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Appraisal Econometrics for Proposed Transport Corridors

Optimal Placement, Intervention Design,
and Wider Economic Benefit

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Abstract

Transport corridors to stimulate regional integration and trade have become a popular development tool. But when they fail to generate the expected wider economic benefits, they can become wasteful or unequitable investments. This paper evaluates the relative strengths and weaknesses of econometric methods as applied today to appraise the proposed placement of transport corridors and the project design to distribute benefits more widely; the future potential of these methods; and an emerging synthesis in some recent studies. The review focuses on

network, reduced-form, and structural (general equilibrium) econometrics. At the current juncture, from the policy-making perspective, combining network econometrics based on the notion of centrality with reduced-form regressions comprising interactive effects could be the most practical approach. Future research could focus on advancing structural general equilibrium econometrics to cover multiple markets together with network econometrics to consider the interaction of heterogeneous agents.

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Appraisal Econometrics for Proposed Transport Corridors: Optimal Placement, Intervention Design, and Wider Economic Benefits*

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1. Introduction

Put simply, countries build transport corridors with the hope of creating large aggregate surpluses while avoiding the risk of white elephants (wasteful infrastructure that is not used). If indeed created, these aggregate surpluses need to be distributed fairly—that is, diffused efficiently throughout the population—to maximize social welfare. Two questions are thus crucial in assessing a transport corridor proposal: (1) Is the proposed placement of the corridor the best possible, and (2) Do the interventions complementing the trunk (main) infrastructure investment ensure fair distribution of net economic benefits across the population?

The placement of a corridor is typically chosen to maximize the impact on cross-border, regional, and transregional integration and trade. The overall corridor package could also include complementary interventions (geographically specific and spatially informed policy and institutional reforms) to address existing market frictions and missing public goods that constrain the fair distribution of economic benefits the most.

Traditionally, questions (1) and (2) have been addressed through piecemeal cost-benefit analysis. However, faced with many proposals for transport corridors with uncertain net economic benefits, limited funding,¹ and competing public investments such as education and health—which carry high opportunity costs—policy makers are calling for more rigorous appraisals of the two questions. How can policy makers tell which proposal could be economically more promising, and how it can be improved to amplify and fairly distribute the wider economic benefits (WEBs)—

¹ In cases where fiscal positions are weak, the private sector is not interested in social returns, and/or the public and private sectors both face uncertainty in investing in transport corridors and associated infrastructure.

including income, consumption, social inclusion, equity, environmental quality, and economic resilience?²

Econometrics with spatial data can provide more detailed and comprehensive analysis at a more localized level to meet policy makers' needs. This paper discusses the relative ability (comparative advantages) of the approaches to help policy makers appraise the proposed placement and design of corridor intervention packages for large transport infrastructure investments. The discussion groups the econometric approaches into three categories: single-equation, reduced-form (RF), structural (general equilibrium) (GE), and agent network econometrics.

Although many of these approaches have been applied in ex post evaluations after investments have been made, the emphasis here is on rigorous ex ante evaluation during the planning stage, going beyond conventional cost-benefit analysis. The focus is not on the theories motivating these modeling approaches. For instance, the theory of new economic geography (NEG) can motivate both the application of reduced-form and structural (general equilibrium) econometrics using spatial data. Similarly, more than one theory could motivate the application of reduced-form econometrics. For instance, both the theories of trade gravity and new economic geography could motivate application of least square regressions.

Most recently, several studies have reviewed the literature on the impacts of transport infrastructure investments to summarize and organize its approaches and findings. Some use more qualitative approaches (Berg et al. 2017; Redding and Turner 2014; Straub 2011; Bosker and Garretsen 2010), while others use more quantitative methods (Melo, Graham, and Brage-Ardao

² See ADB, DFID, JICA, and WBG (forthcoming), which defines five categories of wider economic benefits (WEBs): economic welfare, social inclusion, equity, environmental quality, and economic resilience.

2013; Bougna et al. forthcoming). Although they discuss the comparative advantages of different modeling approaches (see, for instance, Redding and Turner 2014), they do not emphasize the ex ante perspective of project appraisals and the possible range of econometric approaches policy makers could consider as more reliable. For instance, Bakker, Koopmans, and Nijkamp (2010) take the project appraisal perspective, but focus mainly on cost-benefit analyses in the urban context. Laird and Veneables (2017) also take the project appraisal view, proposing a disciplining structure to encourage more rigorous cost-benefit analysis. But their useful think piece stops at intermediate development outcomes (such as productivity)—apart from employment—rather than the ultimate goal of WEBs that matter to households. This paper focuses on the ex ante perspective and WEBs to fill a gap in the literature, inform policy makers, and provide some direction for future research that could better inform policy-making decisions on transport corridors.

