



JOINT TRANSPORT RESEARCH CENTRE

*Discussion Paper No. 2007-8  
December 2007*

# ***The Wider Economic Benefits of Transportation: An Overview***

**T.R. LAKSHMANAN  
Boston University, USA**

# The Wider Economic Benefits Of Transportation: An Overview

**T.R. Lakshmanan**  
**Boston University**

## I. INTRODUCTION AND OVERVIEW

Economic contributions of investments of transport infrastructure are typically assessed from a microeconomic perspective, which tries to identify the link between specific transport infrastructure improvements and the productivity of specific production units. The traditional economic tool of the microeconomic perspective is cost benefit analysis (CBA), an *ex ante* tool which tries to capture the benefits of time and cost savings --- as well as further gains from logistical improvements and facilities consolidation made possible by transport improvements --- and the associated costs including external costs. The objective of this Round Table sponsored by OECD / ECMT and Boston University is to identify and move towards methods which incorporate the *wider economic benefits* of transport infrastructure, not typically captured in the CBA estimates of benefits and costs.

The aim of this brief paper is to offer an overview of such wider economic benefits ensuing from transport infrastructure investments. Section II offers a brief review of the recent literature on macroeconomic models which argue that there are externalities to investments in infrastructure which are not captured in microeconomic CBA studies. The economy-wide cost reductions and output expansion due to transport infrastructure are identified in these macroeconomic models. While the overall inference of a positive and modest economic contribution of transport infrastructure is offered, the utility of such a result is open to question in view of two serious drawbacks of this macroeconomic modeling stream: *first*, the sharp differences and conflicts on *the magnitudes and direction* of economic impacts of infrastructure, *second*, the macroeconomic models offer little clue to the mechanisms linking transport improvements and the broader economy. Section III attempts to identify the wider economic benefits of transport capital and the economic processes involved in the generation of these wider economic benefits as gleaned from the Economic History literature on studies of economic transformation attendant on large investments in railroads and waterways around the world. Section IV provides a discussion of our contemporary understanding how transport infrastructure improvements open up markets, achieve gains from trade, promote interregional integration, and enhance performance of factor markets. Further, there are two other mechanisms, in activity clusters made possible by transport improvements, one dealing with spatial agglomeration benefits, and the other with innovation and commercialization of new knowledge. This section discusses these mechanisms in the context of recent theoretical research respectively in the 'New Economic Geography' and Innovation research associated with the 'Economies of Variety'. Section V concludes the paper.

## II. MACROECONOMIC MODELING OF ECONOMIC IMPACTS OF TRANSPORT INFRASTRUCTURE

Macroeconomic models offer *ex post* econometric analyses of the contributions that transport infrastructure investments offer an economy in terms of cost reductions and output expansion -- such effects typically captured by cost functions and production functions. The idea of the macroeconomic models is that there are externalities to investments in transport infrastructure which are not captured in microeconomic CBA studies. The incorporation of these externalities allows the macroeconomic models potentially to identify social rates of return to transport infrastructure. However, models which represent aggregate output by GDP, can capture the value of time savings from infrastructure *only to the extent* that time saved is applied to production -- missing time savings devoted to leisure (which can be picked up by CBA). Further, analyses focusing on aggregate output may ignore relative price effects of transport facility construction, which can yield a sizeable welfare effect (Haughwout, 1998).

Such macroeconomic analyses of productivity of transport infrastructure have been carried out over the last three decades in Japan, U.S., Sweden, U.K., France, Germany, India, Mexico, and elsewhere. These different studies vary along many dimensions:

- \* in the functional specification of those models, (Cobb-Douglas, CES, or flexible functional forms);
- \* in the types of measures they apply to different model variables such as output (e.g. GDP, personal income, Gross State Product, etc.), or public capital (Value of capital stock or other measures of physical infrastructure);
- \* in the level of disaggregation of economic sectors [e.g. from aggregate output in the Aschauer (1989) model to outputs by 35 sectors in the Nadiri-Mamaneus (1996) model]
- \* in the size of the geographic areas used (nation, region, state, metro area, or county), and
- \* in the temporal level of analysis (time-series, cross section, or pooled)

### *Agreements and Sharp Disagreements in the Literature*

The major agreement that can be gleaned from these macroeconomic analyses of transport-economy linkages is the broad support for the view that transport infrastructure contributes to economic growth and productivity. However, this contribution is modest and variable over time. This inference about the economic impact of infrastructure is robust, as it reflects a great many studies which use various specifications of production and cost functions over different time periods, in different countries, and with slightly different representations of several variables (See Table 1).

