Clio on speed:

A survey of economic history research on transport

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Abstract

Cliometrics has made major advances in the historical analysis of transportation through better measurement, economic modelling and estimation. This essay surveys several topics and recent research. First, the revolutionary changes in transport over the last 300 years are reviewed, including analysis on the rate and sources of productivity growth. It is argued that macro-inventions, like steam power, were important but many incremental innovations mattered too. Second, the effects of transport improvements on market integration, trade, urbanization, and aggregate income are examined. Much research focuses on questions of magnitude. In other words, how big are the effects of transport improvements like railroads? Perhaps surprisingly, there is still disagreement about the relative importance of transport even with the applications of new tools and Geographic Information Software. Two novel areas of research concern mortality and persistence. Studies show that transport improvements contributed to higher mortality and influenced population density long after transport technologies became obsolete. These studies yield new perspectives on the effects of transport. Third, this essay examines why transport services were more efficient in some economies with a focus on the role of institutions as a fundamental factor. Evidence suggests institutions influenced investment in transport networks and the degree of public and private ownership. Ownership mattered for transport efficiency, and government involvement sometimes improved outcomes. Overall, cliometrics research on transport offers many insights on a historically important sector.

Key words:
– Transport, History, Market integration, Urbanization, Institutions, Agglomeration, Shipping, Railways–

JEL Codes

N7, O1, R4

Introduction

Transportation has undergone dramatic changes through the ages. Scholars from a wide range of fields have sought to understand the implications and explain those changes. Cliometrics has made key contributions to this broader literature through innovations in measurement, economic modelling, and estimation. This essay reviews the contributions of cliometrics to seven key topics. The first topic concerns the so-called transport revolution. There is much research tracking transport costs and travel speeds over time, making it possible to quantify the rate of change. This research shows that transport has undergone dramatic productivity improvements over the last 300 years. What caused these changes? Were macro-inventions, like steam power, the primary driver? The literature generally supports the importance of macro-inventions, but at the same time many studies show that productivity changes were incremental and contextual. Several examples are given below.

The second section examines transport, market integration and trade. The trends in market integration are reviewed. Next the effects of transport improvements are examined. Perhaps surprisingly, some research has found that transport improvements were not the most important driver of market integration. But other research finds the opposite. Moreover, in one study, poorly designed transport regulation is argued to be a main driver of market disintegration. The connection between integration and transport is not fully settled.

The third section focuses on the contribution of transport improvements to aggregate incomes. The main question is the following: how much economic growth was attributable to transport improvements? The traditional cliometric methodology calculates the social savings.

Recently, cliometrics has developed new data and econometric methods. As will be discussed below, the new research sometimes yields different estimates of transport's contribution. But in some cases, it appears that the social savings provide a reasonable approximation to the aggregate incomes gains from transport.

The fourth section examines the external effects of transport. Greater urbanization is one key example. Due to lower transport costs, individuals may change their location and affect their neighbors' productivity. Several works analyzing the effects of railroads on city population are reviewed. All find that cities with better railroad access increased their population relative to cities with poor access. An outstanding issue concerns possible reorganization effects, where transport causes population loss in areas with worse transport access. The effects of highways on central city population provide a good example of reorganization.

Higher mortality is another external effect of transport improvement. Pollution related health problems are a major concern in the 21st century. This section also discusses how transportation-related pollution was an issue in the 19th century.

The fifth section examines the connection between transport and the persistence of economic activity across space. Populations tend to settle where there are natural advantages, like a navigable river. Transport improvements can create new locational advantages, which encourage population resettlement. As time goes on some transport technologies become obsolete and one might think that population would resettle elsewhere. However, the literature shows migration from obsolete transport hubs does not necessarily happen.

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The sixth section examines how institutions affect transport. Institutions have long been highlighted in economic history as a fundamental cause of development. In the transport sector, institutions have been linked with the extent and quality of infrastructure networks. Several works are discussed which show that political institutions had a large effect on network development. This suggests that transport is a key channel through which institutions affected development in the past and today.

The seventh and final section discusses public and private ownership in transport. There are theoretical arguments in favor of both forms of ownership. Studies on the impacts of ownership and cost efficiency are discussed. Also, the role of institutions in determining railroad nationalizations in the 19th and early 20th centuries are analyzed. This ties with current debates about when government is more effective in delivering transport services.

