs of these adjustments are particularly large for developing countries. For this reason, Stiglitz and Charlton argue that gross welfare gains from trade liberalization should be balanced against their associated costs.

Stiglitz and Charlton propose three types of assistance to build supply capacity: trade policy and regulations, enterprise development, and infrastructure. Institutional capacity is important to ensure compliance with World Trade Organization (WTO) agreements. Their proposal for aid for trade relies largely on existing institutional arrangements. Dedicated funds for aid for trade—provided through specific binding commitments in the final Doha Agreements and enforceable within the WTO—would be allocated to a specific facility, to be administered by an international organization. They propose that a small Global Trade Facility Secretariat be established to oversee the program, whose governance would be dominated by developing countries to ensure that the facility reflects their perspectives. Their proposal would encourage competition among aid recipients and donors to develop the most-efficient and effective aid-for-trade projects and programs.

Stiglitz and Charlton claim that their aid-for-trade proposal brings the power of commitment and enforcement to promises of aid. Given that developed countries refuse to make significant concessions on agriculture, without aid for trade they have little to offer developing countries. Developing countries are not negotiating in the WTO as equals with the industrial countries; their proposal establishes another binding and meaningful commitment from developed countries. The proposal also recognizes the limitations in the governance of existing institutions and provides a new alternative. According to Stiglitz and Charlton, aid for trade offers the possibility of a trade agreement that will result not in more imports and job losses in developing countries but in more exports and job creation.

Infrastructure for Growth: Emerging Issues

Antonio Estache examines the linkages between infrastructure and growth, the relevance of infrastructure reform for the poor, the fiscal cost of infrastructure, the potential for a private sector role, and corruption. He argues that great uncertainty exists over how and how much infrastructure affects growth. Does the process work the same way at all stages of development, for all regions in the same country, and for rural and urban areas? What are the fiscal costs of infrastructure, in the aggregate and across government levels? Are standard fiscal rules used to assess debt sustainability penalizing the sector unnecessarily? Estache argues that uncertainty about these issues contributes to the weak understanding of the relevance of institutional reforms. He addresses four emerging policy areas: (a) revisiting infrastructure investment priorities in order to promote viable economic growth; (b) anticipating and avoiding policies that lead to regressive outcomes that hurt the poor; (c) reevaluating the role of public sector financing; and (d) responding to concerns about corruption

and governance by strengthening regulation and fostering the accountability of both public and private, domestic, and global actors.

Sustainable Development and Infrastructure: Climate Change, Clean Energy, and Energy Efficiency

Michael Grubb argues that responding to climate change creates opportunities as well as threats to development, with the balance between them determined largely by how public policy responds. Rapidly expanding investment in carbon-intensive infrastructure increases both the environmental risks faced by developing countries and the risk of such investments becoming “stranded” as carbon controls tighten over time. These risks create a compelling case for broad-based action to switch investment toward higher-energy efficiency and lower use of carbon sources. Specific policy responses will vary based on national circumstances, but they must combine three basic elements: carbon pricing, implemented mainly through cap-and-trade systems; policies that address a variety of informational, behavioral, and structural barriers to optimal responses; and policies that reflect the long-term public benefits associated with low-carbon infrastructure and innovation-related investments. Grubb addresses four dimensions of the challenge: (a) the risks associated with changing climatic patterns, the scope for adaptation, and economic approaches to evaluating the scale of these risks; (b) the relation between emissions and development, including potential opportunities between climate-change mitigation and development at the project and sector levels; (c) innovation and macroeconomic dimensions of emissions mitigation in the national and global context; and (d) specific policy responses.

Jiang Kejun presents the results of a study that projects that primary energy demand in 2020 could reach 1.9–2.4 billion tons, depending on technological progress, development in energy-intensive sectors, and regulations. This high demand for energy will put significant pressure on China’s energy supply. Under the lowest energy-demand scenario, China will have to import 200 million tons of oil and 100 billion cubic meters of natural gas. Under the higher energy-demand scenario, nearly 400 million tons of oil, 260 billion cubic meters of natural gas, and 300 million tons of coal will have to be imported. Technological progress is the key to reducing energy demand as well as maintaining a clean environment.

Kejun believes that imposing an energy tax, a resource tax, and an export tax on energy-intensive products would have a positive effect on energy saving and the optimization of the economic structure. He suggests the following strategies: (a) establish an energy security system, contingent on the global oil-demand perspective; establish a multienergy system to diversify energy supply; develop a renewable energy source as an alternative energy source; and substitute biofuel for vehicle fuel; (b) craft and implement national laws, regulations, and standards that promote clean energy, so that the energy industry can achieve its goal of a clean energy system; and (c) emphasize clean coal technology, to mitigate coal-combustion emissions. Kejun predicts that China will continue to rely on energy- and resource-intensive products. This trend should be controlled to prevent China from becoming a provider of raw materials and damaging the environment.

Rural Infrastructure and Agricultural Development

Per Pinstруп-Andersen and Satoru Shimokawa assert that agricultural development is essential for economic growth, rural development, and poverty alleviation in low-income developing countries. They argue that agricultural productivity is an effective driver of economic growth and poverty reduction, both within and outside agricultural sectors. Raising productivity requires adequate rural infrastructure, well-functioning domestic markets, competent institutions, and access to appropriate technology. While the state of rural infrastructure varies widely across developing countries, most lower-income countries suffer severe rural infrastructure deficiencies. Deficiencies in transportation, energy, telecommunications, and related infrastructure translate into poorly functioning domestic markets with little spatial or temporal integration, insufficient price transmission, and weak international competitiveness. Despite the well-documented connection between rural infrastructure and growth and poverty alleviation, high economic rates of return to investments in rural infrastructure, and significant deficiencies of rural infrastructure in most developing countries, neither national governments nor international aid agencies seem to prioritize the construction of new or the maintenance of existing infrastructure.

Pinstруп-Andersen and Shimokawa conclude that because much of the required investment in rural areas is of a public-goods nature, most investments must come from public sources, although public-private partnership should be pursued when appropriate. Failure to accelerate investment in rural infrastructure will make a mockery of efforts to achieve the MDGs in poor countries and severely limit their ability to benefit from trade liberalization, international capital markets, and other potential benefits of globalization.

Masahisa Fujita challenges the notion that agriculture needs to take a back seat in economic development. He argues that when rural innovation dynamics and resource development are appropriately managed and supported by infrastructure, agriculture can become the front-runner in economic development. He describes two Japanese concepts of community-based rural development—the one village one product movement (OVOP) and *Michino Eki* (roadside stations). Both concepts can be viewed as types of brand agriculture, a general strategy for community-based rural development that identifies, cultivates, and fully utilizes local resources (including natural, historical, cultural, and human resources) to develop products or services unique to a particular geographical area. The strategies have proved effective in bridging the gap between cities and rural areas in Japan and several developing countries.

Infrastructure and Regional Cooperation

Haruhiko Kuroda, Masahiro Kawai, and Rita Nangia examine the role of cross-border infrastructure in the process of regional integration in developing Asia. They argue that sustainable economic development requires reductions in transport and logistics costs, the agglomeration of economic areas, and the creation of production clusters. Addressing the region's logistics challenges will thus require cross-border infrastructure. They review four case studies of cross-border infrastructure in Asia

and provide a conceptual framework to address political, economic and financial, and institutional challenges for cross-border infrastructure development. They emphasize that the “software” component is inseparable from the “hardware” component if cross-border connectivity is to be improved. They identify key actions that various stakeholders—Asian governments, the private sector, civil society organizations, and multilateral institutions, such as the Asian Development Bank—need to take to connect Asia.

Closing Remarks

François Bourguignon notes that the infrastructure agenda encompasses diverse sectors in a wide range of settings, from isolated rural regions to burgeoning urban centers, from small local projects to massive multicountry regional initiatives. The scope of the challenge is huge and the complexity enormous—but the need for progress is overwhelming. To move forward, a more systematic framework for evaluating investment choices is needed, and multidimensional policies and approaches must be pursued. Efforts must be directed toward developing data and techniques that permit the same type of approach to be applied at different scales, covering a wider set of factors. Macrolevel analyses, for example, could enhance the understanding of the structural factors and policy levers that affect success; microlevel impact evaluation assessments could help reveal what works and what does not. At the same time, there is a need to assess the costs and benefits of infrastructure projects, including costs and benefits that extend beyond these projects. Bourguignon hopes that this ABCDE will reenergize the development community to put forth new ideas.



Opening Speech

HON. SADAKAZU TANIGAKI

1. Introduction

President Wolfowitz, distinguished guests, ladies and gentlemen,

It is a great pleasure for me to host the first Annual Bank Conference on Development Economics (ABCDE) in East Asia.

Last May, we announced at the ABCDE in Amsterdam that we would host this meeting. Since then, we have been preparing for this conference, in close collaboration with the World Bank Headquarters and its offices in Tokyo and Paris. I would like to extend my appreciation to President Wolfowitz, Chief Economist François Bourguignon, and the Bank staff for their cooperation.

Distinguished academics, practitioners, policy makers, and participants from the private sector have gathered from all over the world to make our discussion fruitful. My thanks also go to all of them who will take part in this meeting.

2. Rethinking Infrastructure

Ladies and gentlemen,

“Rethinking Infrastructure for Development”—this is the theme for this year’s ABCDE.

Since established in 1945, the Bank has been engaged in infrastructure. Japan has its own experience to have relied on the Bank lending in the 1950s and 1960s to build physical infrastructure, such as the Kurobe No. 4 hydroelectric power station, the Tokaido bullet train, and the Tomei Expressway. Some of these Bank assistances brought the significant impact not only in providing financial resources, but also bringing new technologies.

The Hon. Sadakazu Tanigaki is Minister of Finance of Japan.

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However, we must not forget that the environment surrounding infrastructure support and the perspectives on infrastructure have been changing considerably.

The global economic situations surrounding developing economies have changed substantially. We can find these changes in the expansion of free trade, the development of the international financial and capital market, and the widening gap or intensified competition among developing countries.

There has also been a major shift in the view on who should play a central role in infrastructure provision. During the 1990s, it was the prevailing thought that private capital should be a main source of infrastructure investments even in developing countries. However, the necessity of public sector involvement has been recognized again, and it became necessary to further develop the concept of public-private partnerships, fully reflecting the past experience.

Moreover, infrastructure assistance for decades has yielded a great deal of experience and lessons. We have had debates on quite a number of issues in infrastructure development, including:

- Hasn't donors' support simply left "white elephants" behind?
- Have we paid enough attention to adverse environmental and social impacts?
- Have we had sufficient dialogue with stakeholders?

Outcomes of these debates have been reflected in the actual operations of the Bank today. For instance, greater emphasis is placed on institutional and policy reform in the infrastructure-related sector; the Bank increased its focus on enhancing infrastructure's service delivery; detailed environmental and social safeguard policies are in place.

When further efforts are needed to achieve the Millennium Development Goals, there is no question that efficient and effective infrastructure support is indispensable to advance development.

For example, children need lights to study and patients need roads to go to hospitals. The role of infrastructure is also reaffirmed in the context of creating employment opportunities through improving business environment and fostering private sector development. As we see here, the assistance in infrastructure, health, and education are all complementary to each other. Recent Bank surveys on clients also show the importance of infrastructure, which ranked infrastructure as one of the most important sectors in both "significance" and "Bank effectiveness."

When we consider our future engagement in infrastructure, we must not confine ourselves to the conventional idea of building "bricks and mortar." We must develop a new perspective, while taking into account what I mentioned above, namely both the change in the external environment and the lessons we learned.

I hope the discussions at this year's ABCDE will bring together cutting-edge knowledge on infrastructure from both theoretical and practical aspects, thus shedding new light on infrastructure assistance in the future. I believe that the discussions will also give Japan, a major donor in the area of infrastructure, valuable insights into this subject.

3. Themes for Discussion at the ABCDE

Ladies and gentlemen,

Four topics will be featured in the two-day discussion. They are “infrastructure for growth,” “sustainable development and infrastructure,” “rural infrastructure and agricultural development,” and “infrastructure and regional cooperation.” Let me elaborate on each of them.

The *first* topic—infrastructure for growth—seeks to further explore the impact of infrastructure on growth in developing countries. This should also help clarify how we should deal with infrastructure in the context of overall development strategy for a country.

As to the *second* topic—sustainable development and infrastructure—it is meaningful to discuss climate change or energy efficiency in Asia, where energy consumption is expected to increase rapidly. This topic is timely and particularly important among all the infrastructure-related themes, as “investment framework for clean energy and development” is under discussion at the Bank and the Summit process focuses on the energy issue.

The significance of the *third* topic—rural infrastructure and agricultural development—is evident in the fact that many poor live in rural areas. President Wolfowitz mentioned at the last Annual Meetings that agriculture would be one of the focus areas for the Bank. I hope the discussion on this topic will give some valuable input to the assistance for agricultural development.

The *fourth* topic is infrastructure and regional cooperation. Given the increase in intraregional trade and the delayed development in landlocked countries, regional cooperation has a significant role to play in developing cross-border infrastructure. I would invite you to discuss such a correlation between infrastructure and regional cooperation, based on the experiences in Asia and Africa.

4. Japan’s Support and Cooperation for the Bank’s Research Activities

Lastly, I would like to touch upon strengthening cooperation between the Bank and Japan in the academic field.

Hosting the ABCDE in Tokyo provides us an opportunity not only to deepen our discussions on infrastructure, but also to provide an impetus to strengthen the relationship between the Bank and Japan in research and analysis. Japan is determined to further promote such cooperation.

Specifically, we plan to participate in the Knowledge for Change Program (KCP), a World Bank initiative to support research and analysis in the area of development. Through our participation in KCP, we intend to support the Bank’s research and analysis in such areas as agriculture and climate change. The involvement in KCP will also increase the opportunity for Japanese researchers and institutions to exchange their views on development or to conduct joint researches with the Bank. I am glad here to announce that Japan will contribute up to 2 million U.S. dollars for the KCP.

5. Closing

In closing, I would be grateful if you could have cutting-edge discussions on development here in Tokyo and if you could capitalize on this rare opportunity through active exchange of views and opinions.

I also hope that this conference will add new insights into the pool of knowledge on infrastructure, and this, in turn, will contribute to sustainable growth and poverty reduction in developing countries.

Thank you.



Opening Speech

PAUL WOLFOWITZ

Introduction

Minister Tanigaki, ladies and gentlemen,

I would like to express my appreciation to the staff of the Japanese Ministry of Finance for cosponsoring this Annual World Bank Conference on Development Economics (ABCDE) with the World Bank. Their enthusiasm and able logistical support are evident in our setting today and lay the groundwork for a very productive event.

The theme for this year's conference is "Rethinking Infrastructure for Development." I am especially pleased to be hosting this conference in Tokyo, since the Government of Japan, through its development assistance programs has been a strong supporter of infrastructure projects in developing countries. We greatly appreciate being able to partner with you in this area.

Our Current and Future Infrastructure Needs

As we meet here, we know that the global supply of infrastructure is not able to answer the needs of today. We also know that the challenges of tomorrow are even greater:

- Among the 6.3 billion people in the world today, 1.6 billion do not have access to basic energy services—500 million of whom live in Sub-Saharan Africa.
- 2.4 billion people in the world cook their daily meals using wood, dung, or other biomass fuels.
- 2.6 billion people lack access to water and sanitation services.

Paul Wolfowitz is President of the World Bank Group.

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Tomorrow's challenges will grow with our population. In the next 25 years, another 2 billion people will be born—97 percent of them in developing countries. They will need access to water, energy, and sanitation services. And they will need roads to drive on, airports to fly from, and telephones with which to communicate.

But the population isn't just growing. It's also becoming more urban. Here in East Asia, for example in 2000 some 36 percent of people lived in urban areas. By 2025, however, this figure will grow to 57 percent, with an extra 500 million people living in cities.

It is estimated that some time next year, for the first time ever, more people will live in urban areas of the world than in rural areas. In the next 30 years, the urban population of developing countries will double. This is as large a movement of people in developing-world cities as we have seen up to now in all of history.

This unprecedented urban growth comes with enormous challenges of meeting the basic infrastructure needs of people while preserving the environment we live in. We know, however, that this is not an impossible task. Sustainable development *can* go hand-in-hand with responsible infrastructure development which takes into account social and environmental considerations from the outset.

A Deeper Look at the Infrastructure Challenge

Today, Africa presents special challenges for us. The stock of infrastructure on that continent supported economic growth reasonably well through the 1960s and 1970s. Since then, however, high population growth combined with rapid urbanization has led to a severe mismatch between the need for infrastructure and its supply.

By most estimates, African countries need to invest about 9 percent of their GDP—roughly \$40 billion per year—in building new infrastructure and maintaining old facilities if they want to meet the Millennium Development Goals (MDGs). This is more than twice what they have spent over the past 40 years.

For a deeper understanding of the general infrastructure challenges of today and tomorrow, let's look at just one sector—energy.

The International Energy Agency estimates that we need \$320 billion in annual capital investment in developing and transition economies for the next 25 years. This would offer access to basic energy services for those 1.6 billion people who do not have it today, as well as meet new energy demands until 2030.

Yet, we are currently investing far below that amount. In electricity investment alone, only 50 percent of what we need is being funded.

The poor are disproportionately affected by the absence of modern energy services. In many cases, poverty reduction strategies, especially in Africa, rarely or barely mention energy projects aimed specifically at the poor. And if there are such projects, they are often large-scale works.

Such large-scale infrastructure for energy generation and transmission is fundamental for Africa's development. But it has to be complemented by investments in grid extension to the poor and decentralized solutions for rural remote schools, health centers, and communities.

And we cannot forget the 89 percent of the population in Africa who rely on biomass for energy. They need specific support for sustainable forest management and improved cooking stoves and fuels to reduce the air pollution inside their homes.

The picture in the next 25 years becomes even more complex if we want to keep our commitment to achieving sustainable development.

The world is paying increasing attention to the pattern of global energy use and its link to climate change. We need energy to support economic growth and to fight poverty, but we must meet those energy needs in a way that leaves a smaller environmental “footprint.” This means promoting investments that encourage efficiency and are built around smart technological choices.

Infrastructure and People

The ultimate objective in development, of course, is not simply to spur growth. The most important objective is to reduce poverty and bring real improvements in the lives of the billions of people in the countries we serve.

A year ago, on my first trip to Africa, I had the privilege of meeting a Rwandan businesswoman, who, as she put it to me, came home to “grow beautiful flowers on the ashes of genocide.” She created a flower farm that employed about 200 people, mostly women from rural villages who did not have a good income before. They export their flowers to Europe.

I asked her, “What is your biggest challenge?” She said, “Electricity.” She told me she loses 5 percent of her crop to power outages that cause refrigeration to go down. If you are a business working on a thin margin, that 5 percent can be the difference between a business succeeding and a business going under. She also faced other challenges such as transportation.

Businesses such as hers in developing countries need to have more access to energy and transportation infrastructure if they are going to expand and create jobs. Those jobs ultimately bring livelihoods to people who need them desperately.

Nigeria’s Finance Minister, Ngozi Okonjo-Iweala, recently pointed out to Voice of America that governments must improve infrastructure to attract private investors. She asserts this is the only way to create jobs. It is certainly one important means for doing so.

Infrastructure is also critical to help us meet the MDGs. When the poor do not have water, they have to walk as far as it takes to find it. **And that is why Africans lose 40 billion productive working hours each year to carrying water.**

Think about that. That is 40 billion hours that people in Botswana or Lesotho could spend earning an income or starting new businesses to create jobs. When 40 billion hours a year are spent just carrying water, opportunities are lost.

Even the most basic sanitation systems can substantially reduce the number of people who fall victim to waterborne diseases that rich nations have long forgotten.

With proper telecommunications infrastructure, telephones can link families, the Internet can deliver vital knowledge to schools and hospitals, companies can

participate in global trade, and information technology can enable people to liberate themselves from ignorance.

We all know that infrastructure brings more than water, electricity, sanitation, telecommunications, or transportation. Infrastructure brings opportunities, and opportunities transform lives.

We also know that today's infrastructure challenges can be met. A study by the World Bank, the Asian Development Bank, and the Japan Bank for International Cooperation showed that many East Asian economies had achieved remarkable results in bringing infrastructure to support growth. But even in this region, growing inequalities and disparities in access are an increasing challenge.

How we bring those successes to other countries, while meeting these challenges, is a good part of what we will be discussing in these next two days.

Where Next? A Two-Pillar Strategy

Let me briefly address what “rethinking” infrastructure means for the World Bank Group.

We are moving forward with a strategy built on two pillars. For **the first pillar**, we are reengaging on the lending side after a decline in the 1990s, ramping up our infrastructure investments by about \$1 billion a year.

In the next year or two, we expect to lend about \$9–10 billion annually—close to 40 percent of total Bank lending, which has been more or less our average.

We are paying special attention to Africa. Our Africa Action Plan specifically targets closing the infrastructure gap, developing an African private sector, and supporting regional integration. Infrastructure lending in Sub-Saharan Africa has gone from \$1 billion to about \$1.7 billion per year, and more is planned. These investments will focus on power, roads, urban issues, water and sanitation, and regional integration projects through the New Partnership for Africa's Development (NEPAD).

All of the Bank's infrastructure work will be guided by a focus on regional integration, and we have already had successes in regional infrastructure projects, such as the South Africa-Mozambique Pipeline and the West Africa Gas Pipeline.

The vast infrastructure agenda calls for strong partnerships and collaboration. Donor coordination through the recently established Africa Infrastructure Consortium will be critically important in order to harmonize approaches and maximize impact. The World Bank Group is also strengthening internal coordination between the International Bank for Reconstruction and Development (IBRD), the International Finance Corporation (IFC), and the Multilateral Investment Guarantee Agency (MIGA), and a joint stream of projects has been developed.

For its part, the IFC plans to increase its annual infrastructure investments worldwide to \$950 million by 2008. Almost 20 percent of that will take place in frontier countries and sectors.

MIGA has outstanding exposure in infrastructure guarantees of more than 40 percent of its portfolio. It, too, is focusing on encouraging investments in the more difficult frontier markets, as well as at the subsovereign level.

While this increase in our lending activities is a clear step forward, it must be put into perspective. Total investments in developing countries—from developing-country governments themselves, from official development assistance, and from the private sector—amount to about \$1.5 trillion annually. This is about 100 times what the Bank lends each year.

In the global order of things, we are a “1 percent solution.” It is the same story with infrastructure investment. Roughly \$400 billion is invested annually in developing countries’ infrastructure. Our share of that is about 2 percent.

The World Bank may be relatively small in terms of dollars. But we are not small in ideas. And we are not small in the world of policies and proposals on how to shape institutions, improve governance, and build the right investment climate.

This brings me to the **second pillar**. We must use the Bank Group’s knowledge and technical expertise to more effectively mobilize other investments and to help create the right economic, financial, and regulatory environment for infrastructure investment.

This includes working with countries to promote sensible economic policies. These policies should reward investment, good governance practices, strong institutions, and the rule of law. They should also encourage the use of risk mitigation instruments, a long-term regulatory regime, and other reforms.

Identifying What Works and Why

The challenges I raise suggest the need to take a hard look at infrastructure investment in the past, if we want to have any hope of meeting the enormous needs that I just outlined.

At the World Bank, we have completed an analysis of our infrastructure work over the last two decades. I want to share just a few of the conclusions.

First, our approach to infrastructure must focus not just on economic growth or human growth. It must also focus on “smart” growth: that is, growth that is economically sound, environmentally friendly, socially acceptable, locally desirable, and most important, growth that makes a difference in people’s lives.

Smart investments allow infrastructure to support the international community’s push toward the MDGs. That means the investments must focus not just on fighting poverty, but also in improving human development outcomes and sustainable development.

We continue to support cost recovery for infrastructure operators. But we recognize that it could make some services unaffordable to the very people they are designed to help. Full cost recovery sends the right price signals to the market. But for some activities in the poorest countries, subsidies may be unavoidable. Where subsidies are used, we need to ensure that they truly expand access to services for the poor at affordable rates.

Second, attempts to draw a line between “public” and “private” approaches to infrastructure provision are misplaced.

We have moved away from a paradigm that once expected the private sector to play the dominant role in infrastructure. The private sector can—and does—play an important role in increasing investment and strengthening service delivery.

But it is apparent that the capacity or willingness of the private sector to respond to *all* the infrastructure needs is limited.

Private sector investment in infrastructure in developing countries peaked about \$128 billion in 1997, before dropping by half to \$58 billion in 2003. In Africa, foreign private capital has contributed, at most, 10–15 percent of the infrastructure investments on the continent since the mid-1980s. This is substantial, but it is far from what was expected and far from what was needed.

Experience points to a compelling need to consider responses along the full public-private spectrum. In some sectors and countries, the private sector will offer the best solution to deliver projects effectively. In other contexts, greater involvement by the public sector will be necessary, in some cases, as a direct provider of services and in others as an enabler.

One key facet of this enabling role is to create an appropriate and long-term regulatory environment in which providers—either public or private—can operate efficiently.

Finally, we must get tough—and stay tough—on corruption. This requires vigilance not only on Bank-financed projects—where our fiduciary responsibility to shareholders demands high accountability—but also in the broader country and global environments in which we operate.

This requires attention to the “big ticket” items such as bidding and tender procedures for large projects, and to local circumstances as well.

Ordinary people will not fully benefit from new infrastructure such as roads if—as in the case of certain projects in Asia—the improved access is accompanied by “information” levies or charges that raise transport costs back to previous levels.

We are working with stakeholders in the Extractive Industries Technology Initiative to ensure that revenues from oil, gas, and mining are used to fight poverty and promote development. Other sectors, such as the construction industry, may also benefit from similar initiatives in the future.

Conclusion

These are just some of the “lessons learned” in our own study of infrastructure over the past two decades. There are undoubtedly others.

Over the next two days, I would encourage you to examine some of the pressing issues confronting us and to help us continue to rethink infrastructure.

Our challenge at this conference is to “rethink” infrastructure with the goal of achieving successful development and putting the transforming power of opportunity into the hands of the poor.

It is not an easy task—as you are all aware—but it is an exciting one. I wish you all the greatest success in your efforts and look forward to reviewing the conclusions you reach.

Mr. Chairman, ladies and gentlemen, thank you.



Keynote Address

DONALD KABERUKA

Introduction

Your Excellencies,
Ladies and Gentlemen,

On behalf of the African Development Bank Group (ADB) and on my own behalf I wish to thank the World Bank for inviting me to this year's Annual World Bank Conference on Development Economics. The theme of this conference, *Rethinking Infrastructure for Development* is of particular importance to the ADB and its regional member countries given the central role of infrastructure in our efforts to improve the living standards of our peoples.

Indeed, by coincidence, at the just concluded ADB Annual Meetings in Ouagadougou, Burkina Faso, *Infrastructure Development and Regional Integration* was the theme of our Ministerial Round Table and High Level Seminars. This coincidence reflects the changing view within multilateral development banks and the international community and recipient countries that the financing of infrastructure is at the center of enhancing economic growth and a linchpin in our joint efforts to meet the Millennium Development Goals (MDGs).

In the case of Africa, poor infrastructure has constrained integration of the continent into the global trading environment. Beyond this, there is a lack of or limited interconnectivity between African countries that has frustrated our efforts in promoting regional economic integration and private sector investments. The market size of the African economies remains relatively small and is characterized by high costs of doing business, making Africa less competitive relative to the rest of the world.

If Africa is to accelerate current levels of growth and reduce imbalances in the global economic environment, the prioritization and financing of infrastructure must be scaled up.

Donald Kaberuka is President of the African Development Bank.

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The African Development Bank recognizes this challenge and attaches great importance to the promotion of regional infrastructure in Africa. Developing regionally focused infrastructure projects will assist in increasing market sizes and subsequently, creating larger economies of scale. This will provide appropriate incentives that can sustain an expanding private sector.

The State of Infrastructure in Africa

In all areas of infrastructure services, such as transport, energy, finance, information, and communication technology, there is a large gap when one compares Africa to the rest of the world. For instance, Africa's access to electricity is only 30 percent compared to over 75 percent for other least-developed countries (LDCs); access to water and sanitation is about 65 percent compared to 80 percent for other LDCs; access to roads is 34 percent compared to 50 percent for other LDCs; and the penetration rate for telecommunications is less than 13 percent compared to 40 percent in other LDCs. Furthermore, out of the 1.5 million km of road network in Sub-Saharan Africa, only 19 percent is paved compared to 27 percent for Latin America and 43 percent for South Asia. Other statistics are equally disappointing: Africa's rail transport is only 3 percent of the total for developing countries, while sea transportation in Africa constitutes only 18 percent of the total for developing countries.

Let me highlight a few examples to illustrate the limitations placed on economic activities by the poor state of infrastructure. Surveys of rural travel and transport patterns in villages in Burkina Faso, Uganda, and Zambia have shown that owing to lack of basic transport infrastructure, African women move, on average, usually with head-loading, especially of water and fuel wood, 26 metric ton-kms a year. This is a major health hazard to women and girls in these countries. In Dar-es-Salaam, Tanzania, the daily purchase of a single roundtrip minibuss ticket amounts to 10 percent of total expenditure by a household in the lowest income bracket. As a result, many people are unable to access basic transport to their work places, with adverse implications for productivity.

The lack of basic transport facilities in Africa has translated into higher transportation and insurance costs in international consignment and placed limitations on international competitiveness as well as domestic trade. Today, total freight costs in Africa are a much higher proportion of import value than in other developing countries—12.65 percent and 8.70 percent, respectively. In Mozambique, for instance, the lack of north-south transport links makes the cost of trucking a 22–24 ton container from Maputo to the north of the country nearly 2.5 times as high as that of shipping the same container from Dubai or Guangzhou to Maputo.

On the other hand, positive impact of basic infrastructure in Africa can be overwhelming: In Morocco, for example, the presence of a paved road boosted school attendance rate from 21 percent to 48 percent for girls and from 58 percent to 76 percent for boys. In Mali, a new road (between Sevare and Gao) linking the cereal production area to the dry north of the country has contributed to the improvement of food security.

Perhaps needless to say, the financing challenge of the infrastructural gap in Africa requires concerted efforts from all funding agencies to achieve the desired development objectives and the MDGs. Through initiatives such as the New Partnership for Africa's Development (NEPAD) and the Group of Eight (G-8) Gleneagles Declaration, the need to scale up investments to bridge the Africa infrastructure gap is beginning to be realized. However, more needs to be done in order to meet the infrastructure financing needs, which the Commission for Africa puts at an annual investment requirement in Sub-Saharan Africa alone at about US\$20 billion. In this regard, a globally coordinated approach is needed.

Rethinking Infrastructure for Development

As we all know, in the last decade infrastructure was largely overlooked in Africa, as far as the distribution of aid resources was concerned, in favor of the social sectors. The case for reversing the trend now in aid allocation to infrastructure is strongly supported by the positive economic and political developments that are occurring in the continent.

While the mobilization of increased resources is possibly the most pressing challenge for donors, using official development assistance (ODA) to leverage private and other public resources more efficiently and reducing the inefficiencies of some current aid modalities—such as tied aid, use of project implementation units, and differing procedures—are equally important. Of equal importance must be the realization of the fact that returns to investments in infrastructure are realized over the medium to long term or otherwise in terms of social as opposed to economic returns. Thus, the terms of lending for infrastructural projects must be soft enough to be compatible with debt sustainability.

A case in point of a successful initiative is the multidonor-funded Sub-Saharan Africa Transport Policy Program (SSATP), which is providing support to 26 African countries to undertake a participatory process by which national stakeholders (public, private, civil society) review the links and coherence between their national transport and poverty reduction strategies. The SSATP supports formulating action plans so that transport improves its contribution to poverty reduction. In Tanzania, it has led to the creation of a transport-economic sector working group under the Poverty Reduction Strategy Technical Committee and plans to address capacity gaps in the line Ministry and improve stakeholder involvement, particularly from the private sector.

Certainly, the challenges of financing the rehabilitation and development of infrastructure are prohibitive for either the public or the private sector acting alone. Partnerships to facilitate private sector participation; a redefined role for the public sector; local community participation; and involvement by regional and continental organizations and international donors are all requisite ingredients. In the past, the provision of infrastructure in Africa has largely been the preserve of government. Given the central role assigned to infrastructure in development and the availability of private capital flows that can benefit the sector, we need to rethink infrastructure development.

It may not be realistic to assume active participation of the private sector in all areas of infrastructure across Africa. However, the time is now opportune to attract the private sector into financing infrastructure, especially infrastructure with positive economic returns. This is possible because the African economy has continued on a path of economic recovery. Our estimates indicate that economic growth in Africa remained steady in 2005 and is expected to improve in 2006 and 2007. The macro-economic environment has continued to improve, with a number of countries registering low inflation. There is a gradual shift from state control of factors of production to market-based management of the economies. Various sectors of the economy have been opened to competition and state enterprises largely privatized. The regulatory environment is being strengthened in a number of countries. The political environment has continued to improve, with a number of countries shifting to multiparty politics and regularly holding elections. The process has been strengthened by the introduction of the African Peer Review Mechanism.

The above developments have opened up new opportunities for financing infrastructure. In cases where an infrastructure project generates revenue, through charging of user fees, private sector participation can be attracted. The added advantage of this approach is to tap into the efficiency of project implementation and sound management of infrastructure facilities by the private sector. However, we remain cognizant of the dangers of this new partnership in a manner that promotes better risk management and equitable profit sharing. It would be unfair to the public sector if the private sector were to use the partnership to transfer all project risks to the public sector.

Success has been recorded in attracting the private sector in the areas of telecommunications, airlines, railways, and power. But more needs to be achieved, especially in the participation of the private sector in regional projects. This requires the Regional Economic Groupings to intensify measures toward convergence and harmonization of legal frameworks and regulatory standards. The public sector will remain active in all areas that may not be attractive to private sector participation, especially in large capital investment projects and in rural infrastructure.

Conclusion

I would like to conclude my remarks by emphasizing that money alone should not be enough in our rethinking of infrastructure for development. The policy and regulatory environment must remain right in Africa. A clearly defined policy and institutional framework to accelerate the development and maintenance of infrastructural projects is needed. Also needed is greater transparency on the part of governments in infrastructure financing. International efforts will then complement efforts made by Africans for Africa, for in the end, the ultimate responsibility must rest with Africans.



Keynote Address

Infrastructure Development and Human Security

SADAKO OGATA

It gives me great pleasure to address the Annual World Bank Conference on Development Economics (ABCDE). Although held annually, this is the first such conference to take place in Asia, and I am particularly pleased that it is hosted here in Tokyo.

Sixty years ago, much of Japan was suffering from destruction and poverty in the aftermath of the war. Enormous efforts were then launched to rebuild the country's basic infrastructure. Acting in full capacity under its former title, the International Bank for Reconstruction and Development, the World Bank played a major role in the rebuilding of the country. The initial Bank loans were advanced for the construction of hydroelectric power plants, followed by a series of heavy industry plants and highways crisscrossing the country. The Bank is well known for its assistance in building the high-speed bullet train connecting Tokyo to Nagoya and then to Osaka, which today extends to points beyond.

The 31 projects financed by World Bank loans were targeted toward infrastructure building. For the reconstruction of advanced industrial countries such as Japan, the most effective boost to the economy was to reinstall the industrial power base. Much of the governance structure as well as the industrial labor force, although heavily strained by the war, were in place to carry out the challenges of postwar reconstruction.

It is no surprise that Japan, thanks to its own reconstruction experience, would concentrate on infrastructure development and technical assistance as it began to aid Asian countries. Japan's assistance was also implemented as part of its war reparation to Southeast Asian countries. By the mid 1960s, Japan began to characterize its official development assistance as a major foreign policy tool, in place of military means that had marred its past. As many Asian countries have achieved remarkable economic growth, Japan has extended its official development assistance globally, and is now increasingly engaged in Africa.

Sadako Ogata is President of Japan International Cooperation Agency (JICA).

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Last October, when I met with World Bank President Paul Wolfowitz, we agreed that our two organizations, the Bank and the Japan International Cooperation Agency (JICA), would collaborate on two scores: infrastructure development and focus on the Africa region. We have since carried out a series of consultations on the region. Some African governments and leaders have requested infrastructure development assistance—particularly targeting roads, ports, and water supplies.

In extending infrastructure assistance to Africa today, however, we cannot simply follow the traditional approaches such as those taken in the postwar reconstruction of Japan or those extended to some other Asian countries. The times—and the needs—have changed. We live in a globalizing world where states and people are vastly affected by what goes on across national boundaries. In addition to money, people, goods, and information; as well as infectious diseases, natural disasters, and environmental degradation proliferate across borders. To tackle today's global challenges, we need a type of infrastructure assistance backed up by social and economic development that strengthens the people themselves. The concept of “human security” thus was developed in response to the search for a more holistic approach to safeguard both the safety and prosperity of states and peoples.

I had the pleasure to participate in the attempt to explore the concept of “human security” as a cochair of the Commission on Human Security with Professor Amartya Sen in 2001–03. While giving due recognition to the importance of strengthening the governing capacity of the state, emphasizing the importance of empowering the people was considered most significant. The Commission's overall message was to advocate a “bottom-up” approach so that people would not be regarded as passive beneficiaries of assistance but active promoters of development and change. We concluded that people empowered through education, health care, and participation in public life would be better equipped to deal with threats—be they weak governance, conflicts, or drastic economic or social downturns—and could eventually turn their situation around.

JICA has introduced the human security approach in its development assistance planning and implementation. With regard to infrastructure development, it focuses on the benefits it brings to the people as well as the inputs gained from community involvement. JICA defines “infrastructure” more broadly than other organizations, as that which provides the foundation of basic services, and which guarantees people the right to safety and well being. Combined with appropriate technical assistance, infrastructure can ultimately enhance people's empowerment.

Investment in infrastructure development with a human security perspective provides the beneficiaries with new resources and opportunities. It can serve as a trigger to prompt the state to adopt institutional policies that link the people and the state. The great advantage is the multiplier effect ultimately for enhancing human state security.

Ladies and Gentlemen,

Now I would like to illustrate, in more concrete terms, how JICA has attempted to incorporate the “human security” approach in its infrastructure development

work. Simply put, there are three focuses: first, community-based; second, comprehensive; and third, cross-sectoral.

By the first keyword, “community-based,” JICA emphasizes the community as the basic arena of human livelihood. Identifying target populations and community needs is the first important step. Beyond examining the availability of schools, health clinics, water points, and their specific locations have an enormous impact on their usefulness. While a road that divides service facilities becomes virtually useless, one that unites them would add additional value. By focusing attention at the community level, we can more effectively address the actual needs of the people. Perhaps needless to say, the community-based approach to infrastructure development should be complemented by institutional and capacity development of local authorities concerned, if we are to expect any assistance program to have a cumulative effect.

An illuminating example of a community-based approach can be found in Niger, where JICA and the national government jointly embarked on an education program building schools. In the course of designing appropriate school facilities, the parents and community leaders got involved. They not only became aware of the importance of education but also learned to organize local school management committees. The experience led to the training of parents in fundraising exercises for the schools, and eventually in designing various community projects on their own initiatives.

The second keyword, “comprehensive,” stands for ensuring the full use of physical infrastructure facilities. Going beyond the building of roads, schools, or hospital buildings, assistance should include measures that encompass their full maintenance and utilization by adding service-delivery mechanisms. In this regard, infrastructure development should be coupled with technical assistance and institution building to strengthen the necessary human capacities. Funds and technical skills are frequently required for road repairs and school and hospital innovations. In too many situations, the lack of follow-up servicing capacities has resulted in failed or abandoned infrastructures.

I was pleased to witness a successful, comprehensive water supply project in Senegal. To ensure access to safe drinking water, JICA had constructed 109 water towers in rural communities. With technical assistance from JICA, some villages had developed the capacity to set up a sustainable maintenance system. A bitter experience earlier of a sudden loss of village water due to a breakdown of the water tower led the villagers to collect funds and learn to restore necessary parts for immediate repair. The women in the villages backed up the servicing system by managing a practical water use payment system. Furthermore, with the experience of collecting communal funds, the villagers began to embark on poultry farming and other small enterprises.

The third critical point of emphasis is “cross-sectoral.” It is not necessarily difficult to recognize that the needs of the people, especially the poor, are multifaceted and complex; however, linking the diverse development sectors into an overall program has proven extremely difficult. To begin with, experts and institutions are usually compartmentalized along functional lines. Building roads, hospitals, and water supply systems do not necessarily go hand in hand. While people expect to benefit

from all social services as an integrated community system, local and national governments as well as international organizations frequently respond along sectoral lines. The clue to sustainable development then lies in insisting on linking community-based development projects, in line with the basic principles of human security. We need to insist whenever and wherever we can, to cross the boundaries—sometimes even the national boundaries—of the conventional “sector-oriented approach.” This must be at the basis of infrastructure development.

Currently, JICA is undertaking cross-sectoral infrastructure development in Africa, focused on transcountry road construction. Globalization has had a particular impact in Africa, where many countries share borders with many neighbors. To successfully compete in a global economy, these countries have to come together to try to strengthen regional, rather than simply country-based, economies. Infrastructure such as interstate highways, in fact, holds special significance, and many governments have approached JICA to undertake surveys to explore the benefits of cooperation.

There are plans for building five major highways across the continent, such as the Nacala Development Corridor between Zambia and Mozambique, via Malawi, and the South Corridor Development between Mali and Senegal. In addition, JICA is planning to extend assistance to New Partnership for Africa’s Development’s (NEPAD’s) so-called one-stop border-post projects, which have the potential to bring enormous benefits by facilitating the cross-border transportation of goods and people. A major component of this project will be the training of the officials and specialists to improve their border management skills. The project should help enhance efficiency and minimize transportation and transaction costs, and ultimately, together with the eventual construction of cross-border highways, serve to vitalize regional economic activities.

Ladies and Gentlemen,

Very recently, Prime Minister Junichiro Koizumi launched, under a policy entitled “Small Government,” an ambitious plan to downsize the sprawling administrative apparatus in Japan. The reorganization process, which will culminate in 2008, began in 2005 when a council chaired by the Prime Minister approved a “Basic Policy for the Reform of Public Financial Institutions.” By March 2005, the Cabinet Council had approved a bill for the basic law on the enhancement of administrative reforms.

A major component of the official development assistance (ODA) reform, as part of the overall administrative reforms now underway, will result in a merger between JICA and ODA loans divisions of the Japan Bank for International Cooperation (JBIC). By 2008, the new JICA will be able to offer not just the technical assistance it currently provides to developing countries, but also grant and loan assistance—all under one roof.

JICA will effectively be the world’s largest bilateral development agency, and, overall, second only to the World Bank. With an annual budget estimated at about US\$9 billion, it will become a unique aid agency providing technical assistance, grant aid, and ODA loans in an integrated manner.

The reorganization is truly a major challenge for everyone involved in the reshaping of Japan’s ODA, and I believe it is one of the most important and welcome

developments in the history of Japanese ODA. It will allow us to translate people's development needs into larger-scale development programs, by connecting technical assistance, grants for infrastructure improvement, and financial assistance for larger-scale development.

Whatever the change, JICA seeks to place people at the center of our development assistance. JICA has been sending numerous technical experts and overseas volunteers to developing countries under technical assistance programs to work jointly with their recipient-country counterparts. JICA will further promote such field-level efforts for program identification, implementation, and monitoring. It will also seek to replicate and extend the effects of successful models, making use of financial assistance to scale them up.

At a time of rapid and unprecedented changes in global development economics, we need innovative ideas and programs as well as financial resources to tackle the problems of the developing world. To be sure, JICA will be undergoing a process of trials and errors, but I can promise one thing: in pursuing an effective and efficient development aid system, JICA will remain committed to human security as its operational base. I would like to request support and collaboration from the World Bank, international organizations, governments, and nongovernmental agencies present here today, so that together we can better contribute to the happiness and improvement of the lives of millions of the world's poorest people.

Thank you very much.



Keynote Address

Aid for Trade

JOSEPH STIGLITZ AND ANDREW CHARLTON

Aid for trade must complement tariff reduction if developing countries are to realize gains from a multilateral trade round. In many of the poorest countries, tariff barriers are not binding constraints to export growth. Rather, a range of internal barriers prevents the expansion and diversification of trade. These countries will need aid to ease these supply constraints. Many of the world's poorest countries will also require assistance to meet the costs of adjusting to a new global trading system.

The next two years represent a critical opportunity for progress on trade-related development assistance. Following the Group of Eight (G8) and European Union (EU) summits in 2005 and various other recent commitments by developed countries, annual development aid is expected to increase by \$50 billion between 2006 and 2010. This will make more resources available for all kinds of aid.

Aid for trade has been attracting special attention. One reason why is that donors are becoming more aware that increased aid flows may have unintended negative consequences for developing countries, especially if more aid leads to real exchange rate appreciations (Dutch disease), which reduce their international competitiveness. The threat of such an outcome will focus donors' attention on counterbalancing programs, including trade development, trade facilitation, and other programs to boost competitiveness in developing countries.¹

Joseph Stiglitz is a university professor at Columbia University, chair of Columbia University's Committee on Global Thought, cofounder and president of the Initiative for Policy Dialogue at Columbia, and chair of the Brooks World Poverty Institute at the University of Manchester. Andrew Charlton is a research economist at the Centre for Economic Performance at the London School of Economics and Political Science. This article is based on a report prepared for the Commonwealth Secretariat. The authors acknowledge the comments of participants at the meeting organized by the Commonwealth and held at the United Nations Conference on Trade and Development (UNCTAD) March 21–22, 2006. They also acknowledge comments received at the conference "An Assessment of the Doha Round after Hong Kong," held February 2–3, 2006. The conference was organized by the Initiative for Policy Dialogue at Columbia University and hosted by the Brooks World Poverty Institute at Manchester University. Without implicating them in the opinions expressed in the report, the authors would like to thank Dan Curiak, Simon Evenett, Roman Grynberg, Hilde Johnson, Ricardo Melendez-Ortiz, Julia Nielson, Sheila Page, Susan Prowse, and Dirk Willem te Velde for their valuable comments.

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Another reason why aid for trade is receiving attention is that the next two years are also a critical period for the World Trade Organization (WTO), during which it hopes to conclude the Doha Round of trade negotiations.² The imperative to make good on the development promise of the round, as a prerequisite for its conclusion, provides a political focus for aid for trade.³

One and a half decades after Williamson's articulation of the Washington Consensus (1990), the world has come to acknowledge that free trade is not a magic wand.⁴ The old trade framework assumed that trade liberalization would automatically lead to increased trade, that increased trade would lead to faster growth and development, and that trade-induced growth would lead everyone to be better off. Subsequent research has produced a new trade policy framework that has questioned each of these hypotheses. First, while trade liberalization may be necessary for sustained expansion of trade volumes, it is not the only factor that contributes to the growth of exports and imports.⁵ Second, while trade may be necessary for sustained industrial development, it is not sufficient. Third, while trade liberalization may lead to more trade and more growth, there are attendant costs to liberalization that have received insufficient attention. Even if there is more trade and more growth and the benefits of trade liberalization exceed the costs for the country as a whole, particular groups may be worse off: there may be more losers than winners. And even if the winners could compensate the losers, they seldom do.⁶

The aid-for-trade agenda does not seek to resolve all of these problems. It focuses mainly on the first issue—ensuring that trade liberalization is more likely to lead to increased trade. It reflects the realization that, for developing countries, the investments needed to realize the full benefits of new market opportunities are particularly large, and the capacity to meet them particularly small.

There is an emerging consensus that the current WTO Doha Round will require adequate trade-related assistance to mitigate the detrimental effects of trade reforms and to enhance the trading capacity of developing countries. This was put forcefully by Pascal Lamy, Secretary General of the WTO, when he was the European Union Commissioner for Trade: “Duty-free access alone is not enough to enable the poorest countries to benefit from liberalized trade. We need to help them build their capacity to supply goods of export quality and we reaffirm the Commission's commitment to continued technical and financial assistance to this end” (European Commission 2000).

The final Declaration of the WTO Doha Ministerial meeting reiterates the importance of technical assistance and “reaffirms . . . the important role of sustainably financed technical assistance and capacity-building programmes” (paragraph 41). Of course, in the Uruguay Round there was recognition that developing countries would need technical assistance to implement the agreement—and a promise that such assistance would be given (though, as the G77 has repeatedly noted, assistance has not been forthcoming, at least to the extent promised). But it is now clear that the extent and range of assistance required is far larger than was envisioned a decade ago.⁷

The first part of this article sets forth the case for aid for trade, explaining why without such aid, it is unlikely that the promised benefits from trade liberalization will materialize. The second and third parts discuss what an aid for trade program

might look like. The last part of the article explains why the proposal put forth here is both novel and important, especially if the development round is to live up to its promise of creating jobs, promoting trade, and enhancing living standards in developing countries.

The Case for Aid for Trade and the New Trade Policy Framework

The case for aid for trade grows out of a new trade policy framework that seeks to explain why trade liberalization has so often failed to live up to its promises of increased trade, growth, or welfare. There are several potential explanations.

Trade Liberalization May Not Lead to More Trade

In the right circumstances, trade liberalization creates opportunities for trade and development. A variety of factors determines the extent to which those opportunities are realized and whether the increased trade leads to an increase in welfare and overall growth. The Everything but Arms (EBA) and Africa Growth and Opportunity Act (AGOA) experiments gave least developed countries (LDCs) free access to U.S. and European markets but resulted (in most cases) in disappointing increases in exports.⁸

Similarly, LDCs have been granted new market access opportunities in successive rounds of trade negotiations, as well as in a range of preferential market access schemes. In each case, studies have assessed the potential benefits of these opportunities, invariably making claims about the large anticipated effect on LDCs' exports and welfare. These studies make a number of optimistic assumptions about supply elasticities in LDCs. In contrast, most ex post analysis has found that new market opportunities have led to little increase in LDC exports. Indeed, despite decades of multilateral liberalization and increasingly "generous" preferential schemes, LDCs' share of world trade has been falling over the past 20 years (Assaf 1998).

Trade has failed to increase because of the absence of "export infrastructure" and other internal barriers to trade and because of "supply constraints." In the past the hope was that new market access by itself would spur investment in supply capacity in the LDCs. But experience has repeatedly shown that without decent roads, efficient ports, and the technical capability to produce and distribute goods of sufficient quality (all of which collectively may be thought of as the *exporting infrastructure*), new trading opportunities are meaningless for the poorest countries.⁹ By the same token, without access to credit, it will be difficult for new enterprises to be created or old enterprises to expand to take advantage of any new opportunities. Public and private investments are, of course, complementary: even were finance available, without the necessary infrastructure, internal barriers to trade will remain large. The reason why the benefits reaped by LDCs so far have been so much smaller than those received by developed countries is simple: the "internal" barriers to trade are much more important for LDCs, so the elimination of tariffs represents a much smaller change in the total barriers to trade.¹⁰

More Trade May Not Lead to More Growth

Even when exports do increase, they may not lead to robust growth. For example, Brazil's exports have doubled in the past three years, but its growth remains anemic. More generally, there has been a reassessment of the overall benefits and costs, resulting in a far more nuanced understanding of the role of trade in development than previously presented by many international institutions.¹¹

While most of the economic theory of trade liberalization has focused on static welfare gains, the long-term effects of trade liberalization are determined by its effect on the economy's rate of growth. Recent models of growth have important implications for the theoretical relation between free trade and economic growth. Greenwald and Stiglitz (2006) show that in some circumstances, developing countries maximize their welfare by supporting industries outside their static comparative advantage. If advanced industrial sectors drive innovation, and this innovation is determined by the size of the industrial sector, especially if the productivity gains are transmitted between industries but not across national borders, then developing countries may benefit from policies that support these industries and sectors.

Adjustment Costs May Be Large

Any gross welfare gains from trade liberalization must be balanced against their associated costs. As a result of liberalization, countries face large adjustment costs, as resources are moved from one sector to another in the process of reform; whereas it may take decades for multilateral trade reform to deliver gains to developing countries, the adjustment costs are automatic and usually upfront. The costs of these adjustments are particularly large for developing countries, while their ability to bear them is limited. Money spent on adjustment is money that could have been spent on high-return investments elsewhere in the economy, which is perhaps part of the reason why the growth benefits of trade liberalization appear so limited.

Adjustment costs include fiscal losses, preference erosion, the direct and indirect costs of industrial restructuring, and the costs of implementing new regulatory regimes.¹² In a sense, these adjustment costs can be thought of as the price to be paid for the benefits of multilateral tariff reduction. Together these adjustment costs and trade benefits determine the net effect of trade reform for each country.

The Doha Round has renewed emphasis on the importance of sharing the benefits of trade reform fairly among developed and developing countries. Less attention has been paid, however, to the distribution of adjustment costs among countries.

A theme that runs through the empirical evidence is that the adjustment process resulting from the Doha Round proposals will affect the people and governments of developing countries, especially smaller developing countries, particularly harshly. There are several reasons for this asymmetry. First, developing countries are particularly vulnerable to policy shocks because their export industries are the least diversified—many are dependent on one or two exports and hence the world price of just one or two commodities. Second, developing countries are likely to need to make the largest changes to comply with international regulations. Third, the structure of world trade is most distorted in the industries of importance to developing countries.

World markets for agriculture, processed foods, textiles, and other critical goods are the most distorted by developed countries' tariff and subsidy policies. Consequently, these industries will be greatly affected by liberalization: even where reform has long-run net positive effects for developing countries, it will force these countries to cope with adjustment costs, investment costs, and redistributive effects. Fourth, and most important, developing countries are home to the world's poorest people and the weakest credit markets. These people are particularly vulnerable to adjustment costs. Fifth, almost by definition, markets are less well-developed in developing countries; their economies are marked by much larger market imperfections. Well-functioning markets enable resources to be deployed easily; in poorly functioning markets, such redeployments are more likely to be slow, with longer periods during which resources are not fully utilized.¹³ Sixth, developing countries are more dependent on tariffs as a source of revenues—and for good reason: the costs of alternative sources of revenue are high. Tariff reductions force them to shift the burden of taxation to these alternatives.¹⁴ For all of these reasons, the adjustment to new trading rules is a radically different experience for developed and developing countries. Moreover, the adjustment costs may not be just a one-time cost. Trade liberalization may, for instance, expose developing countries to more shocks, their economies may be less capable of absorbing the shocks, and their people may be less able to cope with the consequences.¹⁵

The Empirical Evidence

Standard economic theory never claimed that trade liberalization would lead to increased growth; it simply argued that it would lead to welfare gains and that the winners could compensate the losers. There was a one-time gain in efficiency from trade liberalization, during which growth would be higher.

It is difficult to identify the original evidentiary source of the bullishness for unqualified trade liberalization during the era of the Washington Consensus. Several studies in the early 1990s purported to show a positive relation between trade openness and economic growth (Dollar 1992; Ben-David 1993; Sachs and Warner 1995), but even these were careful to qualify their results.¹⁶ Rodriguez and Rodrik (2001) have persuasively shown that the conclusions of these studies should be interpreted with extreme caution.¹⁷ Most of these studies focus on the consequences of trade *openness*, not trade *liberalization*. For instance, the countries of East Asia promoted trade and grew rapidly, but they focused on exports and did not liberalize quickly. In fact, their periods of most rapid growth preceded trade liberalization: one study that focused explicitly on trade liberalization showed no relation with economic growth (UNDP 2003).

To recognize the weaknesses of the empirical evidence in this field is not to argue that trade protection is good for growth, but it does suggest that the relationship between trade liberalization and growth is not simple. For instance, trade liberalization may have positive effects on some countries (for example, those with low unemployment rates and fewer market imperfections) but negative effects on others (for example, those with high unemployment rates, weak credit markets, and weak safety nets).

Aid for Trade for What?

Aid for trade involves the flow of development finance from rich to poor countries for the purpose of enhancing the world trading system. The design of an aid-for-trade framework involves three key questions: what should be funded, in what form should the money be given, and who should manage the transfers.

In the context of trade, the answers to these questions depend critically on the purpose of any aid-for-trade fund and its relation to the trading system—fundamental issues that remain up in the air. Several (nonexclusive) purposes for trade-related development assistance have been floated that have very different implications for the design of an aid-for-trade mechanism.

First, and most straightforward, is the political motivation often ascribed to the rich countries; namely, that aid for trade is an instrument to buy progress in the Doha Round. Put bluntly, this view conceives of aid for trade as a “normal negotiating side payment”¹⁸ necessary to ensure that the Doha Round package results in Pareto improvements for all developing countries—arguably a necessary condition for progress in the WTO’s bargaining process, which is characterized by both a single undertaking and consensus agreement (Evenett 2005). This view leads to the conclusion that aid should be directed to those countries that would be net losers from the Doha Round and have an incentive to block its progress.¹⁹

A second argument for aid for trade is discernable in the demands for compensation leveled by preference-dependent countries, such as net food importers and those facing costs associated with industrial restructuring following the end of the textiles agreement. This compensation motivation appears to be based on the view that developing countries should be compensated for losses arising from specific elements of the agreement, independent of their gains in other areas or the deal as a whole. This rationale leads some proponents of aid for trade to envisage compensatory schemes to address specific categories of adjustment costs arising from changes to the world trading system following implementation of the agreement.

A third (related but more general) rationale for aid for trade is fairness. There is no doubt that an ambitious Doha Round will deliver significant gains to rich countries and that these gains will far outweigh the gains to poor countries. For some, aid for trade is a mechanism of redistribution through which the reality of the unbalanced outcome can be squared with the rhetoric of the Development Round.

There is a further question: should countries or individuals be compensated? Compensation to the country that (as a whole) may be worse off may not reach the individuals who bear the costs of adjustment, but designing aid mechanisms that deliver assistance to those adversely affected may be extremely difficult. Few of the aid-for-trade advocates seem to have compensation to individuals in mind.

All of these rationales see aid for trade as an exchange: a payment, compensation, or gift in return for complicity in the multilateral trade liberalization agenda. While we believe that each of these rationales has some merit, we have several concerns with their application.

The basic problem is that all three rationales place undue and unhelpful constraints on aid for trade. First, limiting aid for trade to a compensation concept

limits the pool of donors. The problem of preference losses, for example, is arguably an issue between the recipients and the granters of preferences (the European Union and to a smaller extent the United States); other rich countries may be reluctant to commit resources to resolve a problem they did little to create.

A more important concern is that a compensation approach limits the beneficiaries of aid and may prevent aid for trade from reaching the neediest countries. Losses from preference erosion, for example, are heavily concentrated in the handful of countries that have managed to benefit from preferential access, and these are not, for the most part, the LDCs. Moreover, some have expressed concerns about whether, as an ethical matter, the erosion of rents arising from historical preferential schemes gives rise to a right to compensation. Another question is how losses in some areas of the agreement should be treated relative to losses in other areas. That is, should losses arising from terms-of-trade effects related to the elimination of export subsidies be compensated in the same way as losses arising from preference erosion? Should losses from preferential access in free trade agreements be treated in the same way as preferential schemes? Should losses from agreements in previous rounds—such as losses from the costs of the Trade-Related Aspects of Intellectual Property Rights (TRIPS) agreement—be included?²⁰

In our view, the most serious reservation about the compensation approach is that it does not necessarily imply that funds would be directed to the poorest countries—or even to those countries facing the largest net losses from the round as a whole. With these concerns in mind, we use a fourth rationale to motivate aid for trade. Rather than seeing aid as an exchange for progress in the Doha Round, we see it as a necessary complement to the core market access issues at the center of the Round. Lack of supply capacity and the other problems noted earlier are barriers to trade that limit market access for poor countries. Aid for trade should be seen as an essential component of market access offers to poor countries. The message from LDCs in the Doha negotiations should be as follows: “Aid for trade must be part of the market access agenda. It is meaningless to give us tariff-free entry if we are unable to use it. In the context of supply constraints, giving us access to your markets must mean giving us both free entry and aid to ensure we can use it.”

In our view, aid for trade should be motivated by the imperative to create “effective market access” by removing internal barriers to trade. All countries facing adjustment shocks (for example, preference-dependent countries and LDCs facing adverse terms-of-trade shocks and tariff losses) should receive funding. However, while adjustment costs should motivate donors and identify recipients, aid disbursements should have the purpose of promoting future exports, not compensating the loss of past exports. The objective should be to increase the volume and value-added of exports, diversify export products and export markets, and attract foreign investment to generate jobs and exports.

Aid for Trade versus Development Aid

This expansive definition of aid for trade raises the question of how aid for trade differs from development aid in general. If a road is being built, how close does it have

to be to the port to become an aid-for-trade project? If there is no clear dividing line between aid-for-trade expenditure and general development expenditure, is there merit in complicating the aid system by creating separate frameworks and structures for trade-related assistance?

There is value in a separate approach to aid for trade to the extent that it is useful to recognize that the world trading system is imposing costs on developing countries and that the beneficiaries of the system, that is, the developed countries, should bear these costs. There is a value in focusing explicitly on these market-expanding expenditures if the rhetoric that trade is good, or even essential, to the growth of developing countries is to be taken seriously. The WTO is a useful forum in which to recognize these costs and commit funds to redressing them, to ensure that the aid itself is not just a political instrument that can be withdrawn if the country does something the donor country does not like (such as voting the wrong way at the United Nations). The Doha Round agreement would provide a contract in which these commitments can be made binding; the dispute settlement system could then be used to enforce them. That said, the WTO has no capacity to manage or disburse aid funds, and there is little value in reinventing the wheel to create a new channel through which to deliver aid for trade.

Building Supply Capacity

The central rationale for aid for trade, then, is that market access on its own is not sufficient to bring the benefits of trade to developing countries. LDCs are in many cases unable to take significant advantage of new trading opportunities, because their supply capacity is extremely limited and internal barriers to trade, such as lack of infrastructure (ports and roads), are severe. Easing supply constraints requires going beyond bolstering public institutions through technical assistance to promoting private enterprise and financing infrastructure.

Assistance to build supply capacity is of three types (outlined in Stiglitz and Charlton 2006), each of which should be the focus of an expanded aid-for-trade agenda:

- trade policy and regulations, to help countries participate in the multilateral trading system and reform their own trade policies;
- enterprise development, to create a favorable business climate, help create new private sector enterprises, and expand old enterprises to increase trade; and
- infrastructure, to assist in the identification of infrastructure bottlenecks and finance infrastructure projects.

Developing institutional capacity is important not only to ensure compliance with WTO agreements. Trade costs will be increased if customs procedures, inspections, and certifying bodies are inefficient.

Private sector development centers on improving the business environment for exporters. This involves helping developing countries design and implement a trade development strategy as part of a broader national development strategy. It also means helping developing countries improve financial markets, both by creating new instruments to mitigate risk and by improving local financial markets.

The bulk of the funds should almost surely be spent on infrastructure. Poor transport infrastructure can prevent local farmers from accessing large domestic markets and international ports, poor storage facilities can increase inventory costs, and bad energy and water supplies can disrupt production or increase costs.

In Uganda, for example, poor infrastructure cripples local exporters. More than half of Ugandan roads are in poor condition, placing a large burden on farmers (IMF 2004). Increased transport costs associated with poor roads add the equivalent of an 80 percent tax on exported clothing. Most companies rely on generators to bridge periods of blackout and to avoid damage to equipment from power fluctuations. The average generator installed by small and medium-sized enterprises in Uganda costs about \$25,000 to purchase and requires considerable ongoing maintenance and fuel costs, making this form of energy far less efficient than grid power (Donaldson, Sader, and Wagle 1997). Power generation can increase business start-up costs by more than 30 percent. For businesses in countries without adequate infrastructure, tariff barriers are inconsequential when compared with the costs imposed by domestic obstacles.

Despite the importance of these “behind-the-border” costs, aid for infrastructure has been falling for a decade. There is now recognition in development quarters that donor-supported public funding is an essential prerequisite for boosting or upgrading supply capacity and infrastructure building in LDCs. The sharper focus on infrastructure needs is reflected in the World Bank’s plans to increase infrastructure lending by \$1 billion a year to about \$10 billion by 2008 and the Gleneagles agreement by the G8 “to boost growth, attract new investment and contribute to Africa’s capacity to trade” by establishing the Infrastructure Consortium for Africa, jointly supported by African countries, the European Commission, G8, and key multilaterals (European Commission 2005).

Good roads and port facilities alone, however, do not guarantee an expansion of trade: the value of infrastructure projects is easily eroded by poor economic policies or inefficient and corrupt customs services (Hoeffler 1999). This means good macroeconomic policy—not only avoiding high inflation but also achieving real stability, with low and stable real interest rates.²¹ Research also indicates that returns to infrastructure projects can vary widely and are affected by the quality of the business environment.

New Mechanisms for Aid for Trade

In recent years a number of institutions have made efforts to deal with trade adjustment and capacity building. These include the Integrated Framework for Trade-Related Assistance and the Trade-Integration Mechanism (TIM) of the International Monetary Fund (IMF). At the same time, bilateral aid for trade has been increasing, and multilateral development banks have stepped up their technical assistance programs and increased support for trade-related investments.

As aid flows begin to increase significantly and the scope of trade development projects widens, it is appropriate to consider alternative mechanisms to deliver aid for trade more effectively—in particular to ensure predictability, coherence, country ownership, and additionality. Three options are available: continuing with existing mechanisms, creating a new trade-specific fund, or reforming existing mechanisms.

Institutional design reflects a number of competing considerations. On the one hand, one does not want to duplicate what already exists, and a new institution would exacerbate the problems of coordination required for achieving donor coherence. On the other hand, the success of the market economy is based on competition, which often entails duplication: there cannot be competition if there is a single producer of a product. In general, the gains from competition outweigh the costs of duplication, particularly in the international arena, where governance structures are similar (the advanced industrial countries predominate in all the multilateral financial institutions, though in some, such as the IMF, the power of the United States may be greater than in others).²² It is, then, not surprising that there is a certain similarity in perspectives on development strategies, with the failed Washington Consensus policies long dominating.²³

In many respects, existing mechanisms have been relatively successful in managing the policy dimension of aid for trade. They have made some progress in integrating aid for trade into national poverty reduction strategies, and they have increased the coherence of programs run by multilateral institutions. The Integrated Framework emerged from the 1996 WTO Singapore Ministerial Conference, as part of the WTO Action Plan to boost the participation of LDCs in the world trading system. The framework is supported by six multilateral institutions: the World Bank, the WTO, the IMF, the International Trade Centre (ITC), the United Nations Conference on Trade and Development (UNCTAD), and the United Nations Development Program (UNDP). Its objectives are to embed a trade agenda into national poverty reduction strategies (enhancing country ownership) and to assist in the coordinated delivery of trade-related technical assistance from multiple donors (promoting coherence).²⁴ But the Integrated Framework's institutional structure—designed to provide and coordinate advice, not to administer aid—means that it is ill equipped to translate policy into the delivery and implementation of aid for trade. Its management is too diffuse, and it has insufficient in-country presence to manage projects.

By the same token, we are skeptical about the merits of a new stand-alone fund dedicated to aid for trade. Page and Kleen (2004) propose that a new fund be established within the WTO to deal with preference-dependent economies. Its funding would come from legally irrevocable commitments from developed countries, which would be determined by various criteria. Funding would be allocated to recipient countries based on the estimation of their loss of preferences.

Grynberg and Silva (2004) suggest creating a Special Fund for Diversification to benefit preference-dependent countries. One attractive feature of this scheme is that a share of funds would be allocated for private sector development, including start-up financing for small and medium-size enterprises. But more important than offsetting these advantages are the problems it would present: a dedicated fund would be costly to set up, it would lack coherence with existing efforts, and it would be less likely to consider adjustment needs in the context of broader development efforts and policy reforms that constitute a holistic approach to development assistance.

A second attractive feature of dedicated funds is that by identifying specific costs to developing countries arising from the trade round (that is, preference losses), these

proposals create well-defined obligations on the rich countries. We consider this an essential feature of any aid-for-trade scheme. However, these proposals for dedicated funds link aid for trade to the rationales based on compensation, which should not underlie aid for trade.²⁵ While we believe that the problem of preference erosion is important (and one of the determinants of need) and that funds will be required so that these countries will not find themselves worse off at the end of the Development Round, a new aid-for-trade facility should encompass broader objectives.

Our proposal represents a balancing of these various institutional concerns. Rather than establishing a new fund, our proposal relies largely on existing institutional arrangements. In particular, dedicated funds for aid for trade—provided through specific binding commitments in the final Doha agreements and subsequently enforceable within the WTO—should be allocated to a special facility to be administered by an international organization (such as UNCTAD), much as the Global Environment Facility is administered by the World Bank. A small Global Trade Facility (GTF) Secretariat could be established, which would oversee the GTF program, allocate funds according to an agreed set of principles and priorities, monitor their usage, evaluate performance, and ensure that the developed countries comply with their obligations, bringing cases of failure to the WTO for sanctions (using, for instance, the system of auctionable sanctions.) The GTF Secretariat would not directly administer the assistance programs but would review proposals from countries, multilateral institutions (including the World Bank and regional development banks), and nongovernmental organizations for assistance.²⁶ This would encourage competition among aid recipients and deliverers to develop the most effective and efficient aid-for-trade projects and programs. The secretariat would evaluate the outcome of these projects, assessing success in both promoting trade and enhancing development.

Governance and Funding

Essential for a successful aid-for-trade program are *governance* and *competition*. There is now a consensus on the importance of country ownership. But assistance programs designed by international institutions will inevitably suffer from their flawed governance structure, in which the perspectives of the advanced industrial countries and their interests predominate. For this reason, it is essential that developing countries predominate in the governance of the new GTF.

There is another reason why the governance structure should be different from that of the World Bank, where voting is dominated by donor countries: the GTF is the result of a negotiated global trade agreement. Indeed, one of the principal responsibilities of the GTF is to enforce the obligations and commitments of the advanced industrial countries. This means that it cannot be controlled by the advanced industrial countries.

We suggest the following structure for the GTF:

- a board of 24, with 8 seats reserved for low-income countries, 8 for middle-income countries, and 8 for advanced industrial countries;
- a 60 percent supermajority required for major decisions;

- seats to be held by WTO members, on a rotating basis, chosen to ensure a diversity of geography and economic interests (for example, no more than three seats within any of the groupings to be held by countries in any one region, with at least one seat for an agriculture exporter).

Any aid-for-trade initiative enforceable within the WTO framework, including the proposal here for a GTF, would require commitments from developed countries. While the size and distribution of those commitments will inevitably be a matter of intense negotiation among the members of the WTO, the following proposal suggests a set of principles that might guide those discussions.

Any meaningful aid-for-trade facility must be large enough that it could actually make a difference, yet not so large that it would overwhelm other aid initiatives, including those for social purposes or maintaining the environment (such as the Global Environment Facility). It also makes sense to relate aid-for-trade commitments to the size of the benefits from global trade, particularly to trade with developing countries. Finally, those countries that impose large costs on developing countries through their failure to liberalize (eliminate agriculture subsidies) should make additional commitments. Overall, the failure to achieve fair liberalization (eliminating agricultural subsidies and higher tariffs on products produced by developing countries) accounts for much of the disappointment with liberalization in many developing countries. Such a levy would have the additional advantage of providing an incentive to eliminate the distortionary and inequitable policies.

We propose a three-part commitment:

- The advanced industrial countries would contribute 0.05 percent of their GDP to the GTF. This means that the aid-for-trade facility would represent about 7 percent of the total commitment of assistance (of 0.7 percent of GDP) that the developed countries have made to developing countries, an amount that seems balanced within the framework of overall development needs.
- The advanced industrial countries would make an additional commitment of a small percentage of the value of their exports to LDCs. This commitment can be thought of as a partial substitution of the revenues that would have been received as tariffs, but it takes advantage of the greater administrative capacity of the developed countries and avoids all of the distortionary and political economy “costs” associated with tariffs. The advanced industrial countries need not actually levy the amount as a tax on exports; they can simply pay the amount (which is small relative to their GDP) out of general revenues.
- There would be an additional commitment by advanced industrial countries of 5 percent of all agricultural subsidies and 15 percent of all arms sales to developing countries, partially reflecting the costs that these policies impose on developing countries.

Many voices are resisting proposals to earmark funds for particular purposes, because of the belief that earmarking introduces rigidities or inefficiencies into aid programs. Why should trade not compete with other priorities for the general pool of aid funding? Our proposal is sufficiently modest that that earmarking will not

result in any significant distortion in the efficiency of the overall aid program. The focus on trade would be salutary and bring needed funds to a neglected area.

We believe that the middle-income countries should also make a contribution to lower-income countries. It might be appropriate for the contribution to be at a significantly lower rate (say, half or a quarter of the rate for the advanced industrial countries). Moreover, some of their contribution might be in kind (for example, providing training programs on what they have done to expand and facilitate trade).

Contributions to an aid-for-trade facility cannot be made at the expense of other forms of assistance. There has to be some maintenance of effort commitment. There are several problems in defining an appropriate commitment. One should not, for instance, count debt write-offs, especially for debts that would not in any case have been repaid. The basis of the maintenance of effort commitment should, perhaps, be defined in terms of net flows of funds to developing countries for assistance purposes (as a percentage of GDP) over the past five years. We are concerned with development assistance, not military assistance. We therefore suggest that the maintenance of effort should be defined to include assistance exclusive of reconstruction activities in war zones and exclusive of all military assistance.²⁷

Although new structures will be required to deliver increased trade assistance, they should build on the progress of existing programs and leverage the capacity of existing institutions rather than stand apart from them. New options for aid for trade need to be developed within the context of the “new aid framework” (Hoekman and Prowse 2005), which emphasizes coordination between donors and coherence with national policies and priorities. We believe that the proposal suggested here has the potential of meeting these criteria.