**Table 1. Summary of Output and Cost Elasticities of Highway and Other Public Capital in Various Countries**

Country	Sample	Infrastructure Measure	Elasticity Range
United States	aggregate (ts) states (xs) states (ts/xs) regions, trucking industry (ts/xs)	public capital public capital highway capital highway capital	output: 0.05 to 0.39 output: 0.19 to 0.26 output: 0.04 to 0.15 cost: - 0.044 to -0.07
Japan	regions (ts/xs)	transportation & communication infrastructure	Output: 0.35 to 0.42
United Kingdom	aggregate (ts)	public capital	cost: negative, statistically significant
France	regions (xs)	public capital	output: positive, statistically significant
Germany	industry (ts/xs)	public capital, highway capital	cost: negative, statistically significant
India	aggregate (ts), states (xs)	economic infrastructure: roads, rail, electric capacity	cost: -0.01 to -0.47
Mexico	national, 26 industries	transportation, communication & electricity, public capital	returns to public capital: 5.4% - 7.3%

Note: ts=time-series; xs= cross-section

However, this inference of a modest positive economic contribution of infrastructure investments masks some sharp differences and conflicts in the results of recent studies. If one compares the different measures of economic contribution of infrastructure (e.g. output elasticities, cost elasticities or rates of return of transport infrastructure), there appear to be sharply different results among the recent studies:

- \* for the same country overall, and at different periods of time,
- \* for different countries at comparable stages of development,
- \* for countries at different stages of development and,
- \* where threshold effects and accelerated growth are evident.

This large variety of conflicting results can not be attributed to methodological deficiencies as many of them are associated with recent studies employing sophisticated functional forms and statistical methods.

#### *Differential Results for the Same Country or Countries at Similar Stages of Development*

Table 2 illustrates one aspect of this dissonance among the studies about the impact of public capital. Pereira (2001) and Demetriades and Mamuneas (D-M, 2000) apply sophisticated production functions to analyze the relationships between public capital and output in 12 OECD countries for approximately the same period, using respectively a Vector Auto Regressive/ Error Correction Mechanism (VAR / ECM) framework and a flexible functional form for the profit function.

First, the D-M (2000) study estimates output elasticities of public capital for the U.S. (and for Sweden and Germany) *four times* as large as the Pereira (2001) study does. For U.K. and Japan, the estimates are *twice* as large. Further, the five OECD countries in Table 2 are affluent industrialized countries with comparable levels of technological evolution, industrial composition and income and consumption. As the various *transport-using firms* respond to

transport infrastructure and service improvements in an economy, the many market mechanisms and structural processes interact and generate the economic effects rippling through the economy and culminating in the growth in GDP. Such effects in these five economies can be expected to be of comparable magnitude. Yet, D-M (2000) study's estimates of the output elasticities, however, range from 1.03 (U.S.) to 0.358 (U.K.); Pereira's estimates range from 0.2573 (U.S.) to 0.143 (U.K.). Such sharp differences in parameters for the same country and for countries in comparable levels of development need an explanation.

**Table 2. Productivity Effects of Public Capital: Sharply Dissonant Results**

	U.S	Japan	U.K.	Sweden	Germany
Pereira (2001) Vector Auto Regressive/Error Correction. Mechanism - data early 1960s to later 1980s	L.R. (10 yr) 0.2573	0.2525	0.1430	0.2270	0.1905
Demetriades and Mamuneas (2000). Flexible functional form for profit function (data for 1972- 1991)	1.03	0.499	0.358	1.217	0.768

Figure 1 traces the variation of infrastructure productivity over time in the U.S. The Nadiri-Mamuneas (1996) identify net rates of return of Highway capital (which makes up a major part of public capital):

- \* Between 30% to 45% for years 1951-67,
- \* from 15% to 30% for years 1968-78 and,
- \* Below 15% for 1979 to 1987

The net rate of return of public capital was higher than that of private capital from 1951 to 1978. In subsequent years, private capital had higher rates of return than highway capital.

