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Table of Contents

A. The model and recent applications

B. Building in the Stylized Facts: Business as Usual vs. Benchmark

C. International comparison of subsidies across selected countries

D. Trade under Non-Revenue-Neutral Gradual Subsidy Phaseout vs. Business as Usual..........................

E. Partial Neutrality

F. Non-Neutral Elimination of Energy Subsidies and Expansion of VAT to Food and Medicines

G. Universal Social Insurance Proposal

H. Trade under Dual Policy Implementation vs. Business as Usual

I. International Comparisons of CO2 Emissions per GDP

TABLES:

FIGURES:

Acronyms

CES	Constant Elasticity Of Substitution
CGE	Dynamic Computable General Equilibrium
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent
DAC	High-Consumption Tariff
GDP	Gross Domestic Product
IEPS	*Impuesto Especial sobre Produccion y Servicios*
INEGI	*Instituto Nacional de Estadística y Geografía*
LPG	Liquefied Petroleum Gas
MPSGE	Mathematical Programming System for General Equilibrium
MtCO2e	CO_2 equivalent
PECC	Special Program on Climate Change (*Programa Especial de Cambio Climático*)
SAM	Social Transactions Matrix
SHCP	Ministry of the Treasury (*Secretaría de Hacienda y Crédito Público*)
SO_2	Sulfur Dioxide
VAT	Value-Added Tax

Executive Summary

This paper analyzes the economic, distributional, and environmental impact that energy subsidy reductions and alternative compensating mechanisms might have in Mexico[1]. To achieve that goal, we use a computable general equilibrium model of the Mexican economy (for a detailed description, see Ibarrarán and Boyd 2006). We build the energy subsidies (to gasoline, diesel, and electricity) into the benchmark and then do an array of simulations to see the effects of removing such subsidies. We report results for 2012, which is the initial year; 2018, which would be the end of the next administration; and 2024 and 2030, which represent the medium and long term, respectively. When doing the simulations, we look at possible compensation mechanisms and analyze the impact on the income groups that may be affected by the reduction of energy subsidies.

Energy subsidies are a politically sensitive topic in Mexico. They include subsidies to electricity, gasoline, diesel, and liquefied petroleum gas (LPG). Between 2005 and 2009, subsidies were, on average, equal to Mex$200.4 billion per year (SHCP 2010). Subsidies to electricity alone represent roughly 1 percent of GDP. Subsidies to gasoline are equivalent to 25 percent of revenues collected from the value-added tax (VAT). The amount of money used toward these subsidies has increasingly been questioned because of their fiscal, environmental, and distributional implications. In addition, energy subsidies have not given the correct incentives toward energy efficiency, and have backfired in terms of local and global emissions, contributing to health problems and climate change. However, because eliminating these subsidies is a politically charged issue, concrete alternatives must be proposed to use those resources toward other policies that may be perceived as welfare enhancing.

One possible compensation mechanism in addition to many others is to reallocate the funds to finance a universal healthcare program. Several authors have proposed alternative packages (Antón, Hernández, and Levy 2012; Chávez Presa, Hernández Trillo, and López-Calva 2012, among others). Toward that end, we examine the implications of financing a expanded healthcare system with a cost of approximately Mex$560 billion a year. Depending on the specifics of the proposal, this might entail some combination of healthcare coverage, life insurance, and/or pension systems. The more ample the package, the higher its cost, so ultimately it will be up to the social security reform experts to put together the best combination of policies they can finance. The exercise presented here does not advocate for any particular package; rather, it presents to what extent a package of certain cost can be financed with the savings from energy subsidies.

At the same time, Mexico is a growing emitter of greenhouse gases. Even though it is ranked 13th worldwide and its emissions are only about 1.6 percent of total global emissions (CICC 2009), Mexico contributes approximately 25 percent of the emissions of Latin America and the Caribbean. Since Mexico is an upper-middle income developing country that is interested in becoming a significant player in climate change policy worldwide, this makes emission abatement policy relevant. In 2006, 28 percent of greenhouse gas emissions came from energy generation and 33 percent from energy use. Energy subsidies play a large role in this. Of total emissions from energy use, 62 percent are emitted by the transport sector and 10 percent by the residential sector (CICC 2009). Both of these sectors are

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[1] Energy subsidies are measured as the sales price with respect to production costs for each energy source. In the case of electricity, domestic production costs are used to estimate the subsidies; for all other fuels, international prices are taken into account to estimate the reference cost. No externalities are taken into account. The numbers used for the subsidies were provided by SHCP.

heavily subsidized. The Mexican government has put forth a plan to mitigate emissions, the Special Program on Climate Change (*Programa Especial de Cambio Climático*, PECC), running from 2009 to 2012. Overall, it estimates that 129.03 million tons of CO_2 equivalent (MtCO2e) would be eliminated during that four-year period, 50.65 in 2012 alone. Subsidy elimination was not considered within the PECC.

Additionally to climate change mitigation commitments, Mexico faces severe problems related to air pollution and groundwater exhaustion. All of these problems are exacerbated by energy subsidies that allow for lower cost fuels that cause pollution and promote water extraction through subsidized electricity tariffs to the agricultural sector. Thus, eliminating energy subsidies may help address many of these problems simultaneously.

The use of a computable general equilibrium model of the Mexican economy allows us to analyze the economic, distributional, and environmental impact of energy subsidy reductions. We first build the benchmark scenario and then we include some stylized facts of the economy (such as slower growth in the production of oil, unemployment, and formal and informal work in various sectors); this is the Business as Usual Scenario. We then simulate the elimination of subsidies to energy, and the Government retains those saved resources. There are negative short term effects both in GDP and investment, positive effects in aggregate GDP of the order of 1.5%, mainly explained by a significant increase in investment by the Government, and growth in the production and consumption of the various sectors and assets in the long term. On the other hand, this increase in investment leads to a progressive and positive effect on well-being of the various income groups, only affecting negatively the highest income groups, i.e. which are heavy consumers of energy.

The short run negative effects of subsidy elimination may be partially compensated using different schemes to transfer those saved resources to the population, sometimes to all, others to low-income groups, and sometimes only part of the resources saved from the subsidies. This in itself avoids a stagnation of economic activity and keeps up both expenditure and demand. We also provide results for these simulations and discuss some of the sensitivity analysis we carry out. In any case, over these runs, the energy-intensive sectors are significantly affected because now they do not receive the subsidy. Effects are quite similar under a gradual and a sudden removal of subsidies, given the same compensation mechanisms.

We then simulate the effect of expanding healthcare. Healthcare is not readily available to all workers in Mexico, and those that are not covered by any of the existing health systems face catastrophic expenditures and expensive private services if they happen to need medical attention. We run an expanded healthcare scenario where we first look into expanding the VAT to food and medicines since they are currently not covered by that tax[2] and from a fiscal standpoint this is a first step toward any tax reform. Additionally, the purpose of building this into the model is to partially finance the expanded healthcare coverage. The main results in this case are a significant increase in GDP, in the order of 2.8% by the end of 2030, growth in investment and capital accumulation, significant and progressive gains in welfare, and an increase in production and consumption across the board. The

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[2] Even though this is somehow not central to the central argument of this paper, VAT on food and medicine is bound to be a central component of any fiscal reform to close loop holes, for its progressivity and revenue raising capacity, and for the clarity of the tax system, so we include it as a building block to the expanded healthcare scenario. This increased coverage of VAT has been debated in Mexico under recent years, and is thus politically relevant.

universal healthcare program promotes formality in the Mexican economy and leads to higher productivity, with a more equitable income distribution. We then provide some sensitivity analysis for different rates of substitution among formal and informal workers across sectors.

Finally, when energy subsidies are eliminated and the expanded healthcare programs are combined, the results are highly desirable. For example, growth in GDP with respect to the Business as Usual case is in the order or 3%. This leads to the conclusion that these reforms help reduce distortions to the economy; increase its productivity and have positive effects on growth, investment, and capital accumulation; promote a more equitable income distribution; and reduce emissions that have both global and local effects.

Eliminating subsidies to energy achieves several goals. It cuts back on the use of a valuable non-renewable resource and the extraction costs of which are rising, and it promotes energy savings and efficiency. This, in turn, reduces emissions that have both global and local effects, contributing to improved air quality and reduced health costs. In addition, this contributes to mitigating climate change, since subsidy cutbacks alone get 80 percent of Mexico's yearly abatement goals for CO_2 emissions, as set by the 2008–2012 Special Program on Climate Change. Lower CO_2 emissions also imply lower local emissions, leading to improved environmental quality across the board. This is relevant since air pollution imposes a yearly cost of 1.5 percent of GDP on Mexico, mainly measured through urban impacts. Finally, since a significant part of energy subsidies goes to pumping water for agriculture, eliminating them may also help reduce groundwater extraction and therefore the replenishment of such sources. In summary, this exercise shows that the proposed reallocations of resources used to subsidize energy produce higher welfare (especially for low-income groups), promote overall economic growth, and improve environmental conditions and health.

Introduction

1.   This paper analyzes the economic, distributional, and environmental impact that energy subsidy reductions and alternative compensating mechanisms might have in Mexico. To achieve that goal, we use a computable general equilibrium model of the Mexican economy (for a detailed description, see Ibarrarán and Boyd 2006). We make several important changes to the original model to build the energy subsidies (to gasoline, diesel, electricity and LPG) into the benchmark and then do an array of simulations to see the effects of removing such subsidies. We report results for 2012, which is the initial year; 2018, which would be the end of the next administration; and 2024 and 2030, which represent the medium and long term, respectively.

2.   There can be basically an infinite array of alternative ways to make changes to the energy pricing policy. When doing the simulations, we first look at the elimination of energy subsidies, and then at different scenarios and several possible compensation mechanisms and analyze the impact on the income groups that may be affected by the reduction of energy subsidies. First we look at different types and magnitudes of lump-sum transfers, where all the saved subsidies are transferred to all of the population on a per capita basis, and then we consider variations on this, like only transferring half of the resources saved to the 50% lower income groups. Another option to use the saved funds is to finance an expanded healthcare program. Several authors have proposed alternative packages (Antón, Hernández, and Levy 2012; Chávez Presa, Hernández Trillo, and López-Calva 2012, among others). Toward that end, we examine the dynamic implications of financing a healthcare system with a cost of approximately Mex\$560 billion a year[3]. This helps illustrate how those resources could be spent. Other proposals that entail different aspects and/or coverage could well be simulated. Depending on the specifics of the proposal, this might entail some combination of healthcare coverage, life insurance, and/or pension systems. The more ample the package, the higher its cost, so ultimately it will be up to the social security reform experts to put together the best combination of policies they can finance. The exercise presented here does not advocate for any particular package; rather, it presents to what extent a package of certain cost can be financed with the savings from energy subsidies.

3.   On the other hand, Mexico is a growing emitter of greenhouse gases. Even though it is ranked 13th worldwide, it contributes approximately 25 percent of the emissions of Latin America and the Caribbean, although its emissions are only about 1.6 percent of total global emissions (CICC 2009). This makes emission abatement policy relevant since Mexico is a high-income developing country that is interested in becoming a significant player in climate change policy worldwide. In 2006, 28 percent of greenhouse gas emissions came from energy generation and 33 percent from energy use. Energy subsidies play a large role in this. Of total emissions from energy use, 62 percent are emitted by the transport sector and 10 percent by the residential sector (CICC 2009). Both of these sectors are heavily subsidized. The Mexican government has put forth a plan to mitigate emissions, the Special Program on Climate Change (Programa Especial de Cambio Climático, PECC), running from 2009 to 2012. Overall, it estimates that 129.03 million tons of CO_2 equivalent (MtCO2e) would be eliminated during that four-year period, 50.65 MtCO2e alone in 2012. Subsidy elimination was not considered within the PECC. Results of the model presented here show that roughly 80 percent of CO_2 emissions could be

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[3] As an illustration, we assume that the current cost in health per worker is \$10,118 pesos. Given a workforce of 39.03 million workers, the cost of health insurance would be Mex\$394.9 billion. To this amount, Mex\$136.3 billion are added to cover retirement pensions and Mex\$28.1 billion for life and disability insurance. This gives a total cost of Mex\$559.3 billion according to Anton et al (2012).

abated only by the elimination of energy subsidies, significantly contributing to the mitigation goals stated under PECC. Other environmental goals can also be achieved such as pollution reduction and thus health costs and reducing groundwater overexploitation.

4.   This paper is organized as follows. Section 1 describes the model, section 2 describes the scenarios and results, section 3 discusses the environmental impacts of these policies, and section 4 analyzes the findings from a public policy perspective. The Appendix contains supporting information helpful for the analysis and the discussion of the results.

1. The Dynamic Computable General Equilibrium Model

5. We turn to the issue of modeling the general equilibrium effects of eliminating energy taxes across the board, basically to gasoline, diesel, and electricity. These policies that affect large and interrelated sectors are not conducive to an analysis within a simplified framework, since they can have important repercussions throughout the economy. Such problems are appropriately dealt with using general equilibrium analysis. In this type of framework all the sectors in the economy are seen as one linked system in which a change in any part affects prices and output economywide. Mathematically, an interlinked economy can be described by a large system of simultaneous equations. More precisely in an economy with N markets, we require N-1 equations to solve for all of the prices and outputs in the system.

6. In this paper we look at a national model that has 12 producing sectors.[4] The primary sector is disaggregated into agriculture, livestock, fisheries, and forestry (see Table 1). This was done so that we can now explicitly deal with and quantify the interaction of sector-specific policies with other sectors when policies are initiated. It is particularly important to do this given that the simulations we run affect across-the-board energy subsidies and several taxes to finance expanded healthcare, for example. The model has four household (income) categories (listed in table 1) and nine consumption sectors (in Table 2). There is also a foreign sector and a government in this model. This model uses the latest information from the input-output matrix produced by the Instituto Nacional de Estadística y Geografía (INEGI), which uses 2003 as the base year, and other data from both national and international sources.

Table 1: Household Categories Based on Income

Category	Income Group
Agent 1	Bottom 2 deciles: 1–2
Agent 2	Deciles 3–5
Agent 3	Deciles 6–8
Agent 4	Top 2 deciles: 9–10

Source: Authors.

7. The economic variables determined by the model are investment, capital accumulation, production by each sector, household consumption by sector, imports and exports, relative prices, wages and interest rates, government budget expenditures and revenues, and total wage income. The level of depreciation and the initial return to capital are taken as exogenous, as is the rate of labor force growth. For a detailed explanation of the model and its recent application, see Appendix A.

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[4] Data restrictions prevent us from constructing a regional model. Furthermore, a regional model is impractical given that the capital in any given region is owned by individuals and corporations throughout the country. Lack of regionalization is not a major drawback, however.