1. The transport revolution

The transport revolution is one of the most significant developments in human history, and equals the industrial revolution in significance. According to historians (e.g. Taylor 2015 and Bagwell 2002), the transport revolution involved dramatic reductions in the time and costs of moving goods and people and in the cost of communication. Britain's transport revolution provides an example of these significant changes. The real freight rate by rail in 1870 was 5% of the real freight rate by road in 1700. The speed of road travel in 1700 was only 8% of the speed by train in 1870 (Bogart 2014). Dispatch times for letters in 1860 were 33% of what they had

been in 1820 (Kaukiainen 2001). For comparison, one can look at the falling price of high-valued manufactured goods, which were impacted by mechanization during the British industrial revolution. In 1840, the real price of fine printed cloth, known as calicoes, was 25% of their price in 1770, implying a 2% annual rate of decline (Harley 1988a). The overland freight rates mentioned above declined at an annual rate of 1.7% and dispatch times declined at an annual rate of 2.7%. These and other examples reveal that the transport sector was revolutionized to the same extent as manufacturing.

Much attention has focused on dating the transport revolution in various countries and for inland versus coastal and ocean shipping. In some cases, it is hard to identify the timing of significant change due to the gradual process of improvements. For example, there is evidence that shipping freight rates started to decline in the European trades during the early 1600s (Menard 1991). There is also evidence for greater productivity and lower sailing times in the transatlantic and East Indian trades during the late 1700s (Ronnback 2012, Solar 2013). The big changes in shipping productivity and freight rates arguably occurred in the mid-1800s with the introduction of steam power. Steamships were a global technology and brought lower freight rates to much of the world's trade, including India and China. Real shipping freight rates continued to decline between the late 19th and early 20th century. The peak for productivity in pre-World War I ocean shipping was 1913 (Mohammed and Williamson 2004). For the next 50 years, shipping freight rates fluctuated significantly, mainly due to wars and policy decisions. More recently, that is in the last 50 years (1960 to 2010), freight rates declined once again as

ships got larger and accommodated containers. The downward trend in freight rates in the last 50 years looks like the 1870 to 1913 era.

Inland transport costs also evolved over time. As an illustration, Walton and Rockoff (2013) summarize freight rates in the United States up to 1900. Around 1800 there were two main forms of inland transport: wagon and river. Wagon freight rates were 34 cents a ton mile, while river transport was between 2 and 10 cents a ton mile depending on whether boats travelled upstream or downstream. Significant changes occurred starting in the 1820s. The upstream river rate dropped to 1 cent a ton mile with the arrival of the steamboat. Building canals brought cheap water transport to areas without navigable rivers (around 5 cents a ton). Wagon rates fall to 15 cents a ton mile due to better roads. The introduction of railroads around 1840 was the next phase of the inland transport revolution. It brought low freight rates and greater speed to areas that did have canals because of geography. Freight rates by rail started at 6 cents a ton mile and declined to less than 1 cent a ton mile by 1900. Note that freight rates continued to fall on railroads and canals after they are introduced. These technologies unleashed a period of exceptionally high productivity growth in the US.

These patterns of lower inland freight rates and travel times were not seen worldwide however. In a few economies, mostly northwestern Europe and the US, there were improvements in inland transport starting in the 1700s (De Vries 1981, Bogart 2005, Gerhold 2014). But in other economies, including India, China, and Japan, it was only with the railway that inland freight rates and travel times fell (see Huenemann 1984, Ericson 1996, Kerr 2007).

One explanation is that these economies did not improve their roads and waterway networks to the same degree as northwestern Europe and the US in the late 18th and early 19th centuries.

The 20th century has witnessed another transport revolution associated with the automobile and airplane. Their economic impact has been large since the 1950s. Air travel is the most recent example. It has led to dramatic declines in the cost of passenger travel and improvements in communication. The average speed of air passenger travel went from 180 miles per hour in 1950 to 408 mph in 1990 (Carter et. al. 2006). That is, speeds increased by 2.25 times in 40 years. One effect in the US has been the concentration of employment near cities with airports (Brueckner 2003).

Over the longer term consider the following facts. In 1700, most wealthy individuals travelled on coaches at speeds less than 3 miles per hour. In 2000, the wealthy travel in airplanes at more than 500 miles an hour. That implies long distance travel speeds are 166 times faster today than 300 years ago for the rich! In 1700, the poor did not usually travel, but when they did it was generally by foot, moving at 2 to 2.5 miles per hour. In 2000, the poor often travel at speeds ranging between 20 and 60 miles an hour depending on congestion, roads, and vehicle types. Therefore, travel speeds for the poor are 10 to 24 times faster than 300 years ago. In the long-run perspective, it is evident that transportation has radically changed, but the rich have enjoyed more gains than the poor. Transport improvements are *not* neutral in their distributional effects.

This brief review should raise questions about the causal factors behind the transport revolution. One issue concerns the importance of large-scale technological changes (i.e. macro-

inventions) versus incremental changes (i.e. micro-inventions). The thrust of much research in cliometrics points to the importance of incremental changes without minimizing macro-changes like steam power, the ship container, and the internal combustion engine.