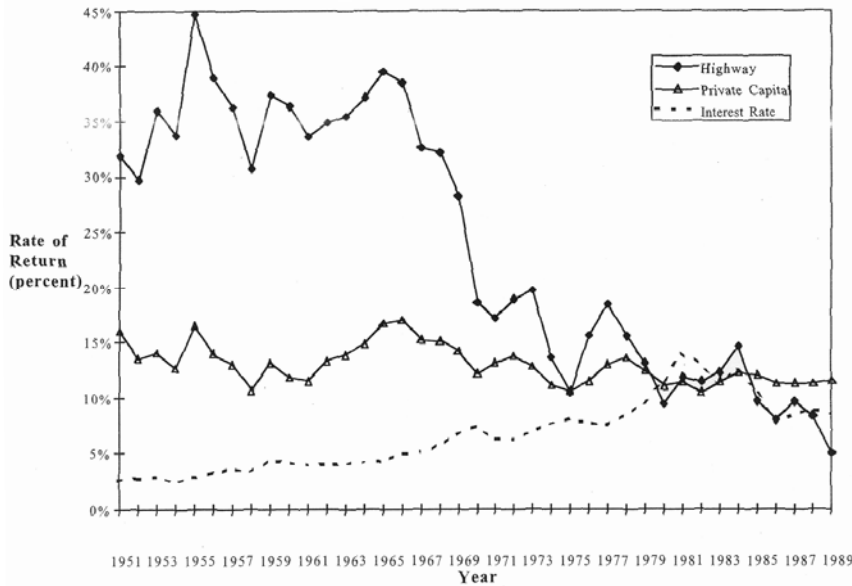
Fernald's (1999) analysis of public capital's contribution to U.S. industry productivity between 1953 and 1989 suggests a similar time pattern of effects. He suggests that the massive road-building of the 1950s and 1960s (the interstate system) offered 'a one-time' increase<sup>1</sup> in the level of productivity (in the pre-1973 period).

Demetriades and Mamuneas (2000), on the other hand, arrive at a time pattern of productivity effects in the U.S., different from that espoused by Nadiri- Mamuneas and Fernald. They identify net rates of return of public capital, which exceed consistently private net rates of return of private capital in the U.S. all the way from 1972 to 1991. Indeed, the estimated long-run net rates of return to public capital in the U.S. (and Canada, Japan, Germany, France, Italy and U.K.) remained above those of private capital. In other words, an extra dollar of investment in the early 1990s (according to Demetriades and Mamuneas) would have been socially more productive in the long-run if it were invested as public capital.

<sup>1</sup> Fernald (1999) argues that the aggregate correlation between productivity and public capital primarily reflects causation from public capital to productivity, and the slowdown in productivity growth after 1973 may reflect the public investment patterns in that period.

Thus, for the period of the mid 1970s to early 1990s, two different patterns of productivity performance of public capital are offered by the Nadiri - Mamuneas and Fernald studies on the one hand and by Demetriades and Mamuneas on the other.

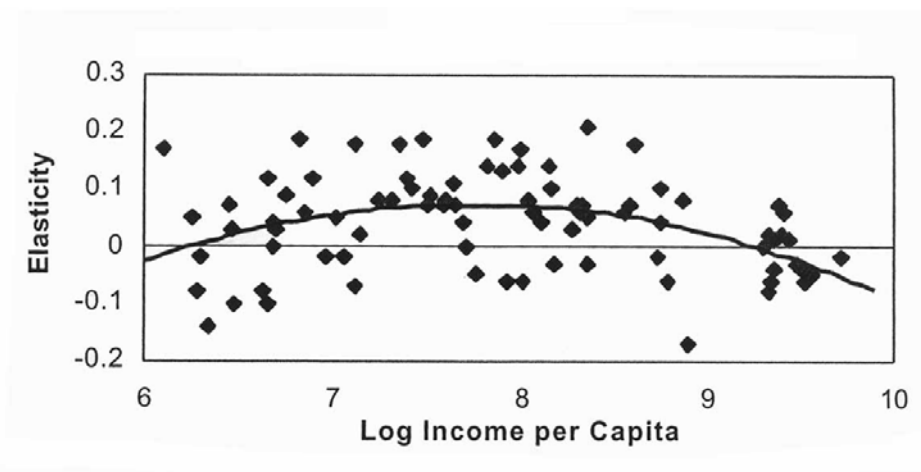
**Figure 1. Net Rate of Return of Highway Capital, Private Capital, and Private Interest Rate (1951 - 1989) from Nadiri and Mamuneas (1996)**



*Countries at Different Stages of Development and Threshold Effects*

Figure 2 presents the estimates of the elasticities of output with respect to public capital for a panel of countries in different stages of development (Canning and Bennathan, 2000). There is an inverted U shape, with higher elasticities in middle income countries and somewhat lower in the low and the high ends of the income distribution.

**Figure 2. Elasticity of Output with Respect to Paved Roads**



**Table 3. Transport Infrastructure Productivity in Countries at Different Stages of Development**

	Countries in Lower Quartile of Incomes	Countries in Middle Quartile of Incomes	Countries in Upper Quartile of Incomes
Output Elasticity of Paved Roads	0.05	0.09	0.04

Source: Canning and Besanathan, 2000.