Table 2: Producing Sectors and Consumption Goods

Producing Sectors	Consumption Goods
Agriculture	Food
Livestock	Household and other goods
Fisheries	Consumption services
Forestry	Energy (electricity and LPG)
Manufacturing	Autos
Chemicals & plastics	Gasoline
Mining	Public transport
Oil and gas	Housing
Transport	Water
Electricity	n.a.
Services	n.a.
Refining	n.a.

Source: Authors.
Note: n.a. = Not applicable.

Production[5]

8.   In each time period producers maximize profits in a competitive environment. Profit maximization, based on the described production technology, yields output supply and factor demands for each production sector and factor market in the model. Output and input prices are treated as variables. Taxes are also included, with producers facing tax-exclusive prices and consumers (and input-consuming firms) facing tax-inclusive prices.

9.   As a word of caution, the goods produced in the model's production sectors are not the same final goods consumed by consumers. Agricultural products, for example, must be combined with transportation services, manufacturing, and chemicals before they can be consumed by individuals as food. Hence, in our model we use a matrix to map from the vector of production goods to the vector of consumption goods. We do this through the use of nested functions to the production side of the economy and to the production of final consumption goods and services. This allows for different degrees of substitution for the inputs considered, particularly between labor, capital, energy, and non-energy inputs. Technologies are represented by production functions that exhibit constant elasticities of substitution. Technical progress is taken as exogenous to the model.

Consumption and Income Distribution

10.   On the demand side, the model reflects both the behavior of domestic consumers and foreigners (who can also invest through their savings) and that of the government. Domestic consumers are assigned to four groups (agents) according to income, and a demand equation is specified for each group, which has a different consumption bundle depending on its income. All four groups are

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[5] For a formal mathematical description of the model, see Ibarrarán and Boyd (2006, 114–26).

endowed with labor. Since only the wealthy actually have (formal) savings in Mexico, we assume here (in accordance with the latest data from INEGI) that only the top two groups (agents 3 and 4) own capital.[6] The gross income of each group rises by the rate of population growth plus the rate of technological change, which is taken as capital augmenting. These resources are rented out to firms in order to finance the purchase of domestic or foreign goods and services, to save, or to pay taxes to the government. The membership of each group is fixed, and although group income increases (or decreases) with GDP, individuals do not "migrate," as such, from group to group.[7]

Government

11.   The government agent is modeled with an expenditure function similar to the household expenditure functions (that is, based on a constant elasticity of substitution [CES] utility function). Revenues derived from all taxes and tariffs are spent according to an expenditure function. Within this expenditure function the government spends its revenues on goods and services from the various private production sectors discussed above. Consistent with the treatment of Ballard et al. (1985) and others, we posit an elasticity of substitution between inputs to the government's utility function. This allows for price responsiveness in the provision of government-purchased goods. The government also spends its revenues on labor. Together, these arguments represent the government purchases and payment of government employees necessary for it to carry on its work. The government also separately redistributes income through exogenously set subsidies and transfer payments, and the government budget is assumed to be balanced.

12.   Taxes in the model are expressed ad valorem and include personal income taxes, labor taxes, capital taxes, property taxes, revenue taxes (such as payments from oil and gas activities), value-added taxes, sales taxes, and import tariffs. The taxes on final goods such as gasoline differ from other consumer goods because of special taxes levied on them by the government, that is, the Impuesto Especial sobre Produccion y Servicios (excise tax, IEPS). By the same token, final goods such as electricity differ in treatment due to existing government subsidies. Income taxes are based on marginal tax rates. Subsidies to industries are essentially treated as negative taxes, and in these cases the government transfers funds back to a sector in proportion to that sector's output. Thus, if these subsidies are abolished, the government has more revenue.

Trade

13.   International trade within the model is handled by means of a foreign agent. Output in each of the producing sectors is exported to the foreign agent in exchange for foreign-produced imports. Under this setup, the aggregate level of imports is set and grows at the steady state level, but the level of individual imports may change in response to changes in relative prices. Exports are exogenous, as well, and are assumed to follow a constant growth path. They are, however, responsive to changing prices, and can change as individual sectors are shocked. Transfer payments, however, are endogenous

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[6] Household savings here have a certain degree of endogeneity. The level of savings for each income group (that is, Agents 3 and 4) are set at the levels that actually occurred in the base year of the dataset (that is, 2004). After that time, however, they are allowed to vary in response to changes in the relative prices of consumption and savings.

[7] Such migration, though a concept to explore, is computationally beyond the scope of this model. Furthermore, our chief concern with income distribution is how different income groups with varying consumption bundles and income streams are differentially impacted by the effects of policies.

and act to clear the model. The exchange rate is determined then by the interaction of capital made available for external uses, goods supplied for export, and the exogenous level of imports.[8] Price-dependent import supply schedules are derived from elasticity estimates found in the literature.[9] In specifying the level of substitutability between goods, we rely on the Armington (1969) assumptions, which allow for imperfect substitutability between foreign and domestically produced goods.

14.   In this model, we assume that Mexico has no market power in the world petroleum market. Hence, we treat the international price of oil as a given, and Mexican oil producers as price takers in the market. Consequently, when the Mexican government institutes investment policies to increase aggregate oil output, the domestic price drops as output increases and more is exported as the international price increases relative to the domestic price.[10] Oil depletion, however, represents a curbing investment.

Labor Growth and Capital Formation

15.   Growth within our Dynamic Computable General Equilibrium (CGE) model is brought about by the changes over time in both the labor force and the capital stock. In keeping with the theoretical underpinning of the Ramsey model (1928), we take the changes in the population as exogenous and constant over the time period considered. In the absence of any perturbation, Ramsey predicts that the economy will grow at the labor supply growth rate in the steady state.

16.   In the model, we assume that there is only one type of raw capital good, which goes into the various sectors. In addition, to add realism, we assume that the capital that goes into a sector works like putty and clay. More specifically, we assume that capital that is new can be readily combined with other inputs to produce outputs. Over time, this capital becomes locked into an older technology (that is, clay) and has a harder time combining with other inputs. In the growth literature, this is also known as "vintage capital." This is plausible as illustrated by sectors such as electricity production, which has been subject to a great deal of technological change over the years. The capital growth rate is modeled in accordance with neoclassical capital theory assumptions. More specifically, the growth of capital is modeled as investment net of economic depreciation.

Benefits of a computable general equilibrium model

17.   Some sectors are crucial to the way an economy works. Energy is one of such sectors, so any changes to pricing policies such as subsidy reductions will have effects over the entire economy. The use of a computable general equilibrium model, that is, a framework where all the sectors in the economy are seen as one linked system in which a change in any part affects prices and output economy-wide, is highly recommended, as opposed to a simplified framework of just one sector (i.e. partial analysis) that can have important limitations since no interaction effects may be captured. Economy-wide effects are appropriately dealt with a computable general equilibrium model specially designed for Mexico that is able to capture all the interrelations across the different sectors and on the

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[8] As a side note, closure in our model is determined by the equality of domestic and foreign leakages and domestic and foreign injections. More formally, we have *(S + M) = (I + X)* where *S* is domestic savings, *M* is imports (current account), *X* is exports (current account), and *I* is the total amount of investment made available from foreign and domestic agents.

[9] See, for example, Fernandez (1997); Romero (1994); Serra-Puche (1984); and and Wylie (1995).

[10] The domestic and international prices of oil may differ due to quality and transportation costs.

different consumer groups. Additionally this is a dynamic model, so there is growth and capital accumulation along the period of analysis. This allows to a better understanding of how different variables adjust through time and reflects the way the economy works. It enables making complex simulations on different policies that may alter the long-term situation of the economy. Some applications of the same basic model used in this paper are described in Appendix A.

Caveats

18.   Even though these models are very powerful, the usefulness of the results depends basically on the quality of the information that is fed, such as data from the input-output matrix and technical parameters of substitution, price and income elasticities, and other national data. On the other hand, even though this information is accurate, there is uncertainty about the exact value of the parameters, and of certain assumptions such as long term growth and population dynamics, for example, among other key variables. Therefore, the results should be interpreted with caution. For example, the basic take-home points should be the sign, the trend of the different variables, and the relative magnitude of the resulting numbers more than the values themselves. These results then show if the policy has positive effects, if they grow in time and what sectors are affected relatively more.

19.   On the other hand, this is a national level model that has no regional interpretation. To have a regional model we would need regional input-output data and social accounting matrices. This, however, is not a drawback in this particular exercise given that the energy sector, and labor for that matter, across all sectors.

2. Scenarios and Results

20.   This section describes the various scenarios we ran for this project and their comparison. We start by building the subsidies into the benchmark and then adding selected stylized facts of the Mexican economy, such as oil depletion and unemployment. We then simulate elimination of energy subsidies together with different types of lump-sum transfers to the population. Since lump-sum transfers are difficult to achieve because of the practical complications of getting the money to the people, we looked for alternative public policies to finance so the energy subsidies elimination is revenue neutral. One option among many is an expanded healthcare policy to cover employees in the formal and informal sectors under equivalent healthcare programs. To achieve this, we model a partial removal (about two-thirds) of social security employee-employer contributions, and the expansion of the VAT to food, medicines, and medical services[11]. We run this scenario under different elasticities of substitution for labor across the formal and informal sectors. Finally, we combine the elimination of energy subsidies with the expanded healthcare program, supported by some tax changes[12].

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[11] These are currently not covered under VAT, but there has been an ongoing discussion in Mexico on the option of expanding such coverage to these categories within any future fiscal reform.

[12] The reader may decide to only focus on scenarios 3 and 6 to see the effect of energy subsidy elimination alone and the joint implementation of both policies under study, i.e. elimination of energy subsidies and an expansion of the healthcare system financed by both saved energy subsidies and an extended VAT to food and medicines. For detailed explanations, review the appropriate scenarios.

Scenario 1. Benchmark

21.   Initially, we want to make sure that our CGE model is balanced both in terms of the social transactions matrix (SAM) constructed and in terms of its dynamic capital and labor components. To do this we run the model without any policy changes or dynamic constraints whatsoever. If the model is properly constructed, this should result in an algebraically consistent replication of the 2004 economy growing at the pre-specified rate of economic growth of 3.2 percent per year and at the pre-specified level of capital depreciation and investment per year. Doing this, we find that the model is indeed specified correctly and that the Mexican economy is growing at the proper "steady state." Results for this simulation are not shown (given their lack of intuition for policy analysis), but can be obtained from the authors upon request.

Scenario 2. The Business-as-Usual Case

22.   This balanced "steady state" run, though computationally important to our analysis, is unrealistic and of no use to the policy questions we are trying to answer. It assumes that the rate of growth is constant in all sectors including nonrenewable extraction of oil and natural gas. It also assumes no unemployment.

23.   Thus, to begin our formal analysis, we assume that the level of oil extraction is initially approximately 2.6 million barrels per day and follows Secretaría de Energía de México (Ministry of Energy) estimates (SENER 2012), flattening out at approximately to 3.3 million barrels per day. Natural gas goes from 6.2 million cubic feet to 8.7 million cubic feet. Unemployment is included in the model at 3.3 percent (frictional) in the initial year, that is, 2004. The aggregate results of the comparison between business as usual and the benchmark are presented in Appendix A1. They are not listed below because they are not directly relevant to the policy analyses proposed in this exercise. However, we present the dynamics of the different sectors once all the stylized facts described above are incorporated. Figure 1 shows how investment and selected sectors grow relative to each other under this scenario. The driving force behind lower growth in some sectors is oil depletion.

Figure 1: Business-as-Usual Case

Source: Authors.

24.   Looking at our results for production and consumption, we find that there is a general decline in activities in all sectors. Growth is even more negative in production sectors such as electricity and refining, which are closely related to the burning of fossil fuels. Growth is also negative in consumer sectors such as energy and gasoline.

25.   As for the foreign sector, oil and natural gas and refining sector imports grow to compensate for the domestic exhaustion of oil. The rest of the sectors are not significantly affected in terms of imports and exports. In all cases, the business-as-usual case is crucial since all of the following scenarios will be compared against it. The main results are presented in Appendix B.

Scenario 3. From Business as Usual to Non-Neutral Gradual Removal of Energy Subsidies

26.   In Scenario 3, we look at the effect on the Mexican economy of gradually removing energy subsidies. The amount of subsidies was provided by the Secretaría de Hacienda y Crédito Público (Ministry of Finance). The subsidies (expressed as a share of price) to electricity and gasoline are shown in tables 3 and 4, respectively. The electricity consumption of the residential sector is divided into a highly subsidized category (T1 and TF1 may have subsidies above 200 percent), and a high-consumption tariff (DAC) that is much less subsidized or even taxed, depending on the year analyzed. However, the DAC is less than 5 percent of residential power consumption[13].

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[13] Subsidies to electricity were provided by SHCP and they are subsidy/price. In the case of electricity, the size of a subsidy is not easy to determine as it implies dealing basically with a non-tradable good. The subsidy estimate is based on a

Table 3: Subsidies to Electricity (% of price), 2005–10

Sector	Electricity Subsidy (% of price)					
	2005	2006	2007	2008	2009	2010
Residential	157.8	145.3	132.6	177.8	179.4	149.4
T1–T1F	190.2	182.9	183.7	245.2	214.6	182.7
DAC	2.6	-1.0	2.0	9.6	8.5	-16.7
Commercial	14.1	6.7	-2.9	13.6	19.0	-4.5
Services	30.4	28.8	25.0	44.9	40.8	14.4
Street lighting	26.4	25.8	24.2	42.2	25.4	3.1
Water pumping	40.4	36.6	38.1	66.6	48.9	41.5
Agriculture	251.1	227.0	213.5	258.4	244.8	242.8
9–9M[a]	163.5	96.5	65.4	67.8	60.0	61.4
Incentive rate	282.1	297.3	290.4	357.2	291.7	314.2
Industrial	14.9	9.9	8.7	8.7	31.6	4.2
Medium voltage	16.2	14.3	15.1	13.6	35.1	3.1
High voltage	11.0	1.1	1.8	-2.0	23.5	1.5

27.   Gasoline prices are fixed by the government but with no transparent rule. This leads to some years in which it is highly subsidized and other periods when it is taxed[14]. We use 2010 as the reference year to determine subsidies that again are expressed as a share of the price (to see some international comparisons see Appendix C). These are the subsidies that we eliminate in the next simulations[15].

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calculation of the longer-term marginal cost of production with an administratively determined rate of return on assets. Inefficiencies in the production, transmission and distribution are part of the subsidy estimate and the latter is largely implicit as the government usually does not transfer a subsidy to the electricity company but largely foregoes a return on the assets it has historically invested. However, final price increases to consumer would have the effects described in this section.