This paper does not go as far as reviewing the different objective functions that policy makers could have, and that could be empirically derived from data. Although policy objectives and preferences are crucial for policy decisions, they can be separated from the appraised expected impacts of corridor interventions. At least, this paper assumes so. The policy objective function simply weighs the appraised expected impacts—such as the expected positive impact on income versus the expected negative impact on environmental quality. The weights can be zero if policy makers ignore some outcomes. The outcomes that enter the policy objective function could refer to a country, if the policy maker is the national government, or to a region or continent if the decision maker is a supranational entity such as an international organization. Hence, the level at which policy making is conducted can also determine decisions about corridors. For example, Bougna et al. (forthcoming) propose a simple policy-maker's objective function allowing for multiple wider economic benefits.

The remainder of the paper is organized as follows. Sections 2, 3, and 4 discuss the network, reduced-form, and structural (general equilibrium) econometrics, and the comparative advantages of the current applications of these strands of econometrics to appraise the placement and potential for wider economic benefits. Section 5 points to some emerging literature that strives to bridge the different econometrics approaches discussed in sections 2, 3, and 4. Section 6 concludes.

2. Network Econometrics

Network econometrics could be a useful approach to estimate how transport corridor investment could unleash the formation of economic corridors—that is, stimulate the geographically defined socioeconomic activity that surrounds the primarily cross-border transport corridors. However, the comparative advantage of network econometrics could be in appraising the proposed placements of corridors, rather than the intervention design for diffusing the aggregate surpluses generated across spatial units (state districts) and ultimately populations.

In its basic form, network econometrics endorses proposals to revive historical corridor routes such as the Silk Road or the Grand Truck Road.³ Such proposals are motivated by the idea that the historical, rich networks of agents have not completely disappeared. They assume that, despite new borders and other obstacles to movements of trade, capital, and labor, these rich networks have survived in a restrained form, maintaining their proximity in terms of culture, business, and trust (Starr 2007). Proponents of these investments argue that alleviating restraints by improving trunk infrastructure as well as transport and trade facilitation will produce greater surpluses—and perhaps even diffusion effects—than a greenfield project driven by a competing idea.

³ See https://en.wikipedia.org/wiki/Silk_Road and https://en.wikipedia.org/wiki/Grand_Trunk_Road.

Moving from transnational or transcontinental transport corridors to more localized contexts (urban, regional, national), network econometrics typically concentrates on optimizing the logistics and engineering of a road (rail) transport network, for instance, in terms of travel time. Within a given budget constraint, analyses primarily optimize the transport network, considering transport costs, typography, and existing traffic flows (Gastner and Newman 2006). The engineering and logistics optimization does not link the transport network optimization to broader development objectives such as trade, income, or environmental quality. But recently the transport network optimizations have penetrated economics that examines such development objectives. Consequently, hybrid papers that bridge the disciplines of engineering, logistics, and economics have been emerging (see section 5).

The idea of optimizing logistics is not far from the notion of maximizing market access. It makes sense for the placement of a transport corridor to maximize access to markets for both exporters and importers. In turn, this should create economic opportunities for those who get newly or better connected to markets. But how can the market access relevant for higher development objectives such as household income and consumption be measured best? One simple way to measure market access has been as the sum of the population in all the domestic and foreign cities above X million to which tradable goods and services can be transported from a given domestic city divided by the travel distance from the domestic city to all other domestic and foreign cities. The benefit of connectivity to markets of big cities very far away is thus discounted to zero by the increasing transport distance (cost) (Burgess et al. 2015). For instance, placing a trunk highway across country borders in a way that maximizes the access to markets for all cities above X million in the co-financing countries could be the policy-maker's objective when deciding on placement of a transport corridor.

Network econometrics based on simple market access measures could miss important aspects for deciding on the placement of transport corridors. Two such aspects are the “Importance” and “Relevance” of potential market access or trade connectivity. Page et al. (1999) identify the two concepts as components of “Centrality” in the context of a different kind of web, Google’s PageRank. “Importance” calls for considering whether the new (transport) connection from one city is to a “well-connected” city that offers many other connections that provide indirect connections for the first city, or to a not so “well-connected” city that does not provide these indirect markets access connections. For instance, Donaldson and Hornbeck (2016) adjust the simple measure of market access for Importance.