The rates of return to paved roads displayed in Figure 2 and categorized in Table 3 are obtained from a translog production function (Canning and Bennathan, 2000) in a set of countries which span the world income distribution. High rates of return to paved roads are evident in some middle income developing countries (Chile, Columbia, South Korea, and the Philippines). By contrast, low rates of return accrue to paved roads in affluent developed countries and in some developing countries.<sup>2</sup>

#### *Mechanisms Linking Transport Improvements and the Economy*

While the macroeconomic models help determine whether and to what degree transport infrastructure lowers production costs, increases the level of economic output, and enhances the productivity of private capital, its analytical apparatus is a ‘black box’ variety. We have little inkling about the causal mechanisms and processes which translate infrastructure improvements into output and productivity enhancements. Such mechanisms are activated by the monetary and time savings induced by transport infrastructure improvements, and experienced at the regional and interregional levels by economic agents in different types of markets. The lowered costs and greater accessibility for transport-using production sectors and firms shipping goods from firms to retail outlets, and for households engaged in shopping and in commuting are likely to lead to the types and sequences of consequences such as: expansion of markets, higher efficiencies through scale economies, economic restructuring through entry and exit firms exposed to new competition, spatial agglomeration economies and innovation benefits in spatial clusters made possible by transport infrastructure, etc.

This brief review of the drawbacks of macroeconomic models---the uncertainties in the magnitudes and direction of economic effects of transport infrastructure and the little light they shed on the mechanisms and processes underlying transport-economy linkages—suggests that we look elsewhere for guidance on delineating and estimating the broader economic benefits of transportation. Indeed, the many economic economic mechanisms and processes which translate transport improvements into a wide range of (and often transformational) consequences in the

---

<sup>2</sup> It is generally observed that private returns to capital are quite low in the poorer developing countries, and that diminishing returns to capital set in slowly in affluent industrialized countries --- because they can keep up their marginal productivity up by accumulating large amounts of human capital (Canning and Bennathan, 2000). The higher returns to private capital are also understandable in the middle income newly industrializing countries (NICs), which have received in recent years considerable flows of foreign direct investment (and associated technologies) from developed countries and participate in the global production system. If one assumes that NICs have invested in transport infrastructure to facilitate participation in global production and trade, a legitimate question arises: whether the high rates of return to paved roads observed in such countries reflect an expansion of transport networks to a critical density at which interregional economic integration occurs, thereby promoting regional specialization and accelerated growth in those economies.

broader economy have been analyzed and reported in the case of railroads and waterways in a many countries in the Economic History literature. We turn briefly to this literature to highlight the broad range of wider consequences of transport infrastructure.

### III. LESSONS FROM ECONOMIC HISTORY

Economic historians have attempted to measure in many countries the impact of the diffusion of railroad networks on economic growth and development.<sup>3</sup> In the process, they have shown how the time and cost savings induced by railroad expansion course through the countries' economies linking product and factor markets, promoting interregional trade, specialization and, increasing returns to scale, and reallocating economic activities.

A frequently used measure of the importance of railroads to a country's economy is *Social Savings*, computed as the *costs* of coping without railroads for one year. A counterfactual situation is envisaged where the producers, in the context of closing down of the railroad network for a year, transport the same volume of freight to the same destinations using alternative modes<sup>4</sup>. Table 3 provides estimates of social savings for railroads (which have been in full operation) in 10 countries.

**Table 3. Estimates of Social Savings on Freight Transported by Railways, 1865-1913**

Country	Date	S.S. Expressed as a Share of G.N.P.
England and Wales	1865	4.1%
England and Wales	1890	11.0%
USA	1859	3.7%
USA	1890	8.9%
Russia	1907	4.6%
France	1872	5.8%
Germany	1890s	5.0%
Spain	1878	11.8%
Spain	1912	18.5%
Belgium	1865	2.5%
Belgium	1912	4.5%
Mexico	1910	25% - 39%
Argentina	1913	21-26%

Source: Patrick O'Brien (1983)

<sup>3</sup> There was a rapid expansion of rail networks across Europe --- growing from 3000 kms of track in 1840 to 362,000 kms by 1913 (O'Brien, 1982). U.S. and many countries in Latin America and India witnessed rapid growth in their railroads in a comparable period.

<sup>4</sup> Extra costs are incurred since freight will now move along longer and circuitous routes, at lower speeds, and at higher tariffs. First formulated by Fogel (1964) for the U.S., social savings have been computed for many countries. There can be some problems with the data quality and assumptions on prices in these estimates.