[14] For fuels, subsidies in all of the simulations are estimated by SHCP and they reflect the subsidy as a share of domestic price. Given that fuel prices in Mexico are fixed by the government, volatility in international prices (that are taken into account when estimating costs) some years lead to negative subsidies and some to positive subsidies. In 2010 we observed a positive subsidy and that is the level of subsidies we work on eliminating in this document,

[15] Even though there may be price volatility in gasoline and oil prices, we take the subsidies in 2010 as a possible example. Other options could have been used such as having the average subsidy over some time period, for example. A fact is that price volatility affects the size of subsidies. In any case, lower subsidies will most likely have an impact on energy efficiency as is shown in the paper, when particularly electricity and gasoline consumption falls as prices rise.

Table 4: Subsidies to Gasoline (% of price), in 2010

Sector	Gasoline Subsidy, 2010 (% of price)
Agricultural sector diesel	13.55
Marine diesel	10.68
Auto vehicles diesel	13.55
Auto vehicles gasoline	18.69
Agricultural sector gasoline	18.76

Source: Secretaría de Hacienda y Crédito Público, Subsecretaria de Ingresos – Unidad de Política de Ingresos.

28.   Thus, in this simulation, we calculate the impact of removing the existing gasoline, diesel, and electricity subsidies on consumers, public transportation, agriculture, fisheries, public lighting, and various manufacturing industries. In our simulation, the subsidy removal begins in 2012 and is completed in 2018 to avoid any sudden shock to the economy. In addition, to concentrate solely on the substitution effects of the subsidy removal, the policy is done in a non-revenue-neutral manner, with all funds from subsidy removal being collected by the government and then invested according to its own welfare goals. To give us a frame of reference, we run the model as described with subsidy removal taking place along with fossil fuel depletion, and compare our results with those of the business-as-usual case described in Scenario 2, above.

29.   Looking first at the aggregate numbers in Table 5, we see that removing energy subsidies increases the aggregate level of welfare by 0.84 percent[16]. Aggregate GDP declines slightly initially (that is, in 2012) due to adjustment processes, but rebounds quickly and increases by 0.34 percent in 2018 and 1.54 percent by the final period of the analysis. Aggregate investment increases significantly in the latter part of the analysis, and the final level of the capital stock goes up by 7.13 percent as a result of new investment. The aggregate level of government welfare goes up by 3.5 percent and the welfare levels of the poorest agents go up by 1.10 percent and 1.01 percent, respectively, in spite of rising expenses as the gross domestic product (GDP) rises. Agent 3 sees a smaller increase of only 0.43 percent, and Agent 4 sees a slight decline of 0.18 percent. Thus, economic growth declines only in the very earliest part of the analysis and then speeds up in the later periods. A total removal of energy subsidies, it would seem at first glance, is beneficial to the level of economic welfare in Mexico over the 2004 to 2030 period studied. Welfare gains are larger for lower income agents because they consume proportionally less energy than the rich and therefore they lose less of their purchasing power once subsidies to energy are removed.

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[16] The results of each variable under each scenario are compared with the value obtained in the same year but under the business-as-usual case, for example, GDP for 2012 under the scenario of elimination of subsidies is compared with the value of GDP in 2012 under business-as-usual scenario. The variations that are reported in the text correspond to the percentage changes between these two scenarios.

Table 5: Change in Aggregate Results,
Non-Revenue-Neutral Gradual Subsidy Phaseout vs. Business as Usual

Category	2012 (%)	2018 (%)	2024 (%)	2030 (%)
GDP	-0.9359	0.3358	0.6884	1.5397
Investment	-2.8067	-0.0347	3.3236	16.1049
Government[17]	6.2460	6.4166	5.8566	5.0945
Capital Stock	—	—	—	7.1322
Aggregate welfare (∑Agent 1–4)	—	—	—	0.2920
Agent 1	—	—	—	1.0967
Agent 2	—	—	—	1.0063
Agent 3	—	—	—	0.4340
Agent 4	—	—	—	-0.1820
Government welfare	—	—	—	3.5042
Aggregate welfare	—	—	—	0.8403

Source: Authors.

Note: — = results not reported.

30.   Several other things are worth noting here. First, the total level of government income plus consumer welfare rises because a subsidy removal increases net welfare by eliminating the welfare loss. Because the elasticities of demand for gasoline and energy goods are relatively inelastic (that is, ranging from -0.28 for gasoline to -0.32 for residential electricity[18]), the revenue gains by the government are fairly substantial even though the aggregate welfare gains are quite modest. This is consistent with partial equilibrium theory, since taxing (subsidizing) a good with an inelastic demand generates (expends) a large amount of revenue while leading to a small deadweight welfare loss (see, for example, Atkinson and Stiglitz [1980] for an extensive review of this theory[19]).

31.   Turning next to the individual sectors, we find that, with the exception of the initial period (when capital and labor are adjusting to the subsidy removal), some or most production sectors see increases throughout the analysis. As would be expected, declines occur in the fossil fuel and electricity sectors that are most negatively impacted by the subsidy removal. Indeed, our model projects that, in 2030, electricity production will decline by approximately 25.3 percent compared to the business-as-usual case. Even though this number is high, it is explained by the extent of the subsidy removed. Significant losses are also experienced by the petroleum, natural gas, chemical (which includes petrochemicals), and refinery sectors. Increases are generally seen in all other sectors. Because of the large increases in investment, manufacturing (the largest supplier of investment goods)

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[17] Government refers to the total expenditure that, under a balanced budget, we assume here it is equal to total income from tax revenue and sales of publically provided goods and services. Since the idea here is to see how this concept changes when different policies are simulated, it out of the scope of this paper to include how the overall deficit will behave once policies are enacted in terms of its long terms sustainability. What we want to show here is how this balance in government revenues (or expenditure) changes under different policies.

[18] Our gasoline elasticity is taken from Reyes Martínez, Escalante, and Matas (2010), and our residential electricity demand is taken from Bernstein and Griffin (2006) (this study is for the United States). All estimates of elasticities for energy demand, however, are inelastic in nature. Commercial demand for electricity was assumed to be about 1 (which is consistent with estimates by Bernstein and Griffin [2006] and Berndt and Samaniego [1983] for Mexico).

[19] While, strictly speaking, welfare generation in CGE models is measured by equivalent variation (see Ballard et al. 1985), the partial equilibrium results follow their general equilibrium counterparts here fairly closely.

goes up by almost 14 percent by 2030. Fairly substantial increases are also experienced in the massive services sector for most of the analysis (Table 6). Here is important to note that even though sectoral growth lags with respect to aggregate GDP growth, services and manufacturing have positive growth even in 2018. This pulls aggregate growth even though individual smaller sectors linger behind.

Table 6: Change in Production,
Non-Revenue-Neutral Gradual Subsidy Phaseout vs. Business as Usual

Sector	2012 (%)	2018 (%)	2024 (%)	2030 (%)
Agriculture	-2.1029	-1.4120	1.3247	8.9637
Livestock	-1.6484	-0.4198	2.5197	10.1736
Forestry	-0.8658	0.3597	3.2738	10.6729
Fisheries	-2.0134	-2.2727	-0.9524	2.3622
Oil	-5.5083	-8.4084	-6.5328	0.2007
Natural gas	-5.4565	-8.3945	-6.4797	0.2523
Mining	-3.6179	-2.3143	1.9057	12.7644
Refining	-9.1142	-14.9005	-12.2972	-3.9018
Transport	-1.2193	-1.0664	0.4664	4.1557
Electricity	-24.5343	-35.6061	-32.7927	-25.3132
Chemicals & plastics	-5.5546	-5.7596	-0.5537	14.0324
Services	-0.2402	0.2896	1.7343	5.2546
Manufacturing	-1.8774	0.0973	4.0762	13.9500

Source: Authors.

32.   Figure 2 shows how particular sectors and investment behave once energy subsidies are gradually eliminated during the first years of the analysis.

Figure 2: Gradual Subsidy Removal: Non-Revenue Neutral

Source: Authors.

33.   Consumption goes up in all sectors with the exception of energy and gasoline (because of the large subsidies that both commodities receive in the business-as-usual case and that are eliminated in this scenario).

34.   Finally, except for petroleum, chemicals, and refinery products, trade in most commodities is largely unaffected by the elimination of energy subsidies. This is explained by the fact that eliminating subsidies has a local effect, bringing local prices closer to international prices.

35.   As noted, the aggregate effect of subsidy elimination would seem to be highly positive, and this is fully in accord with economic theory since resources are directed to more productive areas of the economy. Initially, however, growth goes down slightly for several years. This is due to the fact that there is unemployment in the model, and both labor and capital need a short time to adjust as the initial effects of an energy subsidy removal provide a shock to the economy. Hence, we should not be surprised to see this result, especially since both capital and labor participation grow rapidly throughout the rest of the analysis. Not only does the directly measured level of welfare increase here, but a welfare gain also comes from considerations external to our analysis in the model, such as lower emissions and more sustainable groundwater sources that will be discussed later on.

36.   First, and most important, the results in Tables 6 and 7 show that sectors that consume fossil fuels decline substantially from the business-as-usual case. This, in turn, means that the emissions of pollutants such as carbon dioxide (CO_2), sulfur dioxide (SO_2), nitrous oxides, carbon monoxide (CO),

and particulates will also decline, resulting in a large unambiguous increase in welfare through better air quality and, therefore, health.

37.   Second, if the elimination of subsidies were to be accompanied by a transfer to the poorer agents, as we will see in Scenario 4, there will be larger equity gains. These environmental co-benefits will be discussed later in the report.
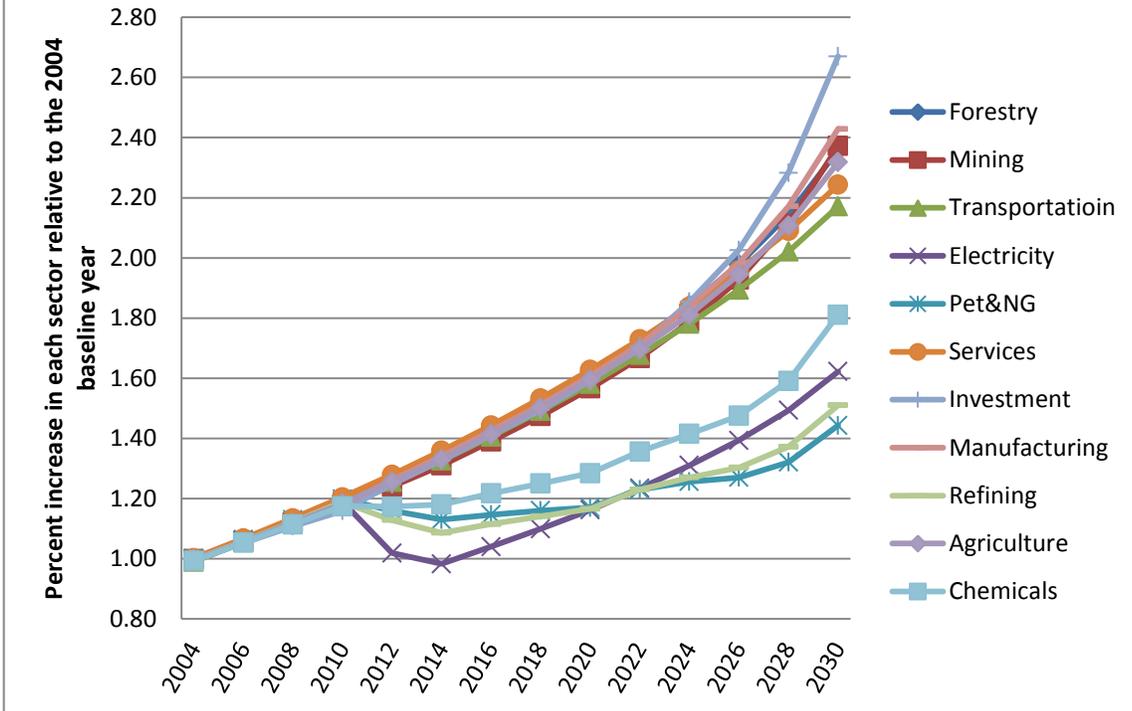
Table 7: Change in Consumption,
Non-Revenue-Neutral Gradual Subsidy Phaseout vs. Business as Usual

Category	2012 (%)	2018 (%)	2024 (%)	2030 (%)
Food	-0.3580	-0.2945	0.6063	2.1070
Household goods	-0.5087	-0.4493	0.5024	2.0484
Consumer services	-0.5929	-0.4951	0.4027	1.9066
Autos	-0.7860	-0.6573	0.3002	1.8484
Electricity and LPG	-8.4621	-12.9987	-11.9806	-10.3041
Public transport	-0.6107	-0.7806	0.1122	1.5883
Gasoline	-1.8651	-2.8691	-2.1657	-0.4723
Water	-0.4622	-0.2571	0.6452	2.1641
Housing	-0.5644	-0.4711	0.4300	1.9231

Source: Authors.

38.   One more point that is worth mentioning is the relevance of technological change. Even though we do not explicitly model it in any of the simulations, substitution elasticities across fuels are built into the model, so when relative prices of different energy sources change, adjustments in the fuel matrix take place. Technological change could also be modeled explicitly when energy efficiency is modeled as a scenario rather than as a result. Alternatively, some models take technological change as an endogenous variable, reacting to any changes in energy prices. Again, trade in most commodities is largely unaffected by the elimination of energy subsidies. These results are presented in Appendix D[20].

Caveats

39.   Some caveats have to be made with regard to the definition of energy subsidies and the way subsidies are modeled in this exercise. Most of these issues are explained in the footnotes above but it is important to discuss them overall. Subsidies are defined comparing final sales prices with production costs for electricity or considering international prices for other fuels. Occasionally, high subsidies reflect high inefficiencies in production. Subsidies could be reduced significantly by reducing production costs. If subsidies are cut back this way, then there will be effects on welfare if the costs are reduced inexpensively, otherwise there may be a need to factor them into the calculations.

40.   We are taking subsidies for 2010 and assuming they remain at the same rate in the business-as usual-scenario. This may be misleading since energy prices, particularly those of oil and gasoline vary in time, and therefore so do subsidies and final prices that may respond to volatility in world markets. This may affect the size of the subsidy since these international prices may be determining the final

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[20] Trade results for selected scenarios are presented in different parts of the Appendix. Results for other scenarios that are not listed are available from the authors upon request.

sales price. In any case we take the subsidies in 2010 as an example, but other exercises could have been made using an average over some period or some other projection for subsidies based on expected changes in production costs and international prices.