The “Relevance” of the potential direct and indirect connections that a transport corridor can provide also needs to be considered. For example, the potential of connecting to big but already highly competitive markets may not be as useful for a particular city in a developing country as connecting to another big city with less competitive markets that the country’s exporters can penetrate more easily with old or new products. For instance, Baum-Snow et al. (2016) consider the Relevance of market access and adjust for market competition in their market access measure. But Relevance could be a much richer concept, including matching demand preferences and supply industry structure as well as distinguishing between market access Relevance for exporters and importers (Duranton, Morrow, and Turner 2013). For instance, in calculating market access, the possible new transport connection of a pork exporting district in country A to a large Jewish city in neighboring country B could be viewed as offering new market potential. However, this market could be irrelevant for the pork exporting district and should be heavily discounted.

Existing transport and trade obstacles (such as prohibitive border crossings, and tariff and nontariff trade barriers) need to be considered for Relevance too. The literature on trade

connectivity considers such aspects of Relevance, but without the focus on the WEBs to households along transport corridors (Baniya et al. 2017). The probability of removing these obstacles in the future also affects the Relevance of the potential new connections.

Given the growing number of considerations, the Relevance and Importance—and thus the Centrality—of a proposed transport corridor could be summarized by spatial propensity scores that capture the extent to which exporters and importers in each location—such as a district through which the potential transport corridor would pass—would benefit from the new connectivity and market access. But even such rich and spatially disaggregated propensity scores could fall short of the future reality because of changing global value chains, urbanization, and development strategies of cities. Such dynamics could be important for determining transport corridor placement.

In this dynamic context, potential cities to be connected by transport corridors could be thought of as agents with varied decision rules (heterogeneous response functions). Similarly, corporations that shape the growth of these cities could decide to revise their global supply chains as market dynamics change. Suppose that, in the next 20 years, one city wants to become an international financial center, another city wants to attract research and development clusters and become the next Silicon Valley, and yet another city wants to become a major manufacturing hub. These three cities would be expected to respond to the potential of connectivity differently. Further, knowing or observing the responses of other cities, a city can reinforce its strategy or change it. Considering agents' varied decision rules could be important for determining which two

cities (in bordering countries) are the priority to connect through transport corridors and through which mode of transport (road, rails, waterways, airways).⁴

To exploit the full potential of network econometrics and incorporate the historical, current, and forward-looking perspectives, Agent Based Modeling (ABMs)⁵ could be helpful. As the system-wide general equilibrium econometrics to reduced-form regression, ABMs could provide greater structure to network econometrics identifying how a corridor intervention could affect different cities, countries, regions, and continents directly and indirectly through second-round and systemic interactions. But as general equilibrium econometrics, ABMs need many assumptions. Their highly nonlinear nature makes them prone to big errors if mis-specified (even partly). Moreover, simpler market access measures could be readily linked to development outcomes such as income growth, at least in a reduced-form manner (Donaldson and Hornbeck 2016; Duranton, Morrow, and Turner 2013). This second step could be prohibitive for more complex network econometric approaches such as the ABMs.

Given the state of development in network econometrics, a combination of approaches could be useful to help determine priority placements for transport corridors. Computations based on the notion of “centrality” could be the most reliable at the current juncture. In contrast, more research into developing Agent Based Modeling that views cities as heterogeneous agents could be the most promising to help determine corridor placements in the future.

⁴ Railway and waterways are more suitable for bulk transport, while roads and airways could be more suitable for fragmented supply chains (boutique production such as Italian shoes) or high-value perishables (Maldivian tuna to Japan).

⁵ See https://en.wikipedia.org/wiki/Agent-based_model.

3. Reduced-Form Econometrics

Single-equation, reduced-form (RF) econometrics is the most popular method in the literature to evaluate the ex post impact of transport infrastructure on development outcomes. The most rigorous set-ups involve difference-in-difference estimation (based on a carefully selected control group) with an instrumental variable(s) (IV) (to address possible biases due to endogenous placements). Such a set-up is often complemented by a set of conditioning variables, matching techniques, or placebo treatments to further sharpen identification (Bougna et al. forthcoming; Redding and Turner 2014).⁶ With proper IV identification and controls, reduced-form regressions are readily applicable to ex post evaluations. Further, their flexible functional form helps in adding interaction terms to study varied (heterogeneous) effects and the effects of complementary policies (Melecky et al. forthcoming). Carefully selecting control groups and finding both a valid and relevant instrument—one that is both exogenous to the dependent variable and able to sufficiently explain the treatment variable—are probably the biggest technical struggles for the RF literature.