Political Economy Considerations

It is important to consider how an aid-for-trade agreement would affect the political context of the Doha Round negotiations. Some observers worry that aid might provide a “way out” for developed countries to avoid making concessions on agriculture. Others are concerned that the offer of aid might be used to extort more concessions from developing countries on liberalization. While the full analysis of the consequences of expanding the scope of bargaining is complicated and beyond the scope of this short article, we believe that aid for trade may help the negotiations. Ultimately, the outcomes of the round will be driven by the interests of the largest players, including (for the first time) Brazil and India. Brazil will not be a recipient of aid for trade, so its interest in eliminating agricultural subsidies will be unaffected by the initiative. India’s interest in certain aspects of service sector liberalization may be even stronger than some of the more developed countries (which worry about outsourcing to India.) The liberalization agreements that emerge from the negotiations of these major players will be little affected by the LDCs’ receipt of aid. Indeed, the aid-for-trade initiative provides the LDCs with an incentive to cooperate with, rather than block, such agreements.²⁸ LDCs should demand that aid for trade be seen as a complement rather than a substitute for the liberalization offers of the United States and European Union.²⁹

Conclusion

For several years the governments of many developed countries have argued that “trade not aid” is the answer to the problems of the developing countries. The insincerity of their approach has been revealed in successive rounds of trade negotiations, in which they have been reluctant to open their markets to poor countries. More recently, their claims of the benefits from these agreements have also been exposed as fundamentally inaccurate, as liberalization has failed to result in either export growth or development for many of the poorest countries. This poor outcome is not the result of a Machiavellian plot to cheat the developing countries, but the outcomes of trade deals are determined by *real politik* considerations and special interests in developing countries; many good intentions of trade negotiators get lost along the way. The international trade regime has not provided a level playing field: the developing countries face enormous challenges in expanding exports, and they face greater adjustment costs and barriers to seizing new opportunities. If the chances that a development round of trade negotiations leads to development are to increase, the playing field must be made more level and aid must be provided to help developing countries.

We have argued that increased aid is vital for poor countries if they are to grasp the opportunities provided through trade and absorb the costs of adjustment. Adjustment to a post-Doha trading regime will be disproportionately costly and difficult for developing countries because of the loss of preference margins; the loss of revenue from trade taxes; institutional weaknesses, including the absence of adequate safety nets; implementation costs; the lack of finance required to restructure the economy; and the limited ability of poor populations to manage short-term unemployment.

In arguing that additional assistance should be provided to enable developing countries to expand their capacities to trade, we are not suggesting that trade, when combined with aid, will be a panacea. Interactions among trade, aid, and broader development policies and reforms are important. Trade reform is just one of many potential shocks and opportunities faced by developing countries; internal as well as external reforms will be essential in ensuring that these countries realize their development potential. Without aid, however, the prospects of trade liberalization bringing the benefits that its advocates have promised are dim.

What is new about our proposal? First, previous rounds of trade negotiations have expanded the purview of these negotiations, going well beyond simply reducing tariffs. They have recognized that domestic legislation in areas related to investment and intellectual property can affect trade. These issues were brought within the ambit of the WTO precisely because of its enforcement mechanism. There already existed a World Intellectual Property Organization (WIPO), but discussion of intellectual property moved to the WTO because WIPO had no effective enforcement mechanism. But finance is even more central to trade. For the first time, the aid-for-trade proposal brings the power of commitment and enforcement to promises of aid.³⁰

Second, without aid for trade, developed countries have little to offer developing countries—especially as they refuse to make any significant concessions on agriculture—but they wield enormous powers to impose demands, both within and

outside the context of WTO negotiations.^{31,32} To be sure, in WTO negotiations, the developing countries are not negotiating as equals with the advanced industrial countries, and while the voices at the table may have expanded, the voices of the LDCs may still not be heard or at least paid attention to. With aid for trade, for the first time, the developed countries have another binding and meaningful commitment that they can offer developing countries. We are hopeful that the outcomes of such a negotiation will be more favorable to developing countries—and perhaps even more favorable to liberalization itself. Third, the new proposal recognizes the limitations in the governance of existing institutions and provides the beginning of an alternative.

Aid for trade offers the possibility that rather than leaving developing countries worse off—as so many were following the last round of trade negotiations—trade agreements could actually make them better off. It offers the possibility of a trade agreement that will result not in more imports and job losses in developing countries but in more exports and job creation.

Notes

1. For a discussion of aid for trade, see Page (2006).
2. There are concerns that the Round may not be finished within two years (see Evenett 2006). As this article goes to press, these worries seem increasingly warranted.
3. For a broader discussion of the development potential of the Doha Round, see Stiglitz and Charlton (2005).
4. Pascal Lamy, Secretary General of the WTO, introduced the wand imagery in reference to the role of the WTO Secretariat in the conclusion of the negotiations. He made this point by bringing a wand to the opening session of the Hong Kong Ministerial, held December 13, 2005.
5. For example, the focus on trade facilitation measures reflects recognition by the developed countries that their ability to sell goods to developing countries does not depend only on tariffs. The discussion here highlights the range of other barriers that may be especially important in allowing developing countries to obtain meaningful access to developed countries' markets.
6. The adverse distributive effects of trade liberalization for developed countries were predicted long ago by Samuelson and Stolper (1941). But trade liberalization also seems to have adverse distributional impacts within developing countries. Some of the arguments for aid for trade focus on these effects. For a fuller discussion of these distributional consequences and the appropriate responses, see Stiglitz (2006).
7. The developed countries have not even lived up to the commitments for technical assistance they made at the conclusion of the Uruguay Round.
8. For a survey of some of the evidence, see Stiglitz and Charlton (2005).
9. Fugazza (2004) shows, for example, that Africa's ability to reap benefits from improved market access has been constrained by the poor development of supply capacity factors.
10. One way of understanding the problem is the following: there are both natural (economic) barriers to trade and man-made barriers to trade (such as tariffs). Trade liberalization reduces the man-made barriers. For developed countries, with good roads and ports, these are the major barriers, while for developing countries, the natural barriers are the major barriers. In effect, trade liberalization reduces the barriers to trade by a much larger percentage for developing countries than for developed countries.

11. The IMF's former First Deputy Managing Director, Stanley Fischer, boasted that the "Fund is a powerful voice and actor for free trade" and suggested that this is because "integration into the world economy is the best way for countries to grow" (Fischer 2000).
12. See Stiglitz and Charlton (2005) for further evidence of these costs.
13. Even in developed countries, there is evidence that less well-educated workers that are displaced experience greater adjustment costs.
14. For instance, while the value-added tax is an efficient (though regressive) tax for developed countries, it is typically inefficient for developing countries, because of the difficulty (impossibility) of taxing the large informal sector (see Emran and Stiglitz 2004). By the same token, tariff protection may be a relatively efficient method of encouraging the development of the industrial sector; forcing developing countries to resort to other instruments may be costly (see Greenwald and Stiglitz 2006).
15. There are other ongoing costs, such as the incremental burden of shifting from tariffs to other third-best revenue sources.
16. In the conclusion to their paper, Sachs and Warner (1995) point out several of the important caveats to their study.
17. They find that the indices of openness used in these studies conflated the effects of trade policies with other phenomena. In particular, the studies identified the negative effects of macroeconomic imbalances, instability, and geographic location, and misattributed them to trade restrictions. Because of these methodological weaknesses, the policy conclusions drawn from these studies are not strongly supported by the data they present.
18. Comment by Gary Hufbauer, of the Institute for International Economics, at a meeting of trade experts hosted by International Trade Canada, Ottawa, March 3, 2006.
19. The potential relevance of this concern is highlighted by the fact that so many developing countries were worse off after the last round of trade negotiations (UNDP 1997). The fact that they acceded to the agreement shows that aid for trade may not be necessary to achieve agreement, reinforcing the conclusion that this should not be a rationale for aid for trade. To be sure, the developing countries are far more aware of potential adverse effects of trade agreements than they were a decade or more ago; the 2003 WTO Ministerial Conference in Cancun showed their heightened willingness to resist.
20. By the same token, there is a question of whether the gains from trade liberalization should be used to offset the adjustment costs.
21. In this sense, the macroeconomic policies advocated by the IMF have often been counter-productive (see Stiglitz and others 2006).
22. In the IMF, the United States has effective veto on important matters, given the requirements for supermajority votes.
23. There are differences among institutions. The World Bank, at least under President Wolfensohn, distanced itself from these strategies as their failures became more evident; the IMF was far slower in responding.
24. In this way the Integrated Framework mechanism embodies many features of the "new aid framework," which aims to improve harmonization among providers of trade assistance and place trade within the context of a country's broader development strategy.
25. This means that there is no reason in principle that the aid should be related to trade development rather than channeled as direct transfers. There are other problems with adopting compensation as the basis underlying the aid for trade program, several of which have already been discussed. There are additional questions as well. For instance, many of the preferences have always been temporary, though they have been continually renewed. Does the country (individual) need compensation as if they were permanent (which could be large) or only for the period of the explicit program (in which case they might be very small)?

26. The GTF Secretariat might be housed within UNCTAD, in order to ensure that the perspectives of the developing countries play a larger role than they do within existing aid institutions. The diversity of perspectives might complicate the problem of aid coordination, but the gains from diversification would likely more than offset any incremental coordination costs.
27. Reconstruction activities are important, but they should not be at the expense of the broader commitment to development.
28. In this sense, it opens up the possibility of Pareto-superior outcomes.
29. It is important that aid for trade not be seen as a way of buying agreement to discriminatory practices. Nondiscrimination has been the hallmark of the movement to create a more global trading system for more than 60 years. (A particularly egregious example of such discrimination is the U.S. proposal of opening up its markets “97 percent” to the least developed countries—an offer widely viewed as designed to protect the United States against imports of textiles and apparel from Bangladesh and Cambodia.)
30. The importance of enforcing such commitments for assistance is highlighted by the failure of the developed countries to deliver on the promises of technical assistance within the Uruguay Round.
31. The agenda of trade for development is much broader than just agriculture, as we point out in *Fair Trade for All* (Stiglitz and Charlton 2005). But most of the key issues were not on the agenda of the Development Round.
32. They have, for instance, often imposed trade liberalization conditions on assistance programs.

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Infrastructure and Development: A Survey of Recent and Upcoming Issues

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Governments and donors have learned many key lessons about infrastructure and development over the past 15 years. Published and unpublished research over this period yields a snapshot of the main dimensions of the sector and examines the linkages between infrastructure and growth, the relevance of infrastructure reform for the poor, the fiscal cost of the sector, the potential for a private sector role, and corruption.

Infrastructure seems to be returning to the agenda of development economists.¹ This follows the recent return of infrastructure to the top of the agenda for many governments and donors. After roughly 10 years of a relatively modest profile, this “born again” policy and academic interest in infrastructure should not really be a surprise.² Access to affordable infrastructure services continues to be rationed for a large share of the poorest populations of the world. In Africa, for instance, increases in water and electricity services barely managed to catch up with population growth during the 1990s; coverage is still the lowest in the world, particularly for the poorest income classes.

Growth is so obviously constrained by infrastructure bottlenecks in a wide range of developing countries that governments are not really surprised when investment climate surveys tell them that they should rank infrastructure as a top priority. According to the World Bank, the poorest countries need to spend about 9 percent of their GDP on operation, maintenance, and expansion of their infrastructure if they are to reach the Millennium Development Goals (MDGs). They are now probably spending about half that, although it is difficult to know, as no one is measuring the allocation of public resources to the various sectors properly.

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While governments and donors are uncertain about specific investment needs, they have learned many lessons over the past 15 years about what matters for the operation, regulation, financing, and political management of infrastructure services. In addition to the specific lessons discussed below, the most dramatic lesson the international infrastructure community may have learned is humility. This humility reflects the limits to its knowledge on a wide variety of issues relevant to policy making in infrastructure.

There is, for instance, still great uncertainty over how, and how much, infrastructure affects growth. Does it work in the same way at all stages of development, for all regions in the same country, for rural and urban areas? There is probably even more uncertainty on many fiscal dimensions relevant to the sector. How and how much did reforms change the fiscal cost of infrastructure in the aggregate and across government levels? Are standard fiscal rules used to assess debt sustainability penalizing the sector unnecessarily? Can the public sector deliver services without the private sector? There are also many issues related to the weak understanding of the relevance of institutional reforms. For instance, are regulatory agencies really needed? If so, do they need to be independent? Can reform be built on institutional models mixing Anglo-Saxon and other legal traditions? What kind of institutional reforms are needed to improve accountability and eradicate corruption in this sector? Finally, there is still much that is not known about the infrastructure-poverty nexus, because good baselines are lacking on how much the poor actually spend and consume on infrastructure services.

This article sums up the key lessons learned on these issues in the past 15 years. It relies largely on recently published research but also on some current unpublished research that is already making significant contributions to the way policy makers are dealing with infrastructure. It provides a rough blueprint for a research agenda on infrastructure, as one of the main overarching lessons is that the knowledge gap is great.

The article is organized as follows. The next section provides a snapshot of the main dimensions of the sector. The second section examines the linkages between infrastructure and growth. The third section reviews the evidence on the relevance of infrastructure reform for the poor. The fourth section summarizes the main debates on the fiscal cost of the sector and on the potential for a private sector role in the sector. The fifth section examines corruption. Some concluding comments are presented in the last section.

The State of the Infrastructure Sectors

A large proportion of infrastructure services are still delivered mainly by the state in many countries.³ The relative importance of the private sector has increased significantly in some sectors, but the public sector continues to finance and often also deliver many services. Many governments faced with fiscal constraints did try to cut their financing role in the sector during much of the 1990s, but not many really succeeded in attracting private capital; where they did succeed, the record has been mixed.

Table 1. Percentage of Countries with Large-Scale Private Investment in Infrastructure, by Sector, 2004

Country income level	Electricity generation	Electricity distribution	Water and sanitation	Railways	Fixed-line telecommunications
Low	41	29	18	34	50
Lower-middle	48	37	50	26	62
Upper-middle	58	48	47	60	72
Developing	47	36	35	36	59

Source: Estache and Goicoechea 2005a.

Note: Data for railways are from 2002.

Table 2. Percentage of Countries with Independent Regulatory Agencies, by Sector, 2004

Country income level	Electricity	Water and sanitation	Railways	Fixed-line telecommunications
Low	38	13	2	69
Lower-middle	63	32	8	60
Upper-middle	63	28	19	71
Developing	51	22	8	66

Source: Estache and Goicoechea 2005a.

Note: Data for railways are from 2002.

A recent survey reveals the extent to which the large-scale private sector is making a significant contribution to the financing of various infrastructure subsectors in developing countries (table 1). As expected, the involvement of the private sector is greatest in the highest-income countries. Less expected is the fact that the presence of the private sector is much less widespread than sometimes argued.⁴ Only about a third of developing countries can count on private sector operators for the delivery of electricity, water, or railway services. The largest private sector presence is in the fixed line telecommunication sector, where about 60 percent of countries rely on private operators. Overall, the private sector has provided roughly 20–25 percent of the investment realized in developing countries on average over the past 15 years or so.⁵ In Africa it has probably contributed less than 10 percent of the needs.

To many countries, in particular the poorest countries, this low participation by the private sector in the operation and financing of key infrastructure investments has been a significant disappointment. Many of these countries followed the prescriptions of “specialists” in order to attract the private sector. They unbundled their services, introduced competition where they could (in and for the market), and created independent regulatory agencies (table 2).⁶

But, as table 2 shows, having an independent regulatory agency, one of the main policy recommendations in infrastructure of the past 10–15 years, does not guarantee private participation. Indeed, there are more countries with such agencies than countries with private participation in electricity distribution. Conversely, a country does not need an agency to attract the private sector: there are more countries with

private participation in water or rail than countries with independent regulators in those sectors.

The apparent paradox between tables 1 and 2 is not real. The participation of the private sector depends on many more dimensions than the risks associated with not having an independent regulator or having a bad regulator. Exchange rate risks, commercial risks, and political instability can be just as damaging. These risks are typically accounted for in estimates of the minimum rate of return that private operators want from a deal in a given country. Ignoring for now the strategic motivations that may lead an operator to enter a country even if the returns on a specific transaction are not high, it is usually believed that estimates of the cost of capital associated with a transaction can be a good approximation of the expected minimum return.

Several recent articles estimate this cost of capital.⁷ They show why there is less private capital in lower-income countries. Indeed, these estimates suggest that the returns required to start a project in lower-income countries have to be at least 2–3 percentage points higher than in richer developing countries and more than twice what is generally expected in developed countries in infrastructure activities.⁸ The average rate of return has actually often been below this cost of capital, in particular in Eastern Europe and in Latin America, where the public sector is coming back strongly to operate utilities. These numbers imply that, all nonfinancial conditions being equal, the average tariff necessary to generate the minimum required rate of return in the poorest developing countries has to be higher than elsewhere, because it needs to cover a higher cost of capital. This is politically a very difficult position to hold, and fewer and fewer private operators are willing to do so, in particular in politically sensitive sectors, such as water and passenger transport.

Reform experiences have provided insights into what needs to be better analyzed by researchers and where policy makers need to focus their attention. The lessons are, however, quite diverse across regions. Latin America has probably been the most effective in showing that infrastructure matters to growth, with much evidence on the cost to growth of the slowdown of investment in infrastructure in the region (see Easterly and Servén 2003, for instance). There is also a growing body of evidence on infrastructure as an explanation of the gap between rich and poor regions within large countries. Latin America's recent experience has shown the need to study the social and political risks better, because they matter to the effectiveness of reforms and hence their sustainability. Reforming by decree without an effort to build up support is no longer an option. In this region, the poor have very clearly voiced their view on what kind of infrastructure services they want.⁹ Very often this implies that policy makers have to understand how to better balance the concern for equity with the need for incentives to invest that has dominated the past 15 years of reforms. The experience also shows that it is worth looking more carefully into the options to ensure the commitment of government and operators to increased accountability to users and taxpayers. This can be achieved by adopting regulatory models that allow transparent documentation of efficiency, equity, and fiscal considerations.¹⁰

The experience of the past 15 years has also shown that the international community does not yet know how to address risk effectively. East Asia may have been the most effective in revealing that foreign exchange risk matters to infrastructure

financing.¹¹ The first generation of public-private partnerships in East Asia was hit hard by the 1997 crisis. Ten years later, these partnerships have not yet fully recovered, except in China. Experience in Eastern Europe and Africa has shown that there is still a long way to go to understand how institutional reforms work in this sector. It may be that reforms have to be introduced slowly. Better documentation is needed of just how counterproductive trying to force institutional changes without taking the time to build the institutional capacity consistent with the desired reforms can be. In francophone Africa, for example, it has been difficult to implement concession contracts, which are derived from the Anglo-Saxon legal tradition. The importance of this risk in Africa has been less well studied than the intensity and the drivers of renegotiation (see Guasch 2004 for an overview of the issues in Latin America).

Experience also shows that politics matter. Anecdotal evidence from Asia, Eastern Europe, and Latin America suggests that politicians are unlikely to give up control of a sector that buys votes in democratic societies. Moreover, in societies in which corruption is rampant, they will not give up control of a sector involving large amounts of money and in which contract award processes often provide opportunities for unchecked transactions.

Finally, there is a widespread sense among specialists that economic regulation and regulatory processes need to be taken much more seriously by actors concerned with corruption. There is, however, little evidence of the direct link between corruption and lax regulation. As discussed below, evidence is starting to emerge, but it is still too modest to validate the intuition of regulatory experts. Regulation will probably never really be independent, but much more transparency and accountability is achievable. It is worth testing more formally whether doing so is worth the effort and time demanded from governments busy with many other components of the reform agenda.

Improving accountability of regulators and operators will have to start by improving the way the various dimensions of the sector are measured. The international community, for instance, has very little knowledge of access rates, affordability, quality, or fiscal cost of the sector. Most of the information necessary to ensure a minimum level of accountability from government, donors, and operators is either estimated very roughly and very occasionally or never collected at all.

Before turning to what is known and what needs to be known on each issue, it may be useful to conclude this section with a quantitative snapshot of the sector (table 3). Consider this snapshot to be a baseline from which progress from reform is measured. The most fundamental performance baseline may be the share of the population with access to basic infrastructure services. The table points to a major gap between the lowest-income countries and the middle-income countries and suggests that there is a long way to go for the development community.

Table 3 hides one of the most unfortunate dimensions of coverage gaps—the extent of hardship endured by the poorest people.¹² Briceño and Klytchnikova (2006) show that across country groups, the poorest 20 percent are significantly poorer than the richest 20 percent, and the gap is largest for the lowest income level (table 4).

Table 3. Access to Utilities Services, by Sector

Income level	Percentage of population with access to networked electricity (2000)	Number of telephone subscribers per 1,000 people (2003)	Percentage of population with access to improved water sources (2002)	Percentage of population with access to sanitation (2002)
Low	31	76	65	41
Lower-middle	82	319	85	72
Upper-middle	87	672	93	86
Developing	58	290	77	59

Source: Estache, Goicoechea, and Trujillo 2006.

Table 4. Access to Basic Infrastructure Services by Richest and Poorest 20 Percent of the Population

(percentage of population receiving services)

Country income level	Electricity		Water		Sanitation		Telephone	
	Poorest 20%	Richest 20%	Poorest 20%	Richest 20%	Poorest 20%	Richest 20%	Poorest 20%	Richest 20%
Low	9.7	68.7	41.1	78.5	27.2	68.8	3.2	24.5
Lower-middle	79.5	99.3	64.5	86.6	48.2	78.7	21.2	66.1
Upper-middle	81.4	99.5	76.7	95	73.4	96.4	32	73.1

Source: Briceño and Klytchnikova 2006.

Note: Data are the most recent available for 2000–04.

Commitments to improve access rates in water and to some extent in telecommunications have been picked by the MDGs.¹³ The commitments to electrification have been added as part of the Johannesburg Declaration. There is no similar commitment for the transport sector, and very little information is available on what could be a reasonable baseline to assess the performance of the sector. Road density in the poorest developing countries is about a third what it is in the richest developing countries and about a sixth what it is in developed countries (Estache and Goicoechea 2005b). Most of the evidence on the relevance of the transport sector stems from macroeconomic work looking into the engine of growth, discussed in the next section.

An ideal baseline to track progress quantitatively would include information on affordability and the quality of services. This information is not available for a large majority of developing countries. Most of the related information published is anecdotal, and cross-country comparisons are often not meaningful, because definitions for quality standards and service pricing practices vary significantly across countries.

An ideal baseline would also include information on the cost of the sector. This is particularly important in view of the size of the projects and the importance of the associated financial transactions. Comparable cost data in infrastructure are largely unknown in this sector in developing countries, despite a standard policy message that aims at telling policy makers to improve cost recovery because it costs too much to the taxpayers. In fact, the cost of this sector to taxpayers is not known.

The IMF's Government Financial Statistics, the standard reference on public finance data, report very little information relevant to assessing the performance of the infrastructure sector.¹⁴

The experience of the past 15 years has shown that much work remains to be done to ensure that the lessons of experience are properly internalized in the advice given to policy makers in infrastructure. This experience has also shown that the international community needs to assess performance better, in order to both measure the degree of effectiveness of reform and to ensure improved accountability by all actors—governments, operators, bankers and other financial actors, users, and donors.

What Effect Does Infrastructure Have on Growth?

Since the late 1980s, more than 200 published articles in English, French, and Spanish—and at least as many unpublished ones—have analyzed the macroeconomic effects of infrastructure. This is probably still the most widely covered theme in the economic literature on infrastructure, as well as the best known outside the infrastructure community. This literature boom has been the result mainly of conceptual and technical developments associated with new growth theory and associated discussions of regional policies (see de la Fuente [2002] for a survey that includes a discussion of infrastructure).

Among the most useful outcomes of this literature has been a debate on the importance of infrastructure spending at different stages of development. The main message from this literature seems to be that how much infrastructure spending matters is an empirical matter and that infrastructure matters more in low-income countries or regions than in richer countries or regions.

The most common way of quantitatively assessing the relevance of infrastructure spending is to estimate social economic rates of return of past and new investments using a production function. Most of the academic literature estimates these returns using macroeconomic growth regressions. These are usually calculated using data for a specific country or group of countries over several years. In recent years these methods have suggested economic returns on investment projects averaging 30–40 percent for telecommunications, more than 40 percent for electricity generation, and more than 200 percent for roads (when the outliers are excluded, the average is about 80 percent for roads). Returns tend to be higher in low-income than in middle-income countries (Canning and Bennathan 2000; Briceño, Estache, and Shafik 2004).

New growth theory has also analyzed factors leading to the convergence—and disparities—of growth rates between poor and rich regions within and across countries. This research has generated comparative rankings of sectors across regions in the same country, showing that one size does not fit all when it comes to assessing a country's public investment needs.¹⁵

Many insights emerged from the new economic geography theory, which boomed following the seminal contribution by Krugman (1991). Its basic concern is how firms decide on the locations for their production. The main tradeoff—between market

proximity and production concentration—is driven by transportation costs and economies of scale in production. In connection with this theory, there is also a (re-)emergence of the concept of territorial planning, with a view to direct expenditures on the basis of territorial priorities instead of sectoral priorities. But many other factors are also relevant, causing this literature to develop at a very rapid pace.¹⁶ The upshot at this stage may be that while theory points to a significant potential role for infrastructure, much more empirical evidence is needed.

Much of the literature on the importance of growth discusses whether priority should be given to rural or urban development. This may be the most important area of research in the future.¹⁷ Because rural poor people live in relatively low-density areas and rely heavily on natural resource-based production, their demands for infrastructure are different from those of the urban poor.¹⁸ Both groups tend to have limited access to public infrastructure and services, but the constraints on physical access to job and product markets are greater concerns for the rural poor (see the case studies by Fan and his various coauthors on China, Thailand, and Uganda; see van de Walle and Cratty [2004] for recent detailed studies). Recent household surveys seem to indicate that the urban poor are often unable to afford the infrastructure services provided by utilities. Access by the rural poor to network utilities is less important, because many prefer more cost-effective local solutions for their needs, such as solar energy, water pumps, and satellite-based telecommunications. In the context of urbanization, the growth of large cities is fast becoming a major source of demand for additional infrastructure, creating a sense of urgency in some policy circles.¹⁹ But this sense of urgency is criticized by some academics as favoring an excessive urban concentration (Henderson 2002). There is indeed a hot debate as to whether new infrastructure, particularly in interregional transport, also creates additional incentives for rural-urban migration. The debate is as hot as the evidence provided by both sides of the debate is scarce, with most of the discussion based on descriptive case studies rather than technical analysis.

How Has Infrastructure Reform Affected the Poor?

In just the past four years, international organizations, bilateral agencies, and think tanks have produced seven major books on how infrastructure reforms affect poor people (Estache, Foster, and Wodon [2002] on Latin America for the World Bank; Ugaz and Waddams-Price [2003] on Latin American and Europe for the United Nations; Brook and Irwin [2003] on the world experience for the Department for International Development and the World Bank; Kessides [2004] for the World Bank; Nellis and Birdsall [2005] on the world experience for the Center for Global Development; Alam and others [2005] on Eastern Europe for the World Bank; and Estache and Wodon [2006] on Africa for the World Bank).²⁰ The main message of this research is that the reforms of the 1990s have generally increased the efficiency of infrastructure sectors but that these efficiency gains have not always been shared with users, particularly the poor. The six main reasons why the poor have not always benefited can be summarized as follows: (a) when tariffs were redesigned to

be more efficient (when countries eliminated cross-subsidies, for example), they sometimes became less progressive or more regressive; (b) major increases in indirect tax rates—which tend to be more regressive than other taxes—were applied to reformed infrastructure sectors to allow the state to capture part of the rent generated by efficiency gains; (c) operators increased enforcement of revenue collections; (d) increases in quality made services unaffordable for some users; (e) cream-skimming in the design of restructuring eliminated cross-regional subsidies, slowing investment programs in the poorest regions when governments could not compensate through increased subsidies; and (f) failures to alleviate credit rationing added to the difficulties of financing poor users' expansion needs.

All this implies that poverty was not addressed carefully in the regulatory and other reform packages implemented during the 1990s. Recent studies on Eastern Europe show that affordability may be just as important a challenge as access.²¹ In most cases, the negative poverty effects result from mistargeted subsidies.

Infrastructure policy makers tend to target access and affordability separately, relying on different instruments to achieve these goals. For access there are three basic types of instruments: (a) instrument requiring operators to provide access (a service obligation to avoid unilateral exclusion by the provider);²² (b) instruments reducing connection costs (through cross-subsidies or direct subsidies built into the tariff design or through credit or discriminatory payment plans in favor of the poor); and (c) instruments increasing the range of suppliers (to give users choice, including the option of cutting costs by choosing lower-quality service providers).

For affordability, broadly speaking, all instruments work in at least one of three ways: (a) by reducing bills for poor households (through lifelines or means-tested subsidies based on socioeconomic characteristics or the characteristics of the connection, financed through cross-subsidies or direct subsidies built into the tariff design); (b) by reducing the cost of services (by avoiding granting a monopoly right when it is not necessary or by providing an incentive for operators to reduce costs and pass on the cost reductions to users); and (c) by facilitating the payment of bills (by allowing discriminatory administrative arrangements in favor of the permanently or temporarily poor) (Estache, Foster, and Wodon 2002).

For a long time, analysis of these instruments focused on efficiency and was conducted at a fairly theoretical level by public finance specialists. Enormous methodological progress over the past 10–15 years has allowed the academic world to make much better assessments of the performance of these instruments, not only in terms of efficiency but also in terms of their effects on the behavior of poor people and service providers. Methodological developments have occurred in three fields: micro-econometrics (especially developments in the econometrics of panel data), evaluation techniques, and incentive theory applied to the theory of regulation. Bourguignon and Pereira da Silva (2003) provide an exhaustive overview of the status of evaluation techniques. Although not yet widespread, much of this work builds on the incentive theory presented in Laffont and Tirole (1993) in general and in Laffont (2005) for developing countries.

A look at the associated empirical evidence is somewhat disappointing for infrastructure policy makers. The leading academic economic journals contain relatively

few articles on targeting, affordability, or regulation for infrastructure services in developing countries (even for health and education services, where there is much more data and the data quality lends itself better to academic publications).²³

While much more empirical evidence needs to be generated, the partial results available so far are surprising. Despite their popularity in policy circles, particularly for infrastructure, targeted subsidies (as well as safety nets) have long been held in low regard by academics for their alleged ineffectiveness (in terms of economic efficiency and incentive costs). But new data suggest that in many cases these costs are modest: direct subsidies and cross-subsidies are not always as bad as they are thought to be. These results seem to hold for both temporary and chronic poverty.²⁴ This finding confirms the intuition of many infrastructure practitioners.²⁵

The evidence suggests that the poor can be deprived of infrastructure services in many ways. They often need a connection subsidy, as often mentioned by analysts of the access problem, but they also often need a subsidy to be able to afford a minimum level of consumption.²⁶ Providing access when consumption is unaffordable is useless.

The evidence also suggests that because of the limited fiscal ability of many governments to generate enough revenue to finance targeted subsidies from general revenue, cross-subsidies are often the only realistic solution. Such subsidies help finance the needs of the poorest through redistribution within a sector. For every documented mistargeted cross-subsidy, there is a documented success story of an effective cross-subsidy, suggesting that they are an option to consider. But it is also important to recognize that well-intended targeting mechanisms have also been regressive and that this regressiveness may come from a failure to target access, consumption, or both.²⁷

Poverty is also very often a distributional issue. Evaluation techniques now allow for very systematic assessments of the distributional implications of reforms. A reform can help poor people and be regressive, but it can also be regressive without helping the poor. These issues can now be reliably handled quantitatively. New techniques allow identification and monitoring of the most vulnerable groups with respect to reforms, as well as good evaluations of the relative and nominal impacts of reforms. But this literature provides much more than *ex post* assessments of policy reforms. It makes the case for systematic monitoring of the effects of new reforms and projects to ensure that they internalize lessons of the past. This can be done at the project level (see Baker [2003] and Duflo [2003] for surveys), at the sector level (see Torero and von Braun 2006 for a large set of country-specific cases studies in telecommunications), or at the macroeconomic level. Systematic monitoring can be important when microhousehold data are weak or interactions with other sectors need to be assessed.

Infrastructure reforms do not occur in a vacuum; they have an impact on the poor through their impact on other markets (such as the labor market and investment savings market) that matter to the poor. These feedback effects are potentially significant for poverty alleviation; an economywide analysis is therefore needed. This usually calls for a multiagent, multicommodity model. Computable general equilibrium (CGE) models are increasingly becoming a useful analytical response to these needs.

CGE models simulate the economic and social impacts of reforms. They are based on the socioeconomic structure of a social accounting matrix (SAM), with its multi-sectoral disaggregation. The basic idea behind a SAM is to identify the linkages in an economic system. The basic elements when constructing a SAM are input-output tables, combined with government accounts and household surveys. The household surveys are crucial for performing impact analysis on welfare and poverty. How deep the analysis can go depends on data availability. The CGE literature on the effects of public infrastructure service reform is rather modest.²⁸ Their main contribution is to show the importance of infrastructure for achieving the MDGs and, perhaps most important, to show that good regulation is redistributive and progressive.

These techniques have not yet helped address one old battle in infrastructure—the debate on the need to address urban and rural concerns differently. There is wide agreement that infrastructure in rural areas can improve agricultural productivity and reduce rural poverty.²⁹ But there is also some ongoing research on the impact on the rural-urban gap that can be credited or blamed on reforms. Boccanfuso, Estache, and Savard (2006) show that water reforms in Senegal have had a very different initial impact in the capital city, secondary cities, and rural areas. Unless interregional cross-subsidies are an option, most common cost-recovery financing policies hurt the poor differently in each region when the fact that each region is dominated by a different provider type (that is, large public, large private, or small private) is accounted for.

Adam and Bevan (2005) find that infrastructure investments in Uganda that support tradables have different impacts on the distribution of poverty between rural and urban areas as well as on the real exchange rate and other macroeconomic variables. When infrastructure investment is biased toward sectors that favor tradables (that is, telecommunications or energy, which tend to enjoy a much stronger demand from manufacturing and services than transport), the real exchange appreciation is strongest. When it is biased toward nontradables (for example, rural and urban roads), there is hardly any change in the real exchange rate. The main difference between the two scenarios is a distributional one. Support to tradables helps all income classes; support to nontradables helps the urban poor and, somewhat counterintuitively, hurts the rural poor, if population migration is ignored. The rural poor gain from more access to food, but they lose from the lower income they receive from food production. This loss is greater the more the infrastructure aid is biased toward nontradable goods.

Adam and Bevan (2005) provide one of the rare quantitative illustrations of the current policy relevance of the old debate on the importance of rural versus urban needs in infrastructure. There are many less quantitative debates. One is the extent to which there may be a bias in favor of alleviating rural rather than urban poverty.³⁰ Because there is little research on infrastructure on this topic, policy makers must rely on anecdotal evidence. A related concern not addressed by researchers includes the possibility of a difference on this front across sectors (that is, water versus energy versus telecommunications versus transport).

All this assumes, of course, that the evolution of poverty is understood. There is plenty of evidence showing that poor people urbanize more rapidly than the

population as a whole, which implies that anticipating their needs will require a stronger focus on urban issues.³¹ Yet in many regions, the sheer numbers argue otherwise. In Africa, for instance, more than two-thirds of the population remains rural today, and it will likely be a while before the urban population becomes the majority. More generally, experiences across countries suggest that a majority of poor people will still live in rural areas long after most people in the developing world live in urban areas (Ravallion 2002).³²

The choice between urban and rural infrastructure is an empirical question (Reardon 2001; Sahn, Stifel, and Younger 2003; Lall, Harris, and Shalizi 2006), hence data matter. Living Standard Measurement Surveys (LSMS), Demographic and Health Surveys (DHS), and household consumption surveys do not provide the required data to address the issue well, for several reasons.³³ First, the infrastructure sector is generally not well covered in these surveys. Second, there are significant differences in the quality of the data available for urban and rural areas.³⁴

These data problems are important but can be circumvented. Lokshin and Yemtsov (2005) complement community-level panel data from a regular household survey with a special module, which they use to measure the impact of infrastructure rehabilitation projects in Georgia between 1998 and 2001. The analysis yields plausible rankings of welfare gains from different types of projects at low data costs for a specific country. The approach can be useful in assessing the impact of large-scale community-driven microprojects or government-run decentralized investment programs.

Researchers have failed to address some fundamental questions. How consistent are the ideal strategies implicit in these differentiated needs assessments for the rural and urban poor with strategies to maximize the odds of meeting the MDGs' poverty target? Where is the poverty reduction from an additional dollar of investment higher, in highly dispersed rural populations or in highly concentrated urban or peri-urban populations? There are clear trade-offs depending on the cost of technology (low unit costs in rural areas versus low average costs from economies of scale in urban areas). Unless the needs of rural and urban needs are disaggregated across the MDGs, rural poverty reduction will probably not receive the priority it deserves.³⁵ The fact that the MDGs do not distinguish between persistent and transient poverty favors the rural poor. This implies that strategies designed to accelerate growth to achieve the desired reduction in an overall index of poverty may be better than those that benefit the persistently poor (Gaiha 2003).

Fiscal and Other Financing Options as Challenges

The main policy and academic debates on the fiscal dimensions of the sector are about the macroeconomic limits to public and private sector financing. The most important source of disagreement is probably the extent to which there is fiscal space to finance the major increase in infrastructure expenditures demanded by growth and concerns for poverty alleviation. The debate is particularly sensitive because private participation is increasingly associated with implicit fiscal commitments, because of

complex guarantees granted by the public sector.³⁶ The debate is also fueled by the fact that it is increasingly clear that in the poorest countries there is a limit to full cost recovery that can be imposed on the poorest. This implies that direct or cross-subsidies are likely to be part of the financial equation.

Fiscal requirements and financing options are closely intertwined. They are two interconnecting sides of the same issue: how much budget expenditures can be allocated to achieve a certain level of growth depends on the extent to which the users can cover the costs of the investments or operations and the level of affordability.

The core of the debate is about the importance of the design of macroeconomic fiscal adjustment programs for the level of investments in infrastructure. Standard fiscal rules adopted to ensure debt sustainability as part of macroeconomic adjustment programs are increasingly being criticized as excessively binding constraints on appropriate countercyclical action. Moreover, there is widespread concern that these rules may permanently reduce the public sector's contribution to capital accumulation, particularly in infrastructure. Under a wide range of circumstances, compression of public investment in infrastructure can be—and has been—associated with lower economic growth and less efficient poverty alleviation. This, in turn, has fueled fiscal insolvency, the main concern expenditure cuts were supposed to address.

This debate has been intense in Europe as part of the assessment of the Stability Pact (for overviews, see Turrini [2004] and Buiter and Grafe [2004]). Recently, it has emerged in developing countries in the context of the search for an increased role of the private sector in the financing of infrastructure. Raised in a book edited by Easterly and Serven in 2003, it has now been mainstreamed in the policy arena. In 2004 both the Brazilian and Pakistani heads of state mentioned the need to find alternative solutions to fiscal adjustment that do not penalize infrastructure projects while recognizing that the new rules have to avoid white elephants.

The debate can be summarized as follows. Standard IMF adjustment programs want to ensure that public expenditures, including sectoral allocations of expenditures, are consistent with (a) the short-term liquidity constraint faced by a country, (b) the short-term aggregate balance (no inflationary pressure due to excess demand), (c) medium-term debt sustainability, (d) the need to avoid endorsing excessively costly or inefficient levels of public expenditures, and (e) the promotion of private participation in infrastructure. There is disagreement on how to address each of these concerns, because there is no agreement on the specific measures to consider; for each issue, there is some scope for sensitivity analysis.

There is concern that the liquidity constraint provides a lower bound for all the expenditure levels to consider rather than a precise indicator. While this constraint is a useful indicator, it needs to be complemented by an upper bound. This upper bound comes from three sources: (a) the definition of liquidity (Easterly and Serven 2003 for illustrations from Latin America), (b) the time horizon during which this liquidity needs to be considered and averaged out, and (c) the level and type of expenditures to be included.³⁷

In addition, it seems reasonable to have a better sense of the relevance of the level, origin, and timing of the financing sources for the assessment of the desirability of

infrastructure investment, in view of the fact that this has been one of the most creative areas in infrastructure policy over the past 10–15 years. The basic questions that need to be answered include the following: Which kind of financing sources, fiscal or quasi-fiscal, need to be covered? Do the sources (international financial institutions, bilateral donors, or others) matter? When are guarantees part of the quasi-fiscal deficit? What share of private participation throws the project off balance? Will this choice lead to cream skimming in the design of projects? Should it be driven by risk-sharing levels or by something else?

Many related technical issues go beyond the scope of this article. One, however, deserves highlighting. What needs to be recognized in estimates of the fiscal space is that solvency is by definition an intertemporal concept. Indeed, solvency has to rely on the present value of both assets and liabilities. Many academics have pointed out that it does not seem correct to assess the strength of fiscal accounts only from the time path of gross financial liabilities.³⁸

Of particular interest in this context is the fact that infrastructure has an unusual cash flow, with high short-term costs and high long-term returns. Standard fiscal accounting ignores this and introduces a bias against any project with a cash-flow stream that is initially negative, with costs incurred in the present and returns accruing only over time. This bias leads to excessive compression of investment as well as operation and maintenance expenditures, particularly during the transition toward a deficit target; it can be particularly damaging for expenditures that help enhance future growth. Indeed, any analysis of infrastructure needs to distinguish between recurrent and capital expenditures and rate them according to their contribution to the growth and social agenda. The two are linked, but their relative importance varies significantly across sectors. Yet cuts tend to be across the board—with brutal (including regressive) distributional consequences (Calderon and Chong 2004).

Recent research is widening the debate. Engel, Fisher, and Galetovic (2006) suggest that it is useful to look at the fiscal cost of private participation in infrastructure from the viewpoint of the relevance of the financing modes to the public sector accounts. They establish an “irrelevance result,” arguing that under a reasonable set of circumstances, the deficit should not be influenced by the financing mode of infrastructure. This irrelevance result does not hold in many situations, but the point of the authors is that it should be possible to forecast the sign of the impact based on the specific situations to be addressed. Tirole (2006a) widens the debate into politics and the need to link the assessments of incentive problems in the sector to their fiscal consequences.

This is not only an accounting problem. Over the past 20 years, political decision making has replaced economic criteria in determining the allocation of resources in developing countries. Twenty years ago all the multilateral development institutions had their own manuals of economic cost-benefit analysis that were supposed to be used as part of annual public expenditure reviews. These reviews were supposed to guide the allocation of resources across sectors. Sectoral allocations and intrasectoral investment decisions were easy to implement, because they were driven by economic rates of return. The changes in the resource allocation process over the past 20 years

have resulted in less investment in infrastructure (to a large extent because of its lower profile in the overseas development assistance agenda), without much regard to the economic returns.

At least as important for some sectors and for some countries, there is a need to monitor the allocation of resources to the maintenance of assets. Rioja (2003) shows that in some countries, maintenance may actually be more important to growth than investment. Using an infrastructure-led growth model, Kalaitzidakis and Kalyvitis (2004) show that the durability of public capital is endogenous and varies according to its usage and the level of maintenance expenditure. They also show that changes in total expenditures and the maintenance share drive the steady state and the dynamic behavior of the economy. Allocation rules that imply lasting fixed proportions between investment and operational expenditures can thus have dramatic long-term consequences.

Whatever the outcome of ongoing research on the sustainable degree of public expenditures in infrastructure and its allocation between maintenance and investment, for many countries, partnerships with the private sector will continue to be a rational option. The most challenging dimension of these partnerships will probably be assessing the impact of risk allocation between the public and the private sector on the decision of the private sector to enter a deal.

Despite the relevance of the design of risk-allocation mechanisms, there is relatively little innovative theoretical infrastructure-specific literature on this topic from researchers specializing in the modeling of agency problems. This is surprising, as the theoretical literature on the scope for public-private partnerships is large.³⁹

This research has generated several useful insights. The first is that regulators must arbitrate between risk levels and their distribution, the efficiency levels that can be achieved in infrastructure, and the rents that remain with operators. In other words, to be viable, a financing mechanism and a regulatory regime may need to rely on a risk allocation that does not yield the most efficient outcome in service delivery. This means, for instance, that when risk levels are perceived to be very high, rate of return regulation may be more effective than a price-cap regime in attracting private capital. More generally, this literature argues that the characteristics of developing countries should often lead to recommendations quite different from those for infrastructure restructuring in industrial countries. Indeed, the limited enforcement capabilities in developing countries are significant and, along with unusually high risk levels, one of the main reasons why one size does not fit all when reforming infrastructure. This literature also hints at the relevance of many other institutional issues, including the relevance of the degree of capital market development.

A second strand of research focuses on issues associated with the degree of development of local financial markets. This strand typically deals with more than just the financing needs of infrastructure (see Bortolotti and Siniscalco [2004] for a recent survey on the world experience and von Hirschhausen [2002] for an insightful discussion of the interactions between institutional development and infrastructure reform in Eastern Europe). The main message—that institutions matter—is now the bread and butter of many aid agencies.

A third area of research focuses on the optimal distribution of risks among the players in the financing game. It involves the development of innovative risk-mitigation products and applications to foster private capital mobilization for infrastructure development (see Esty [2004] for a broad review; Irwin [2003] for an application to infrastructure). The literature offers four main lessons to policy makers:

- From a strictly financial viewpoint, the financial structure matters—in ways that are relevant to the design of financing strategies in developing countries. Of particular interest is the importance of the governance structure associated with the financing of infrastructure projects (Tirole 2006b).
- Improved risk-allocation mechanisms addressing currency risks and regulatory risks can help reduce uncertainties faced by private investors assuming infrastructure-related risks (Irwin 2007).
- Credit providers can gain from coordination to reduce everyone's risks levels when capital markets are imperfect (Tirole 2006b).
- A growing body of research demonstrates the importance of auditing and the limits of creativity in financial designs when financial accountability is limited (Iossa and Legros 2004).

The fourth area of research reflects the fact that a large part of infrastructure development takes place at the subsovereign level, with subsovereign entities responsible for providing public services (see Freire and Peterson [2004] for an overview). Fiscal capacity is a major issue when it comes to financing subnational investment needs (see Lewis [2003] on Indonesia). Supporting the transition of these entities from sole central government funding to market-based funding where they can also access private financial markets for their needs is therefore critical to mobilizing additional private capital for infrastructure services.

While these four branches of research all provide interesting insights, the punch line is a modest one. The main lesson of this literature may be that new instruments will have to do better at generating the appropriate credit enhancement to achieve creditworthiness at the project level and often at the local government level. Very little is known about how to implement this advice in real deals with high risk levels. The next generation of infrastructure contracts between the public and the private sector will have to do a better job at allocating these risks.

Of particular interest is the development of a law and economics research agenda that would investigate the relevance of risks associated with the mismatch between legal systems and the choices of regulatory instruments associated with infrastructure reforms (that is, concession or *affermage* contracts and the creation of independent regulatory agencies). Francophone Africa and many countries in other parts of the world have often reacted negatively to the imposition of independent regulators that did not fit into their legal tradition. Concession contracts have passed on to these regulators rights that typically go through other channels under existing constitutional arrangements dividing responsibilities among the three branches of government. As a result, regulators are sometimes viewed as a fourth branch of government. While

much work has been done on the relative effectiveness of the various legal systems in their pure forms in terms of their efficiency, equity, or fiscal effects, few studies have looked at the cost of hybrid solutions in which sectoral legal systems, contract forms, and regulatory processes or instruments from various legal traditions are combined. Until this issue is solved, regulatory and legal risks will continue to be major obstacles to successful public-private partnerships in the infrastructure sector.

Corruption

The final broad research theme emerging from the recent reform experiences in infrastructure may be the most complex one. At face value, it is about corruption. Ultimately, it is about accountability for governance failures, but it deals with a type of failure requiring much more political commitment than skills, particularly in a sector where corruption has long existed.⁴⁰

In addition to the usual explanation of low wages in the public sector, two important features of infrastructure drive the higher than average risks of corruption: projects tend to be larger than in other sectors, and services are often granted with a monopoly on delivery as well control of the information needed to ensure that there is no abuse by the monopoly.⁴¹ While these characteristics have not changed much over time for electricity and water distribution and for much of transport infrastructure, the perception of their impact on corruption has evolved. In the early 1990s, the existence of widespread corruption among public monopolies in the sector was often one of the arguments used to motivate privatization. This anecdotal evidence was supported by the theoretical modeling of corruption as the nonbenevolence of government by authors such as Shapiro and Willig (1990), Shleifer and Vishny (1993), and Boycko, Shleifer, and Vishny (1996), as well as much anecdotal evidence.⁴² Assuming that it is easier for corrupt politicians to control public firms than private firms, these researchers argued that privatization could reduce the control government has over the rent offered by the full control of the sector by making political interference more costly or more visible.

Many reforms later, the main debate has now shifted from the interactions between public operators and users to those between private operators and government. This can be seen in the survey prepared for Transparency International on corruption and privatization in infrastructure in developing countries (Boehm and Polanco 2003; Transparency International 2005). It is also clear in various publications by nongovernmental organizations (Allouche and Finger 2002; Hall and Lobina 2002), documenting legal events that have demonstrated incidents of corruption in the sector. Friends of the Earth (2001) and various political scientists have documented the role of corruption as a cost driver in contract negotiations and renegotiations in the sector. There is also an increasing body of academic evidence. Flyvbjerg, Skamris Holm, and Buhl (2002, 2003); Flyvbjerg, Bruzelius, and Rothengatter (2003); Naess, Flyvbjerg, and Buhl (2006); and Mitlin (2004) document undesirable practices costing practices at the project level. More conceptual research (Benitez and

Estache 2005) is analyzing the changes in the global market structure characterized by an increased domination by a few players. Celentani, Ganuza, and Peydros (2004) developed a model consistent with the fact that an increase in competition in international business transactions can increase corruption in the sector.

Most of the evidence offered by these surveys is anecdotal and indirect. There is no real systematic measurement of the level of corruption in the sector. With the exception of a database compiled by Clarke and Xhu (2004) for Eastern Europe and a ranking of utilities among corrupt institutions from the *Global Corruption Report* published by Transparency International (2005), the annual *Global Competitiveness Report* provides the only comparable, quantitative, multicountry overview of corruption in infrastructure sectors, ranking 59 developing countries according to the perceived degree of corruption (based on interviews with private firms), among many other criteria.⁴³

A small body of research documents the effects of corruption on infrastructure performance. Most is for utilities. A few studies report direct measures of corruption in the sector (Davis [2004] on South Asia; Clark and Xhu [2004] on Eastern Europe; Lovei and McKechnie [2000] on Eastern Europe and South Asia; and Reinikka and Svensson [2002] and Svensson [2003] on public services in Uganda). A few other studies provide indirect impact assessments from regression analysis testing of the statistical significance of countrywide corruption measures on infrastructure performance indicators (Rossi and del Bo [2004] on Latin American electricity companies; Estache and Kouassi [2002] on African water companies; Estache, Goicoechea, and Trujillo [2006] for all utilities across developing countries).

A very promising research area is the use of randomized field experiments. Olken (2007) reports the results of a randomized experiment in Indonesia that measures missing expenditures in more than 600 village projects. The study compares the villages' official expenditure reports with estimates of the prices and quality of all inputs used in road construction and maintenance, each made by independent engineers. This approach allows the sample to be separated into subsamples in order to test the effectiveness of various types of policies in reducing corruption.

What do these studies show? First, the basic data analysis from the *Global Competitiveness* report suggests that the frequency with which firms have had to make undocumented extra payments or bribes to get connected to public utilities or to gain public contracts is, on average, negatively correlated with national income: the poorer a country is, the higher the level of corruption in its infrastructure sector. While these data are useful, they are not precise. They are based on executive surveys, which are problematic, because they tell only one side of the story and rely on fairly subjective assessments. More important, the results say little about what the government or users of the residential infrastructure think about corruption.

Second, corruption can be tracked to greater constraints on utility capacity and less competition among utilities, as Clarke and Xu (2004) find for 21 Eastern European countries. They find that public ownership in that region is more closely correlated with corruption than private ownership of utilities.

Third, corruption can be associated with higher than expected costs. The most detailed studies (Flyvbjerg and various colleagues) show that excess costs can be

attributed to procurement rules that give bidders an incentive to announce low costs to increase their chances of winning projects and then renegotiate.

Procurement rules by themselves are not enough. Auditing contractual compliance also matters. Olken's (2007) detailed analysis of Indonesian road projects is a good illustration. He tests the potential payoff of audits and other policy instruments intended to reduce the costs of corruption. His assessment implies that announcing an increased probability of a government audit from a baseline of 4 percent to 100 percent reduces unexplained costs by about 8 percentage points. This cost saving justifies the cost of the audits.

Not all results are as expected. Most of the surprises come from indirect estimates of the effects of corruption on infrastructure services based on cross-country regression models measuring corruption at the country level rather than at the sector or project level. Mauro (1997) and Tanzi and Davoodi (1997) find opposite signs on the effect of corruption on public spending: Mauro finds that it increases these expenditures, while Tanzi and Davoodi claim that it lowers them. The two results may not be inconsistent. It may be, for example, that corruption raises unit costs and hence increases spending in one sample, while under the budget constraints dominating the other sample, it reduces the number of projects and (because projects are lumpy) decreases spending in the sector.

Estache, Goicoechea, and Trujillo (2006) offer an econometric test of the impact of the 1990s infrastructure reforms and of corruption, as well as of their interactions on access, affordability, and quality of infrastructure services in developing countries. They find that corruption reduces access rates and quality in electricity and telecommunications affordability for residential users, has no statistically significant effect on water access rates or water and electricity affordability, and increases access rates and quality in telecommunications. The explanation for these results may be as follows. In many countries, the telecommunications sector was the first to privatize. This did not happen easily, and many of the participants to these initial transactions report that the opening of the market required side payments. This does not make these right. The outcome, however, was an increase in access and quality. These improved access rates came at a cost: higher tariffs for users, in a sector in which technology keeps pushing costs lower. For electricity, corruption did not affect prices, but it did reduce quality and access rates. In sum, when corruption is about money—rather than power or other nonmonetary factors—it will eventually generate higher cash flows for the corrupt parties. It can do so by increasing revenue from infrastructure services (that is, increasing access and hence users or prices) or by cutting costs (that is, reducing quality). Both of these strategies are easier to implement for a monopoly when it is poorly regulated or when the regulators and the operators collude, as discussed in Laffont (2005) and below.

Another puzzling finding comes from Rock and Bonnett (2004). They show that while in most regions corruption has the expected negative effects, in large East Asian countries with governments with long time horizons, corruption has had positive short- to medium-term effects on growth, thanks to collusion between governments and their big business partners. Rock and Bennett note that it is not clear that the investment choices associated with corruption in these countries are the right ones for

long-term growth, because they cater to the preferences of local businesses. Corruption has long-term costs in this case as well, but these are much more difficult to assess.

What can be done to reduce corruption in infrastructure? Theoretical researchers have been pushing in four main directions for the past 20 years: privatization, regulation and related processes, increased decentralization, and adoption of participatory process in the selection, implementation, and supervision of projects. Since many countries have adopted these recommendations, there are now enough facts to analyze. This analysis is still very new, but it is already yielding interesting results.

The evidence on the impact of infrastructure privatization on corruption is not yet very substantial.⁴⁴ Laffont and Meleu (1999) provide a general description of the interactions between the two phenomena. Looking at Africa's experiences, they point to a *U*-shaped interaction between corruption and the privatization rate: up to a point, corruption facilitates privatization, but eventually it hurts it. This finding needs to be contrasted with the fact that, in a recent survey (reported in Nwanko and Richards [2001]), corruption was considered the greatest obstacle to doing business in the region. These two stories imply that for now, corruption in Africa is an impediment to the adoption of a policy that could reduce corruption.

Some of the literature on the impact of the nature of ownership on the efficiency of operators can be interpreted as a proxy for the impact of privatization on corruption when efficiency is measured by costs. Among the few studies offering this possibility is Kirkpatrick and Parker (2004), who report on several studies they have conducted. The first of interest here is their analysis of a large sample of African water utilities in 2000. They find that ownership did not statistically significantly affect costs. While the authors do not formally test the linkages between corruption and ownership, it could be argued that if costs were influenced by corruption, ownership has no impact on corruption. A second relevant study refers to a large sample of electricity companies, for which privatization needs to be coupled with regulation to have the desired impact on prices. This result could be interpreted as meaning that a well-regulated switch to private ownership could reduce corruption.

Looking at a much larger data sample and covering a longer time period (1990–2002), Estache, Goicoechea, and Trujillo (2006) provide a formal test of the interaction between privatization and corruption by assessing their impact on access, affordability, and quality of infrastructure services in developing countries. Relying on a set of interaction dummies in a model explaining these variables, they find that privatization generally does not statistically significantly interact with corruption in electricity, telecommunications, or water. This is in contrast with the conclusion drawn by Clarke and Xu (2004), who find that switching from public to private ownership did reduce the level of corruption in Eastern Europe.

The fact that this survey reports only three studies suggests that there is little formal testing of the effectiveness of privatization as a way of reducing corruption. There is a clear need to consider complementing the relatively large literature on the impact of infrastructure privatization on efficiency, quality, and equity. Research also needs to get to the core of what seems to characterize monopolies, as suggested by

Estache, Giscoechea, and Trujillo (2006). The monopolies' objective is to maximize profits. However, researchers have tended to focus on prices, quantities, and quality independently, because data on profits are not available. They now need to start looking at how reforms jointly affect these variables, and hence profits, to offset the consequences of corruption (for example, there is no need to affect prices if quality and hence costs can be cut to increase profits).

The second instrument generally recommended by researchers is regulation. Regulation must promote (static and dynamic) efficiency while protecting consumers, in particular the poor, from potential monopolist abuses and investors and operators from political influence. Some degree of flexibility is desirable, but the track record of governments in their use of flexibility is generally perceived as having been so problematic that the rules built into various privatization instruments are designed to limit this flexibility. One of the key components of these safeguard mechanisms is the specific design of regulatory institutions and the concern for the importance of independent, autonomous, and accountable regulatory institutions for sustainable reforms in regulated sectors. A major contribution of the theoretical literature summarized in Laffont (2005) in the context of developing countries is to show that processes, particularly quantitative processes, matter much more than policy makers seem to appreciate. In practice, this means reforming planning processes to get incentives right and to make information more transparent and better audited. The adoption of regulatory accounting guidelines, for instance, is commonly omitted by reformers, even though it is central to the ability to come up with fair, efficient, and accountable regulatory decisions (Estache and others [2003]; Schlirf, Rodriguez-Pardina, and Groom forthcoming). These guidelines are consistent with the theoretical case for monitoring, auditing, and associated penalty systems (Laffont, Faure-Grimaud, and Martimort 1999; Armstrong and Rochet 1999; and Khalil and Lawarree 2001).

New databases are emerging that cover a long enough time span to generate useful information. The most promising line of research may be that pursued by Olken (2007) to test the effectiveness of regulatory processes such as audits. But this type of research takes time and resources. A complement in the short run is to rely on cross-country econometrics to squeeze as much information as possible from international databases. Recognizing the difficulty of modeling something as complex as regulation, Estache, Goicoechea, and Trujillo (2006) rely on the largest current data set to test the interaction between corruption and regulation in terms of its impact on access and prices of utilities services in developing countries. Regulation in their model is approximated by the existence of an independent regulatory agency, that is, an institutional variable to address an institutional problem. They find that these agencies have often been effective but that they do not perform equally well across sectors or regulatory objectives. Regulatory agencies have offset the impact of corruption on electricity and telecommunications access but have had no effect on water access. Regulation reduces the impact of corruption on residential phone services and on industrial electricity prices; it has no effect on other prices. These mixed results are generally consistent with partial results obtained by other authors. In their analysis

of African water utilities, Kirkpatrick and Parker (2004) find that regulation does not have a statistically significant impact on their costs. Following a rationale similar to that adopted in the case of privatization, if costs are influenced by corruption, regulation has no impact on corruption. For electricity and in a wider country sample, Kirkpatrick and Parker find that regulation can improve performance but not for all types of indicators. These results are consistent with those of Estache, Goicoechea, and Trujillo (2006). As in the case of privatization, the extent to which regulation offsets the undesirable effects of corruption on infrastructure services is also a promising research topic.

Guasch and Straub (2005) model the interaction between corruption and regulation in the context of its effects on the renegotiation of infrastructure concessions in Latin America. They find that the higher the level of corruption, the more important it is to have a regulator in place to limit the incidence of renegotiations. There is also a very large body of theoretical literature on what regulation and how regulation can help (see Laffont [2005] on what it means for developing countries). The evidence on this topic is not consistent across papers.

Decentralization is the third way suggested by theory to increase accountability and hence reduce corruption.⁴⁵ Since the 1970s many countries, particularly developing countries, have seen a major increase in decentralization. Although a large body of economic research has been conducted on the topic in general, the results for infrastructure have been modest. Bardhan and Mookherjee (2000, 2003) offer some of the most influential findings on the topic. They focus on infrastructure, highlighting the role of local corruption on the effectiveness of public service decentralization. They show that under fairly mild assumptions, decentralization financed by user fees rather than local taxes or intergovernmental grants is superior, no matter how poorly local democracy works. More important, if user fees are not used, the superiority of decentralized over centralized service provision is no longer as clear-cut as many policy advisers seem to believe when corruption is explicitly taken into account. Finally, when ability to pay is constrained and user charges cannot be used to finance antipoverty programs, the optimal degree of decentralization depends on the degree of corruption in local and central governments. This is research that begs to be tested.

For now, there are relatively predictable tests of the impact of decentralization on the efficiency of the various delivery modes and types of infrastructure, especially in developing countries (see Shah, Thompson, and Zhou [2004] for a general survey). Very little work has been done on the interaction with corruption, however. Bardhan and Mookherjee (2006b) conducted a survey of the scarce evidence.⁴⁶ The first relevant empirical results date from 1995, when Estache and Sinha showed that for a sample of 10 industrial and 10 developing countries covering the 1970–92 period, decentralization tends to increase total and subnational spending on infrastructure much more in developing than in industrial countries. This could imply either preferences change with decentralization or cost increase with decentralization. The models tested do not allow differentiating between the two explanations.

There is then a gap in research until 2002, when Fisman and Gatti reached similar but more specific results, using a much more sophisticated model specification

applied to a data set of 59 countries. They find a negative correlation between corruption and decentralization for 1980–95.

Faguet's (2004) results suggest that decentralization is more of a demand-revelation mechanism than a stimulus to corruption. He shows that in Bolivia, decentralization has led to a reranking of investment programs in favor of agriculture, education, and water and sanitation. These are useful preliminary results, but they beg for confirmation. More country-specific studies such as Faguet's or cross-country studies that perform a fuller diagnostic are needed before the claim can be made that decentralization reduces corruption.

The last interesting area of research looks at the interaction between infrastructure decentralization and privatization. Working with a data panel of 40 countries between 1990 and 2000, Ghosh Banerjee, Oetzel, and Ranganathan (2006) find that fiscal decentralization significantly affects the level and frequency of private participation, but administrative and political decentralization do not. Fiscal decentralization tends to increase private sector participation in infrastructure. If decentralization is a demand-revelation mechanism, this result is somewhat surprising in view of the increasingly loud voices against private operation of public services in Latin America.

In many ways, the recommendation of more participatory approaches to service delivery—the fourth type of policy solution to mitigate the risks of corruption—can be seen as a by-product of the literature on decentralization (see Turk [2001] on how this is playing out in Vietnam). As with decentralization, little of the published economic research focuses on infrastructure services (recent exceptions include Chuwa, Zovu, and Mbula [2002] and Ackerman [2004]). Yet efforts to promote participation in projects, programs, and policy consultations are now common in the international community. While there is nothing specific to infrastructure, many of the assessments of these approaches are based on qualitative or impressionistic rather than quantitative assessments (Isham, Narayan, and Pritchett 1995 is a notable exception). As Ghazala (2004) notes, until his own 2004 paper, not a single study had established a quantitative causal relation between any outcome and participatory elements of a community-based development project.

The main picture emerging on the effectiveness of participation gives reason for concern. Ghazala (2004) and Cornwall (2003) observe that projects claiming “full participation” and “empowerment” have turned out to be driven by particular interests or elites, leaving the least powerful without voice or much choice. The poverty reduction effectiveness of these programs needs to be measured more systematically as well. The one quantitative study of an infrastructure activity is by Olken (2007), who finds that increasing grassroots participation had little impact in reducing corruption associated with road expenditure in Indonesia. He shows that top-down monitoring may be a better solution, even in a highly corrupt environment. In other words, traditional regulatory instruments have been more effective than participatory instruments in Indonesia's road program.

This overview of a large volume of theoretical research on how to deal with corruption suggests two main areas in which further efforts are needed. The first is data. The measurement of corruption in the sector is still approximated by the level

of corruption in the country. The second area is assessment of the effectiveness of policy instruments for the infrastructure sector. The main message of this discussion of the effectiveness of theoretical solutions may be that there is not enough evidence to get a sense of how much and under what circumstances each really matters. When evidence is available, it is too narrow or insufficiently robust. This defines an important research agenda for the sector. Finding out more about the effectiveness of the theoretical recommendations on how to deal with corruption in the sector should be a higher priority.

Concluding Comments

This literature review omits much good research conducted on the topics addressed here. In addition, it excludes many relevant topics, not because they are not be important but simply because they have not been on researchers' radar screens for some. Chief among these omitted topics is the need to revisit the issue of how to improve the performance of public providers of infrastructure services when privatization is not an option. Much energy has been spent over the past 10 years in identifying what works and what doesn't with public-private partnerships; very little has been allocated to thinking about how to manage public enterprises better (a rare exception is Gomez-Ibanez [2006]). In retrospect, this is unfortunate. The private sector financed just 20–25 percent of total infrastructure investments in developing countries and transition economies in recent years, and the trend is now declining. The good deals in energy and telecommunications have been signed; massive new inflows are unlikely for a while. In the foreseeable future, the public sector will continue to be a key actor, particularly in the lowest-income countries.

Closely related is the need to look into the regulation of public operators. Most of the research on infrastructure has tended to focus on the independent regulation of private operators. What about the independent regulation of public operators? Should the regulatory instruments be the same for public and private monopolies? Should regulatory accounting standards be the same for these two types of monopolies? Should public-private partnerships that do not require private sector investment affect the choice and design of regulation?

Also related is the need to establish a much better bridge between the theoretical research being conducted on procurement and the design and implementation of policies to procure public services in infrastructure. While auction theory has had a huge impact on telecommunications (spectrum auction), electricity (the design of power pools), and airports (slot allocations), its major contributions have hardly trickled down to more standard public sector procurement at the country level or in the procurement practices of bilateral or multilateral donors. The potential costs savings and cost controls that can be achieved from auctions are seldom considered in public sector reform. Similarly, the private sector has done a much better job than the public sector at internalizing theoretical research results in screening participants, structuring contracts, and centralizing procurement decisions.⁴⁷ Recent research has

developed much more advanced tests to minimize the risks of collusion while continuing to benefit from the interest of a wide range of bidders.

Finally, a common point in all of the themes touched on in this article is the need to generate data. More data are needed, and not just to produce more and better research that will eventually guide future reforms and policy choices in the longer run. More data are needed above all to increase the short- to medium-run accountability of all actors involved. Trying to improve the accountability of donors, governments, politicians, operators, investors, and users through institutional reforms will not go very far until there is enough quantitative information to spell out a baseline from which progress can be measured. The MDGs are a good start, but accountability should not be only about access, it should also be about affordability, public and private costs, risks, and quality. Without more and better data on these dimensions of infrastructure service delivery, there will be no accountability in the sector, inevitably leaving the poorest users and the taxpayers to bear the bulk of the costs of poor service and corruption.

Notes

1. The concept of *infrastructure* has a wide range of definitions in the literature. In this article, the term refers to all facilities used to deliver energy, water and sanitation, telecommunication, and transport services. Irrigation is not included, although it is an essential dimension of the management of the water sector.
2. The last time the academic world became massively interested in infrastructure was after the publication of Aschauer's 1989 article on the importance of public capital in the United States.
3. See Estache and Goicoechea (2005a) for a longer discussion.
4. This is not to deny the presence of the private sector. In fact, where the state and the larger private sector have failed to deliver services, the small-scale, generally local, private sector has filled the gap. The evidence on their role, and details of their costs, is mostly anecdotal, however.
5. This estimate has been made independently by researchers at the Department for International Development (DFID) and the World Bank (2005). Very roughly, it has been worked out as follows. The international community has some sense of the physical capital stocks per country and can hence value them at constant prices. The change in the value of these stocks gives a sense of the total investment in the sectors. The contribution of the private sector to that investment is given by the total commitments made during the same period by the private sector according to the World Bank private participation in infrastructure (PPI) database. This is likely to be an overestimate, because commitments are not necessarily disbursed.
6. No countries have fully independent regulatory agencies. Often these agencies have some degree of autonomy from the ministry covering the sector they are responsible for. When politicians want to take over the regulatory function, they simply do so, as the Latin American experience of the past three years suggests.
7. See Estache and Pinglo (2005) for all developing countries and Sirtaine and others (2005) for Latin America.

8. Sirtaine and others (2005) provide a detailed analysis of the evolution of the cost of capital in Latin America and compare it to the rate of return that can be estimated from the balance sheet of the main infrastructure operators in the region.
9. The rejection of the infrastructure reforms of the 1990s, in particular the increased role of the private sector in the delivery of services, did not play a minor role in the wave of political change in Argentina, Bolivia, Brazil, Uruguay, or Venezuela.
10. Indeed, reforms often have fiscal costs, often generated as part of renegotiations that could have been anticipated if consistency framework documenting the sources of costs and incomes of the regulatory operators accounting for reasonable demand forecast had been adopted more widely. Of crucial importance is the need to recognize that the gap between the rate of return of the business and the costs of capital will be paid by taxpayers or users. It turns out that the taxpayer has been called upon much more often than is sometimes recognized. See Campos and others (2003) on the actual fiscal cost of the sector after 10 years of reform in Latin America.
11. Investors in Argentina would probably argue that the pesofication of the economy implemented in January 2002 is the best evidence so far of what that risk means.
12. In the Demographic and Health Survey data, the poorer and richer are defined based on an asset index used as a proxy of the welfare level. In the Living Standard Measurement Survey data, households are ranked by total per capita expenditure.
13. The most recent evidence suggests that the MDGs are unlikely to be met in many countries of the world (World Bank 2005).
14. Some countries are starting to draw their own baselines independently. India, for example, has created the very useful annual *India Infrastructure Report* series, edited by 3iNetwork.
15. See the analysis of Spain by de la Fuente and Vives (1995) for a perfect example of how creative empirics building on good theory can guide public investment decisions.
16. See Baldwin and others (2003) for an overview, including a chapter on the relevance of infrastructure for effective regional policies.
17. The minimum population threshold for defining urban areas varies dramatically among countries, but “urban” is typically characterized by density of settlement in a contiguously built-up area, by the structure of economic activity, and sometimes by administrative attributes.
18. Diversification of income sources is a key component of rural poverty reduction strategies and one that depends on infrastructure to be effective (see Ellis [1998] for a survey). In a survey of the literature identifying a poverty trap similar to the one observed in regions with large rural populations, as in Africa, Booth (2004) lists eight factors used by all authors to explain poverty that is mostly rural in those regions. One is poor land and sea transport infrastructure, which makes market development unusually difficult. Fan, Jitsuchon, and Methakunnavut (2004); Fan, Zhang, and Rao (2004); and Fan and Chan-Kang (2004) provide impressive evidence on the various channels through which infrastructure contributes to poverty reduction and show how different these channels can be across as well as within countries.
19. There are more than 400 cities with a population of more than 1 million—up from 16 cities 100 years ago.
20. These institutions have also generated a huge number of unpublished studies and working papers, some of which are available on their Web sites. There are too many to do them justice here.
21. See Alam and others (2005) and Estache and Wodon (2002) on Africa; Estache, Foster, and Wodon (2002) on Latin America; and Komives, Whittington, and Wu (2003) for a sample of countries in various regions.