**Table 4. The Wider Effects of Railroad Investments (1850-1914)**

Author	Country	Broader Effects of Transportation Infrastructure
Hurd (EEH, 1975)	India (1861-1921)	Prices across India began to converge and India-wide market in grains developed.
Collins (EEH, 1999)	India (1873-106)	Wage dispersion narrowed, Real wages in initially low wage areas grew faster
J. Metzger (JEH, 1974)	Czarist Russia (1870-1910)	Evolution of a national grain market. Improved interregional terms of trade. Narrower prices $\Rightarrow$ regional specialization $\Rightarrow$ Better resource allocation
Summerhill (JEH, 2005)	Brazil (1898-1913)	A purchase of specialization that boosted productivity
Summerhill (Mimeo, 2001)	Argentina (1857-1913)	Social savings 12-26% of GDP, Most gains went to Argentina producers and consumers
Heronz-Lancon (JEH, 2006)	Spain (1850-1913)	Growth accounting studies. TFP gains of Spanish RR. By 1914 11% of income per capita growth (cf. 14% in UK) Case against Fogel
Fishlow (1965)	U.S. Midwest (1848-1890)	Agricultural and industrial expansion of Great Lakes States and Integration into U.S. and World Economies

The closure of a fully operational rail network has a considerable penalty in terms of GNP loss, especially for Spain, Mexico, and Argentina. In continental economies such as U.S. and Russia railroads did not provide a much cheaper service than waterways per ton-mile of freight over long and similar routes, with the result that social savings are lower.

However, Fogel's social savings measure is viewed currently as static and ignoring the 'forward linkages' from railways to the economy (Williamson, 1974), and a variety of indirect and induced effects of railways as gleaned from many studies of long run impacts of railways and case studies (Foreman-Peck, 1991).

Table 4. lists some of these wider effects of railroad infrastructure from 7 case studies. In 19<sup>th</sup> century India railroads lowered transport costs 80% per mile, thereby initiating grain bulk shipments, creating an India-wide market for foodgrains, and promoting a convergence of prices across India (Hurd, 1975).<sup>5</sup> In a separate study of factor markets in India, Collins (1999) showed that falling transport costs in Indian railroads facilitated regional wage convergence by facilitating both labor mobility and interregional commodity trade, especially in the areas surrounding the premier cities of Calcutta and Bombay. In late 19<sup>th</sup> and early 20<sup>th</sup> centuries European Russia, rail networks promoted market integration, based on the realization of gains from trade (Metzger, 1974). The narrowing of commodity price differentials increased regional specialization of production thereby improving resource allocation. In this regard, Metzger (1982) and O'Brien (1991) argue that the benefits from market integration are *additional* to those embodied in Fogel's Social savings, and these integration benefits lead to internal and external economies that promote efficiency and enhance production (as compared to the pre-railroad situation).

<sup>5</sup> The prices of grain in some districts in 1860s were 8 to 10 times higher than prices in others (Hurd, 1975).

Railroad investments in Brazil represented a purchase of specialization and enhanced productivity (Summerhill, 2005). This impact was large for overland movements given the absence of an affordable alternative to railroads, which further attracted large inflows of labor and capital which was used in other activities that raised national income. In the case of Argentina, the benefits from railroads built with British capital went largely to Argentine producers and consumers, enhanced aggregate productivity gains, and the transformation of the Argentine pampas (Summerhill 2001). The TFP gains deriving from the Spanish railroads were substantial, both through the shift from alternative modes of transport and through productivity improvements within the railroad networks.

A far more comprehensive analysis of the wider economic impacts of railroads has been carried out for U.S. railroad investments in the 19<sup>th</sup> century (Fishlow, 1965, Chandler 1965). Only a selective listing of the cascade of successive economic effects that ensued from the cost and time savings due to railroad expansion in 19<sup>th</sup> century from the Northeast U.S. to Midwest first and later to the rest of the country is possible here. As the lower costs and increased accessibility due to railroads coursed through markets and were experienced by different market actors (producers, consumers, laborers) a successive series of economic impacts ensued. This cascade of economic consequences include: expansion of settlements and agriculture; market expansion and integration; regional specialization in agriculture and industry; promotion of volume production and the realization of scale economies; enablement of lower inventories and the rise of a logistical revolution and the rise of wholesaling; the need to tap idle savings and channel them into railroad investment inducing development of financial institutions and raising the savings rate; the extension of mass production techniques (e.g. volume production of goods with interchangeable parts developed in New England) to mass produce a whole range of goods; the promotion of the complementary communication service (postal service); and eventually the integration of the Northeast to the Midwest to form the “Manufacturing Belt” (Chandler, 1965; Lakshmanan and Anderson, 2007; Kim and Margo, 2003).