The main issue for policy decision making is that reduced-form regressions do not enable structural identification of the transmission mechanisms and the analysis of general equilibrium (system-wide) effects—including second-round (indirect) effects and effects beyond the immediate vicinity of the transport corridor. Moreover, the traditional reduced-form set-ups are constrained to analyzing the corridor effect on one development outcome at a time.

Some of the shortcomings of the single-equation RF econometrics could be remedied by readily available extensions of the approach. For instance, RF regressions with a common factor (a corridor intervention) for a panel of development outcomes can help analyze the joint impact of

⁶ Other empirical “reduced-form” methods include semi- and non-parametric econometrics (see Graham, McCoy, and Stephens 2014; Pagan and Ullah 1999).

transport infrastructure investment on multiple development outcomes (such as income, equity, and environmental quality) together.⁷ Likewise, extending the single-equation RF regressions to a system of RF equations such as vector auto-regressions (VARs) can help analyze general equilibrium effects in a reduced-form manner. For instance, new economic geography theory could be used to motivate the vector of endogenous variables to be included in the VAR without imposing the possibly problematic structural restrictions (functional form, cross-equation coefficient restrictions) implied by the theory. One example of an effort in this direction is the work of Revoltella et al. (2016) on transport connectivity and economic resilience.

To date, RF regressions have typically focused on the effects near transport corridors and not those further away. While using macroeconomic data and simulations lacks locational specifics compared to spatial data, it could be a good complement to capture more system-wide (general equilibrium) effects when using RF econometrics.

4. Structural (General Equilibrium) Econometrics

The second most popular econometrics for appraising the impact of transport connectivity on development outcomes is structural econometrics, including structural general equilibrium (GE), using calibrated or estimated parameters (Bosker, Deichmann, and Roberts 2015; Burgess and Donaldson 2012). It helps analyze several development outcomes jointly, while identifying clear transmission channels, linking model parameters to micro-founded behaviors, and considering feedback effects and counterfactuals. The potential of these models is great. But the current applications are rather far from exploiting it.

⁷ See Bougna et al. forthcoming for application of that idea in the context of a meta-regression analysis.

From the current policy-making perspective, the existing applications of GE econometrics—not necessarily the approach’s potential—have some shortcomings. The typical GE application considers only a limited number of transmission mechanisms and clearing markets (such as labor mobility only, ignoring land and capital market channels). Neglecting some transmission mechanisms can distort the predicted dynamics, including due to the omitted variable bias if the structural GE model without some important markets is estimated. The efficiency (precision) of the structural estimation could be increased by the assumed functional forms and cross-equation coefficient restriction (see, for instance, Bosker Deichmann, and Roberts 2015, Appendix A). However, if not in line with the actual data-generating process, these restrictions could result in low fit to the data (reality) and low predictive ability.⁸

This is not to imply, however, that GE econometrics should be seen as inferior for future policy making and abandoned. On the contrary, more effort is needed to develop this promising econometric tool for transport corridor appraisals—probably the most promising for appraising the wider economic benefits (WEBs) of transport corridor interventions. These developments should focus on covering all important markets, heterogeneous impacts, and system estimations that could help improve the data fit of structural GE and other structural models.⁹ The econometrics also need to be back-tested, including simulating moments of the model variables and comparing them to the moments of actual data.

⁸ For comparison to RF models to be fair, one must compare the log-linearized version of the nonlinear structural GE models to the RF models. But in this case, the predicted number of relevant variables to be included in the econometrics is typically smaller than the number typically used by RF models. Also, the cross-equation restrictions are binding and increase the efficiency-robustness trade-offs, especially when the log-linearization is done at a higher-order Taylor expansion.

⁹ See Lall, Wang, and Deichmann 2010 for the three-stage least squares approach (3SLS) and Fan and Chan-Kang 2008 for the full information maximum likelihood (FIML) estimation.