22. This issue is not addressed here; interested readers should see Chisari, Estache, and Waddams-Price (2003); Clarke and Wallsten (2002); Cremer and others (2001); Gasmi and others (2002); and Laffont (2005).
23. For an overview of the literature on subsidies of relevance to infrastructure see Komives and others (2005).
24. For a useful review of the debate and survey of the empirical evidence, see Ravallion (2003).
25. See Foster, Gomez-Lobo, and Halpern (2000a, 2000b); Foster and Irusta (2003); Foster and Araujo (2004); and Gomez-Lobo and Contreras (2003) for examples.
26. International organizations and most countries define minimum consumption levels for water and energy. The rules of thumb are that households in developing countries should not spend more than 5 percent of their income on water and sanitation or more than 5–10 percent on energy (depending on the region).
27. Estache, Foster, and Wodon (2002) show how common this is in Latin America.
28. See Chisari, Estache, and Romero (1999); Chisari, Estache, and Waddams-Price (2003); and Navajas (2000) for Argentina. See Andersen and Faris (2002) for natural gas in Bolivia; Boccanfusso, Estache, and Savard (2006) for Senegal; and Adam and Bevan (2004) for Uganda.
29. See van de Walle and Nead (1995); Lanjouw (1999); Jacoby (2000); van de Walle (2002); Gibson and Rozelle (2001); Renkow, Hallstrom, and Karanja (2004); Lokshin and Yemtsov (2005); and Warr (2005).
30. Many in the water community would argue against this, at least for their sector. According to World Health Organization statistics, rural areas in developing regions have 5.3 times more unserved people for water supply and 3.6 times more unserved people for sanitation than urban areas (WHO Web site). This service gap is not well correlated with the direction of the lending program of many donors. For instance, in the World Bank's lending portfolio between 1990 and 2001, urban areas received nearly six times more in loan funds than rural areas, a difference that is not explained by differences in unit costs. The difference may reflect more strategic decisions on resource allocations. According to the World Bank Evaluation Department, each dollar spent on a rural water system provides about four times the population coverage offered by an equivalent urban investment. This could imply that more should be done to cover rural areas, at least in some regions. It could also imply that these numbers reflect a selection bias in the World Bank's portfolio. Improving collective knowledge on this issue could be an interesting research area.
31. See Ravallion (2002) and Cohen (2004) for a discussion of population trends.
32. This is not a new debate. Lipton (1977) and Mellor (1976) were concerned with the opposite question: was the urban bias of the international community rational?
33. See Sahn, Stifel, and Younger (2003) for a more relevant approach to assessing the relative importance of infrastructure in poor people's expenditure patterns.
34. Satterthwaite (2004) provides an interesting discussion of the data issues.
35. According to Mitlin (2004), because of the typical failure to break down urban averages (where access invariably looks much better than in rural areas, because the rich live in cities), the benefit of the doubt in most country assistance planning, including Poverty Reduction Strategy Papers (PRSPs), is being given to the rural areas. She documents her point in a review of 23 PRSPs, finding that they do not give much weight to urban areas.
36. For a good overview of the issues, see Irwin (2007).
37. Questions include the following: Which kind of public enterprises should be included? Should they have hard budget constraints? Should public enterprises be outside the budget (as in Chile)? Which kind of projects should be included? Which kind of guarantees

- should be accounted for as expenditures and at what time? Should these guarantees be accounted for on a cash or accrual basis? Should recurrent and capital expenditures be systematically separated for every sector (à la Blanchard and Giavazzi [2003])?
38. For an economic discussion, see Ballasone and Franco (2000); Blanchard and Giavazzi (2003); Buiter and Grafe (2004); and Turrini (2004). For an accounting viewpoint, see McCrae and Aiken (2000).
 39. Laffont and Tirole (1993) catalyzed this literature. See also Armstrong and Sappington (forthcoming); Bos (1994, 2003); Hart (2003); Laffont (2000, 2005); and Newberry (2000).
 40. Flyvberg, Bruzelius, and Rothengatter (2003) give an excellent sense of the size of the problem in this sector, in particular in developed economies.
 41. Favoritism, fraud, cronyism, patronage, embezzlement, bribes, and state capture are all concepts that have long been associated with the delivery of infrastructure services in many countries. There is extensive literature on how to define corruption and on the semantic practices of different institutions; a helpful recent survey is Lanyi (2004). For a recent survey on economic analysis of corruption, see Aidt (2003); on levels of corruption, see Kaufmann, Kraay, and Mastruzzi (2003).
 42. New models include incentive structures that are consistent with the Latin American stylized facts (Martimort and Straub 2006). They show that private ownership can foster investment while increasing corruption.
 43. There are also country-specific databases dealing with public services, but these are the exception rather than the rule (see Reinikka and Svensson [2002]; Svensson [2003]; and many of the country reports from Transparency International available on its Web site).
 44. The evidence on the governance payoffs of privatization does not necessarily apply to infrastructure privatization. Privatization of competitive industries, most of them unrelated to any concept of public service, entails very different actors and interests. These differences have seldom been accounted for in the literature on privatization, which tends to extrapolate whatever is learned from telecommunications, the most competitive of the infrastructure services, to all other infrastructure sectors.
 45. A notable exception is Shleifer and Vishny (1993), who argue that more vertical tiers of government tend to weaken governance.
 46. A large body of public administration literature documents the impacts of various forms of public service decentralization in developing countries. Analysis of decentralized health and education services is reviewed in the *World Development Report 2003* (World Bank 2002).
 47. A forthcoming book edited by Dimitri, Piga, and Spagnolo may be the first since Laffont and Tirole (1993) that addresses the procurement issues thoroughly. This book also has the benefit of many more illustrations of relevance to practitioners.

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Comment on "Infrastructure: A Survey of Recent and Upcoming Issues," by Antonio Estache

HADI SALEHI ESFAHANI

This is a very interesting and important paper. It deals with an issue that has preoccupied economists and policy makers ever since they became concerned with development policy. In the past decade or so, research on the role of infrastructure slowed and took indirect forms, partly because many related theoretical and empirical details needed to be worked out first. In particular, governance issues, which became popular in part through the infrastructure literature, required more extensive investigation in broader contexts. As governance and other agendas, such as liberalization and poverty reduction, gained greater prominence, infrastructure research went out of fashion for a while. The need for improved infrastructure provision did not go away, however, especially among the poor, for whom infrastructure represents the opportunity to better their lives. So it is good to see that the World Bank is moving research on infrastructure toward the top of its agenda again. It is very rewarding to see an extensive survey of infrastructure literature along with so many related papers in this conference.

Looking at where we are in the context of research on infrastructure and where we need to go, it is clear that the range of issues is truly vast and that we face a real dilemma choosing the most urgent step. This extensive survey helps us find our place on the research map and suggests good ideas about the research needed in the near future.

Estache summarizes his observations in the form of six broad conclusions. I briefly review his explicit conclusions along with some additional points I learned from his survey. I then add a few important concerns that are not emphasized or covered by the article before reflecting on current research priorities based on those observations.

Estache highlights the fact that infrastructure matters for growth and poverty reduction, especially in poor countries, and that infrastructure services are still quite

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inadequate for large parts of the world population. In the late 1980s and 1990s, there was hope that private sector participation and reliance on markets would solve most infrastructure problems. That hope has not materialized in many countries. Investments are not automatically flowing to infrastructure projects with the highest rates of social return, and the poor often remain excluded. Direct government involvement, planning, and policy coordination in infrastructure remain important in most service areas in developing countries.

Given that governments remain involved extensively one way or another, what policies are best to follow? The literature has been telling governments to focus on efficiency first, to address equity concerns through cash or direct subsidies, and to set up efficient regulations and appoint independent regulators for managing infrastructure services. Estache's survey shows that the trade-offs between efficiency and equity are complex and need to be diagnosed and managed properly to ensure sustainability and the broad distribution of benefits. Efficiency first does not quite work. Fiscal constraints limit governments' ability to address access and equity concerns. As a result, more intrusive interventions and cross-subsidization may remain practical alternatives for these purposes, at least in the short and medium runs.

Estache's review of governance in infrastructure shows that the results are mixed. He concludes that corruption probably hurts, while decentralization and independent regulators may help, though not in all situations. One of the greatest hopes that he finds dashed is the use of participatory approaches to service delivery.

Estache does not quite delve into the debates over the role of macro institutions, such as legal origins, rule of law, commitment, politics, and administrative capability. These issues became important in the infrastructure literature in the 1990s and continue to be actively studied in other contexts. I believe these issues are still important, at least in tailoring infrastructure policies to country conditions. Estache touches on some of these issues in the context of finance options, which is important and interesting. But the role of macro institutions goes well beyond finance. They are significant parts of the country-specific conditions that seem to be responsible for the differences in the outcomes of similar infrastructure policies in different contexts. To give a rather striking example, Singapore has had no problem delivering first-rate infrastructure services through public enterprises, while similar attempts elsewhere have produced meager results.

Another major issue that shows up only in limited ways in Estache's article is the connection between infrastructure policies and broader development strategies. He carefully examines the distributional consequences of infrastructure built to support tradable industries. He also discusses possible undue restrictions on infrastructure because of concern over fiscal sustainability. However, there is much more to such interactions. Consider, for example, a government that has had difficulty initiating a rapid industrialization process because of lack of infrastructure and other factors. Now suppose it manages to redesign its policies around export promotion and begins to develop its infrastructure based on the needs of that activity—as, for example, the Republic of Korea did in the 1960s. This may have some distributional consequences,

but that effect can be dwarfed by the growth effects the policy coordination and resource mobilization bring about.

To provide good policy advice, we really need to examine infrastructure policies in the context of a country's institutions, politics, economic conditions, and development strategy, all of which seem to interact with one another, as Estache notes. That is a truly tall order, which begs the question: where should we begin?

As Estache shows, the first step is clear: we need more data. Indeed, the data gaps are huge. This is surprising, especially given the importance of infrastructure in the economy and the fact that detailed and accurate data are crucial for effectively monitoring, assessing, and implementing infrastructure policies. More extensive data should help shed light on the multitude of questions that remain unanswered concerning infrastructure policy. They should also help improve policy advice and implementation.

Evidently, the lack of adequate means of data collection is part of the missing infrastructure. A key task therefore seems to be to develop an infrastructure for data collection and analysis at disaggregated and detailed levels. We also need to analyze the data at local levels, applying new and more rigorous theories and econometric methods. As Estache points out, there is much room for developing better models of public sector performance and regulation.

Another step that should be taken at the same time is to examine the cases of countries that have managed to develop their infrastructure successfully. Studying successful cases is useful because it can offer some sets of sufficient conditions for good performance from which one may extract policy lessons for other countries. In contrast, failure cases are less informative for isolating the combination of factors that raise the likelihood of success. We need to ask how the high performers succeeded. How did they manage to get the right data and motivate their service providers? Were accurate quantitative data on service outcomes an important factor in their success, or were the form of organization and the right data about the process key? To what extent was infrastructure development a by-product of their development strategy rather than a carefully planned effort of its own? What were the roles of the political and administrative processes in ensuring that the job got done? The answers to these questions can better inform us about the kind of data we need and the research questions we should ask next.



Comment on "Infrastructure: A Survey of Recent and Upcoming Issues," by Antonio Estache

KEIJIRO OTSUKA

Antonio Estache provides a comprehensive and useful survey of the recent literature on the role of infrastructure in poor countries. He reviews the literature in four areas: the role of infrastructure in economic growth, its impact on the poor, fiscal and other financing options, and corruption. There is no question that these four issues are all critically important.

The first question I have is how these four issues are conceptually related. Estache's paper reviews macroeconomic growth regression, looking at the effects of fiscal expenditures on economic growth. Important findings here are the extremely high rates of return to expenditures on infrastructure, ranging from 30–40 percent to 200 percent. This is useful information, but the nature of macroeconomic analysis means that the relation between expenditures and growth is in a black box. Frankly, I wish to see inside the black box. In order to do so, detailed and careful microeconomic studies based on household survey data are essential. Indeed, the author argues that household surveys are crucial for performing impact analysis on welfare and poverty. I could not find, however, the relevant literature review. The author indicates the dearth of relevant literature in this area. In fact, lacking are not simply empirical studies of poor households but long-term analyses of panel data, particularly in Sub-Saharan Africa, that allow us to assess the impacts of investments in infrastructure on poverty reduction over time.

Fiscal expenditures on infrastructure can be supplemented by cooperation with the private sectors, full or near full cost recovery, and the prudent use of cross-subsidies, in order to increase net investment. I have two comments here. First, although the author seems to advocate the use of cross-subsidies, empirical justification for them is lacking, and most economists do not support them. Second, the survey of benefit-cost analysis is very brief. After all, the issues of fiscal and other financing options boil down to benefits and costs. According to the author, the

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conventional benefit-cost analysis may not be directly useful for analyzing poverty reduction. I do not think that benefit-cost analysis is useless for this purpose: what can guide the investment allocation decisions without benefit-cost analysis of some sort? The challenge is to make the best use of benefit-cost analysis in order to assess the impacts of investments in infrastructure on poverty reduction.

The discussion of corruption is useful, albeit at best suggestive, as reliable data on corruption are hard to obtain. The author notes that privatization, regulation, decentralization, and participatory approaches could reduce corruption. This can be true, but all these variables are endogenous. I therefore wonder how much sense it makes to discuss the impact of endogenous variables on another endogenous variable. After all, can we reduce corruption by forcing corrupt governments to privatize, regulate, decentralize, and adopt participatory approaches?

My fundamental criticism of this article is the lack of a “strategy” for growth and poverty reduction by means of investment in infrastructure. The implicit and basic assumption of this article is that what is important for poverty reduction is improving the access of the poor to infrastructure services. There is no denying that this is important. However, another important role of investment in infrastructure should be to facilitate the development of industries and agriculture in order to provide employment opportunities for the poor. I strongly believe that widespread poverty cannot be reduced significantly unless investments in infrastructure are made in such a way as to stimulate pro-poor economic growth. For such purposes, microlevel analysis of how infrastructure investments affect the welfare of poor households, not only directly but also indirectly by stimulating growth of industries and agriculture, is indispensable. Tetsushi Sonobe and I have been making such an attempt by looking at how industries develop over time in East Asia (Sonobe and Otsuka 2006). I propose strengthening the linkage between the analyses of infrastructure and development of industries and agriculture.

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Climate Change Impacts, Energy, and Development

MICHAEL GRUBB

Climate change poses a major challenge, but responding to it creates opportunities as well as threats to development. The balance between them will to a large degree be a function of how public policy responds. Rapidly expanding investment in carbon-intensive infrastructure increases both the environmental risks faced by developing countries and the financial risk of such investments becoming “stranded assets” as carbon controls tighten over time. This creates a compelling case for broad-based action now to switch investment toward higher energy efficiency and lower use of carbon sources. Specific policy responses will vary based on national circumstances, but they must combine three basic elements: carbon pricing, implemented mainly through cap-and-trade systems; policies to address a variety of informational, behavioral, and structural barriers to optimal responses; and policies to reflect long-term public benefits associated with low-carbon infrastructure and innovation-related investments.

General acceptance that climate is a real and pressing problem is moving the issue from scientific debate and observation toward questions about the impact of climate change on economic development and the implications of measures to tackle it. This article briefly summarizes the scientific evidence and nature of the problem before discussing the implications and relation to economic and development policy. Its focus is the implications of climate change for development, with an emphasis on investment and infrastructure, in accordance with the theme of this year’s ABCDE conference.

The article is divided into four main sections. The first section summarizes the scientific evidence, presents projections, and discusses key points on evaluating impacts, particularly for developing countries. The second section presents some

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empirical evidence on the relation between emissions and economic development, presenting four facts about and four opportunities created by the relation between development and carbon dioxide (CO₂) emissions. The third section analyzes the global macroeconomics of emissions mitigation, including the role of infrastructure and innovation. The fourth section concludes with a brief survey of policy instruments that can be adopted to tackle emissions while minimizing costs and maximizing opportunities.

Although the article takes the form of a wide-ranging review, it has a unifying theme: that the problem of climate change can be tackled and that, although countries face hugely different circumstances and are at very different stages of development, it is in the interest of every country to take appropriate action to do so. The magnitude of the problem, and the inertia inherent in responses, mean that waiting—or blaming others—is no longer a credible option.

Science and the Nature of the Challenge

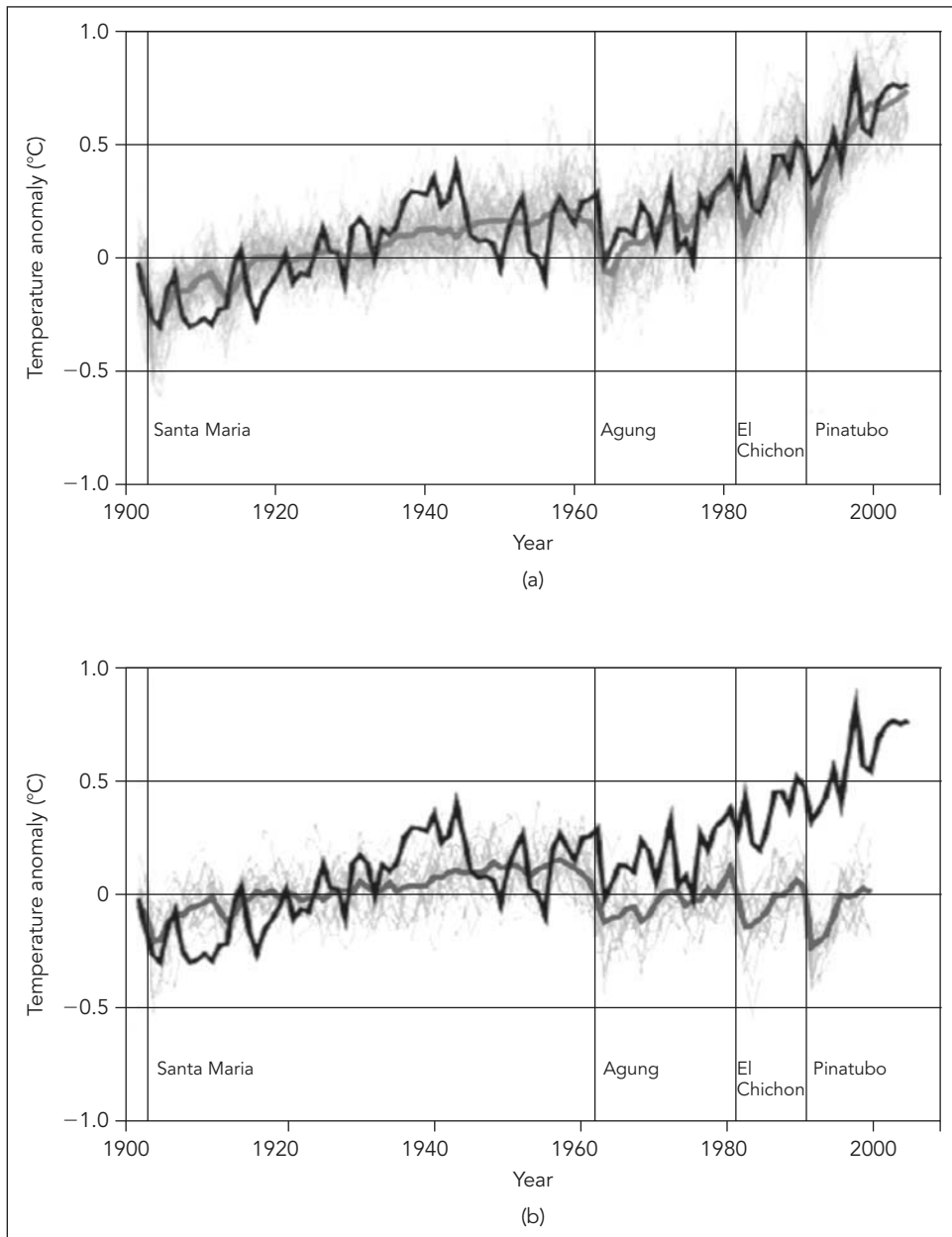
Emissions of various gases from industrial and other human activities are changing the atmosphere.¹ *Climate change* encapsulates the wide variety of accompanying impacts on temperature, weather patterns, and other natural systems. Despite decades of research, important questions remain uncertain, but much is also now established beyond a reasonable doubt.

The fundamentals of climate change have long been well understood, because they involve the same basic physics that keeps the earth habitable. Heat-trapping greenhouse gases in the atmosphere (of which the two most important are water vapor and CO₂) let through short-wave radiation from the sun but absorb the long-wave heat radiation coming back from the earth's surface and reradiate it. These gases act like a blanket, keeping the surface and the lower atmosphere about 33°C warmer than it would be without them.

Primarily as a result of the burning of fossil fuels and deforestation, humans have been increasing the concentration of CO₂ and other greenhouse gases in the atmosphere since the Industrial Revolution began, thickening the greenhouse blanket. Surface warming in recent decades is established beyond doubt (figure 1). So too is the cooling of the stratosphere (the layer above the main blanket), as would be expected from greenhouse warming that traps more heat near the surface. Direct temperature records back to the middle of the nineteenth century are considered to be reliable enough to establish that recent temperatures are warmer than any since direct measurements began. Since the 1980s, partly as the result of the clean-up of other industrial pollutants (some of which had masked underlying warming), the underlying long-term greenhouse warming has emerged more clearly: all of the 10 warmest years have occurred since 1990, including each year since 1995. Better accounting for these and other factors can now generate a good fit between the observed temperature trend and the results of computer simulations that incorporate these multiple factors.

Although debate continues about the exact temperatures during medieval times, a wide variety of proxy indicators (tree rings, coral layering, glacier records) give a high

FIGURE 1
Temperature Variance, 1900–2000



Source: IPCC 2007a.

Note: The dark lines show the observed difference compared to multimodel simulated global temperature anomalies (lighter lines) with both natural and anthropogenic (human-induced) influences (upper panel) and simulated anomalies from natural forcing only (lower panel).

Vertical gray lines indicate the timing of major volcanic events.

level of confidence that the warming observed today is unprecedented. Indeed, it appears that annual global average temperatures have varied by less than one degree Celsius for thousands of years and probably during the entire post-Ice Age period (during which human civilization developed), suggesting that recent years have probably been the warmest in more than 100,000 years. Scientists have been unable to identify natural factors that could explain either the degree or the pattern of the surface warming and stratosphere cooling observed over recent decades. Understanding is still incomplete, but the fundamentals are clear and supported by a long list of other accumulating impacts.

The list of observed changes other than temperature and sea level is growing rapidly. These include “the thawing of permafrost, later freezing and earlier break-up of ice on rivers and lakes, lengthening of mid- to high-latitude growing seasons, poleward and altitudinal shifts of plant and animal ranges, declines of some plant and animal populations, and earlier flowering of trees, emergence of insects, and egg-laying in birds” (IPCC 2001c, p. 3).

Perhaps the clearest, most prominent and consistent indicator of warming is the retreat of mountain glaciers, which has occurred throughout most of the world. Impacts on ice are also clear around the poles. The Arctic ice cap is shrinking, and the Larsen Ice Shelf around the Antarctic Peninsula has undergone unprecedented disintegration. Coral reefs have been bleaching, at least partly because of rising sea-surface temperatures.

Many areas have seen fewer long cold spells and more long hot spells in ways that are consistent with the predictions of climate models. Warming increases evaporation and precipitation, and both aggregate rainfall and the occurrences of “heavy precipitation events” in northern midlatitudes (such as Europe and the United States)—the principal cause of flooding—have increased in recent decades. In tropical regions, the potential for more intense hurricanes and typhoons increases in a warmer world, but the data are sufficiently sparse and complex that the trend remains in dispute.

Since by definition extreme events occur infrequently, trends are hard to prove. Unlike the general trends of temperature, ice level, and sea level, it may always be questionable to attribute any one particular weather event to climate change, because all weather events have multiple causes. So the question “was X due to climate change?” cannot be answered simply, whether X is record temperatures, exceptional storms, floods, or droughts. Nevertheless, science may increasingly be able to estimate how much past emissions increase the risk of extreme high temperatures and in some areas droughts and flood events.²

There is little dispute, however, about the potential for weather-related extreme events to inflict devastating human and economic impact. In recent years, El Niño has caused damage equivalent to 3 percent of GDP in Central America (www.eclac.cl/mexico/); flooding in Mozambique has caused damage equivalent to 4–6 percent of GDP (Cairncross and Alvarinho 2006); and Hurricane Mitch caused damage equivalent to 7 percent of GDP in Honduras and Nicaragua (Satterthwaite 2007). The extent to which such events might be exacerbated by climate change is thus a critical—and very complex—concern.

Projected Impacts of Climate Change

The distinction between climate and weather is a bit like that between sea level and waves. Sea level sets average conditions, which vary locally according to tides and coastline, but understanding these factors does not mean that one can easily pick out trends from individual waves or predict them in detail. The complexities and uncertainties around climate change should not obscure the basic facts, however. The fundamental mechanics of climate change are well understood: the world is warming, and much of the warming is due to human emissions of greenhouse gases.

Some persistent trends can already be projected with confidence. The snows of Kilimanjaro, for example, already much shrunk, are expected to disappear entirely within the next few decades—it is already too late to avert this (Alverson and others 2001). Glaciers and sea ice will continue to shrink, and there may be no Arctic Sea ice in the summer by the end of this century. Being in a much colder climate, the Antarctic ice sheet is less likely to lose mass, but some ice shelves around it will disappear.

Existing zones of preferred vegetation and associated crops will migrate toward the poles, forcing farming practices and ecosystems to adapt. Many species and ecosystems have limited scope to move, however, because of variety of barriers. The most comprehensive study to date estimates that about a quarter of the world's known animals and plants—more than a million species—will eventually die out because of the warming projected to take place in the next 50 years (Thomas and others 2004).

In addition to the broad physical and biological trends of warming and glacier retreat, sea-level rise, and the migration and loss of species and ecosystems, other predicted impacts of climate change are many and varied. And as research continues and experience begins to accumulate, the list grows longer.

The most authoritative source of analysis is the Intergovernmental Panel on Climate Change (IPCC), which has recently completed its Fourth Assessment. It projects the impacts of climate change by category and sector, at various levels of confidence (table 1).

There are several broad approaches to thinking about the potential implications of such impacts for human economies and societies. During the 1990s, scientific emphases on physical impacts and risks tended to contrast with economic studies, which tended to be far more optimistic. The economic debate was stimulated largely by Nordhaus (1991), who argued that quantifiable impacts of a warmer climate would be modest and justified only very limited action to mitigate emissions, and by Cline (1992), who adopted broadly comparable methods but found quite different results depending largely on discounting assumptions. Mendelsohn, Nordhaus, and Shaw (1994) developed more detailed analyses of agricultural impacts in the United States, concluding that moderate levels of climate change could boost U.S. agricultural output. During the 1990s these analysts extended this work to other sectors and other countries. These studies, considered below, indicated that impacts would be highly diverse, with some regions benefiting and low-latitude developing countries bearing the brunt of the damage.

TABLE 1. Possible Impacts as a Result of Changes in Extreme Weather and Climate Events, by Sector

Phenomena and direction of trend [WGI SPM]	Likelihood of trend in 21st C [WGI SPM]	Major impacts by sector			
		Agriculture, forestry	Water resources	Human health/mortality	Industry/settlement/society
Warmer/fewer cold days/nights; warmer/more hot days/nights over most land areas	Virtually certain	Increased yields in colder environments; decreased yields in warmer environments	Effects on water resources relying on snow melt	Reduced human mortality from decreased cold exposure	Reduced energy demand for heating; increased demand for cooling; declining air quality in cities; reduced effects of snow, ice, etc.
Warm spells/heat waves: frequency increases over most land areas	Very likely	Reduced yields in warmer regions due to heat stress; fire danger increase	Increased water demand; water quality problems, e.g., algal blooms	Increased risk of heat-related mortality	Reduction in quality of life for people in warm areas without air conditioning; impacts on elderly and very young; reduced thermoelectric power production efficiency
Heavy precipitation events: frequency increases over most areas	Very likely	Damage to crops; soil erosion, inability to cultivate land, water logging of soils	Adverse effects on quality of surface and ground-water; contamination of water supply	Deaths, injuries, infectious diseases, allergies and dermatitis from floods and landslides	Disruption of settlements, commerce, transport, and societies due to flooding; pressures on urban and rural infrastructures
Area affected by drought: increases	Likely	Land degradation, lower yields/crop damage and failure; livestock deaths	More widespread water stress	Increased risk of food and water shortage and wild fires; increased risk of water- and food-borne diseases	Water shortages for settlements, industry, and societies; reduced hydropower generation potentials; potentials for population migration
Number of intense tropical cyclones: increases	Likely	Damage to crops; wind-throw of trees	Power outages cause disruption of public water supply	Increased risk of deaths, injuries, water- and food-borne diseases	Disruption by flood and high winds; withdrawal of risk coverage in vulnerable areas by private insurers
Incidence of extreme high sea level: increases	Likely	Salinization of irrigation and well water	Decreased freshwater availability due to saltwater intrusion	Increase in deaths by drowning in floods; increase in stress-related disease	Costs of coastal protection versus costs of land-use relocation; also see tropical cyclones above

Source: IPCC 2007c.

Note: Impacts are based on projections through the mid- to late 21st century. Virtually certain = >99 percent probability of occurrence; extremely likely = >95 percent probability of occurrence; very likely = >90 percent probability of occurrence; likely = >66 percent probability of occurrence.

These relatively optimistic economic analyses have been based primarily on projections of aggregate average warming (or comparative static) patterns and effective adaptation to them. For these reasons, they have come under extensive criticism. Certainly, any evaluation of human implications needs to start from a more comprehensive understanding of the likely nature of impacts than displayed in these early economic evaluations, as discussed below. Moreover, human impacts depend on specific changes in regions and localities. Localized changes are likely to be both more varied and harder to predict than global averages. All projections are thus still quite speculative.

Two regional examples help illustrate possible consequences.³ Summer drying and heat waves in and around the Mediterranean could further stress water supplies in some regions that are already politically less stable and heavily dependent on irrigation for agriculture. Such changes could also drive expanded migration into northern Europe, which might itself come under growing pressure from increased floods and heat waves.

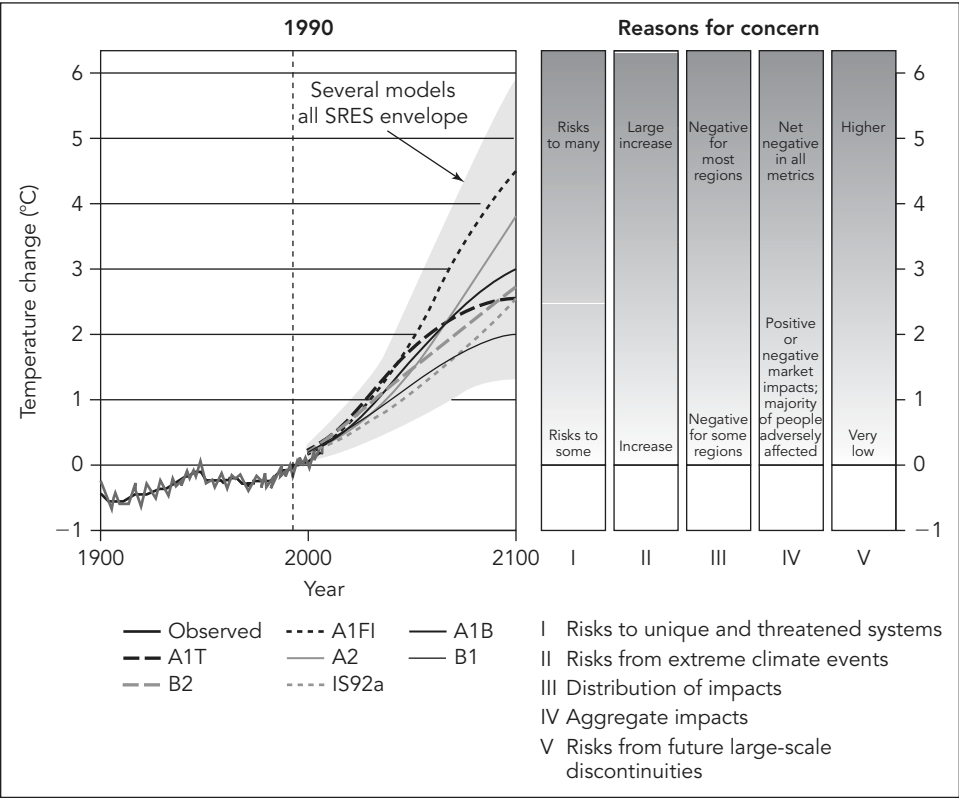
On the Indian subcontinent, Bangladesh and northeast India could face a number of diverse pressures: rising seas and storms inundating the Ganges delta region; a more variable monsoon, undermining the agricultural foundations that feed a quarter of a billion people; and changing patterns of river flow as climate change affects the Himalayan glaciers that feed the rivers, with corresponding international tensions across already volatile borders.

These are just examples; the possible human consequences of climate change are only just beginning to be seriously considered. A particularly complex consideration is that while most scientific studies have focused on the possible impacts of a warmer world, most human impacts may flow from the nature of a warming world, in which change—often hard to predict at the local level—may be the most difficult characteristic for societies to handle. Farming practices, water industries, and innumerable other social and infrastructural systems designed for the last century's climate will not necessarily adapt easily to the accelerating change now projected, particularly as some of the underlying natural systems are also under pressure from global economic and population growth.

Such considerations inform the risk assessment-led approach to considering impacts. One form of this is illustrated in figure 2, in which the impacts of projected climate changes are grouped into five risk categories. This approach suggests that even under the most optimistic projections, some unique and threatened ecosystems will disappear and some regions will be exposed to adverse impacts. In the midrange, many unique systems may be at risk and the impact of extreme events will rise, with developing countries hurt the most; the impact on the aggregate global economy could still be modest. Change toward the upper end poses significant risks to all, and the risk of abrupt planetary-scale disruptions becomes significant.

To date, the debate between economists (who quantify specific, potentially measurable, and monetizeable impacts) and scientists (who focus on risk indices and scenarios) over impact has been largely a dialogue of the deaf. The next section sets out more formally a structure for thinking about these different dimensions.

FIGURE 2
Five Risk Indicators Associated with Projected Changes in Global Temperatures



Source: IPCC 2001c.

Note: The IPCC 2001 developed the Special Report on Emissions Scenarios (SRES), which reports on the development of multiple GHG emissions baselines based on different future world views. For a description of the scenarios please refer to the source. The gray area signifies the total database range.

Economic Evaluation of Climate Change Impacts: Frameworks and Challenges

How costly may climate change really be? This is a natural question for economists in particular to ask but an extraordinarily difficult one to answer. Continuing scientific uncertainties about the nature, timing, and severity of natural impacts are multiplied by many layers of uncertainty about how society will cope with growing impacts and how to quantify them. The impacts literature is dominated by natural scientists. Economists seek insights into the optimal trade-off between reducing impacts in lower-emission pathways and the presumed costs of reducing emissions. This section outlines the intellectual framework of quantification and sets out six challenges in evaluation.

Attempts by economists to quantify impacts in monetary terms have tended to concentrate on a few measurable dimensions, using either model simulations or comparative-static (cross-sectional) studies that compare indices such as land value

TABLE 2. Categorization of Studies of the Social Cost of Climate Change

Nature of climate change considered	Item	Valuation uncertainties		
		Market (direct) value	Nonmarket (indirect use and options) value	Socially contingent costs, existence value, and bequest value ^a
	Mean climate	Global studies	Some global studies	None
	Climate variability and extremes	Regional studies, some global studies	Some local and regional studies	None
	System changes and singularities	Few sensitivity studies	None	None

Source: Adapted from Downing and others 2005; Jones and Yohe 2006.

a. Socially contingent costs are those that may be amplified by the inability of society to respond to impacts optimally, such as failures of governance or the frictions associated with migration or deeper disturbances. Existence value is that identified in environmental economics as the value that society accords to the existence of an environmental good, whether or not it is used. Bequest value can be understood as the explicit value of preserving options for future use.

and other indicators as a function of temperature. Since Mendelsohn, Nordhaus, and Shaw (1994), the “Ricardian” method of comparative-static estimates has been applied to other sectors, such as timber, energy, and water supply (see Mendelsohn and Williams 2004).

The essential foundation of such studies is that the explicitly climate-vulnerable sectors of the economy account for a relatively limited share of GDP. Ricardian approaches suggest that there are optimum temperatures for most sectors, which lie somewhat above the average temperatures typical in midlatitude regions. This notion drives the principal findings that climate damages are modest in midlatitude regions, adverse in low-latitude regions, and positive in high-latitude regions. Since midlatitude countries dominate world GDP, the net impact of climate change is modest across the century. Nordhaus and Boyer (2000) present the classic set of studies that argue this perspective. Mendelsohn and Williams (2004) conclude that globally aggregated damages and benefits are about equal for the next several decades, with damages starting to dominate after about 2050 and getting worse thereafter.

Table 2, drawn from a major review study of the social cost of carbon (Downing and others 2005) helps set such studies in perspective. As the authors note, more than 95 percent of the studies that seek to put a monetized value on climate impacts focus on only two out of the nine elements of the matrix—namely, the market and non-market costs associated with smooth projected change. Indeed, the Ricardian analyses, which compare the costs of two assumed climates, neglect the transitional costs of shifting systems from one climate to another (a climate that would itself still be changing). This is true of many of the studies cited above. Nordhaus’ estimates try to quantify a wide range of measurable impacts, but he still has to resort to various assumptions by extrapolation that other impacts are correspondingly modest.

Discounting. The long timescales of climate change make discounting over time a critical determinant of the present value of impact assessments. The discounting

literature is enormous and has yielded consensus that market-based discount rates are not appropriate for evaluating very long-term issues like climate change. Indeed, it is now general practice to use discount rates for public policy evaluation that are well below market interest rates, particularly for longer-term endeavors; uncertainty around future economic growth rates lowers applicable rates further (see, for example, Weitzman 1998). The literature increasingly questions the form as well as the number used for discounting: while Heal's (1998) call for a logarithmic form has not been generally accepted, Groom and others (2003) conclude that the classical single exponential form is not tenable, and the British government itself has adopted a rate that declines over time (UK Treasury 2004). All these revisions tend to amplify the present value of climate change impacts, most of which occur in the longer term.

These revisions establish that the long-term cumulative impacts of climate change cannot be wholly discounted away in evaluating climate damages, as Downing and others (2005) note. The Stern report (Stern 2007) adds another twist to the arguments. The ethical basis for discounting in public policy evaluation rests fundamentally on the belief that future generations will be better off. If impacts may be nonmarginal—particularly if they may be severe enough to prevent future generations from being better off in per capita terms—then the underlying basis for discounting is undermined. If climate change may have nonmarginal impacts, the discount rate needs to be endogenous—higher impacts are accompanied by lower discount rates and such scenarios are weighted more heavily.

A recent study (Ackerman and Finlayson 2007) demonstrates unequivocally how the combination of discounting and impact assumptions determine the results of Nordhaus and Boyer (2000). Their assumed discount rate weights the modest gains assumed in early decades far more heavily than the subsequent losses. Using the same model but adopting an equity-based time preference and dropping the assumption that the initial warming in midlatitudes boosts GDP increases the present social cost of carbon by a factor of 20.

Valuation over space: Contingent valuation, statistical life, and equity weightings. Similar scrutiny needs to be applied to evaluating transboundary impacts. Contingent valuation methods based on willingness to pay lead to valuation of mortality based on national value of statistical life (VOSL). These values are heavily constrained by national income and can differ by a factor of more than 10 across countries, a disparity that led to bitter political disputes when applied by economists to evaluate impacts in the IPCC Second Assessment (IPCC 1995; for a contributing author's subsequent analysis of the issues, see Tol, Fankhauser, and Pearce 1999). In aggregate, there is a huge North-South asymmetry between the principal emitters and the most severely affected potential victims: it is the rich countries whose mitigation expenditures would be most affected by changes in estimated global damages, not the poor. Hence the case for using national VOSL (or other willingness-to-pay based measures) is unclear. A logical link can be maintained only by appeal to the argument that abatement expenditure in rich countries would displace foreign assistance for adaptation or other aid (an indirect opportunity cost argument). But there is no evidence that mitigation expenditure does or would displace foreign aid. Moreover, foreign adaptation assistance is

likely to be a highly imperfect substitute for reduced climate variability (because of institutional constraints and the dynamic uncertainties documented below).

Equity weightings introduce a multiplier for VOSL or other willingness-to-pay-based impact measures in poorer countries to increase their weighting in global economic aggregation indices (Tol, Fankhauser, and Pearce 1999; Groom and Koundouri 2005) in an attempt to correct for the apparent inequities arising from such approaches. The basis and derivation for such weights is unclear, however, revealing some complex ethical issues underpinning global aggregation of damages that have yet to be resolved. Simply taking a purely egalitarian approach (for example, assuming a constant VOSL across humanity at the level of rich countries) vastly increases estimates of climate change impacts, but it, too, is riddled with inconsistencies.

Transitional impacts and adaptive capacity. The literature on the dynamic and “socially contingent” aspects of impacts is extremely limited. A few points are clear, however.

Aggregating over space and time based on static comparisons may mask the bulk of social costs, which may be those associated with transitions and extremes: adaptation to a changed climate, predicted *ex ante*, may be very different from adaptation to a changing climate, with attendant changes in the distribution and scale of extremes. Both theory and recent experiences (such as Asia and New Orleans) suggest that what matters is the joint effect of climate with socioeconomic factors. Consequently, the scale of losses may be sensitive to the preexisting conditions of the economy on which climate change impacts may fall.

Hallegatte, Hourcade, and Dumas (2007) argue that impacts may be exacerbated by constraints on (a) reconstruction capabilities; (b) cost-sharing mechanisms, including insurance and international assistance; (c) local obstacles, including rigid agricultural practices; (d) knock-on economic impacts arising from depreciation of land- and weather-related capital stocks (through real estate and property ownership); and (e) ecological constraints. Drawing in part on the wider development literature on the economics of natural disasters (Benson and Clay 2004), Hallegatte, Hourcade, and Dumas (2007) present a model in which poor societies are unable to recover from one extreme climate event before the next disaster strikes, leaving such countries trapped in a cycle of underdevelopment.

Mechanisms for adaptation, compensation, and cost-sharing are inevitably weaker at the international level, though they are slowly developing (Gurenko 2006). This may increase the probability that adverse effects propagate across regions (including through migration), blurring any distinction between “winners” and “losers.”

Uncertainty and the limits to adaptation. Adaptive capacity needs to be strengthened significantly. This is unquestionably true but incomplete, not least because of the uncertain nature of impacts (particularly extremes) combined with the demonstrated incapacity of societies to prepare adequately on the basis of risk warnings. The main impact of climate change may arise from the interplay between climate uncertainty and the constraints and sources of inertia in social and economic systems. The dilemma is neatly illustrated by the juxtaposition of two papers that appeared in *Climate*

Policy. The first, Olsen (2006), is an agricultural model of the capacity of optimal adaptation to yield net benefits in Mali. The second, Butt, McCarl, and Kergna (2006), is a political economy study of the fact that a decade of international assistance efforts have made little headway in influencing practical policy in Uganda.

Three important factors constrain the capacity for preparatory adaptation: (a) uncertainty in regional climate predictions, probably an order of magnitude greater than that in global average predictions; (b) the masking effect of natural climate variability, which means that climate change signals may be undetected, ignored, or misinterpreted; and (c) the capital-intensive nature and inertia of adaptation strategies. Together these factors create a significant risk of maladaptation.

The first lesson that emerges from comparing optimal control models is that costs and responses can be very different under perfect foresight and decision making than under high uncertainty. Unfortunately, clairvoyant farmers—and perfect planners—are not a feature of the real world.

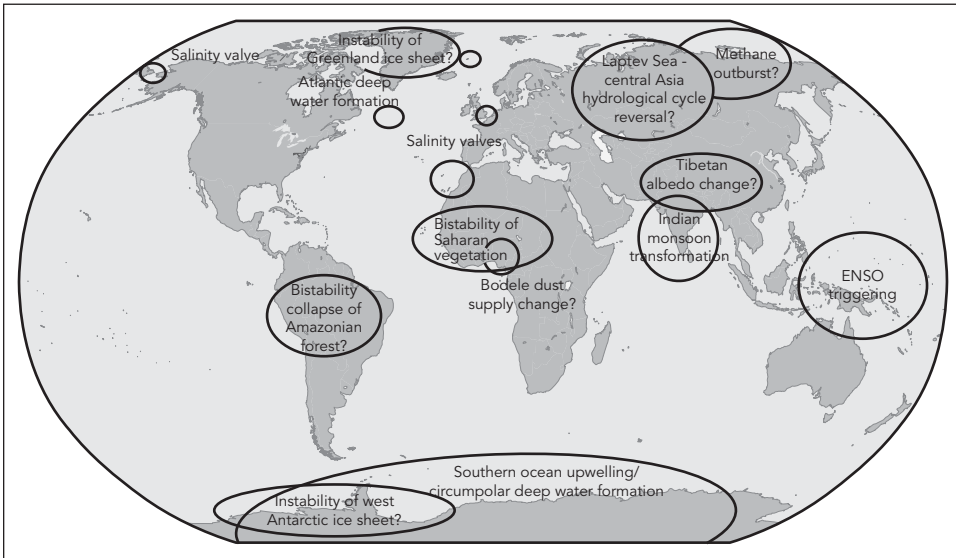
Risks, feedbacks, and surprises. These difficulties are amplified by the remaining elements in the risk matrix—namely, larger-scale risks and surprises in the climatic system, particularly when combined with inertia. Scientists studying the interaction between different components of the climate system and related natural systems express concern about various possible instabilities. The North Atlantic Ocean circulation is the best known but by no means the only example. The Hadley Centre in the United Kingdom projects that climate changes over Amazonia will lead to loss of the rainforest during this century. Other very long-term possibilities include the melting or collapse of the Greenland and West Antarctic Ice sheets (figure 3). The scale of threats posed by structural disruption is extremely difficult to evaluate but clearly should not be ignored in any quantification that claims to be comprehensive.

Feedbacks also concern scientists. Drying of the Amazonian rainforest system would feed more carbon back into the atmosphere. Thawing permafrost in the far north is likely to release pent-up methane (a potent greenhouse gas). Far larger amounts of methane are currently locked on the sea bed and could ultimately be released, though only over much longer time periods (centuries or millennia, if as expected warming penetrates the ocean floors).

There are inherent uncertainties about such systems; the dynamics that keep them stable, and their limits, are not well understood. When it comes to such big questions about complex systems, uncertainty is endemic. But especially given the inertia in all these systems—including the inertia in economic systems discussed below—by the time limits are fully understood, they may be unavoidable. Several of the examples noted above—systemic changes in monsoon patterns, desertification of the Amazon, and slowdown of the thermohaline circulation—may be clearly identifiable only through observational data. But by the time changes can be observed in the data with sufficient statistical certainty to understand and project much further, it may be too late to prevent such transitions.

The very long term. A fundamental characteristic of the climate problem is the inertia involved. Atmospheric greenhouse gas concentrations will not stabilize until

FIGURE 3
Potentially Sensitive “Switch-Point” Areas in Which Local Effects May Trigger Large-Scale Changes



Source: Schellnhuber and Held 2002.

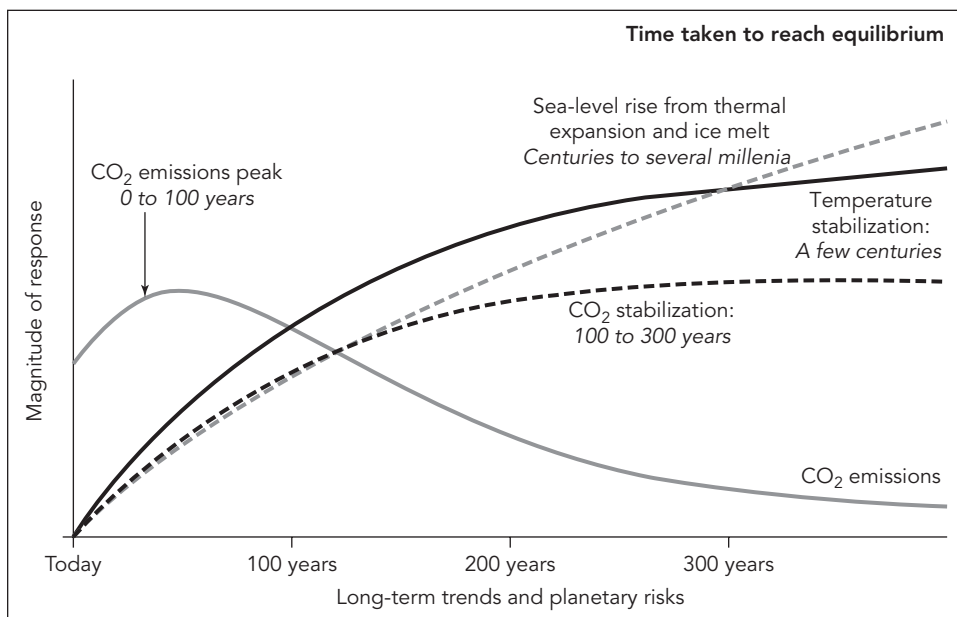
ENSO = El Niño-Southern oscillation.

global greenhouse gas emissions are reduced to a small fraction of today's levels, which few expect before the end of the century. Even after the atmosphere stabilizes, other effects will continue to accumulate. Global temperatures will continue to rise for decades, as the oceans slowly adjust to the higher heat input. Sea levels will rise, as a result of both thermal expansion and ice melt—effects that will cumulate over hundreds (thermal expansion) to thousands (ice melt) of years. Over centuries, sea levels will rise many meters if and as the Greenland or West Antarctic ice sheets disintegrate (figure 4). Although these problems seem far away, there are economic reasons, discussed below, why choices over the next few decades will affect emissions and concentrations for decades beyond that and thus do much to determine the degree of commitment to a range of temperature, sea level, and other kinds of risks and instabilities noted below.

Conclusions on Climate Impacts, Evaluation, and Adaptation

The survey of issues of climate impacts, and the six specific challenges facing attempts to quantify impacts in economic terms, are sobering. Uncertainty is nothing new to economics, and several economists (such as Tol 2003) have defended the broad cost-benefit approach while acknowledging the wide-ranging uncertainties. The specific concerns and debates are crucial to understand the limitations and likely implications of climate change.

FIGURE 4
Cumulative Impacts of Climate Change over the Long Term, 2000–2300



Source: IPCC 2001a.

Quantitative Evaluation of Impacts

Even the simple projections of smooth change raise profound issues about evaluation and aggregation over space and time. In addition, the full risk matrix requires some consideration of dynamic and “socially contingent” issues that depend upon the actual capacity of societies to prepare for and tackle climate-related changes. Societal constraints may affect the welfare consequences of impacts (or limit adaptation) in ways beyond the evaluation of direct market and nonmarket measures currently employed. In addition, risks may arise from regionally variable (nontrend) changes within the broad envelope of projected climate variation including extreme events (“bounded risks”), and larger-scale system surprises.

There is no a priori ground for believing that these elements are insignificant compared with those economists have sought to quantify. This drives the conclusions of Downing and others (2005) that the social cost of carbon—the present value of damages associated with a tonne of carbon emissions—is characterized by huge uncertainties. They suggest that values could span a range from 1 to 1,000£/tC, though they argue that the very low values in this range are unlikely.

The most recent and comprehensive effort, conducted in the Stern report (Stern 2007), emphasizes the need for analysis that is explicitly stochastic, reflecting the wide range of scientific possibilities of both less and more damaging climate sensitivities and damage functions. It also argues for discount rates that reflect the fundamental principles of consequentialist ethics—and that correspondingly are endogenized to be consistent in the face of impacts that could challenge the underlying assumption that future generations will be better off.

Putting these two fundamental pillars together in a quantitative analysis leads the Stern report to close the apparent gulf between the scientific/precautionary approach and the cost-benefit approach. The report's analysis concludes that climate change is indeed a problem of huge import and a fundamental threat to human development that requires urgent action. Stern's application of "balance-growth equivalent" methodology estimates the equivalent cost of climate change, left unchecked, to be potentially a double-digit percentage of gross world product.

The economics of impacts cannot provide a strictly objective answer to the problem of climate change, let alone one that is accepted as such by the most relevant parties. In the absence of this, the only ethically defensible approach to developing global responses has to be based on negotiations that seek to represent both emitters and victims. This is problematic, however, because many of the victims have not yet been born.

Limits to Adaptation

Early efforts to cost climate impacts were criticized on the grounds that they assumed little or no adaptation ("dumb farmers"). Since a substantial degree of climate change is already unavoidable, there is no question that far greater efforts are needed to help societies adapt to its likely impacts and that doing so has the potential to lower the cost of such impacts. But assuming that adaptation can radically reduce the costs of impacts is questionable, not least because of the fundamental nature of the uncertainties at the microlevel, where adaptation is actually relevant but uncertainties are greatest. In economic terms, it is by no means clear that replacing assumptions of "dumb farmers" (no adaptation) with assumptions of "clairvoyant farmers" (perfect adaptation) is more realistic.

The risks associated with uncertainties and irreversibilities are considerable and constrain the ability of adaptive measures to prevent adverse impacts. Moreover, climate change is not a discrete phenomenon with an identifiable end point to which the world needs to adapt. To the contrary, the projected growth of global emissions means simply that it will be an ongoing and accelerating process of continual climatic change, without any identifiable prospect of stability, and growing risk of planetary-scale disruption. From all these perspectives, adaptation is likely to contain adverse impacts only if combined with serious moves toward slowing atmospheric change and ultimately stabilizing concentrations.

Climatic Stability as an Intrinsic Good

Hallegatte, Hourcade, and Dumas (2007) argue that from an economic standpoint, climate stability is a component in utility functions that should be explicitly represented; given loss aversion (one of the most stable findings in behavioral economics), there is an intrinsic value to avoiding an unstable climate. In economic terms, a stable climate thus has characteristics of an intrinsic good. Moreover, although it is poorer societies that may suffer most from an unstable climate, the decreasing marginal utility of income means that high-income populations and generations should be more willing to spend resources on climate protection. Climate stability is thus a "superior good," which may influence some policy insights, including those relating

to the cost-effective distribution of mitigation investments. This economic perspective reflects a more pragmatic view, which is becoming more widespread, that stabilizing the atmosphere by reducing emissions should be considered as one of the intrinsic goals of global development.

Emissions and Development: An Empirical Overview

Despite the emerging efforts to tackle the problem, global CO₂ emissions are widely projected to grow. If industrial countries fail to limit their emissions and energy-intensive and fossil fuel-driven energy systems remain a foundation of economic growth, it is hard to see rapid emissions growth in the rest of world being much curtailed, as other countries aspire to the same levels of economic development. Yet the link between wealth and emissions is weaker than generally supposed.

The literature on responding to climate change has frequently been characterized by inadequate attention to the factual base of the issue. Economic discourses based on supply and demand curves may assume away issues of deep-seated market imperfections, inertia, and equity. Political stances often ignore the fundamentally global nature of the problem. Both may ignore the scope for endogenous change in economic and technological systems.

Four Facts about Emissions and Growth

This section sets out four facts about the relation between global economic growth and increases in emissions. The following section then outlines four opportunities that arise in the context of considering lower-emitting development paths, as an empirical basis for the subsequent discussion of macroeconomics and policy responses.

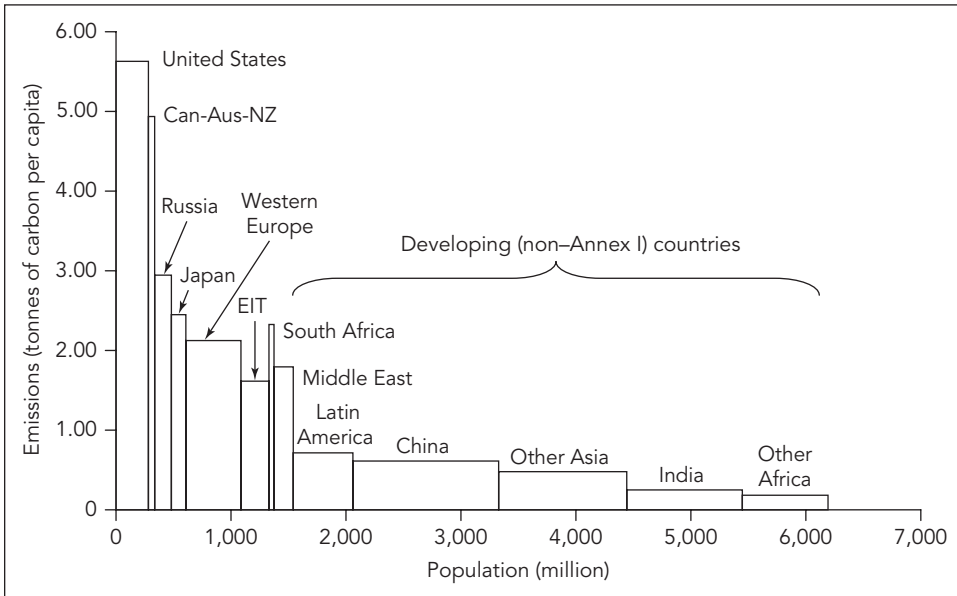
Large Disparities in Emissions Combined with Population and Economic Growth Create Enormous Potential for Global Increases in Emissions if Countries Pursue Existing Models of Development

Per capita emissions in the industrial countries are typically as much as 10 times the average in the more populous developing countries, particularly those in Africa and the Indian subcontinent (figure 5). The potential for global emissions growth is thus huge, even if leading countries start to embark on more serious efforts to reduce emissions.

Recent debates have tended to lower populations projections for this century, in view of sharply declining birth rates. Most, however, still project that global population will expand by about 50 percent during the 21st century.⁴

Recent debates about the relation between CO₂ and GDP, projections focused on metrics of measurement,⁵ and expectations of economic convergence versus a continued bimodal distribution of world per capita income levels (for example, Jones 1997; Quah 1993, 1996; Barro and Sala-i-Martin 1997; Riahi 2005). However, none of these factors change the big picture: almost all scenarios involve considerable

FIGURE 5
Population and per Capita CO₂ Emissions, by Region, 2000



Source: Grubb 2004b.

Note: Area of block represents annual emissions.

EIT: Economies in transition.

economic growth in developing countries that, in the absence of counteracting policies, will raise their per capita emission levels closer to those of the industrial world.

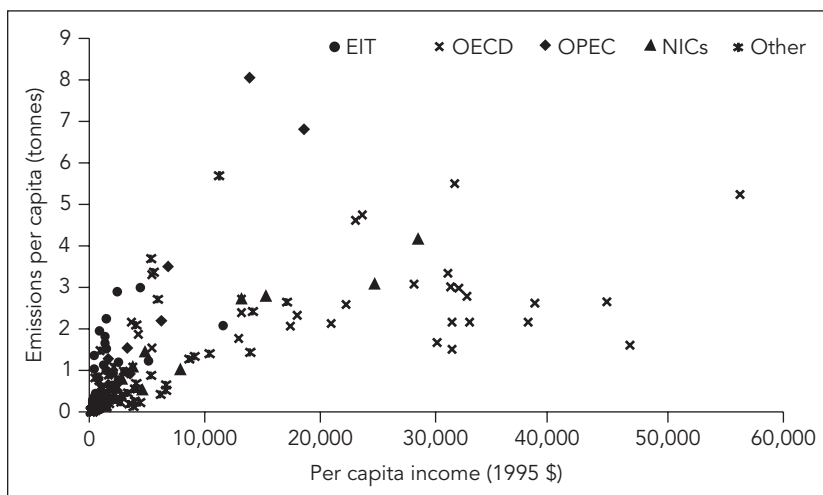
Mainly as a result of these two forces, the vast majority of nonintervention scenarios in the peer-reviewed literature (as reviewed for the IPCC Fourth Assessment) result in global CO₂ emissions almost doubling by about midcentury and reaching two to four times current levels by 2100. These projections take the world far beyond the “doubled CO₂ concentrations” scenarios that were the traditional focus of climate change modeling.

Beyond the Stage of Basic Industrialization, There Are Large Differences in Per Capita Emissions and Huge Variability in the Relation between CO₂ and GDP

Currently, no country with income above about \$10,000 per capita emits less than about 1.5 tonnes carbon per capita (tC/cap) (figure 6). This reflects the emissions inherent in building basic industrial and urban infrastructures—a fact that implies considerable growth in developing-country emissions.

There are wide variations among the richer countries. Per capita CO₂ emissions in the “new world” developed economies (North America, Australasia) (of 5–6 tC/cap) tend to be about twice the levels typical in “old world” economies (Europe, Japan, the Russian Federation). Looked at more closely, the differences are even more extensive. This diversity provides a modest source of hope, even based on current patterns,

FIGURE 6
CO₂ Emissions per Capita, by Country Type



Source: Data are from World Resources Institute 2003.

Note: EIT = economies in transition; OECD = Organisation for Economic Co-operation and Development; OPEC = Organization of the Petroleum Exporting Countries; NICs = newly industrialized countries.

because it implies a large degree of freedom over long-run emissions even in the absence of radical technological breakthroughs or major lifestyle changes.⁶ A world in which most countries emit 1.5–2.5 tC/cap by the end of the century clearly has far lower climate risks than one in which they emit three times those levels.

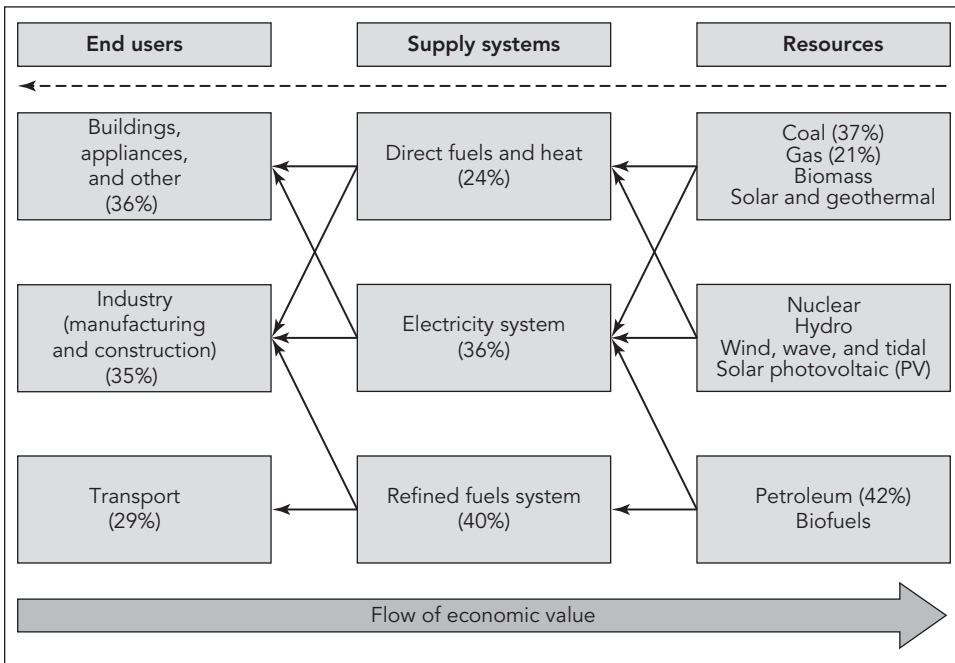
The difference between these levels is not primarily a function of wealth. Rather, it depends on technology and infrastructure choices that affect the development, scale, and efficiency of buildings, industrial and transport systems, and supply systems (particularly electricity).

Emissions Arise from a Wide Diversity of Activities, but Many of Them Offer a Wide Array of Technology Options That Affect the Level of Emissions

The climate problem requires the world to reduce a number of different gases and sources of emissions in addition to fossil fuels; greenhouse gases emanate not only from fossil fuels but also from agriculture, land use, and direct industrial-process emissions. For some developing countries, nonenergy sources (particularly deforestation and other land-use activities) dominate, and the desirability of addressing them is widely recognized. But the relative role of energy-related emissions tends to grow with development.

Even fossil fuel-related emissions result from several different systems, each of which involves fundamentally different processes. These processes are driven by energy demand in three main components (buildings, industry, and transport), supplied increasingly through three main systems (electricity, refined fuels, and direct fuel delivery) (figure 7).

FIGURE 7
Main Components of Global Energy System and CO₂ Emissions



Source: Figures on resources are from EIA 2002; figures on supply systems and end-use are from IEA 2002a.

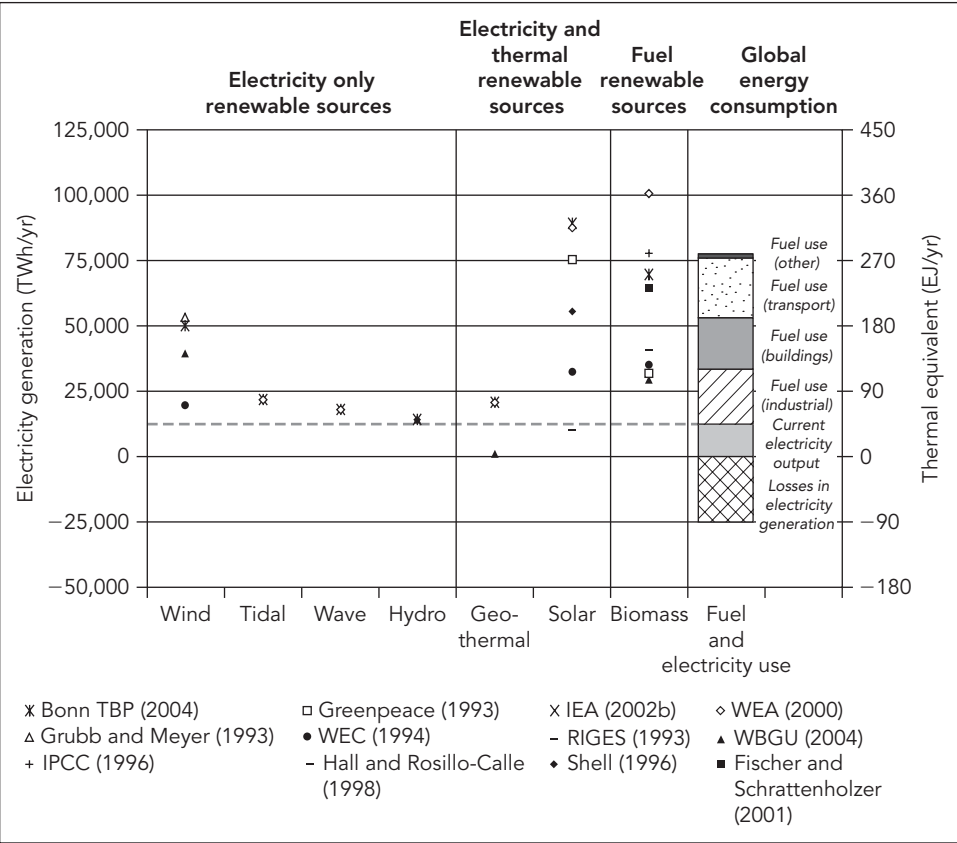
Note: The data show the percentage of global energy-related CO₂ emissions associated with the different parts of the energy system. Some small flows that account for less than 1 percent of global energy flows (for example, electricity and natural gas contributions to transport) are not shown.

Patterns of emission across regions (emission from industry, for example, are lower and transport higher in developed economies). Different sectors are also growing at different rates.

In most cases, the options for different technologies and systems are extensive. Buildings differ radically in the efficiency with which they consume energy. Urban planners are regularly faced with choices between road and rail investments. Electrical power is generated from a wide array of technologies.⁷

Even in terms of energy resources, most options, including renewable energy sources, are not seriously limited. Although constraints limit what is feasible, the estimated global potential for tidal, wave, and hydropower are comparable to the scale of global electricity consumption, while most estimates of practicable wind and solar resources are substantially greater still (figure 8). As with natural gas, key issues for delivery include the systems and the fact that (with the exceptions of direct solar heating and lighting and geothermal heating) all but one (biomass) produce primary electricity. Constraints concern the economics of matching sources and systems to demands. It is often said that countries will not leave their domestic energy resources (such as coal) in the ground. There is no fundamental reason why the same logic should not apply to the renewable energy resources that sweep most countries: the options developed are a matter of cost, technological capacity, and political choices.

FIGURE 8
Estimates of Global Renewable Energy Potential



Source: Neuhoﬀ 2005.

Note: TWh = TeraWatt hours; EJ = Exajoule; IEA = International Panel on Climate Change; RIGES = renewables-intensive global energy scenario; TBP = thematic background papers; WBGU = Wissenschaftliche Beirat der Bundesregierung Globale Umweltveränderungen (German Advisory Council on Global Change; WEA = World Energy Assessment; WEC = World Energy Council.

The Most Important Determinants of Future Emissions Will Be the Combination of the Patterns Set by Industrial Countries and the Capacity of Developing Countries to Leapfrog to Higher-Income but Lower-Emitting Patterns of Development

Development economics has increasingly emphasized the scope of development choices and their dependence on institutional capacity in developing countries (Meier 2001). The same is likely to be true about emissions. Since one impact of weak institutions is that economies operate farther from the efficiency frontier, it cannot a priori be concluded that stronger institutions and resulting higher economic growth will result in higher emissions. Greater dependence on fossil fuels is not intrinsically good for development, and it carries numerous attendant problems, ranging from other environmental impacts to exposure to international fossil fuel

price variability. Institutional capacity to accelerate efficiency improvements and foster lower fossil fuel paths could put countries on pathways that create lower emissions and are better for development.⁸

The concept of developing countries leapfrogging to more advanced conditions is not new, but it tends to have been confined to academic discussion far from the realities of the ongoing struggle for economic development. Leapfrogging does not represent a simplistic view of what could in theory be done, and it can no longer be relegated to the margins of the debate. It is a necessity that represents a set of specific opportunities described in the next section.

Four Opportunities

Moving development to a more environmentally sustainable path can create four types of opportunities.

Opportunities for Enhancing Energy and Economic Efficiency

There is a long-standing literature on the apparently favorable economics of improving energy efficiency (see, for example, IPCC 2007d). Global studies date back to Goldemberg (1988). Even in developed countries that made large strides during the 1980s and 1990s, considerable cost-effective potential remains.⁹ Numerous World Bank studies have highlighted that the potential in developing countries tends to be even greater than in industrial countries.

Many factors explain the wastage; the literature on barriers to energy efficiency is enormous. One factor is the continuing degree of energy sector subsidies, which are generally recognized to be macroeconomically detrimental.¹⁰

Reforming subsidies, or introducing stronger regulatory measures for energy efficiency, is not easy. In such conditions, it is not uncommon that additional issues can offer leverage to achieve reforms that would anyway be desirable. It is perfectly possible that climate change could help play such a role—blaming the medicine on the need to tackle emissions may be one factor in making it easier to swallow.

Cobenefits

Removal of fossil fuel subsidies and stronger measures for energy efficiency may improve the internal efficiency of the energy sector. They may also yield wider “cobenefits” in the forestry, energy, and transport sectors. Energy is a source of multiple emissions. Higher energy consumption also means greater exposure to the impacts of price volatility in international fuel markets. Studies suggest that such cobenefits could justify a significant degree of measures that also reduce CO₂ emissions (see chapters 11 and 12 of IPCC 2007).

Leapfrogging in Infrastructure

The most important single consideration in tackling emissions growth in developing countries is altering investments in new capital stock. Most of the sectors shown in figure 7 are characterized by inertia. Industrial equipment that consumes, generates, or processes energy has a lifetime that is measured in decades. The buildings that consume

energy, the road and rail systems that determine transport demands, and the pipeline and port infrastructures required for direct fuel delivery can set infrastructure patterns for a century or more.

Much has been learned since rich countries started locking themselves into higher-emitting patterns of infrastructure. The wasteful nature of the United Kingdom's building stock remains one of greatest headaches for the government's energy policy. North America's exceptional energy intensity, and resulting dependence on oil imports, is to an important degree driven by choices in the transport sector made in the first half of the 20th century. Inefficient industrial equipment installed during those decades is often still operating, with continual cycles of refurbishment that rarely bring performance up to the standard of new plants (Alic, Mowery, and Rubin 2003). Leapfrogging in infrastructure—making choices at the leading edge for the long term—represents a huge opportunity.

Leapfrogging in Technology

Some major developing countries could move to the frontier of technological developments in domestic investment and in capturing a growing share of the global market for energy-efficient and low-CO₂ technologies. Brazil's dominance in biofuel technology is now reaping large rewards. Technological development based on the large investment needs in key areas is a real opportunity, with solar photovoltaic (PV) technology perhaps the biggest prize of all, because of the almost unlimited quantity of this resource in most developing countries.

Time is not on our side. In energy use and supply, emission patterns will be set by how the world chooses to invest tens of trillions of dollars over the next few decades, investments that will have irreversible impacts throughout the century. The uncertainties surrounding the growth of global emissions and the extent to which trends depend on choices about the deployment of capital are underlined by the International Energy Agency's *World Energy Outlook* (2004), which estimates that about \$16 trillion will be invested in energy supplies through 2030 (about \$10 trillion of this in the power sector), divided roughly equally between industrial and developing countries. In their "reference" scenario, most of the generation investments are in carbon-intensive stock; the "alternative" scenario involves more rapid growth in less carbon-intensive investments. Although this is more expensive per unit, the scenario actually requires less capital investment overall, because of the increased efficiency of end use (even when the end-use investments are included). The choice of path out to 2030 will have profound implications for the structure of capital stock and its carbon intensity well into the second half of this century and even beyond.¹¹

None of this should deflect attention from the need for industrial countries to set their emissions on a declining course. Indeed, as emphasized by a leading Chinese researcher (Zhou 2005), it will be much harder for developing countries to achieve progress if the world's industrial powerhouses do not simultaneously develop lower-carbon technologies, businesses, capacities, and institutional models. But a debate that ignores the crucial importance of emissions growth in developing countries is simply not a mature debate.

Moreover, ignoring the opportunities that are consistent with the need to reduce emissions would not be in the interests of developing countries themselves. The brake on embracing such opportunities appears to be partly political (the position in global negotiations that developing countries have no responsibility to act), partly institutional (the sheer difficulty of thinking long-term in the crush of development pressures), and partly motivated by fears of economic consequences.

Global Macroeconomic Dimensions of Atmospheric Stabilization

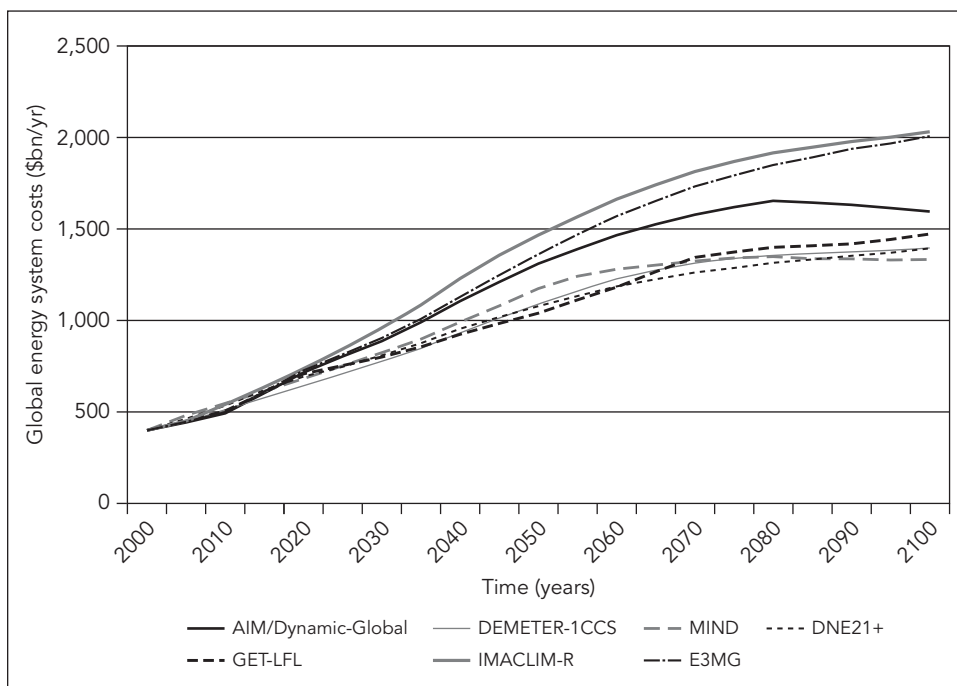
Achieving the scale of change required to stabilize concentrations will require strong policy measures. Most models represent “policy” in terms of the carbon price required to drive factor substitution toward low-carbon options, coupled with price elasticities to derive the impacts of higher prices on energy demand.

Costs of Stabilization

A recent set of modeling studies, the Innovation Modeling Comparison Project (IMCP), considers how such incentives may trigger technical change through various mechanisms (Edenhofer and others 2006). As chair of the IMCP, the author had access to the source data for the 10 diverse models involved in the study.¹² These models form the main basis for this subsection.