#### **IV. THE WIDER ECONOMIC BENEFITS OF TRANSPORT: AN OVERVIEW**

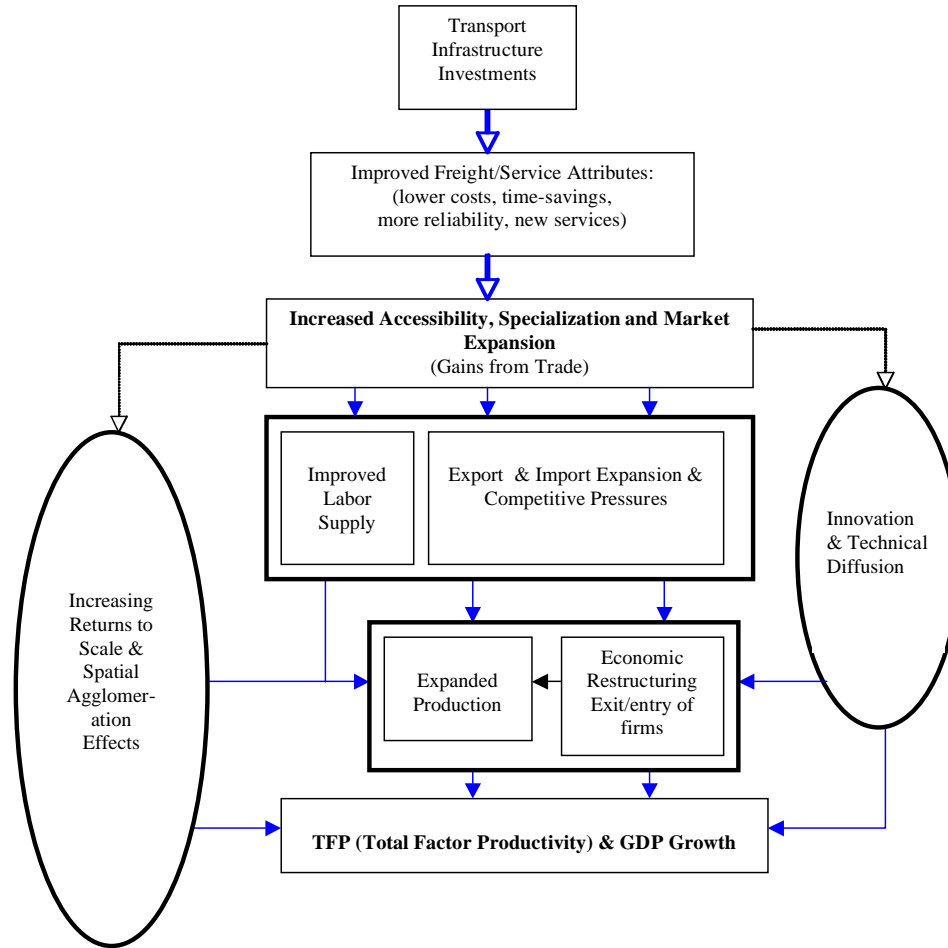
Figure 3 offers one view of the mechanisms and processes underlying the wider economic benefits of transport infrastructure investments. It is a contemporary version of what Williamson (1974) and O’Brien (1983) call “forward linkages” of transport infrastructure. The lower costs and increased accessibility due to transport improvements modify the marginal costs of transport producers, the households’ mobility and demand for goods and services. Such changes ripple through the market mechanisms endogenizing employment, output, and income in the short run. Over time *dynamic development effects* derive from the mechanisms set in motion when transport service improvements activate a variety of interconnected economy-wide processes and yield a range of sectoral, spatial, and regional effects, that augment overall productivity.

The lower costs and enhanced accessibility due to transport infrastructure and service improvements expand markets for individual transport-using firms. As such market expansion links the economies of different localities and regions, there is a major consequence in terms of shifting from local and regional autarky to increasing specialization and trade and the resultant upsurge in productivity. Thus, the U.S. Interstate Highway System, the Trans-European Network

Programme and super-efficient ocean ports all contribute to “Smithian” growth --- growth arising from specialization and trade.

Opportunities for exporting and importing goods are enhanced, in turn opening up several channels of economic effects, both in product markets and in factor markets -- in a manner analogous to the results from tariff reduction and trade area expansion.

**Figure 3. Transport Infrastructure and Economy-wide Benefits**



First, export expansion will lead to higher levels of output, which allow higher sales to cover fixed costs of operation, yielding efficiencies; Second, increasing imports put competitive pressures on local prices. Such pressures lead not only to the removal of monopoly rents but also to improved efficiency. Schumpeterian dynamics come into play — firm entry, exit, expansion, and contraction. As firms promote leaner production processes, which lower costs of production and raise productivity, further restructuring of the economy occurs. Third, lower transport costs and increased accessibility enlarge the markets for labor and other factor inputs. Firms will likely draw labor from a broader area and with a greater range of attributes improving labor supply and

with lower costs. Similar effects in land and other factor markets are likely as transport improvements open up new land for economic activities.<sup>6</sup>

Finally, Figure 3 suggests that the two mechanisms in the oval boxes, one dealing with *innovation* and the other with *spatial arrangements* in the economy. These two mechanisms create, *in the context of transport infrastructure improvements*, conditions (in activity clusters) which enhance economic performance, and promote total factor productivity and endogenous growth. Our understanding of these two mechanisms of innovation and spatial arrangements derive from recent research on “Innovation-Friendly Locales” and the ‘New Economic Geography’.