Sensitivity Analysis – Single-Year Option

41.   We did sensitivity analysis to this scenario by simulating a sudden elimination of energy subsidies. The results are very similar to the previous scenarios but with greatest adjustment costs in the initial years. In this case, instead of gradually removing the energy subsidies between 2012 and 2018, we complete the entire policy in a single year. This has the advantage of avoiding delays. It does, however, have the disadvantage of causing a sudden disruption to the economy when it is first done. As before, to concentrate solely on the substitution effects of the subsidy removal, the policy is done in a revenue-neutral manner with the excess government funds being distributed to the lowest two income groups. We compare our results here with those of the business-as-usual case.

42.   We see that a sudden removal of energy subsidies increases aggregate welfare slightly. This is a change in the same direction, albeit a bit less than when the subsidies were removed gradually. It would seem, then, that a sudden removal of subsidies is a little more disruptive than removing them gradually. The change, however, is not large. As in Scenario 3, GDP declines slightly in the first year but increases strongly in all subsequent years. Investment again increases throughout the analysis, and the final level of the capital stock goes up. The welfare level of the poorest agents rises as the added government funds are siphoned off to Agents 1 and 2. Agents 3 and 4, again experience more modest percentage gains but definitely gain welfare over the period of the analysis. Economic growth declines in the first year of the analysis but then turns around immediately and then speeds up in the later periods, as before. As with welfare and the level of the capital stock, all of the other aggregate variables show growth relative to business as usual, but the improvement is not quite as pronounced as when subsidies were removed gradually.

43.   When we examine the individual sectors, we find that, as in Scenario 3, most sectors increase from the business-as-usual case for the entire period of the analysis. We see that electricity production now goes down compared to the business-as-usual case, almost the same as before. Again, there is a large decline in the petroleum, natural gas, and refinery sectors, while the levels in all other sectors rise.

44.   Consumption again goes up in all sectors except in energy and gasoline (again because of the large subsidies that both commodities now receive that are eliminated in this run). Most other sectors see gains, but transportation (another recipient of energy subsidies) sees those gains only in the very last part of the analysis. Food and water experience the largest percentage gains due to the government's lump-sum adjustments to the poorer agents.

Scenario 4. Removal of Energy Subsidies under Revenue Neutrality

45.   We have looked at the effect on the Mexican economy of gradually removing energy subsidies. Here, however, the policy is done in a revenue-neutral manner, with all funds from the subsidy removal collected by the government being returned to the various agents so that government funds are

the same as in the business-as-usual case. Lump-sum transfers are made to all agents in proportion to the population of that income group so as not to favor either rich or poor consumers. Again, to give us a frame of reference we compare our results with those of the business-as-usual case described in Scenario 2.

46.   First, looking at the aggregate numbers, we see that applying energy subsidies increases the aggregate level of welfare by 0.73 percent, which is slightly lower than the non-revenue-neutral case. As before, the numbers are positive for all agents but Agent 4. The reason for this progressive result is that the wealthiest consumers consume a higher percentage of gasoline than their lower-income counterparts and, hence, despite a lump-sum transfer, the level of their welfare slightly decreases. Economic growth declines here until 2018, but becomes positive during the rest of the analysis.

Table 8: Change in Aggregate Results, Neutral Subsidy Phaseout vs. Business as Usual

Category	2012 (%)	2018 (%)	2024 (%)	2030 (%)
GDP	-1.0231	-0.1000	1.2327	2.0839
Investment	-2.6421	0.9031	1.7038	16.8214
Government	0.0000	0.0000	0.0000	0.0000
Capital stock	—	—	—	7.1003
Total welfare (∑Agent 1–4)	—	—	—	0.7252
Agent 1	—	—	—	6.6970
Agent 2	—	—	—	2.2141
Agent 3	—	—	—	0.3186
Agent 4	—	—	—	-0.4779
Government welfare	—	—	—	0.0000
Aggregate welfare	—	—	—	0.7252

Source: Authors.
Note: —   = Results not reported.

47.   One result of all our subsidy scenarios that seems a bit perplexing at first is that the expenditures of all agents go down throughout the analysis when their cumulative welfare goes up. This occurs because consumer spending makes up only part of total economic welfare. In addition to spending their money, consumers get utility and hence welfare out of their leisure time. Furthermore, Agents 3 and 4 have the option of saving their money instead of spending it, and the income that goes into savings also adds to utility. On balance, then, consumer welfare goes up in spite of slightly less spending activity (Table 8)[21]. Welfare gains are larger for lower income agents because they consume proportionally less energy than the rich and therefore they lose less of their purchasing power once subsidies to energy are removed. Additionally, the fact that Agents 1 and 2 benefit from the lump-sum transfers as opposed to the rich, give them further welfare gains. Overall Agent 4 loses because it is unambiguously affected by the subsidy removal given their large energy consumers.

48.   Turning next to the individual sectors, we find that, both within the production sectors (Table 9) and the consumption sectors (Table 10) results are almost exactly the same as in the non-revenue-

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[21] Leisure goes up when subsidies are eliminated because there is substitution between labor and leisure and the extra income earned allows consumers to work less and increase their utility by having more leisure time.

neutral case. Indeed, since the amount of redistributed wealth is quite a bit less than aggregate output, these results are entirely in keeping with our expectations. Furthermore, there is no substantial change in the international sectors, with the exports of fossil fuels and chemicals falling quite sharply and little else changing very much.

Table 9: Change in Production, Neutral Subsidy Phaseout vs. Business as Usual

Sector	2012 (%)	2018 (%)	2024 (%)	2030 (%)
Agriculture	-1.4552	-1.0632	1.4015	9.1847
Livestock	-1.1851	-0.3432	2.4275	10.3053
Forestry	-0.4310	0.3597	3.2738	10.6729
Fisheries	-1.3333	-2.2727	-0.9524	2.7451
Oil	-5.1397	-8.3000	-6.6805	0.1205
Natural gas	-5.1255	-8.2809	-6.6860	0.1684
Mining	-3.3189	-2.4390	1.5106	12.7644
Refining	-8.7559	-14.8590	-12.5163	-3.8734
Transport	-0.7574	-0.8183	0.4732	4.0369
Electricity	-24.1957	-35.6632	-33.1683	-25.5993
Chemicals & plastics	-4.9750	-5.9092	-1.0854	13.9301
Services	-0.3938	-0.0801	1.1363	4.5538
Manufacturing	-1.5274	-0.1223	3.7084	13.9623

Source: Authors.

Table 10: Change in Consumption, Neutral Subsidy Phaseout vs. Business as Usual

Sector	2012 (%)	2018 (%)	2024 (%)	2030 (%)
Food	0.4274	0.3483	0.9859	2.1776
Household goods	0.0266	-0.0821	0.6148	1.8463
Consumer services	-0.3871	-0.4347	0.2056	1.4071
Autos	-0.7860	-0.8381	-0.1256	1.1005
Electricity and LPG	-7.7485	-12.4200	-11.7394	-10.3542
Public transport	-0.0528	-0.3553	0.2801	1.4488
Gasoline	-1.7775	-2.9195	-2.2619	-1.0734
Water	0.3058	0.2558	0.8584	2.0758
Housing	-0.3584	-0.4281	0.1796	1.3897

Source: Authors.

49.   Finally, as before, fossil fuel use declines substantially from the business-as-usual case, resulting in a large unambiguous increase in welfare reflected as health benefits.

Sensitivity Analysis – Different Schemes of Lump-sum Transfers

50.   We did sensitivity analysis to see the impact of different schemes of lump-sum transfers. First we look at the case where only 50 percent of the saved resources are transferred to all the population as lump-sum payments. Then we analyze the impact of only giving transfers to the poorest 50 percent of the population. Finally, we discuss the results of simultaneously eliminating energy subsidies and

expanding the VAT to food and medicines as a building block toward financing a more ample healthcare system that will be presented in Scenarios 5 and 6.

Transfers to the poorest 50 percent.

51.   Here we look at the effect of gradually removing energy subsidies and giving back the total savings from the subsidies to the lowest two income groups in a revenue-neutral manner.[22] We compare our results with those of the business as usual scenario. Results seem very similar to the original case; GDP declines slightly initially (that is, in 2012) but rebounds quickly in 2018. By the final period of the analysis GDP grows, as does investment and the final capital stock. The aggregate level of government welfare is unchanged (by design), and the welfare level of the poorest agents rises as the added government funds are siphoned off to Agents 1 and 2. Agents 3 and 4, however, see smaller percentage increases. Economic growth declines only in the very earliest part of the analysis and then speeds up in the later periods. However, in this case we see fairly large increases in the agricultural sector as low-income consumers are given transfers and spend a large portion of their disposable income on food and related products.

Transfer of 50 percent of saved subsidies.

52.   Just as before, we calculate the impact of gradually removing the existing energy subsidies. The only difference from the previous scenario is in the size of the lump-sum transfer. Here, we transfer only half of the funds so that in this scenario we are not revenue neutral. As would be expected, the results are quite similar to the previous scenarios and require very little added explanation. The only thing to note in comparing all subsidy removal scenarios is that the total welfare gain seems to be slightly higher in the case where the government was allowed to keep all of the funds (non-revenue neutral). This, in turn, suggests that a subsidy removal might be most effective when used to finance other programs, as we will see below. The numbers for this scenario are listed in part E of the Appendix.

A building block toward more resources.

53.   In preparation toward financing a large-impact public policy such as expanded healthcare, we look at the impact of eliminating energy subsidies and at the same time expanding the VAT to food, medicines, and medical services. These health programs are usually expensive and savings arising from the elimination of energy subsidies are most likely not enough to finance such an endeavor. The purpose of this simulation, then, is to see how much revenue can be generated by a combination of these new taxes and the elimination of energy subsidies. In so doing, we also wish to ascertain the impacts of this policy on the level of consumer welfare, fossil-fuel use, and economic growth at both an aggregate and sectoral level. Results are presented in part F of the Appendix as percentage deviations from the business as usual scenario.

54.   When we look at the aggregate welfare and GDP numbers, we see that a combination of energy subsidy removal and VAT tax increases leads to gains in the aggregate level of welfare. Now,

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[22] Revenue neutrality is achieved due to the *cumulative* effect of the removal rather than on a year-by-year basis. Thus, in our results, we do not necessarily have revenue neutrality in each individual year. Government revenues are, however, neutral over the entire period of the analysis.

however, the welfare level rises by only 0.396 percent because a welfare "adding" subsidy removal has been combined with a welfare "taking" tax increase. As before, aggregate GDP declines initially and then goes up. The declines, however, are more severe than in previous cases and the gains are more modest. Furthermore, the losses persist until the very last period of the analysis.

55.   Aggregate investment shows a similar pattern for GDP but, as before, the gains in investment are significant in the final years of the analysis, and, as a consequence, the level of the capital stock again rises by over 7 percent. Because of the added taxes, government revenues rise significantly and the cumulative level of government revenue goes up by about 4.36 percent. Cumulative welfare also rises for Agents 1 and 2. Agents 3 and 4, however, experience declines in welfare of 0.25 percent and 0.93 percent, respectively. Hence, we can conclude that a combination of tax increases and subsidy removals leads to higher government revenue totals but at the expense of some consumer welfare and some economic growth.

56.   Looking more closely at where the gains and losses occur, we find that the consumption sectors are initially hurt as the policy takes effect, and, only in the very latter stages of the analysis do most of the numbers start rising compared to the business-as-usual case. As before, the gasoline and electricity sectors are the hardest hit. Now, however, serious declines result in foods, consumer services, and consumer goods because the VAT hits these items, as well. Negative impacts are also more persistent in the production sectors. By the final period of the analysis, however, the results return to a fairly familiar pattern, with all sectors experiencing gains except the fossil fuel and electricity sectors.

57.   As in previous cases, the international sectors are largely unaffected except with respect to the import and export of fossil fuels, and, as before, less production in the fossil fuel and fossil-fuel-related sectors leads to a decline in the externalities associated with greenhouse gases and other forms of airborne pollution.

Scenario 5. Removal of Selected Private Social Security Contributions and Expansion of the VAT: Financing an Expanded Healthcare Package

58.   In Scenarios 3 and 4, we were primarily concerned about the energy sector in the Mexican economy and the general equilibrium impact of a removal of the present system of energy subsidies on both aggregate and sectoral variables over time. In Scenarios 5 and 6, the focus of our analysis changes somewhat as we look at the general equilibrium impacts of a more extensive type of tax reform aimed at higher economic growth by increasing the quality of human capital, namely through enhanced access to healthcare. To be more specific, we examine the dynamic implications of an expanded healthcare reform.

59.   Based on several authors, we model a fundamental change in the Mexican health policy accompanied by a radical overhaul of the present tax system and changes to the private contributions to social security. The main modification to the tax system that we include deals with having food and medicines pay the same 16% rate of the VAT that all other goods pay. This is an ongoing discussion taking place in Mexico that at this stage could be promoted given that it may generate additional resources to pay for the expansion of the healthcare system[23]. This would have the effect of moving

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[23] Obviously there are other loopholes that would have to be closed to make the tax system more efficient, but at this point this is out of the scope of this paper.

labor from the informal sector (which does not formally and consistently contribute to social security) to the more efficient formal sector (which is currently taxed to provide security and health benefits).

60.   To make up for the loss in revenue from these contributions, we recommend extending the current VAT (which is 16 percent) to food, medicines, and medical goods and services that are currently exempt. In addition, a certain amount of all VAT revenues would be earmarked to cover the new national healthcare and social security system, and the government would subsidize the remainder from energy subsidies. This to some extent follows Anton et al 2012. As a note of caution, even though we think theirs is an interesting proposal, we do not model it exactly as they present it. For example, we do not eliminate private employee-employer contributions toward daycare, housing, and retirement savings. We do not compensate for the extra VAT that lower-income groups are paying. Nor do we model any of the extensions they present in their paper. We do take some of their numbers, such as the overall cost of Mex$560 billion a year as an estimated cost of a comprehensive healthcare program[24]. Other authors believe this number is too low for such a program, but we use this amount only as a ballpark estimate of possible costs, acknowledging that there may be infinite combinations of costs and policies. To see the main details of Anton et al 2012, see Appendix G.

61.   As before, to measure the impact of the parametric changes in this simulation, we compare our results to those of the business-as-usual case and give the percentage changes. Overall, the changes turn out to be dramatic and quite welfare enhancing. Furthermore, all the numbers tend to increase over time, lending support to the notion that this kind of policy could be quite effective for the Mexican economy.

62.   Turning first, to the aggregate impacts, we see that there is a large increase in GDP over time. Indeed, when compared to business as usual, the level of GDP grows by about 2.7 percent in 2018 to about 2.8 percent in 2030. These increases are primarily due to two factors.

63.   First, as some of the private social security contributions are removed and labor moves from the informal to the formal sector, more labor is hired. The level of unemployment goes from over 3 percent in the business-as-usual case to no unemployment in the latter years of this analysis.