The carbon prices required to achieve stabilization span a wide range, both in absolute terms and in the time profile. For stabilization at 450 parts per million of CO₂ (450 ppm CO₂), in most of the IMCP models, carbon prices rise to about \$100/tC (c. \$27/t CO₂) plus or minus 50 percent by 2030. By 2050 carbon prices are in the range \$50–\$250/tC. After that, they diverge enormously, with some soaring, as allowable emissions shrink to low levels, and others rising more modestly. One model echoes the results of some simpler studies (for example, Anderson and Cavendish 2001) based on learning curves that suggest that carbon prices may peak around midcentury and then decline, as new low-carbon technology systems come to dominate. Some other models, which do not intrinsically include innovation responses to economic incentives, predict significantly higher carbon prices and GDP impacts (for comprehensive review, see IPCC 2007d).

Rising carbon prices increase the costs of energy systems. Figure 9 shows the impact on energy system costs in seven of the participating models.¹³ In the baseline case, with no CO₂ constraints, the cost of the global energy system rises from \$400 billion a year to about \$1 trillion a year by midcentury. Models estimating the costs of stabilization at 450 ppm fall into two main groups: models that predict that this rise increases energy sector costs by midcentury by 50–100 percent and those that predict close to a tripling of energy system costs by midcentury. Interestingly, most models suggest that costs do not rise much beyond this during the second half of the century, with some showing a slight reversal, presumably because the ongoing decarbonization of the system means the carbon price (the marginal incentive) has a declining impact on actual energy sector costs.

FIGURE 9**Baseline Projections of Undiscounted Global Energy System Costs for Stabilization at 450 ppm CO₂**

Source: Author.

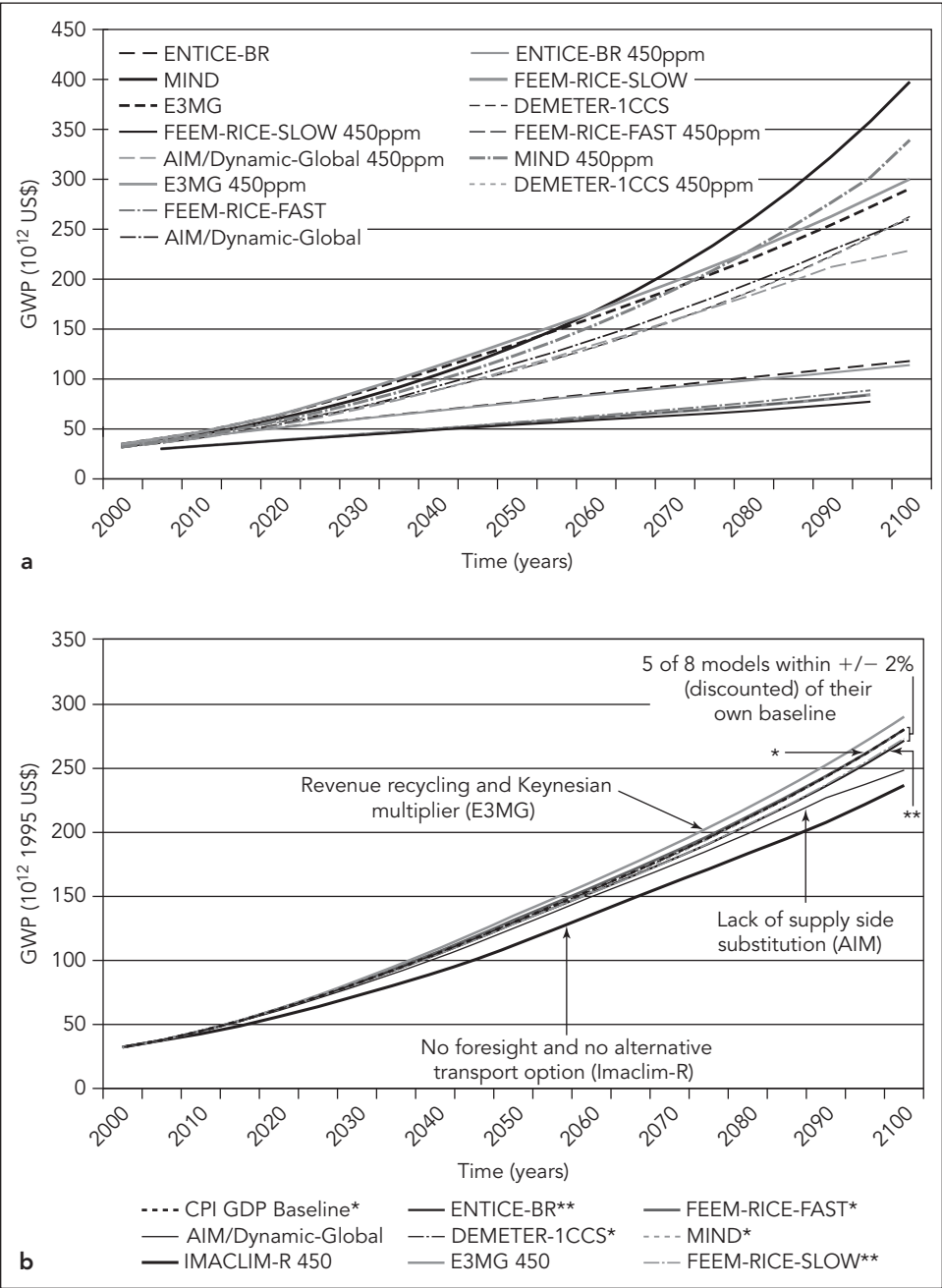
Note: The models participating in the IMCP are described in Edenhofer and others (2006) and detailed in the individual papers of the special issue of the *Energy Journal* devoted to endogenous technological change. The models span a range of economic methodologies and originate from various research centers in Europe, Japan, and the United States.

How do these costs affect the global economy? Figure 10a shows gross world product (or an equivalent proxy for global GDP) under the baseline projection and the (relative) impact on this measure of 450 ppm stabilization for each model in the IMCP.¹⁴ Figure 10b shows the equivalent data normalized to an “average” baseline, which makes it easier to see relative impacts, together with principal reasons for the outliers.

There are intrinsic uncertainties around such modeling. In particular, the incorporation of endogenous technological change is fraught with complexity and hard to parametrize.¹⁵ Data thus need to be treated with caution. Several conclusions nevertheless flow from such analyses:

- The uncertainties in baseline projections of GDP swamp the uncertainties surrounding the cost of atmospheric stabilization itself. In other words, good policy making that creates a strong macroeconomic framework is a far more important determinant of future welfare than the costs associated with stabilizing the atmosphere; to the extent that good macroeconomic management may go hand in hand with good environmental management, the two do not conflict.

FIGURE 10
Projected Impact on Gross World Product of CO₂ Stabilization at 450 Parts per Million



(a) Absolute projections of different models
(b) Economic impact of stabilization relative to a normalized baseline with indication of "outliers"

Source: Author.

Note: The models participating in the IMCP are described in Edenhofer and others (2006) and detailed in the individual papers of the special issue of the *Energy Journal* devoted to endogenous technological change. The models span a range of economic methodologies and originate from various research centers in Europe, Japan, and the United States.

- In most studies the costs of stabilization, even at low levels like 450 ppm CO₂, appear to be less than a year's forgone economic growth when the global response is optimized and a range of options is included. A closer examination of time profiles in the IMCP (Grubb, Carraro, and Schellnhuber 2006) suggests that this conclusion is robust at least out to 2050 for all but one of the models, after which there is greater divergence across model estimates of forgone GDP, as the constraints bite even deeper and become more dependent on assumed technical progress.
- Some frameworks and assumptions generate outliers. Two models illustrate factors that could lead to a larger decline in GDP. One focuses on the investment in energy-saving capital as a mitigation option but does not include endogenous change in supply technologies, making it much harder to decouple economic growth from emissions. The other assumes there are no low-carbon options for the transport sector and that investment in infrastructure continues without foresight—actors simply react to the carbon prices they see. The result in this high-cost model is that the world gets trapped by inappropriate investment in high-carbon infrastructure during the first few decades of this century, making it very hard to then cut emissions back.
- In sharp contrast, two other studies suggest that reducing CO₂ emissions could boost GDP. In one study the negative costs originate from the Keynesian treatment of demand-side long-term growth. Because of increasing returns to production and employment, the recycling of carbon-tax revenues has the potential to boost output partly by reducing the cost of labor and hence boosting employment in developing countries. In the other model, accelerated development and diffusion of new technologies induced by climate policy have the potential to boost growth. This model captures the fact that the world underinvests in R&D; in certain parametrizations the innovation needed to stabilize the atmosphere brings the world economy closer to an optimum level of innovation investment.¹⁶

The essential dynamic in all the optimizing models is that in both energy sector and endogenous-growth models, the early decades are characterized by a switch in investment patterns. The associated GDP impacts are initially small, for a number of reasons. First, mitigation policies initially target low-cost, low-hanging fruit at low carbon prices, changing the trajectory of emissions without high costs. Second, the “learning investments” are in emerging low-carbon sectors; because these sectors are initially relatively small, the scale of learning investment is also limited. Finally, in the growth models, additional investment can boost GDP. In most—but not all—of the models, these factors are ultimately overtaken by the sustained increased costs of the energy system, but to widely varying degrees that depend largely on the degree of endogenous technological response. These dynamic mechanisms are not available in the highest-cost models, in which the costs are amplified by the inadequate foresight and lack of option-building.

This analysis leads to three key conclusions:

- The cost of tackling CO₂ emissions and moving a long way toward atmospheric stabilization can be contained to manageable levels that need not significantly impede economic development.

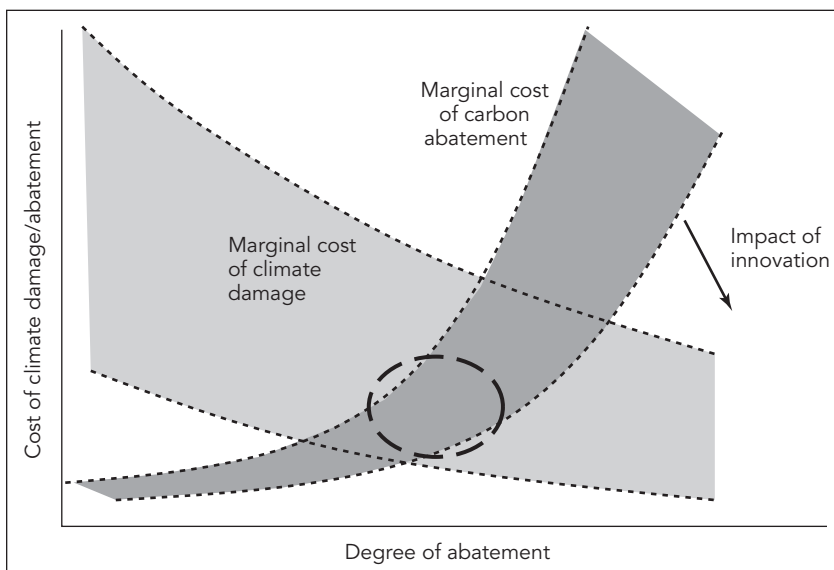
- Strong measures may be needed to drive the wholesale structural changes implied, with an appropriate mix of policies with timely and widespread participation. Inadequate action, too late or too narrowly spread, may significantly raise the costs.
- Along with the costs, there are opportunities associated with aligning macroeconomic development with lower emission pathways.

Implications for Goals in Tackling Climate Change

What are the implications of the huge uncertainties in quantifications of climate damages, set alongside such analyses of mitigation costs? The uncertainties seem to suggest that an optimum level cannot be set and emphasize the need for a sequential decision-making process. Yet there is a clear case for strong action now. Studies of global mitigation costs imply that mitigation has the potential to yield deep reductions, at costs much lower than that associated with leaving the problem unchecked, and that waiting will magnify costs on all fronts. In the context of infrastructural investment, there is a need to develop a sense of long-term goals.

The classic treatment of uncertainty (Weitzman 1974) suggests that in a context of high uncertainty about damage costs, the main policy instrument should be prices. This does not entirely address the challenge, however, which must include a sense of how much carbon-intensive infrastructure can be accommodated and the longer-term stabilization goals that might be appropriate. Figure 11 suggests that in a situation of high damage uncertainty, the other factor to consider is the point at which the costs of mitigation rise steeply. It illustrates the cost-benefit trade-off in the face of uncertainty and convexity. The cost of climate damage declines as the degree of abatement

FIGURE 11
Plausible Abatement Marginal Cost and Benefit Schedules



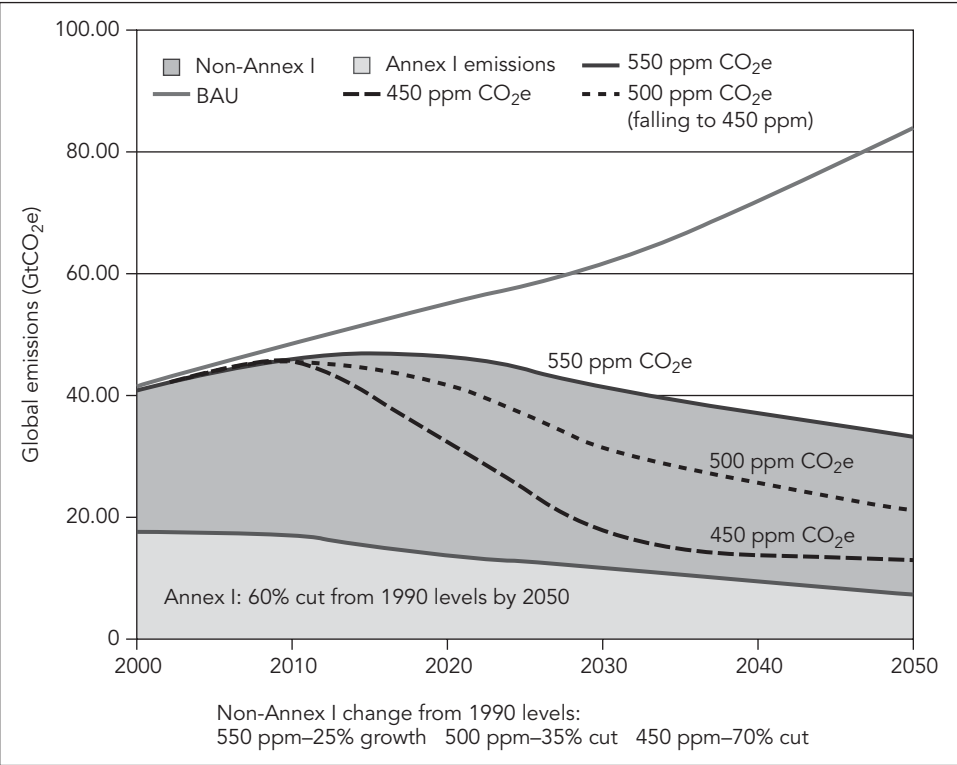
Source: Grubb and Newbery forthcoming.

increases, but it is highly uncertain. The cost of abatement may be modest for small cuts, but both the cost and the uncertainty rise steeply for much more aggressive cut-backs. The dotted circle in figure 11 indicates that a rational trade-off would be to pursue abatement to a level just before these costs start to rise sharply, while using innovation policies to generate new options to bring down the cost of deeper emission cuts.

Almost all of the IMCP studies suggest that the costs of moving toward stabilization, for levels as low as 450 ppm CO₂, are modest (less than 1 percent GDP) up to about midcentury. These trajectories are accompanied by global CO₂ reductions to well below today's levels. This appears to be a reasonable planning target in considering infrastructure investment. It implies the need for radical change.

Figure 12 underlines this need by indicating separately for industrial countries (as listed in Annex I to the UNFCCC) and developing countries the trajectories associated with the Stern review's recommended range of 450–550 ppm CO₂e.¹⁷ The figure indicates the developing-country trajectories if the industrial countries cut back by 60 percent below current levels by 2050; the Stern review also illustrates what

FIGURE 12
Projected Emissions Reductions in Developed and Developing Countries, 2000–50



Source: Stern 2007.

Note: Projections assume that developed countries take responsibility for cuts equal to 60 percent of their 1990 emissions by 2050. BAU: Business as usual.

happens if industrial countries cutback by 90 percent. Doing so gives developing countries a little extra headroom, but not much, particularly under 500–550 ppm CO₂e stabilization. This is because even a 60 percent cutback by industrial countries means that developing countries dominate emissions by 2050; additional industrial country cutbacks make less and less difference to the global total. CO₂ emissions are a global problem; to meet even 550 ppm, they need to be reduced below current levels by midcentury. Doing so will require that all significant emitting countries reduce emissions, a daunting task.

Policy Instruments

A great deal of theory has been written about optimal responses to climate change. One of the great empirical lessons from development economics over the past half century is that theory needs to be carefully grounded in realities if it is to lead to useful policy advice. The principal emphasis in this section is thus on the empirical structure of the mitigation problem.

Types of Emitters

From a policy perspective, sources of greenhouse gas emissions can be divided into two structural types of entity:

- Type 1 (large unitary) entities are principally capital-intensive firms for which energy or carbon forms a significant part of their cost base. This is typical of power generation and energy-intensive industries; it is also often applicable to forestry, where carbon costs could make a significant impact on the economics of the industry.
- Type 2 (small distributed entities) are individuals driving or occupying their homes, small businesses, and farmers, for whom energy and carbon costs represent a small fraction of their expenditure; innumerable other factors bear on their behavior.

Energy accounts for about two-thirds of global greenhouse gas emissions. Power generation accounts for about a third of energy sector emissions; direct industrial use of energy for manufacturing processes accounts for about another 20 percent. With nonenergy emissions broadly divided between forestry and agriculture, this implies that each of the two fundamental types accounts for about half of global emissions.

The two types of entities differ in the likely significance of measures related to carbon prices, in the capacity of actors to analyze quantitatively consistent economic trade-offs, in typical time horizons, and in the significance of transaction costs and potential cobenefits of emissions' limitations (table 3). In all these respects, it can be expected that measures related directly to carbon pricing may be more effective in relation to large unitary actors. However, these actors also tend to be most exposed to international competition arising from price differentials.

Distinguishing between the two types of entities underlines that climate change is not a problem for which there is a “one size fits all” solution. About half of emitting

TABLE 3. Types of Emitting Entities for Policy Evaluation

	Type 1: Large centralized entities	Type 2: Small distributed entities
Typical sectors	Power generation, heavy industry and forestry	Transport, commercial, domestic, and agriculture
Direct significance of energy/ carbon prices in cost base	High	Low
Capacity of actors to evaluate options and trade-offs	High	Low
Typical investment horizon	Decades	A few years
Relative significance of transaction costs and behavioral characteristics	Low	High
Competitiveness exposure ^a	Medium to high	Low
Significance of cobenefits ^b	Low to medium	Medium to high

Source: Author.

a. Competitiveness exposure is complex and varied and depends on specific products, geography, and infrastructure. For example, power production will be not exposed at all for isolated production systems; extensive transmission interlinkages with neighboring power systems may make production in one region highly exposed.

b. Cobenefits may relate to local health (associated, for example, with domestic coal or biomass burning and vehicle emissions); congestion and energy security (transport); and various aspects of land use (for agriculture).

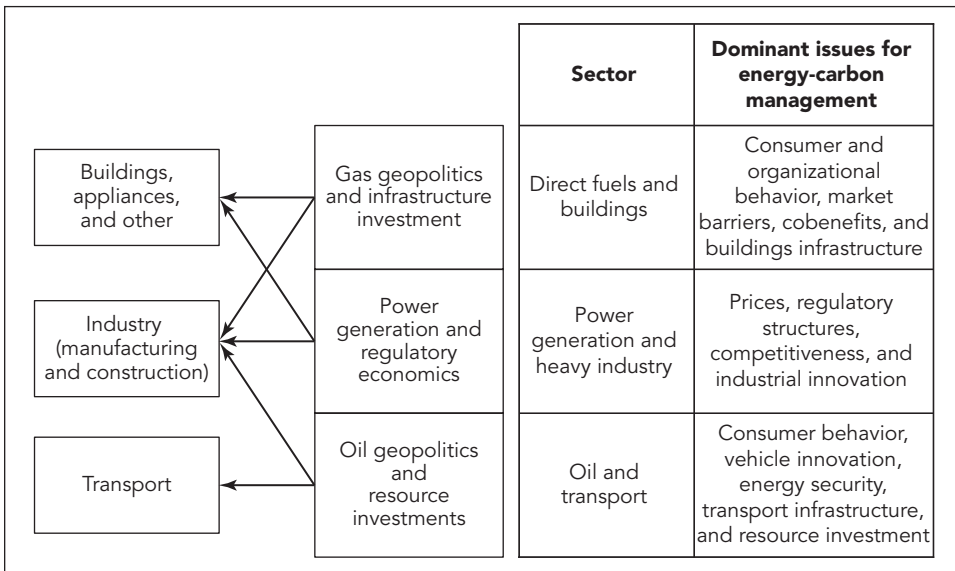
entities may be reasonably well behaved, in an economic sense, with a relatively high and rational responsiveness, for example, to price instruments. The other half may be much more problematic. For these diverse actors, encompassing almost the entire population, energy and carbon costs may be a trivial if irritating intrusion on their busy lives, and their capacity to manage them—or even to conceptually to link their behavior to energy costs or climate change—may be extremely limited.

Classifying Economic Processes and Policy Instrument in the Energy Sector

Three broad categories of economic processes are involved in moving to a low-carbon economy. The first is factor substitution—that is, the substitution of low-carbon for higher-carbon activities, for given supply and demand curves, as determined by relative prices. Most economic studies, particularly those involving modeling, focus almost exclusively on this dimension; these analyses lead to the conclusion that the price of carbon is the main policy instrument.

The long timescales and the numerous market failures associated with energy (considered further below) make two other broad categories important as well. The first is addressing market failures, barriers, and behavioral characteristics that lead to behavior that is, from a macroeconomic standpoint, nonoptimal for a given set of prices. The second is innovation and infrastructural changes that are concerned with changing the long-run production function of the economy—that is, the capacity to produce the same output for a given set of inputs and prices.

FIGURE 13
Key Characteristics of Principal Emitting Sectors



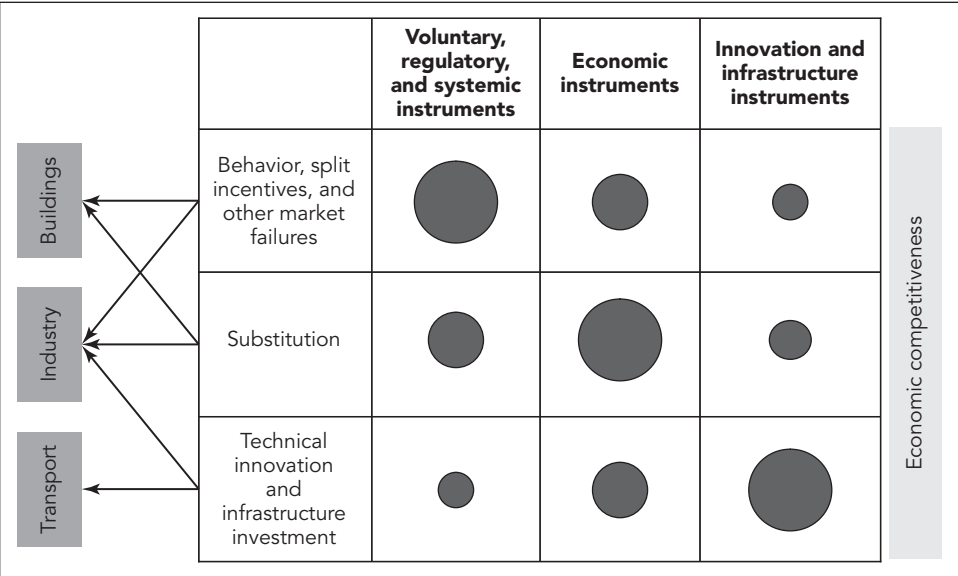
Source: Author.

Addressing these other two processes implies the need for additional kinds of instruments. Figure 13 maps the different economic components of emissions to their main structural characteristics' economic processes; figure 14 maps these classes of economic processes against policy instruments.

This framing places factor substitution and carbon pricing at the center of a more complex matrix of economic processes and policies. Each of the three broad categories of processes tends to be associated with different kinds of policy responses. Various kinds of market failure (other than the pure carbon externality) affect energy use, perhaps predominantly in the way that consumers use energy in buildings (which, including the embodied emissions attributable to power consumption, account for more than a third of fossil fuel emissions). These failures imply a need for active policies to promote energy efficiency that can take a wide range of forms, from product standards to negotiated agreements and many other more targeted interventions. Innovation and infrastructure represent two ways in which investments profoundly affect the long-run options and capacity to curtail CO₂ emissions, in ways that are unlikely to be adequately reflected purely through carbon price. Instruments for addressing these issues include standards, dedicated market supports, and direct government expenditure on R&D and infrastructure (such as public transport) that yield longer-term benefits.

Each class of instrument generally has some spillover effects on other economic processes (see figure 14). Price effects may also invoke behavioral changes over and above factor substitution. The literature on endogenous technological change is largely about the impact of price changes on innovation; spillovers from other policy instruments may be less important, but they exist.

FIGURE 14
Schematic Mapping of Economic Processes to Policy Instruments



Source: Author.

Note: The relative importance of interactions is indicated by the size of each circle.

Implications for Developing-Country Policies

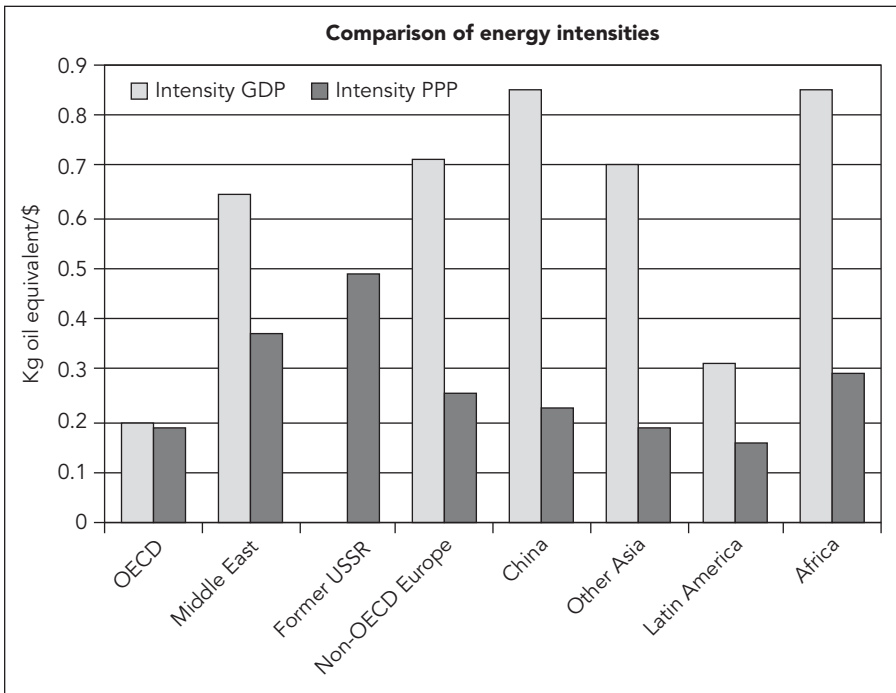
A detailed elaboration of policies is beyond the scope of this article; many publications, including the IPCC Mitigation Reports, World Bank studies, and analyses by the International Energy Agency, detail options and growing experience. This section has the more modest aim of examining some policy implications for developing countries.

Energy-Efficiency Measures

Improving energy efficiency is a global opportunity—but one with particular resonance for many developing countries. This is partly because of their greater relative exposure to the costs of energy imports but also because of the scale of opportunities. Measured at market exchange rates, most developing countries use three to four times as much energy per unit GDP as the OECD average (figure 15). Measured in purchasing power parity, the differences are much smaller, but these statistics embody only commercial energy, and energy intensity can easily rise in the earlier stages of development as more people connect to commercial energy. Increasing the efficiency with which they do so, leapfrogging to more advanced use of local resources, or both, offer big opportunities.

Many measures relating to energy efficiency—such as setting and enforcing energy-efficiency standards and legislation to ensure that adequate information on energy performance is available to consumers—depend purely on domestic policy. But in some cases, international mechanisms can help. Many World Bank programs

FIGURE 15
Energy Use per Unit of GDP, by Region, 2004



Source: Derived from IEA 2006.

Note: Data for the former Soviet Union at market exchange rates are off scale and omitted because of difficulties interpreting market exchange rates in these countries.

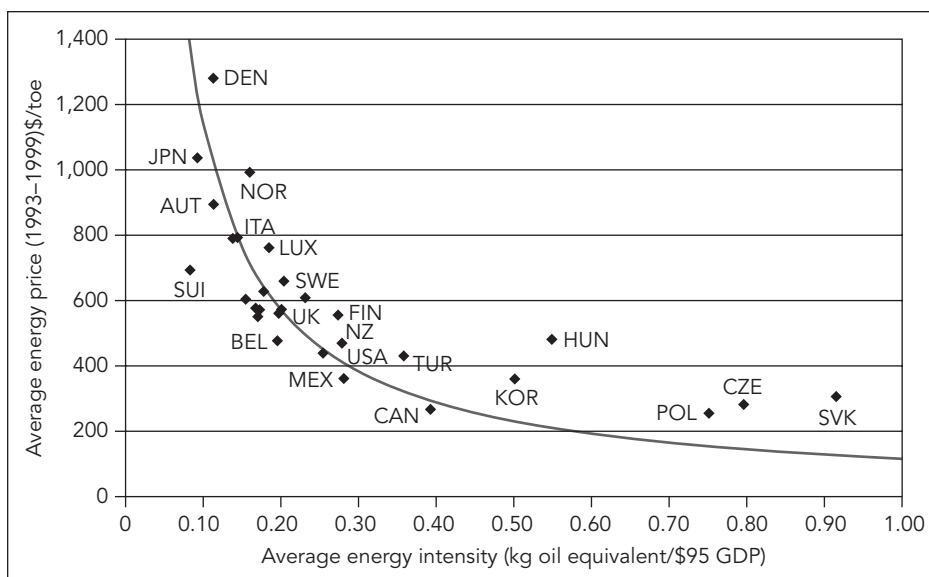
have targeted energy efficiency.¹⁸ The Clean Development Mechanism is another source of potential finance, although the need for scale and demonstration of additional emission savings often makes it better suited to supply-side investments.¹⁹ Stronger action on energy efficiency helps enable—and improves responsiveness to—the central economic plank of policy, namely, energy and carbon pricing.

Energy and Carbon Pricing

While specific regulatory interventions can accelerate energy efficiency, there is no question that energy pricing is an important factor. Traditionally, many developing countries have subsidized energy. The drawbacks of doing so are well known: inefficient use, poor infrastructure, inability to attract new investment, and a greater tax burden on the rest of the economy.

In addition, cross-sectional data suggest a long-run price elasticity of about -1.0 —a figure that suggests that countries do not in the long run pay more for energy as a result of higher prices, because they end up making proportional reductions in the intensity with which they use energy (figure 16). This response is substantially greater than elasticities estimated from time series (typically less than 0.5). The difference probably reflects a range of economic processes associated with price rises

FIGURE 16
Relation between Energy Price and Energy Intensity in Selected Countries



Source: Newbery 2003.

toe: tonnes of oil equivalent.

and spillover of higher prices into provoking other policy responses (in infrastructure investment and building standards, for example) that also reduce energy intensity.

Despite decades of economic advice to remove energy subsidies, many countries still provide them. These subsidies often reflect the entrenched interests of those who have historically benefited from subsidized energy. Since policy tends to arise from coalitions of interests, concern about environment and climate change may be a useful additional factor encouraging countries to remove inappropriate subsidies.

Going beyond this to implement explicit carbon pricing—either through taxes or emissions trading—may be hard for developing countries to contemplate, but there are serious reasons why they may wish to do so. In addition to the role of carbon pricing as an essential tool in tackling climate change (and the role of energy taxes more generally as a way of reducing exposure to international energy markets), such taxes raise revenue in ways that may well be less distortionary than other taxes (such as labor taxes). Indeed, the boost to GDP from CO₂ found in the E3MG model arises directly through this mechanism, particularly in developing countries, where high rates of unemployment mean that lowering labor-related taxes yields a proportionately greater economic benefit.

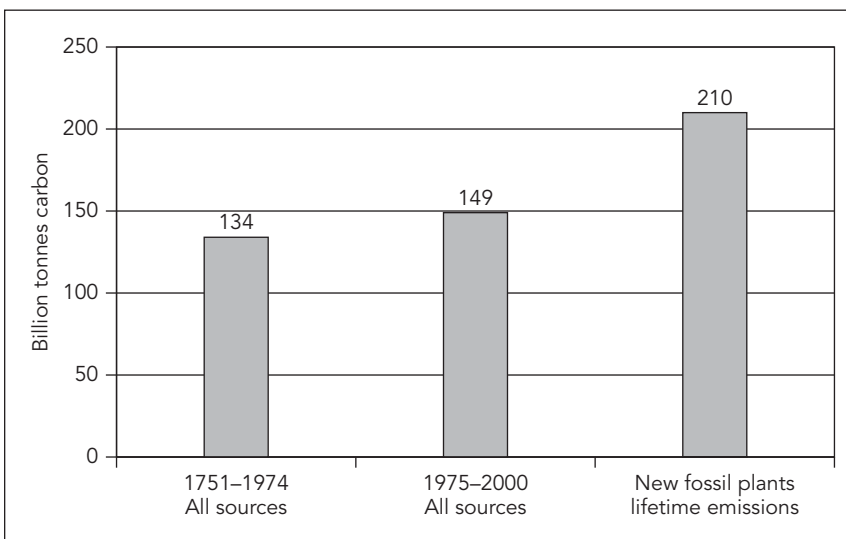
The experience in the European Emissions Trading Scheme (Grubb and Neuhoﬀ 2006) demonstrates unequivocally that emissions trading increases the profitability of power generators. In developing countries this may be a useful way of raising resources in a sector in which investment is crucial to future development.

Infrastructure and Innovation

The most compelling case for developing-country action is the sheer pace of investment in carbon-intensive infrastructure. The International Energy Agency's *World Energy Outlook* projects that \$11–\$17 trillion will be invested in energy infrastructure out to 2030. Much of this investment will be in equipment designed to last much longer. The planned lifetime emissions from a new coal plant projected to be constructed during this period amount to more than 200Gt CO₂—almost 40 percent more than the total emissions from all sources in the previous quarter century and almost a third of the total allowable CO₂ emissions for the century that would be consistent with stabilizing at 550 ppm CO₂e, the upper limit of ranges considered in the Stern review (figure 17). If the climate problem turns out to be even more severe, there is a high risk that much of this capital investment may become “stranded assets,” as the need to tighten CO₂ controls becomes overwhelming.

Coal power plants are not the only kind of infrastructure under construction. The choice between road and rail investment, for example, has even longer-term implications. The study by Crassous, Hourcade, and Sassi (2006) underlines the potential costs of pursuing investments in carbon-intensive transport infrastructure if low-carbon vehicles do not become available at scale. New buildings will last many decades or even centuries; the costs of retrofitting insulation measures are much higher than installing low-carbon buildings in the first place. Of course, many countries are still investing in infrastructure, but the sheer pace of construction in developing countries places a special need for them to consider the long-run implications of investment—and for the international community to consider ways of helping

FIGURE 17
Historic Lifetime Emissions and Expected Emissions from Coal Power Plants Projected for Construction, 2003–30



Source: www.e3g.org.

decarbonize the process of economic development globally, with particular attention to long-lived infrastructure.

One of the most generic findings of the literature on sustainable development is that the goals of environmental protection and development are closely interrelated (see, for example Swart, Robinson and Cohen 2003). Long-term emissions depend on wide social and macroeconomic choices about development paths (in assimilating new and more efficient technologies, for example), while the ability to address both environment and development objectives draw upon a common basis of institutional capacity. At a more concrete level, in the course of development, the key to an effective integrated response to climate change is to combine all three kinds of policies identified (improving market efficiency, carbon pricing, and infrastructure and innovation policy), at both the national and international level. Only such broad-ranging responses, implemented urgently, offer much hope of tackling this most daunting of global challenges.

Notes

1. The first half of this section draws heavily on Grubb (2004a). Many of the source data are from IPCC (2001a, b, c) and from the updated IPCC Fourth Assessment (IPCC 2007a, b, c, d).
2. The IPCC Third Assessment (IPCC 2001e) detailed observations, trends, and projections. Working Group II assessed observed and projected impacts. The Fourth Assessment will present enhanced data on impacts and projections, including at the regional level.
3. For discussion of these and innumerable other cases, see IPCC (2007b, chapter 7), the most extensive of the three Working Group reports, with 20 chapters of regional and sectoral assessments.
4. Out of 115 population scenarios collated recently by the International Institute for Applied Systems Analysis for the IPCC (Lutz and Sanderson 2001; UN 2005; World Bank 2005; U.S. Census Bureau 2005), most project population in the second half of the century to be moderately stable, at about 9–10 billion people. Only one scenario involves global population declining below 5 billion by the end of the century.
5. An extensive debate has focused on the use of purchasing power parity (PPP) versus market exchange rates (MER) and assumptions about economic convergence. While the choice of GDP denominator would not be expected to have a first-order impact on projections of a physical quantity such as emissions (Holtmark and Alfsen 2004a, b), it may have second-order impacts as a result of structural effects. Nordhaus (2005) concludes that the “jury is still out” and recommends a hybrid treatment using PPP base-year calibration with MER growth rates. Dixon and Rimmer (2005) present evidence that PPP treatments could lower emission projections as a result of differential structural effects and associated sectoral emission intensities and elasticities.
6. According to Lecocq (2006), “the econometric evidence is mixed. If cross-country data show the predicted relationship (albeit with controversies: country-level analysis shows a relatively weak relationship between levels of GDP and emissions), econometric analysis does not support an optimistic interpretation of the hypothesis that ‘the problem will take care of itself’ with economic growth. . . . but the pessimistic interpretation, that growth and CO₂ emissions would be irrevocably related, is not supported by the data either. Case studies confirm that there are major degrees of flexibility.”

7. Pacala and Socolow (2004) frame the debate in terms of “technology wedges” that could each deliver savings of 1 gigatonne of carbon (GtC) a year by midcentury. They list 15 possible wedges.
8. Chapter 12 of IPCC (2007d) covers these issues in depth.
9. The United Kingdom improved its national energy productivity (the ratio of GDP to energy consumption) by more than 20 percent during the 1990s, but the government’s Performance Innovation Unit still estimated the potential net value of additional energy savings to the U.K. economy in 2000 at more than £2 billion a year (PIU 2002).
10. Larsen and Shah (1992) estimate that subsidies for energy totaled more than \$230 billion a year.
11. Ulph and Ulph (1997, p. 648) note that “information acquisition and irreversibility could make a significant difference to policy advice,” but models of irreversibility effects (Pindyck 2000; Kolstad 1996) appear to have treated carbon- and non-carbon-intensive investments asymmetrically, assuming that only non-carbon-intensive investments are irreversible. In practice, both embody considerable inertia: every major investment has irreversible consequences. The dominant net irreversibility is the carbon in the atmosphere and associated damages. Uncertainty about impacts (relative to best estimates) consequently increases the attractiveness of low-carbon paths to a degree that depends on the potential damages, risks, and degrees of irreversibility.
12. Some other models span an ever wider range; IPCC (2007a, chapter 8) contains a comprehensive review.
13. The other three are IMCP models that are sufficiently aggregated so that they do not report energy-system costs. The exact coverage of energy-system costs may differ somewhat across models and cannot always be readily separated. These figures therefore need to be treated with caution.
14. Three of the models represent only the energy sector and are therefore not included in the GDP data.
15. For a set of studies of more classical global energy-economy models that also cover non-CO₂ gases, see the EMF studies (<http://www.stanford.edu/group/EMF/>).
16. The model was designed to show how effective technical change can be in reducing stabilization costs if appropriate policies and investments are undertaken and crowding out effects are limited. When these particular features of technical change dynamics are switched off, as they are in the FEEM-RICE SLOW model, costs become positive and consistent with those estimated by the other models.
17. CO_{2e} means “CO₂ equivalent,” that is, the carbon equivalent impact of emissions including non-CO₂ emissions. The range 450–550 ppm CO_{2e} corresponds to roughly 400–475 ppm CO₂ only.
18. World Bank commitments to energy efficiency and renewable resources have expanded rapidly, to \$680 million in 2005.
19. The CDM allows investments in emission-reducing projects in developing countries to generate “certified emission reduction units,” which may be used by industrial country investors in those projects to meet their commitments under national legislation and international agreements that set emission limits.

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Managing China's Energy Resources

JIANG KEJUN

Quantitative scenario analysis suggests that energy demand in China could reach 2.1 billion metric tons of oil equivalent (Mtoe) in 2020 and 2.7 billion tons of oil equivalent (toe) in 2030. These volumes would force China to import huge quantities of energy. Technological progress and the right policies could reduce the pressure on energy supplies.

The extraordinary economic growth in China over the past several years has caused enormous increases in energy consumption. This chapter examines the country's energy supply and demand in order to project energy demand and the need for imports in 2020 and 2030 under various scenarios.

Energy Demand in China

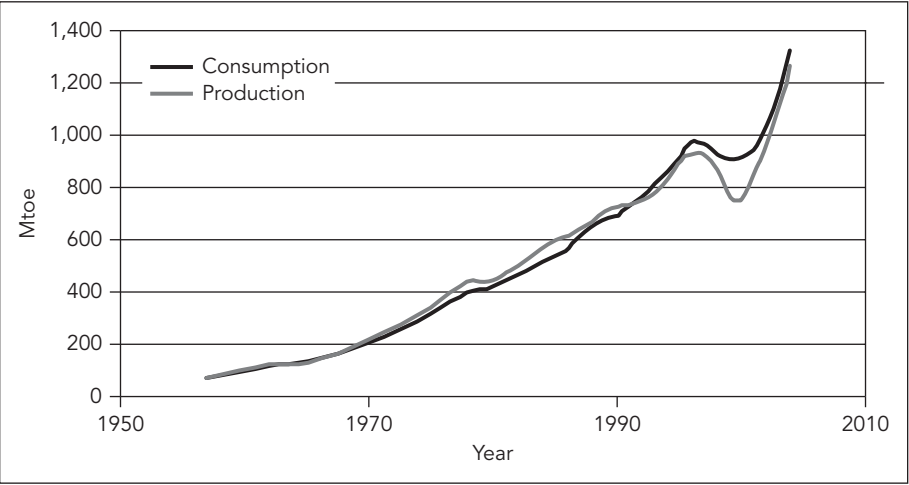
As a result of rapid economic growth, total primary energy consumption in China increased from 400 million metric tons of oil equivalent (Mtoe)¹ in 1978 to nearly 1,320 Mtoe in 2004, an annual average increase of 4.7 percent (State Statistical Bureau 2004) (figure 1). Coal is the major energy source, providing 71 percent of total primary energy use in 1978 and 69 percent in 2004 (figure 2). Recent years have witnessed a dramatic surge in the rate of increase of energy use in China and widespread energy shortages.

The major reason for the surge in energy demand in China is the rapid extension of energy-intensive production. For example, steel output increased from 131 million metric tons (Mt) in 2000 to 297 million tons in 2004. Production of other energy-intensive products also rose (figure 3).

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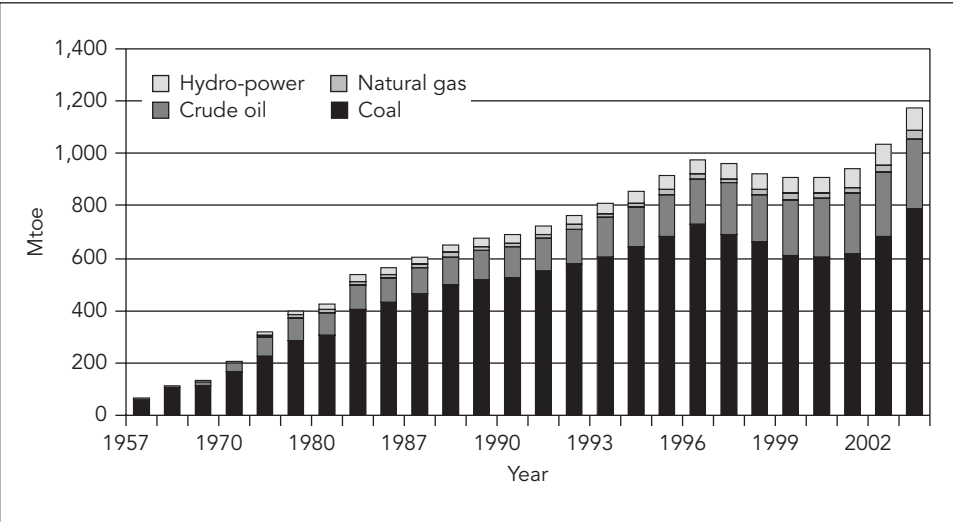
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FIGURE 1
Energy Production and Consumption in China, 1950–2004



Source: China National Bureau of Statistics 2005.

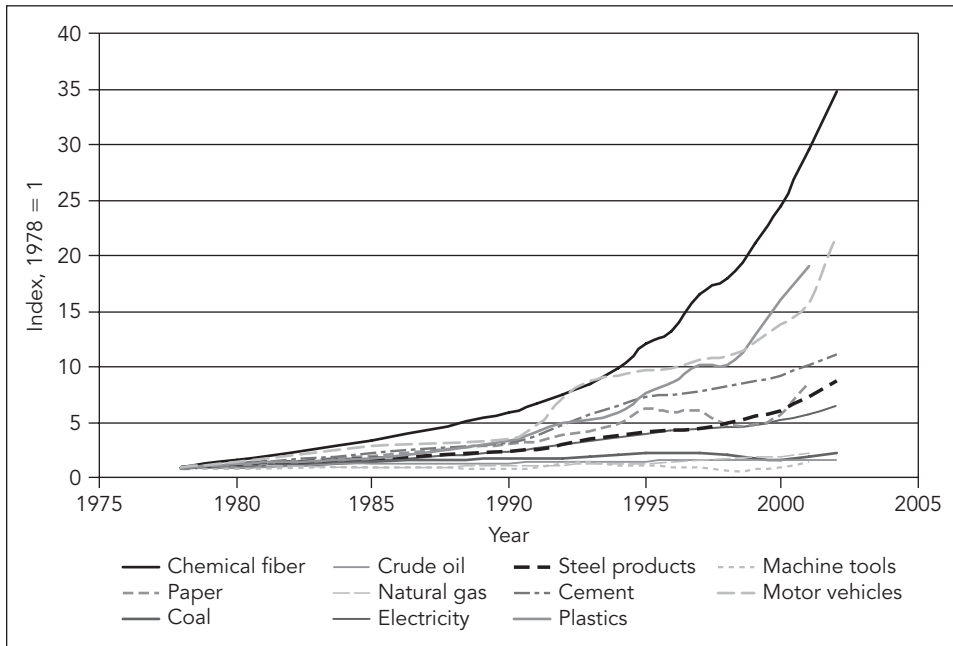
FIGURE 2
Primary Energy Use in China, by Energy Type, 1957–2004



Source: China National Bureau of Statistics 2005.

China is the largest coal-producing and -consuming country in the world. Between 1980 and 2004, total raw coal output increased from 620 million Mt to more than 1,900 Mt, an average annual increase of 4.8 percent. Before 2000 the share of coal use in total energy use decreased, but it increased again from 66 percent in 2000 to 72 percent in 2004. The heavy dependence on coal has led to serious environmental problems and represents a burden for the transportation system.

FIGURE 3
Production of Energy-Intensive Products in China, 1977–2004



Source: China National Bureau of Statistics 2005.

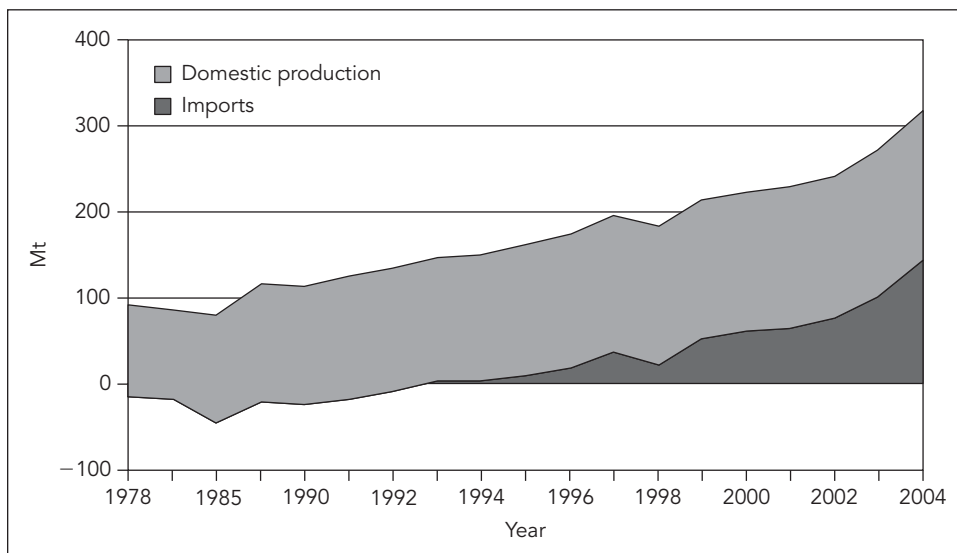
From 1980 to 2004, total installed capacity of electricity power generation increased from 66 gigawatts (GW) (of which hydropower is 20 GW, accounting for 31 percent) to 440 GW (of which hydropower is 100 GW, accounting for 23 percent). Over the same period, electricity output increased from 300 terawatt hours (TWh) (of which hydropower is 58 TWh, accounting for 19 percent) to 1,870 TWh (of which hydropower is 220 TWh, accounting for 12 percent). In 2004 newly installed capacity reached 50 GW; newly installed capacity in 2005 and 2006 was expected be about 60–70 GW (Power Industry Information 2005).

Power shortages appeared after 2002, with 24 of China's 31 provinces (excluding Hong Kong, Macao, and Taiwan) reportedly suffering from power shortages during the summer of 2004. These shortages were a key driving force behind very large increases in newly installed capacity.

Between 1980 and 2004, total crude oil output increased from 106 Mt to 175 Mt (an average annual increase of 2.1 percent). In 2002, 149 Mt was produced on land and 18 Mt was produced offshore.

Crude oil output in China accounts for 4.7 percent of the world total. Rapid increases in demand for petroleum over the past several years have increased oil imports, which rose to 45 percent of China's total oil supply in 2004 (figure 4). This increase has a significant impact on the international oil market and the future strategies of China's oil companies.

FIGURE 4
Petroleum Supply in China, 1978–2004



Source: China National Bureau of Statistics 2005.

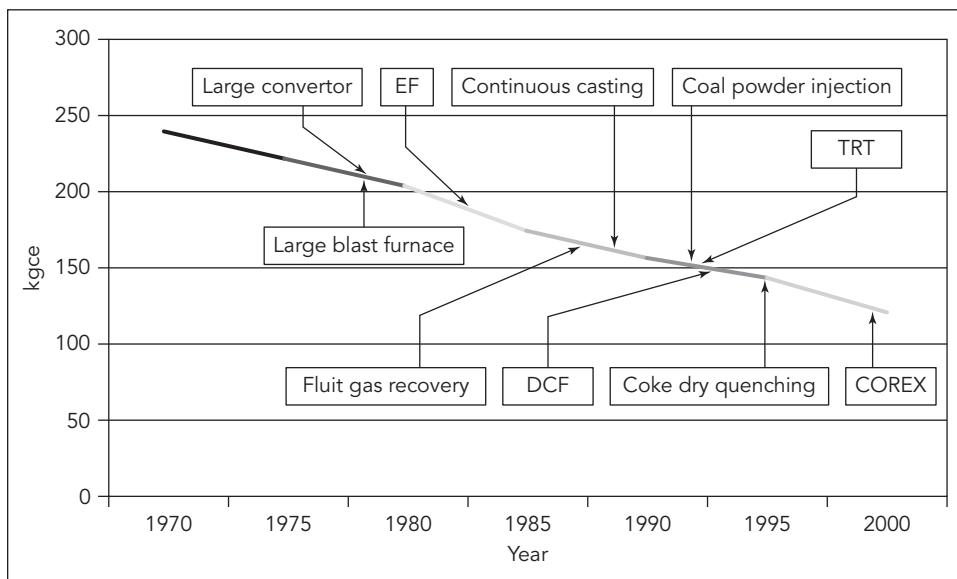
Conservation and improvements in energy are given high priority in the energy development strategy in China, as is the efficient and clean use of coal and other fossil energy sources. The objective of developing clean coal technology is to improve coal utilization efficiency, reduce environmental pollution, and promote economic development. High efficiency and clean technology will be crucial for China to achieve a low-emission development path.

Energy-efficiency improvements in the steelmaking industry have been driven by the diffusion of advanced technology (figure 5). Despite these improvements, steelmaking in China remains about 20 percent less efficient than in Japan.

Recent increases in energy demand have caused shortages and environmental problems. Recognizing the energy situation, the Chinese government has made efforts to try to soften energy pressure, by introducing various policies and instructions. Especially after 2004, energy has become one of the government's top concerns. Recent energy policies include the Medium- and Long-Term Energy Conservation Plan, the 11th Five-Year Energy Plan, the Renewable Energy Law, and the Fuel Efficiency Standard for Passenger Vehicles.

In 2005 the government set a target of reducing energy intensity by 20 percent between 2005 and 2010. In order to reach the target, several programs were introduced, including 10 key energy conservation projects and 1,000 large energy user monitoring programs (table 1). Subsidies for renewable energy were regulated by the government. A fuel tax and an energy tax are under discussion. The fuel tax will be implemented as part of the 11th Five-Year Plan.

FIGURE 5
Introduction of Energy-Efficiency Improvements in Steelmaking in China, 1970–2000



Source: Jiang and Xiulian 2006.

Note: kgce: kilogram coal equivalent; EF: electric furnace; TRT: top gas pressure recovery turbine; DCF: direct current furnace; COREX: One of the new iron-making technologies that use a molten iron gasifier and a reduction shaft instead of a coke oven and a blast furnace.

Energy and Emission Scenarios for China

Several models were used to project future energy and emission scenarios. This section describes the methodology used to develop the scenarios, defines the scenarios, and presents the results of the simulations.

Methodology

The IPAC–emission model and the IPAC–AIM/technology model—components of the Integrated Policy Assessment Model for China (IPAC)—were used to investigate various quantitative scenarios and to conduct policy option analysis. The models project future energy and pollutant emissions.

The IPAC–emission model (figure 6) is a global model developed for the study of greenhouse gas emission scenarios (Jiang, Morita, and others 2000; IPCC 2001b). It divides the world into nine regions (the United States, the Pacific [OECD], Europe and Canada [OECD], Eastern Europe and the former Soviet Union, the Middle East, China, other Asia, Africa, and Latin America). The model consists of three modules: a macroeconomic module, an end-use module, and a land-use module. It allows major emission sources, including energy activities, industries, land use, agriculture, and forests, to be simulated.

TABLE 1. Energy Conservation Projects Approved by the Chinese Government in 2005

Program	Potential annual energy savings/goal
Conversion of coal-fired industrial boilers and increase in their energy efficiency	70 Mtce (conversion) 35 Mtce (efficiency)
Cogeneration of heat power	5 Mtce
Reduction in residual heat and pressure usage	2.66 Mtce (steel industry) 3 Mtce (cement industry) 1.35 Mtce (coal-mining industry)
Conservation and substitution of oil	35 Mt oil
Conservation of energy used by electrical machinery	20 billion kWh electricity
Optimization of the energy system	Achieve international benchmarks of energy efficiency in steel, petrochemical, and chemical industries
Conservation of energy used in construction	50 Mtce
Green lighting	29 billion kWh electricity
Conservation of energy by government organizations	Reduce energy consumption per capita and per area of office space by 20 percent between 2002 and 2010
Conservation of energy, monitoring of energy use, and construction of technology services system	Start implementation in 2006

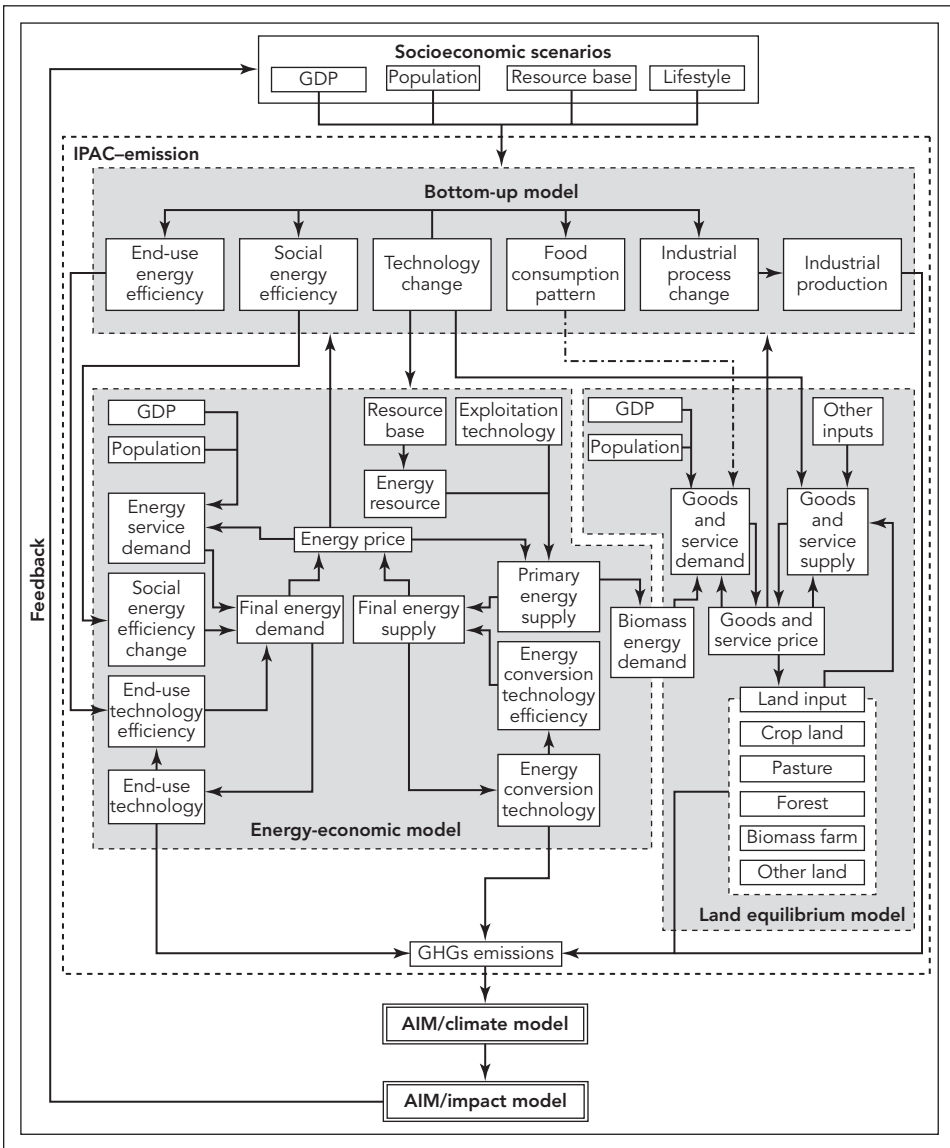
Source: NDRC 2004.

Note: ce: coal equivalent.

The IPAC–emission model was developed based on the Asian-Pacific Integrated emission linkage model (AIM), developed by the National Institute for Environment Studies (NIES) and used for development of the Intergovernmental Panel on Climate Change (IPCC) (Special Report on Emission Scenarios [SRES]). It links several models to calibrate the data and perform scenario quantification. Because of the size of China’s economy and the magnitude of its energy use, China’s development pattern should be analyzed in relation to the global regime, because international issues will strongly influence the country’s future environment, economy, and energy activities. Hence the model framework adopted was a global model divided into key regions, including China. Major emission sources, including energy activities, industries, land use, agriculture, and forests, can be simulated in the model framework.

The components of the model framework were adopted from previous studies. The energy sector top-down module was developed based on the Edmonds-Reilly-Barns (ERB) model (Edmonds and Reilly 1983; Edmonds, Wise, and Barns 1995), which is widely used for emission analysis. The end-use module was taken from the AIM end-use model (AIM Project Team 1996; Hu, Jiang, and Liu 1996). The land-use module was developed from the AGLU (Agriculture, Land Use, and Commercial Biomass Energy) model (Edmonds and others 1996). This model structure maximizes the ability to simulate a variety of inputs at a variety of levels, incorporating the strengths of both top-down and bottom-up approaches.

FIGURE 6
The IPAC-Emission Model



Source: Jiang, Masui, and others 2000.

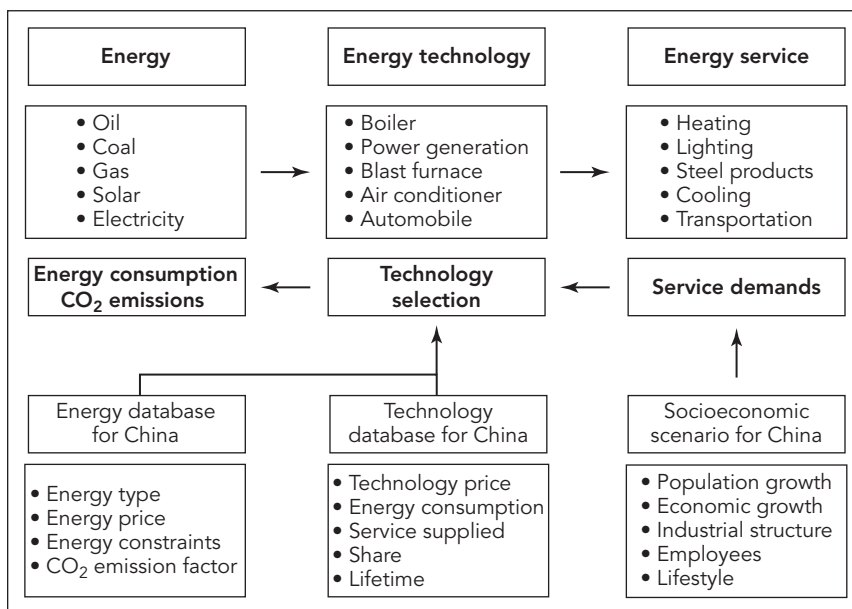
The AIM end-use model is part of the AIM, developed by NIES and Kyoto University. It is a bottom-up, energy-technology model. Based on detailed descriptions of energy services and technologies, it calculates total energy consumption and production in a bottom-up manner. This model has been used to analyze several key countries in Asia. Among the advantages of bottom-up models, the most important is that their results can be interpreted clearly, because they are based on detailed descriptions of changes in human activities and technologies.

The top-down model for the energy sector provides a consistent, conditional representation of economic, demographic, technical, and policy factors as they affect energy use and production. It is a macroeconomic partial equilibrium model that deals with energy activities and forecasts energy demand over the long term. It uses gross domestic product (GDP) and population as future development drivers, combined with other energy-related parameters to forecast energy demand based on the supply and demand balance. The model specifies three end-use sectors (industrial, residential, and transportation) and one energy-conversion sector (power generation). Energy efficiency is described by improvements in both technology efficiency and social efficiency. A number of technologies in these four sectors are listed in the model to present different possibilities of technological progress. A link between the bottom-up energy model and the top-down energy model has been developed. The detailed energy-use analysis for the developing Asia-Pacific region from the bottom-up model drives the energy use pathway before 2030, while a simplified linkage is presented for other regions in the model.

The AGLU model was developed by the Pacific Northwest National Laboratory (PNNL), in the United States. It is designed to explicitly model agriculture and land use, endogenously determine land use change emission, and explore the use of biomass as an element of a strategy of anthropogenic carbon emission.

The IPAC–AIM/technology model is a single-region model for China, developed based on the AIM end-use model (AIM Project Team 1996; Hu, Jiang, and Liu 1996; Hu and Jiang 2001; Jiang and others 1998). This model includes three modules (energy-service demand projection, energy-efficiency estimation, and technology selection) (figure 7). Demand is divided among the industrial, agricultural, service,

FIGURE 7
Structure of the IPAC–AIM/Technology Model



Source: Jiang and others 1998.

TABLE 2. Classification of Energy End-Use Sectors and Subsectors

Sector	Subsectors
Agriculture	Irrigation, farming works, agricultural-products processing, fishery, animal husbandry
Household	Space heating, cooling, lighting, cooking and hot water, household electrical appliances
Industry	Iron and steel, nonferrous metals, building materials, chemicals, petrochemicals, papermaking, textiles
Service	Space heating, cooling, lighting, cooking and hot water, electrical appliances
Transportation	Passenger and freight: Railway, highway, waterway, airway Freight: Railway, highway, waterway, airway

Source: Jiang and others 1998.

residential, and transportation sectors, which are further divided into subsectors (table 2). On both the demand and supply sides, more than 400 technologies are considered, including existing as well as advanced technologies that may be used in the future (table 3). The model searches for the least-cost technology mix to meet the given energy-service demand. The most up-to-date information on these technologies was collected from a large number of published sources, as well as by consulting experts directly.

Linking these two models allows for both detailed analyses of various sectors and a global analysis of China's energy future (figure 8). The same scenarios and related model assumptions were used for both models. Energy demand for China is given by the IPAC–AIM/technology model by calculating demand from sectors with detailed technology information; energy price and energy import data were derived from the IPAC–emission model. The global energy analysis is based on the SRES B2 scenario (IPCC 2001b); the part for China was revised for this article.

Major Assumptions

GDP is projected to grow at an annual rate of 8.2 percent in the first decade of the 21st century, 7.0 percent in the second decade, and 5.6 percent in the third decade. These growth rates are consistent with government targets and research by the Development Research Center (Zheng, Zhang, and Xu 2004; Tan, Wang, and Jiang 2002; Qu 2003; Liu, Ma, and Fang 2002). Population assumptions come from other studies (table 4).

In order to analyze energy trading, the IPCC SRES B2 scenario (Jiang, Morita, and others 2000) is used as a global scenario in the IPAC–emission model. The IPCC SRES scenario is a scenario family developed by the Intergovernmental Panel on Climate Change in 2001. It includes seven scenario groups. The B2 scenario reflects a world with good intentions that it is not always capable of implementing them. This storyline is most consistent with current national and international developments. On balance, the B2 world is one of central tendencies that can be characterized as

TABLE 3. Major Technologies Considered in the IPAC–AIM/Technology Model

Classification	Technologies
Iron and steel	Coke ovens; sintering machines; blast, open hearth, basic oxygen, and AC and DC electric arc furnaces; ingot-casting machines; continuous-casting machines; continuous-casting machines with rolling machines; steel-rolling machines; continuous steel-rolling machines; dry and wet coke-quenching equipment; electric power generated with residue pressure on top of blast furnace; coke-oven gas, open-hearth gas, and basic oxygen-furnace gas recovery; cogeneration equipment
Nonferrous metal	Aluminum production with sintering process, aluminum production with combination process, aluminum with bayer, electrolytic aluminum with upper-insert cell, electrolytic aluminum with side-insert cell, crude copper production with flash furnace, crude copper production with electric furnace, blast furnaces, reverberator furnaces, lead smelting-sintering in blast furnace, lead smelting with closed blast furnace, zinc smelting with wet method, zinc smelting with vertical pot method
Building materials	Cement: Mechanized-shaft, ordinary-shaft, wet-process, lepol kiln, ling-dry, rotary with pro-heater, dry-process rotary with precalciner, Hoffman, and tunnel kilns; self-owned electric-power generators; electric power generators with residue heat; bricks and tiles Lime: Ordinary-shaft kilns, mechanized-shaft kilns Glass: Floating, vertical, and Colburn processes; smelters
Chemical industry	Synthetic ammonia: Converters, gasification furnaces, gas-making furnaces, synthetic columns; shifting of sulfur-removing equipment Caustic soda production: Electronic cells with graphite process, two-stage effects evaporators, multistage effects evaporators, rectification equipment, ion-membrane method Calcium carbide production: Limestone calciners, closed carbide furnaces, open carbide furnaces, residue heat-recovery equipment Soda ash: Ammonia and saltwater preparation, limestone calcining, distillation columns, filters Fertilizer: Equipment for production of organic products, residue heat utilization
Petrochemical industry	Atmospheric and vacuum distillation, rectification, catalyzing and cracking, cracking with hydrogen adding, delayed-coking, and light-carbon cracking facilities; sequential separators; naphtha, diesel, and depropane crackers; deethane separators; crackers; facilities of residue heat utilization from ethylene
Papermaking	Cookers; distillation, washing, and bleaching facilities; evaporators, crushers; water separator, finishing, residue heat utilization, and black-liquor recovery facilities, cogenerators; and back-pressure electric power and condensing electric power generators
Textiles	Cotton-weaving process, chemical fiber process, wool-weaving and textile process, silk process, printing and dyeing process, garment-making, air conditioners, lighting, space heating

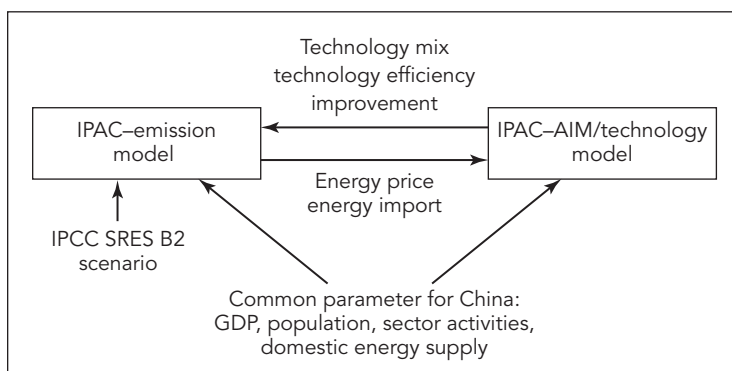
TABLE 3. (Continued)

Classification	Technologies
Machinery	Ingot process: Cupolas, electric arc furnaces, fans Forging process: Coal-fired, gas-fired, and oil-fired preheaters; steam- and electric-hydraulic hammers; pressing machines Heat-processing: coal-fired, oil-fired, gas-fired, and electric heat-processing furnaces Cutting process: Ordinary cutting, high-speed cutting
Irrigation	Diesel engines, electric induct motors
Farming works	Tractors, other agricultural machines
Agricultural production	Diesel engines, electric induct motors, processing machines, coal-fired facilities
Fishery	Diesel engines, electric induct motors
Animal husbandry	Diesel engines, electric induct motors, other machines
Residential space heating	Heat-supplying boilers in thermal power plants, district-heating plant boilers, dispersed boilers, small coal-fired stoves, electric heaters, brick beds linked with stoves (Chinese Kang), energy-saving building
Residential cooling	Air conditioners, high-efficiency air conditioners, electric fans
Residential lighting	Incandescent, fluorescent, and kerosene lamps
Residential cooking and hot water	Gas burners; bulk coal-fired, briquette-fired, methane-fired, cow dung-fired, kerosene, and firewood-fired stoves; electric cookers
Household electrical appliances	Televisions, washing machines, refrigerators, other appliances
Other electrical equipment	Photocopiers, computers, elevator, other appliances
Space heating in the service sector	Heat-supplying boilers in thermal power plants, boilers in district heating plants, dispersed boilers, electric heaters
Cooling	Central air-conditioning, air conditioners, electric fans
Lighting	Incandescent, fluorescent lamps
Cooking and hot water	Gas ranges, electric cookers, hot-water pipelines, coal-fired stoves
Passenger and freight transport	Railways: Steam, internal combustion engine, and electric locomotives Highways: Public diesel, public gasoline, and private vehicles; large diesel freight trucks, large gasoline vehicles, small freight trucks Waterways: Ocean-going, coastal, and inland ships Aviation: Freight and passenger planes
Common technologies	Electric motors; frequency-adjustable electric motors; coal-fired, high-efficiency coal-fired, natural gas-fired, and oil-fired boilers
Power generation	Low-parameter coal-fired, high-pressure critical coal-fired, supercritical coal-fired, natural gas-fired, oil-fired, and nuclear generators; Pressurized Fluid Bed Consumption (PFBC); integrated gasification combined cycle; natural gas combined cycle; wind turbines; hydropower; solar power generation; biomass and landfill power generation

Source: Jiang and others 1998.

FIGURE 8

Link between IPAC–Emission and IPAC–AIM/Technology Models



Source: Author.

TABLE 4. Projected Urban and Rural Population of China, 2000–30
(hundreds of thousands)

Item	2000	2010	2020	2030
Total	1,267	1,380	1,460	1,530
Urban	459	656	847	995
Rural	809	725	613	536

Source: Yu and Shuzhang 2000.

neutral progress across SRES scenarios. Human welfare, equality, and environmental protection all have high priority, but the world proves unable to tackle these concerns at a global level and resolves them as best it can regionally or locally. Generally, high educational levels promote both development and environmental protection. Education and welfare programs are widely pursued, leading to reductions in mortality and to a lesser extent fertility. This results in a central population projection of about 10.4 billion people by 2100, consistent with the median projection by the United Nations. Gross world product (GWP) grows at an intermediate rate of 2 percent a year, reaching about \$235 trillion in 2100.

The B2 storyline also presents a generally favorable climate for innovation and technological change, especially in view of high educational levels compared with today, and relatively efficient markets at the regional level. B2 is a world of “regional stewardship” that, in some regions, is particularly frugal with energy and many other natural resources. Consequently, energy-system structures differ across regions. Overall, high priority is given to environmental protection, although global policies prove elusive and regional policies vary widely. Major assumptions are given in tables 5–7.