5. Emerging Literature Bridging Different Methods of Corridor Econometrics

Some studies are trying to bridge the different econometric methods discussed in this paper to advance our understanding of the effect of large infrastructure projects on socioeconomic development.

Several studies have linked measures of market access (network econometrics) with income growth using reduced-form regressions—including estimated equations motivated by a structural model (Donaldson and Hornbeck 2016; Duranton, Morrow, and Turner 2013). This approach, however, suffers from endogeneity and recursive problems between market access and growth. Endogenizing market access (introducing a first-stage regression) or using instrumental variables could help. But using this approach, the literature links market access only to a single final outcome (income) at a time, not multiple outcomes. It also has not considered general equilibrium effects, including the possibility of losers in regions sending permanent migrants toward the transport corridor, and complementary interventions (such as access to finance to scale up the production of tradeable goods). Therefore, using these ex post evaluations in ex ante appraisals could be problematic.

Some academics and practitioners point to the methodological tension between reduced-form and general equilibrium econometrics. Some recent papers that compare these two econometric approaches quantitatively examine this possible tension. For instance, Rothenberg (2011), Baum-Snow et al. (2016), and Alder, Roberts, Tewari (2017) compare the results of reduced-form and general equilibrium econometrics applied to the India Golden Quadrilateral (GQ) highway. While the RF and GE results differ in all studies, only Baum-Snow et al. (2016) reject the results of structural GE estimation—in favor of the RF estimation—as inferior and possibly misleading.

Most recently, some papers have attempted to combine network and GE econometrics (Alder 2017; Fajgelbaum and Schaal 2017). Because the task is computationally very intensive, heuristic network rules and algorithms from operational research are used to ease the implementation of such approaches. Although the two applications do not go as far as modeling cross-border agent networks—for instance, in trade and global value chains—they are quite promising. For instance, Alder (2017) combines a network algorithm for highway placement with general equilibrium econometrics to estimate a counterfactual for the Indian policy on the Golden Quadrilateral (GQ) highway system by following China’s policy for the National Express Network. He finds that the GQ construction generated aggregate income surpluses, but these surpluses were shared unequally across regions—including because the counterfactual network would have been larger than the GQ, supporting greater sharing with lagging regions and further aggregate gains. Fajgelbaum and Schaal (2017) combine operational research methods and a neoclassical trade model with mobile labor to estimate the GDP gains from optimal expansion of current road network in 25 European countries. They find large gains from such an optimal expansion.

Nevertheless, cross-border applications with corresponding obstacles and imperfections are still scarce. Moreover, neglecting the role of and dynamics in movement of capital and the frictions in land use could make this econometric synthesis incompletely specified when trying to match the model to the processes generating the actual data. Hence, despite the potential leap in theoretical rigor and efficiency, its reliability in practice is problematic.

6. Conclusion

There are trade-offs in using a single econometric approach to estimate the aggregate surpluses that could be generated by the placement of a large transport infrastructure project, and how these aggregate surpluses could be distributed through wider economic impacts.

The main trade-off could be between efficiency and reliability of the chosen econometric approach. Econometrics that is more explicit about the economic structure and transmission mechanisms behind economic corridors could produce much more precise and intelligent estimates if correctly and completely specified. If mis-specified (even partly) or incompletely specified, such econometrics can produce misleading results. In contrast, reduced-form econometrics struggles with endogenous placement issues and ignores indirect effects. This trade-off could apply to estimating both the optimal placement of a transport corridor and the optimal intervention design to diffuse the aggregate economic surpluses created by the corridor.

Conditional effects and interactions of corridor placement with other local factors such as market conditions, policies, and institutions are important but rarely addressed. For reduced-form regressions, the struggle to achieve clean identification—that is, separating transport infrastructure effects from other parallel effects—makes the inclusion of interactive (conditional) effects problematic. Despite possible endogeneity biases, these interactive effects need to be applied more systematically (Melecky et al. forthcoming). Because nonlinear structural GE models are commonly log-linearized using only the first order Taylor series expansion (not a higher order one), interaction terms typically disappear from GE econometrics. But they do not need to disappear if second or higher order Taylor series expansions are used. Hence, GE econometrics has a great potential for credibly researching the conditional effects of transport corridors.