64.   Second, following the stimulus to the aggregate economy, the level of investment increases substantially because the government has additional resources to spend, that come from the VAT to food and medicines, and labor is moving towards the formal sector, which is more productive and more capital intensive. This jump in investment is most apparent in the early years, when it grows by more than 7 percent over the business-as-usual case. The increase declines a bit in later years. Still, it remains above the business-as-usual case throughout the time of the analysis. Spurred by the increase in investment, the final level of the capital stock rises by over 7.9 percent. Furthermore, the welfare level of all agents rises, with the changes being slightly progressive in nature, as seen in Table 11. This occurs to some extent because of the transfers given to the poorest consumers. Still, some of it is due

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[24] Anton et al 2012 assume that the current cost in health worker is $10,118 pesos. Because of a work force of 39.03 million workers, the cost of health insurance would be $394.9 billion pesos (mmp). It should be added to this amount $136.3 mmp to cover pensions for retirement and $28.1 mmp for life and disability insurance. This gives a total cost of this package of $559.3 mmp according to Anton, Hernandez and Levy (2012). We take this number for our computations as one possible example, given this is the most clearly described in a published document.

simply to the nature of the changes that are designed not to inordinately enhance the welfare of the higher-income agents.

Table 11: Change in Aggregate Results, Expanded Healthcare vs. Business as Usual

Category	2012 (%)	2018 (%)	2024 (%)	2030 (%)
GDP	1.2342	2.6968	2.7954	2.8201
Investment	7.1014	5.6811	4.4193	4.3329
Government	-3.8546	-1.1842	-0.5012	-0.2325
Capital stock	—	—	—	7.9196
Total welfare (∑Agent 1–4)	—	—	—	4.6505
Agent 1	—	—	—	5.1138
Agent 2	—	—	—	4.9974
Agent 3	—	—	—	4.5227
Agent 4	—	—	—	4.5297
Government welfare	—	—	—	-3.7730
Aggregate welfare	—	—	—	3.2045

Source: Authors.
Note: — = results not reported.

65. Finally, the tax changes are not revenue neutral and total government income does decrease over the period of the analysis. It bears noting, however, that in the later periods of our simulation, the level of consumer and producer income rises and government revenue is only slightly lower than in the business-as-usual case (though deficits are run throughout the analysis).

66. Because of the complex links among sectors in our model and the multifaceted nature of the tax changes implemented, these changes are a bit harder to interpret than the aggregate changes listed above. Nonetheless, the relative magnitude of these changes can be understood if we look at the basic ways in which the tax reform proposal affects supply and demand in our model.

67. First, as we have noted, the decrease in some of the labor taxes (namely, selected social-security-related contributions) is accompanied by a corresponding increase in labor supply. Hence, the most labor-intensive sectors will be the principal beneficiaries of this supply shock. Second, directly following the change in tax policy, there will be an increase in investment as the income of investors (that is, savers) increases, and this increases the demand to those sectors that are most responsible for the production of investment goods. Third, because of the expansion of the VAT, food and consumer goods (where medical services are accounted for) receive the largest negative shock. Fourth, the income of the government goes down, and this reduces the demand for goods and services (that is, mainly from the services sector). Finally, all production sectors are connected due to input-output effects, and if demand goes up in one of those sectors, the demand will also rise in those sectors that supply most of the inputs. The opposite, of course, happens in the case of a demand decrease for a particular sector.

68. With these general concepts in mind, we now look at the increases for the various production and consumption sectors. In our model, the highest capital-to labor ratios occur in the chemical and manufacturing sectors, while the lowest occur in the agriculture, livestock, and forestry industries.

Furthermore, the input-output matrix used in our model reveals that the highest investment demand (as a percentage of total demand) occurs in the manufacturing, chemicals, petroleum and natural gas, and refinery sectors, while the lowest investment demand occurs in services, fisheries, and transportation. Hence, we see that the production sectors experiencing the biggest increases include chemicals, petroleum and natural gas, refineries, and manufacturing. Mining also rises substantially due to the fact that most of its inputs go into manufacturing, refining, and chemicals.

69.   Conversely, we see that livestock, agriculture, fisheries, forestry, and transportation experience substantial but lower gains. Part of the reason for the smaller gains in the agricultural sector is also likely due to the heavier taxes on food at the consumer level. Finally, we observe that the smallest percentage gains are experienced by the service sector. However, it must be remembered that Table 12 gives only percentage changes, and since the services sector is the largest production sector in Mexico, its "total" gains are approximately the same as those for manufacturing.

Table 12: Change in Production, Expanded Healthcare vs. Business as Usual

Sector	2012 (%)	2018 (%)	2024 (%)	2030 (%)
Agriculture	0.2202	4.7731	7.9700	9.6781
Livestock	2.6316	6.1363	8.6482	9.9975
Forestry	2.1008	5.7823	8.9636	9.4651
Fisheries	1.9355	5.2632	7.4236	9.8182
Oil	1.4500	7.0386	10.8557	13.7680
Natural gas	1.4706	7.1043	10.8502	13.8081
Mining	4.6605	9.0909	12.1294	13.8702
Refining	2.8674	7.2950	10.4528	12.8005
Transport	1.9002	5.2016	7.5256	9.5329
Electricity	3.4859	6.6087	8.8356	10.9830
Chemicals & plastics	5.4406	11.3406	15.7309	18.5830
Services	0.3851	3.6823	6.0085	8.0639
Manufacturing	4.6090	8.3096	10.9359	12.2901

Source: Authors.

70.   Turning now to the consumer goods sectors, we see that goods and autos, with their high manufacturing and chemical content, stand to gain the most. Food experiences a slight increase by 2030 in its final consumption due to reasons outlined at length above. Interestingly, gasoline ranks slightly lower than all consumer goods in terms of its demand increase over the course of the simulation, even before eliminating energy subsidies, as is the case here in table 13.

Table 13: Change in Consumption, Expanded Healthcare vs. Business as Usual

Category	2012	2018	2024	2030
Food	1.0698	4.1242	6.2781	8.5872
Household goods	2.5994	5.4216	7.5023	9.8051
Consumer services	2.2033	5.1237	7.1518	9.6404
Autos	2.4550	5.3917	7.4762	9.8051
Electricity and LPG	2.1898	5.2859	7.4487	9.7661
Public transport	2.1689	5.2024	7.3399	9.6057
Gasoline	2.0690	5.1549	7.3162	9.6045
Water	2.2489	5.2248	7.4148	9.7338
Housing	2.1956	5.2121	7.3358	9.6095

Source: Authors.

71. Finally, since the changes modeled here are primarily domestic in nature, there is little change in the foreign trade of goods and services. Both imports and exports go up as domestic consumption and production increase, but all changes there are relatively minor.

Sensitivity Analysis – Variations in Elasticity of Substitution across Formal and Informal Labor

72. To check the robustness of our results, we vary the elasticity of substitution between informal and formal labor in each of our production sectors. Initially, we set that elasticity at 1 (that is, the Cobb-Douglas case) and then expand it to see the impact such a change has on our models variables over time. We then increase the elasticity of substitution between informal and formal labor in each production sector from $\sigma = 1$ to $\sigma = 2$. This allows labor to travel more easily from the informal to the formal sector following a tax reduction, and allows the economy to adjust more quickly and efficiently to the tax change.[25] Given the relative ease with which labor can be substituted between the formal and the informal sector, this is probably a fairly realistic assumption. The results produced in this simulation are highly similar to those of our previous case.

73. We finally look at the case where the elasticity of substitution between informal labor and formal labor in all production sectors is increased from 2 to 3. These sensitivity analyses are important because, along with the level of economic growth that we assume, the elasticity between labor in the informal and formal economies is the most important parameter to be considered. Furthermore, since it is difficult to find a reliable estimate of this parameter, it is critical that the comparative statics and dynamics in our study be robust with respect to parametric changes here.

74. Basically, what our model shows under higher rates of substitution between formal and informal labor is that an increase in the substitution of elasticity from 2 to 3 has a very similar effect to when it was increased from 1 to 2. Again, the aggregate numbers go up slightly as labor becomes more substitutable. The final level of the capital stock increases. Growth is also seen in aggregate investment, GDP, and government spending in all periods following the healthcare and tax reform.

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[25] More formally, the elasticity σ here represents the change in the percentage quantity of labor (in each sector), which goes from the informal to the formal sector following a 1 percent lowering of the relative price of labor in the formal sector. Such elasticities exist between all sets of inputs, including labor and capital. In the MPSGE (Mathematical Programming System for General Equilibrium) model that we use, the production in each sector follows a "nested" CES structure, allowing us to change these elasticities in the model with relative ease.

Aggregate welfare for all agents goes up over the previous case, with the largest gains accruing to the poorer agents.

75.   Welfare gains for all income groups tend to be marginally close to zero, indicating that, as before, the gains due to larger substitutability are positive but not particularly large. Welfare gains for all groups, however, go up over time with the accumulation of more capital stock. As before, consumption gains are higher in food, leading to slightly larger increases in the agriculture and agricultural-related production sectors. Gasoline consumption also rises a bit more than the average. Foreign sectors are largely unaffected, as in all previous cases.

76.   Finally, it should be noted that model convergence was the most difficult in this particular case of higher substitutability. The relatively high level of the elasticity between labor types caused some concavity issues, and it required more iterations to achieve tangencies between the isocost and isoquant surfaces in the nested production functions used by the model.

Scenario 6. Dual Policy Implementation

77.   In this final scenario, we quantify the economy-wide and sector-specific impacts of an expanded healthcare system financed by a VAT expansion and coupled with energy subsidy removal and a reduction in some of the private contributions to social security. Namely, this is a combination of Scenarios 3 and 5, that is, the non-revenue-neutral energy subsidy removal scenario and the expanded healthcare reform scenario presented above. We list the percentage changes of this scenario from the business-as-usual case. This allows us to see the total impact of carrying out these policy changes, and as can readily be seen from there, this is basically a combination of the two. It is important to remember when examining these impacts, however, that this is not a linear model and that the changes seen here are not strictly a linear combination of the two previous policy change scenarios.

78.   The increase in the level of the aggregate variables brought about by dual policy implementation is both substantial and persistent. As we can see, total welfare in this case rises by 4.2 percent over the business-as-usual case. This represents a fairly substantial case and is fully 1 percent greater than the expanded healthcare and VAT policy results we discussed in Scenario 5. Significantly, the government deficit (relative to the business-as-usual case) is only about .07 percent over the entire period. This, in turn, suggests that the expanded healthcare policy could be almost totally financed with the help of revenues gained from subsidy removal and expansion of the VAT. Both GDP and investment go up in all periods from 2012 on, and by 2030 the level of GDP has risen by about 3 percent over the business-as-usual case. The increases in investment lead to a 7.5 percent increase in the capital stock, and the subsidy removal combined with a growth in income leads to a growth in government revenue by the latter part of the analysis Table 14).

Table 14: Change in Aggregate Results, Joint Policies vs. Business as Usual

Category	2012 (%)	2018 (%)	2024 (%)	2030 (%)
GDP	0.7517	1.9120	2.8208	3.0290
Investment	6.0117	4.6914	4.4717	4.4506
Government	-0.2063	2.4550	3.1721	3.4827
Capital Stock	—	—	—	7.5246
Total welfare (∑Agent 1–4)	—	—	—	3.6562
Agent 1	—	—	—	3.8493
Agent 2	—	—	—	3.7452
Agent 3	—	—	—	3.5033
Agent 4	—	—	—	3.6871
Government welfare	—	—	—	-0.0736
Aggregate welfare	—	—	—	4.2177

Source: Authors.
Note: — = results not reported.

79.   Turning now to the results in the consumption sectors, we see that the aggregate impact of dual policy implementation is quite encouraging. All sectors with the exception of energy see gains. The loss in energy consumption occurs as a consequence of subsidy removal, and is a good thing from a policy standpoint, since a cleaner environment is a goal of this particular simulation exercise. Overall gasoline consumption goes up by about 4.6 percent by 2030, since the marginal effect of subsidy removal is more than offset by the effects of the VAT tax reform (Table 15). Nonetheless, gasoline consumption grows by only half as much as when there was no subsidy removal (see Table 13).

Table 15: Change in Consumption, Joint Policies vs. Business as Usual

Category	2012 (%)	2018 (%)	2024 (%)	2030 (%)
Food	0.0167	2.7290	5.0913	7.5731
Household goods	1.4182	4.0003	6.3043	8.7493
Consumer services	1.3101	4.0216	6.3465	8.7971
Autos	1.6045	4.2354	6.5432	9.0148
Electricity and LPG	-6.7343	-8.2614	-5.6517	-2.8354
Public transport	0.9153	3.3576	5.7203	8.1597
Gasoline	-0.0564	1.6643	4.0685	4.5864
Water	1.2121	3.9409	6.2880	8.7468
Housing	1.2594	3.9705	6.3048	8.7503

Source: Authors.

Table 16: Change in Production, Joint Policies vs. Business as Usual

Sector	2012 (%)	2018 (%)	2024 (%)	2030 (%)
Agriculture	-1.4931	2.4744	6.0584	8.2192
Livestock	1.3333	4.6394	7.5844	9.2414
Forestry	1.2712	5.4608	8.7079	10.6729
Fisheries	0.0000	1.6393	4.0724	6.4151
Oil	-3.0570	-0.5104	3.3912	6.3818
Natural gas	-3.0769	-0.4864	3.4211	6.3931
Mining	1.9178	5.7239	9.2764	11.2903
Refining	-5.0018	-5.9706	-2.2452	0.3924
Transport	0.5081	3.1979	5.7540	7.9797
Electricity	-19.6943	-26.9004	-23.5970	-20.5423
Chemicals & plastics	0.9265	4.6952	9.5167	12.4518
Services	0.1908	3.2893	5.7892	8.0312
Manufacturing	3.4971	7.1829	10.4092	12.0129

Source: Authors.

80. The results in the production sectors are similar to those in the consumption sectors in that they show the overwhelming impact of tax reform of increasing production and consumption almost everywhere. Table 16 shows that all sectors experience gains except the electricity sector. Electricity is a big recipient of the current subsidies, and the marginal impact of subsidy removal is most severely felt in that sector. Refining, natural gas, and petroleum increases are all significantly less than in Table 12 because subsidy removal cuts back on their growth. Nonetheless, with the exception of refining, all are positive for most of the period of the analysis.

81. Figure 3 shows how different sectors grow after both policies have been implemented. Compared to Figure 2, which shows the non-revenue-neutral gradual elimination of energy subsidies, the trends of growth across sectors is fairly similar now under the joint policy. Investment does not grow as much as in Figure 2 since it has now been used to finance expanded healthcare. The energy-related sectors behave quite similarly under the two scenarios.