For the developing Asia-Pacific region, the B2 scenario assumes that economic development uses resources so as to maintain equity for the future while maintaining balance across regions as well as between urban and rural areas. Such an approach is introduced based on the recognition of environmental issues and sustainable development. This scenario can be described as regional stewardship from a global

TABLE 5. Key Drivers for the Developing Asia-Pacific Region and the World in the IPAC-Emission Model

Item	Assumptions
Asia-Pacific population	4.7 billion in 2050, 5.0 billion in 2100
Annual GDP growth rate in Asia-Pacific	5.7 percent from 1990 to 2050, 3.8 percent from 2050 to 2100
World population	11.7 billion in 2100
World GDP	\$250 trillion in 2100
Trends in GDP per capita	Disparity remains; GDP per capita of OECD becomes 7 times of non-OECD (now 13 times)
Autonomous Annual Energy Efficiency Improvement (AEEI)	1.0–1.2 percent
International trade	Low trade across regions, high trade cost
Urbanization	Increase in developing world before 2050, decrease in developed world

Source: Jiang, Masui, and others 2000.

TABLE 6. Assumptions for B2 Scenario for the Developing Asia-Pacific Region and the World

Item	Assumption
Availability of resource	Oil and gas: Medium Coal: High
Cost of energy exploitation	Medium
Cost of noncarbon renewable energy	High for nuclear, medium for solar and other
Availability of biomass	Medium
Improvement in efficiency of end-use technology	Medium
Improvement in social-efficiency	Medium
Conservation in transport	High
Trend toward dematerialization	Medium
Improvement in land-use productivity	Medium
Meat-oriented food habit	Low
Desulphurization degree	High

Source: Jiang, Masui, and others 2000.

perspective, based on a natural evolution of current institutional policies and structures. It is characterized by limited population growth, medium economic growth, reduction in inequality, weak global governance but strong national and regional governance, a strong deurbanization trend, strong pursuit of environmental improvement, and encouragement of renewable energy use. It is a low per capita economic development scenario, with per capita GDP in the region at only one-fifth that of the OECD countries by 2100.

All of China's emission scenarios were developed under the IPCC SRES B2 scenario. In the IPAC-emission model, international energy trade was included in the

TABLE 7. Driving Forces and Policies That Promote Energy-Reducing Changes

Driving force	Sector	Type of change	Policies to promote the change
Social-efficiency change	Industry	Value-added change by subsectors within the sector (as service demand of some subsectors, including machinery, other chemical, other mining, and other industry, could be changed based on change in economic mix) Products structure change within one sector (as service demand in most industrial sectors)	Various policies relative to value added, such as price policy, national plan for key industry, promotion of well-functioning markets, market-oriented policies, national development policies
	Residential and commercial	Change in energy activity within the sector (use of heating, cooling, more efficient electric appliances)	Public education, price policies
	Transport	Change of transport mode (more public transport, nonmobility [walking and biking] traffic volume (as result of decline in use of private cars)	Transport development policies, public education
Technology progress	All sectors	Efficiency progress for technology (improvement in unit energy use); changes in technology mix (more advanced technologies); changes in fuel mix (more renewable energy and nuclear)	Promotion of technology research and development (R&D), market-oriented policies, international collaboration, environmental regulation, national energy industry policies, import and export policies, tax system

Source: Jiang, Masui, and others 2000.

study based on resource availability (Jiang, Masui, and others 2000; Jiang and others 1999). The SRES B2 scenario was selected because the assumptions on economic development, population growth, and technological progress on which it is based are similar to those of the scenario study in China.

Scenarios

Three scenarios are examined here in order to analyze future energy demand and emissions in China:

- *Baseline scenario*: This scenario gives a basic trend to describe future economic activities and international trade. China's economy will be part of the global economy. Under this scenario, China is able to rely on international markets and energy imports to meet part of its energy supply needs.
- *High-demand scenario*: The major driving force under this scenario is China's assumed role as a center for manufacturing following accession to the World Trade Organization, which will increase Chinese production of energy-intensive products. More technology transfer and R&D on high-efficiency energy-use technologies is also assumed.
- *Policy scenario*: Various energy and emission-control policies are assumed for this low-demand scenario, which reflects energy supply and environmental constraints.

The basic assumptions for the three scenarios, such as population and GDP growth, are the same. Sector service output for the three scenarios is given in table 8. For the global B2 scenario, there is no change for other regions under the three scenarios.

TABLE 8. Assumptions about Energy-Intensive Products in the Model

Product	2002	Baseline and policy scenarios		High-demand scenario	
		2020	2030	2020	2030
Aluminum (Mt)	4.51	10	14	12	18
Ammonia (Mt)	36.75	47	49	50	56
Cement (Mt)	725	1,000	900	1,100	1,100
Chemical fertilizer (Mt)	37.9	48	50	52	58
Copper (Mt)	1.63	4.5	5.2	5.2	5.8
Ethylene, (Mt)	5.43	12	16	14	20
Glass (million cases)	234.4	480	530	520	560
Steel (Mt)	182.4	380	320	430	380
Vehicles (million)	3.25	11	12	15	17

Source: Jiang and Xiulian 2006.

TABLE 9. Policy Options Used in the Modeling Study

Policy option	Explanation
Technology-promotion policy	Efficiency of end-use technology increases as a result of new technologies
Energy-efficiency standard for buildings	New buildings reach 75 percent energy efficiency in 2030
Renewable energy development	Policy includes subsidy for wind power and biomass power generation, as well as government support to village biogas supply system
Energy tax	Vehicle tax introduced by 2005; energy tax introduced by 2015
Public transport	Share of traffic volume by urban public transport will be 10–15 percent higher in 2030 than 2000
Increases in transport efficiency	High fuel-efficiency vehicles, including hybrid vehicles, compact cars, and advanced diesel cars, widely used
Increases in power generation efficiency	Efficiency of coal-fired power plants increases to 40 percent by 2030
Natural gas incentive	Natural gas supply enhanced, technology localized to reduce cost
Nuclear power development	Target setting in national promotion program, enhanced government investment, technology development

Source: Jiang and Xiulian 2006.

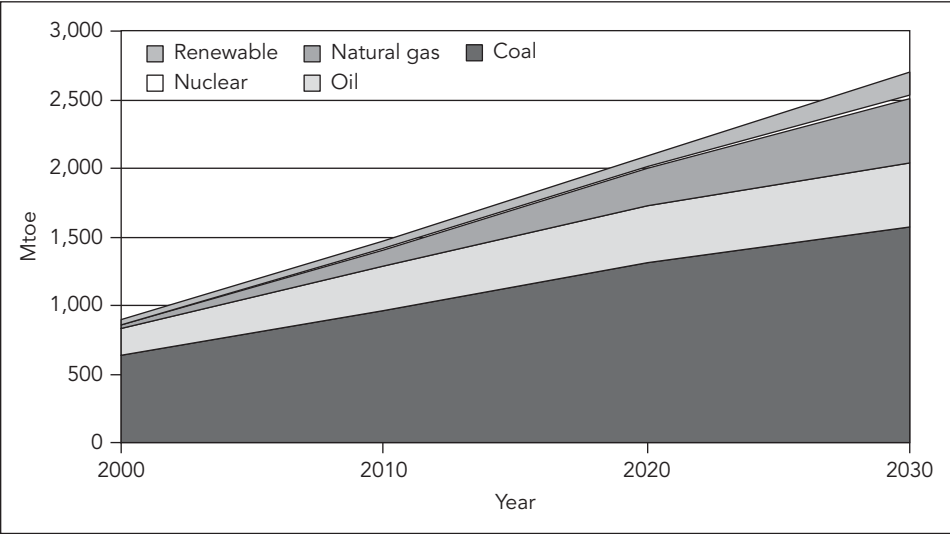
The policy options to be considered were defined based on policy potential in China and technology trends (Qu 2003; Liu, Ma, and Fang 2002; IPCC 2001a; IPCC 2002) (table 9). Many of these policies are already in place but need further implementation and strict standards, such as technology-efficiency standards, renewable-energy targets and fiscal policies, national energy targets, and so forth. Some new policies, including taxes, are also designed.

Results

According to the IPAC–emission model, primary energy demand in the baseline scenario could go to 2.1 billion toe in 2020 and 2.7 billion toe in 2030 (figure 9). The annual growth rate from 2000 to 2030 is 3.6 percent, while the energy elasticity of GDP is 0.58. Coal will be the major energy in China (1.5 billion toe in 2030), accounting for 58 percent of total energy demand; 61 percent of coal will go to power generation, with the remainder used by other sectors. There is a rapid increase for natural gas demand in China, with its share in total primary energy use increasing from 4 percent in 2000 to 17.3 percent in 2030 (an average annual growth rate of 10 percent).

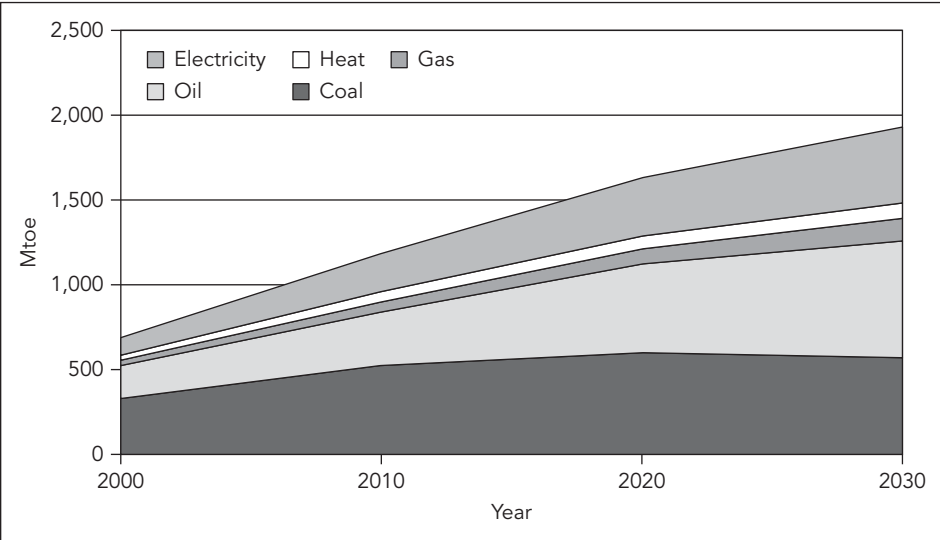
With respect to final energy use, electricity and oil increase rapidly (figure 10). Electricity demand increases from 112 million toe in 2000 to 451 million toe in 2030

FIGURE 9
Primary Energy Demand in China under Baseline Scenario, 2000–30



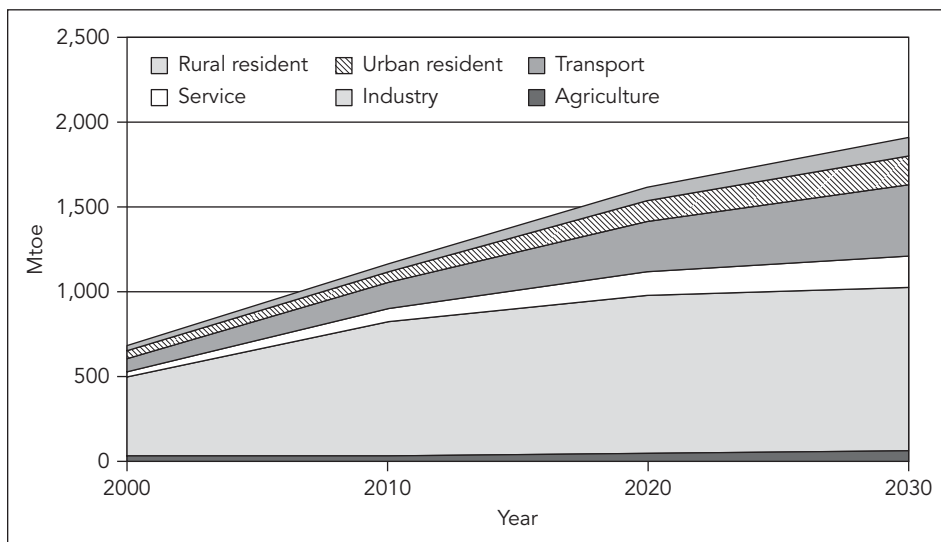
Source: Jiang and Xiulian 2006.

FIGURE 10
Final Energy Demand in China under Baseline Scenario, 2000–30



Source: Jiang and Xiulian 2006.

FIGURE 11
Final Energy Demand in China under Baseline Scenario, by Sector, 2000–30



Source: Jiang and Xiulian 2006.

with annual growth of 7.2 percent. Coal use increases in the residential sector generally decrease, replaced by gas and electricity; coal will be used mainly for boilers and in the steel and cement industries, reflecting the increase in energy-intensive industry. Demand for oil products used for transport increases quickly, with the rapid growth of vehicles in China, rising from 74 million Mtoe in 2000 to 410 million Mtoe in 2030, with annual growth of 8.9 percent (figure 11).

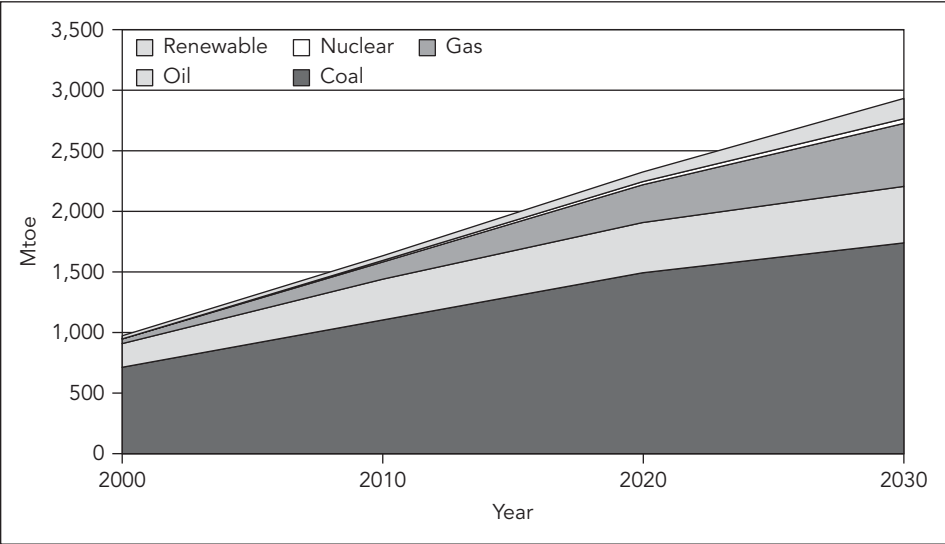
For the high-demand scenario, primary energy demand in 2030 is 2.9 billion Mtoe, 250 million tons more than in the baseline scenario. Of the total primary energy demand, coal provides 59 percent, oil 16 percent, natural gas 18 percent, and nuclear power about 1 percent. Because this scenario assumes better integration in international markets, there is greater reliance on imported energy, such as natural gas and oil (figures 12 and 13).

The policy scenario results shown in figures 14 and 15 assume that energy and environmental policy measures are adopted. Compared with the baseline scenario, energy demand declines by almost 245 Mtoe in 2020 and 280 Mtoe in 2030. There is enormous pressure to adopt these policy options in order to reach the lower energy-demand scenario. These policies need to be introduced early, because of the “lock-in” effects of energy technologies.

Primary and final energy demand in 2030 under the three scenarios are summarized in tables 10 and 11.

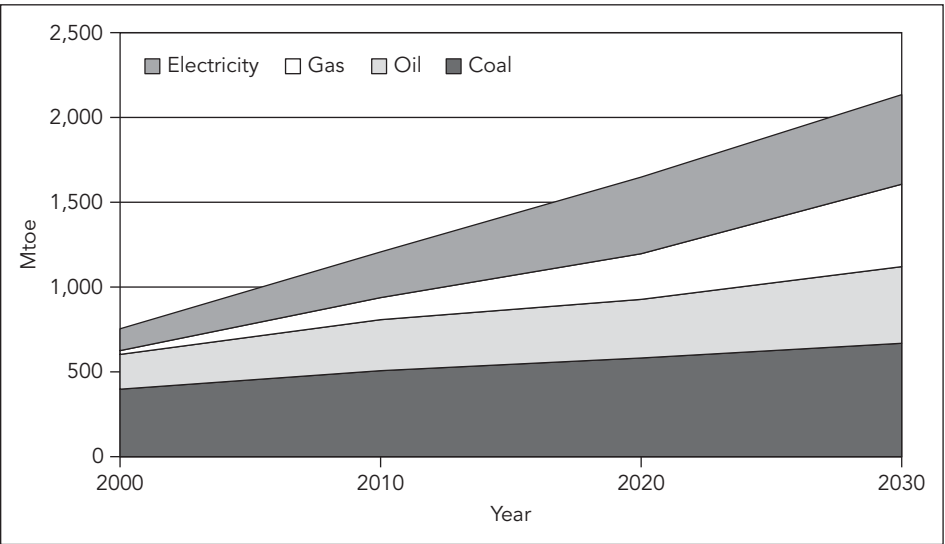
Emissions of sulfur dioxide (SO₂), nitrogen oxide (NO_x), total suspended particulate (TSP), and carbon dioxide (CO₂) from energy activities also increase (figures 16–19). SO₂ emission continues to increase through 2010, with the rapid

FIGURE 12
Primary Energy Demand in China under High-Demand Scenario, 2000–30



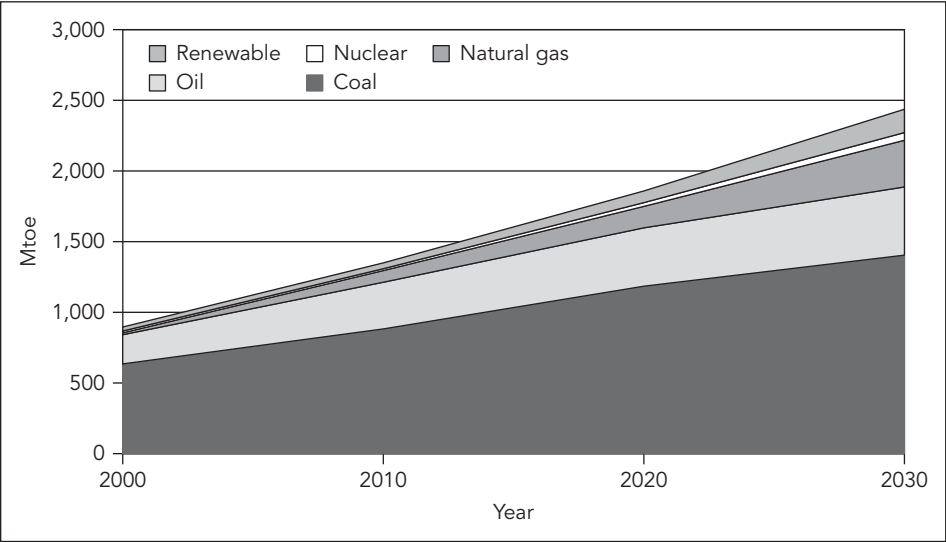
Source: Jiang and Xiulian 2006.

FIGURE 13
Final Energy Demand in China under High-Demand Scenario, 2000–30



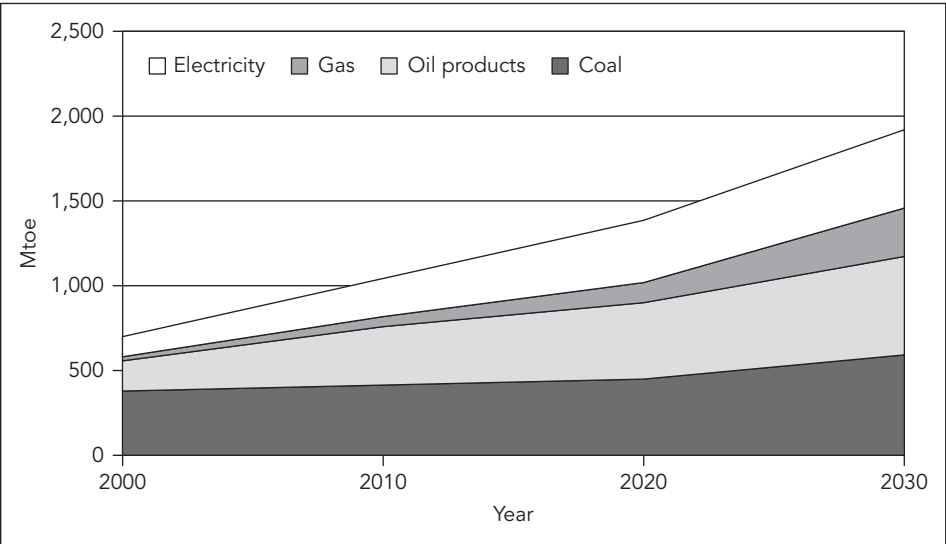
Source: Jiang and Xiulian 2006.

FIGURE 14
Primary Energy Demand in China under Policy Scenario, 2000–30



Source: Jiang and Xiulian 2006.

FIGURE 15
Final Energy Demand in China under Policy Scenario, 2000–30



Source: Jiang and Xiulian 2006.

TABLE 10. Primary Energy Demand in China under Various Scenarios, 2000 and 2030
(Mtoe)

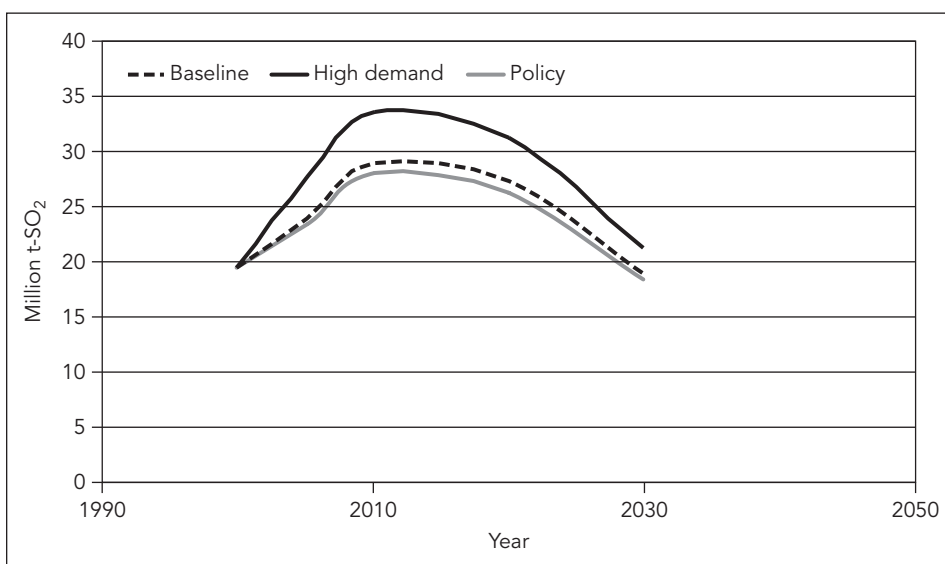
Type of energy	2000	2030		
		Baseline	High demand	Policy
Coal	635	1,569	1,734	1,409
Oil	198	472	472	472
Natural gas	26	466	521	339
Nuclear	2	30	34	43
Renewable	29	162	172	172

Source: Jiang and Xiulian 2006.

TABLE 11. Final Energy Demand in China under Various Scenarios, 2000 and 2030
(Mtoe)

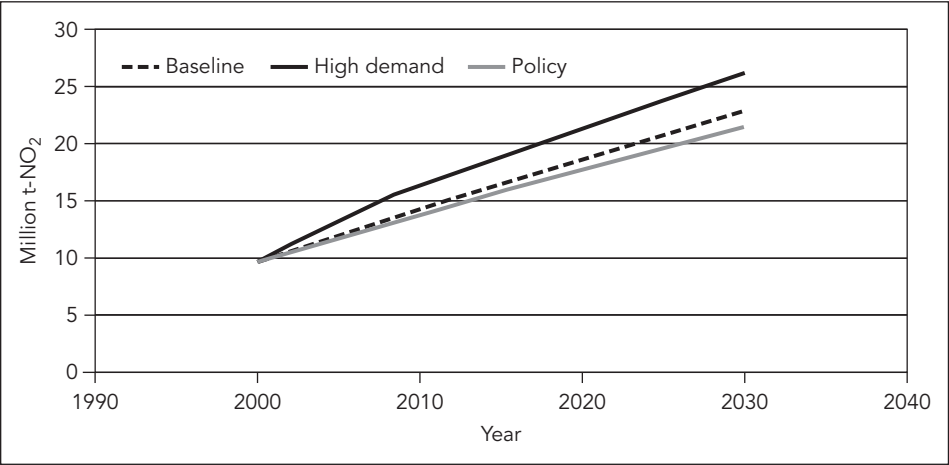
Type of energy	2000	2030		
		Baseline	High-demand	Policy
Coal	375	623	669	592
Oil Products	186	361	451	576
Gas	21	437	487	291
Electricity	112	478	530	456

Source: Jiang and Xiulian 2006.

FIGURE 16
Actual and Projected SO₂ Emissions in China, 2000–30

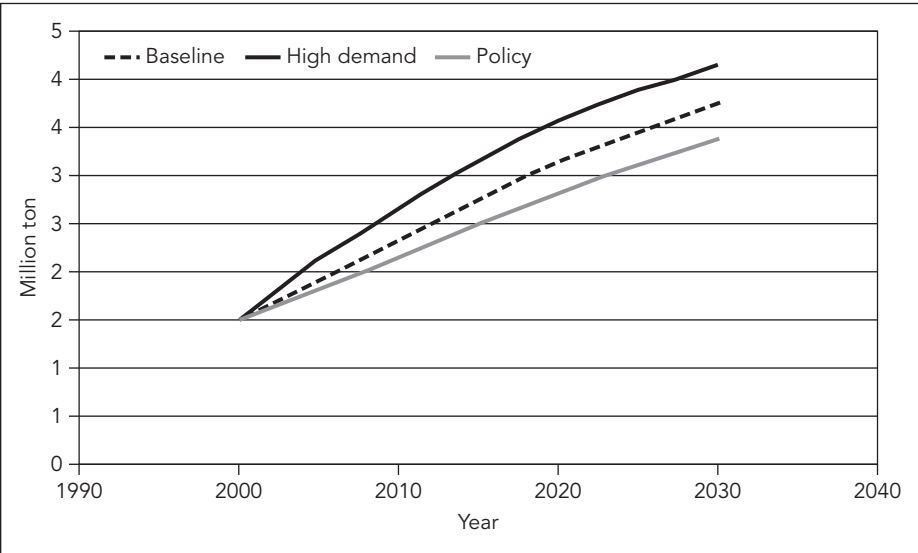
Source: Jiang and Xiulian 2006.

FIGURE 17
Actual and Projected NO_x Emissions in China, 2000–30



Source: Jiang and Xiulian 2006.

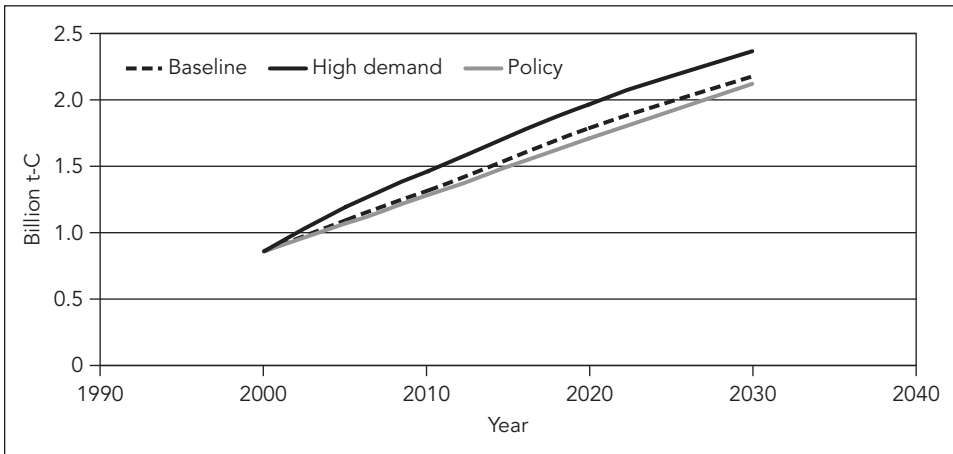
FIGURE 18
Actual and Projected TSP Emissions in China, 2000–30



Source: Jiang and Xiulian 2006.

increase of coal use in China. After 2010 more and more desulphurization technologies will be used, reducing SO₂ emissions from fossil fuel use. Under the baseline scenario, SO₂ emissions in 2010 are 4.5 million tons lower than under the high-demand scenario, but they still increase 9.45 million tons over 2000. These emissions represent an important challenge for the government to target. Because of lack of policy to control NO_x, these emission continue to rise.

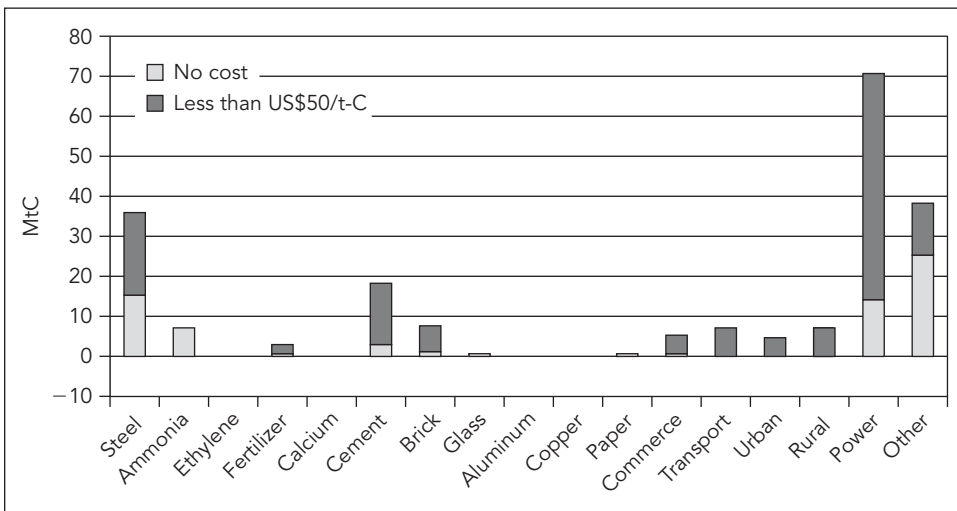
FIGURE 19
Actual and Projected CO₂ Emissions in China, 2000–30



Source: Jiang and Xiulian 2006.

Note: C: carbon.

FIGURE 20
Potential Reductions in Emissions from No-Cost or Low-Cost Interventions, by Sector



Source: Jiang and Xiulian 2006.

Note: C: carbon.

A package of policy options could be adopted now to reduce the growth of energy demand. Policies that would help China move to a low-energy demand scenario include promotion of high energy-efficiency technologies; adoption of fiscal energy and environment policies, including taxes on vehicle fuel, emissions, and resources and provision of subsidies for renewable energy; and promotion of public involvement in energy conservation (table 12). Significant emissions could be enjoyed at either no cost or a cost of less than \$50 per ton carbon (tC) (figure 20).

TABLE 12. Technologies That Save Energy and Reduce Greenhouse Gas Emissions in the Short and Medium Term, by Sector

Sector	Technologies
Steel	Large-size equipment (coke ovens, blast furnaces, basic oxygen furnaces); coke dry-quenching equipment; continuous casting machines; blast-furnace gas recovery; continuous rolling machines; coke-oven gas equipment; open hearth gas and blast furnace gas recovery; DC electric arc furnaces
Chemicals	Large-size equipment for chemical production, waste-heat recover systems, ion membrane technology, improvements in existing technology
Papermaking	Cogeneration systems, residue-heat utilization facilities, black-liquor recovery systems, continuous distillation systems
Textiles	Cogeneration systems, shuttleless looms, high-speed printing and dyeing
Nonferrous metal	Reverberator furnaces, waste-heat recover systems, new furnaces for lead and zinc production
Building materials	Dry-process rotary kilns with precalciners, electric power generators with residue heat, Colburn process, Hoffman and tunnel kilns
Machinery	High-speed cutting, electric-hydraulic hammers, heat-preservation furnaces
Residential	Cooking by gas, centralized space-heating system, energy-saving electric appliances, more efficient lighting, solar thermal for heating water, insulation of buildings, energy-efficient windows
Service	Centralized space-heating systems, centralized cooling systems, cogeneration systems, energy-saving electrical appliances, high-efficiency lighting
Transport	Hybrid vehicles, advanced diesel trucks, low energy-use cars, electric cars, fuel-cell vehicles, natural gas cars, electric railway locomotives, public transport development
Common use technology	High-efficiency boiler, fluid-bed combustion technology, high-efficiency electric motors, speed-adjustable motors, centrifugal electric fans, energy-saving lighting
Power generation	Supercritical units, natural gas combined cycles, pressured fluid-bed combustion boilers, wind turbines, integrated gasification combined cycles, smaller-scale hydropower, biomass-based power generation

Source: Jiang and Xiulian 2006.

Energy-Resource and Energy-Supply Scenarios in China

Domestic energy resources are key to China's energy security. This section examines energy resource development in China and examines various scenarios for energy supply.

China's Energy Resources

China's energy sources include fossil fuels, renewable energy, and nuclear power. Each is discussed below.

Fossil Fuel

China has large quantities of coal, which accounts for 96 percent of confirmed sources of total domestic fossil fuel energy resources (Feng and Zhou 2003). Coal will play a key role in China's energy security.

The stock of confirmed oil reserves in China was 2.36 billion tons (2.34 billion Mtoe) by the end of 2003; natural gas reserves were 572.3 trillion cubic meters (542 billion Mtoe) by the end of 2000, with economic reserves of only 1 trillion cubic meters (0.95 billion Mtoe).

Natural gas is a clean fuel. Historically, it has received less attention than other sources of energy, with much less investment on resource exploration. The Chinese government and Chinese companies have recently increased investment on natural gas resource exploration. In past two years, three very large natural gas resources were found in China.

Hydropower

Water resources appropriate to small-scale hydropower are plentiful in China. According to China's latest hydropower resource survey, the potential total capacity of small-scale hydropower that could be feasibly developed is 125 GW. The resource base is widely distributed, including sites in more than 1,600 counties (or cities), spread over 30 of China's provinces (or provincial-level municipalities). Sixty-five percent of these counties are in southwest China, which accounts for more than half of the country's total small-scale hydropower resource capacity (Li 2004).

The Chinese government has implemented policies that strongly support small-scale hydropower, and it has included small-scale hydropower in its rural electrification plans. Small-scale hydropower has already played a very important role in electrification in China, particularly in rural areas. About one-third of China's counties rely on small-scale hydropower as their main source of electricity. China has made the building of small-scale hydropower stations a critical component of rural energy development in its Western China Cropland Conversion Program and its Western China Energy Development Program, providing special funds derived from government bonds for small-scale hydropower development. Existing small-scale hydropower stations, with an installed capacity of 30 GW, represent about 20 percent of the total projected potential capacity. It is expected that between 2020 and 2030, China's small-scale hydropower resources will be almost fully developed, with a capacity of 100 GW. By 2030 hydropower will account for about 10 percent of China's total installed power capacity.

Development of hydropower has faced several problems. These include inadequate transportation to remote sites, construction problems, the vast distances over which power is transmitted, ecosystem problems, the long payback period, and difficulty raising capital.

Nuclear Power

China has good conditions for developing nuclear power. Economically uranium resource is 650,000 Mt. The international stock of uranium is large, with about

3–4 million tons available at a cost of \$80 per kilogram or less—enough for more than 50 years use for power generation worldwide. If it is used in a fast-breed reactor, this stock of uranium could provide the world with energy for more than 3,000 years.

Chinese companies already have 300-MW light-water reactor technologies, and nuclear power plants could be constructed with Chinese technologies. Chinese companies can already produce three to four sets of nuclear power generators. More than 40–50 GW of nuclear power is expected to come on line in China by 2020. China also has the ability to produce nuclear fuel and process used fuels (Gao 2004).

Biomass Energy

Whether burned directly, used to produce electricity, or used as a substitute liquid fuel, biomass energy resources have the potential to play a decisive role in China's energy supply (Li 2004). These resources include agricultural waste, scrap from the forestry and forest product industries, and municipal waste.

Annual production of crop stalks suitable to energy production is estimated at 2,870 Mtoe. Wastes from the processing of agricultural products and manure from livestock farms could yield nearly 80 billion cubic meters of biogas. Scrap from forestry and forest product industries represents a resource equivalent to 1,913 Mtoe a year. With implementation of China's Natural Forest Protection Program (which includes logging bans and logging reductions over much of the nation's natural forests) and its Sloping Cropland Conversion Program (which calls for the conversion of much of the nation's sloping cropland to trees and grasses), the volume of scrap from the forestry and forest product industries used in energy applications is expected to increase substantially, with the potential of reaching 2,870 Mtoe a year by 2020.

Municipal waste in China is expected to reach 210 million tons a year in 2020. If 60 percent of this is used in landfill methane applications, 2–10 billion cubic meters of methane could be produced.

"Energy crops" are a biomass energy resource with the potential for commercialization. Many types of energy crops are suited to growing in China. Chief among these are rapeseed and other edible oil plants and some plants that grow in the wild, such as sumac, Chinese goldthread, and sweet broomcorn. By 2020 such crops could potentially yield more than 50 million tons of liquid fuel a year, including more than 28 Mt of ethanol and 24 Mt of biodiesel.

Wind Power

With a large land mass and a long coastline, China has relatively abundant wind resources (Li 2004). According to estimates by the China Meteorology Research Institute, land-based exploitable wind resources have a potential power-generation capacity of 253 GW (based on wind resources at a height of 10 meters above the ground). The institute estimates the exploitable potential of ocean-based wind resources at about 750 GW, yielding a total estimated wind-power potential of China of about 1,000 GW.

Areas rich in wind resources are located mainly along the southeast coast and nearby islands and in Inner Mongolia, Xinjiang, Gansu Province's Hexi Corridor, and in some parts of Northeast China, Northwest China, North China, and the Qinghai-Tibetan Plateau. Parts of China's interior are also rich in wind resources. China has large marine areas, and ocean-based wind resources are plentiful. With current technology, wind turbines could be installed in the ocean up to 10 kilometers away from the coast, at depths of up to 20 meters.

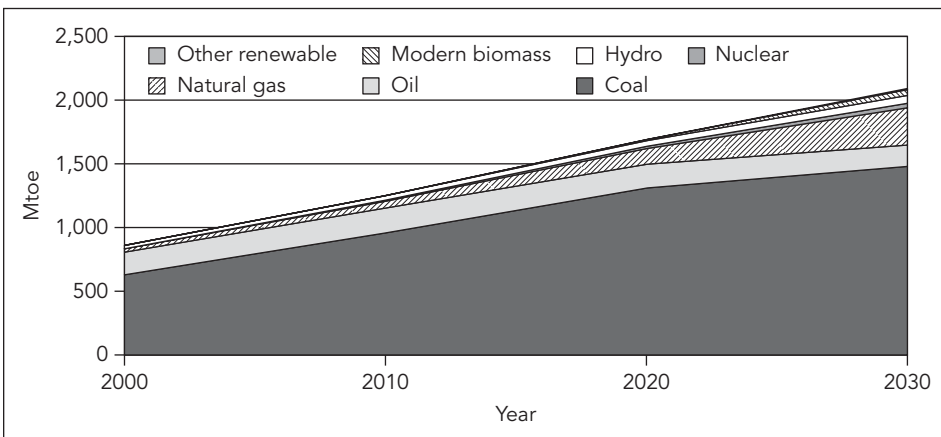
By the end of 2003, total grid-connected installed capacity of wind power in China was 560 MW. China is 10th in the world in terms of total installed wind-power capacity. In addition to grid-connected installations, China also has about 200,000 stand-alone small-scale wind turbines (with installed capacity of 25 MW), which provide electricity to rural households in remote areas.

China has fully mastered the manufacture of large-scale wind turbines of 750 kW or less and is in the process of developing megawatt-scale turbines. It has also established 40 wind farms, mastered wind farm operation and management, and trained technical personnel in designing and constructing wind power turbines. Thus a sound base for developing large-scale wind power in China has been developed.

Energy-Supply Scenarios

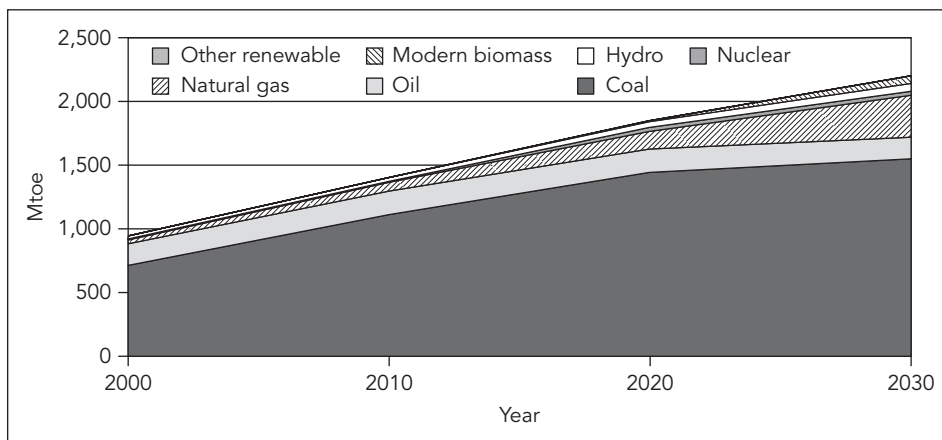
Future energy production in China is simulated under two scenarios (figures 21 and 22). According to these simulations, coal production could reach 1.31 billion Mtoe by 2020 and 1.48 billion Mtoe by 2030. Chinese coal industry experts estimate an upper bound of coal production of 1.2 billion Mtoe by 2020. Coal demand, therefore, could exceed domestic coal production in China.

FIGURE 21
China's Energy Production under the Baseline Scenario, 2000–30



Source: Jiang and Xiulian 2006.

FIGURE 22

China's Energy Production under the High-Demand Scenario, 2000–30

Source: Jiang and Xiulian 2006.

Oil production is projected to reach 190 million tons in 2020 and 175 million tons in 2030. This is within the range of forecasts by oil industry experts of 180–200 million tons in 2020. Natural gas production is projected to reach 133 billion cubic meters in 2020 and 312 billion cubic meters in 2030. This estimate is also within the range of energy experts' forecasts of 130–150 billion cubic meters in 2020.

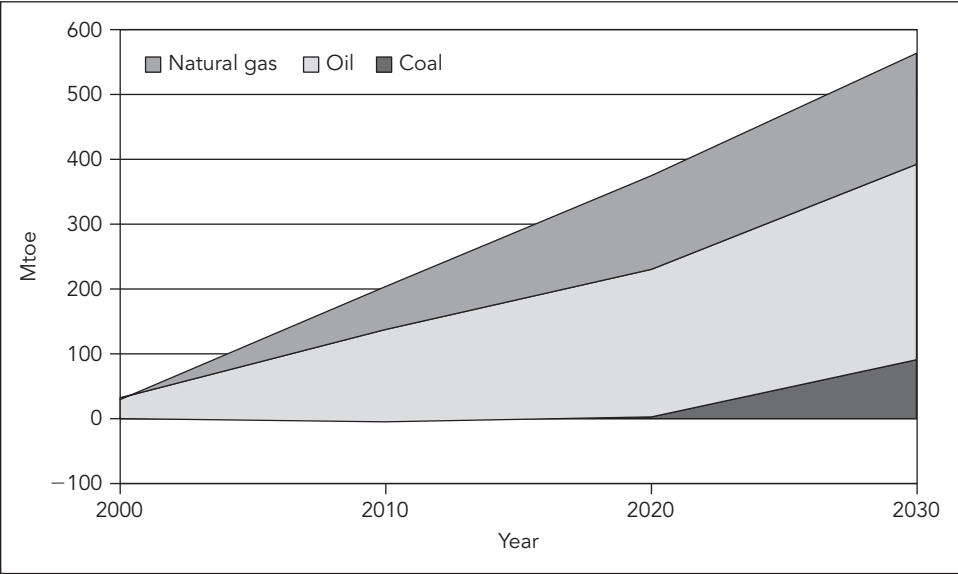
Nuclear power generation is projected to increase quickly in the future, but because of its high cost, it will still represent only a small share of total power supply. The simulations show that nuclear power generation could reach 256 TWh in 2020 and 344 TWh in 2030, up from 16.7 TWh in 2000. Installed capacity is projected to reach 39,400 MW in 2020 and 53,030 MW in 2030.

Hydropower output is projected to increase from 224 TWh in 2000 to 555 TWh in 2020 and 722 TWh in 2030. Capacity will reach 154 GW in 2020 and 201 GW in 2030.

Given estimates of energy demand and production, the need for future energy imports can be calculated (figures 23 and 24). In the baseline scenario, future fossil energy imports could reach 375 million Mtoe annually in 2020 and 562 million Mtoe in 2030 (for comparison, in 2000 the United States imported 870 million Mtoe). Oil will be the major energy source to be imported, with imports reaching 230 million tons in 2020 and 300 million tons in 2030. Natural gas imports are projected to reach 154 billion cubic meters in 2020 and 183 billion cubic meters in 2030. Even coal will be imported after 2020, with 129 million tons of coal needed annually by 2030.

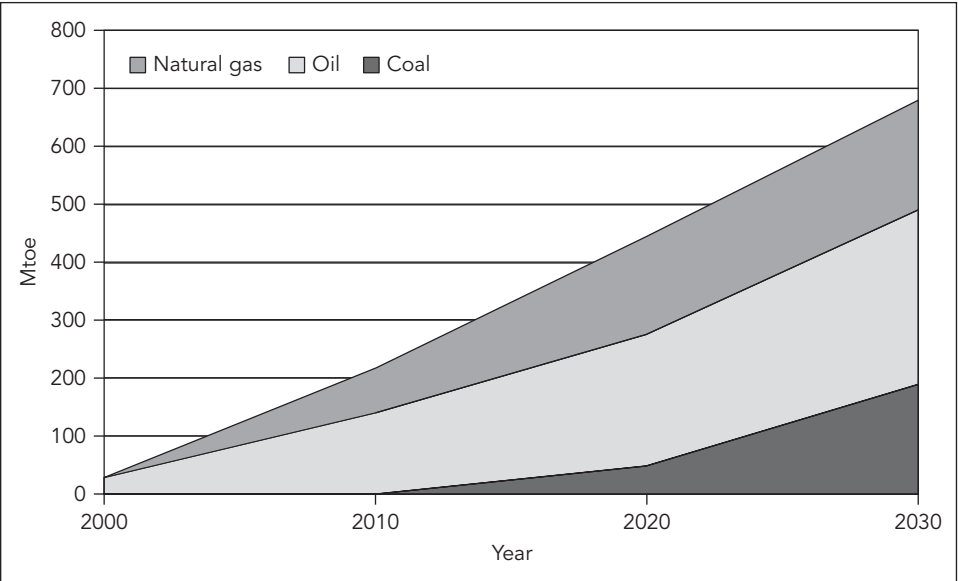
In the high-demand scenario, energy imports are much larger. Total fossil-energy imports will be 445 million Mtoe in 2020 and 680 million Mtoe in 2030. Coal imports will reach 189 million Mtoe in 2030.

FIGURE 23
China's Energy Imports under the Baseline Scenario, 2000–30



Source: Jiang and Xiulian 2006.

FIGURE 24
China's Energy Imports under the High-Demand Scenario, 2000–30



Source: Jiang and Xiulian 2006.

Conclusion

The simulations presented here project primary energy demand in China in 2020 at 1.9–2.4 billion Mtoe. The actual level will depend on technological progress, development of the energy-intensive sector development, and policies. Very high energy demand will put enormous pressure on energy supply in China.

This simulation shows that by 2020 the domestic energy supply could include 200 million tons of oil, 160 billion cubic meters of natural gas, and 2.8 billion tons of coal. This means that under the low energy-demand scenario, China would have to import 200 million tons of oil and 100 billion cubic meters of natural gas; under the high energy-demand scenario, imports would reach nearly 400 million tons of oil, 260 billion cubic meters of natural gas, and 300 million tons of coal.

Such a high level of energy demand and imports will put heavy pressure on China's energy-supply industry. A well-designed strategy for the energy system and energy industry development in China should therefore be prepared. That strategy could consider the following options:

- Because technological progress is key to reducing energy demand and ensuring a clean future, much more emphasis should be placed on new-generation technologies. In the simulation, technological progress will contribute much of the energy saving, with no negative effect on welfare.
- Energy taxes, resource taxes, export taxes for energy-intensive products, and similar taxes have significant effects on energy saving and optimization of economic structure. They should be given much more attention.
- Like other developed countries that have high levels of energy imports, China should establish an energy security system. The size of strategic storage should be determined based on a global perspective of oil demand.
- A multienergy system should be established to diversify energy supply. Renewable energy should be developed as an alternative energy source. Biofuel for vehicle fuel could reduce energy imports.
- Various national laws, regulations, and standards for energy industry should be prepared to reach the target of a clean energy system. Currently, the relevant legislation is very weak.
- Clean coal technology should be emphasized to mitigate emissions from coal combustion. Only a few countries in the world are using coal on a large scale; development of clean coal technologies therefore depends on them. China is the largest user of coal in the world, and its use of coal will increase in the future (by 2020 China could account for more than 40 percent of world coal consumption). Therefore, clean coal technology is crucial. China should have a clear development plan to promote clean coal technology, working in close coordination with other countries to develop a new generation of clean coal technologies.

Because of its low production costs, China is likely to become a major manufacturing center, producing energy- and resource-intensive products. This trend should be avoided in order to prevent reliance on raw materials and damage to the environment. Planning for energy- and resource-intensive products should be made, and external costs should be included in production costs.

Note

1. Tons are metric throughout this paper.

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Comment on “Managing China’s Energy Resources” by Jiang Kejun and “Climate Change Impacts, Energy, and Development” by Michael Grubb

SURESH P. PRABHU

The papers by Jiang Kejun and Michael Grubb together capture the dilemma faced by developing countries in balancing the urgent imperative to meet their growing energy needs with the global need to manage their emissions of greenhouse gases. These issues force policy makers to deal with several dualities and inherent contradictions within them at the same time. Human survival is threatened by climate change, but improving the quality of life requires more energy use. A utopian vision of the world would like to remove global disparity, but some countries seek to maintain superiority.

As a politician, I know that the needs of my constituents will always take priority over the needs of “others.” Framed in this manner, the “dilemma” between energy growth and greenhouse gas reduction is no dilemma at all: I will always push energy growth in my country to meet all energy needs of the type mentioned in Mr. Jiang’s paper. However, reality is never so simple.

For one thing, the adverse impacts of climate change threaten development itself. Every development activity—whether a state intervention, such as an irrigation project, or a private entrepreneurial initiative, such as that of a farmer—faces the risk that it may not yield the expected benefits because of climate change impacts on natural resources and infrastructure. This makes climate change—or at least adaptation to climate change—important to me and to my fellow politicians from the developing world. The threats of climate change make it even more important to us that water resources are managed effectively; that biodiversity is conserved; that building codes, road designs, and urban land use planning take current climate variability and impending climate change into account. In other words, climate change provides a powerful rationale for us to do things we want to do anyway.

This is also true on the mitigation side of the climate change debate. The interventions that promote climate change mitigation—renewables, energy efficiency, fuel

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pricing—are those that we are pushing for anyway, in order to enhance energy access, promote productivity, facilitate energy security, and improve local environmental quality. In this context, mitigating climate change becomes a partner in enabling changes in the energy sector. The financial resources provided by the Global Environment Facility (GEF) and the Clean Development Mechanism (CDM), though very small, help mainstream changes into the energy sector; they serve as wedges to open the door to change and to form new constituencies that can become the drivers of change.

The key question, which both papers address, is how to integrate climate mitigation and adaptation concerns into the development process in developing countries. There is little doubt that energy use in China (and other developing countries) will increase rapidly, led largely by growth in the industrial sector. However, the growth-energy link will not be as linear as projected in the paper. As China opens its economy and integrates with the World Trade Organization, there will be competing pressures. The larger players will face competitive pressures to reduce energy costs. They will be more sensitive and responsive to global concerns and choose internationally acceptable practices. This will reduce the industrial energy growth rate. It is also probable that imports of fuels will favor gas, which will reduce greenhouse gas emissions and enhance energy efficiency in the industrial sector. Energy growth will also come from the burgeoning small-scale sector, known in China as town and village enterprises (TVEs). These will probably not be as susceptible to global pressures and will pose a challenge to policy makers. How policy makers choose to resolve this dichotomy within the industrial sector and frame guidelines governing energy efficiency in TVEs will determine the energy profile of the industrial sector.

Policies in two other key areas will influence energy growth in China and other developing countries: (a) energy standards for buildings and policies for appliances and (b) urban mass transport. These are areas where substantial energy growth is occurring.

I am surprised at the low impact of renewables in the model outputs presented in the paper by Professor Grubb and wonder whether this is a result of the modeling assumptions and design. Renewables, particularly modern biomass, have the potential to meet rural energy demand—and are already doing so in many parts of the developing world. I believe that if we can replace the current inefficient and dirty use of biomass by modern technologies, we can meet higher-quality energy needs, reduce biomass use, and prevent the shift from biomass to fossil fuels with greenhouse gas emissions.

These choices make an important difference. As Professor Grubb's paper shows, there are large differences in per capita CO₂ emissions across developed countries. These differences emerge from the policy, infrastructural, and lifestyle choices different countries make.

Green energy, energy efficiency, and low-energy infrastructure development provide technological solutions. Low greenhouse gas-technological choices exist and are in use around the world. The key is to accelerate their adoption in developing countries, where nearly half of crucial infrastructure is yet to be built. The early adoption of cleaner technology helps “lock in” a society to their use. Even if renewable energy

appears an expensive option now, promotion of early adoption makes sense, because it familiarizes a society in its use and develops the manufacturing, supply, financing, and operational experience that help reduce its cost and enhance its sustainability.

Renewables also provide a level of comfort, as the world increasingly worries about energy security. They offer the best solution, because they are nonpolluting, provide local benefits, and are not subject to the vagaries of geopolitics.

Renewables are also desirable because they enhance energy access and reduce local pollution. Appropriate financing and volume growth will bring down initial high costs. India, for example, has a tremendous potential in renewable energy generation. Recently, the private sector has shown a keen interest in developing this sector, which has now started to show results. Last year, the addition of renewable capacity to the grid exceeded that of fossil fuels, and the annual electricity supply from renewables now exceeds that from nuclear power. Even so, not enough effort has been made to involve the general public in supporting development of renewables, which can be promoted through notions such as green power. This presents a tremendous opportunity for consumer involvement and accelerated growth of renewable energy. Renewables can be viewed as an international public good, which might help bolster their development and provide easier access to finances and technology. Thus global climate change concerns can be piggy-backed on to local concerns.

Developmental paths that lead to a high-quality, low greenhouse gas trajectory are clearly possible, particularly when the full costs of any infrastructure project—that is, costs that include the financial, social, and environmental costs—are taken into account. The clearest example is the contrast between the development of the transportation sector in Europe and the United States. European countries, by and large, have promoted the development of excellent mass rapid transport systems and enabled and encouraged their people to take to the healthy habit of cycling as means of daily commute and sport. In contrast, different infrastructure patterns and societal norms have locked the United States into a lifestyle based on automobile use. This has created a vicious spiral, in which infrastructure development in the transportation sector was targeted mainly toward the automobile, which in turn became one of the defining elements of American society. This example illustrates that lifestyle choices matter and that early infrastructural choices can lock societies into lifestyles based on high or low greenhouse gas emissions.

There is also the issue of intracountry disparity in regional planning. Resource-rich regions are often developmental laggards. Integrating these regions into the high-development economy will reduce the greenhouse gas emissions associated with transport from these regions.

Thus although technological fixes (through early technological lock-ins) do exist, lifestyle choices will play a significant role in defining the rate and extent of climate change. Lifestyle will determine almost everything, from the profile of household waste to the environmental footprint. With the proliferation of mass media, millions of people around the world are exposed to and attracted by the glamour of Western lifestyles. Denying them these "goodies" will not be easy.

Spirituality can play a significant tempering role, along with a public information campaign identifying the follies of high-consumption developmental paths. As

Mahatma Gandhi said, the world has enough resources to meet the needs of everyone, though not to satisfy everyone's greed. When I was the Indian environment minister, I called for a meeting of heads of all prominent religious groups in India and solicited their help in protecting and conserving the environment. Former World Bank President James Wolfenson reached out to religious heads in a similar attempt.

I would now like to spend some time addressing adaptation concerns. The adverse impacts of climate change increase the vulnerability of people, especially those whose livelihoods depend on natural resources. Such people—farmers, fishers, and the like—form the bulk of the population in developing countries. Ensuring that their lifestyles and livelihoods adapt to climate change is therefore an urgent challenge.

Climate change impacts come on top of the already overstretched carrying capacity of most of the world's ecosystems. Population growth and carrying capacity are already in conflict, posing a dire threat to the most vulnerable people, who are already poor and subsist on meager natural resources for their daily survival.

Climate variability and climate change also pose serious threats to poverty eradication. Such development challenges are being grappled with at the national as well as the international level. Integrating climate change concerns into development programs will be key to achieving the Millennium Development and Sustainable Development Goals. I commend the lead taken by the World Bank in developing the tools and pilot projects to support this integration.

To meet these challenges, I see a need to study and assimilate adverse impacts of climate change into the process of development planning. The problem is that the impacts are local and specific to communities and cannot often be generalized. To operationalize these measures, we need to undertake sectoral assessments of the impacts of climate change on water resources, agriculture, forestry, natural ecosystems, coastal zones, human health, energy, and infrastructure.

As a result of climate change, there will likely be a change in the amount, timing, and distribution of rain and runoff, leading to changes in water availability as well as competition for water resources. Changes are also likely in the timing, intensity, and duration of both floods and droughts, with related changes in water quality. In this context, it is essential to assess the likely water demands of different sectors and the impact of climate change on the spatial and temporal patterns of water availability. These assessments will help us figure out where problems will occur, what kinds of problems will occur, and what kind of tensions need to be addressed.

The impact of climate change on agricultural productivity of crops needs to be evaluated. Climate outputs of regional models need to be integrated with crop assessment models, and sensitivity analysis needs to be conducted of different components of the agricultural sector to climatic variability. The impacts on livestock of a changing pattern of feedstock availability as a result of climate change need to be assessed. Projections of sea-surface temperature should be used to assess the conditions of fishing habitats and changes in breeding and movement of fish along coastlines. These projections will help policy makers identify and prioritize interventions.

Natural systems are especially vulnerable to climate change, because of their limited adaptive capacity; some of these systems may undergo significant and irreversible

damage. There needs to be a systematic program of documenting ecosystem processes, modeling climate change impacts, and formulating strategies for adaptation.

More detailed assessments of sea-level rise need to be conducted. In addition, assessments need to be made of vulnerability, measured in terms of loss of life, damage to assets, and loss of employment and livelihood systems as a result of sea-level rise and changes in the frequency and intensity of storm surges and cyclones.

Huge investments are being committed to infrastructure projects. Climate change can adversely affect infrastructure if care is not taken in its design. Warming will result in increased demand for cooling and decreased demand for heating energy, with the overall net effect varying with geographic region.

Some studies have examined the effect of climate change on vectorborne disease, such as malaria. Socioeconomic and land use considerations need to be incorporated into these studies, along with climate parameters. Other diseases, such as dengue, and the impacts of heat stress also need investigation.

There is an urgent need to integrate adaptive responses in design and planning. These responses will be in the context of the choices of technologies, institutions, and social and economic instruments. Options for risk mitigation and risk coverage through insurance need to be explored.

We need to understand what we need to do differently in the face of climate impacts. We need to understand when we need to act differently, where we need to act differently, and how our actions need to change. Knowledge of these what's, when's, where's, and how's is at the heart of adaptation. I think generation of this knowledge, and efforts to enable its use, form the basis of the transitional costs that Prof. Grubb spoke about. I believe these transitional costs—which are knowledge-based incremental costs—should be financed largely by the global community.

I would like to end by reiterating the need to move beyond financial gross national product (GNP) as a measure of a country's progress. Both the use of energy resources and the adverse impacts of climate change reemphasize the need for a broader criteria for growth and progress, one that integrates natural resource depletion and environmental degradation. Use of such a measure would help focus politicians' attention, since they focus largely on what is measured. I would request the World Bank to initiate reporting of green GNP for all countries along with the conventional GNP that is reported.



Comment on “Climate Change Impacts, Energy, and Development,” by Michael Grubb

ZMARAK SHALIZI

Michael Grubb’s paper eloquently makes the point that climate change is a real problem. Here I add a few complementary points that are important for thinking about current actions and their future implications. Global climate has warmed over the past century—on this point there is no controversy. To a large extent this is associated with human activities—on this point there is some but not much remaining controversy. The physics is quite clear: more greenhouse gas emissions lead to more atmospheric concentrations, which in turn lead to higher average temperatures. The economic implications are becoming clearer: higher temperatures increase local and global damages, including the economic consequences of changes in the location and intensity of precipitation, increasing glacial melts and severity of storm surges, shifts in the Gulf stream, and other potentially catastrophic events.

There are still, however, genuine uncertainties regarding the nature, magnitude, and thresholds at which the medium- and long-term impacts of climate change will occur and their associated economic costs. Uncertainty about physical impact is higher at the local level than at the global level. Uncertainty is higher for the variance and for extreme events than for average physical trends. Unfortunately, some low-probability events can have potentially catastrophic consequences that cannot be self-insured and remain of concern, hence the controversy on what to do. While industrial countries account for the bulk of past emissions and existing concentrations of greenhouse gases, developing countries will account for more than half of future emissions (but not concentrations) starting between 2020 and 2035 (IPCC 2000).

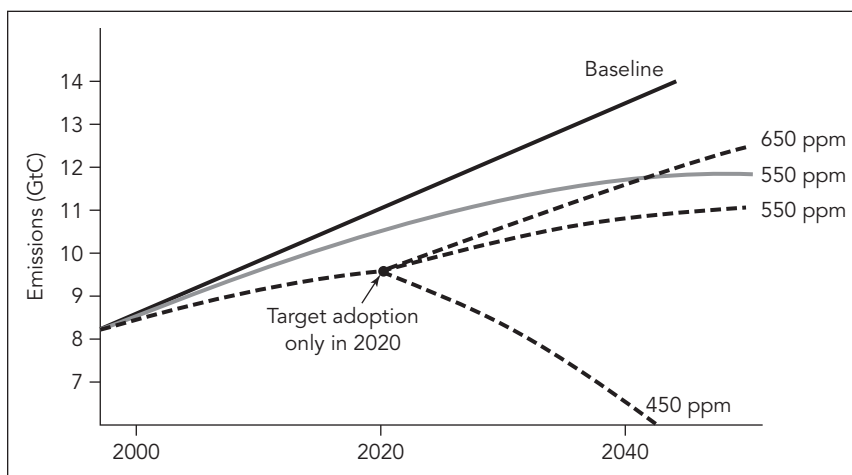
How much action is needed requires balancing the benefits of delaying action until more information and more cost-effective technologies are available against the costs of uncertainty and path dependency. In light of uncertainty on the safe threshold, action should commence earlier and be modified as new information

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FIGURE 1
Optimal CO₂ Emission Strategy in the Presence of Uncertainty and Certainty



Source: Ha-Duong, Grubb, and Hourcade 1997.

Note: ppm = parts per million; GtC = giga tonnes carbon.

Baseline (—) Under certainty (—) Under uncertainty (-----)

becomes available (Ha-Duong, Grubb, and Hourcade 1997). Action today should target a lower threshold than might be required in a world of certainty, with the option for midcourse corrections if new information warrants accelerating or decelerating actions (figure 1).

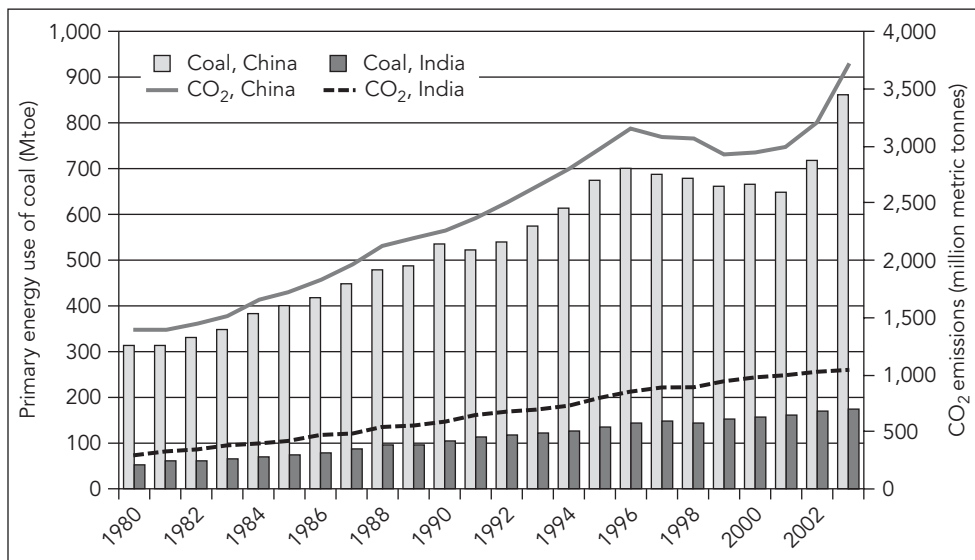
This prescription needs to be augmented with the recognition that some current investments in long-lasting infrastructure will create path dependencies that can “lock in” inefficient energy structures for decades, limiting the scope for midcourse corrections. This is particularly important in the case of the two giant economies in Asia (China and India). The economies of both of these countries are growing rapidly, and both are undergoing one-time demographic/urbanization transitions, with implications for massive infrastructure investments that can lock in energy consumption patterns.

Take the case of space heating and cooling in China and India. A massive building boom is underway in both countries for commercial and residential use, requiring heating and air-conditioning. A 2001 World Bank study shows that space heating for residential buildings in China consumes 50–100 percent more energy than in Western Europe or North America at equivalent latitudes. China’s space heating alone consumes 130 million tons of standard coal equivalent per year—more coal than Germany consumes for all purposes (in energy terms). Burning of this coal yields 350 million tons of greenhouse gas a year, equivalent to the total annual greenhouse gas emissions of France or Poland. The government of China has promulgated new energy-efficiency standards for buildings, but most buildings being constructed are still based on old, highly energy-inefficient designs, because standards are generally not enforced (for multiple reasons, including split incentives).

More than half of China’s urban residential and commercial building stock in 2015 will have been built after 2000. The construction boom will continue until the

FIGURE 2

Primary Energy Use of Coal and Total CO₂ Emissions from Fossil-Fuel Consumption in China and India, 1980–2003



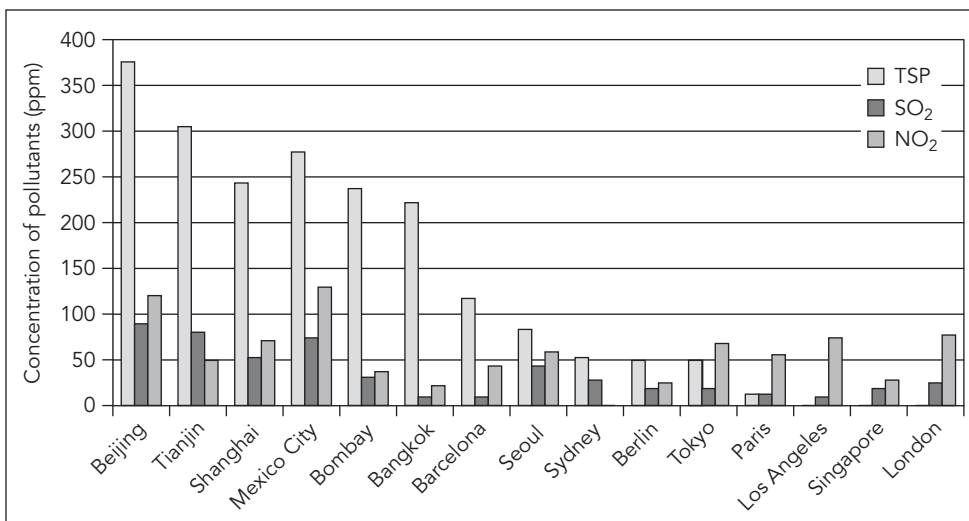
Source: IEA 2005a, 2005b.

urbanization process is completed. Thereafter the physical capital stock will turn over at a much slower rate. This suggests that there is a one-time opportunity now to rapidly “grow out” of the enormous energy waste problem. By acting immediately to make buildings more energy efficient, it is possible to save more than 50 percent in energy costs by incurring a 10 percent increase in construction costs—for a large net gain. Taking action would significantly reduce greenhouse gas emissions, with positive implications for global warming. If actions are not taken now, lock-ins will limit options in the future. Every year lost in developing more efficient buildings locks in some 700–800 million square meters of urban residential and commercial building floor area, creating inefficient energy use for 60–70 years; retrofitting these buildings is costly. The story for India is analogous. Whether actions are taken today will determine the long-term gain/loss to individuals and society in China and India, as well as the world.

Because the efficiency and reliability of the power/electricity sector is important for both households and firms, both China and India have fast-growing electric power industries. Industry accounted for much of the growth in electricity demand in the past (figure 2). In contrast, in the future the residential/commercial sector is expected to generate the most rapid growth in electricity demand. Electricity production is fueled primarily by cheap domestic coal, which generates harmful emissions globally and locally. Local pollutants from fossil fuels are much higher in China and India than in Organisation for Economic Co-operation and Development (OECD) countries (figure 3).

Between 1997 and 2001, GDP in China grew 34 percent. Yet carbon dioxide (CO₂) emissions rose just 0.2 percent, not the 14 percent that would have been

FIGURE 3
Level of Air Pollutants in Selected Cities, 2000



Source: Hao and Wang 2005.

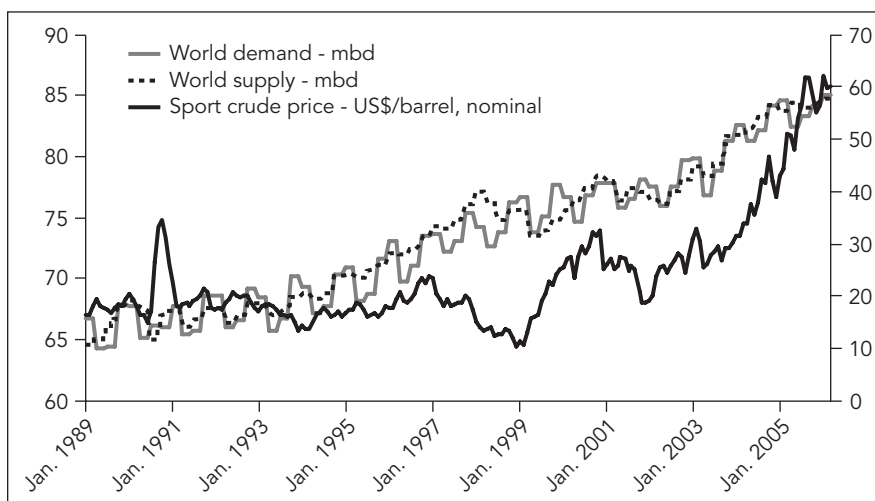
ppm: parts per million.

expected based on the historical relation between emissions and GDP over the 1980–97 period. The negligible increase gave rise to much optimism regarding the potential for decoupling emissions from GDP growth.

Several factors explain this performance; their relative weight is still being debated. Poor statistical reporting may account for a significant part of the apparent decoupling. But there is also agreement that the closing of a large number of small and inefficient coal producers was a contributing factor. Unfortunately, keeping this coal off the market could not be sustained. In the presence of low power tariffs, black-outs, and power shortages arising from 9–10 percent annual GDP growth, it has not been possible to avoid using all power-generating capacity, no matter how inefficient. This has resulted in a resumption of growth in coal use and in emissions of CO₂ and sulfur dioxide (SO₂).

As a result of these problems, major investments are now underway to expand the share of alternatives to fossil fuels in generating electricity, such as nuclear, hydro, wind, and solar energy. Although coal is likely to remain the most significant fossil fuel throughout the next two decades, electricity generation is the sector in which leap-frogging through fuel switching has the most potential benefits—albeit with higher costs.

Both China and India have embraced motorization for personal and commercial purposes. The transport sector will soon emerge as a leading consumer of energy, generating a variety of harmful emissions at the local, regional, and global levels. The rapid growth in the demand for mobility (road transport as well as aviation) is leading to a surge in demand for oil in both countries. This is contributing to long-term pressures on international oil and oil product markets, though the most recent short-term price increases reflect tightening of supplies as a result of geopolitical problems

FIGURE 4**Global Demand for and Average Spot Prices of Crude Oil, 1989–2005**

Source: IEA 2006.

mbd: million barrels a day.

and growing uncertainties regarding spare capacity by the Organization of Petroleum Exporting Countries (OPEC) (figure 4).

In the medium run, the introduction of hybrids and biofuels is the most promising way to reduce carbon emissions. Both governments, particularly the Chinese government, are creating the necessary enabling frameworks. It may still take decades to fully displace oil. Both India and China will also have to address more seriously the issue of urban form¹ and establish more balanced multimodal transport systems by designing transport infrastructure systems that generate fewer externalities, including carbon emissions.

Developing countries need substantial growth to meet the needs of their growing population and to improve standards of living. Achieving rapid growth will necessitate massive investment in new infrastructure (long-lived capital) that does not lock in inefficient energy paths. Investing in clean energy options sooner will be less costly than retrofitting them later. But investing in these alternative fuels may still be more costly than investing in fossil fuels, the market prices of which do not reflect the cost of externalities imposed, in the near term. Reforming incentives² and institutions will be a precondition for successful adoption of clean technologies.

OECD countries are in a better position to augment change in developing countries by supporting joint development of cutting-edge technology and providing additional financing for higher-cost technologies in developing countries when abatement options are more expensive in OECD countries. Little financing, beyond what has already been committed, is likely from the Clean Development Mechanism/Joint Implementation (CDM/JI) program in the short run (that is, the Kyoto period up to 2012). These project-based mechanisms have high transaction costs per project; they are unlikely to be scaled up sufficiently to make a significant contribution to covering the financial requirements of the additional investment required to move from a

business-as-usual to a low-carbon scenario. To receive substantial coverage of their additional energy financing requirements, China and India may have to agree to quotas or some equivalent commitment in internationally agreed commitments beyond the Kyoto period (there could be a one to two decade transition before full commitments go into effect). More research is required on the infrastructure and energy investment opportunities and constraints facing China and India, given their centrality to global energy and emissions trajectories in the next few decades.