Transport improvements can have an endogenous growth effect to the degree they impact the rate of growth of the economy through the creation and commercialization of new knowledge -- thereby promoting Total Factor Productivity (TFP) growth, and the *rate of growth* of the economy. In the contemporary knowledge economy, firms are concerned with the reduction of a new class of costs — *adaptive costs* — incurred by the firm as it monitors the environment for changes in technology and products, identifies competitive strategies, and implements such strategies quickly enough to retain or improve market share (Hage and Alter, 1997; Lakshmanan and Button, 2008) The key notion in this case of spatial proximity is that innovation derives from the *Jacobsonian Economies* (1969) or *the Economies of Variety* (Quigley, 1998) and the firms minimize their adaptive costs by participating in economic networks in the activity cluster or agglomeration --- made possible by transport infrastructure improvements.

Research on imperfect competition and the increasing returns to scale extends to locational analysis and emphasizes the importance of the interactions between transport costs on the one hand and market size and economies of scale on the other.<sup>7</sup> With dropping transport costs and economies of scale, a firm in a location gains a larger market area and dominance, which in turn promotes the concentration of other firms in the same location. This idea of a location with good access to markets and suppliers for one firm improves market and supply access for other producers there, and the process of *cumulative causation* (where a location becomes more attractive to successive firms as more firms locate) derives from earlier ideas in Economic Geography. The central feature of this theory of agglomeration (as has been noted for a long time in economic geography and regional science) is the presence of external economies of scale in the Marshallian sense. Different firms clustered in a location experience positive externalities in the form of agglomeration economies, industrial complexes and social networks engaged in untraded interdependencies. In short order, regional specialization develops. Indeed, without increasing returns to scale in the context of transport improvements, it is impossible to account

---

<sup>6</sup> However, in an integrated market, there are likely some feedback effects associated with expanded production, which may dampen the initial strong positive impacts of transport improvements noted above. Since production expansion deriving from market expansion will raise the demand for labor and land, wages and rents will go up offsetting part of the initial lowering of costs and gains in competitiveness. The wage rises, if persistent, will have migration consequences. Finally, higher production may induce congestion in the networks and a rise in transport costs. The point to be made here is that transport improvements initiate a sequence of economic effects and feedback effects in a number of interacting markets.

<sup>7</sup> The core idea of the ‘new economic geography’ is the notion of increasing returns, an idea that has earlier transformed both trade theory and growth theory (Fujita, Krugman, and Venables, 1999). Taking advantage of Dixit and Stiglitz’s (1977) formalization of monopolistic competition, tractable models of competition in the presence of increasing returns have been developed in the fields of industrial organization, international trade, economic growth and location theory

for the observed spatial concentration of firms and regional specialization in regional and national economies.

In contemporary spatial agglomerations of economic activity — where there are frequent transactions between suppliers and customers and where high-end business services often accompany goods delivery -- the cost of transactions are likely to be lower inside such centers than outside them. Further, some interregional links gain advantages from the existence of increasing returns to transportation and transactions, which may help form transportation and transaction hubs as noted by Krugman (1999). The notion of *density* (of economic activities, social opportunities and transaction options) and *economic milieu* in such locations as leading to self-reinforcing and cumulative causation effects have been used by Johansson (1998) and Ciccone and Hall (1996).

## V. CONCLUDING COMMENTS

The purpose of our discussion is to show how transport infrastructure and transport improvements open up markets and create conditions, in the context of spatial agglomerations and technical change and diffusion, which influence economic structure and performance. A broad variety of interactions take place within firms and between firms, within sectors and between sectors and more broadly within and between households and organizations. Hence the first inference we draw is *the importance of general equilibrium analysis of transport-economy linkages*. The implication is that the impacts of transport improvements must be examined in a general equilibrium fashion, dealing with linkages between sectors and within sectors, where sectors exhibit different transport requirements, varying competitive strengths, and diverse spatial markets. These effects are realized through the operation of product markets and factor (labor, land, etc.) markets and technological and structural changes. Since these interactions are not only numerous and multiple and complex but may also operate to enhance or dampen the initial economic impacts of transport improvements, a more disaggregate analysis than is currently the case is called for in future analyses of transport-economy linkages.