82. Finally, since all policy changes considered here are concerned with domestic policy, there is little to report with respect to the foreign sector (trade effects are listed in Appendix H). With that said, however, we should note that there is an overall increase in both imports and exports. More domestic production and higher consumption spawns foreign trade activity and increases trade links with foreign trade partners.

Figure 3: Eliminating Energy Subsidies and Financing Universal Healthcare

Source: Authors.

3. Environmental Impacts of Reforms

83.   One of the goals of this study is to address the environmental effects of eliminating energy subsidies. Lower emissions are a goal in itself for the Mexican economy, which is now looking at low emission development strategies that focus significantly on mitigation. In addition, it has implemented the Special Program on Climate Change (Programa Especial de Cambio Climático, PECC) to achieve this. Eliminating subsidies to energy use may contribute significantly toward a low-carbon economy, as can be seen from this exercise.

84.   Eliminating subsides to energy use across the board leads to lower use of fossil fuels and thus to a reduction in emissions (a list of country-level emissions proportional to GDP is shown in Appendix I). In this analysis, we look at only CO_2 emissions from the burning of fossil fuels. We do not consider any other greenhouse gas emissions or any CO_2 emissions from land use change.

85.   Looking at energy use, we estimate that 41.7 million tons of CO_2 are abated every year during the period of analysis. PECC has an abatement goal of 51 million tons per year for 2012. This implies that only by eliminating energy subsidies are we able to meet roughly 80 percent of Mexico's annual emission abatement goals. As mentioned above, this does not include other greenhouse gases that

could add to even more CO2e abatement. These results are encouraging since they highlight the environmental benefit of these types of policies. In addition, they uphold the argument that elimination of energy subsidies is not regressive in terms of income distribution.

86.   Lower CO2 emissions also imply lower local emissions, leading to improved environmental quality across the board. This is relevant since a rough but educated guess shows that air pollution imposes a yearly cost of 1.5 percent of GDP on Mexico. This only measures the urban impacts on health in Ciudad Juárez, Guadalajara, León, Mexicali, Mexico City, Monterrey, Puebla, Tijuana, and Toluca, as estimated by the World Bank for 2012 (Table 17).

Table 17: Burden of Health Impacts of Urban Air Pollution

Health Impact	Cases	Million US$
Premature mortality	12,220	123.94
Premature mortality, children	1,934	19.62
Chronic bronchitis	19,648	1.79
Hospital admissions	56,760	2.81
Emergency room visits	1,113,442	4.78
Restricted activity days	187,662,750	54.19
Lower respiratory illness in children	2,478,047	4.82
Respiratory symptoms	597,257,100	3.66
Total		**216 (1.5% GDP)**

Source: Authors.

87.   Finally, these types of policies are bound to have an impact on other natural resources[26]. For example, currently there is a subsidy to electricity used in water pumping for agriculture. This has led to a significant overexploitation of groundwater resources. Policies such as these that increase the effective cost of water extraction will lead to a more rational use of water and therefore less overexploitation of the resource (Ávila et al 2005).

4. Policy Implications and Future Work

88.   The use of a computable general equilibrium model of the Mexican economy allowed us to analyze the economic, distributional, and environmental impact of energy subsidy reductions. When subsidies to energy use are eliminated, either gradually throughout 2012 to 2018 or suddenly in 2012, distortions are reduced and government resources are liberated, but short-run negative welfare effects take place. To avoid this we test different schemes to transfer those saved resources to the population, sometimes to all, others to the lower 50% in terms of income, and sometimes only part of the resources saved from the subsidies. This in itself avoids a stagnation of economic activity and keeps up both expenditure and demand.

89.   The energy-intensive sectors are significantly affected because they do not now receive the subsidy. However, since subsidies cause distortions, when they are eliminated there are positive and progressive welfare gains for most income groups, with higher gains to lower-income agents. Effects are quite similar under a gradual and a sudden removal of subsidies, given the same compensation

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[26] This does not stem from the analysis but is it worth discussing as an effect of elimination of electricity subsidies.

mechanisms. It remains to be seen, however, whether effective mechanisms that guarantee lump-sum transfers reach the targeted population.

90.   We then simulate the effect of an expanded healthcare program. We run this policy with the model and make some sensitivity analysis for different rates of substitution among formal and informal workers across sectors. The main results in this case are a significant increase in GDP, investment and capital accumulation, significant and progressive gains in welfare, and basically an increase in production and consumption across the board. The general equilibrium effects of the healthcare program, to increase coverage to all workers, whether formal or informal, and to promote formality in the Mexican economy, does indeed lead to a much more productive economy, with a more equitable income distribution, and with lower emissions as well.

91.   Finally, when energy subsidies are eliminated and other important reforms such as an expanded healthcare program covering all workers are combined, the results are highly desirable. This leads to the conclusion that these reforms help reduce distortions to the economy; increase its productivity and have positive effects on growth, investment, and capital accumulation; they promote a more equitable income distribution; and reduce emissions.

92.   In terms of the environmental effects, eliminating subsidies to energy in itself achieves several goals. It cuts back on the use of a non-renewable resource that is currently facing depletion and the extraction costs of which are rising, and it promotes energy savings and efficiency. This, in turn, reduces emissions that have both global and local effects, contributing to improved air quality and reduced health costs. In addition, this contributes to mitigating climate change, since subsidy cutbacks alone get 80 percent of Mexico's yearly abatement goals for CO_2 emissions, as set by the 2008–2012 Special Program on Climate Change. Finally, since a significant part of energy subsidies goes to pumping water for agriculture, eliminating them may also help reduce groundwater extraction and therefore the replenishment of such sources.

93.   As explained above, energy subsidies impose high fiscal costs and distortions to the Mexican economy. Healthcare is not readily available to all workers, and those that are not covered by any of the existing health systems face catastrophic expenditures and expensive private services if they happen to need medical attention. This exercise demonstrates that there may be other productive uses for those energy subsidies that may be welfare enhancing, promote overall economic growth, and that may certainly increase the quality of health of many more Mexicans, both directly and indirectly through a cleaner and more sustainable environment.

Future Work

94.   As usual, the scope of this paper is limited and throughout the analysis and discussion with colleagues an important set of possible extensions came up. Some recommendations came up regarding what could be built into the baseline, what those resources saved from energy subsidies could be used for, and finally other interesting simulations that could provide resources.

95.   In terms of the baseline, for example, if Mexico decides to exploit its natural gas reserves of tight gas, the baseline would change and this in turn could change relative prices of fuels. Assumptions

on a slower or faster rate of oil exhaustion could also be built into the baseline and that would lead to a different set of possible simulations.

96.   As for the type of programs that could be financed with resources from energy subsidies, the conditional cash transfer program Oportunidades could be expanded, investment in energy efficiency equipment that in the long run will translate into energy savings, generation of clean energy, and to the provision of cleaner and more efficient public transport. These exercises could definitely be done with the model in the future. Some of these policies have previously been done with the model.

97.   Finally, to gain further insight of the energy sector, simulations to address the marginal effect of eliminating subsidies to each energy source could be done separately. This would provide a better understanding on the impact economic and distributional effects of different subsidies. Conversely, a set of simulations could be done to see the effects of imposing carbon taxes. This could provide arguments for international negotiations, as well as fund some of the other projects such as clean energy, energy efficiency, and clean transport discussed above.

References

Antón, A., F. Hernández, and S. Levy. 2012. The End of Informality in Mexico? Fiscal Reform for Universal Social Insurance. Inter-American Development Bank, Washington, DC.

Armington, P. 1969. "A Theory of Demand for Products Distinguished by Place of Production." IMF Staff Paper 16, International Monetary Fund, Washington, DC.

Atkinson, A. B., and J. B. Stiglitz. 1980. Lectures on Public Economics. London and New York: McGraw-Hill Book Co.

Ávila, S., C. Muñoz, L. Jaramillo, A. Martínez. 2005. Un análisis del subsidio a la tarifa 09. Gaceta Ecológica. Abril-junio, 75. Instituto Nacional de Ecología, México: 65-76.

Ballard, C., D. Fullerton, J. Shoven, and J. Whalley. 1985. A General Equilibrium Model for Tax Policy Evaluation. Chicago: University of Chicago Press.

Berndt, R. E. and R. Samaniego. 1983. "Residential Electricity Demand in Mexico; A Model Distinguishing Access from Consumption." Working Paper, Massachusetts Institute of Technology, Cambridge, MA.

Bernstein, M. A., and J. Griffin. 2006. "Regional Differences on the Price–Elasticity of Demand for Energy." National Renewable Energy Laboratory, Santa Monica, California.

Chávez Presa, J. A., F. Hernández Trillo, and L. F. López-Calva. 2012. "El México del 2012: Reformas a la Hacienda Pública y al Sistema de Protección Social." Centro de Estudios Espinosa Yglesias, México D.F.

Charles, C. and P. Wooders. 2011. Subsidies to Liquid Transport Fuels: A comparative review of estimates. The International Institute for Sustainable Development. Geneva.

CICC (Comisión Intersecretarial de Cambio Climático). 2009. Programa Especial de Cambio Climático 2009–2012. DOF 28/08/2009. México DF.

Fernández, O. 1997. "Efectos de la Aplicación, de un Impuesto Ecológico Neutral en México: Análisis Mediante un Modelo de Equilibrio General Computable." In Instrumentos Económicos para un Comportamiento Empresarial Favorable al Ambiente en México, ed. A. M. García. Mexico City: Colegio de México, pp. 105–19.

Ibarrarán, M. E., and R. G. Boyd. 2006. Hacia el Futuro: Energy, Economics and the Environment in 21st Century Mexico. New York: Springer.

IEA (International Energy Administration). 2011a. World Energy Outlook 2011, U.S. Department of Energy and U.S. Energy Information Administration.

IEA (International Energy Administration), 2011b. CO2 Emissions from Fuel Combustion (2011 Edition), IEA, Paris.

Ramsey, F. 1928. "A Mathematical Theory of Saving." Economic Journal 38 (152): 543–59.

Reyes Martínez, O., R. Escalante, and A. Matas. 2010. "La demanda de gasolinas en México : efectos y alternativas ante el cambio climático." Economía: teoría y práctica 32.2010: 83–111. México, DF, ISSN 0188-8250, ZDB-ID 14333053.

Romero, J. 1994. "Energía, Emisiones y Precios Relativos." In Medio Ambiente: Problemas y Soluciones, ed. A. Yúnez-Naude. Mexico City: Colegio de Mexico, 41–52.

SENER (Secretaría de Energía de México). 2012. "Estrategia Nacional de Energía 2012–2026." México DF.

Serra-Puche, J. 1984. "A General Equilibrium Model for the Mexican Economy." In Applied General Equilibrium Analysis, ed. H. E. Scarf and J. B. Shoven. Cambridge, England: Cambridge University press, 64–87.

Wylie, P. J. 1995. "Partial Equilibrium Estimates of Manufacture, Trade Creation, and Diversion due to NAFTA." North American Journal of Economics and Finance 6 (1): 65–84.

Appendix

A. The model and recent applications

Production

Production in each sector for every time period is represented as a constant elasticity of substitution (CES) value added function of capital, labor, energy and material inputs, where the elasticity of substitution can vary between zero and infinity. Hence,

$$(1) \quad V_t = \phi_t [\, \delta_L L_t^{(\sigma-1)/\sigma} + \delta_K K_t^{(\sigma-1)/\sigma} + \delta_E E_t^{(\sigma-1)/\sigma} + \delta_M M_t^{(\sigma-1)/\sigma} \,]^{\sigma/(\sigma-1)}$$

where V_t is the value added at time t, σ is the elasticity of substitution between inputs, ϕ_t is an efficiency parameter that shifts the whole production function, L_t is labor at time t, K_t is capital at time t, E_t is energy at time t, M_t are material inputs at time t, δ are share parameters defined so that

$$\delta_L, \delta_K, \delta_M, \delta_E > 0 \quad y$$
$$\delta_L + \delta_K + \delta_M + \delta_E = 1$$

Prices of all goods and services are equal to one, so that V_t refers to quantity as well as value of production. Material inputs are all inputs from the sectors of production, and M_t refers to a composite good based on a nested CES production function, where inputs from all sectors are included (See Figure A.1) . These nested functions are used for production and consumption, permitting different levels of substitution between inputs or goods and services. For the production function, substitution is allowed between labor, capital, and energy as well as between energy inputs and non-energy inputs.

<center>Figure A.1 Nested production function</center>

Source: Ibarrarán y Boyd, 2006.

Consumption

Total utility for each household c is modeled by

$$(2) \quad U_c = \Sigma_t \, U_{c,t} \, (X_{c,t}, R_{c,t}) * (1+\rho)^{-t} \qquad t = 1, \dots, n$$

where U_c is household utility over all n time periods, $U_{c,t}$ is the utility derived from the present period consumption of goods and services, $X_{c,t}$ (a 7-dimensional vector) and leisure $R_{c,t}$, and where ρ is the rate of time preference. Each U_c is taken to be a nested CES utility function defined for all consumer goods as well as all time periods. The value of household utility is given by the addition of the value of consumption plus the value of leisure, which is equal to the number of hours devoted to leisure times the net wage per hour worked (Ballard et al., 1985).

Each consumer's expenditure constraint can be written as:

$$(3) \sum_{t=1}^{n} (TG_{c,t} + TF_{c,t} + (P_{L,t} * L_{c,t}) + (r * K_t * S_{c,t})) =$$

$$\sum_{t=1}^{n} ((INV_t * S_{c,t}) + (P_{I,t} * X_{c,t}) + (P_{L,t} * R_{c,t}))$$

Where endowments are given on the left-hand side of the equation and expenditures are placed on the right hand side. $TG_{c,t}$ and $TF_{c,t}$ represent the transfer to the consumer from the government and the foreign agents; $P_{L,t}$ is the price of labor y r is

the rental of capital. K_t is the level of stock capital in period t; $S_{c,t}$ is the share of total capital owned by consumer c, INV_t is the total investment in time period t; and $P_{I,t}$ is the vector of prices for consumer goods

Maximizing the nested utility function (2) with respect to the expenditure constraint (3), simultaneously determines the consumption level of the consumer goods and services, the amount of labor supply, and the consumers level of saving and investment in each of the periods.

Government

The government sector is treated as a separate agent (Ballard et al 1985). The government agent is modeled with an expenditure function similar to the household expenditure functions (based on a CES utility function). The equations that describe the behavior of the government are:

$$G_u = x_1^{\alpha_1} x_2^{\alpha_2} x_i^{\alpha_i} x_n^{\alpha_n}$$

$$(4) \qquad \sum_i \alpha_i = 1$$

$$E = \prod_{i=1}^{n} P_i^{\alpha_i}$$

where G_u is the utility function of the government and α_i represents the share of the sectors, and x_i are the units that the government consumes. E is total expenditure by the government; and P_i are the market prices of the goods and services.