Notes

1. Compact cities generate fewer vehicle miles traveled (see Bento and others 2003).
2. Oil prices in China are currently implicitly subsidized; retail prices are 20–30 percent lower than costs/international prices. Exchange rate appreciation in China over time will make oil cheaper in local-currency terms, which could fuel increased demand for oil. These subsidies could be removed simultaneously with an exchange-rate appreciation to offset the drop in local prices, thereby limiting the expansion of demand at low social cost. However, once implicit price subsidies have been removed, Pigouvian taxes will have to be considered seriously. India will also have to consider addressing fossil-fuel externalities through taxes and regulations.

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Rural Infrastructure and Agricultural Development

PER PINSTRUP-ANDERSEN AND SATORU SHIMOKAWA

Agricultural development is essential for economic growth, rural development, and poverty alleviation in low-income developing countries. Increasing agricultural productivity is an effective driver of economic growth and poverty reduction, both within and outside agricultural sectors. Increasing productivity requires good rural infrastructure, well-functioning domestic markets, appropriate institutions, and access to appropriate technology. Despite the well-documented importance of rural infrastructure to promote growth and reduce poverty, high economic rates of return to investments in rural infrastructure, and significant deficiencies of rural infrastructure in most developing countries, neither national governments nor international aid agencies seem to prioritize investments in the construction of new infrastructure or the maintenance of existing infrastructure. Failure to accelerate investments in rural infrastructure will make a mockery of efforts to achieve the Millennium Development Goals in poor developing countries and severely limit their ability to benefit from trade liberalization, international capital markets, and other potential benefits of globalization.

Agricultural development is important for overall economic growth and poverty reduction, and rural infrastructure is crucial in achieving or accelerating agricultural development. Yet rural infrastructure has been inadequate in developing countries. Worse still, investment in rural infrastructure has been decreasing in developing countries since the 1990s. Enhanced investment in the construction of new rural infrastructure and the maintenance of existing infrastructure is necessary for developing countries to achieve or accelerate economic development and reduce poverty.

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Importance of Agricultural Development for Economic Growth, Rural Development, and Poverty Alleviation

Agriculture constitutes the core of the economy of most low-income developing countries. In heavily indebted poor countries, the agricultural sector generated 33 percent of gross domestic product (GDP) and 52 percent of total merchandise exports in 2002 (World Bank 2005). The sector accounted for about 60 percent of employment in low-income countries in 1995. Even in East Asia and the Pacific, where economic growth has been rapid, the agricultural sector accounted for 46 percent of employment, generated 16 percent of GDP, and was responsible for 10 percent of total merchandise exports in 2000.

Such economic dominance of agriculture demonstrates the importance of agricultural development for economic growth and poverty alleviation in developing countries. Moreover, although the relative contribution of agriculture to overall economic growth decreases as an economy develops, agricultural development provides a crucial foundation for economic growth in both agricultural and nonagricultural sectors. Virtually every high- and middle-income country, with the exception of city-nations such as Singapore and Dubai, has gone through a period of development during which agricultural growth was essential to foster general economic growth and poverty alleviation.

Low-income countries with stagnant agriculture usually have a stagnant economy. Moreover, endeavors to jump directly to modern industrialization without paying enough attention to agricultural development in the early stages of development have tended to result in slow economic growth and weak poverty alleviation (Rottso and Torvik 2003; Gulati, Fan, and Dalafi 2005).

Agriculture as the Driver of Economic Growth

The early development literature considered the role of agriculture in economic development to be a supportive one for industrial sectors—ensuring a supply of cheap food for workers in industrial sectors, for example (Lewis 1954). Since the 1960s, a more active role of agriculture as the driving force of overall economic growth has been recognized and emphasized (see, for example, Johnston and Mellor [1961]; Schultz [1964]; Mellor [1966]). A large share of subsistence and semisubsistence agriculture has been transformed through the adoption of new technology, investments in rural infrastructure and markets, and the design and implementation of appropriate policies. This transformation leads to an increase in the productivity of land and labor, rising incomes for farmers and farm workers, and enhanced purchasing power for consumers. Low food prices achieved by reduced unit costs of production contribute to lower wages in nonagricultural sectors and thus facilitate industrial growth. Agricultural growth also contributes to economic activity in input, processing, distribution, and storage industries, generating multiplier effects beyond agriculture. In addition, higher agricultural incomes induce a rise in demand for goods and services produced in other sectors (Hazell and Röell 1983).

A number of empirical studies (Hazell and Röell 1983; Haggblade, Hammer, and Hazell 1991; Delgado and others 1998; Fan, Hazell, and Thorat 2000; Fan, Zhang, and Zhang 2002) conclude that the multiplier effects of agricultural growth are usually greater than two. The size of the multiplier varies spatially and over time, reflecting differences in consumption, investment, and saving patterns. Mellor (1976) finds that multiplier effects become large when productivity among small farms in a rural economy in Asian countries increases significantly. Small- to medium-size farm households typically have more favorable expenditure patterns for promoting growth of the local nonfarm economy, including rural towns, because they spend larger shares of income on rural nontraded goods and services, which are also generally more labor intensive (Hazell and Röell 1983).

In a study of four African countries, Delgado and others (1998) estimate the income multiplier to be about 2.5, meaning that each additional \$1 of income from agriculture generates about \$2.50 of economic growth in the economy as a whole. In the more open economies of Asia, where rice was more tradable than most African staple foods and local prices more easily reflected border prices, the multiplier effects were close to 2 in the early stages of agricultural modernization, when productivity gains were fastest. Using data for 62 developing countries during 1960–90, Gollin, Parente, and Rogerson (2002) find that agricultural growth explains 54 percent, nonagricultural growth 17 percent, and sectoral labor shifts 29 percent of the growth of GDP per worker.

Agricultural Development and Pro-Poor Growth

Agricultural development has significant potential to contribute to nationwide poverty reduction, through direct effects on farm incomes and employment and indirect effects on overall economic growth, as well as its impact on food prices. A number of studies have found a positive correlation between agricultural growth and poverty alleviation (see Byerlee, Diao, and Jackson [2005] for a detailed review). These studies show empirically that poor people tend to benefit more from economic growth originating in agricultural sectors than from growth originating in industrial or service sectors (Ravallion and Datt 1996; Ravallion and Chen 2004; Timmer 2002, 2005). In addition, using data for India for 1951–90, Ravallion and Datt (1996) show that rural growth through agricultural development reduces poverty not only in rural areas but also in urban areas and hence has a significant and positive effect on national poverty reduction.

Several studies find that the elasticity of poverty reduction with respect to agricultural productivity is significant, positive, and higher than the elasticity with respect to productivity in other sectors, especially during the early stages of development. Thirtle, Lin, and Piesse (2003) estimate the elasticity of the reduction in the number of people living on less than \$1 per day with respect to agricultural productivity growth using data from 59 countries for 1985–95. According to their estimates, the elasticity was 0.72 in Africa (73 percent of the total impact of increases in per capita GDP) and 0.48 in Asia (67 percent of the total impact). Using state-level data for

India for 1957–91, Datt and Ravallion (1998) estimate the elasticity with respect to agricultural value added per hectare. Their estimates are 0.38 for the poverty headcount, 0.55 for the poverty gap, and 0.80 for the squared poverty gap.

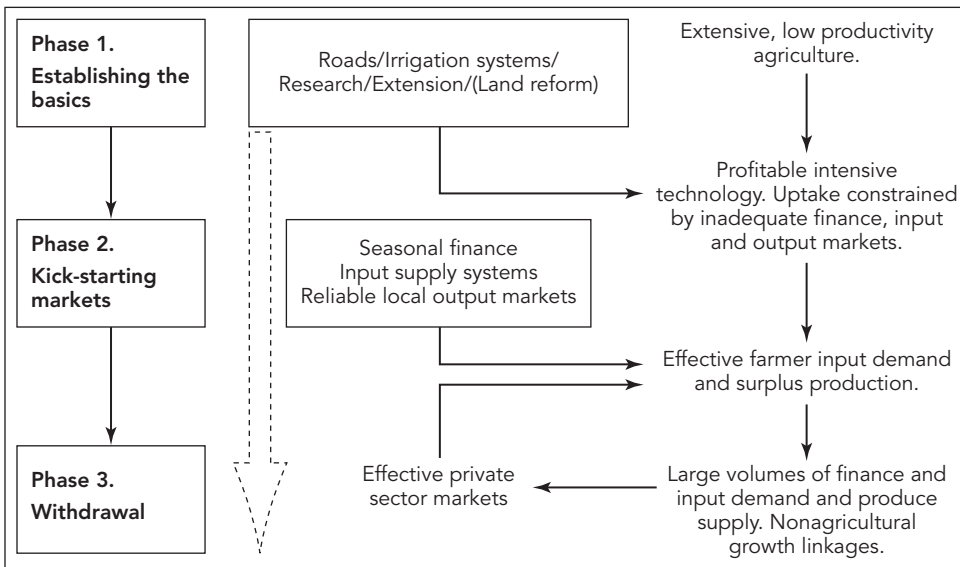
An increasing number of studies have questioned the effect of agricultural growth on poverty reduction following several failures of earlier investments in agriculture-led development, increased recognition of the importance of nonfarm activities in rural livelihoods, and increased difficulties in the global environment for sustaining pro-poor agricultural growth (as a result of such factors as decreasing agricultural prices, trade liberalization, and the spread of HIV/AIDS) (Dorward and others 2004a). Despite the significant potential contribution of agricultural growth to overall economic development, a combination of market failures and poor policy environments in many developing countries has led to failures of agriculture-led development. Moreover, the failure to liberalize agricultural trade or reduce domestic agricultural subsidies in the Organisation for Economic Co-operation and Development (OECD) countries has resulted in low world market prices of agricultural commodities, making agriculture less profitable for developing countries and reducing private and public investments in agriculture. The question is thus not whether agricultural growth is essential to generate rapid economic growth and poverty alleviation in poor countries but whether these countries and the international policy and trade environment surrounding them create an enabling environment for it to do so, including trade liberalization, appropriate economic policies, investments in research and technology, and the building of the necessary rural infrastructure and well-functioning domestic markets.

There are few, if any, other candidates with the same potential for supporting broad-based pro-poor growth. Agriculture thus remains a critical element in efforts to promote broad-based economic growth and poverty alleviation, despite the policy failures mentioned above. Several recent studies (Diao and others 2006; Dorward and others 2004a, b; Kydd and others 2004) emphasize the importance of institutional development (both the institutional environment and arrangement¹) to overcome these difficulties. Key functions of governments and other actors promoting development (such as the World Bank) are then to support institutional development and rural infrastructure that will reduce transaction costs.

Several processes are necessary for rapid growth in food production and the wider economy in poor rural areas. Technical, infrastructure, and market interventions contribute to pro-poor agricultural growth in each phase of development (figure 1).

Phase 1 involves basic interventions (such as infrastructure) to establish conditions for productive intensive cereal technologies. Once these are in place, uptake is likely to be limited to a small number of farmers with access to seasonal finance and markets. Agricultural transformation may then be kick-started by government interventions (in phase 2) to enable farmers to access seasonal finance and seasonal input and output markets at low cost and low risk. Subsidies are required primarily to cover transaction costs, not to adjust basic prices. Once farmers become familiar with the new technologies, their demand for credit and input and their supply of output will build up and transaction costs per unit will fall. Such farm activity positively influences volumes of nonfarm activity through its linkages, which contribute to a further

FIGURE 1
Policy Phases to Support Agricultural Transformation



Source: Dorward and others 2004a, 2004b.

reduction in transactions costs. Governments can then withdraw from these market activities and let private sectors take over (phase 3), reallocating their efforts to supporting conditions that will promote development of the nonfarm rural economy (Dorward and others 2004a, b).

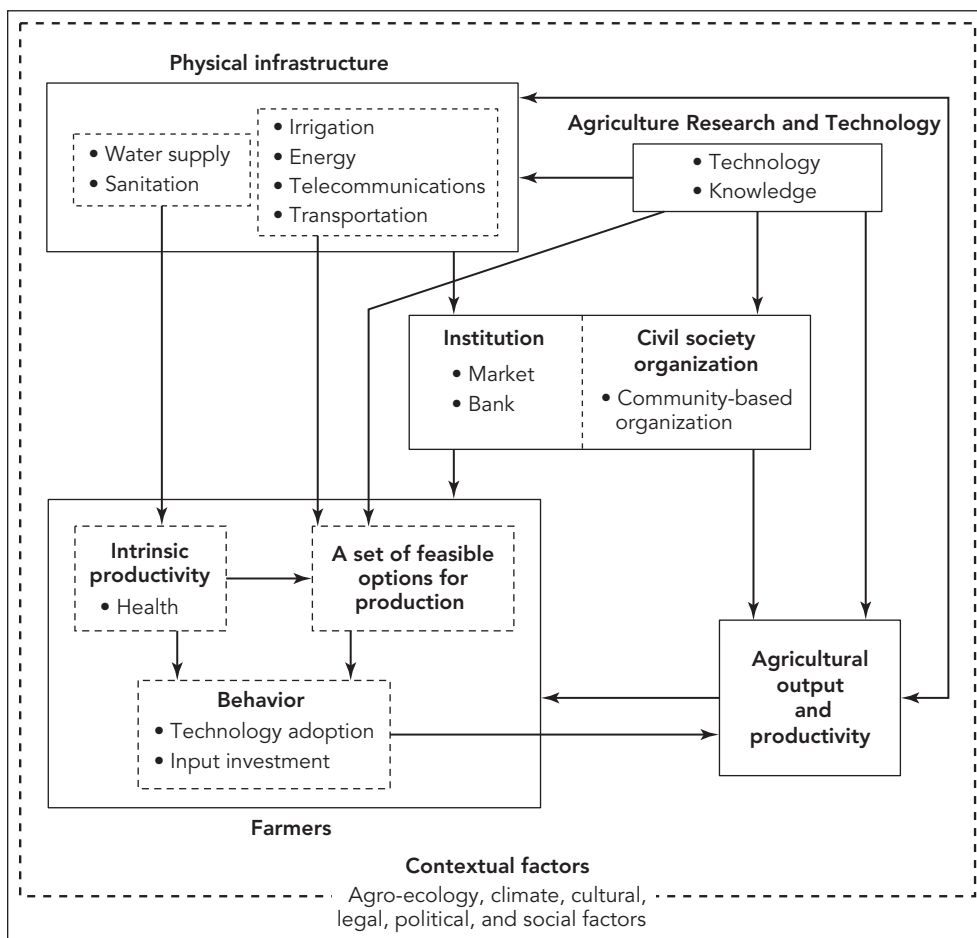
Importance of Infrastructure for Agricultural Development

One of the technical background documents for the World Food Summit, held in 1996, concluded that “roads, electricity supplies, telecommunications, and other infrastructure services are limited in all rural areas, although they are of key importance to stimulate agricultural investment and growth” (FAO 1996, p. 15). The document argued that “better communications are a key requirement. They reduce transportation cost, increase competition, reduce marketing margins, and in this way can directly improve farm incomes and private investment opportunities” (FAO 1996, p. 15). These conclusions are supported by several studies of infrastructure in developing countries (Antle 1984; Binswanger, Khandker, and Rosenzweig 1993; Fan, Hazell, and Thorat 2000; Mundlak, Larson, and Butzer 2002; Fan, Zhang, and Zhang 2002; Fan and Zhang 2004). These studies demonstrate that investment in infrastructure is essential to increase farmers’ access to input and output markets, stimulate the rural nonfarm economy and vitalize rural towns, increase consumer demand in rural areas, and facilitate the integration of less-favored rural areas into national and international economies.

Figure 2 describes the causal relations between physical infrastructure, agricultural research and technology, institutions, civil society organizations, farmer’s behaviors,

FIGURE 2

How Infrastructure Promotes Agricultural Development



Source: Authors.

and agricultural output and productivity. Physical infrastructure is divided into two groups, water supply and sanitation sectors and other sectors (irrigation, energy, telecommunication, and transportation), because the channels through which the sectors influence agricultural output and productivity are different. Irrigation, energy, telecommunications, and transportation create more options for production; water supply and sanitation improve health conditions and productivity. Based on this conceptual framework, the direct and indirect effects of infrastructure investments on agricultural output and productivity, market access and integration, and the development of institutions needed for successful agricultural development in developing countries are examined.

Agricultural Research and Technology

Insufficient infrastructure is one of the key bottlenecks for successful utilization of agricultural research and technology, because it limits farmers' options for production

and agricultural output. Where rural infrastructure provides a facilitating environment, economic returns to research and technology are usually high.

On the basis of data from 44 developing countries in three regions (Africa, Asia, and Latin America), Thirtle, Lin, and Piesse (2003) find high rates of return to agricultural research and technology. They find that Asia (12 countries) had the highest annual rate of return (31 percent), followed by Africa (22 percent; 18 countries), and Latin America (6 percent; 13 countries). Annual rate of returns were especially high (40–50 percent) in Ethiopia, Morocco, Pakistan, the Philippines, and Uganda. Rates of return were negative in Lesotho, Senegal, Sri Lanka, and Tanzania.

Fan, Zhang, and Zhang (2002) and Fan, Zhang, and Rao (2004) find that government spending on agricultural research and technology improved agricultural production substantially. They find marginal returns of 9.54 yuan per yuan expenditure in China (1997) and 12.1 shelling per shelling expenditure in Uganda (1992–99).

Several econometric studies estimate the effects of infrastructure investment (or stock) on agricultural output and productivity. Most of these studies find a positive and significant effect (see, for example, Antle [1984]; Binswanger, Khandker, and Rosenzweig [1993]; Mundlak, Larson, and Butzer [2002]; and Fan and Zhang [2004]).

A key concern in these studies is how to control for reverse causality from agricultural growth to infrastructure investments to obtain a consistent estimate of the causal effect of infrastructure on agricultural growth.² One of the most widely used methods to control for reverse causality is to take the difference between two time periods, as done in the fixed-effects model. However, the use of such a method can eliminate any long-term relation in the data. By capturing only short-term impacts, these models underestimate the effects of infrastructure (Fan and Zhang 2004; Munnell 1992).

Table 1 summarizes the estimation methods and results from selected studies. Although some results are not directly comparable because measurements of output and infrastructure investments differ, the results show that the magnitude of the effects of infrastructure varies across countries. The effects of infrastructure tend to be smaller when the endogeneity of infrastructure investment is controlled for.

Fan and Zhang (2004) present one of the most careful econometric analyses performed on the subject. They control for the reverse causality problem by employing a dynamic generalized moment of methods (GMM) technique. According to their estimates, investments in roads and irrigation contribute significantly to agricultural growth. Agricultural growth induces a much larger demand effect on irrigation than on roads. This may be because irrigation is sector-specific infrastructure, demand for which is more directly influenced by agricultural growth, while demand for roads depends on factors other than agricultural growth (Fan and Zhang 2004). Fan, Hazell, and Thorat (2000) find that public investment in rural roads has a large positive impact on agricultural productivity growth in India. Road investment also significantly contributes to agricultural growth as well as to growth in the nonfarm sector and the national economy (Fan, Zhang, and Zhang 2002; Fan and Chan-Kang 2005).

The quality of infrastructure is an important determinant of the effects of infrastructure on agricultural growth and poverty reduction (Fan and Chan-Kang 2005). When measured by kilometer of new road, Fan and Chan-Kang find that investment

TABLE 1. Effects of Infrastructure on Agricultural Productivity and Output in Selected Developing Countries

Country	Period	Method	Source	Control for endogeneity?	Agricultural productivity or output indicator	Infrastructure indicator (unit)	Effect
China	1997	SEM	Fan, Zhang, and Zhang (2002)	Yes	Agricultural GDP	Investment in irrigation (yuan)	1.88
						Investment in roads (yuan)	2.12
						Investment in electricity (yuan)	0.54
						Investment in telephone (yuan)	1.91
	1982–99	SEM	Fan and Chan-Kang (2005)	Yes	Agricultural GDP	High-quality roads (km)	—
						Low-quality roads (km)	1.16
					Agricultural GDP	Investment in high-quality roads (yuan)	—
						Investment in low-quality roads (yuan)	1.57
India	1970–71	OLS	Antle (1984)	No	Rice production (100 kg/farm)	Irrigation (dummy)	0.28**
						High-yielding variety (dummy)	0.21**
	1960–81		Binswanger, Khandker, and Rosenzweig (1993)	Yes	Aggregate output index	Irrigation ('000 hectares/10 sq. km)	0.026
						Electricity (number/10 sq. km)	0.028*
	1970–94	SEM	Fan, Hazell, and Thorat (2000)	Yes	Total factor productivity	Road (percentage change in expenditure)	0.057*
						Irrigation (percentage change in expenditure)	0.036*
						Electricity (percentage change in expenditure)	0.004
						Irrigation (percentage share)	0.081**
	1971–94	GMM	Fan and Zhang (2004)	Yes	Total factor productivity	Road density (km/sq. km)	0.042**
						High-yielding variety (percentage of cropped area)	0.039**

Indonesia	1971–98	PC	Mundlak, Larson, and Butzer (2002)	No	Agricultural GDP	Road (percentage growth in km [?])	0.084**
						Irrigation (percentage growth in share [?])	0.583**
Thailand	1971–95	PC	Mundlak, Larson, and Butzer (2002)	No	Agricultural GDP (percentage growth)	Road (percentage growth in km [?])	0.081**
						Irrigation (percentage growth in share [?])	0.103**
						Electricity (percentage growth in use [?])	0.045**
	1977–2000	SEM	Fan, Jitsuchon, and Methakunnavut (2004)	Yes	Agricultural output	Investment in irrigation (Baht)	0.71
Philippines	1961–98	PC	Mundlak, Larson, and Butzer (2002)	No	Agricultural GDP	Irrigation (percentage growth in share [?])	2.21**
Vietnam	1993–2003	SEM	Fan, Huong, and Long (2004)	Yes	Agricultural total product	Investment in irrigation (dongs)	0.42
					Value	Investment in roads (dongs)	3.01
67 LDCs	1961–90	OLS with dummies	Craig, Pardey, and Roseboom (1997)	No	Output per worker [?]	Road density (km/sq. km)	0.012
						Irrigated land (percentage share)	–0.29**
43 LDCs	1980–98	OLS	Fan and Rao (2003)	No	FAO agricultural output index	Road density (km/sq. km)	0.177*
						Irrigation (percentage share)	0.245**

Source: Mundlak, Larson, and Butzer 2002.

Note: SEM = simultaneous equation model; PC = principal component; OLS = ordinary least squares; GMM = generalized method of moments. [?] = unit of indicator was not stated explicitly in the source.

— Not available.

* Statistically significant at the 10 percent level.

** Statistically significant at the 5 percent.

in high-quality roads in China has close to 50 percent higher returns to total GDP than investments in low-quality roads. Investments in low-quality roads have the largest returns in total GDP in rural areas (41.5 percent higher), while the effects of high-quality roads are almost twice as high as those of low-quality roads in urban areas. In addition, once the effects are examined using the ratio of returns to costs (that is, taking the cost of construction into account), high-quality roads have lower returns per yuan than low-quality roads in all areas and regions. In other words, the economic rate of return per yuan is higher for low-quality roads than for high-quality ones.

Agricultural Input and Output Markets

Market integration over space and time requires good infrastructure and effective market institutions. Where spatial market integration is poor, favorable local growing conditions, improved production practices, or adoption of modern technologies that result in higher marketable surpluses may result in drastic drops in prices locally, while other areas may suffer from shortages and rapidly increasing prices. Such large spatial price differences and abrupt intertemporal price changes are common in low-income countries with poor infrastructure, poorly functioning markets, or both. Maize prices in Ethiopia, for example, tripled between 1997/98 and 1999/2000, followed by an 80 percent drop in prices from 1999/2000 to 2000/2001. In Malawi, the price of maize quadrupled between April 2001 and April 2002 (Pinstrup-Andersen 2002).

The supply response by small farmers is also seriously affected by the state of infrastructure and market. Chhibber (1988) finds that a 1 percent increase in output prices would result in a supply response of 0.3–0.5 percent in areas with poor infrastructure and 0.7–0.9 in areas with good infrastructure. Farmers' willingness to adopt productivity-enhancing technology depends very significantly on the infrastructure and market situation they face.

In most low-income developing countries, market integration is limited by poor transport, storage, and communication infrastructure; lack of effective competition among market agents; limited rule of law; and restricted access to commercial finance. Price changes in urban or world markets may not be fully transmitted to producers and traders. Worse still, without effective competition, economic agents with greater market power may exercise control over pricing strategies that result in a slow and incomplete pass-through of price increases and a rapid and complete transmission of price decreases.

While privatizing agricultural marketing has benefited farmers, consumers, or both in many countries, it is important to recognize the role of the state in facilitating private transactions. A number of public interventions, such as standardization, grading, and enforcement of contracts and regulations, are needed to make private markets work.

Other Institutions

In addition to facilitating access to output and input markets, financial institutions provide access to credit and savings for farmers. Microcredit schemes have been successful in providing access to small amounts of credit for the rural poor, mostly

in Asia. However, the credit market for smallholders—notably in Sub-Saharan Africa—often functions very poorly, and credit constraints are a major reason why smallholders fail to increase productivity and choose more profitable production strategies. Credit constraints negatively affect plot size (Hazarika and Alwang 2003); fertilizer use (Croppenstedt, Demeke, and Meschi 2003); and total productivity (Freeman, Ehui, and Jabbar 1998).

Public investment in infrastructure is important to create the enabling environment for a well-functioning capital market in rural areas. However, publicly financed or managed financial institutions have a very poor track record. Fortunately, infrastructure improvements tend to attract private financial institutions to rural areas. Binswanger, Khandker, and Rosenzweig (1993) show that private banks are more likely to locate in areas with better road infrastructure and marketing systems. Improved rural infrastructure also encourages marketing agents to extend credit to farmers at lower interest rates, because risks are lower.

It is reasonable to expect that more profitable and better-equipped environments facilitate the formation of civil society organizations (CSO), such as community-based organizations, nongovernmental organizations, and foundations. Pretty (2003) argues that CSO activity could contribute to improving local knowledge and social capital, which are effective in strengthening watershed/catchment management, irrigation management, microfinance delivery, forest management, integrated pest management, wildlife management, and farmers' research groups. An important contribution of CSOs in developing countries has been the development of credit and savings systems for poor families, which helps poor people find a way out of the credit trap.

Rural Infrastructure and Poverty Alleviation

Rural infrastructure affects the environment for the poor and their ability to connect to the national and international economy in several ways. The positive effects of infrastructure investments on real incomes in both agriculture and nonagriculture sectors help reduce poverty. Infrastructure also reduces poverty directly by providing and supporting the delivery of key services, such as access to safe water and basic sanitation, especially in the very early stages of development. The examination of such effects of infrastructure is especially important in the context of achieving the Millennium Development Goals (MDGs). In addition, human development (for example, education and health) relies on services that require supportive infrastructure—water and sanitation to prevent disease, electricity to serve schools and health clinics, and roads to access the facilities (Datt and Ravallion 1998; Deininger and Okidi 2003). The lack of appropriate infrastructure is a major bottleneck in efforts to achieve the MDGs and accelerate poverty alleviation in developing countries.

In a comprehensive analysis of the impact of rural roads in Bangladesh, Khandker, Bakht, and Koolwal (2006) find significant poverty reduction (5–6 percent) brought about through increased agricultural production, higher wages, lower transportation costs, and higher output prices. Investments in rural roads also led to increased schooling, with proportionally greater gains for poor people than the nonpoor.

Several studies estimate the effects of infrastructure investments on poverty measurements (table 2). These studies in six developing countries simultaneously

TABLE 2. Effects of Infrastructure on Poverty Reduction in Selected Developing Countries

Country	Year	Method	Source	Poverty measure	Infrastructure indicator	Effect
China	1997	SEM	Fan, Zhang, and Zhang (2002)	Number of poor reduced	Investment in irrigation (10,000 yuan)	1.33
					Investment in roads (10,000 yuan)	3.22
					Investment in electricity (10,000 yuan)	2.27
					Investment in telephone (10,000 yuan)	2.21
	1982–99	SEM	Fan and Chan-Kang (2005)	Number of urban poor reduced	High-quality roads (km)	5.53
					Low-quality roads (km)	3.61
				Number of urban poor reduced	Investment in high-quality roads (million yuan)	8
					Investment in low-quality roads (million yuan)	27
				Number of rural poor reduced	High-quality roads (km)	8.97
				Number of rural poor reduced	Low-quality roads (km)	21.59
					Investment in high-quality roads (million yuan)	13
					Investment in low-quality roads (million yuan)	161
India	1970–94	SEM	Fan, Hazell, and Thorat (2000)	Number of poor reduced	Investment in roads (million rupees)	123.8
					Investment in irrigation (million rupees)	9.7
					Investment in electricity (million rupees)	3.8

Tanzania	2000–01	SEM	Fan, Nyange, and Rao (2005)	Number of poor reduced	Investment in roads (million shillings)	26.53
					Access to electricity (percent)	141,962
Thailand	1977–2000	SEM	Fan, Jitsuchon, and Methakunnavut (2004)	Number of poor reduced	Investment in irrigation (million bahts)	7.69
					Investment in roads (million bahts)	107.23
					Investment in electricity (million bahts)	276.07
Uganda	1992–99	SEM	Fan, Zhang, and Rao (2004)	Number of poor reduced	Investment in feeder roads (million shillings)	33.77
					Investment in murram roads (million shillings)	9.70
					Investment in Tarmac roads (million shillings)	9.73
Vietnam	1993–2002	SEM	Fan, Huong, and Long (2004)	Number of poor reduced	Investment in irrigation (billion dongs)	12.93
					Investment in roads (billion dongs)	132.34
43 LDCs	2000	QR	Leipziger and others (2003)	Child mortality (per 1,000)	Access to piped water (percent)	–0.08**
					Access to electricity (percent)	0.00
					No improved sanitation (percent)	–0.01

Source: Authors, based on sources cited in the table.

Note: SEM = simultaneous equation model; QR = quintile regression.

* Statistically significant at the 10 percent level.

** Statistically significant at the 5 percent.

estimate the effects of infrastructure investments on some endogenous economic factors (such as wages and labor productivity) and poverty reduction, using a simultaneous equation model (SEM). This is one way of controlling for the endogeneity of infrastructure investments without losing information about the long-run effects of infrastructure by differencing. These studies consistently show the importance of infrastructure in promoting poverty alleviation. Fan, Zhang, and Zhang (2002) document the critical role of infrastructure development—particularly roads and telecommunications—in reducing rural poverty in China between 1978 and 1997. They also show that poverty fell as a result of the growth in rural nonfarm employment that followed the expansion of infrastructure. Infrastructure investments along with appropriate institutions can reduce rural poverty in a variety of ways. Microcredit schemes have been successful in generating incomes in both small-scale agriculture and, in particular, nonagricultural rural enterprises. Similarly, the introduction of fixed and mobile phones to the rural poor has provided new opportunities for income generation and poverty reduction (see, for example, Torero and von Braun 2005). Innovative uses of the Internet offer new opportunities that are yet to be fully exploited.

Infrastructure investments do not have to be costly to have a sizable impact, as Fan, Zhang, and Rao (2004) show for rural Uganda. Indeed, investments in low-grade roads (that is, feeder roads) reduced the number of poor Ugandans by more than three times as much as investments in more costly high-grade (murrum or tarmac) roads. Fan and Chan-Kang (2005) show that an additional 1 kilometer of low-quality roads has a higher return than that of high-quality roads in rural areas of China, although the opposite is true for urban areas. Moreover, an additional 1 million yuan invested in high-quality roads has much weaker effects on poverty reduction than a similar investment in low-quality roads.

Leipziger and others (2003) examine the effects of safe water supply and improved sanitation on poverty reduction. Their study of 43 developing countries finds that differences in access to safe water explain about 25 percent of the difference in infant mortality and 37 percent of the difference in child mortality between the poorest and richest quintiles. These results imply that increasing the level of access to piped water by the poorest quintile to that of the richest quintile (that is, from 3 percent to 55 percent) would eliminate more than 25 percent of the difference in infant mortality and 30 percent of the difference in child mortality between the poorest and richest groups. The difference in access to sanitation between the poorest and richest quintiles accounts for 20 percent of the difference in the prevalence of malnutrition between the richest and poorest quintiles. Improving access to safe water also contributes to a significant decrease in the average prevalence and duration of diarrhea among children under five (Jalan and Ravallion 2001) and an increase in women's time allocation for market-oriented activity that could contribute to increasing household income (Ilahi and Grimard 2000).

The poverty effects of infrastructure may also contribute to reducing rural/urban income inequality. Calderón and Servén (2004) show that income inequality declined with higher infrastructure quantity and quality in rural areas of developing countries between 1960 and 2000.

The impact of investments in infrastructure on the poor may be very limited if the poor cannot afford services. Appropriate pricing of services has been a very controversial aspect of the reform toward privatization of services such as water supply, traditionally provided by the public sector.

Rural Infrastructure, International Competitiveness, and Globalization

Insufficient domestic rural infrastructure is a major bottleneck to achieving the potential benefits from international trade liberalization and other aspects of globalization. Without significant investments in rural infrastructure and related institutions, low-income developing countries and low-income communities will not be fully integrated into the process of economic globalization.

China's recent experience illustrates the point. During China's reform period, the trend toward dual economies was exacerbated, as a large share of the rural population—particularly those living in remote areas—fell further into poverty while the urban population and people living in rural areas with good infrastructure benefited from the opening of the economy toward trade. Irrespective of the ethical problems and the economic gains forgone, such a development is likely to create social instability.

Despite the importance of agricultural exports for low-income developing countries, the performance of most developing countries has been disappointing. The share of developing countries in total agricultural export values decreased from 32.3 percent in 1975 to 29.5 percent in 2004 (FAO 2005). Between 1975 and 2004, Africa's share decreased the most, falling from 8 percent to 3 percent, while that of East and South Asia increased, from 5 percent to 7 percent. Brazil and Thailand performed better than average, with Brazil's share of agricultural exports rising from 3.9 percent to 4.5 percent and Thailand's rising from 1.2 percent to 2.0 percent in 2004. Uganda's share of agricultural exports fell, from 0.21 percent to 0.06 percent, during the same period.

One of the key determinants of international competitiveness is the availability of adequate and efficient domestic infrastructure. Better domestic infrastructure can contribute to international competitiveness through at least three channels: improving price competitiveness, improving nonprice competitiveness, and attracting foreign direct investment (FDI) (Oshikoya and Hussain 2002).

Improving price competitiveness. Wages, labor and land productivity, transportation costs, input costs, and exchange rates are key determinants of a country's price competitiveness in international agricultural markets.³ In most low-income developing countries, transportation costs are high, productivity is low, and the supply of basic inputs, such as electricity, is unstable, reducing these countries' price competitiveness. In Burundi in the early 1990s, for example, the average road transport costs for exports were 17.4 percent of cost, insurance, and freight (cif) prices with break-bulk cargo and 13.6 percent of cif prices with containerized shipments (Oshikoya and Hussain 2002). Investments in export sectors are also less productive in poorer countries (Dawson 2005). To improve the situation, investments in domestic infrastructure as well as institutional and policy reforms are essential.

Improving nonprice competitiveness. Nonprice competitiveness includes marketing-related aspects and product quality. Key factors for marketing are market information, negotiation, packaging, delivery, and after-sale services. The quality of the product is influenced by the production environment and the delivery technology, especially for agricultural commodities. Improving the poor status of information and communication services in rural areas in developing countries, especially in South Asia and Africa, would contribute significantly to obtaining more precise and timelier information about international markets for farmers.⁴ Improving communication between exporters and importers also allows timely and safe delivery of goods. Better-quality (that is, faster and safer) transport services are also crucial for improving nonprice competitiveness. In addition, improvement in the supply of basic utilities (such as gas, water, and electricity) is essential for improving the quality of products.

Increasing foreign direct investment. Private capital inflows have been increasingly recognized as one of the most important factors for successful development of export sectors. Some studies demonstrate that the status of domestic infrastructure is an important determinant of the magnitude of private capital inflow (see, for example, Wheeler and Mody [1992]; Asiedu and Lien [2004]). Efficient transportation, reliable energy supply, access to safe water, and modern telecommunication systems are critical to attracting foreign investment.

Rural Infrastructure in Selected Developing Countries

The poor status of infrastructure stocks and services in most developing countries has been compounded by rapid decline in both public and private investments. The problem of poor infrastructure is particularly severe in the least developed countries. For example, while 73 percent of the roads were paved in OECD countries in 1990, only 16 percent were paved in the least developed countries. Worse still, the percentage of paved roads decreased to 13 percent in the least developed countries during the 1990s and increased to 88 percent in OECD countries (World Bank 2005). Comparison between the road density in Africa in the early 1990s and the road density in India in 1950 provides a powerful illustration of the infrastructure problem facing Africa (table 3). Many African countries are landlocked, and the very limited rail system reflects colonial times priorities for linking mines to harbors.

Infrastructure stocks and services are particularly poor in rural areas, although urban infrastructure is also under pressure. All regions have a biased distribution in favor of urban areas in the water supply and improved sanitation facilities, although the percentage of people with access to such facilities increased more rapidly in rural areas in most regions between 1990 and 2002 (figure 3).

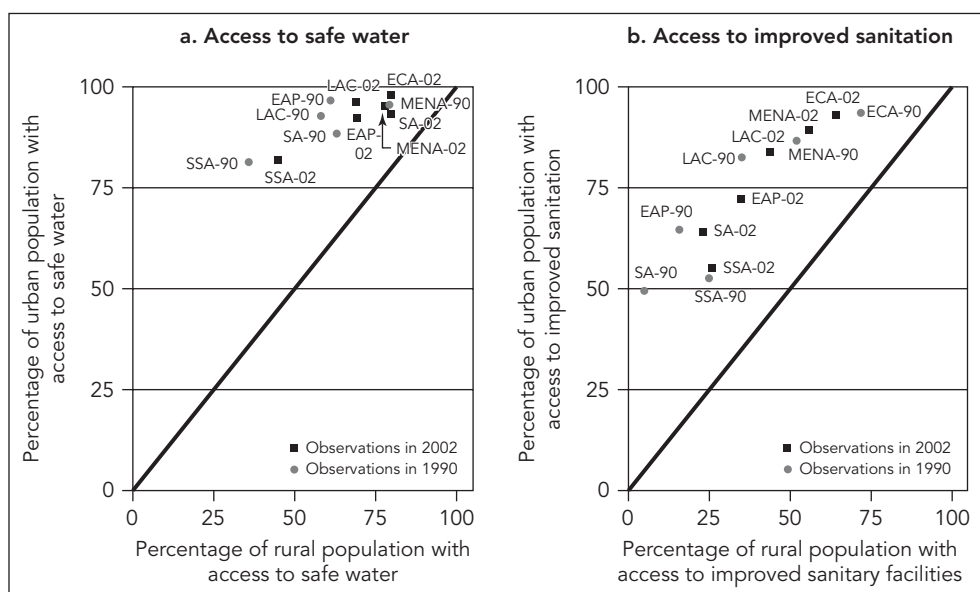
The rural-urban distribution of safe water and sanitation differs across regions. In 1990, the proportion of people with access to safe water was 17 percentage points higher in urban areas in the Middle East and North Africa and 46 percentage points higher in Sub-Saharan Africa. During the 1990s, the rural-urban gap in the proportion of people with access to improved sanitation decreased 12 percentage points in East Asia and Pacific and increased 7 percentage points in Europe and Central Asia.

TABLE 3. Road Density in Selected African Countries in Early 1990s
(kilometers per hundred thousand square kilometers)

Country	Road density	Density needed to match that of India in 1950
Benin	36	291
Cameroon	38	168
Côte d'Ivoire	94	258
Ghana	17	429
Madagascar	67	137
Mozambique	17	135
Nigeria	97	718
Sierra Leone	80	391
Tanzania	66	181
Zambia	36	110

Source: World Bank 2003b and Spencer 1994.

FIGURE 3
Rural-Urban Distribution of Safe Water and Sanitation in Developing Regions, 1990–2002



Source: Authors, based on data from World Bank 2005.

Note: EAP = East Asia and the Pacific; ECA = Europe and Central Asia; LAC = Latin America and the Caribbean; MENA = Middle East and North Africa; SA = South Asia; SSA = Sub-Saharan Africa. The percentage of the rural population with access to safe water in ECA was not observed in 1990 and is thus not plotted.

Data for other rural infrastructure in developing countries appear to be publicly available for only five developing countries (table 4). In this limited sample, rural infrastructure tends to be better in Asian than in African countries. For example, although Tanzania has about a 70 percent larger land area than Thailand, as well as a larger share of rural area, the total length of rural roads there was less than 30 percent of

TABLE 4. State of Rural Infrastructure in Selected Developing Countries

Country	Source	Original data source	Infrastructure indicator	Year	Rural infrastructure	National average level
China	Fan and Zhang (2004)	Author calculation from agricultural census	Road density (km/1,000 sq · km)	1996	1,679	—
			Electricity use (kW/person)	1996	260	686
			Telephone lines (sets/10,000 people)	1996	283	440
	Fan, Zhang, and Zhang (2002)	China Rural Statistical Yearbook	Irrigated land in total arable land (percent)	1990	54.9	—
				1996	58.1	—
				1990	102	424
		China Rural Statistical Yearbook	Electricity use ^a (kW/person)	1996	200	686
				1990	21	60
				1996	197	440
				1996	197	440
India	Fan, Hazell, and Thorat (2000)	Various state statistical abstracts and published government data	Irrigated land in total cropped area (percent)	1970	23	—
				1995	34	—
				1970	34	—
		Various state statistical abstracts and published government data	Villages electrified (percent)	1995	89	—
				1970	2,614	—
				1995	5,704	—
Tanzania	Fan, Nyange, and Rao (2005)	Ministry of Works	Paved roads (km)	1996	91	3,528
				2000	159	—
			Unpaved roads (km)	1996	17,450	84,672
				2000	18,650	—

Thailand	Fan, Jitsuchon, and Methakunnavut (2004)	Agricultural statistics of Thailand (various years) and Thailand Development Research Institute	Irrigated land in total arable land ^a (percent)	1970	13.7	—
				1996	28.9	—
				2000	31.6	—
		National Energy Policy Office	Electricity use ^a (kW/person)	1977	29	227
				1996	627	1,312
				2000	788	1,448
	Fan, Zhang, and Rao (2004)	Telephone Organization of Thailand and Socio-Economic Survey	Telephone lines ^a (sets/10,000 people)	1977	10	60
				1996	299	720
				2000	690	920
		Public Works Department, Ministry of Interior	Road density (km/1,000 sq · km)	1977	12	—
				1996	83	—
				2000	124	—
Uganda	Fan, Zhang, and Rao (2004)	Ministry of Works, Transport and Communication	Road length (km)	2000	—	25,632
		Author calculations based on data from Uganda National Household Survey 1999/2000	Households with access to electricity (percent)	2000	2.1	—
			Villages electrified (percent)	2000	12	—

Source: Data sources for rural infrastructure are listed in the second column. Data for national average levels come from World Bank (2005), except for road length for Uganda, for which data source is the same as that for rural infrastructure.

Note: To make data comparable across countries, they have been transformed into per person, per 10,000 person, or percent of arable land using data for population and arable land area from World Bank (2005).

a. Data were presented at the province or national level in original studies.

— Not available.

that in Thailand in 2000. While the share of electrified villages reached 89 percent by 1995 in India, it was just 12 percent in 2000 in Uganda, and just 2.1 percent of rural Ugandan households had access to electricity (table 4).

The status of rural infrastructure also differs widely across Asia. Until 1996, road density was significantly higher in India than in China and Thailand. Telephones were much more widely available in rural areas in Thailand. The share of irrigated land in arable land was the highest in China and the lowest in Thailand. However, without a common denominator, it is difficult to say which country has the best rural infrastructure.

The last column in table 4 presents national averages for infrastructure provision. The difference between these average levels and the observations for rural areas imply a gap in infrastructure provision between urban and rural areas. The differences are large for all types of infrastructure in all five countries, with the largest difference in Tanzania.

Data on rural infrastructure can differ widely even within the same country. Fan and Zhang (2004) compare the newly calculated agricultural census data in China with the official data published in the China Statistical Yearbook by the State Statistical Bureau. Compared with the official data released by the State Statistical Bureau, the census data are 34 percent higher for road density, 43 percent higher for rural telephone, and 30 percent higher for rural electricity consumption.

Investment in Rural Infrastructure

More investment is needed in rural infrastructure to improve infrastructure provision in rural areas. But investments in rural infrastructure decreased in the 1990s. This section examines why investment declined and what the consequences of the decline are.

Rate of Return to Investment in Rural Infrastructure

How profitable are investments in rural infrastructure in developing countries? The answer depends on whether profitability is measured in terms of private or public benefits and whether externalities are considered. For example, return to investment in transportation infrastructure is more than a decrease in transport costs. Investments in transportation infrastructure also benefit society by widening the market, increasing competition in the market, and disseminating knowledge and technology. Because of such characteristics of infrastructure investments, relying on the private sector is very likely to result in underinvestment. Even the public sector may not adequately invest in infrastructure if it fails to consider external effects.

While there is some evidence of high rates of return on infrastructure investments in general (see, for example, World Bank [1994, 2003b]),⁵ few estimates have been made of the rate of return on investments in rural infrastructure. Table 5 presents the estimated marginal returns to investments in rural infrastructure in selected developing countries. In these studies the contributions of rural infrastructure are measured

TABLE 5. Marginal Returns on Investment in Rural Infrastructure in Developing Countries

Country	Year	Method	Source	Measure of returns	Infrastructure Indicator	Effect
China	1997	SEM	Fan, Zhang, and Zhang (2002)	Rural GDP	Investment in irrigation (yuan)	1.88
					Investment in roads (yuan)	8.83
					Investment in electricity (yuan)	1.26
					Investment in telephone (yuan)	6.98
Uganda	1992–99	SEM	Fan, Zhang, and Rao (2004)	Total GDP	Feeder roads (Shelling)	7.16
Tanzania	2000–01	SEM	Fan, Nyange, and Rao (2005)	Total output	Roads (Shelling)	9.13
China	1982–99	SEM	Fan and Chan-Kang (2005)	Total GDP	High-quality roads (km)	1.73 million
					Low-quality roads (km)	1.16 million
				Total GDP	Investment in high-quality roads (yuan)	1.45
					Investment in low-quality roads (yuan)	6.37

Source: Authors, based on sources cited in the table.

Note: SEM = a simultaneous equation model.

by the impact on aggregate output of an economy. All estimates are significantly higher than one, signaling underinvestment. Investments in roads and telephone lines have particularly high returns.

Are investments in rural infrastructure more profitable than other investments? No studies appear to directly answer this question. Canning and Bennathan (2000) provide some indications of relative profitability of investments in infrastructure. They estimate the rate of return to electricity-generating capacity for 51 countries and the rate of return to paved roads for 41 countries over the past four decades. They find that investments in electricity-generating capacity are more profitable than other public investments in 20 out of 51 countries and that investments in paved roads are more profitable than other public investments in 22 out of 41 countries. The rate of return to electricity-generating capacity tends to be high in low-income countries; returns to paved roads tend to be high in middle-income countries. Unfortunately, these findings are not specifically for investments in rural infrastructure.

Based on the direct and indirect evidence presented above, it appears that investment in rural infrastructure in low- and middle-income developing countries is lower

than optimal and that expanded investment is justified on economic grounds. Taken together with earlier evidence of the impact on agricultural development and poverty alleviation, the evidence presented here provides strong arguments for expanding investment in rural infrastructure. Failure to do so will continue to hamper economic growth and poverty alleviation in developing countries.

Why Is Investment So Low—and What Are the Consequences?

Despite high economic returns to infrastructure investments, annual infrastructure investments in developing countries appear to have decreased during the 1990s. This subsection examines potential reasons why this is the case.

Developing countries' infrastructure, including rural infrastructure, is financed by three main sources: the public sector, the private sector, and official development assistance (ODA). During the 1990s, about 70 percent of investment in infrastructure came from the public sector, about 22 percent from the private sector, and about 8 percent from ODA (World Bank 2004). That the domestic public sector is the key player for financing infrastructure in developing countries should be no surprise, as most infrastructure has public goods' characteristics.

Public investment in infrastructure appears to represent about 2–4 percent of GDP on average in most developing countries (Briceño-Garmendia, Estache, and Shafik 2004). The level and intertemporal changes of public investment in infrastructure vary across countries. Calderón and Servén (2004) estimate the levels of public investment in infrastructure in nine Latin American countries. They show that in 1997 the levels ranged from about 0.2 percent of GDP in Argentina to about 4.5 percent in Colombia.

In most developing countries, public investment expenditures, particularly in infrastructure, were reduced disproportionately during the 1990s as a result of fiscal retrenchment. For example, between 1992 and 1998, public investment in infrastructure decreased from about 1.0 percent to 0.2 percent in Argentina and from about 4.0 percent to 2.0 percent in Bolivia. The decline was sharpest in the power sector in Argentina and in the transport sector in Bolivia (Calderón and Servén 2004).

The decline in public investment in infrastructure has been compounded by a sharp fall in ODA for infrastructure investment. The commitment level for infrastructure by multilateral development banks fell from \$18 billion in 1996 to \$13.5 billion in 1999. These commitments recovered to about \$16 billion in 2002. Bilateral development aid for infrastructure investment declined from \$15 billion in 1996 to about \$8 billion in 2002, with the share of infrastructure in total commitments falling from 27 percent to 14 percent.

Private investment in developing countries' infrastructure also decreased during the 1990s. A main source of private finance is commercial banks, often in connection with officially backed export credit agencies and multilateral organizations. During the 1990s, private investment was about \$67 billion a year. It peaked at about \$120 billion in 1997, falling to about \$50 billion by 2001 (World Bank 2004).

The reduction in public infrastructure investment could be attributable to several factors: (a) many earlier investments in rural infrastructure were deemed failures; (b) private sector participation in infrastructure investments was disappointingly low; (c) politicians seek short-term impact and the gestation period of investment in infrastructure is long; (d) fiscal adjustment programs reduced public spending; and (e) decentralization resulted in mismatches between resources and needs. Obtaining higher revenues required to finance infrastructure investments through higher taxes may be perceived to negatively affect overall economic growth. Thus even where the importance and profitability of infrastructure is recognized, it is often difficult for donors and governments to design and gain approval for specific investment programs. Moreover, postponing large and costly infrastructure investments is far easier for a ministry of finance than cutting current expenditures, such as public sector wages and debt services (Briceño-Garmendia, Estache, and Shafik 2004).

An indirect but important cause of underinvestment in infrastructure is that subsidies in OECD countries result in low international prices for agricultural commodities such as sugar, cotton, groundnuts, maize, rice, meat, and dairy products. Use of these artificially low prices in *ex ante* estimates of expected economic returns from investments in rural areas reduces the economic justification for making such investments.

What are the consequences of these low investments in rural infrastructure in developing countries? Failure to make needed investments creates a critical bottleneck for future growth in agricultural and economic output and poverty alleviation in developing countries. Moreover, low levels of domestic infrastructure reduce competitiveness in international markets and make it very difficult for low-income countries to capture the benefits from trade liberalization and international capital markets.

How Much Investment Is Needed?

Estimates of the investments needed to bring rural infrastructure up to an appropriate level vary widely across countries and institutions, as do the judgments about what is appropriate. Three studies (FAO 2002, 2003; Fay and Yepes 2003) estimate the aggregate amount of infrastructure investment needed for developing countries. The estimates in these studies are not directly comparable, because they examine different sectors based on different judgments of an appropriate infrastructure level. The estimates are presented here simply for reference. Because these estimates are evaluated at different points in time, they are deflated using the International Monetary Fund's world consumer price index (2000 = 100) in order to estimate present values.

The Food and Agricultural Organization (FAO) estimates the investment needed for support services and infrastructure to achieve the World Food Summit goal at \$53.7 billion for 2002–15 (FAO 2002); most of this would be public funding. In addition, \$7.3 billion would be needed annually for investment in rural infrastructure and improved market access in developing countries (\$6.3 billion for new construction and maintenance of roads) (FAO 2003).

Fay and Yepes (2003) suggest that a much higher level of investment will be needed to meet the demand for roads, railroads, telecommunications, electricity, water, and sanitation in developing countries between 2005 and 2010. According to their estimates, about \$465 billion a year is needed for all developing countries, half of which would be for new infrastructure and the other half for maintenance. About \$75.7 billion is needed for the new construction and maintenance of roads—more than 10 times the FAO estimate.⁶

Recommended Action

A massive investment campaign for the construction of new rural infrastructure and maintenance of existing infrastructure in low-income developing countries is long overdue. Without such a campaign, the many plans, goals, and targets for economic development and poverty alleviation—including the Poverty Reduction Strategy Papers, the Millennium Development Goals, and many other declarations—will not be achieved. Furthermore, low-income developing countries and the poor people who live in them are not likely to reap the potential benefits embodied in globalization. High transaction costs, imperfect competition, large marketing margins, and low price transmission will promote continued poverty and low levels of competitiveness. In addition to investment in physical infrastructure, the campaign must include efforts to design and implement new rural institutions, improve domestic rural markets for inputs, outputs and capital, generate appropriate technology for small-scale farmers, facilitate nonagricultural enterprises in rural areas, and remove trade distorting agricultural policies by OECD countries.

The economic pay-off to society from investments in rural infrastructure is likely to be high. Because of the public goods nature of most of the investments needed, most of the money must come from the public sector, including governments of poor countries and international development institutions, regional development banks, and bilateral donor agencies.

Public-private partnership should be pursued when appropriate, but its feasibility varies across sectors and countries. Its use thus needs to be examined on a case-by-case basis. In general, partnership seems to be more feasible in telecommunications, electricity generation, and high-quality road sectors than in the sanitation and water supply sectors (see, for example, Warlters, Irwin, and Juan [2005]).

To ensure that infrastructure services become affordable and accessible for the poor in rural areas, government may need to set a service price below cost. In this case the government should provide subsidies for low-income households, both to cover the gap between the lower price and the cost and to motivate private firms to invest in infrastructure sectors and extend their services to poor rural areas. Wellenius, Foster, and Malmberg-Calvo (2004) suggest the use of competition among firms for rural service subsidies.

Investment in rural infrastructure is capital intensive; low agricultural prices may make *ex ante* assessment of infrastructure projects look questionable. However,

without these investments, a large area of the world will continue to be unable to contribute significantly to economic growth; a large portion of the world's current and future population will be relegated to poverty, hunger, and human misery; and deteriorations in equity and stability will affect us all.

Notes

1. An example of institutional environment is governing property rights and general relations between economic agents. Institutional arrangement is the specific rules governing specific transactions (Davis and North 1970).
2. Tatom (1993) and Fan and Zhang (2004) find a two-way impact productivity and infrastructure capital. Holtz-Eakin (1994) finds a one-way impact of infrastructure on productivity growth.
3. Market distortions in international agricultural markets are discussed in the next section.
4. For example, the number of telephone faults per 100 mainlines was 156 in South Asia, 75 in Africa, and 6 in OECD countries in 2002 (World Development Indicators Online).
5. World Bank (2003a) reported a higher economic rate of return for road projects, for example, 40 percent in Bangladesh during 1996–2003 and 460 percent in Togo during 1997–2003, than for energy projects, for example, 17 percent in Uganda during 1991–2002 and 21 percent in Lithuania during 1994–2003. The World Bank (1994) also reports that the average economic rate of return for World Bank projects evaluated over the period 1983–1992 was 11 percent for electricity projects and 29 percent for road building.
6. These values are not directly comparable. While the estimates in Fay and Yepes (2003) are for a whole country, the estimates in FAO (2003) are only for rural areas. The way to define an appropriate level of infrastructure investments is also different.

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Spurring Economic Development by Capitalizing on Brand Agriculture: Turning Development Strategy on Its Head

MASAHISA FUJITA

The notion that agriculture needs to take a backseat in economic development may not be valid; when rural innovation dynamics and resource development are appropriately managed and supported by infrastructure, agriculture can become the front-runner in economic development. Two unique Japanese concepts of community-based rural development—the one village one product movement (OVOP) and Michino Eki (roadside stations)—have attracted widespread attention in many developing countries as potential tools for bridging the gap between cities and rural areas. Both concepts can be viewed as types of brand agriculture, a general strategy for community-based rural development that identifies, cultivates, and fully utilizes local resources (including natural, historical, cultural, and human resources) to develop products or services unique to a certain geographical area. The strategies have proved effective in Japan as well as in several developing countries that have adopted them.

If farmers are rich, then the country will be prosperous. If villages are stable, then the society will also be stable.

—President Hu Jintao, China
(*Time*, March 13, 2006)

Economic development is commonly believed to proceed by transforming the main sector of the economy from agriculture to industry and then to services. The principal role of rural areas is, therefore, to provide cities with food; excess labor gradually migrates from rural to urban areas. The engine of economic growth resides in cities, where most innovation and learning activities take place. In accordance with this perception of development, most textbooks in development economics posit a role for the agrarian sector that consists of producing generic commodities or foods under

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constant returns to scale, paying little attention to product differentiation, endogenous innovations, or knowledge externalities in the agrarian sector or rural areas. Consideration is almost never given to the location of agrarian activities, except in general studies on the dichotomy of urban-rural areas or North-South regions.

This article challenges this treatment of the agrarian sector in development economics.¹ It proposes a strategy for rural areas located on the periphery—that is, areas that are inherently disadvantageous in the cultivation of generic agrarian commodities such as wheat, rice, and other standard products because of steep topography, mountainous land, scarce water supply, extreme weather, or poor transportation access to major markets. Most countries abound in such peripheral areas. Moreover, in landlocked parts of Africa, Asia, and Latin America, many countries are almost entirely on the periphery.

This article examines two Japanese concepts of community-based rural development—the one village one product movement (OVOP) and *Michino Eki* (roadside stations)—from the viewpoint of spatial economics and endogenous growth theory, paying special attention the role of various types of infrastructure in the effective promotion of these programs. Both OVOP and *Michino Eki* belong to a broader category of rural development strategy based on brand agriculture.

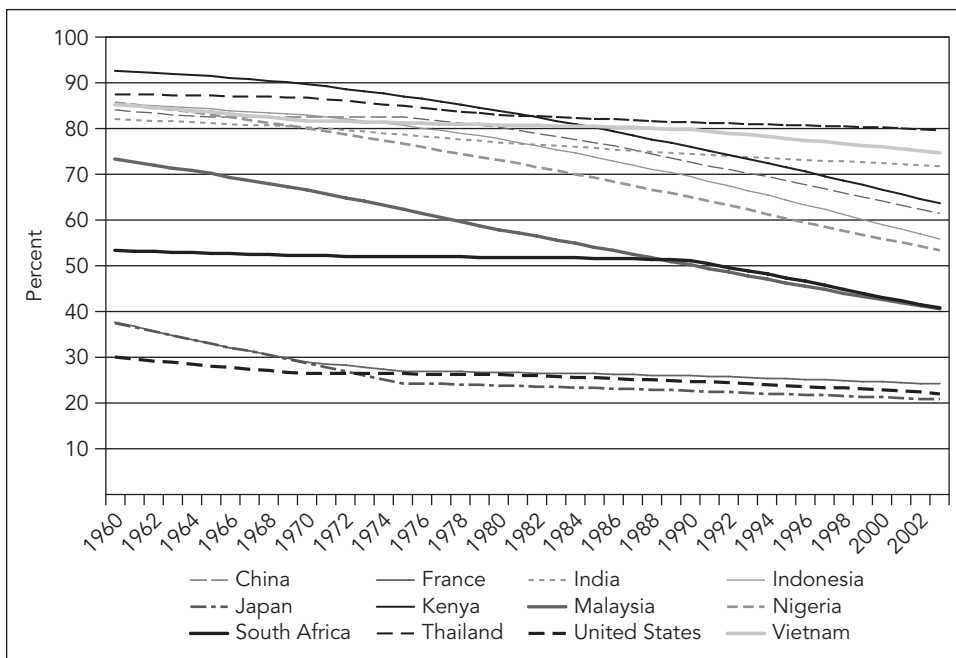
The chapter begins by reviewing the importance of rural areas. It then presents a framework for analyzing brand agriculture based on spatial economics and endogenous growth theory. The third section describes OVOP and *Michino Eki* in Japan. The article concludes with a discussion of policy implications and possible strategies for successful promotion of brand agriculture in developing countries.

The Importance of Rural Areas

From the viewpoint of domestic and international economic policy, the revitalization of the agrarian sector and rural areas is of great importance, not only for developing countries but also for developed countries. Sizable segments of the population continue to reside in rural areas (figure 1). Rural areas, of course, are not entirely populated by full-time farmers. Yet given that most people in rural areas are directly or indirectly connected to the agriculture or local resource-based activities, and given that the majority of the poor in the developing world reside in rural areas, the revitalization of agriculture and related activities is essential for invigorating rural economies.

Although the share of full-time farmers in the population is very low in most developed countries, the share of the rural population continues to be significant in most countries. In the United States, for example, over the past 200 years the farming population has fallen from 70 percent to 2 percent, while the nonfarming segment in rural areas has stayed remarkably stable at about 20 percent (Kilkenny 2004). In France, although the number of farmers has fallen dramatically, the nonfarming rural population has remained at about 8 million since 1850 (de Ravignan and Roux 1990). In Latin America and the Caribbean, a highly urbanized region, projections for 2020 by the World Bank (2005) show that while the urbanization trend will continue, the

FIGURE 1
Share of Rural Population in Selected Countries, 1960–2002



Source: World Bank 2005.

absolute number of people living in rural areas will remain roughly the same. Thus for the sake of balanced growth in both rural and urban areas, invigoration of rural economies remains of crucial importance for both developing and developed countries.

To invigorate rural areas, many things should be done. Infrastructure—including both hard infrastructure (electricity, water, sanitation, transportation, telecommunications) and soft infrastructure (administration, management, financing, marketing, technical and technological assistance, research and development [R&D] institutions)—needs to be developed. Human capital needs to be built, by supporting health, education, and training. Agriculture, including local resource-based agriculture, services, and manufacturing need to be promoted.

Given that all rural areas are unique in many aspects, general strategies for rural development are not useful. The focus here is on rural areas located on the periphery.

Growing generic agrarian commodities in the periphery means that governments pay heavy subsidies, farmers remain poor, and young people leave the area, even in rich countries. In 2003, for example, all of the 20 poorest counties (in terms of average wages and salaries) in the United States, located on the eastern flank of the Rockies and the western Great Plains, were engaged in the production of agricultural commodities, mostly wheat, soybeans, and cattle (*Economist*, December 10, 2005). The federal government spent an average of \$9,000 per person in North Dakota counties in 2003, mostly in the form of farm subsidies. Agriculture in the region has entirely failed to adapt to a world of cheap grain and cattle.

Japan is perhaps the best example of a country whose agricultural policy has almost entirely failed to adapt to the globalizing world. Since the early 1960s, Japanese agriculture has been heavily protected, through subsidies, tariffs, and other policy measures. The degree of protection of Japan's major crops has been extraordinarily high, both absolutely and compared with other countries (Hayami and Goudo 2002). Not surprisingly, this agricultural policy has heavily distorted the working of normal mechanisms in the agricultural and related markets, while impeding the modernization and adaptation of Japanese agriculture in the globalizing world.

Despite such a misguided agricultural policy, however, the future of agriculture and rural development in Japan is not entirely hopeless. Indeed, since the early 1960s, a grassroots movement for rural development has spontaneously arisen in many villages located on the periphery. Although each movement has evolved in a unique way, all successful rural development programs share the common basic strategy that identifies, cultivates, and utilizes local resources (including the labor of women and older people) for the sustained development of a greater variety of unique local products and services (often including local tourism). Through increasingly sophisticated marketing, these unique local products have been sold in larger markets, often establishing distinctive regional brand names identifying the local manufacturers of these products.

Such grassroots movement arose despite, and often in the opposite direction of, the national agricultural policy of promoting rice production everywhere in Japan. The continued production of rice in inherently disadvantageous locations provides no hope for the future. Grassroots action in Japan's remote villages invariably arose out of people's desperate struggle to escape from the increasing poverty and depopulation of these areas. The movement suddenly became popular and accelerated shortly after Morihiko Hiramatsu, then governor of Oita prefecture (located in the western periphery of Japan; see figure 2), named it the OVOP movement in 1979.

Since its introduction in China in 1983, OVOP has attracted the serious attention of many developing countries. It has been implemented in many countries including Cambodia, Indonesia, Lao People's Democratic Republic, Malawi, Malaysia, Mongolia, the Philippines, and Thailand. The potential attractiveness of OVOP for rural development in developing countries lies in the fact that it has been initiated spontaneously by local communities in the peripheries of Japan with little help from the national government.

In the early 1990s, another unique concept for local community development called *Michino Eki* (roadside stations), was initiated in Japan. The *Michino Eki* are different from highway or motorway service areas or rest areas in other parts of the world, for three reasons (Yokota 2006). First, although the *Michino Eki* in Japan are under the general guidance of the Ministry of Land, Infrastructure and Transportation, the planning, implementation, operation, and management of each station are left almost entirely in the hands of the local community. Not surprisingly, *Michino Eki* provide much stronger links between local communities and the users of the highways, while competing with one another on the basis of their uniqueness in terms

FIGURE 2
Map of Japan, with Cited Locations



Source: Author.

of the design of their buildings as well as the functions and services they offer. A typical *Michino Eki* sells a large set of unique local products developed and produced either within the vicinity or in the surrounding rural communities. By providing opportunities for entrepreneurship, the *Michino Eki* empower local residents, particularly women and elderly people. Second, in addition to economic services through market functions, *Michino Eki* serve as a venue for the provision of a wide variety of public services to the local community, such as sanitation, health care, education and training, and cultural activities. Third, while a normal way station or service area is intended primarily for highway users and focuses on traveler services, a *Michino Eki* targets local residents as well people who arrive by vehicle, on foot, or by bicycle. Since the first group of *Michino Eki* was implemented in 1993, the number has increased to more than 830 throughout Japan (all outside major metropolitan areas).

Like OVOP, the *Michino Eki* idea has attracted the attention of many developing countries. Under the guidance of Japan's Ministry of Land, Infrastructure and Transportation, Japan Bank for International Cooperation (JBIC), and the World

Bank, *Michino Eki* are now being implemented or piloted in many developing countries, including China, India, Kenya, Mexico, Thailand, Turkey, and Yemen.²

Both OVOP and *Michino Eki* have high potential for bridging the gap between cities and rural areas in developing countries through community-driven development. However, their attractive names tend to disguise the complexity of the concepts behind them, often resulting in misunderstanding.

Economic Theory and Brand Agriculture

What are the essential differences between agriculture and manufacturing or services? Every person has one stomach, hence the capacity for food consumption is limited. But the same is true for manufacturing and services. Each person has a single body, thus the capacity for consuming basic products such as clothes, television sets, and cars is also limited. Likewise, people cannot watch TV, play video games, or read books more than 24 hours a day.

Although the quantity of goods purchased may be limited, the amount spent on them is not. Consumers are happy to buy fashionable clothes, digital TV sets, and the newest model of a BMW or Toyota. Some people can hardly wait for the new Korean soap operas (which are enormously popular in Asia), the latest Play Station 3 game, or the next Harry Potter book.

By the same token, many people are eager to try new varieties of fruits and sweets, to receive flower bouquets, to visit a hot spring resort, or enjoy a \$100 dinner from time to time.³ And some people are ready to pay almost any price for organically grown, pesticide-free crops and vegetables.

After basic needs have been satisfied, people have almost limitless potential desires for new things. The essence of economic development thus lies in the sustained development of new products (both tangible and intangible ones) that cultivate and fulfill such potential desires. This is true not only in manufacturing and services but also in agriculture.

There exist, of course, fundamental differences between agriculture and manufacturing or services.⁴ The basic characteristics of agriculture are as follows:

- It is bound to land and nature.
- Because of land constraint, its activities are geographically dispersed and thus cannot form a large dense concentration.
- People engaged in agriculture are bound to the land, work and live in a rural community, and form a rather closed society.

These characteristics of agriculture mean that innovation dynamics and resource development are different in rural areas from cities. When such innovation dynamics and resource development are appropriately managed and supported by infrastructure, agriculture can again become the front-runner in economic development.

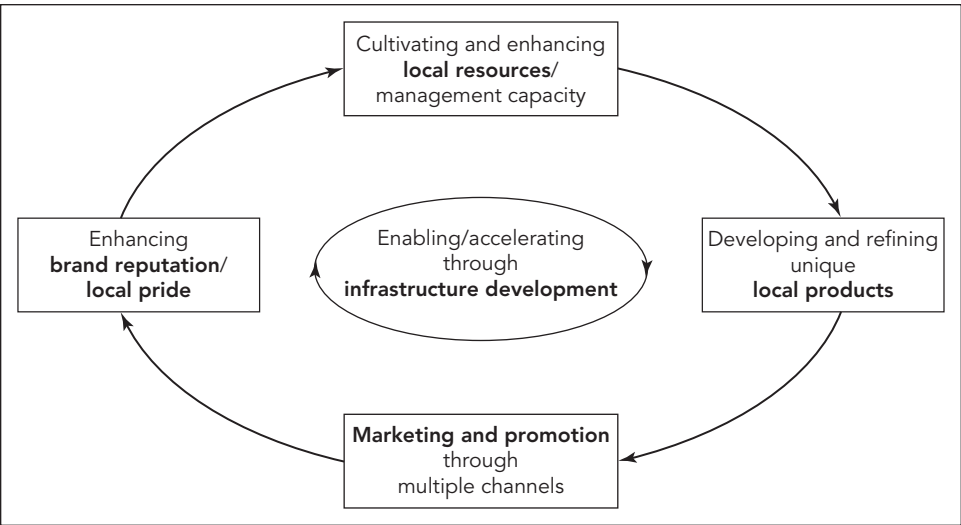
Brand agriculture represents a general strategy for community-based rural development that successively identifies, cultivates, and fully utilizes local resources

(including natural, historical, cultural, and human resources) for the continual development of an increasingly greater variety of unique local products and services (including local tourism). Through increasingly sophisticated marketing, these unique local products are sold in larger markets, gradually establishing local brands to identify them. The community accumulates technical skills, know-how, and practical knowledge learned by inference through experience (tacit knowledge) while developing the human resources essential for sustained or continual innovation of their unique local products and management system.

The theoretical framework of spatial economics and endogenous growth theory can deepen the understanding of the OVOP and *Michino Eki* in the broader context of brand agriculture.⁵ Like spatial economics and endogenous growth theory, brand agriculture puts special emphasis on product differentiation. To attain higher value added in increasingly competitive domestic and global markets, it is essential for producers to differentiate their products from others and avoid direct competition in price and cost. The sustained development of differentiated products constitutes the engine of economic growth.

Unlike the manufacturing and service industries in standard spatial economics, however, product differentiation in agriculture does not lead to the formation of large agglomerations of producers and consumers, which is not possible in agriculture. The key question in the theory of brand agriculture is how to achieve the sustained development of rural areas in dispersed environments. The answer lies in the role that product differentiation plays in the symbiotic evolution of local resources, local products, and infrastructure, leading to the sustained development of rural communities (figure 3).

FIGURE 3
Evolution of Brand Agriculture Through Double-Loop Processes



Source: Author.

To understand figure 3, consider a hypothetical story, representing a typical example of OVOP. Focusing first on the outside loop in figure 3, suppose that a group of farmers in a village get together and try to develop unique products that will eventually supplant the traditional crops grown there. This may be caused by a certain catastrophic event that renders the growing of traditional crops hopeless. The first step is to identify the village's existing local resources (both tangible and intangible). In the absence of any extraordinary or precious local resources, communities need to focus on developing a few local products in which they have comparative advantages under the given set of local resources. They then need to try to produce better products at lower costs. Given that their products are still not very competitive in the national market, they should aim at regional markets located nearby while trying at the same time to establish a brand reputation for their products through stable and continuous supply.

The experience and know-how gained through this initial period of operations will enrich the local resource base (including various skills and know-how) and management capacity of the group. At the same time, the group may become larger, as new participants from the same village join the group. This larger group of farmers will take a fresh look at initial products and try to refine them further, while adding a few new products (some of which may be processed products of local materials). The new group is better able to exploit the economies of scale/scope, leading to the supply of a larger variety of products with higher quality at lower costs. One outcome from such developments would be more stable supply and a better product reputation in larger markets. In this manner, the brand agriculture of the village gradually evolves; in the course of that evolution, the village usually periodically introduces a new set of core products. Eventually, the growing reputation of the village paves the ground for promoting local tourism. As experience has shown, several full-fledged companies using local resources may appear, selling their brand products nationwide and, perhaps, overseas. In this way, the village becomes a more invigorated place with growing local pride.

This hypothetical example is hardly complete. In particular, the evolution of brand agriculture cannot proceed smoothly without consecutive improvement of various kinds of infrastructure (represented by the inside loop in figure 3). The availability of various kinds of basic infrastructure (water, roads, electricity) is a prerequisite to the initiation of such an evolutionary process, although the determination of what is basic depends to a great extent on the general environment of the society. Furthermore, although too much assistance from outside agents (in the form of subsidies, for example) often turns out to be harmful, timely help in developing key new infrastructure (such as better access roads and telecommunication systems) as well as technical and marketing support will yield enormous benefits in accelerating the process of brand agriculture. This type of infrastructure will yield sustained positive externalities.

A few additional comments are in order with regard to the hypothetical example above and the key terms in figure 3.

Local resources: Although some villages may be endowed with truly valuable resources, most rural areas are devoid of such resources. It is therefore encouraging

to see that many successful cases of OVOP and *Michino Eki* have managed to change seemingly ubiquitous resources such as ordinary plants and elderly people into lucrative assets, as shown below. Rich local resources cannot be deemed as heaven sent but rather as having to be created or cultivated through sheer struggle. This also suggests that unique brand agriculture can be developed in almost any region. Furthermore, in identifying valuable local resources in a region, the different thinking and fresh viewpoint of people from other places often turn out to be of great help, as elaborated on below.