## REFERENCES

- Aschauer, D.A. 1989. "Is public expenditure productive?" *Journal of Monetary Economics*, vol. 23, 177 - 200.
- Canning, David and Esra Bennathan 2001. *The Social Rate of Return on Infrastructure Investments*, World Bank Research Project on "Infrastructure and Growth: A Multicountry Panel Study," 48 pages.
- Chandler, Alfred D. 1965. *The Railroads, the Nation's First Business*, Harcourt, Brace & World, Inc., New York.
- Collins, William J. 1999. "Labor mobility, market integration, and wage convergence in late 19<sup>th</sup> century India," *Explorations in Economic History*, 36, 246 - 277.
- Ciccone, A. and R.E. Hall 1996. "Productivity and density of economic activity," *American Economic Review*, 86: 54 - 70.
- Demetriades, Panicos and T.F. Mameneus 2000. "Intertemporal output and employment effects of public infrastructure capital: evidence from 12 OECD countries," *The Economic Journal*, 110, 687 - 712.
- Fernald, John G. 1999. "Roads to prosperity? Assessing the link between public capital and productivity," *The American Economic Review*, 89: 3, 619 - 638.
- Fishlow, Albert 1965. *American Railroads and the Transformation of the Ante-bellum Economy*, Cambridge, MA: Harvard University Press.
- Fogel, Robert W. 1964. *Railroads and American Economic Growth: Essays in Econometric History*, Baltimore: The Johns Hopkins University Press.
- Foreman-Peck, James 1991. "Railways and Late Victorian Economic Growth" in *New Perspectives in the Late Victorian Economy, 1860-1914*, (ed.) James Foreman-Peck, Cambridge University Press, 73-95.
- Fujita, M., Paul Krugman and A.J. Venables 1999. *The Spatial Economy*, The M.I.T. Press. Cambridge, MA.
- Hage, J. and C. Alter 1997. "A Typology of Interorganizational Relationships and Networks" in *Contemporary Capitalism*, (eds.) J.R. Hollingsworth and R. Boyer, New York; Cambridge University Press. 94 - 126.
- Haughwout, A.F. 1998. "Aggregate production functions, interregional equilibrium, and the measurement of infrastructure productivity," *Journal of Urban Economics*, 44: 216 - 227.
- Herraz-Loncan, Alfonso 2006. "Railroad impact in backward economies: Spain, 1850-1913," *The Journal of Economic History*, 66, 853 - 881.
- Hurd II, John 1975. "Railways and the expansion of markets in India, 1861-1921," *Explorations in Economic History*. 12, 263-288.
- Jacobs, Jane 1969. *The Economy of Cities*. New York: Random House.
- Kim, S. and R.A. Margo 2003. "Historical perspectives in U.S. economic geography" in *Handbook of Regional and Urban Economics* (eds.) V. Henderson and J-F. Thisse, Vol. 4. North-Holland, New York.
- Lakshmanan, T.R. and K.J. Button 2008. (forthcoming) "Institutions and Regional Economic Development" in *Advances in Regional Economics* (eds.) R. Cappello and P. Nijkamp.

- Lakshmanan, T.R., and William P. Anderson 2002. *Transport Infrastructure, Freight Services Sector and Economic Growth: A White Paper* prepared for the U.S. Department of Transportation, January. 127 pages.
- 2007. "Transport's Role in Regional Integration Processes" in *Market Access, Trade in Transport Services and Trade Facilitation*, Round Table 134. Paris: OECD-ECMT, 45 - 71.
- Metzer, Jacob 1974. "Railroad development and market integration: The case of tsarist Russia," *The Journal of Economic History*, 34, 529 - 550.
- 1984. "Railroads and the efficiency of internal markets: Some conceptual and practical considerations," *Economic Development and Cultural Change*, 33, 61 - 70.
- Nadiri, Ishaq M. and T. P. Mamuneas 1996. *Constitution of Highway Capital to Industry and National Productivity Groups*. Report prepared for FHWA. Office of Policy Development.
- O'Brien, Patrick 1983. "Transport and Economic Development in Europe, 1789-1914" in *Railways and the Economic Growth of Western Europe*, (ed.) Patrick O'Brien, 1-27, London: Macmillan.
- Quigley, John M. 1998. "Urban diversity and economic growth," *The Journal of Economic Perspectives*. 12:2, 127-138.
- Summerhill, William R. 2005. "Big social savings in a small laggard economy: Railroad-led growth in Brazil," *The Journal of Economic History*, 65, 72 - 102.
- "Profit and Productivity on Argentine Railroads, 1857-1913", Los Angeles: Department of History UCLA (Mimeo).
- Williamson, Jeffrey G. 1974. *Late Nineteenth-Century American Development: A General Equilibrium History*. London: Cambridge University Press.