Trade

International trade within the model is handled by means of a foreing agent. The balance of trade relationship is given by

$$(5) \qquad \Sigma(P_{m,t} * IM_{j,t}) = \Sigma(P_{j,t} * EX_{j,t}) + \Sigma TF_{c,t} \qquad t = 1, ..., n$$

where $IM_{j,t}$ is a vector representing the quantity of each to the producer goods imported; $P_{m,t}$ is the vector of imported goods prices, $EX_{j,t}$ is the vector of producer goods exported, $P_{j,t}$ is the vector of producer goods prices, including tariffs, and $TF_{c,t}$ is the level of transfers.

Labor growth and capital formation

The growth of labor over time is given by

$$(6) \qquad L_{t+1} = L_t(1+\gamma)$$

where γ is the labor growth rate over time. In absence of any perturbation the Ramsey model predicts that the economy will grow at the labor growth rate in the steady state. Capital growth rate is represented by a system of three equations:

$$(7) \qquad P_{A,t} = P_{k,t+1} \qquad t = 1, ..., T$$

where $P_{A,t}$ is the weighted price of consumption and $P_{k,t+1}$ is next year's price of capital. We also have

$$(8) \qquad P_{k,t} = (1+r_t) P_{k,t+1} \qquad t = 1, ..., T$$

meaning that the price of capital in this period $P_{k,t}$ must be equal to the present period's rental value of capital plus next period's price of capital $P_{k,t+1}$. Finally we have

$$(9) \qquad K_{t+1} = K_t(1-\Delta) + INV_t \qquad t = 1, ..., T$$

where Δ stands for the rate of depreciation and INV stands for gross investment. This states that the capital stock in the next period must be equal to this year's capital stock plus net investment. Taken together, eqs. 7-9 insure that economic growth will be consistent with profit maximization behavior on the part of investors.

Terminal conditions

A few adjustments are necessary to design a model which when solved over a finite horizon approximates infinite horizon choices (Lau, Puhlke, and Rutherford, 1997). We divide the problem into two distinct sub-problems, one defined over the finite period from t = 0 to t = T, and the second the infinite period from t = T+1 to T = ∞. Hence, the first problem is

$$(10) \qquad \text{Max} \sum_{t=0}^{T} \left(\frac{1}{1+\rho}\right)^t U_{c,t}(X_{c,t}, R_{c,t})$$

subject to

$$(11) \qquad \sum_{t=0}^{T} P_{A,t} X_{c,t} = \sum_{t=0}^{T} P_{L,t} \overline{L}_{c,t} + P_{k,0} K_{c,0} S_{C,t} - P_{k,T+1} \overline{K}_{c,T+1} S_{C,T+1} \qquad \text{and}$$

(11a) $\bar{L}_{c,t} = L_{c,t} + R_{c,t}$ for all $t = 0, 1, ... T$

And the second problem is

(12) $\text{Max} \displaystyle\sum_{t=T+1}^{\infty} (\frac{1}{1+\rho})^t U_{ct}(X_{c,t}, R_{c,t})$

subject to

(13) $\displaystyle\sum_{t=T+1}^{\infty} P_{I,t} \cdot X_{c,t} = \sum_{t=T+1}^{\infty} P_{L,t} L_{c,t} + P_{K,T+1} \bar{K}_{c,T+1} S_{c,t+1}$

(13a) $\bar{L}_{c,t} = L_{c,t} + R_{c,t}$ for all $t=T+1, ...\infty$

where ρ is the rate or time preferences, r_o and $K_{c,o}$ refer to the rental value of capital and quantity of capital before the terminal period, r_{T+1} y $\bar{K}_{c,T+1}$ refer to these variables after the terminal period, and $\bar{L}_{c,t}$ is total labor plus leisure for each agent in the tth time period. $P_{K,t}$ is the price of capital, and $P_{I,t}$ and $P_{L,t}$ are the prices of the consumption goods and the price of labor, both net of taxes.

We include the level of post-terminal capital as a variable and add a constraint on investment growth in the final period

(14) $INV_T/INV_{T-1} = Y_T/Y_{T-1}$

where Y_T gives the GDP at time T.

Table A1: Recent applications of the model

Study	Publication/Institution
Cost of Compliance with the Kyoto Protocol: A Developing Country´s Perspective	*Paper published in Energy Economics,* 2002
Hacia el Futuro: Energy, Economics and the Environment in 21st Century Mexico	*Book by Springer*, 2006
Macroeconomic Impacts of Mitigation Policies in Selected Sectors	Project for Centro Mario Molina, 2008
Evaluación de las implicaciones económicas de las políticas de adaptación y mitigación frente al cambio climático en México: Análisis de equilibrio general de la vulnerabilidad intersectorial	Project for Instituto Nacional de Ecología, 2008
Impactos de Cambios en Precios Relativos de Combustibles y de Automóviles	Project for UNAM, 2009
MEDEC policies under a general equilibrium approach, Mexico, 2009	Project for The World Bank, 2009
Extreme Climate Events and Adaptation: An exploratory analysis of drought in Mexico	*Paper published in Environmental and Development Economics*, 2009
La ruta de México hacia una economía sustentable de baja intensidad de carbono	Project for Centro Mario Molina, 2010
Evaluación macroeconómica de políticas de mitigación de gases de efecto invernadero: Hacia una estrategia de crecimiento con bajas emisiones de carbono (LEDS)	Project for Programa de las Naciones Unidas para el Desarrollo e Instituto Nacional de Ecología, 2012
Impactos macroeconómicos del cambio climático sobre los principales sectores económicos en México	Project for Programa de las Naciones Unidas para el Desarrollo e Instituto Nacional de Ecología, 2012

Source: Authors.

B. Building in the Stylized Facts: Business as Usual vs. Benchmark

Table B1: Change in Aggregate Results, Business as Usual vs. Benchmark

Category	2012 (%)	2018 (%)	2024 (%)	2030 (%)
GDP	-0.4328	-1.7853	-3.7682	-5.5366
Investment	-0.3915	-3.9731	-6.7126	-4.7218
Government	3.5903	3.1886	1.7197	-0.6611
Capital stock	—	—	—	-4.3383
Aggregate welfare ($\sum$Agent 1–4)	—	—	—	-2.9707
Agent 1	—	—	—	-3.0514
Agent 2	—	—	—	-2.9288
Agent 3	—	—	—	-2.8299
Agent 4	—	—	—	-3.0602

Source: Authors.

Note: — = results not reported.

Table B2: Change in Production, Business as Usual vs. Benchmark

Sector	2012 (%)	2018 (%)	2024 (%)	2030 (%)
Agriculture	0.0368	-1.2995	-3.8168	-5.8142
Livestock	-0.1351	-1.7864	-4.2326	-5.7991
Forestry	0.0000	-1.4440	-4.3077	-5.9740
Fisheries	-1.3158	-3.3333	-5.1887	-8.4677
Oil	-4.6749	-22.6454	-38.6782	-50.0171
Natural gas	-4.6766	-22.6525	-38.6921	-50.0590
Mining	0.4190	-2.2619	-5.8282	-7.9654
Refining	-4.0590	-17.6267	-30.0491	-42.3845
Transport	-0.8673	-2.3458	-4.6582	-7.3340
Electricity	-0.9850	-3.4761	-6.6383	-9.9068
Chemicals & plastics	-3.4237	-16.6345	-30.3414	-43.4230
Services	0.0585	-0.8640	-2.7657	-5.0673
Manufacturing	0.2911	-2.1048	-5.2126	-6.8343

Source: Authors.

Table B3: Change in Consumption, Business as Usual vs. Benchmark

Category	2012 (%)	2018 (%)	2024 (%)	2030 (%)
Food	-1.4660	-2.1904	-3.9515	-6.6582
Household goods	-1.6162	-2.7507	-4.8034	-7.7935
Consumer services	-1.4708	-2.1687	-3.9112	-6.6060
Autos	-1.5952	-2.4636	-4.3413	-7.1902
Electricity and LPG	-1.6282	-2.7335	-4.7229	-7.6955
Public transport	-1.5571	-2.5669	-4.5506	-7.4624
Gasoline	-1.8873	-3.8617	-6.5138	-10.0627
Water	-1.3804	-2.0513	-3.7879	-6.4516
Housing	-1.4796	-2.0887	-3.8143	-6.4951

Source: Authors.

Table B4: Change in Imports, Business as Usual vs. Benchmark

Sector	2012 (%)	2018 (%)	2024 (%)	2030 (%)
Agriculture	-0.4702%	-1.5789%	-2.4229%	-3.2258%
Livestock	0.0000%	-3.5714%	-2.9412%	-2.4390%
Forestry	0.0000%	0.0000%	0.0000%	-5.7143%
Fisheries	-0.0744%	-0.2339%	0.0000%	0.0000%
Oil	0.0523%	0.1704%	0.2401%	0.2951%
Natural gas	0.0486%	0.1980%	0.2822%	0.3036%
Mining	0.0000%	-1.2048%	-2.0202%	-2.5316%
Refining	0.0321%	0.1271%	0.1829%	0.2296%
Transport	0.0000%	-0.5405%	-1.3575%	-1.5038%
Electricity	0.0000%	0.0000%	0.0000%	0.0000%
Chemicals & plastics	0.0094%	0.0323%	0.0468%	0.0590%
Services	-0.5270%	-1.8847%	-2.7855%	-3.6547%
Manufacturing	-0.2625%	-0.9855%	-1.5178%	-2.0147%

Source: Authors.

Table B5: Change in Exports, Business as Usual vs. Benchmark

Sector	2012 (%)	2018 (%)	2024 (%)	2030 (%)
Agriculture	2.4259%	1.7978%	0.3788%	-1.9324%
Livestock	1.8182%	1.5152%	0.0000%	-2.1739%
Forestry	0.0000%	0.0000%	0.0000%	0.0000%
Fisheries	0.0000%	0.0000%	0.0000%	-4.1667%
Oil	-0.0340%	-0.2003%	-0.3416%	-0.4922%
Natural gas	-0.0297%	-0.2415%	-0.4197%	-0.5169%
Mining	2.1277%	1.7857%	0.0000%	-2.5641%
Refining	-0.0160%	-0.1400%	-0.2500%	-0.3678%
Transport	2.2251%	1.0989%	-0.7435%	-3.5714%
Electricity	0.0000%	0.0000%	-6.6667%	-5.5556%
Chemicals & plastics	0.0111%	-0.0288%	-0.0698%	-0.1182%
Services	2.4612%	2.2068%	0.7964%	-1.5336%
Manufacturing	2.2743%	1.3939%	-0.4409%	-3.1834%

Source: Authors.

C. International comparison of subsidies across selected countries

Table C1: Fuel subsidies (US cents) per kilowatt-hour (kWh), 2008 Data

Country	Oil product (US cents/kWh)
Petroleum Producing Countries *	3.35
Argentina	2.51
Mexico	2.47
Colombia	0.71
China	0.67

Note: Petroleum producing countries include Algeria, Angola, Azerbaijan, Ecuador, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Russian Federation, Saudi Arabia, Turkmenistan, UAE, Uzbekistan, and Venezuela. The lower bound figure for the group is 1.26 US cents/kWh and the upper bound figure is 6.45 US cents/kWh.
Source: Charles and Wooders (2011).

Table C2: Fossil fuel consumption subsidy rates as proportion of the full cost of supply

Country	Average subsidization rate, 2010

Mexico	12.5
Argentina	22
Colombia	4.3
China	3.8
India	13.5

Source: IEA, World Energy Outlook, 2011a.

D. Trade under Non-Revenue-Neutral Gradual Subsidy Phaseout vs. Business as Usual

Table D1: Change in Imports,
Non-Revenue-Neutral Gradual Subsidy Phaseout vs. Business as Usual

Sector	2012 (%)	2018 (%)	2024 (%)	2030 (%)
Agriculture	0.0000%	-0.6519%	-1.1970%	-1.7257%
Livestock	0.0000%	0.0000%	-2.9412%	-2.4390%
Forestry	0.0000%	0.0000%	0.0000%	-5.7143%
Fisheries	1.2638%	2.0939%	0.0000%	0.0000%
Oil	0.0664%	0.1979%	0.2699%	0.3218%
Natural gas	-0.0150%	0.1082%	0.2123%	0.2552%
Mining	-0.7246%	-1.8182%	-2.0202%	-2.5316%
Refining	0.0163%	0.1025%	0.1662%	0.2207%
Transport	0.6452%	0.0000%	0.0000%	-0.3717%
Electricity	0.0000%	0.0000%	0.0000%	0.0000%
Chemicals & plastics	0.0122%	0.0385%	0.0536%	0.0652%
Services	-0.5270%	-1.8847%	-2.6902%	-3.4135%
Manufacturing	-0.3001%	-1.1032%	-1.6927%	-2.2251%

Source: Authors.

Table D2: Change in Exports,
Non-Revenue-Neutral Gradual Subsidy Phaseout vs. Business as Usual

Sector	2012 (%)	2018 (%)	2024 (%)	2030 (%)
Agriculture	1.3624%	0.6818%	-0.1905%	-1.1182%
Livestock	0.0000%	0.0000%	0.0000%	-1.0753%
Forestry	0.0000%	0.0000%	0.0000%	0.0000%
Fisheries	0.0000%	-5.8824%	-5.0000%	-4.1667%
Oil	-0.0587%	-0.2471%	-0.3883%	-0.5181%
Natural gas	0.0265%	-0.1213%	-0.2863%	-0.4806%
Mining	2.1277%	1.7857%	0.0000%	0.0000%
Refining	-0.0053%	-0.1122%	-0.2168%	-0.3187%
Transport	0.9284%	-0.3344%	-1.4032%	-2.6751%
Electricity	0.0000%	0.0000%	-6.6667%	-5.5556%
Chemicals & plastics	-0.0009%	-0.0397%	-0.0713%	-0.1011%
Services	1.6794%	1.8354%	1.2682%	0.4203%
Manufacturing	1.4727%	1.0773%	0.3422%	-0.6976%

Source: Authors.

E. Partial Neutrality

Table E1: Change in Aggregate Results,
Partial Neutrality of Subsidy Phaseout vs. Business as Usual

Category	2012 (%)	2018 (%)	2024 (%)	2030 (%)
GDP	-0.9830	0.1581	0.4775	1.1608
Investment	-2.6421	-3.9031	-0.6494	16.9448
Government	5.3269	5.3153	4.5038	3.4095
Capital Stock	—	—	—	7.1530
Aggregate welfare	—	—	—	0.2151
Agent 1	—	—	—	3.3922
Agent 2	—	—	—	1.3617
Agent 3	—	—	—	0.1232
Agent 4	—	—	—	-0.6228

Source: Authors.