Table 1 attempts to systematize the critique, policy advice, and directions for future research presented in this paper. It crudely sorts the discussed corridor econometrics by their current ability (first column) and the econometric potential (second column) to help policy makers precisely and reliably determine the corridor placement and the design of a corridor intervention package to maximize wider economic benefits. The table closes by gauging the gap between the current ability and the potential (third column). For instance, network econometrics probably has the best ability currently to address optimal placement of cross-border transport corridors. But its ability to appraise the design of a corridor intervention package for its potential to generate WEBs is rather small because network econometrics focuses more on immediate and intermediate outcomes than final development outcomes (the WEBs incurred by households). Current structural GE econometrics could be efficient in appraising expected WEBs, but its efficiency possibly comes at the cost of lower reliability. The greatest econometric potential to appraise WEBs efficiently and reliably could lie with structural GE econometrics. But considerable research is needed to realize this potential.

Table 1. There are trade-offs between different econometric approaches to appraise proposed corridors

Econometrics approach	Current reliability in determining:		Econometric potential in determining:		Further research needed to attain the potential:	
	Placement	WEBs	Placement	WEBs	Placement	WEBs
Network	High	Lowest	High	Low	High	Low
Reduced-form	Low	Highest	Low	Medium	Low	Medium
General equilibrium	Low	High	Medium	High	Low	High

Source: The author

Note: WEBs = wider economic benefits.

Because the process of deciding on the placement and design of transport corridor intervention is dynamic, sequencing more reliable and more efficient econometric methods could be also useful.

Prefeasibility studies and assessments could deploy only simpler and more reliable econometrics (network econometrics focused on the concept of centrality, combined with reduced-form regressions). At a later stage, feasibility studies and project appraisals could introduce more efficient methods (network econometrics based on the integration of heterogeneous agents and structural GE econometrics) to think through possibly richer dynamics of interactions, as well as direct, indirect, and second-round effects due to the corridor intervention.

Finally, the appraisal econometrics available today still does not estimate the link between the potential for market access and the actual use of this access by firms (through trade and travel) and people (for travel for jobs, education, health care, and so on). The econometrics largely assumes the link exists and is on average the same in every context. This assumption could be problematic. For instance, if complementary factors are needed for firms and people to embrace the market access potential provided by transport connectivity and actually use it, this link cannot be assumed. It can be broken in many countries, or vary greatly across different economic actors and/or geographic units. Appraisal econometrics and research should aspire to shed more light on the empirics of this microeconomic mechanism—including by building on the existing anecdotal evidence (see, for example, Spotlights 1 and 2 in ADB, DFID, JICA, and WBG forthcoming).

References

- ADB, DFID, JICA, and WBG (Asian Development Bank, UK Department for International Development, Japan International Cooperation Agency and World Bank Group). Forthcoming. *The WEB of Transport Corridors in South Asia*. Washington, DC: World Bank.
- Alder, S. 2017. “Chinese Roads in India: The Effect of Transport Infrastructure on Economic Development.” Working Paper, University of North Carolina.
- Alder, S., M. Roberts, and M. Tewari. 2017. The Effect of Transport Infrastructure on India’s Urban and Rural Development. University of North Carolina at Chapel Hill, World Bank, Green Growth Knowledge Platform (GGKP), GGKP Annual Conference. <http://www.greengrowthknowledge.org/resource/effect-transport-infrastructure-india%E2%80%99s-urban-and-rural-development>
- Bakker, P., C. Koopmans, and P. Nijkamp. 2010. “Appraisal of Integrated Transport Policies.” In *Integrated Transport: From Policy to Practice*, edited by David Banister, 117–36. Abingdon, United Kingdom: Routledge.
- Baniya, S., S. Murray, N. Rocha, and M. Ruta. 2017. “The Trade Effects of the New Silk Road.” Presentation, World Bank Group, June.
- Baum-Snow, N. B., J. V. Henderson, M. A. Turner, Q. Zhang, and L. Brandt. 2016. “Highways, Market Access and Urban Growth in China.” Working Paper C-89114-CHN-1, International Growth Centre, London School of Economics and Political Science and Oxford University.
- Berg, C. N., U. Deichmann, Y. Liu, and H. Selod. 2017. “Transport Policies and Development.” *The Journal of Development Studies* 53 (4): 465–80.