Lock-in effects of local resources: Successful manufacturing industries (in particular, ones that are not tied to specific local resources) eventually move out of the original region and relocate in big cities, seeking better access to markets. Fortunately, however, since successful brand agriculture is deeply rooted in specific local resources cultivated in the community, it tends to continue to develop in the same region. This represents the great advantage of rural development based on brand agriculture.

Shipped-to versus shopped-for products: As is well known in location theory, the effective marketing strategy for “shipped-to products” is quite different from that for “shopped-for products.” Shipped-to products are goods that are delivered to consumers through ordinary distribution channels; shopped-for products are goods or services that consumers come to purchase, such as local tourism and products sold at *Michino Eki*. This point is elaborated on below.

Scale economies in brand establishment: Branding an agrarian product requires a certain scale in terms of the number of farmers and the amount of land involved in the operation (see Kojima 2003). In addition to the economies of scale in mechanization, a certain scale is necessary to achieve a stable and continuous supply of products to key markets while attaining the continuous refinement of the product through a cooperative and competitive organization.

Scope economies leading to “centipede” agriculture: Successful brand agriculture often proceeds with the successive introduction of new products, leading to “centipede agriculture” (the production of a large number of products).⁶ This expansion of products is due to the accumulation of local resources (including skills and know-how) and the enhancement of management capacity, yielding scope economies in product development and marketing. In particular, as emphasized in endogenous growth theory, the cost of developing a new product tends to fall with the number of related products developed in the region in the past. Furthermore, the establishment of a regional brand makes marketing new products easier.

Transfusing new blood into the community while retaining its social capital: An initially successful brand often stops developing, leading to the stagnation of the community. This tends to happen because of the nature of rural society, where the same group of people live and work together in a rather closed community. In such a society, imitation tends to be directed toward the past, custom rules, and society becomes static (Toynbee 1946). Custom can be broken by creative personalities who initiate brand agriculture.

In order to sustain the village in dynamic motion of brand agriculture, the society needs to develop an organizational system that encourages the constant transfusion

of new blood (new personalities, new knowledge) while developing the networks of mutual learning with other groups of brand agriculture in the nation and abroad. For this purpose, it is useful, as shown below, to set up a corporate organization composed of experts who coordinate the activity and operations of independent farmers in the village and motivate the support of local institutions, such as technical centers and universities.

Location of Brand Agriculture: The Potential Function Approach

In the past, the location of agriculture was studied using the *bid rent approach* originated by von Thünen (see Fujita and Thisse 2002). This model, however, is based on the same theoretical framework as neoclassical economics; it assumes perfect competition in the markets of agrarian products and constant returns in production. In contrast, the theory of brand agriculture assumes increasing returns to scale in production and imperfect competition in product markets. A new tool is therefore needed for the study of the location of brand agriculture.

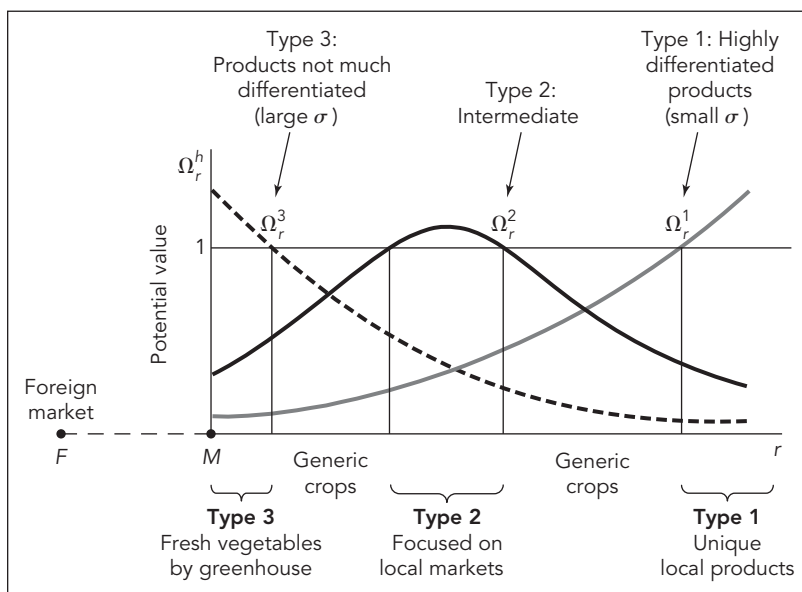
The potential function approach in spatial economics was developed by Fujita, Krugman, and Venables (1999) for the study of the location of manufacturing activities involving product differentiation and increasing returns. It is applied here to the location of brand agriculture.

The potential function measures the profitability of each location in the operation of each specific type of brand agriculture. The monopolistic competition model used in spatial economics and endogenous growth theory is used here to derive the function for each type of brand agriculture. (For details of the analysis below, see the appendix in Fujita [2006].) To do so, all possible types of brand agriculture are divided into H types, with each denoted by an index $h = 1, 2, \dots, H$. In each type of brand agriculture, a large variety of products are produced, which are differentiated from one another but share the same basic characteristics in terms of consumers' tastes, location of markets and transport costs, and production technology.

Consumer tastes on type h products are specified by the substitution parameter, σ_h , which represents the elasticity of substitution between any two varieties in type h , which in turn shows the price elasticity of each product in type h . The parameter σ_h takes a value greater than 1. A value of σ_h close to 1 means that type h products are highly differentiated from each other and hence have a low price elasticity. In contrast, when σ_h has a large value, type h products are highly substitutable and hence have a high price elasticity.

Concerning geography and transport costs, consider a specific spatial structure of the economy, represented by the bottom horizontal axis in figure 4. The representative foreign country locates at point F , whereas the domestic economy extends linearly from point M to the right-hand side along the horizontal axis r . The major market of the domestic economy is concentrated at point M (metropolis), while small regions of about the same size (in terms of area and income) locate contiguously along the axis r . The foreign country at F is connected with the domestic economy through the port at M . This spatial structure represents roughly the economic geography of many countries dominated by major port cities, such as Japan and many

FIGURE 4
Potential Curves for the Three Types of Brand Agriculture Products



Source: Author.

developing countries. The focus of the analysis here is the possible location of each type's brand agriculture inside the domestic economy along the axis r . The transport cost per unit of product between each pair of regions is given exogenously for each type of product. (Possible fixed costs in transportation are considered later.)

Turning to the production side, assume that, across all regions, all varieties in the same type have the same production technology, involving economies of scale at the level of individual variety. (Economies of scope are considered later.) Specifically, in any region, each marginal input of the composite of one unit of land and c_h units of labor yields b_h units of a type h product; in addition to such marginal inputs, the production of any variety requires f_h fixed units of the same composite of land and labor. By assumption, the production technology yields constant returns in terms of marginal inputs. However, since the costs of fixed inputs f_h are spread over the total output, the unit production cost becomes lower as the output level increases. Thus on the whole, the production of any variety exhibits economies of scale. Indeed, the fixed-cost term is introduced here in order to represent in the simplest way the scale economies in production. (In practice, in the following discussion, fixed costs can include all the costs associated with the economies of scale in product development, management, production, and transportation.)

The location of brand agriculture is examined here within a partial equilibrium framework.⁷ Before the location of brand agriculture is chosen, agricultural land in the hinterland of the metropolis M is used to produce generic commodities, such as rice, wheat, and soybeans. Let W_r be the wage rate of farm workers and R_r the land rent in each region r that reflect the zero-profit equilibrium conditions in the production of

generic agrarian commodities in each region. If a type h variety is cultivated in region r , its marginal cost is given by $c_h W_r + R_r$ whereas the fixed cost is $f_h(c_h W_r + R_r)$, implying that both costs are evaluated in terms of the wage rate and land rent prevailing in each region before brand agriculture takes place. Reflecting the standard results of the von Thünen model for the location of generic agrarian activities, assume that both the wage rate W_r and land rent R_r decrease monotonically with the distance from the metropolis M , implying that the same is true for the marginal production cost and the fixed cost.

To calculate the value of the potential function, Ω_r^h , for each type h in each region r , for convenience the economy is divided into two markets: M , the metropolitan market (combined with the foreign market), and \tilde{r}_h , the local markets surrounding region r . Assume that the local market, \tilde{r}_h , of region r for each product type h has been specified appropriately, which includes region r itself and an appropriate set of regions adjacent to region r . (For simplicity, the effective demand in markets elsewhere is assumed to be negligibly small and is hence dropped.)

Figure 4 shows the potential curves Ω_r^h for three representative types of brand agriculture ($h = 1, 2, 3$).⁸ The value of Ω_r^h shows the profitability of cultivating a type h variety in region r . It is a normalized measure of profitability, such that when the production of a type h variety in region r just breaks even, the value of Ω_r^h equals 1; when it yields a positive profit, Ω_r^h is greater than 1. Thus by examining how different from 1 the value of potential Ω_r^h is in each region r , one can judge the profitability of type h brand agriculture in each region.

Before examining the location of brand agriculture in a more specific context, recall that before choosing the location of brand agriculture, each region is involved in the most profitable generic agrarian activity under the zero-profit equilibrium. By definition, then, the potential function of (the most profitable) generic agrarian activity in each region is unity. In figure 4, the horizontal line crossing the vertical axis at 1 represents the potential curve (or line) of the generic agrarian activity.

Three types of brand agriculture are considered. Type 1 cultivates highly unique products, which are marketed to the metropolitan market. Type 2 cultivates products aimed at local markets. Type 3 cultivates homogenous products with high transport costs, which are marketed to the metropolitan market. (For convenience, type 3 is discussed before type 2.)

Type 1: Highly Unique Products Targeting the Metropolitan Market

When products are highly differentiated from one other (that is, σ_h is small) and hence have a low price elasticity, demand is less sensitive to the marginal supply cost, the sum of the marginal production cost and transport cost. Thus even a rather high transport cost does not decrease much the effective demand at the destination. In contrast, the fixed cost of production must be borne entirely by the producer as a direct cost. By assumption, the fixed cost of production (as well as the marginal production cost) decreases monotonically toward the periphery. Thus when the major market is at the metropolis M and transport costs to the market are not exceedingly high, the associated potential curve (measuring the normalized profitability at each location) increases monotonically toward the periphery, implying that the periphery

is the best location for this type of brand agriculture. When demand for this type of product at the market M is sufficiently large, the associated potential curve will exceed at the periphery, as shown in figure 4, implying that this type of brand agriculture can actually grow there. The majority of highly unique agrarian products belong to this type.

Type 3: Homogenous Products with High Transport Costs Targeting the Metropolitan Market

Suppose that the major market of the products is at the metropolis M , that the products are not much differentiated from one another, and that the transport cost of the products increases rapidly with the distance from the market M . In this case, effective demand at the market for each product is quite sensitive to its marginal supply cost. As a result, the effective demand for a product diminishes rapidly as the transport cost from the production site to the market M increases. For this type of products, the associated potential curve, Ω_r^1 , decreases monotonically from the metropolis, implying that the suburbs of the metropolis are the best location for this type of brand agriculture. Cultivating standard fresh vegetables in greenhouses belongs to this type of brand agriculture.

Type 2: Products Aimed at Local Markets

In the intermediate case between type 1 and type 3, the degree of product differentiation and the transport cost are intermediate, so that the negative effect of higher transport cost to the market M and the positive effect of lower production cost (as the production location moves away from M) tend to cancel one another out. In such a case, as depicted in figure 4 by the curve Ω_r^2 , the associated potential function tends to achieve the maximum at a middle location, where local demand for the product is high. This may happen when the brand is not yet very competitive in the metropolitan market and hence its main target is local markets. A successful *Michino Eki* tends to be at an intermediate location where motorists wish to make a brief stop to rest.

Figure 4 shows where each of the three types will most successfully thrive. The periphery has the comparative advantage in type 1, the middle location has the advantage in type 2, and the suburbs of the metropolis have the advantage in type 3. The remaining areas continue to be occupied by traditional agriculture cultivating generic commodities. Given that the main concern here is the development of rural areas on the periphery through development of unique local agrarian activities, the rest of the article focuses on types 1 and 2 brand agriculture.

Strategies in Promoting Brand Agriculture and the Role of Infrastructure

In deriving the three basic types of brand agriculture using the potential functions above, both the fixed input parameter f_b and the productivity parameter b_b have been assumed to be independent of region r . In practice, these parameters may differ across regions, affected by local nature as well as local nurture. Parameter f_b is therefore replaced by f_r^b , and b_b is replaced by b_r^b , where the index r indicates the possible differences in their values across regions.

In this more general context, this section examines the infrastructure and related policies affecting the values of these parameters and hence potential functions. The focus is on possible infrastructure policies that enhance the potential functions of type 1 and type 2 in the peripheral regions. Neither the costs of infrastructure improvement nor general equilibrium effects are considered explicitly. The discussion is thus only suggestive of the possible directions in the promotion of brand agriculture in a given region.

The productivity parameter b_r^b can be enhanced by improving hard infrastructure, such as electricity and irrigation, in region r ; improving soft infrastructure, such as the management and marketing systems and technical assistance; or both. Improving telecommunications infrastructure will also enhance productivity through better management and marketing. Increasing human capital development (by improving health, education, and training) will improve the productivity parameter b_r^b in the long run.

The fixed-input parameter f_r^b represents three different things. To the extent that it represents private infrastructure, such as water pumps and private roads, it can be partly replaced by more effective public infrastructure, making f_r^b smaller. When f_r^b represents the minimum input scale of land and farm workers for the stable and continual supply of an agricultural brand product, it can be reduced by appropriate assistance provided by public organizations such as agricultural cooperation and public distribution systems. In a dynamic context, if f_r^b represents the costs (or necessary inputs) of developing a new agricultural product, it can be reduced by public assistance in technical development and R&D. Such development costs can be reduced by accumulating learning-by-doing experiences in the region and developing mutual learning networks with other brand-agricultural groups, as well as with other learning and academic institutions, both in the same country and abroad. (This point is elaborated below with actual examples.)

The transport cost parameters affecting the potential functions can be reduced in many different ways. Improving transport infrastructure will certainly reduce transport costs. Introducing modern communication and information systems, such as telephones, computers, and Internet connections, and setting up home pages and portal sites will also reduce transport costs (broadly defined), through better management, marketing, and distribution. Promoting brand reputation will lower transport costs.

These transport policies apply to both shipped-to and shopped-for products. However, establishing *Michino Eki* and *Satono Eki* (village stations) is the most effective way of reducing transport costs for shopped-for products, such as local tourism and restaurants, as well as products sold at the stations. Cooperation (as well as mutual differentiation) among nearby *Michino Eki* will also reduce transport costs by attracting more people to the region.

For the sustained development of brand agriculture in peripheral regions, it is essential to gradually upgrade products from type 2 to type 3 or from generic products to type 3 by continually refining existing products and introducing new unique products. For the nationwide promotion of brand agriculture, it may be useful to introduce commercial laws protecting regional brands on agrarian products (while keeping in mind that such protective laws may cause some negative effects in the long run).⁹

The Evolution of Brand Agriculture in Japan

Even in the absence of particular natural resources, type 1 products can be developed in peripheral regions and type 2 products can be developed in middle regions. Both have been successfully developed in Japan.

OVOP Initiatives in Japan

One of the earliest grassroots movements occurred in Oyama Cho, a small mountain village deep inside Oita Prefecture in Kyushu Island (see map).¹⁰ In 1961, the conversion of rice fields to orchards for plums and chestnuts started in Oyama Cho under the leadership of Harumi Yahata, then the president of the village's agricultural cooperative. This movement, called the New Plum and Chestnut (NPC) movement, was initiated mainly by young farmers, over the strong opposition of elderly farmers (who inherited their rice fields). The movement ran in opposition to the agricultural policy of Oita prefecture and the Japanese government, which promoted rice production. The NPC movement sprung up because of farmers' desire to escape from increasing poverty.

Plums and chestnuts were chosen because they were the ubiquitous wild fruits in the village at the time. The NPC movement was initiated with the slogan "Let's go to Hawaii by cultivating plums and chestnuts." (In the early 1960s, it was a dream for the people in Oyama village to visit Hawaii. In 1967, 16 farmers from the village realized their dream, visiting Hawaii for the first time.)

Despite many ups and downs, the NPC movement grew constantly by adding new local products, such as large grapes, watercress, and various kinds of herbs and mushrooms, while gradually expanding their markets. The cultivation of mushrooms started in 1973 by using sawdust (which was abundant in the village) turned out to be a great success, making up about half of total agricultural sales by 1993. The transformation of agriculture from traditional to various specialty crops not only increased the income of farmers, it also reduced the burden of agricultural work, contributing greatly to the empowerment of female workers. Recently, Oyama Cho has been promoting various ecotourism projects in the village, attracting 1.9 million visitors and earning 1.4 billion yen in 2003 (Matsui and Yamagami 2006).

Similar grassroots movements have arisen in many other remote villages in Oita Prefecture (as well as in a large number of villages throughout Japan) since the early 1960s. After carefully examining the grassroots movement in several villages (including Oyama Cho) in Oita Prefecture, the governor developed the three principles of OVOP (Oita OVOP 21 Promotion Committee 2000):

- *Local yet global*: Creating globally accepted products that reflect pride in the local culture.
- *Self-reliance and creativity*: Realizing OVOP through independent actions that develop the potential of the region.
- *Human resource development*: Fostering people with a pioneering and creative spirit.

Table 1. One Village One Product Projects in Oita Prefecture, 2000

Project type	Number of projects
Specialty products	329
Agricultural products	157
Stock-raising products	35
Stock-raising processed goods	39
Fishery products	38
Forestry products	27
Handicraft and other	33
Special facilities	134
Cultural activities	124
Community promotion activities	103
Environmental activities	76
Total	766

Source: Oita OVOP Survey 2000.

Hiramatsu put great emphasis on human resource development, noting that OVOP's ultimate goal was fostering global-minded, pioneering leaders who could drive OVOP to further success. For this purpose, a number of regional training schools, including the OVOP Woman's 100 Member Group, were funded in Oita Prefecture to educate potential leaders. According to the Oita OVOP International Exchange Promotion Committee, in 2002, 10 years after the schools first opened, there were 1,991 graduates, all actively involved in OVOP in their regions.

During Hiramatsu's 24-year tenure as governor of Oita Prefecture (from 1979 to 2003), the OVOP movement was actively promoted in 58 villages, towns, and cities in Oita, triggering its gradual spread throughout Japan. In 2000, the OVOP movement in Oita covered a wide range of activities, from community-promotion activity (103 projects) to production of specialty products (329 projects), including agricultural products (157) and handicrafts and other items (33) (table 1 and box 1).

OVOP initiatives have spread to hundreds of villages and towns in other prefectures of Japan.¹¹ One example is the Irodori Project in Kamikatsu. Kamikatsu Cho is located deep in the mountains of Tokushima Prefecture, about 40 kilometers from Tokushima City (see map). It used to represent a typical depopulated rural town in Japan: the population numbered 2,100 (down from 6,200 in 1955), with 46 percent older than 65.

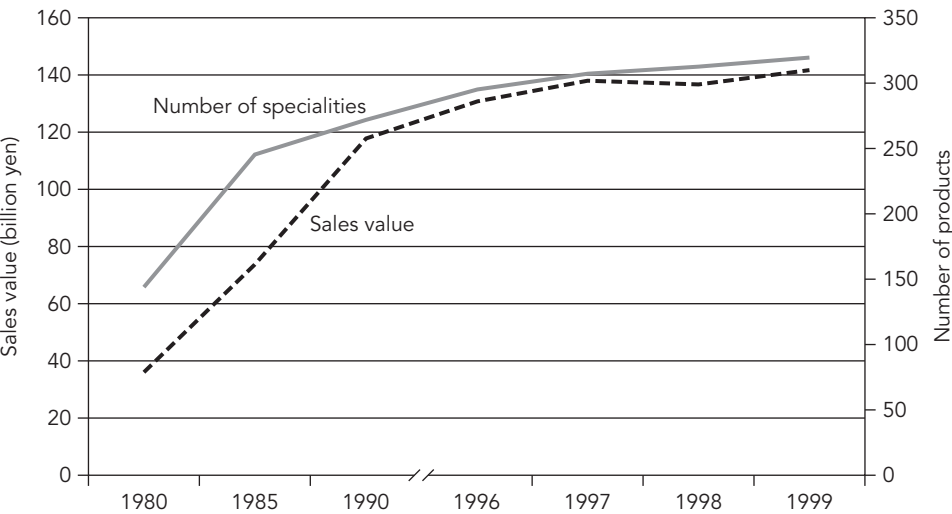
Despite its daunting demographics, Kamikatsu Cho is well known in Japan as "the town that changed leaves into money," because of its Irodori (Colorful Decoration) Project.¹² The main products of the Irodori Project, a town enterprise, are *tsumamono*, the seasonal tree leaves and small flowers used as decoration and garnish for dishes served in Japanese restaurants. Together with four other related initiatives in the town, the Irodori Project has invigorated the once hopeless town, attracting about 4,000 domestic and foreign visitors a year.

The town of Kamikatsu marks 1979 as the turning point in its development. That year Tomoji Yokoishi, a fresh graduate of the Tokushima Prefecture Agricultural

BOX 1. Developing Specialty Products in Japan

Shochu (distilled Japanese liquor) was traditionally made of sweet potatoes and sold mostly to aficionados at cheap prices. OVOP farmers in Oita developed a new kind of *shochu* made of wheat, which is much smoother and more conducive to health than traditional ones. This new *shochu* greatly changed the traditional image of *shochu* in Japan, pushing domestic sales of the product beyond those of sake. In ecotourism, the town of Yufuin (with a population of 10,000) in Oita developed its rustic hot springs as a popular getaway. In 2004, it attracted about 4 million visitors. Overall, the number of OVOP specialty products in Oita Prefecture rose from 143 in 1980 to 329 1999, with a corresponding jump in sales value from 35 billion yen to 142 billion yen (figure).

Number and Value of OVOP Specialty Products in Oita Prefecture, 1980–99



Source: Oita OVOP 21 Promotion Committee 2000.

College, came to work as an agricultural cooperative extension worker. Upon reaching the gloomy town, where farmers earned meager incomes out of small rice fields and forestry in the deep valleys, he started asking himself how to prevent the imminent demise of the town. The crisis worsened when the citrus tree orchards, a vital source of income supplement for the farmers, perished in a severe snowstorm in 1981. The answer came to him while he was in Osaka on business in 1985. While dining in a sushi restaurant, his attention was caught by young girls at a nearby table who were quite excited about something. To his surprise, they were excited not about the sushi but about the small colorful leaves served as artful garnish. When they started wrapping the leaves carefully with their handkerchiefs, the idea of the Irodori Project hit him. Kamikatsu has beautiful tree leaves in abundance. In addition, unlike heavy oranges, leaves can easily be handled by Kamikatsu’s elderly population. Yokoishi knew that he could engineer the town’s turnaround with this novel idea.

His plan to sell leaves to Japanese restaurants was resisted by Kamikatsu townspeople. Reaction was highly negative (“If one could make money by selling leaves, everybody in rural Japan would be rich!” “Who would ask for money in exchange for leaves? We are not beggars!” “Leave our town immediately!”).

This phenomenon seems to illustrate the point made by Arnold Toynbee about rural societies such as Kamikatsu: imitation tends to be directed toward the past. Custom needs to be broken by creative individuals such as Tomoji Yokoishi.

Unfazed by the lack of enthusiasm and determined, Yokoishi continued to campaign for support, especially among elderly female farmers. Together with some supporters, he initiated the Irodori Project as a town cooperative in 1986. The first year, sales were just 1.2 million yen. With untiring efforts in gathering information—and spending most of his salary in expensive Japanese restaurants in Tokushima, Osaka, and Kyoto—Yokoishi gradually learned product development and marketing techniques and quickly worked with his supporters to improve Irodori products. As the group accumulated the necessary know-how on product development, quality control, distribution, and marketing, the number of participants gradually increased and the brand image of the Irodori Project began to take shape. The sales value of the project increased to 50 million yen in 5 years and to 170 million yen in 10 years.

Today the Irodori Project consists of 190 independent farmers (mostly elderly women). All of the enterprise’s activity is coordinated by the Irodori Corporation consisting of just three people (Yokoishi and two young assistants). The average age of Irodori members is 67, with the eldest (a woman) 92. In 2005, sales of Irodori Project reached 270 million yen, or about 1.4 million yen per member. Before the initiation of the Irodori Project 20 years ago, the community depended solely on cultivating generic commodities, such as rice, wheat, and oranges, earning annually less than 0.2 million yen per farming household. Considering that more than one member of a farming household regularly participates in the project, on average farmers participating in the project increased their annual income about 10 times over the 20-year period. Given that most participants of Irodori Project are women and that female workers in traditional farming were no more than helpers earning meager cash income, this fact indicates the magnitude of the contribution of the project to the empowerment of women in Kamikatsu. Most participants in the Irodori Project have difficulty spending their income, often sending money to their children and grandchildren in cities.

Each season Irodori provides about 300 different products for nearly 90 wholesalers located in major cities throughout Japan. The decision about what and how much of each product to supply each day is made by individual farmers, who cultivate trees and flowers on their land; the total supply of each product is controlled by the Irodori Corporation. Farmers must make longer-term decisions about which type and how many trees and flowers to grow on their land. Farmers thus need up-to-date information (such as the most recent prices) as well as long-term information (such as past trends and future projections). Such information is collected and processed by the Irodori Corporation and provided to individual farmers through the computer system. The Irodori Corporation regularly provides seminars for all members on how to read and use the information in their daily business. Each morning, farmers watch

the computer screen and review faxed information before deciding how much of each product to supply and notifying the Corporation of their decision. Farmers operate their computers using special accessories (simple keyboards and large mice) developed for elderly people. Each farmer then collects leaves, sprigs, and flowers and packs them for shipping. All packages are collected at the Agricultural Cooperative of Kamikatsu before 4 p.m. They are then transported on special trucks to nearby cities or to Tokushima airport and sent by plane to Tokyo and other distant cities.

In this way, the entire operation of the Irodori Project is supported by the modern information-transportation infrastructure. The special computer system was developed in 1999, at a cost of about 300 million yen (supported partly by the national government and partly by Kamikatsu Cho). It boosted sales of the Irodori Project by nearly 50 percent.

Each evening, each member's ranking in terms of sales value is communicated to him or her by computer. A delicate communication game then takes place, as members are eager to know how well other farmers did. Each day ends with a handwritten facsimile letter from Yokoishi that summarizes in a friendly and encouraging tone the results for that day, together with his suggestions for the next day's activity.

The dramatic increase in sales of the cooperative has been accompanied by a constant increase in the number of products, from a few dozen basic products initially to about 300 products today. All new products were developed by individual farmers, using local resources that are ubiquitous in the town. Partly because all members of Irodori are closely connected with the markets in major cities of Japan through the daily management of their activities and partly because they frequently visit high-end Japanese restaurants in various cities in order to find how their products are actually used and what kind of product is appreciated there, they can think about their resources with a fresh outlook, which helps them continue to develop new products. For example, one day, walking along a footpath between rice fields, a woman (in her mid-80s) got the idea of making miniature boats out of tall green grass. The item turned out to be very popular for holding wasabi and other condiments, which encouraged her to develop a variety of similar miniature items for decorating dishes. Another woman created a variety of colorful miniature items out of leaves and berries for decorating tables. In this way, Irodori members are constantly stimulated mentally and physically, which sustains their well-being.¹³

Michino Eki Initiatives in Japan

Since 1993, more than 830 *Michino Eki* have been developed throughout Japan under the general guidance of the Ministry of Land, Infrastructure and Transportation. A *Michino Eki* is a combination of a highway service or rest area, an OVOP center, and a community center. Given that the implementation and management of each *Michino Eki* is almost entirely in the hands of the local community, most of these structures and the underlying organizations are unique in terms of their design, functions, services, and management.

Michino Eki Tomiura is located along a national highway near the southern end of the Chiba Prefecture peninsula, about a 3.5-hour drive from Tokyo (see map).¹⁴ Its main building (containing several shops and restaurants) is European in style and takes advantage of an attractive landscape.

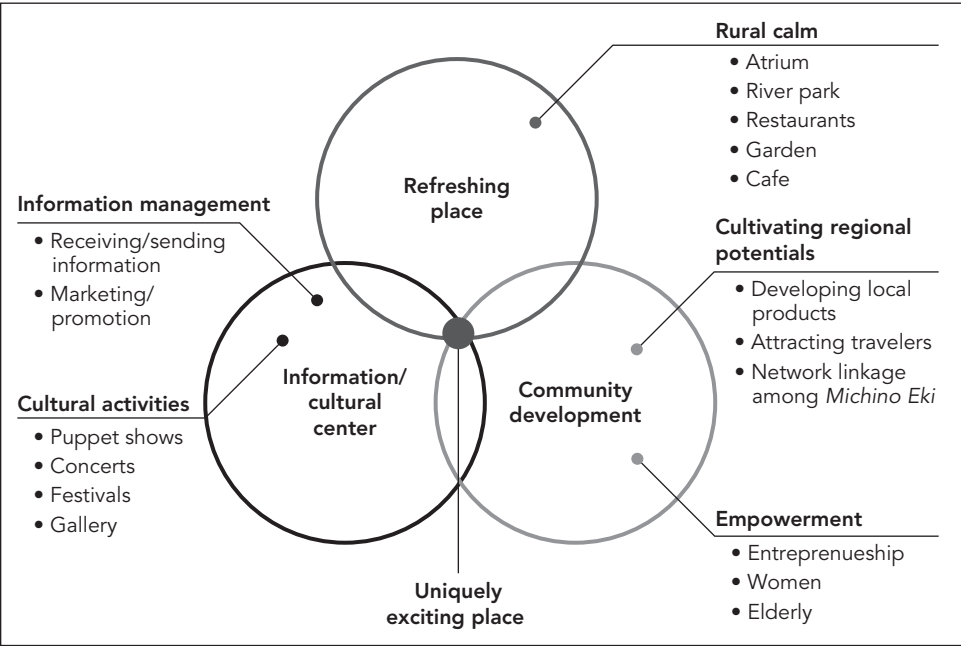
Michino Eki Tomiura has earned the moniker “Loquat Club,” because a large variety of OVOP products sold at its shops are made of loquats grown in the surrounding regions. The *Michino Eki* is managed by Tomiura Inc., a town enterprise with nine members, funded and supported by the Tomiura Cho government. It employs about 60 local workers (mostly women, who work part time), about 1 percent of the town’s population. The number of annual visitors has increased from 220,000 in 1994 to about 700,000 in 2003, with annual sales rising from 384 million yen in 1994 to 631 million yen in 2003. *The Michino Eki* makes a significant contribution to the local economy today.

Spearheading the development of the Loquat Club is Fumio Kato. In 1991, then a young official of Tomiura, he was selected by the town chieftain as the person in charge of the revitalization of Tomiura, a typical depopulated remote town. Suffering through sleepless nights for more than a year, he learned about the new idea of *Michino Eki* being developed by the national government. He immediately realized its potential usefulness to achieve his objective. Although a main national highway encircling the large peninsula passes through the center of the town, most cars and buses simply ran through the town, creating noise and air pollution. An attractive *Michino Eki* at Tomiura could generate income and employment. It could also promote the town nationwide. A *Michino Eki* could also become the focal point of the town, functioning as the community center. Integrating his ideas, Kato developed his concept of a *Michino Eki*, which consists of three core functions: providing a refreshing place for travelers and others, spurring community development, and serving as an information/cultural center (figure 5).

In 1993, when the town launched the *Michino Eki*, members’ focus was on developing an attractive and refreshing place. Given that they were ordered by the town chieftain to make the *Michino Eki* financially profitable as soon as possible, they also started researching the possibility of developing unique local products to be sold at the *Michino Eki*. They soon came up with the idea of using loquats as the main material for specialties. They focused on loquats partly because they were ubiquitous in the region and partly because most people associated little commercial value on these items, causing no opposition to starting a new business based on these fruits. In fact, when Kato asked the Agricultural Cooperation of Tomiura for the permission to sell loquats at the *Michino Eki*, the answer was “Who cares about loquats?”

Members soon started selling loquats grown in the region at the *Michino Eki* as well as through wholesalers in Tokyo (they now also sell them nationwide over the Internet). Most loquats were either defective or of low grade, with little commercial value. Even perfect loquats are not much appreciated by consumers, because each loquat contains large seeds with little pulp. In addition, loquats are available only in the early summer. Efforts went into developing new products using damaged or low-grade loquats as well as leaves of loquat trees, which were previously thrown away as waste. To develop products and process loquats, a large factory was built inside

FIGURE 5
Concept and Functions of *Michino Eki* Tomiura



Source: Management office of *Michino Eki* Tomiura.

the *Michino Eki*. With the support of local small manufacturers and management consultants, the *Michino Eki* started developing a variety of loquat products.

Today the main shop of the *Michino Eki* is full of loquat products. One of the early favorites was soft ice cream made of loquat puree, 24 million yen worth of which was sold at the *Michino Eki* in 2005. With the support of Tokyo Electric Power Co., a large wet-air cooling room was built to keep the loquats fresh for more than half a year, contributing to job stability at the factory throughout the year.

Around the main building, the *Michino Eki* built several greenhouses, in which a variety of fruits and flowers are harvested throughout the year. Since the operation of the *Michino Eki* became financially stable in 1995, various cultural and educational activities, such as art exhibits by local artists, puppet shows, concerts, and cultural forums (which today are performed mainly in the cultural center built in the adjacent site), have also been initiated.

The *Michino Eki* Tomiura also inaugurated the sister *Michino Eki*, called the Flower Club, in 1993, about four kilometers away. In the Flower Club, a variety of exotic flowers, most of them imported from Africa, are grown in large greenhouses. Visitors, who pay an entrance fee, can roam around and pick flowers. The two clubs complement each other in various ways, attracting nearly 1 million visitors in 2005 alone.

In attracting such a large number of visitors, the information management system of the *Michino Eki* has played a major role. It organizes bus trips from Tokyo and other nearby cities to Tomiura (in cooperation with a Tokyo tourist company),

arranging for tourists to visit not only the two clubs but also various sightseeing places, souvenir shops, and restaurants throughout the town. In 2005, for example, the *Michino Eki* attracted nearly 3,000 tour buses (about 100,000 people) from Tokyo and neighboring cities.

The central key player in developing this information management system left his previous job as a marketing manager in one of Japan's largest retail companies and returned to his hometown to become the new manager. Under his initiative, in 2001 the *Michino Eki* started operating a portal site in which any person in the town can post a link to his or her own business Web site or other business contact details free of charge. In this way, *Michino Eki* Tomiura has been contributing to the invigoration of the town.

Promoting Brand Agriculture in Developing Countries

Both OVOP and *Michino Eki* have already attracted widespread attention in many developing countries as potential tools for bridging the gap between cities and rural areas through community-driven development. In promoting these initiatives abroad, Japan, often together with the World Bank, has been actively cooperating with national and local governments in each country, through agencies such as the Japan International Cooperation Agency (JICA), the Japan Bank for International Cooperation (JBIC), and the Japan External Trade Organization (JETRO), as well as through many Japanese nongovernmental organizations (NGOs), local governments, and individual volunteers.

Experiences vary substantially from country to country. Thailand has been the most eager and successful in promoting both OVOP and *Michino Eki* to date.¹⁵

The brand agriculture strategy is potentially useful in invigorating seemingly hopeless places, especially villages and towns in remote areas. In order for the strategy to be successful, however, a village or town needs to have the following three basic ingredients:

- People who are highly motivated and willing to use their brains in addition to their bodies;
- Some specific resources based on nature; and
- A socioeconomic network that is connected to the rest of the world.

When these three conditions are met, any village or town can adopt brand agriculture, provided it is supported by timely and well-focused infrastructure development.

A rich resource base is helpful in the beginning. However, brand agriculture does not represent a one-off project but a sustained movement. When one climbs up an endless cliff, starting with a higher position does not necessarily ensure the capability to progress. Likewise, being endowed with rich resources is neither necessary nor sufficient for successful brand agriculture. The essential ingredient is the sustained effort at developing unique products out of seemingly ubiquitous resources, such as leaves

in Kamikatsu, loquats in Tomiura, bamboo in Thailand, and climate in Uganda (used to produce high-quality roses that are exported to Europe).

The last condition—a socioeconomic network that is connected to the rest of the world—is the most difficult to meet. But it can be met through the help of a small number of young outsiders, as in the case of Kamikatsu village, or creative insiders (often young people) who have had the chance to visit and learn about successful initiatives in other villages or towns. In either case, it is essential for all members of the initiative to be connected to the rest of the world through marketing and learning networks. It is important to develop and promote learning networks not only within a country but also between advanced and developing countries as well as among developing countries. In particular, given that brand agriculture in developed countries is often highly advanced (in terms of technology, management, and marketing), South-to-South networks are particularly useful. Development agencies (including NGOs) as well as individual volunteers can play vital roles in these networks.

In conclusion, the factors that will bring backward areas to the forefront are the same as those that are at work in the heart of prosperous metropolitan areas: product differentiation, innovation, and information. Happily, the same basic strategies can materialize under a wide variety of surprising situations—whether in manufacturing, services, or agriculture.

Notes

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1. This is no mere academic exercise. Indeed, if one accepts the hypothesis regarding the role of the agrarian sector as true, the agrarian sector and rural areas would have no choice but to remain forever in the backseat of economic development. If one assumes constant returns and perfect competition in the agrarian sector, all of agricultural output will have to be paid as returns to input factors—nothing will remain as possible compensation for technological innovations (Romer 1992). Thus productivity enhancement and product innovation could be achieved only through public investments in infrastructure and research and development, leaving no possibility for endogenous innovation dynamics to arise inside the agrarian sector or rural areas. Furthermore, if farmers were to continue producing only generic goods, they would have no way of escaping from direct competition on price and cost. Given the increasingly severe competition in the commodities markets as a result of globalization and expanding domestic markets, farmers (except those in the most advantageous locations) would be able to survive only under increasing subsidies and protection, and their wages and incomes would gradually decline.
2. For a comprehensive introduction to and guidance on *Michino Eki*, see Yokota (2006).
3. This is also true for basic foods. Even in the production of the most basic crop, rice, just 10 years since the partial deregulation of its markets, more than 100 varieties of rice for daily consumption are being cultivated in Japan today, some of which are exported

overseas. One brand, Koshihikari, cultivated in Minami Uonuma (in Niigata Prefecture), sells for 766 yen per kilogram, more than twice the average price of rice in Japan.

4. *Agriculture* is considered here to include forestry, fishery, and stock-raising as well as all local resource-based industries and activities, such as local food-processing, crafts, restaurants, and tourism.
5. Spatial economics is often called the New Economic Geography (NEG). See Fujita, Krugman, and Venables (1999) for a comprehensive exposition of the NEG. See also Fujita and Thisse (2002) and Baldwin and others (2003) for the recent development of the NEG. For endogenous growth theory, see, for example, Grossman and Helpman (1991), Barro and Sala-i-Martin (1995), and Aghion and Howitt (1998).
6. The term *centipede agriculture* is from Matsui and Yamagami (2006).
7. For the study of the location of brand agriculture in a general equilibrium framework (involving the migration of farm workers and the endogenous determination of W_t and R_t), see Fujita and Hamaguchi (2006). The article's main conclusions on the location of brand agriculture are confirmed in Fujita and Hamaguchi (2006).
8. For the explicit mathematical expression of the potential function, see equation (A.26) in Fujita (2006).
9. For example, a new trademark law was recently introduced in Japan that permits trademarks with a combination of regional name and product/service name. The law is intended both to protect well-recognized regional products and to encourage the development of new ones. Although the law is rather restrictive, permitted only to regional groups (not individual producers), the Japanese Patent Office estimates that more than 10,000 products are potentially qualified to be regional trademarks (Nihon Keizai Shinbun, April 3, 2006).
10. See Matsui and Yamagami (2006) and Oita OVOP 21 Promotion Committee (2000) for a comprehensive discussion of OVOP in as well as outside Japan, including a discussion of Oyama Cho.
11. Given that the definition of OVOP is not very clear, it is not easy to estimate the number of such movements initiated in Japan in the 1960s. However, given that Oita Prefecture (a rather small prefecture in Japan) alone has 766 designated OVOP initiatives in 2000, there are likely to be thousands nationwide.
12. Information on the Irodori Project is available (in English and Japanese) at www.irodori.co.jp/. See also JICA (2005).
13. Only two of Kamikatsu's villagers are bedridden.
14. For information on this effort, see www.town.tomiura.chiba.jp/top/biwakurabu/.
15. For actual experiences of OVOP and *Michino Eki* initiatives, see Matsui and Yamagami (2006), Yokota (2006), and Department of Industrial Promotion and Tourism Authority of Thailand and JBIC (2004).

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Comment on "Rural Infrastructure and Agricultural Development," by Per Pinstруп-Andersen and Satoru Shimokawa and "Spurring Economic Development by Capitalizing on Brand Agriculture: Turning Development Strategy on Its Head," by Masahisa Fujita



LOUIS KASEKENDE

An emerging theme from the two studies is that countries can build a dynamic and viable agricultural sector capable of providing rewarding employment to the many people who depend on the sector. Both studies reveal a shortcoming in strategic planning in many countries whereby the agricultural sector is recognized as the mainstay of the economy but resource allocation does not fully reflect its importance. Pinstруп-Andersen and Shimokawa argue that increasing productivity in agriculture is an effective driver of economic growth and poverty reduction, both within and outside the agricultural sector. Indeed, for governments focused on reaching the millennium target on poverty reduction, there is a need to prioritize spending on appropriate rural infrastructure that, combined with functioning domestic markets, appropriate institutions, and appropriate technology, enhances productivity in the agricultural sector.

Fujita takes the argument farther by stating that countries can design strategies to overcome disadvantages such as poor transport access to major markets, scarce water supply, and extreme weather to build a viable agricultural sector that does not survive on subsidies and protection. However, for the brand agriculture he proposes to succeed, several prerequisites need to be in place. These include basic infrastructure (water, roads, and electricity); telecommunications; technical and marketing support; access to research and extension; and commercial laws to protect branded products. Public investment is needed to support the branding of agriculture.

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In many developing countries, rural areas are home to the majority of the population. The percentage differs depending on the level of development, but for most developing countries, 40–60 percent of the population are rural dwellers. Furthermore, agriculture accounts for a significant share of employment and exports, and it is a major source of food. Any effective efforts at poverty reduction should therefore be rooted in increasing the productivity and efficiency of the agricultural sector.

Both papers recognize the central role of agriculture and present mechanisms for possible transitions from subsistence agriculture to market-based agriculture and from cultivation of generic agrarian commodities to cultivation of specialized and sophisticated agricultural products. The transition is premised on the provision of supporting infrastructure to facilitate the integration of rural areas into local and global markets. The absence of such infrastructure would deny the rural areas the links to markets.

In both papers desirable infrastructure stretches beyond roads. Both papers reveal a need for infrastructure that improves the well-being of rural dwellers, including improvements in the water, financial, education, health, and communication sectors. The message from the two papers, especially the paper by Pinstrup-Andersen and Shimokawa, is that poor infrastructure imposes a binding constraint on agricultural productivity and output and creates a biased distribution of the benefits of market liberalization in favor of urban areas.

The desired infrastructure need not be in place and functioning efficiently before productivity gains are recognized, however. Both papers argue for incremental development of infrastructure. Indeed, Fujita finds that low-quality infrastructure is superior to no infrastructure in terms of productivity. There is a strong case for public involvement in the development of such infrastructure, including the extension of subsidies to the sector in the early stages of development. However, as agriculture becomes sophisticated, subsidies could be a source of distortions if sustained longer than is necessary.

Fujita points out that the rural population is endowed with wide-ranging skills and other resources that can be developed to promote the sustainable development of rural areas. These skills can be tapped to develop unique products under a scheme of one village one product (OVOP). The OVOP idea can be looked at as a way of leveraging the skill resources of the rural population in a participatory approach to modernize rural areas. The products developed do not necessarily have to be agricultural, but they should be marketable locally, globally, or both. This approach will help address the lack of product differentiation currently afflicting rural areas.

The agricultural sector lies at the center of most African economies. It accounts for more than a third of GDP, employs nearly 70 percent of the labor force, supplies the bulk of basic food, provides subsistence and income for large rural populations, and represents a major source of foreign exchange. Indeed, continued heavy reliance on agricultural commodity exports as a major source of foreign exchange has made these economies vulnerable to the vicissitudes of markets. Significant progress in promoting economic growth, reducing poverty, and enhancing food security cannot be achieved in most African countries without more fully developing African rural infrastructure

and its contribution to overall agricultural production and productivity, which have been on a downward trend for the past two to three decades.

In an effort to reflect on how best to reverse this trend and ensure harmonious development of the agricultural sector in Africa, the New Partnership for Africa's Development (NEPAD) Secretariat, at the request of the NEPAD Steering Committee, prepared the Comprehensive Africa Agriculture Development Program (CAADP). Endorsed by ministers of agriculture and heads of state, the program constitutes a framework and a reference that national governments and regional economic communities can use to formulate their own programs and projects in the agricultural sector. It promotes interventions that best respond to the widely recognized crisis of African agriculture.

The CAADP focuses on investments in three mutually reinforcing "pillars" that can make the earliest difference to Africa. One pillar is improving rural infrastructure and trade-related capacities for improved market access. The focus of this pillar is on complementary investments in rural infrastructure, particularly rural roads, storage, processing, and marketing facilities, that are required to support the expected growth in agricultural production and improve the competitiveness of the agricultural sector.

Rural infrastructure is basic to the quality of life in rural areas and critical to economic development. The importance of rural transport infrastructure for agricultural development has been well established. One empirical study (Spencer 1994) finds that in villages with better access to roads, fertilizer costs were 14 percent lower, wages 12 percent higher, and crop output 32 percent higher. Rural road construction in Africa has been found to be associated with increases in agricultural production, especially in nonfood export crops; expanded use of agricultural credit; increases in land values; proliferation of small shops; and expansion of rural markets (Anderson and others 1982).

The rural transport system in most of Sub-Saharan Africa is grossly inadequate. The average density of rural roads is about 63 kilometers per thousand square kilometers, with the lowest coverage in the Congo and the highest in Nigeria (Spencer 1994). These densities are much lower than in other developing countries and lower than required given population density.

Only 3.7 percent of agricultural land in Sub-Saharan Africa was irrigated in 2002—a much lower percentage than in China (35.7 percent) or India (33.6 percent) (World Resources Institute 2005). Moreover, these figures overstate the level of irrigated crop land, as they include virtually all wetlands. While 52 percent of wetland rice in India and 95 percent in China can be regarded as properly irrigated, only 34 percent falls into this category in the humid and subhumid tropics of Africa.

The importance of infrastructure in the development of rural areas, especially of rural agriculture, is widely recognized. The question, then, is, why have countries failed to provide sufficient resources to develop the sector?

Part of the blame lies with governments for their biases in allocating public expenditure. In some cases resources have been allocated to sectors in which returns have been very low. (Military expenditure comes to mind.) In an attempt to provide resources to sectors that benefit the poor, there has been a tendency in the recent

past to ring-fence resources in favor of social spending. This has left infrastructure, especially in rural areas, in a state of disrepair. Many governments are currently rebalancing their expenditures to accommodate infrastructure. Neither of the papers discusses the challenge of dealing with competing demands under a tight resource constraint.

Beyond governments, donor countries and multilateral development banks need to recognize the critical role infrastructure plays in sustaining growth and poverty reduction. Donor assistance should not be biased in favor of social spending. The two papers should have acknowledged this problem, given the heavy dependency of developing countries on donor assistance.

The proposal by Fujita to exploit the knowledge base and skills of a particular community is very welcome. Rural households are assisted in specializing in an area in which support services are readily available in the community. The challenge lies in differentiating the products and providing patent protection to communities. There is a tendency by rural dwellers to shift resources to products that provide the highest return and that are unlikely to respect patents. Even in the presence of commercial laws, it may be difficult to extend patent protection to a community. The issue, then, is whether there are limits to product differentiation and whether the proposal can be used in all developing countries in an attempt to develop a viable agricultural sector.

There is also a need to discuss sequencing. Can all developing countries use brand agriculture to modernize the rural sector? It seems to me that branding, as proposed by Fujita, will succeed only after basic infrastructure has been put in place. First-round efforts should focus on integrating rural areas with markets and providing access to research and extension services, thereby facilitating the transition from subsistence to market-based agriculture. Only after providing for the basics should specialization and sophistication be introduced.

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Infrastructure and Regional Cooperation

HARUHIKO KURODA, MASAHIRO KAWAI, AND RITA NANGIA

Continuing Asia's extraordinary transformation will require improving regional connectivity and logistic systems. Because most cross-border infrastructure projects are very complex, various stakeholders—Asian governments, the private sector, civil society organizations, and multilateral institutions—will need to take action to connect Asian economies.

As late as 1750, Asia occupied an important position in the global economy, not only in population and production but also in trade, capital formation, productivity, and competitiveness (Sakakibara and Yamakawa 2003).¹ During the 15th–17th centuries, Asia played a key role in ensuring the global division of labor. Intra-Asian trade, involving exclusively Asian merchants, ships, and goods, was well developed long before Europeans arrived in the region.

Several Japanese historians claim that the economic growth of Asian countries was led by intra-Asian trade (Akita 1999) and that the economic success of Japan in the late 20th century, as well as that of the newly industrialized economies (NIEs), originated in this intra-Asian trade (Sugihara 1990). Asians developed capabilities to adapt Western cultural elements to suit Asian domestic markets, such as making goods smaller and cheaper or neater and cleaner.

The focus of most of the analytic work on regional cooperation has been on trade and investment, including issues such as tariff and nontariff barriers to trade and foreign direct investment (FDI). With the emergence of global and regional production networks, aspects of transport and logistics have begun to attract greater attention of policy makers, academics, and experts.

This article focuses on the role of cross-border infrastructure in the process of regional integration in developing Asia.² The article is organized as follows. The first

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section sets the context, examining Asia's phenomenal growth in trade and investment over the past two and half decades. It describes how Asia—particularly East Asia—has become a dominant part of international production networks and supply chains.³ The second section reviews four case studies of cross-border infrastructure in Asia. This exercise reveals that most cross-border infrastructure projects and programs are very complex and that there is a need for a comprehensive framework to deal with inherent challenges facing cross-border infrastructure. The third section offers a conceptual framework with which to address political, economic and financial, and institutional challenges for cross-border infrastructure development. It emphasizes that the “software” component is inseparable from the “hardware” component if cross-border connectivity is to be improved. The fourth section identifies key actions that need to be taken by various stakeholders—Asian governments, the private sector, civil society organizations, and multilateral institutions—in connecting Asia.

Asia's Extraordinary Transformation

Economic performance in developing Asia—defined as all 43 developing member countries of the Asian Development Bank (ADB)—has been impressive over the past few decades. The region has grown at an average annual rate of 7 percent since 1980. Poverty has declined rapidly: 300 million fewer people were living in poverty in 2003 than in 1990 (ADB 2005a). The strong growth of exports and FDI has been an important driver for most Asian economies.

Trade, Investment, and Production Networks in Asia

Over the past two decades, developing Asia's exports to the world have grown 12.5 percent a year, rising from \$162 billion in 1980 to \$2.3 trillion in 2005 (IMF 2006). The region now accounts for a quarter of world exports. In recent years this strong export growth has been marked by a rapid increase in intraregional trade, which rose from 35 percent of total trade in 1980 to 55 percent in 2005 if Japan is included and from 22 percent to 45 percent of total trade if Japan is excluded. This share is higher than in the North American Free Trade Agreement (NAFTA) region, although it remains somewhat lower than the share in the original European Union (EU-15) (table 1).

The initial growth in trade that was sparked by Asia's NIEs—Hong Kong (China), the Republic of Korea, Singapore, and Taiwan (China)—and then by the middle-income members of the Association of Southeast Asian Nations (ASEAN) has continued as China has become an important player in regional and global trade. As a result of its robust trade growth, China now accounts for 30 percent of regional trade. Recently, there has been a surge in Asian trade from other exporters, such as India and Vietnam.

Much of this increase has been the result of rapid trade liberalization in these economies since the 1980s—particularly since the 1990s—within the World Trade Organization (WTO) and Asia-Pacific Economic Cooperation (APEC) frameworks.

TABLE 1. Importance of Intraregional Trade, by Region, 1980–2005
(percent of total trade)

Region	1980	1985	1990	1995	2000	2001	2002	2003	2004	2005
East Asia (including Japan)	34.6	37.1	43.0	51.7	51.9	51.5	53.4	54.5	55.1	54.5
Emerging East Asia	22.1	27.5	32.8	39.0	40.4	40.7	43.0	43.7	44.1	44.7
Asian NIEs	6.4	6.5	11.9	15.5	15.5	14.9	15.5	15.0	14.4	13.5
ASEAN	17.9	20.3	18.8	23.9	24.5	23.9	24.3	23.8	23.8	24.0
NAFTA	33.8	38.7	37.9	43.1	48.8	49.1	48.4	47.3	46.4	45.0
European Union-15	60.7	59.8	66.2	64.2	62.3	62.2	62.5	63.0	62.2	60.1

Source: Computed from IMF 2006; CEIC databases.

Note: East Asia includes Japan and emerging East Asia. Emerging East Asia includes the newly industrialized economies in Asia and the members of ASEAN; the Asian NIEs include the newly industrialized economies of Asia. ASEAN is the Association of Southeast Asian Nations. NAFTA is the North American Free Trade Agreement.

Most economies not only reduced tariffs and nontariff barriers but also simplified customs rules and regulations (Dollar and Kraay 2001). Notable is the fact that the expansion of East Asian trade has been accompanied by a rapid rise in FDI, reflecting liberalization of FDI regimes in the region's economies and the global strategies of multinational corporations. Multinational corporations began to establish production networks across East Asia through FDI, generating trade in capital goods, parts, components, and semifinished and finished manufactures across East Asia.

FDI inflows to developing Asia rose more than 28 times between 1980 and 2005. In 2005 East Asian economies accounted for more than 59 percent of all FDI inflows in developing economies (UNCTAD 2006). Today, one of the most important destinations of FDI remains China: from a meager \$57 million in FDI in 1980, China attracted more than \$60 billion in 2005. In addition to middle-income ASEAN members, low-income countries such as Cambodia and Vietnam have also begun to attract FDI (table 2). Most FDI in Asia has been in new, greenfield investments concentrated in manufacturing, though there has also been an increase in cross-border mergers and acquisitions, largely in services.

The European Union, Japan, and the United States have been active investors in East Asia, forming production networks and supply chains. In the past 15 years, the four Asian NIEs have emerged as important sources of FDI in ASEAN and China. Hong Kong (China) is the largest investor in China. More recently, middle-income ASEAN countries, such as Malaysia and Thailand, have actively invested in low-income ASEAN members and China.

A web of FDI activities by global multinational corporations and regional firms, together with advances in information and communications technologies, have led to the growth of regional production networks and well-functioning supply chains in such sectors as textiles, electronics, and automobile parts.⁴ A key contributor to Asia's industrial upgrading has been the participation of local enterprises in regional networks set up by multinational corporations. Through their roles as suppliers of parts and components, and as purchasers of specialized processing equipment, these local firms gain access to important production technology, process and management

TABLE 2. Foreign Direct Investment Stocks in Selected Economies, 1980–2005
(percent of GDP)

Economy	Direction	1980	1985	1990	1995	2000	2001	2002	2003	2004	2005
Brunei											
Darussalam	Inward	0.4	0.8	1.1	12.4	89.8	106.0	127.0	161.0	135.9	145.2
	Outward	—	—	—	6.3	10.3	11.0	11.3	10.4	8.7	8.7
Cambodia	Inward	1.8	1.6	2.2	10.8	46.9	50.7	50.9	49.9	47.2	45.6
	Outward	—	—	—	4.2	5.7	6.2	6.2	6.2	5.8	4.8
China	Inward	0.4	2.0	5.4	14.4	17.9	17.5	17.1	16.2	14.9	14.3
	Outward	—	0.3	1.2	2.5	2.6	3.0	2.9	2.6	2.4	2.1
Hong Kong (China)	Inward	73.2	75.2	59.4	50.1	275.4	257.5	208.2	239.2	277.6	299.9
	Outward	0.5	6.6	15.7	55.6	234.9	216.5	191.6	213.0	246.5	264.7
Indonesia	Inward	6.5	6.7	7.7	10.2	16.5	10.8	4.1	5.0	4.4	7.7
	Outward	0.0	0.1	0.1	2.9	4.6	***	***	***	—	5.0
Japan	Inward	0.3	0.3	0.3	0.6	1.1	1.2	2.0	2.1	2.1	2.2
	Outward	1.8	3.2	6.6	4.5	5.8	7.2	7.6	7.8	7.9	8.5
Korea, Rep. of	Inward	2.1	2.3	2.1	1.9	8.1	9.6	9.2	9.0	8.1	8.0
	Outward	0.2	0.5	0.9	2.1	5.8	6.8	6.5	6.5	5.8	4.6
Lao PDR	Inward	0.3	0.0	1.5	11.9	32.1	33.1	33.1	30.6	26.6	24.5
	Outward	—	—	—	0.4	1.6	1.6	1.5	1.4	1.2	1.0
Malaysia	Inward	21.1	23.7	23.4	32.3	58.6	38.6	38.9	40.4	39.3	36.5
	Outward	0.8	4.4	6.1	12.4	23.6	9.5	10.7	11.4	11.7	34.0
Myanmar	Inward	0.0	0.0	1.6	5.3	9.3	8.1	7.6	7.8	7.9	43.6
	Outward	—	—	—	—	—	—	—	—	—	—
Philippines	Inward	3.9	8.5	7.4	8.2	16.9	14.5	15.3	15.2	14.9	14.4
	Outward	0.5	0.6	0.3	1.6	2.1	1.0	1.0	1.5	1.9	2.1
Singapore	Inward	52.9	73.6	82.6	78.2	123.1	143.1	157.3	160.2	150.2	158.6
	Outward	31.7	24.8	21.2	41.8	62.1	85.1	98.6	100.1	94.5	94.1
Taiwan (China)	Inward	5.8	4.7	6.1	5.9	5.7	13.5	10.0	13.0	12.8	12.1
	Outward	31.4	21.4	19.0	16.1	21.5	25.2	27.3	29.3	29.9	28.1
Thailand	Inward	3.0	5.1	9.7	10.5	24.4	28.9	30.1	33.3	29.7	33.5
	Outward	0.0	0.0	0.5	1.4	1.8	2.3	2.0	2.1	2.1	2.3
Vietnam	Inward	32.9	24.8	25.5	34.5	65.7	69.9	73.7	71.8	66.3	61.2
	Outward	—	—	—	—	—	—	—	—	—	—

Sources: UNCTAD online database from 1980 to 2003; World Investment Report 2005 (annex table B.3) for 2004; World Investment Report 2006 (annex table B.3) for 2005 (table 2 in Kawai 2007).

— Not available.

know-how, and global distribution systems. East Asia has thus been able to create a virtuous cycle of regional trade and investment through the medium of production networks (UNCTAD 2005).

It is now recognized that there is no unique “correct” way to integrate economies with global and regional markets, as the speed and the primary drivers of integration vary across regions. The early architects of the European Union saw economic interdependence—rather than military coordination—as the most important factor

for political cooperation. EU member countries sought to create a single market by policy-driven convergence of market rules. Strong regional institutions were created and granted powers in fields such as education, health, taxation, labor, employment, and transportation. Private sector activities—trade and investment—helped, but it was really the governments and their economic policies that drove the integration process in Europe. Creation of supranational institutions deepened this process further.

East Asia's integration also started with the formation of regional institutions—ASEAN being one of the most important ones. This organization has, however, remained relatively weak: the political will that was so important in European integration was not present in the support provided to ASEAN by its members because of their inherent preference for national sovereignty. Compared with Europe, Asian economies had very different per capita incomes, industrial structures, market infrastructures, institutional and human capacities, and governance standards. As a result, Asia has chosen not to establish strong regional institutions that drive the integration process. East Asian integration has been driven largely by the private sector, assisted by strong market forces in trade and investment. This integration was strengthened by multinational corporations and Asian business houses, without much direct institutional support from regional governments.⁵

This market-driven integration has added pressures to distribution structures requiring complex logistics services. Rising demand for logistics is changing the conventional perspective of comparative advantage, implying that logistics and transportation are more closely integrated with supply chains than previously thought. What seems evident from the East Asian experience is that not only does a combination of abundant skilled labor, capital investment, and advanced technology determine the sustainability of decentralized production systems, but also transportation and logistics support. Most East Asian economies invested significant amounts of resources in industrial and social infrastructure to improve connectivity within networks and with external markets, which such decentralized production systems demanded. These responses focused on improving national connectivity with foreign partners to serve the needs of outward-oriented industrialization.

Logistics, Infrastructure, and Software

Several complex factors determine overall transport and logistics costs. In the United States average transit time fell from 40 days in 1950 to about 10 days in 1980—one of the important factors in reducing logistics cost (Rodrigues, Bowersox, and Calantone 2005). Technological advances have reduced overall logistics costs for the United States but not for China, Europe, or India (table 3). In China and India, land transport costs remain high, as a result of inadequate national transport and communications infrastructure, uncompetitive transport and logistics sectors, and high fuel costs. Developing countries have yet to create efficient multimodal transportation networks and significantly improve the efficiency of existing road or rail systems.⁶ Unlike tariff and other trade barriers, domestic transport and logistics costs—key determinants of where production activities gravitate—vary widely across countries. Given the costs of logistics, a number of developing countries in Asia are actually closer to industrial countries in terms of economic distance than to their regional neighbors.

TABLE 3. Logistics Costs, by Region, 1997–2002

Economy	1997		2000		2002	
	\$ billion	% of GDP	\$ billion	% of GDP	\$ billion	% of GDP
China	718	16.9	975	17.7	1,052	17.9
Europe	884	12.2	1,100	12.8	1,229	13.3
India	236	15.4	433	17.0	487	17.4
North America	1,035	11.0	1,240	10.6	1,203	9.9

Source: Rodrigues, Bowersox, and Calantone 2005.

The deficiencies of Central Asian transport systems—high costs coupled with the low quality of transport and logistics services—have meant that 16–19 percent of the total value of exports and imports is absorbed by transport costs.⁷ In particular, the cost and availability of transport permits and visas for vehicle operators to travel cross-border are a major barrier in Central Asia, hampering regional connectivity: in addition to various other charges, such as road taxes, axel load charges, insurance, and visa charges, it can cost as much as \$400 for a driver from a non–Commonwealth of Independent States (CIS) country to enter Uzbekistan.⁸ A multicountry study shows that a 20 percent reduction in logistics costs would increase the trade to gross domestic product (GDP) ratio by more than 10 percent in Cambodia, China, and the Lao People’s Democratic Republic; by more than 15 percent in Mongolia; and by more than 20 percent in Papua New Guinea (Carruthers and Bajpai 2002).

So far, these costs have not affected the overall competitiveness of Asian products, because some production clusters are located near ports and in coastal areas. Nonetheless, maintaining competitiveness will become a major challenge in the years to come, as manufacturing firms move inland, because of congestion and other factors. It is estimated that in China, inland provinces such as Shaanxi would have to incur additional land transportation costs of more than \$1,500 per 20-foot equivalent unit of electronic goods to transport to Qingdao for export. Though no comprehensive databases are available on the land transport costs of traded goods, several studies provide location-specific information. Almost 63 percent of the cost of transporting goods from Chongqing in China to the west coast of the United States is incurred before arriving at the port for export (Carruthers and Bajpai 2002) (box 1).

Given these logistics and transport challenges, there is potential for improving regional cross-border infrastructure to reinforce regional production and trade. Most of the initial production networks were supported by national governments, which invested in national infrastructure in their countries, with appropriate port linkages to the global and regional economy. The East Asian economies—the NIEs, middle-income ASEAN countries, and more recently China and Vietnam—have invested significant capital resources, building necessary national infrastructure to support these production networks. These networks enjoyed an initial comparative advantage, but there is no guarantee that this advantage will be maintained, as the efficiency of East Asia’s logistics lags that of other regions (ADB, JBIC, and World Bank 2005). Overall, quality and quantity of infrastructure in Indonesia, the Philippines, Thailand,

BOX 1. Regional Trade Expansion and Its Impact on Logistics

During the 1960s and 1970s, the Republic of Korea had one of the most competitive manufacturing sectors in the world, based on cheap, highly skilled labor. However, as labor costs increased, Korea gradually lost its international competitiveness. With the emergence of China as a dominant low-cost producer with strong logistics systems, some of Korea's manufacturing-based industries shifted to China. From a small base of \$42 million in FDI in 1991, China accounted for nearly 38 percent of all Korean FDI outflows (\$2.2 billion) in 2004. Several vertically integrated production networks were created. As much as possible, Korean enterprises attempted to retain high value-added activities locally. As a result, there was a significant impact on freight flows between China and Korea. China, which accounted for only 2.9 percent of Korean trade in 1991, became the most important trade partner in 2004, accounting for 16.6 percent of Korean trade.

Given its geographical proximity, the Yellow Sea Rim area became one of the most important components of bilateral supply chains. Container throughput for the Yellow Sea ports (Qiangdao, Tianjin, and Dalian) increased more than 15 times between 1990 and 2003—a period during which global flows increased only 1.7 times. Korean port throughput increased 5.4 times as a result of regional trade and Chinese transshipment at Korean ports. In 2000 a regionally specialized container shipping service started; by 2003 six freight-only lines created a logistics network to cater to regional trade. This regional network of Yellow Sea ports increased its share of trade from 22.6 percent in 1994 to 32.2 percent in 2004. Along with several other similar examples, this indicates that regional connectivity and logistics improvements have been handled largely within a bilateral structure of trade and production networks.

Source: Lee and Rodrigue 2006.

and to some extent Malaysia may already be inadequate to remain competitive. With differing factor prices, technology levels, workforce capabilities, and logistics costs, most global investors will have much wider choices regarding the location of future production clusters or expanding existing ones.

It is possible to reinforce the region's competitiveness through regional cooperation for cross-border infrastructure, because East Asian economies are still complementary. As Arndt (2001, p. 5) notes, "The basic idea is to think of the region rather than the nation as the production base and to spread component production around the region in accordance with comparative advantage." Regional connectivity through cross-border infrastructure will be crucial in this case, because it supports complementarities in production across the entire region, going beyond national boundaries. Other parts of Asia—South Asia, Central Asia, and the Pacific—have even less national and cross-border infrastructure than East Asia. The need to reduce transport and logistics costs, by connecting production clusters in different countries and linking these clusters with markets, will be a major challenge for many developing countries in Asia in the next few decades.

In discussing infrastructure projects, it is important to focus on both "hardware" and "software" components. Several surveys and benchmarking studies indicate that hard infrastructure facilities are only a part of the overall determinants of cross-border connectivity. "Software" needs to be addressed to promote the smooth flow

of people, services, and goods. “Software” aspects referred to here include legal, regulatory, procedural, and other supporting policy frameworks, as well as human and institutional capacities; “hardware” refers to physical infrastructure components that facilitate physical connectivity. In the power sector, for example, transmission lines and power plants represent hardware, whereas regulatory frameworks, tariff policies, power-trading agreements (grid code, settlement code, security, planning, and maintenance, among others), and harmonization of rules and regulations fall under software. Cross-border physical infrastructure can promote the movement of people, goods, services, and information only if accompanied by supporting software components that address various types of impediments related to policies, regulations, procedures, and standards.

An analysis of trade facilitation measures involving 75 developed and developing countries around the world concludes that if countries currently below the group average in relevant indicators individually cut their deficits to the mean by only 50 percent, total trade among the 75 would expand by 9.7 percent, or \$377 billion (Wilson, Mann, and Otsuki 2004). Initiatives involving customs and trade facilitation can remove procedural barriers to the cross-border movement of people and goods, thereby increasing efficiency, reducing transport costs, and maximizing the economic benefits of cross-border infrastructure. In this sense the infrastructure software component is inseparable from the hardware component.

Cross-Border Infrastructure and Economic Development

Infrastructure investment has been the bedrock of national economic development plans in many economies. National infrastructure projects are essential in connecting various production clusters and markets within a country, thereby helping integrate the national economy. Transport infrastructure has long been considered critical, because of its ability to enlarge markets.⁹

Good infrastructure is now considered a major contributor to economic development in many developing economies. In most developing economies, inadequate and unstable power supply, inefficient transport systems, poor-quality roads, weak and aged railroad systems, badly equipped and congested ports and airports, unreliable communications systems, and grossly inadequate urban infrastructure raise transaction costs, curtail productivity, and often render investments unviable. Efforts to enhance investment in national infrastructure can help accelerate the pace of economic development in many of these economies (box 2).

The infrastructure agenda of the East Asian economies—starting with Japan and spreading to the Asian NIEs and middle-income ASEAN members—has been guided by a strategic vision of the top leadership, using coordination and feedback devices within the planning process to implement or realize that vision. Though each of these economies has followed a country-specific approach, one common attribute has been that inherent priorities have been set by the top leadership of each economy. Rapid infrastructure development has been possible because investments were made ahead of infrastructure demand, at times gambling on large infrastructure projects that may have had questionable viability. Providing infrastructure has been closely linked

BOX 2. Recognizing the Importance of Infrastructure

Although the use of the word *infrastructure* is relatively new, infrastructure has long played an important role in integrating markets across nations (Prud'homme 2005). Adam Smith viewed the provision of certain types of infrastructure (good roads, bridges, navigable canals, harbors) as a clear obligation of the state and a necessity “for facilitating commerce” (Smith 1776).

Since Smith, economists have not always kept such a clear eye on the need for infrastructure investments as a requirement for development. Studies on the linkages of infrastructure to economic growth and development have been sporadic at best, despite the heavy infrastructure investment in the 19th and much of the 20th century. Even during the post-World War II period, when development economics began as a separate branch of economics, infrastructure does not appear much in economic policy discussions. Infrastructure was considered a part of capital, referred to as “social overhead capital,” and often lumped together as a source of technological change. It was largely ignored until the work of David Aschauer in 1989 (Gramlich 1994). Aschauer provided empirical analysis to explain the slowdown in U.S. productivity with the slowdown in infrastructure investments. Aschauer’s papers were “followed by an unusual amount of attention to infrastructure from politicians and economists” (Gramlich 1994, p. 1177). Since then, much attention has been devoted to tracing empirical and theoretical linkages between infrastructure and development.

spurring industrialization and economic growth. Countries such as China, Vietnam, and even India are pursuing this model of infrastructure development today.

The unique aspect of the East Asian model is that these economies developed infrastructure as part of their overall strategy of promoting integration with the regional and global economy. Infrastructure was seen as an important enabling factor in the process of globalization until the recent upsurge in the growth of global production networks. Advances in information and communications technology and the growth of production networks across East Asia have changed this basic role of infrastructure—from an enabling factor to an important decision variable that affects the overall costs of production. Multinational firms have various alternatives for investments. Infrastructure—the quality and quantity of a country’s “hardware” and “software” aspects—can change an investor’s overall cost of trade and production. Cross-border infrastructure can have an immense impact on an economy’s competitiveness by reducing the economic distance from external markets, building economies of scale due to wider markets, increasing FDI inflows, and expanding trade and economic activity in general.

The recent interest by the multilateral and regional development institutions in supporting infrastructure development stems from the impact infrastructure investment has, not only on the overall quality of life and poverty reduction, but also on infrastructure governance—infrastructure design and management along with appropriate regulatory frameworks. Though empirical studies are not conclusive about the impact of infrastructure on economic growth and poverty reduction, there is growing recognition of the positive contribution infrastructure makes to these objectives. National and cross-border infrastructure is an important policy instrument for economic development.

Lessons from Major Cross-Border Infrastructure Investments in Asia

A nation's boundaries often impede cross-border trade, investment, and economic integration. Even in the most open economies, domestic trade is much larger than international trade.

Several regional initiatives are at various stages of implementation in Asia to promote regional cooperation and greater connectivity. In a sense, the 1997–1998 financial crisis was a turning point for regional cooperation among East Asian economies. Before the crisis, the institutional base and policy initiatives were limited to removal of trade and investment barriers under the auspices of the General Agreement on Tariffs and Trade (GATT)/WTO and APEC, while actual integration was driven largely by the private sector. The growing support for regionalism reflected several factors, including the need to reduce financial vulnerabilities at the regional level; the need for greater cooperation with China, given the country's emerging dominance in the world and in regional markets; and the merit of harmonizing policies, regulations, standards, and procedures to enhance the region's competitiveness.¹⁰ Market-led integration since the crisis was supplemented by policy-driven cooperation in money and finance, trade and investment, and the provision of regional public goods. In this context, robust transport and communications links are important building blocks, connecting regional markets by supporting production, trade, and investment (box 3).

The ADB has supported a number of regional and subregional economic cooperation programs involving both hardware and software aspects of infrastructure, including trade and transit facilitation, policy and regulatory harmonization, and capacity building. This section examines four case studies of cross-border infrastructure: the Greater Mekong Subregion (GMS). Northern Economic Corridor and Trade and Transit Harmonization,¹¹ the Nam Theun 2 Hydropower Project, the Regional Cooperation for Pacific Aviation and Information Communications Technology, and the Indonesia-Singapore Gas Transmission program.

The GMS Northern Economic Corridor and Trade and Transit Harmonization

The GMS program has focused on regional cooperation for strengthening cross-border connectivity. Key activities include development of economic corridors: roads to improve access, institutional and policy support for trade facilitation, and transit policy harmonization to reduce logistics costs across the subregion. Five economic corridors (two north-south, one east-west, and two southern) were identified, and several road investments have begun. Feasibility studies are addressing prospective railway improvements. Trade and transit harmonization is a key element, bringing to the GMS program both the hardware and software components of infrastructure development.

The Northern Economic Corridor project (ADB 2002)—which will link Thailand and China via a 228-kilometer road link through the northern and more remote regions of landlocked Lao PDR—was designed to open up economic opportunities across

BOX 3. Cross-Border Infrastructure in Ancient Times

Archeological evidence points to the exchange of goods between Mesopotamia and the Indian and Chinese territories between 7,500 and 4,000 BC. The Persian Royal Routes, which stretched over some 2,900 kilometers and were believed to have been in use as early as 3,500 BC, had all the elements of cross-border infrastructure. Rebuilt by King Darius I and maintained and protected by the Achaemenid Empire (circa 700–330 BC), the facility had postal stations and relays at regular intervals. By having fresh horses and riders ready at each relay point, royal couriers could carry messages across the entire route in nine days, a fraction of the three months it took normal travelers.