Note: — = results not reported.

Table E2: Change in Production, Partial Neutrality of Subsidy Phaseout vs. Business as Usual

Sector	2012 (%)	2018 (%)	2024 (%)	2030 (%)
Agriculture	-1.7590	-1.3802	1.1449	9.0006
Livestock	-1.4162	-0.5734	2.2426	10.1736
Forestry	-0.8658	0.3597	2.9851	10.4651
Fisheries	-1.3333	-2.2727	-1.4354	2.3622
Oil	-5.2448	-8.4355	-6.8040	0.0603
Natural gas	-5.2356	-8.3945	-6.7895	0.0842
Mining	-3.4682	-2.5641	1.4113	12.7644
Refining	-8.9149	-15.0253	-12.6628	-3.9585
Transport	-1.0222	-1.0830	0.2132	3.8149
Electricity	-24.3648	-35.8347	-33.3097	-25.7069
Chemicals & plastics	-5.2377	-6.1929	-1.3393	13.8088
Services	-0.3105	0.0072	1.2251	4.6656
Manufacturing	-1.6589	-0.2496	3.6028	13.9359

Source: Authors.

Table E3: Change in Consumption, Partial Neutrality of Subsidy Phaseout vs. Business as Usual

Sector	2012 (%)	2018 (%)	2024 (%)	2030 (%)
Food	-0.0390	-0.1166	0.5285	1.7232
Household goods	-0.3297	-0.4267	0.2644	1.5076
Consumer services	-0.5873	-0.6348	0.0078	1.2103
Autos	-0.8941	-0.9589	-0.2516	0.9958
Electricity and LPG	-8.2232	-12.8535	-12.1622	-10.8071
Public transport	-0.3975	-0.7132	-0.0750	1.1062
Gasoline	-1.9236	-3.0713	-2.4106	-1.2337
Water	-0.1536	-0.1284	0.5382	1.7210
Housing	-0.5644	-0.6003	0.0000	1.2107

Source: Authors.

Table E4: Change in Imports, Partial Neutrality of Subsidy Phaseout vs. Business as Usual

Sector	2012 (%)	2018 (%)	2024 (%)	2030 (%)
Agriculture	0.0000%	-0.7833%	-1.3072%	-1.9108%

Livestock	0.0000%	0.0000%	-2.9412%	-2.4390%
Forestry	0.0000%	0.0000%	0.0000%	-5.7143%
Fisheries	1.2506%	2.0282%	0.0000%	0.0000%
Oil	0.0664%	0.1969%	0.2689%	0.3200%
Natural gas	-0.0163%	0.1056%	0.2105%	0.2546%
Mining	-0.7246%	-1.8182%	-2.0202%	-2.5316%
Refining	0.0163%	0.1009%	0.1651%	0.2199%
Transport	0.6452%	0.0000%	0.0000%	-0.3717%
Electricity	0.0000%	0.0000%	0.0000%	0.0000%
Chemicals & plastics	0.0122%	0.0383%	0.0536%	0.0650%
Services	-0.6596%	-1.9978%	-2.6902%	-3.4938%
Manufacturing	-0.2947%	-1.0851%	-1.6737%	-2.1996%

Source: Authors.

Table E5: Change in Exports, Partial Neutrality of Subsidy Phaseout vs. Business as Usual

Sector	2012 (%)	2018 (%)	2024 (%)	2030 (%)
Agriculture	1.6304%	0.6818%	-0.1905%	-1.4423%
Livestock	1.8182%	1.5152%	0.0000%	-1.0753%
Forestry	0.0000%	0.0000%	0.0000%	0.0000%
Fisheries	0.0000%	-5.8824%	-5.0000%	-4.1667%
Oil	-0.0563%	-0.2449%	-0.3895%	-0.5221%
Natural gas	0.0299%	-0.1175%	-0.2859%	-0.4873%
Mining	2.1277%	1.7857%	0.0000%	0.0000%
Refining	-0.0053%	-0.1122%	-0.2168%	-0.3240%
Transport	1.1905%	-0.1112%	-1.4981%	-3.0806%
Electricity	0.0000%	0.0000%	-6.6667%	-5.5556%
Chemicals & plastics	0.0019%	-0.0397%	-0.0736%	-0.1070%
Services	1.9414%	1.9595%	1.1114%	-0.0222%
Manufacturing	1.6987%	1.1131%	0.1172%	-1.2643%

Source: Authors.

F. Non-Neutral Elimination of Energy Subsidies and Expansion of VAT to Food and Medicines

Table F1: Change in Aggregate Results, No Energy Subsidies and VAT vs. Business as Usual

Category	2012 (%)	2018 (%)	2024 (%)	2030 (%)
GDP	-1.2090	-2.1677	-0.3520	1.1320
Investment	-2.9719	-4.1835	-0.7584	17.3127
Government	7.2978	7.2883	6.4925	5.4213
Capital stock	—	—	—	7.1195
Total welfare (∑Agent 1–4)	—	—	—	-0.4328
Agent 1	—	—	—	0.2957
Agent 2	—	—	—	0.2953
Agent 3	—	—	—	-0.2487
Agent 4	—	—	—	-0.9274
Government welfare	—	—	—	4.3589
Aggregate welfare	—	—	—	0.3960

Source: Authors. *Note:* — = results not reported.

Table F2: Change in Consumption, No Energy Subsidies and VAT vs. Business as Usual

Category	2012 (%)	2018 (%)	2024 (%)	2030 (%)
Food	-1.5050	-1.5812	-0.9295	0.2875
Household goods	-1.0499	-1.1537	-0.4502	0.7967
Consumer services	-1.1252	-1.1692	-0.5198	0.6873
Autos	-1.2926	-1.3538	-0.6313	0.6168
Electricity and LPG	-9.0237	-13.7306	-13.0174	-11.6215
Public transport	-1.1479	-1.4594	-0.8118	0.3820
Gasoline	-2.3940	-3.5547	-2.8810	-1.6997
Water	-0.9288	-0.9056	-0.3257	0.9132
Housing	-1.0830	-1.1207	-0.5063	0.6997

Source: Authors.

Table F3: Change in Production, No Energy Subsidies and VAT vs. Business as Usual

Sector	2012 (%)	2018 (%)	2024 (%)	2030 (%)
Agriculture	-2.7589	-2.3757	0.2363	8.4251
Livestock	-2.2099	-1.3482	1.5272	9.7765
Forestry	-1.3043	-0.3623	2.4024	10.2564
Fisheries	-2.7027	-3.4483	-2.4155	1.1952
Oil	-5.6670	-8.8442	-7.2009	-0.1208
Natural gas	-5.6782	-8.8514	-7.2055	-0.0844
Mining	-4.0698	-3.1941	0.9119	12.6984
Refining	-9.4748	-15.6114	-13.2156	-4.2146
Transport	-1.6954	-1.7509	-0.4291	3.2910
Electricity	-24.9886	-36.4676	-33.9260	-26.0670
Chemicals & plastics	-6.1764	-7.1894	-2.2379	13.4900
Services	-0.4643	-0.1400	1.0977	4.6196
Manufacturing	-2.2013	-0.7699	3.1793	13.8656

Source: Authors.

Table F4: Change in Imports, No Energy Subsidies and VAT vs. Business as Usual

Sector	2012 (%)	2018 (%)	2024 (%)	2030 (%)
Agriculture	0.0000%	-0.7833%	-1.3072%	-1.9108%
Livestock	0.0000%	0.0000%	-2.9412%	-2.4390%
Forestry	0.0000%	0.0000%	0.0000%	-5.7143%
Fisheries	1.2466%	2.0250%	0.0000%	0.0000%
Oil	0.0669%	0.1974%	0.2694%	0.3203%
Natural gas	-0.0186%	0.1036%	0.2089%	0.2539%
Mining	-0.7246%	-1.8182%	-2.0202%	-2.5316%
Refining	0.0140%	0.1009%	0.1651%	0.2199%
Transport	0.6452%	0.0000%	0.0000%	-0.3717%
Electricity	0.0000%	0.0000%	0.0000%	0.0000%
Chemicals & plastics	0.0124%	0.0385%	0.0536%	0.0650%
Services	-0.6596%	-1.9978%	-2.6902%	-3.4938%
Manufacturing				

Source: Authors.

Table F5: Change in Exports, No Energy Subsidies and VAT vs. Business as Usual

Sector	2012 (%)	2018 (%)	2024 (%)	2030 (%)
Agriculture	1.6304%	0.6818%	-0.1905%	-1.4423%
Livestock	1.8182%	1.5152%	0.0000%	-1.0753%
Forestry	0.0000%	0.0000%	0.0000%	0.0000%
Fisheries	0.0000%	-5.8824%	-5.0000%	-4.1667%
Oil	-0.0568%	-0.2460%	-0.3900%	-0.5226%
Natural gas	0.0320%	-0.1151%	-0.2835%	-0.4859%
Mining	2.1277%	1.7857%	0.0000%	0.0000%
Refining	-0.0053%	-0.1068%	-0.2168%	-0.3240%
Transport	1.1905%	-0.2227%	-1.4981%	-3.1621%
Electricity	0.0000%	0.0000%	-6.6667%	-5.5556%
Chemicals & plastics	0.0019%	-0.0397%	-0.0736%	-0.1070%
Services	1.9414%	1.9285%	1.1114%	-0.0222%
Manufacturing	1.6865%	1.1029%	0.1085%	-1.2717%

Source: Authors.

G. Universal Social Insurance Proposal

Mexico faces a highly segregated labor market, with a formal and a large informal sector. The informal sector does not have the same social insurance as the formal sector. Antón, Hernández, and Levy (2012) describe this in depth. They propose an innovative scheme under which the formal and the informal sector workers would have access to the same bundle of social insurance, deterring people and firms from joining the informal sector by lowering the costs of belonging to a more productive formal sector. They put forward a proposal whereby the current system is replaced by a complete removal of employee-employer contributions to social security. This would have the effect of moving labor from the informal sector (which does not contribute to social security) to the more efficient formal sector (where it is presently taxed to provide security and health benefits).

To make up for the loss in revenue, Antón, Hernández, and Levy recommend including food and medical goods and services under the VAT (they are now not subject to such tax). To prevent any deleterious effect on equity and the

distribution of income, they provide a transfer to the lowest-income consumers to compensate for the higher cost of food and medical supplies that would be incurred. They employ a sophisticated theoretical model to demonstrate the economic soundness of their proposal, and then use an extensive dataset to quantify their theoretical results and test the robustness of their proposals. The model they employ, however, is static in nature.

For this exercise, informality is defined as not contributing, on a sustained basis, to a formal social security system. The data we use for the structure of the labor market are shown in table D1. The costs involved in their proposal include health insurance (Mex$394.9 billion), retirement pensions (Mex$137 billion), and life and disability (Mex$28.1 billion), adding up to roughly Mex$560 billion.

Table G1: Share of Informal Labor in each Sector, 2008

Sector	Informality (% of labor force)
1. Agriculture	0.95
2. Livestock	0.95
3. Fishing	0.85
4. Forestry	0.95
5. Mining	-0.06
6. Oil and gas	0.67
7. Refining output	0.78
8. Chemicals & plastics	-0.04
9. Manufacturing	0.11
10. Electricity	0.01
11. Transport	0.07
12. Services	0.41

Sources: Authors.

Table G2: Comparing USI and other expenditures, 2008

Concept	Total amount (millions of pesos)	Percentage of PIB
PIB (2)	12,181,256	
IMSS (1)	215,469	1.77
USI	559,300	4.60
Seguro Popular (3)	34,603	0.28
Programmable Expenditure (4)	1,899,925	15.60
Programmable Expenditure on Health (4)	288,093	2.37

Source: Antón et al 2012.

H. Trade under Dual Policy Implementation vs. Business as Usual

Table H1: Change in Imports, Dual Policy Implementation vs. Business as Usual

Sector	2012 (%)	2018 (%)	2024 (%)	2030 (%)
Agriculture	2.2866%	1.0256%	0.0000%	-0.6289%
Livestock	0.0000%	0.0000%	-2.9412%	-2.4390%
Forestry	0.0000%	0.0000%	0.0000%	-2.7778%
Fisheries	1.5043%	2.2281%	0.0000%	0.0000%

Oil	0.0749%	0.2003%	0.2689%	0.3252%
Natural gas	0.0366%	0.1434%	0.2326%	0.2561%
Mining	0.7143%	-1.2048%	-2.0202%	-2.1008%
Refining	0.0387%	0.1196%	0.1752%	0.2248%
Transport	1.2821%	1.0638%	0.4444%	0.0000%
Electricity	0.0000%	0.0000%	0.0000%	0.0000%
Chemicals & plastics	0.0131%	0.0407%	0.0573%	0.0725%
Services	0.1309%	-1.5470%	-2.5000%	-3.4135%
Manufacturing	-0.5048%	-1.3031%	-1.8873%	-2.5103%

Source: Authors.

Table H2: Change in Exports, Dual Policy Implementation vs. Business as Usual

Sector	2012 (%)	2018 (%)	2024 (%)	2030 (%)
Agriculture	-2.8409%	-0.4598%	0.7547%	0.9390%
Livestock	-1.8868%	0.0000%	1.2658%	2.0833%
Forestry	0.0000%	0.0000%	0.0000%	6.6667%
Fisheries	-7.1429%	-5.8824%	0.0000%	0.0000%
Oil	-0.0871%	-0.2415%	-0.3574%	-0.4786%
Natural gas	-0.0433%	-0.1587%	-0.2929%	-0.4372%
Mining	0.0000%	1.7857%	1.4706%	2.4390%
Refining	-0.0497%	-0.1232%	-0.2009%	-0.2879%
Transport	-1.6327%	-0.1112%	0.3676%	0.2294%
Electricity	0.0000%	0.0000%	0.0000%	0.0000%
Chemicals & plastics	-0.0191%	-0.0346%	-0.0531%	-0.0756%
Services	-0.6643%	2.2068%	3.1865%	3.4941%
Manufacturing	-0.0189%	2.0211%	2.6159%	2.6658%

Source: Authors.

I. International Comparisons of CO2 Emissions per GDP

Table I1. CO2 emissions from fuel combustion, 2009
(kg CO2 / US dollar (2000 prices))

	CO2 emissions/GDP using exchange rates	CO2 emissions/GDP using purchasing power parities
China	2.17	0.55
India	1.81	0.35
Turkey	0.72	0.32
Chile	0.63	0.33
Mexico	**0.55**	**0.36**
United States	0.46	0.46
Colombia	0.43	0.14
Argentina	0.42	0.27
Brazil	0.39	0.20

Source: IEA 2011b.