- Bosker, E. M., U. Deichmann, and M. Roberts. 2015. "Hukou and Highways: The Impact of China's Spatial Development Policies on Urbanization and Regional Inequality." Policy Research Working Paper 7350, World Bank, Washington, DC.
- Bosker, M. and Garretsen, H. 2010. "Trade costs in empirical New Economic Geography." *Papers in Regional Science* 89(3), 485-511.
- Bougna, T., M. Melecky, M. Roberts, and Y. Xu. Forthcoming. "The Estimated Wider Economic Benefits of Transport Corridors: A Critical Review of the Literature." Policy Research Paper, World Bank, Washington, DC
- Burgess, R., and D. Donaldson. 2012. "Can Openness to Trade Reduce Income Volatility? Evidence from Colonial India's Famine Era." <http://econ.lse.ac.uk/staff/rburgess/wp/BurgessDonaldsonIncomeVolatility.pdf>.
- Burgess, R., R. Jedwab, E. Miguel, and A Morjaria. 2015. "The Value of Democracy: Evidence from Road Building in Kenya." *The American Economic Review* 105 (6): 1817–51.
- Donaldson, D., and R. Hornbeck. 2016. "Railroads and American Economic Growth: A 'Market Access' Approach." *The Quarterly Journal of Economics* 131 (2): 799–858.
- Duranton, G., P. M. Morrow, and M. A. Turner. 2013. "Separate Appendices with Supplemental Material for: Roads and Trade: Evidence from the US." http://real.wharton.upenn.edu/~duranton/Duranton_Papers/Current_Research/Supp_FunTrade.pdf.
- Fajgelbaum, P. D., and E. Schaal. 2017. "Optimal Transport Networks in Spatial Equilibrium." NBER Working Paper 23200, National Bureau of Economic Research, Cambridge, MA.

- Fan, S., and C. Chan-Kang. 2008. "Regional Road Development, Rural and Urban Poverty: Evidence from China." *Transport Policy* 15 (5): 305–14.
- Gastner, M. T., and M. E. Newman. 2006. "Shape and Efficiency in Spatial Distribution Networks." *Journal of Statistical Mechanics: Theory and Experiment* 2006 (01): 1-15.
- Graham, D. J., E. J. McCoy, and D. A. Stephens, 2014. "Quantifying Causal Effects of Road Network Capacity Expansions on Traffic Volume and Density via a Mixed Model Propensity Score Estimator." *Journal of American Statistical Association* 109 (508): 1440–49.
- Laird, J. J., and A. J. Veneables. 2017. "Transport Investment and Economic Performance: A Framework for Project Appraisal." *Transport Policy* 56 (2017): 1–11.
- Lall, S. V., H. G. Wang, and U. Deichmann. 2010. "Infrastructure and City Competitiveness in India." WIDER Working Paper 22/2010, World Institute for Development Economics Research, United Nations University.
- Melecky, Martin, Siddharth Sharma, and Hari Subhash. Forthcoming. "Wider Economic Benefits of Investments in Transport Corridors and the Role of Complementary Policies." Policy Research Paper, World Bank, Washington, DC.
- Melo, P. C., D. J. Graham, and R. Brage-Ardao. 2013. "The Productivity of Transport Infrastructure Investment: A Meta-analysis of Empirical Evidence." *Regional Science and Urban Economics* 43 (5): 695–706.
- Pagan, A., and A. Ullah. 1999. *Nonparametric Econometrics (Themes in Modern Econometrics)*. Cambridge University Press.

- Page, L., S. Brin, R. Motwani, and T. Winograd. 1999. "The PageRank Citation Ranking: Bringing Order to the Web." Stanford InfoLab, Stanford University.
- Redding, S. J., and M. A. Turner. 2014. "Transportation Costs and the Spatial Organization of Economic Activity." NBER Working Paper 20235, National Bureau of Economic Research, Cambridge, MA.
- Revoltella D., P. Brutscher, A. Tsiotras, and C. Weiss. 2016. "Linking Local Business with Global Growth Opportunities: The Role of Infrastructure." *Oxford Review of Economic Policy* 32 (3): 410–30.
- Rothenberg, A. D. 2011. "Transport Infrastructure and Firm Location Choice in Equilibrium: Evidence from Indonesia's Highways." Job Market Paper, Department of Economics, University of California, Berkeley. http://ceg.berkeley.edu/students_29_681674267.pdf
- Starr, S. F. 2007. *The New Silk Roads: Transport and Trade in Greater Central Asia*. Johns Hopkins University Press.
- Straub, S. 2011. "Infrastructure and Development: A Critical Appraisal of the Macro-Level Literature." *Journal of Development Studies* 47 (5): 683–708.