The Roman Empire also had an intricate network of coastal shipping and roads that it used for trade with India and China. As the empire grew, the system was expanded to cover 80,000 kilometers of first-class roads by about 200 AD. Maintenance of the road system was the responsibility of the inhabitants of the district through which the road passed, but access was public.

Connecting Asia and Europe through the Middle East, the Silk Route stretched over 6,000 kilometers. It was not a single road but several alternative trails connecting disparate areas through very difficult terrain and climate zones. Trade along this route involved goods transported by several local caravans in the form of chains and passed through many traders before eventually reaching their final destination. Alongside these caravans, monks and pilgrims traveled, spreading knowledge, culture, and religion.

Like today's production network, the Silk Route created prosperous clusters of towns and trading posts, complete with the so-called “software” aspects of cross-border infrastructure, such as the exchange, distribution, and storage of goods. The Silk Route became a major channel for trade and transfer of technology—it promulgated knowledge-sharing on administrative practices such as standardized weights and measures, a system of numerical notation and identification, the labeling of commercial goods, and the opening of far-flung colonies. Some historians compare the Silk Route to modern-day communications highways.

Weber (cited in van der Vleuten and Kaijser 2005) suggests that the “transport revolution played a major part not only in the economic but political history of Europe” (p. 27). “Leading politicians in the Ottoman and Soviet empires, the Third Reich, as well as individual nations actively used network technologies to build and strengthen their economies.”

Throughout history, cross-border connectivity has played an important role in the expansion of the global economy. And though historiographies recognize the importance of such linkages, only recently has research focused on the analytics of infrastructure. Different phases of globalization are tied to different phases of infrastructure development, connecting regions beyond national boundaries.

Source: Rodrigue 2006; Voute 2005; van der Vleuten and Kaijser 2005.

diverse populations. The trade and transit corridor was estimated to cost \$90 million for the physical investments in building road links and the components that will benefit local communities along the way. A social action plan with provisions for community roads, small water and sanitation schemes, education, HIV/AIDS awareness programs, and local capacity-building programs for environmental management was an integral part of the project design. These components were planned in a participatory process involving many ethnic minority groups.

The project was funded using financial and other resources from the two primary beneficiaries (China and Thailand), in partnership with the ADB. The role of the ADB was multifaceted. It (a) helped mobilize financial resources; (b) assisted in project design to ensure greater regional connectivity and the inclusion of isolated regions of northern Lao PDR in the process of regional integration; (c) assisted Lao PDR as the transit country in negotiations on pricing policies, so that maintaining the newly created assets would not place undue fiscal burden on the country's finances; (d) actively worked to ensure that the distribution of costs and benefits across the three countries was fair (given that the most immediate benefits were expected to accrue to China and Thailand, China and Thailand shared two-thirds of project investments and provided Lao PDR with concessional financing); and (e) ensured that the project adopted a social and environmental management plan to include contracting arrangements that aligned incentives of construction firms to mitigate these risks. Similar projects that seek to coordinate regional infrastructure are underway in the subregion.

The three economic corridors in the GMS—north-south, east-west, and southern—are expected to form a highly efficient transportation system. No matter how good roads are, they are of little use if traffic is held up at the borders, however. Although international conventions exist to address regulatory and procedural barriers to the cross-border movement of people and goods, most GMS members are unable to fully accede to these conventions. Recognizing this, the ADB has been working with countries involved to implement an agreement on the cross-border movement of services and goods. These types of support allow people and goods to travel around the GMS with minimum impediment, cost, or delay, ensuring that a basic framework is in place to support the economic competitiveness of GMS as an integrated area for production, consumption, and distribution.

The GMS Cross-Border Transport Agreement (CBTA)—which entered into force with the ratification by the six GMS member countries in December 2003—is a multilateral instrument designed to facilitate the cross-border transport of people and goods across the subregion. It incorporates the principles of bilateral or multilateral action and flexibility in recognizing differences in procedures in each GMS country. The agreement includes references to existing international conventions that have demonstrated usefulness across a broad range of countries. It also takes into account, and is consistent with, similar ASEAN initiatives.

The CBTA includes a preamble, with 10 parts and 20 annexes and protocols, that applies to selected and mutually agreed upon routes and points of entry and exit among the signatory countries along the east-west, north-south, and southern economic corridors. The preamble covers (a) single-stop inspection; (b) cross-border movement (visas) for people engaged in transport operations; (c) transit traffic regimes, including exemptions from physical customs inspection; (d) bond deposit, escort, and agriculture and veterinary inspection; (e) requirements that road vehicles will have to meet to qualify as cross-border traffic; (f) exchange of commercial traffic rights; and (g) infrastructure, including road and bridge design standards, road signs, and signals.

The Nam Theun 2 Hydropower Project

Nam Theun 2 (NT2) is a 1,070-megawatt hydropower project being implemented in Lao PDR that will export most of its power to Thailand (ADB 2004). The \$1.2 billion project is a private sector undertaking with multilateral and bilateral financial and other support. This enormous project—not only the largest private power project in Lao PDR but also the largest private sector hydroelectric cross-border project in the world—has been under preparation since the mid-1980s. The project has very strong supporters as well as several groups that oppose it.

The Lao PDR government is the major beneficiary of NT2. It will receive about \$1.9 billion over the 25-year operation period, from dividend income, royalties, and taxes. The main costs are borne by local communities and the environment around the project area. These costs arise from construction of the dam, the flooding of the Nakai Plateau, and downstream effects associated with the interbasin transfer of water from NT2 to the Xe Bang Fai River. More than 70,000 local inhabitants (some of them from ethnic minorities) will be affected in varying degrees.

One of the major issues has been ensuring a fair system of distributing costs and benefits, with appropriate compensation to protect those most affected by the project. A total of \$90 million has been designated as capital and operating expenditures for environmental and social mitigation and compensation. These obligations are part of the concession agreement signed by government and private sector concessionaires. Mechanisms have been developed to address weak accountability arrangements in the public finance management system, in particular, to facilitate more effective and transparent targeting of NT2 revenues toward poverty reduction, including improved education, health, and sustainable livelihood.

An adequate system to monitor and build capacity support for the government—provided through multilateral and bilateral institutions—is in place to implement a project that is not only a success in terms of producing and trading power but is also helping Lao PDR further its development agenda of poverty reduction, social development, and economic growth. A key challenge is to ensure that the proposed distribution of costs and benefits among different stakeholders groups is fair and remains on track.

Pacific Cooperation for Aviation and Information Communications Technology

Regional cooperation means something very different for the island economies of the Pacific, which are small, have fragmented markets, and are isolated physically. Cross-border connectivity is a major challenge, as the scope for hard infrastructure to strengthen physical connectivity is limited by geographical dispersion and remoteness. A strong rationale exists for regional cooperation on the software aspects to improve connectivity—through efficient regional aviation, shipping, and information and communications.

Aviation in the Pacific involves 43 air transport operators, 266 aircraft, and nearly 4,000 licensed personnel. The capacity for safety and security regulation and oversight

is difficult to sustain with small individual markets. Noncompliance with international safety standards and other regulations makes air travel in the Pacific less safe and secure than elsewhere, and it reduces connectivity (ADB 2005b). Air travel is vital for Pacific economies given the geographical nature of the region and the importance of tourism.

To establish a strict, rule-based international regulatory environment, a regional agency—the Pacific Aviation Safety Office (PASO)—was formally established. PASO is expected to help reduce overall oversight costs and meet international standards by avoiding duplication, creating economies of scale, harmonizing regulatory systems, and making scarce technical expertise available as and when needed. An investment program will support PASO's continuing development to improve aviation safety and security. The program has four components: (a) harmonizing the regulatory environment, (b) ensuring compliance with international standards, (c) establishing a regional inspection and surveillance system, and (d) upgrading PASO headquarters. The project involves extensive capacity building, formulation of regulatory and legal frameworks, and adoption of necessary documentation systems. The project is expected to be self-sustaining in five years, once revenues match expected costs. It is designed to serve as a model for intergovernmental regional cooperation in the field of regulation services needed to develop adequate regional transportation infrastructure.

For many developed countries, information and communication technology (ICT) provides additional information services over already well-established communications infrastructure. In the Pacific, cross-border ICT—using very small aperture terminal satellite communications (VSAT)—has the potential to radically address two fundamental challenges, distance and small market size. ICT cooperation can aggregate production, so that fishing and agriculture cooperatives, for example, can access larger markets, and even very small enterprises, such as microtourism or agrotourism resorts, can attract the attention of global audiences. Digital connectivity can thus become a lifeline that allows isolated island economies to participate in expanding global and regional markets.

Technological solutions—such as multiple-access VSAT technology—allow data from the Internet to be beamed down to a multitude of places within the footprint of a given satellite. Users located anywhere in the Pacific—on land or sea—can communicate by e-mail, facilitate exchanges between local administration and the central government, and market tourism, for example. Establishment of this or a similar wide-area system would help the Pacific capitalize on its vast human and natural resources more effectively.

Strong communications capacity provides a cluster of countries with opportunities to grow into an integrated region and to thrive on economies of scale—something the Pacific still needs to do. In trade, ICT is important for procurement, exports, or aggregating national production; in governance, the system could improve local administration, human resource deployment, budgeting, and much more. A wide-area communication network also benefits hospital procurement, disaster management, health alerts, and school research, among other activities. In short, digital connectivity—through effective and inexpensive ICT cooperation across island nations—can open up a new window to the world.

Indonesia-Singapore Gas Transmission

Although a large number of Asian countries have gas resources, the region has yet to develop an integrated cross-border gas network. The Indonesia-Singapore gas pipeline began as a domestic pipeline with ADB funding from various multilateral and bilateral sources. The original project was to construct onshore and offshore pipelines to increase domestic use of gas as a substitute for petroleum and to improve energy efficiency. The project included a set of policies to create an enabling environment for private-sector participation in the gas sector and establish a regulatory framework and supporting institutions for transmission and distribution systems. An important policy covenant under the ADB loan was that the state gas company (PT Perusahaan Gas Negara Persero Terbuka) would partially divest a portion of its equity in the project to a suitable strategic partner to spread economic risks and to introduce world-class operations, maintenance, and financing to Indonesia's gas sector.

The 1997–98 financial crisis brought considerable uncertainty to the domestic gas market and delayed securing a strategic investor. In response, the government, in partnership with the ADB, formed Transmisi Gas Indonesia in 2002. Through open competitive bid, it divested 40 percent of its equity to Transasia, a consortium comprising Malaysia's Petronas, Gulf Indonesia, Singapore Petroleum, and Canada's Talisman Energy. Transasia paid \$187.6 million for the 40 percent equity that included about \$58 million toward the cost of extending the Grissik-Batam pipeline to Grissik-Batam-Singapore. The cross-border project is an initial step, not merely in restructuring Indonesia's gas sector but in opening the door to the broader goal of establishing a proposed trans-ASEAN gas pipeline (Thomson Financial 2002).

Lessons Learned

Most of the lessons from these case studies are specific to the context and circumstances of the individual projects. However, a few generic lessons can be drawn:

- Governments involved in cross-border infrastructure projects need to play a larger role, even if the projects are primarily private sector driven. Their role can be multifaceted and, in most cases, context specific—from sharing risks to creating credible policy regimes to providing direct or indirect financial support. For example, if high fixed costs, the long life of assets, and space specificity expose cross-border infrastructure to risks as a result of high sunk costs (or unrecoverable past expenditures), governments need to ensure private-sector confidence by establishing credible policy regimes.
- In the absence of a single pervasive sovereign jurisdiction, aligning the differing interests of two or more nations requires either formal or informal institutional arrangements aimed at lowering transaction costs, reducing any risk of conflict, or both—through, for example, the European Commission or the GMS.¹²
- The presence of multiple constituencies involved in cross-border infrastructure requires capacities and mechanisms to identify the magnitude and distribution of

the benefits and costs of cooperation. When costs and benefits between different groups vary dramatically, a fair system of distribution needs to be introduced and the issue of incentive compatibility must be addressed—and internalized at the planning and design stage. In the case of cross-border transport projects, sufficient incentives should be provided to any transit country to ensure project success.

- Appropriate mitigation plans and adequate financial and technical resources are required to deal with transborder externalities, such as the spread of HIV/AIDS, pollution, the erosion of social values and cultural identities, and the trafficking of vulnerable groups. Bridging shared history, cultural values, norms, and creating cohesiveness based on ethnic identity can help cross-border infrastructure projects build trust across ethnic divides—an essential element for successful regional cooperation.¹³
- Planning and preparation costs are almost always high. Some projects require upfront external financial and other support to be successful.

A Framework for Cross-Border Infrastructure

Given the rapid growth of regional economic activities, trade, and investment in Asia, cross-border infrastructure has become an important building block of regional economic integration in the age of globalization. Many cross-border infrastructure initiatives are specifically directed at facilitating cross-border trade by reducing overall transport and logistics costs. Cross-border infrastructure has also helped improve connectivity within a country or changed the market structure of domestic sectors.

Except in the European Union, which has well-defined rules on market integration to support cross-border infrastructure, these projects are usually planned and designed on a bilateral basis. In some cases, individual project negotiations have worked well. Scandinavian countries have interchanged as much as 7 percent of total subregional power generation based solely on a gentlemen's agreement.

This section proposes a framework for planning and designing cross-border infrastructure in three dimensions: political, economic and financial, and institutional and software. All of these dimensions usually need to be addressed to ensure successful cross-border infrastructure results.

Political Dimensions

Infrastructure often has a political angle. This is particularly true of cross-border infrastructure, because it invariably raises foreign policy issues. More often than not, a cross-border infrastructure project, policy, or program is used to promote or hinder a government's foreign policy goals. In this sense, any cross-border infrastructure project requires strong political leadership at the national level, a strategic vision based on shared priorities for regional integration and development, and political commitment to this bilateral or multilateral coordination.

Several levels of governments are often involved in planning, designing, and coordinating cross-border infrastructure. Even within a country, the central planner often has different perceptions about the value of cross-border infrastructure than local governments and users. This can lead to problems of mismatches in prioritization and resource allocation. Local governments, for example, may have a greater stake in connectivity with neighboring countries than the central government does. The highest political leadership must set a clear strategic vision for national and cross-border infrastructure in order to resolve such mismatches at the national level.

There is a need to develop sufficient mutual trust and goodwill between governments involved in the project. As multiple constituencies are often involved in cross-border infrastructure, institutional mechanisms are needed to sort out the true objectives of cooperation and to resolve any obstacles. This can be done either through formal institutions (such as the European Union) or, as is the case in many Asian groups, through informal political consensus to create such collaborative arrangements. Whichever approach is taken, governments need to make political efforts to develop mutual trust and build consensus among them in various ways, including joint studies, dialogue, and interactions among politicians, experts, news media, and citizens.

A strong political commitment to international coordination for cross-border infrastructure can also reduce overall external risks. Governments involved need to collectively ensure that the underlying policy environment supports cross-border infrastructure, particularly when the project undertaken involves the private sector. Strong political commitment to coordinate using a multilateral framework can make it difficult for individual governments to unilaterally renege on the terms of an agreement under which the infrastructure is supplied, as the other parties naturally would also have an interest in enforcing the agreement. Transparent and predictable governance structures and institutional arrangements for infrastructure projects reduce overall risks and enhance project feasibility.

Economic and Financial Dimensions

Benefits from better connectivity through cross-border infrastructure—in the form of lower logistics costs, expanded trade, higher growth, and greater poverty reduction—tend to be indirect and long term, whereas costs tend to be incurred immediately and up front. These benefits are often asymmetric across countries, making it difficult to agree on the appropriate distribution of costs. This can raise doubts over resource allocation, especially for high-profile projects. Hence economic and financial feasibility and distributional consequences need to be carefully studied and well established. This is particularly the case because political leaders often announce cross-border infrastructure projects without undertaking the necessary economic and financial analyses beforehand.

Cross-border infrastructure projects should be planned and designed within the overall medium-term development strategy of each of the countries involved, and they should be identified within a regional sector planning framework. This framework should not only apply existing tools for sector planning (in terms of least-cost

planning) but also require an institutional arrangement for effective regional policy coordination, including both strategic discussions at a high official level and technical consultations at the working level.¹⁴

Economic and financial analyses of projects identified within a regional sector planning framework are important for any infrastructure; they are particularly important for cross-border infrastructure given the capital intensities; complex structures of costs and benefits; regional public goods attributes; and long-term, indirect impacts. Cross-border infrastructure often involves various groups of stakeholders across national boundaries, and the groups that bear the greatest costs are not necessarily those that enjoy the greatest benefits from the project. With this in mind, a detailed distribution analysis is necessary to assess the project impact.

An appropriate institutional mechanism needs to be designed to ensure that stakeholder groups that are affected unfavorably by cross-border infrastructure projects are compensated fairly.¹⁵ Such an assurance is crucial to ensure a fair system of distribution and obtain support from less powerful countries, regions, or groups.

Institutional and Software Dimensions

Institutional and software components are as important in cross-border infrastructure as the physical (or hardware) components. For any hard infrastructure facility to work, well-designed institutional and software support is essential. It is particularly important for cross-border infrastructure, because of the involvement of multiple constituencies and the associated externalities. Developing a relevant institutional and software agenda for cross-border infrastructure can be complex, because no single legal or policy jurisdiction exists and the agenda often involves a large number of issues.

Successful cross-border infrastructure requires institutional arrangements, formal or informal, that will help reach an optimum outcome arising from cooperation as opposed to independently chosen suboptimal outcomes. Technocratic cooperation is the most critical element. Institutional requirements for coordination vary depending on how complex a sector is. For example, the technical complexity is lower for a cross-border road project (primarily involving agreements on design standards and road signage at the construction stage) than for an electricity project (for which an agreement on technical standards is essential for both construction and operation). The asymmetric distribution of costs and benefits between different stakeholders needs to be addressed at the planning and design stage.¹⁶ Thus sector-specific institutions will be needed for detailed planning, design, coordination, and financial arrangements in any cross-border infrastructure.

It is important to design institutions in a way that provides incentives for long-term success. This is particularly true when costs and benefits of cross-border infrastructure projects vary drastically across groups. Cross-border projects need to align incentives and financing arrangements in ways that allow all participating countries to benefit from the projects.

The strong need for planning and coordination for cross-border infrastructure requires a systematic institutional arrangement, whether formal or informal. In theory, ad hoc institutional and technocratic coordination and negotiations between governments on a project-to-project basis should work well without a formalized institutional or legal framework; in practice, this approach has had high failure rates and long lead times, significantly raising transaction costs and making such collaborations infeasible. Strong institutional coordination helps minimize such costs. A systematic, comprehensive, institutionalized approach is essential for success.

Harmonizing regulatory, procedural, and technical standards and environmental, social, and other safeguard requirements helps reduce risks and lower transaction costs for cross-border infrastructure. Resources are clearly needed for investing in such software aspects, particularly strengthening local capacity and building consensus.

Conclusion: The Future of Cross-Border Infrastructure in Asia

Economic growth and poverty reduction in Asia are closely tied to its ability to reap benefits from regional economic integration. Though logistics have not yet become a serious constraint, action will be required to enhance both the quality and quantity of infrastructure to improve overall efficiency. Growing cross-border economic activities in Asia have important implications for the demand for infrastructure development in the region. Infrastructure needs for feeder seaports and logistics services, among others, will continue to rise rapidly.

With the emergence of China and India as important destinations for exports and sources of imports, cross-border connectivity with different regions of these countries features prominently in Asia's infrastructure development plans. For the neighboring economies in Southeast Asia, South Asia, and Central Asia, export-related transport and logistics will be particularly important, especially those geared toward serving China and India. For poorer countries and poorer areas within countries in which infrastructure is a major constraint to expanding economic opportunities, improved access to larger regional markets will be key to economic success. The efficiency of cross-border infrastructure connectivity will be an important determinant of a country's prospects for economic growth, employment creation, poverty reduction, and social improvement.

Through greater investment in logistics and infrastructure, Asia can further strengthen its productivity and competitiveness. It can gain more from improved connectivity—such as cross-border transport corridors on land and a series of feeder ports and regional hubs—for promoting exports and imports. Connectivity can be increased by improving overall efficiency: by building, rehabilitating, upgrading, and modernizing infrastructure services, equipment, and facilities; supporting capacity building for asset management and maintenance; coordinating cross-border services and harmonizing regulations, procedures, and standards; and facilitating trade and customs. Various stakeholders need to work together to ensure success in this difficult area.

Governments

Asian governments need to play an increasingly important role in cross-border infrastructure, even when projects are handled by the private sector. Their role includes planning at the regional level, coordinating policies and procedures, creating credible legal and regulatory policy regimes, strengthening infrastructure governance (transparency and accountability in financial management), and sharing risk. Cross-border infrastructure requires harmonizing rules and regulations covering the environment and social aspects and crafting policy regimes for private-sector participation.

Asian governments can take several steps to ensure these considerations are taken into account. First, candidate projects and programs for cross-border infrastructure should be identified that enhance the region's trade and integration agenda. Strong political leadership is needed to support such cross-border infrastructure arising from a vision of regional cooperation and integration based on improvements in transport and logistics efficiency and market expansion for the entire region. Asian governments need to reorient existing partnerships to deliver greater regional connectivity.

Second, Asian governments should integrate cross-border infrastructure projects and programs into their countries' own development plans, to demonstrate their willingness and commitment to support such initiatives. They could then establish institutional arrangements to support collaborative cross-border infrastructure projects for technical coordination, legal and regulatory coordination, and risk sharing that are inevitable in such projects and programs. It is important for governments to develop a strong, credible partnership, based on mutual trust.

Third, Asian governments could strengthen their collective work to mobilize a large pool of regional savings for "bankable" regional infrastructure investment. Strengthening national and regional bond markets—though such initiatives as the Asian Bond Markets Initiative and the Asian Bond Fund—is one of the first steps in creating a viable source of infrastructure financing to tap these Asian savings. At the same time, governments can make joint efforts to help create bankable projects through concerted national reforms to improve policy and regulatory environments and infrastructure governance.

The Private Sector

Though the role of the private sector in cross-border infrastructure has been somewhat opportunistic, the sector has brought real "additionality." Several successful cross-border infrastructure projects demonstrate that where relationships are governed purely by commercial considerations, differences are more easily resolved. Given the public sector's resource constraints, the private sector will have to play an increasingly important role in cross-border infrastructure. There are substantial financial rewards to be derived from regional or subregional cooperation in such sectors as energy, telecommunications, and transport.

The private sector is expected to play a critical role in this process, in several ways. First, it can bring additional financial and technical resources for cross-border infrastructure. Together with governments and other development partners, it can

undertake commercially viable cross-border infrastructure investments with an acceptable risk profile.

Second, the private sector can provide the enormous resources needed for improving cross-border connectivity through national and cross-border infrastructure investment projects. To dispel the past perception that these partnerships are often opportunistic and not based on mutual trust, the private sector should be encouraged to act as a reliable and dependable partner. It needs to develop a long-term view of returns and rewards, as infrastructure projects and concessions are long-term business ventures.

Third, there is no better strategy for risk sharing than to reduce the overall risk for the project. Due market and financial diligence remains fundamental to a successful cross-border infrastructure.

Civil Society

Most cross-border infrastructure projects and programs are high-profile investments. Civil society organizations are often critical of them or even oppose them, for several reasons. First, these groups often have serious concerns about the environmental and social costs associated with large infrastructure projects or programs. Second, the asymmetric distribution of costs and benefits among stakeholder groups induces them to pay greater attention to the people who bear the brunt of the costs in terms of loss of land, property, and livelihood rather than the majority of people who benefit from the project. Third, unlike national projects or programs, cross-border projects involve no single jurisdiction. It is thus difficult to ensure a fair system of compensation and processes.

Civil society organizations have a useful and constructive role to play in enhancing the overall outcome of cross-border projects. Most important, civil society can provide a rigorous system of screening and monitoring cross-border infrastructure to ensure that transparent processes are in place for project planning, design, and implementation and for a fair distribution of costs and benefits among different groups of stakeholders. In this way, civil society can give voice to stakeholders who are adversely affected by projects.

Multilateral Institutions

Regional connectivity is a public good with high externalities. Hence multilateral institutions have a crucial role to play in cross-border infrastructure projects. In the European Union, financial instruments are available to identify and design cross-border projects, in order to develop a large internal market and strengthen intraregional connectivity and regional competitiveness. The European Community budget finances part of these costs using “structural funds” at below market rates, involving some form of subsidy, to promote cross-border infrastructure; the European Investment Bank plays a significant role in funding the projects.

In the GMS, the ADB has provided financial resources and capacity building through its technical assistance program. Multilateral institutions like the ADB can

play a special role in ensuring that cross-border infrastructure complements the work being done by local governments and other stakeholders in all areas identified in the framework. They can help in the process of integration, regionally and as part of the larger globalization process.

The role of multilateral institutions in cross-border infrastructure includes many facets. As financiers, multilateral institutions can provide loans and other risk mitigation instruments, such as guarantees, and help mobilize resources from other development partners, including the private sector. As knowledge partners and technical advisors, multilateral institutions can provide expert advice, share lessons learned regionally and globally, and tailor knowledge to the specific needs of and conditions in the countries involved. As capacity builders, multilateral institutions can help developing countries and regional or subregional bodies strengthen their institutional and human capacity to manage cross-border infrastructure, particularly for strengthening infrastructure governance (for example, financial management) and supporting software and institutional aspects. Perhaps most important, as honest brokers, multilateral institutions can play a catalytic role in cross-border infrastructure projects, bringing countries and other stakeholders together impartially and facilitating the dialogue and discussion process so that countries can reach political convergence to strengthen cross-border connectivity.

Financial and technical appraisals are important inputs for multilateral institutions, but so are environmental and social appraisals to ensure the mitigation of negative impacts and a fair distribution of costs and benefits among different stakeholder groups in the project design. Many regions have also benefited from specialized funds to support the identification, design, planning, and even financing of such projects. The success of the GMS program can be attributed, in large measure, to the ADB's sponsorship of financial and other technical resources that supported the collective processes.

Notes

1. Asia in the modern age includes China, India, Japan, and key Southeast Asian economies.
2. *Cross-border infrastructure* is defined as any international infrastructure cooperation initiative between two or more countries to strengthen cross-border connectivity.
3. East Asia includes 15 economies, including the 10 members of the Association of South-east Asian Nations (ASEAN) (Brunei Darussalam, Cambodia, Indonesia, Lao People's Democratic Republic, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam); China; Hong Kong (China); Japan; the Republic of Korea; and Taiwan (China). Emerging East Asia excludes Japan.
4. The discussion on production networks draws on Carruthers, Bajpai, and Hummels 2003; Fujita and Hisa 2004; and Kawai 2005.
5. For this reason, East Asian exporters have made broad-based gains in competitiveness in local markets against many major nonregional suppliers (ADB 2003).
6. In efficient multimodal transportation networks, goods move from one mode of transport to another seamlessly, without storage or human handling in between.

7. A recent study (ADB 2006b) indicates that regional cooperation in trade, transport, and customs transit in the Kyrgyz Republic would yield a potential cumulative gain for the period 2006–15 of \$2.1 billion at 2002 prices.
8. Actual transport costs and time are often much higher than the “ideal world” costs (UNDP 2005). The “ideal world” condition is based on balanced transport flows, competitive markets for transport services, smooth border crossings, low transit fees, and no visa problems or unofficial payments.
9. Canals and railroads in the United States opened up new areas promoting economic growth through regional specialization based on the comparative advantage of each region. Governments (national and subnational) played an active role during 1790–1840, funneling large amounts of foreign and domestic investments into infrastructure projects (Wallis 2000). Europe saw a major expansion of its infrastructure network by way of railway links, telegraph lines, electricity and cables, gas and water works in the 19th century, followed by telephone lines and tramways at the turn of the 20th century. Japan spent considerable resources building infrastructure before World War II, but it was its efforts after the war, when it allocated 6–8 percent of GDP to infrastructure development, that set an example for other East Asian economies. Hong Kong (China), the Republic of Korea, Malaysia, Singapore, and Taiwan (China) followed this lead with similar investment levels (Mody 1997).
10. *Regionalism* here includes formal economic cooperation and integration arrangements covering infrastructure, trade, investment, finance, and various types of regional public goods (see Kawai 2007).
11. The Greater Mekong Subregion (GMS) comprises Cambodia, China, Lao PDR, Myanmar, Thailand, and Vietnam.
12. International arbitration offers a solution to this problem, but recourse to this option must be agreed on and adhered to a priori.
13. In the GMS program, cross-border infrastructure was found to be a crucial building block in developing cultural capital to reap the so-called “peace dividend,” expand markets, and exploit economic opportunities in transborder regions. It also provided a means for smaller nations to become relevant in the process of globalization.
14. For example, within GMS a broad hierarchy of institutional arrangements exists to prepare subregional strategies. There are working groups for energy and transport at ministerial levels, supported by a number of other institutional arrangements for coordinating work at technical level.
15. In the northern economic corridor, for example, the benefits would accrue largely to China and Thailand, while Lao PDR would have to pay large economic and social costs. It was therefore very important to ensure that the interests of pure transit countries—such as Lao PDR—were ensured when structuring the project finance.
16. In NT2, for example, compensation for environmental and social impacts was built into the design of the project and became part of the contracting arrangements.

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Comment on “Infrastructure and Regional Cooperation,” by Haruhiko Kuroda, Masahiro Kawai, and Rita Nangia

A. J. VENABLES

This article provides an interesting overview of the importance of cross-border infrastructure, the role of a regional development bank in developing such infrastructure, and some lessons learned from some recent Asian projects. I will comment on two areas: the importance of infrastructure for trade and growth and the role of an international agency—such as a regional development bank—in enhancing cooperation.

Cross-border infrastructure clearly matters for trade. At its simplest, pipelines and cables are necessary if there is to be trade in gas or power. More generally, infrastructure quality determines transport costs, and we now know a good deal about the importance of transport costs in shaping trade. Doubling transport costs (which amounts to moving from the median to the 75th percentile in the distribution of between-country transport costs) reduces trade volumes by 45 percent (Lima and Venables 2001). Landlocked developing countries have trade costs 50 percent higher and trade volumes 60 percent lower than otherwise similar coastal economies.

Bringing down trade costs is particularly important for some of the new forms of trade that are developing in the global economy. Production networks develop when firms are able to outsource different stages of the production process to different countries. Such networks depend on trade that is cheap, reliable, and quick. Within-country infrastructure is important, but so too is cross-border infrastructure, especially for landlocked countries. Infrastructure is a necessary ingredient to meeting these needs, although it is by no means sufficient. Other border frictions—red tape, border controls, and corruption—are often more important factors inhibiting trade.

The development of regional infrastructure systems is important not only for trade but also for shaping the economic geography of a region. Transport hubs are

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attractive centers for the location of activity, and these effects can be amplified by increasing returns and cumulative causation processes. The increasing returns may be in transport itself (for example, the advantages of a large port, able to handle large vessels, with frequent visits and a relatively high degree of competition between shippers). They may also occur as wider economies of scale and urbanization economies come into play.

In seeking to evaluate the impact of major transport and trade infrastructure, there is a tension between various strands of work. One strand is the traditional, rather narrow cost-benefit analysis. Perhaps the classic example of this type of analysis is the *ex post* evaluation of the impact of 19th century U.S. railroads undertaken by Fogel (1964). Fogel argues that the development of the railroad network—seen by many as having had a transformative impact on the U.S. economy—brought benefits worth less than 5 percent of GDP. According to Fogel, an upper bound on the benefit from railroads is the reduction in transport costs they bring about times the volume of freight shipped once the railroads are in place. Doing the numbers yields a central estimate of 4.7 percent of GDP. This argument is, of course, correct, in its own narrow terms. But Fogel assumes that the railroad network triggered no growth benefits or external increasing returns to scale.

Other strands of work include econometric estimation of the returns to public infrastructure (following the seminal work of Aschauer [1989]) and work estimating the gains from trade. Frankel and Romer (1999) suggest that a 1 percentage point increase in the share of trade (exports plus imports) in GDP is associated with an increase in income of 0.5–2 percent. While subsequent studies have suggested that the outcome may be closer to the bottom than the top of this range, they still point to large gains. Combining results on the effects of infrastructure on trade with these figures for the gains from trade suggest considerably larger gains than those given by a standard cost-benefit approach.

It is important that economic analysis find ways to reconcile these findings from alternative methodologies. The route to doing so involves recognizing that a standard cost-benefit approach fails to take into account all the benefits associated with infrastructure improvements. There are efficiency gains from bringing people closer together, in an economic sense. These operate through several different routes. Large markets relax the trade-off between firm size and monopoly power, enabling firms to operate at larger scale and in a more competitive environment. “Thick market” effects make for better matching, in both the product and labor markets. In the product market, specialized intermediate producers can develop. In the labor market, firms are better able to locate workers with the precise skills they need, and workers have a greater incentive to acquire specialist skills. Areas of dense economic interaction also bring improved learning opportunities and greater knowledge spillovers.

All these mechanisms are the standard fare of urban and regional economics, and they have made it into some parts of international economics. Some of them are difficult to quantify, although there are now a number of robust econometric results. A recent survey (Rosenthal and Strange 2004) finds that, over a wide range of city sizes, doubling the size raises productivity by about 3–8 percent. Evaluations of transport and other infrastructure improvements need to take some of these effects into account,

recognizing that the impacts of improving spatial links are likely to be greater than those included in a traditional narrow cost-benefit study.

The paper describes the role of the Asian Development Bank in the design and financing of a number of projects. What roles can such an institution play to facilitate cross-border investments?

The first role is simply as a coordinator and catalyst. History, language, legal systems, culture, and politics all mean that there are likely to be unexploited opportunities for cross-border trade. Research shows that international borders have a powerful effect in reducing trade. The most celebrated finding is that the border between the United States and Canada chokes off as much trade as would 1,700 miles of physical distance. A regional institution can play a role in identifying opportunities for infrastructure and cross-border trade and in bringing together stakeholders from both sides of the border.

The second role is in evaluating the distribution of costs and benefits of a project. It is likely that the benefits of a project are distributed unequally across countries. This is obviously true for transit corridors, where the benefits accrue primarily to the landlocked country. The propensity of economic activity to agglomerate at one point of a transport system also means that benefits may accrue unequally to the countries involved. A regional institution can play a role in evaluating these effects and using them to inform the allocation of project costs.

A third role involves the contractual issues related to asset specificity. Both the infrastructure investment itself and the related investments are highly dependent on the continuing cooperation of parties on both sides of the border—exactly the sort of circumstance in which a “hold-up” is likely. Agents on one side of the border can demand a renegotiation of the terms of the contract, threatening to restrict use of the asset. Opportunistic behavior of this type is a problem in many situations where contracts cannot be written to foresee every eventuality or be adequately enforced. Such contractual problems are likely to be particularly large in cross-border arrangements, particularly when sovereign states are involved. Regional institutions have a role to play both in writing detailed contracts and in creating an environment in which all parties—including governments—have an incentive to abide by the terms of the contract.

The fourth role is as an advocate of liberalization. Infrastructure is not the only barrier to regional economic activities. Tariffs, border formalities, and cumbersome regulations often provide as great a barrier as does lack of hard infrastructure. The role of the European Union is instructive here. Integration in the European Union was not brought about primarily by building roads and railways but rather by building institutions that enhanced cross-border cooperation and brought about the regulatory change that created the single European market.

Finally, regional institutions have a role in maintaining a balance between national and cross-border investments. There may be occasions where cross-border investments look attractive as political gestures. A regionwide agent, such as a regional bank, can serve a useful role in pointing to the fact that the vast majority of trade is intracountry and the vast majority of economic interactions are local rather than regional.

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Comment on “Infrastructure and Regional Cooperation,” by Haruhiko Kuroda, Masahiro Kawai, and Rita Nangia

R. T. MOCHEBELELE

The paper reports that the economic success of Japan in the late 20th century, as well as that of the newly industrialized economies, originated in intra-Asian trade, spurred by the Asian countries' abilities to adapt Western cultural elements to suit Asian domestic markets, such as making things smaller and cheaper or neater and cleaner. Japan, as an island state, may also have been forced by geography to strive to make contact with other states in the subregion, thereby helping them establish economic and trade links with other Asian states.

Regional trade developed differently in Africa. Africa had many colonial masters, who divided the continent into small states that, in most cases, are not economically viable. Most of these countries looked to their colonial masters for trade partners, supplying them with raw materials for their industries. The infrastructure that was developed was to move commodities to the ports, where they could be shipped to overseas markets. Infrastructure between African countries remained undeveloped.

The African countries have now realized the need for regional cooperation and intra-African trade. The approach has been to establish regional groupings, such as the Regional Economic Communities, as vehicles for economic and political integration.

The authors state that regional infrastructure will be driven by the need to reduce transport and logistics costs, develop economic integration, and connect production clusters and markets in the next few years. Addressing the region's logistics challenges will hence require attention to cross-border infrastructure.

The African situation is different, because the need for regional infrastructure is urgent and interconnections are required now if Africa is to foster and increase economic growth to meet the Millennium Development Goals (MDGs). Africa needs to

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grow quickly to attain a GDP growth of 7 percent if it is to succeed in meeting the MDGs. Africa's GDP growth rate reached 5.15 in 2004, up from 4.4 percent in 2003 and 3.7 percent in the previous five years (African Development Bank 2005). Growing at 7 percent a year will require an additional \$20 billion a year investment in infrastructure, according to the Commission for Africa, in order to boost trade among African countries and to create economies of scale so that Africa can be internationally competitive.

Africa needs to work fast to close the gap with other regions in terms of economic integration. The African heads of state and government have established regional institutions like those in Europe, but political and material support to these institutions is weak. This usually results in inconsistent and ineffective implementation of regional decisions—translating political will into concrete action plans in individual countries. Effective implementation of regional decisions calls for African countries to prioritize regional initiatives in their national plans and to provide the necessary budgetary allocations.

Africa urgently needs regional cross-border infrastructure, because of the small size of the economies of most countries, most of which are also landlocked. This need has been recognized by the African leadership through the African Union, which established the New Partnership for Africa's Development (NEPAD) in 2002. NEPAD has been set up to facilitate regional economic integration; infrastructure development has become a priority to promote African interconnectivity in transport, water resources, energy, and information communication technology.

Most countries think and talk regionally while acting individually, but this tendency changes when the benefits associated with regional infrastructure are demonstrated. Institutional structures have been put in place to oversee the implementation of NEPAD and to provide the necessary political leadership. The NEPAD Secretariat, stationed in South Africa, is responsible for coordinating programs and projects, mobilizing resources, and facilitating and supporting implementation. The Steering Committee, comprising personal representatives of the Heads of State and Government Implementation Committee (HSGIC), meets regularly to ensure that NEPAD programs and projects are implemented smoothly and in a timely manner. The Steering Committee reports to the HSGIC, which in turn reports to the African Union Summit, the highest governing body.

Efforts are also underway to strengthen private-sector participation, so that the private sector can play its role, as it has in East Asia in the regional economic integration process. African governments have set up an African peer review mechanism as part of their efforts to make governance transparent and predictable in order to attract private-sector participation.

The Asian experience that high costs in many countries stem from various factors including the low quality of infrastructure and market-unfriendly legal and regulatory frameworks for the transport sector is borne out by the African experience. In a number of landlocked African countries, transport and insurance represent more than 30 percent of the total value of exports; in some countries the figure exceeds

50 percent (African Development Bank 2005). In most countries, nonphysical barriers, such as visas, transport permits, and customs requirements, are serious obstacles.¹

The soft issues—harmonization of policies and improvement of the regulatory environment, capacity and institutional issues, procedures, and standards—are a major focus in the facilitation of infrastructure development under NEPAD. What is always of concern in Africa is the sequencing between implementing and addressing facilitation measures on the one hand and the implementation of physical capital investment on the other. Development partners sometimes take the view that Africa must deal with these softer issues before capital investment, while reason dictates that addressing soft issues in a vacuum is not sustainable. The two must go hand in hand. If they do not, trained staff, for example, will be lost to other countries unless there are projects to absorb them following training.

Several regional initiatives are at various stages of development and implementation in Africa under the NEPAD framework to promote regional cooperation and greater connectivity. Regional projects face many constraints, including weak implementing institutions, lack of resources for project preparation, lack of financial resources dedicated for regional infrastructure by development partners, and a weak policy and regulatory environment. Efforts are underway to create energy markets by creating regional power pools, to establish transboundary water resources management programs among riparian states, to foster information and communications technology connectivity across borders, and to develop spatial development initiatives intended to facilitate sustainable infrastructure.

The African private sector is weak. This means that government will continue to play a major part in developing infrastructure directly and in creating an environment that will eventually encourage the private sector to participate in infrastructure development and provision.

Countries in Africa have to define sovereignty when it comes to regional infrastructure development, so that they can align their differing interests by establishing joint formal institutions to implement projects on their behalf. Regional infrastructure requires sponsoring states to establish agreements that, among other things, must deal with how the benefits of the project will be shared. Because of their scale, regional projects usually require high up-front project preparation costs. NEPAD has begun tackling the problem by establishing the Infrastructure Project Preparation Facility at the African Development Bank, but support for the facility from partners has been very slow. African governments have responded by seeking ways to mobilize domestic resources, such as pension funds, in support of regional projects. Nigeria and South Africa have each agreed to contribute \$250 million to establish the fund.

As in Asia, the future of Africa is closely linked to its ability to reap benefits from regional economic integration. Demand for regional infrastructure in Asia is propelled by growing cross-border economic activities; in Africa the development of regional infrastructure is expected to contribute to growth in cross-border economic activity because of the small size of most of the economies. Africa's 10 largest

economies—South Africa, Algeria, Egypt, Nigeria, Morocco, Libya, Tunisia, Sudan, Angola, and Cameroon—contribute 77 percent of Africa’s GDP, indicating that the rest are too small to survive on their own.

Africa’s 10 largest economies are important destinations for exports and sources of imports; their physical connectivity will feature prominently in Africa’s infrastructure development plans. Africa needs to put in place strategies that will use the economic activity in these countries to catalyze development in the poorer smaller states, for which improved access to regional markets will be key to economic success. The efficiency of cross-border infrastructure will be an important determinant of Africa’s prospects for economic growth, employment creation, poverty reduction, and social improvements.

Governments are responsible for coordinating and planning regional infrastructure. They must create an environment conducive for investment by addressing the nonphysical barriers that have hindered development of regional infrastructure. Political leadership and support at the highest state level is critical for the success of cross-border infrastructure based on a common regional vision. African governments have committed themselves to providing such leadership through the HSGIC, which is made up of 20 states (4 from each of the 5 African subregions). These countries have committed themselves to projects that support both a regional approach to infrastructure provision and regional integration; to projects that have stalled for political reasons and for which NEPAD intervention could be expected to make a difference; to initiatives that offer solutions to regional policy, regulatory, or institutional blockages to regional infrastructure activities; and to projects that respond to the involvement of the private sector in infrastructure provision.

Both the private sector and civil society have significant roles to play in delivering cross-border infrastructure. The private sector can bring additional financial and technical resources for border infrastructure, and it can share the risk with governments. Many public-private partnership projects have been implemented successfully in South Africa and are being duplicated elsewhere in Africa.

Civil society has a role to play in ensuring transparency in the implementation of cross-border projects and in helping implement and monitor projects in communities. Both the private sector and civil society are built into the principles of NEPAD as ingredients for successful infrastructure programs. Governments, with the support of development partners, are providing both technical and capacity support to enable them to deliver on their key roles. Recognition of their importance represents a major breakthrough in the delivery of infrastructure.

The multilateral institutions have many key roles to play in regional infrastructure provision. These include taking on the role of honest broker, bringing countries together and acting as a catalyst in regional integration, providing capacity support and technical assistance programs, providing financial resources to projects, and coordinating resource transfers from other development partners.

The HSGIC has selected the African Development Bank as the lead agency in providing regional infrastructure in Africa. The African Development Bank has developed a Short-Term Action Plan for regional infrastructure development and

established a NEPAD unit to better fulfill the mandate given to it by the HSGIC. In the past three years, the African Development Bank has mobilized \$2.2 billion, of which it funded \$522 million. Its pipeline of projects under consideration totals \$622 million.

The World Bank is another major player in Africa's infrastructure. It is supporting work in transboundary water resources management (through the Nile Basin Initiative), power pool interconnections, transport, and information and communication interconnections. The World Bank and the African Development Bank are making provisions for resources in their soft loan windows in support of regional cross-border projects. The World Bank has also established a regional department office as another way of responding to NEPAD. Both banks are undertaking two complementary studies, a medium- to long-term strategic framework to regional infrastructure development and the African Infrastructure Country Diagnostic study, which will provide input to the Infrastructure Consortium for Africa, which was established following the publication of the report of the Commission for Africa (2005).

Development partners are expected to support cross-border infrastructure in several ways. These include (a) increasing support for project preparation; (b) aligning partners' actions with NEPAD priorities, harmonizing systems and practices to ensure predictable flow of resources; (c) scaling up resources for infrastructure development and ensuring that commitments are translated into concrete actions; (d) improving mechanisms for channeling assistance to multicountry and regional initiatives; (e) establishing mechanisms for cofinancing of projects and programs; (f) increasing the financial support by industrial countries and multilateral institutions, particularly in support of the MDGs; (g) agreeing on increased resource flows to infrastructure and monitoring of progress on an annual basis; (h) significantly scaling up investment, including asset maintenance; and (i) supporting African initiatives and aligning themselves with the Africa Action Plan.

For their part, African governments are required to improve the investment climate by (a) creating an enabling environment suitable for investment; (b) intensifying private sector participation; (c) establishing "special purpose vehicles" or implementing agencies to expedite the implementation of multicountry, multi-Regional Economic Communities (REC) projects; (d) creating and strengthening the project preparation capacity of RECs; (e) harmonizing regional policies, plans, and programs; and (f) sharing knowledge and good practices. African governments are also expected to (a) consistently and effectively implement regional decisions—translating political will into concrete actions, including the necessary budget allocations; (b) fund regional organizations by member states (ensuring an adequate financial base); (c) address the duplication of effort and confusion in leadership of project implementation as a result of multiple and overlapping regional economic communities; (d) align country development plans with NEPAD principles, goals, and priority programs to enhance effective implementation of projects; (e) include multicountry/regional projects in national infrastructure development plans; and (f) increase domestic resources to fund infrastructure projects.

Note

1. The African countries have recognized the need for liberalizing African air space to reduce the costs of travel and to establish regional hubs and agreed to do so under the Yamoussoukro Decision. But implementation continues to be a problem, because of national jealousies and protection of ailing airlines. As a result, traveling between African cities often involves traveling through colonial masters' capitals in Europe, adding to the cost of travel and hindering intra-African trade.

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Comment on “Infrastructure and Regional Cooperation,” by Haruhiko Kuroda, Masahiro Kawai, and Rita Nangia

NARONGCHAI AKRASANEE

I would like to highlight three important points raised in the paper by President Kuroda, Masahiro Kawai, and Rita Nangia. First, reforms have produced growth and other positive changes in the countries in the Greater Mekong Subregion (GMS) (tables 1 and 2). However, problems relating to poverty, although much less severe than they were, remain in many areas.

TABLE 1. History of the Move toward a Market Economy in the Countries of the Greater Mekong Subregion

Thailand	1932: Constitutional monarchy introduced with parliamentary democracy 1960: Broader market economic system adopted 1982: Thailand joins General Agreement on Tariffs and Trade (GATT)
China	1949: Communists win war against Nationalists 1986: Open door policy initiated 2001: China joins World Trade Organization (WTO)
Myanmar	1948: Independence gained from Great Britain 1989: Open door policy initiated 2001: Myanmar joins the Association of Southeast Asian Nations (ASEAN)
Cambodia	1953: Independence gained from France 1985: Market economy policy adopted 1993: Parliamentary democracy established 2004: Cambodia joins WTO
Vietnam	1954: Independence gained from France; country divided into Communist North and anti-Communist South 1975: Country reunited under Communist rule 1986: Renovation policy (Doi Moi) initiated
LAO PDR	1975: Communist Party takes control of government 1986: New Economic Mechanism established 1997: LAO PDR joins ASEAN

Source: Author.

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TABLE 2. Demographic and Economic Indicators in the Greater Mekong Subregion, by Country, 2005

Indicator	Cambodia	China ^a	Lao PDR	Myanmar	Thailand	Vietnam	Total
Population (million)	14.1	92.3	5.9	50.6	65.5	83.8	312.2
Land area (km ²)	181,040	630,661	236,800	678,500	514,000	329,560	2,570,561
GDP at market prices (\$ million)	5,400	75,362 ^d	3,200	8,700	180,600	52,100	325,362
Real GDP growth (percent)	6.0	11.3 ^d	7.0	2.9 ^b	4.5	8.4	6.7 ^c
GDP per capita (\$)	371	702	456	107	2,563	568	795 ^c
Foreign exchange reserves (\$ million)	955	—	244	720	50,728	8,297	—
Total trade (value of exports and imports) (\$ million)	6,406	7,978 ^d	1,268	5,428	215,169	66,742	302,991
FDI inflows (\$ million)	131 ^d	436 ^d	17 ^d	556 ^d	3,437	2,400	—
Tourist arrivals	1,421,615	2,231,000 ^d	1,095,315	660,000	11,500,000 ^e	3,467,757	20,375,687

Source: National Bureau of Statistics 2004; UNCTAD 2005; IMF 2005; EIU 2006.

— Not available.

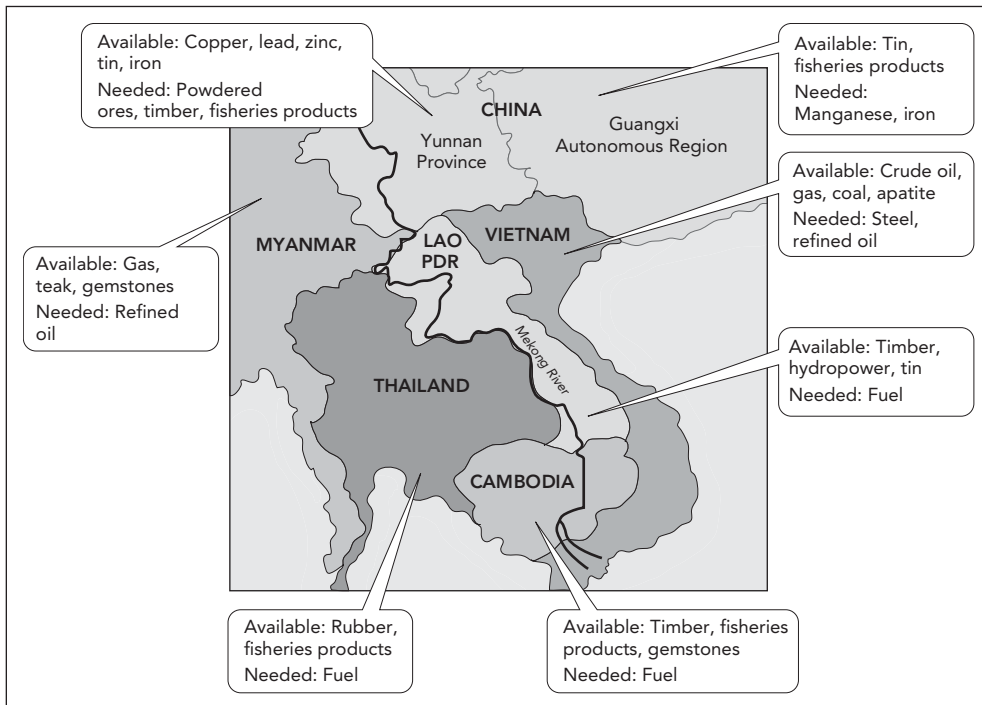
a. Data (for Yunnan and Guangxi Provinces) are for 2003.

b. Data are for fiscal year (April 1, 2005–March 31, 2006).

c. Average for GMS.

d. As of 2004.

e. Targeted.

FIGURE 1**Complementarity of Natural Resources in the Greater Mekong Subregion**

Source: *The World Factbook*, EIU, U.S. Central Intelligence Agency.

Second, cross-border infrastructure is needed in the GMS, for several reasons:

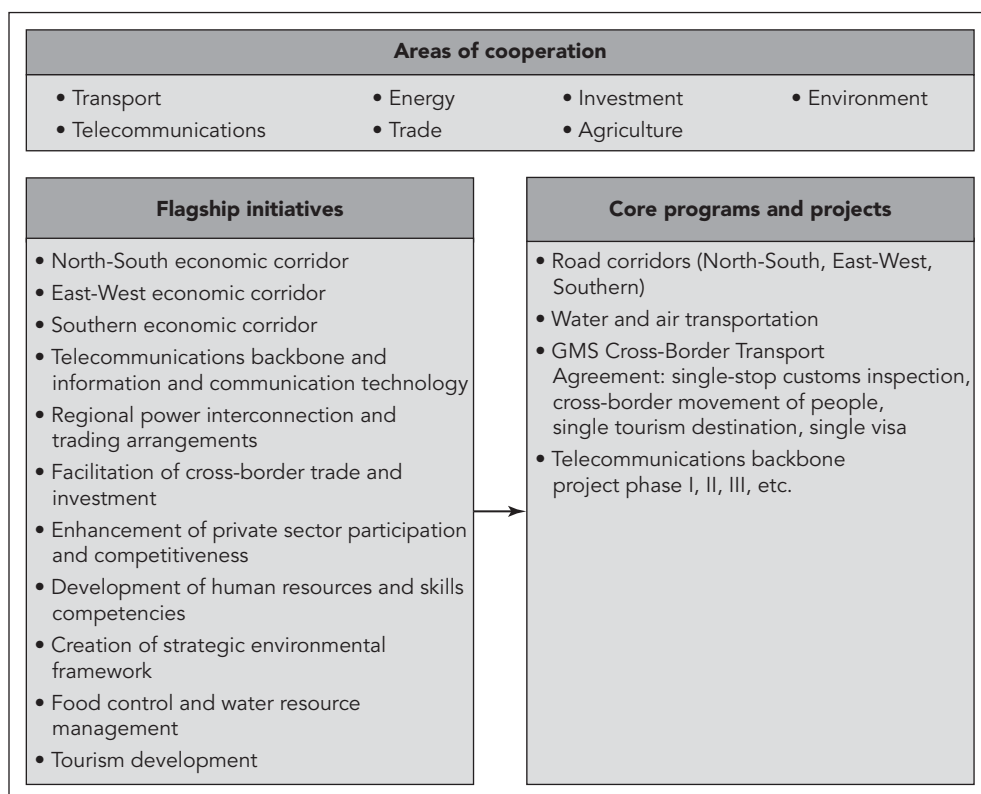
- Some countries have surplus labor, and their residents have a strong desire to work in other countries.
- Some countries have surpluses of natural resources, particularly power, while neighboring countries have deficits.
- Lao People's Democratic Republic (PDR) and Yunnan Province need access to the ocean.

There is some evidence of economic complementarity in the region (figure 1), and some crossborder infrastructure projects are being implemented, particularly in transportation and hydropower (figures 2 and 3). The East-West corridor—the highways linking Lao PDR, Thailand, and Vietnam—is already actively being used.

Third, a number of necessary conditions must be met for cross-border infrastructure projects to be successful:

- The governments concerned must cooperate seriously. Unless governments make a strong commitment to cooperate, crossborder projects will go nowhere.
- Good planning and preparation must be coupled with good coordination. The Asian Development Bank has been working with countries in the region to plan,

FIGURE 2
Areas of Cooperation in the Greater Mekong Subregion



Source: Asian Development Bank.

prepare, and coordinate efforts. Other agencies also need to participate in the process.

- Financing must be adequate. Some cross-border infrastructure projects, such as hydropower projects, are commercial in nature. For these projects, financing is usually available from public and private sources. Other projects have to rely largely on public sources (table 3), which are often limited.
- A legal and regulatory framework must be in place to facilitate the movement of people and goods. This area is a very difficult one, in which progress in the GMS has been slow. The governments in the region, however, now recognize its necessity and are working harder to reach agreements.¹ Third parties are needed and can be very helpful.
- The environmental impact of cross-border projects—particularly the effect on people living near a project—must be examined. Preparation of GMS projects has

TABLE 3. Financing of Cross-Border Infrastructure Projects in the Greater Mekong Subregion

(millions of dollars)

Country	Project	Total project cost	Asian Development Bank	Government	Cofinancing
Cambodia	Phnom Penh–Ho Chi Minh City highway	52.7	40.0	12.7	0
China	Southern Yunnan Road Development	770.3	250.0	520.3	0
Lao PDR	Nam Theun 2 Hydroelectric Project	1,250.0	20.0	0	1,230.0: AFD, Promotion et Participation pour la Cooperation economique (PROPARCO), NIB, EXIM (Thailand), and consortium of commercial banks. Other government equity contributors include the International Development Association (IDA), EIB, and AFD.
Vietnam	East–West Corridor Project	387.0	25.0	72.0	290.0: Japan Bank for International Cooperation and World Bank

Source: ADB 2005.

TABLE 4. Negative Environmental and Social Impacts of the Nam Theun 2 Hydro-electric Project

Environmental features negatively affected by the project	Negative effects of the project on people
<ul style="list-style-type: none">• Hydrology• Water quality• Erosion and sedimentation• Aquatic habitats and fish diversity• Terrestrial biodiversity• Endangered species	<ul style="list-style-type: none">• Relocation of estimated 1,128 households (about 6,224 people)• Social stress caused by resettlement and displacement• Loss of land and changes in local livelihoods, restricted access to resources• Higher risk of sexually transmitted diseases, drug addiction, alcohol abuse, poor sanitation, spread of other communicable diseases, and human trafficking

Source: EXIM Bank of Thailand.

included much work on the environment. The environmental considerations for the Nam Theun 2 hydropower project in Lao PDR set an excellent example for other projects to follow (table 4).

Note

1. Already in place are a cross-border transport agreement (for the facilitation of the cross-border transport of goods and people, the streamlining of regulations, and the reduction of nonphysical barriers) and a quadripartite agreement on commercial navigation on the Lancang-Mekong River (for the construction of a water transport network between Yunnan Province and mainland Southeast Asia that will facilitate commercial navigation).

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Closing Remarks

FRANÇOIS BOURGUIGNON

In keeping with the tradition of past Annual World Bank Conferences on Development Economics, an enormous amount of ground has been covered at this conference: several keynote speeches, four different plenary sessions, numerous parallel sessions that required us to make difficult choices among diverse topics, and countless engaging conversations in the hallways and dining areas. For me, the issues raised and perspectives provided over these two days will require time to absorb—not only at an analytic level but also in terms of how the development community can be energized in response to the ideas put forth.

Because of the richness of our discussions here in Tokyo, the challenge of putting together concluding remarks seems especially daunting: with so much material to choose from, whatever I focus on will necessarily mean other topics are left out. But in closing, it is perhaps useful to return to the theme of our conference, “Rethinking Infrastructure for Development.”

As Mr. Wolfowitz noted in his opening remarks, this title is itself suggestive—we are rethinking infrastructure because what we have been doing has not been working well enough in light of the enormous challenges faced by developing countries. Our discussions have revealed just how broad the infrastructure needs are and how multidimensional the policies and approaches are that must be pursued. The infrastructure agenda encompasses diverse sectors (transport, telecommunications, water, power) in an equally wide range of settings, from isolated lagging rural regions to burgeoning urban centers, from small local projects to massive multicountry regional initiatives. The scope of the problem is huge, the complexity enormous—but the need for progress is overwhelming.

The full range of topics considered during the conference has been broad: sessions on water management, disaster prevention and management, urban infrastructure and governance, foreign aid and aid for trade, poverty-reduction strategies, and

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global development finance. But for my concluding remarks, I would like to draw on the discussions that occurred at the four plenary sessions: infrastructure and growth, infrastructure and climate change, infrastructure and rural development, and infrastructure and regional cooperation. I will first provide a very brief review of what I took away from these four sessions and then consider a number of cross-cutting issues within the context of the broader investment framework.

In the first plenary session, Antonio Estache began by discussing why infrastructure has reemerged on the policy and research agenda. Infrastructure quality and affordability remain serious issues, posing a continuing bottleneck for firms and a drag on the investment climate; in addition, access rates for households lag, and public sector financing has fallen. The perception that infrastructure reforms were widespread is misleading—“privatization” of the sector has been limited; moves toward independent regulators have been uneven across sectors and countries, and progress has been slow in other areas. Estache identified four emerging policy areas: (a) revisiting infrastructure investment priorities—both across sectors and between the national and local levels—so that available resources generate the biggest growth “bang for the buck”; (b) anticipating and avoiding policies that lead to regressive outcomes that “punish the poor”; (c) reevaluating the role of public-sector financing, as it appears that the private sector often cannot—or will not—carry the burden alone; and (d) responding to concerns over corruption and governance by strengthening regulation and fostering transparency in areas still dominated by monopolies, both public and private, domestic and global.

The second plenary session confronted the contentious challenge of how to deal with the growing evidence that human development is contributing to global climate change. Michael Grubb explored the links between global growth, energy use, and climate change and identified the opportunities and tradeoffs that exist in tackling the problem. The link with infrastructure is direct: the pattern of energy use is, to a large extent, driven by infrastructure choices. Given the complex relation between emissions and development, the evolution of future emissions will be driven primarily by the combination of abatement efforts by the industrial countries and the capacity of developing countries to grow while “leapfrogging” toward lower-emitting technologies. The most important channel will be changing the technology embedded in the infrastructure investments that will make up the new capital stock—not just for power generation but for transport systems and buildings as well.

The scenarios for China presented by Jiang Kejun underscore this finding. They describe a range of policy interventions and technology choices that together can reduce the rate of growth of energy use in the coming decades and even more dramatically affect the projected emission of greenhouse gases. As stressed by Zmarak Shalizi, avoiding lock-in situations is essential. By 2015 half of China’s urban residential and commercial buildings will have been built since 2000. Energy use in these new buildings can be cut by half with a 10 percent increase in construction costs. If nothing is done now, it will take 50–100 years to eliminate these excessive emissions.

The third plenary session considered the challenge of infrastructure investment to promote agricultural development. As Per Pinstrup-Andersen noted, agriculture continues to constitute the core of most low-income economies, with significant potential

to contribute to poverty reduction. But performance has not always matched potential, raising the question of whether the policy and institutional environment is sufficiently supportive. In this context, rural infrastructure is key—it complements agricultural research and technology and raises productivity, it facilitates market integration over both space and time, and it can encourage broader institutional development, such as attracting financial institutions to rural areas. Despite its importance, however, the quantity and quality of rural infrastructure is woefully inadequate, especially in the least-developed economies. The limited evidence on the return to rural infrastructure investments suggests relatively high returns, pointing to underinvestment in rural infrastructure. This outcome reflects earlier failed efforts; limited private sector engagement; curtailed public investment, attributable in part to tight fiscal constraints; and a mismatch between centralized resources and decentralized needs.

In a companion paper in this session, Masahisa Fujita looked at the special challenges posed by efforts to develop lagging rural areas. Based on programs developed in Japan—such as “one village one product”—he considers the potential of a rural development strategy based on “brand agriculture” that exploits local resources to develop increasingly sophisticated and varied local products and services that create brand recognition and loyalty. Infrastructure is crucial: brand agriculture cannot evolve without successive improvements in various types of “hard” infrastructure, such as electricity, water, and roads, to “soft” types of infrastructure, including marketing and technical support.

In the final plenary session, Liqun Jin focused on cross-border infrastructure and its role in promoting regional (and global) integration. While trade and foreign direct investment have long been viewed as important drivers of growth, development, and poverty reduction, the potential contribution of regional infrastructure—and the “connectivity” it promotes—is increasingly recognized. The impressive expansion of trade, investment, and production networks that has occurred in Asia over the past two decades places new demands on logistics, distribution channels, and infrastructure. While the successful East Asian economies have invested heavily in infrastructure to meet these demands, there are still tremendous infrastructure deficiencies for poorer Asian economies and lagging regions in faster-growing economies. Reviewing examples of cross-border infrastructure investment, Jin concludes that even when projects are in the private sector, the role of governments—to share risks, facilitate the distribution of benefits and costs across constituencies, deal with cross-border externalities, and provide policy credibility and continuity—is crucial.

This overview of the plenary sessions provides a diverse agenda on topics for which further research is called for. But it does not naturally lead to an obvious policy framework within which to evaluate infrastructure investment options and tradeoffs. To shed some light on this question, I want to comment on the near absence of cost-benefit considerations in the infrastructure sessions—a point made by several plenary session participants—and show how it points to several important cross-cutting issues.

Back in the 1970s, when everything in life seemed simpler, there was a view that all investment projects, public or private, could be analyzed through standard market

indicators. The expected value of a project was simply the discounted sum of costs and benefits over its lifetime. For public projects, the necessary “social” cost-benefit analysis required adjusting some market indicators to reflect that private and public valuations did not always coincide. Shadow prices were used when there were no market prices or when they yielded a distorted signal of the social value of a good or the social cost of a resource. Distributional impacts had to be considered as a possible source of divergence between private and social valuations, and externalities—whether positive or negative—had to be taken into account. These shadow prices, external effects, and distributional effects were increasingly derived from comprehensive models of the whole economy, especially when correcting for monopoly distortions or dealing with projects large enough to affect the overall price system. These were the “good old days” of the Little-Mirrlees manual of cost-benefit analysis or its Dasgupta, Marglin, and Sen competitor. Cost-benefit analysis was the name of the game in the field of public finance, in particular in public spending, in both developed and developing countries. Social rates of return of alternative projects could be computed and the best projects selected, and infrastructure was the field of application par excellence of these techniques.

Thirty years later, cost-benefit analysis appears much less frequently in the toolbox of public finance analysts in developing countries. Yet the problem of measuring the rate of return of specific infrastructure projects has certainly not disappeared—Antonio Estache reported rates of return on infrastructure in Africa of 20–200 percent! The problem of comparing the rate of return of various projects in order to select the “optimal” ones has not disappeared either.

Why has the use of cost-benefit analysis declined? There are several reasons why the empirical implementation of the theoretical construct behind cost-benefit analysis turned out to be overly ambitious. First, for a while we thought that econometrics would solve all measurement problems and provide all the quantifiable information necessary for project analysis. This proved to be overly optimistic—we’ve made progress, but not enough.

Two other related factors may have contributed to the shift away from cost-benefit analysis. The first is the growing faith in the primacy of the market that culminated with the transition-economies period in the 1990s. The second is the underlying “planning” character of cost-benefit analysis that caused it to overlook behavioral responses from both beneficiaries and bureaucrats and the possibility that not all investments would automatically yield results. Mechanistic application of cost-benefit investment appraisal techniques that overlooked factors such as governance and behavioral responses often led to unrealistic evaluations, which in turn often ended up associated with failed projects, without any *ex post* effort to understand whether the problem was a failure in the cost-benefit methodology or in the project itself.

The main point I want to draw from this brief history and critique is simple: moving away from straight cost-benefit analysis to widen our perspective did not automatically resolve these difficulties. Several themes running across the sessions illustrate this and point toward how to move forward.

The first theme is the link between infrastructure and growth. In earlier cost-benefit analysis, the investment-growth link occurred at the micro level—each investment project generated output or income growth, often without any anticipated impact at the macro level. But the scope of interest is now broader—the case for increased infrastructure investment must be built on its expected macro impact on growth and ultimately poverty reduction. Yet the understanding of exactly how this linkage works remains incomplete, empirical evidence of its magnitude is not very robust, and the policy implications are unclear. As Antonio Estache noted, there is growing evidence that infrastructure matters to growth at the macro level but much less clarity on how this translates into sectoral priorities or the pragmatic needs of policy makers to target interventions to lagging regions or address rural-urban divergence. This theme was echoed in the empirical studies reviewed by Per Pinstrup-Andersen, which generally found a positive link between infrastructure and agricultural productivity and in the correlation between growth performance and physical infrastructure investments to improve “connectivity” discussed by Liquin Jin.

The second theme is the need to strike the right balance between public and private involvement, a debate that was largely absent from the cost-benefit approach. The prevailing wisdom on the appropriate role for public and private sectors has swung between extremes, from the dominance of state-controlled and financed activities several decades ago (in the golden era of cost-benefit analysis) to the more recent enthusiasm regarding the capacity and competence of the private sector. Using standard cost-benefit techniques was straightforward when activities were purely public or purely private. But the current consensus is that neither of these extremes is appropriate for dealing with infrastructure needs in developing countries and that no single solution fits all countries and all sectors. The critical importance of public support for financing emerges from the different sessions: Liquin Jin emphasized the role that governments must play in cross-border infrastructure even if private sector financing is used. The privatization experiences of the past decade provide ample evidence that better-designed and more-effective regulatory institutions are a clear priority, but the role of such “soft” institutions was completely missing from earlier cost-benefit approaches. What matters is ensuring that all elements are in place to demonstrate the commitment of both public and private partners to fair outcomes for users, investors, and taxpayers, which in many countries, starts with undertaking institutional reforms that increase the accountability of all actors.

The implication of different public-private financing options was almost completely absent from the traditional cost-benefit approach, which focused primarily on the spending side of the ledger. We now recognize that this public-private balance can matter a great deal. One lesson of the past decade is that the private provision of infrastructure is inadequate to fill the infrastructure gap, suggesting a continuing need for mixed financing vehicles, through which public and private contributions can be combined or public policies used to indirectly support private finance. But care must be exercised here as well: governments must avoid options that create open-ended financing windows or large contingent liabilities, and the level and pattern of financing provided must be carefully balanced against fiscal requirements. A related issue

for the public sector is the appropriate balance between domestic and external resources: while developing countries must shoulder a substantial portion of the financing burden, as they already do, increased aid is needed to complement public resources and accelerate infrastructure investment programs undertaken in the context of efforts to reach the Millennium Development Goals (MDGs).

The third theme is the challenge of dealing with cross-border or global externalities. Standard cost-benefit analysis is ill equipped to incorporate the impact of large externalities (positive or negative) that can occur as a result of major investments. This is evident in considering major cross-border or even national investment projects whose impact will be amplified by increasing returns or cumulative causation, as noted by Tony Venables. More generally, he notes that there are often large efficiency gains from making people “closer together” in an economic sense, which standard evaluations fail to capture. Dealing with externalities becomes even more problematic when one considers the tradeoffs implicit in the long-run adaptation and mitigation climate change scenarios described by Michael Grubb and Jiang Kejun: the challenge of assessing alternative investment interventions to reduce greenhouse emissions is compounded by the difficulty of capturing externalities with global impact that unfold over decades or even centuries.

The fourth theme is the importance of better data and improved evaluation. Researchers and practitioners moved away from cost-benefit analysis in part because of the enormous data demands, but the range of issues just outlined suggests a need for more and even better data. This point is critical: without systematic initiatives to expand the capacity to monitor infrastructure availability (and deficiencies) along with efforts to improve performance measurement and evaluation, there is little likelihood that the ambitious infrastructure agenda can move forward.

Creating the information base that will allow infrastructure projects to be monitored is crucial to increasing accountability for all participants. As Hadi Esfahani noted, the “missing” data are in some sense part of the “missing” infrastructure we must strive to create. As we have seen in global efforts to achieve the MDGs, measuring progress—or lack thereof—depends on having at least two data points. The *Global Monitoring Report* prepared each year to evaluate progress toward the MDGs has emphasized increasing coverage of indicators on the human development MDGs; a similar effort is needed with regard to infrastructure. The indicators developed should look not just at access—as has traditionally been the case—but also at affordability, which is critical to efforts to extend the benefits of infrastructure more broadly, especially to the poor.

With respect to evaluation, the needs are too great and the costs of failure too large to continue allocating resources to investment projects and other interventions for which no assessment of success has been done. One analytical weakness of cost-benefit analysis is that it is impossible to incorporate all possible channels of impact; it is therefore difficult to be certain that the overall assessment is comprehensive. By focusing explicitly on the overall impact of policies and programs, impact evaluation techniques can help fill gaps in the understanding of which policies and interventions work and which do not. Evaluations also provide benchmarks against which projects in different settings can be compared.

The impetus for an increased focus on results comes from various quarters. When donors are financing investment programs, there is a growing focus on “aid effectiveness” that translates into a demand for quantifiable measures of progress, with donors willing to commit large sums of money only to successful programs. When governments are financing investment themselves, the pressures are no less: nearly all face substantial fiscal pressures that call for increased scrutiny and care in choosing among alternative investment options.

If infrastructure is not going to be neglected, it must be better understood. Progress is being achieved through various efforts, including the Development IMPact Evaluation (DIME) initiative, in which the Bank is engaged. These efforts need to be expanded and generalized to countries and multilateral and bilateral donors. Knowing what works and what does not is a key global public good.

In summary, the progressive decline of cost-benefit analysis in public finance and the infrastructure literature may be explained by the formidable demands it places on data availability, on the exhaustive understanding required of economic mechanisms in a noncompetitive model of the economy, and on the knowledge demanded about institutions and governance parameters. But these issues still loom large in evaluating infrastructure policies and investment choices—they are not being dealt with in a comprehensive framework.

Moving forward, efforts are required to build a more systematic framework for evaluating investment choices. This certainly does not mean reviving traditional cost-benefit approaches: many of the shortcomings identified earlier continue to hold. Instead, efforts must be directed toward developing data and techniques that permit the same type of approach to be applied to a different scale, covering a wider set of factors, such as macro-level analyses that enhance the understanding of the structural factors and policy levers that affect success or micro-level impact evaluation assessments that help reveal what works and what does not. And yes, there is still a need for quantitative assessment of costs and benefits that goes beyond these areas, especially with regard to choosing among projects or sectors in allocating scarce resources.

In conclusion, let me again acknowledge all of the enthusiasm and expertise that have come together to make this conference a success and take one final opportunity to heartily thank our Japanese hosts for their hospitality and efficiency in organizing this event. While we will all take away our own perspectives on what the key messages have been, and what the priorities should be, I am firmly convinced that we have helped move the infrastructure agenda ahead—and I look forward to seeing what can be achieved in the months and years to come.

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