Shipping provides a good example of this research. One narrative is that the productivity of sailing ships changed little over the centuries in comparison to advances associated with steamships. Harley (1988b) made this argument starkly in the case of British shipping. Using a real freight rate series, Harley argued that little changed from 1740 to 1830, but after 1830 when steam ships became more common, there was a precipitous decline in real freight rates (see figure 1). Harley's series challenged those of previous scholars like North (1958) who suggested that transatlantic freight rates declined as much in the age of sail as the age of steam. Harley used a different freight rate series and price deflator. As is often the case in cliometrics, measurement matters.
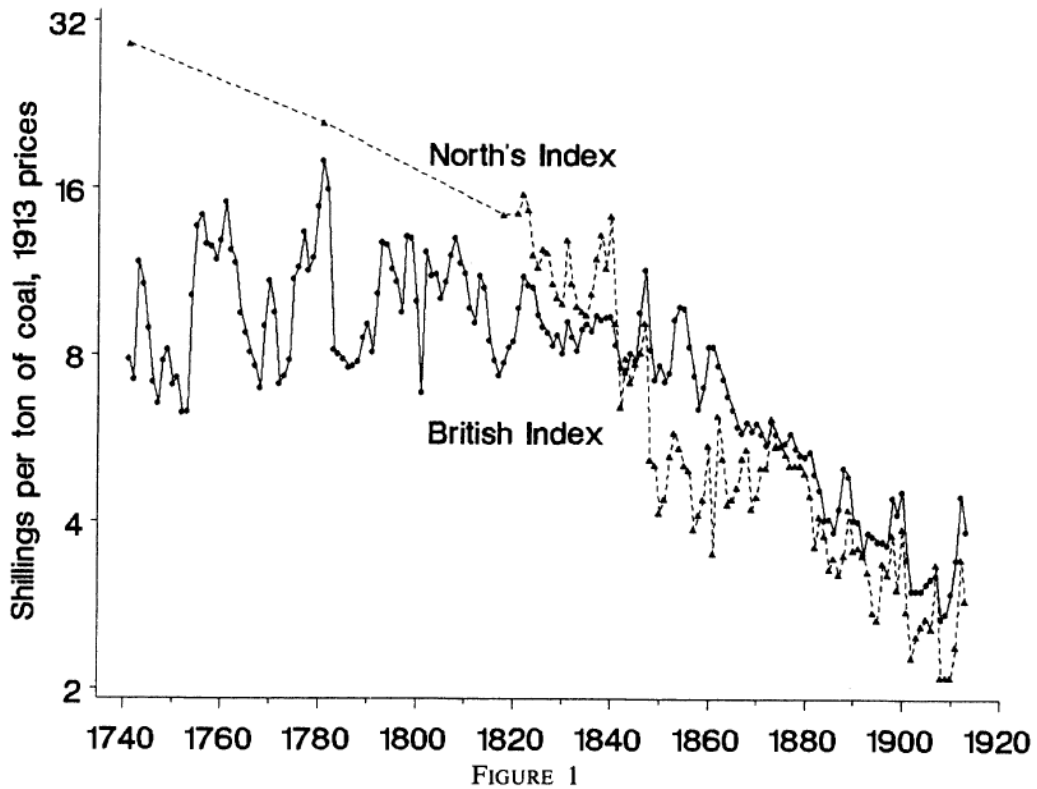
Figure 1: Two shipping Freight rate indices

FIGURE 1

FREIGHT RATE INDICES, 1741–1913
(deflated by U.K. GNP Deflator, Ratio Scale)

Source: Harley (1988).

While steam was clearly important, subsequent research has shown that Harley over-states stagnation in the age of sail. From the 1780s copper-sheathing protected wooden hulls from ship worm, significantly prolonging ships' lives and incidentally making ships faster and more maneuverable. This new technology reduced freight costs by about a third in the trade between Europe and Asia and led to a significant fall in mortality in the slave trade in the late 18th century (Solar 2013; Solar and Rönnbäck 2015). Menard (1991) and Shepherd and Walton

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(1972) show that freight rates in the transatlantic trade declined in real terms in the 17th and 18th centuries. In the case of the Chesapeake to London tobacco trade, real freight rates declined at an annual rate of 2.1% up to 1774. These authors attribute over 80% of the decline in freight rates to lower port times, and specifically better packaging.

It is striking that something seemingly simple, like packaging, could make a key contribution to the transport revolution. The emphasis on packaging relates to an important point about transport costs: the product being shipped matters. Tobacco, cotton, and sugar were amendable to packaging improvements in the pre-industrial world. Other products like coal were not. The combination of products was also important. In another article, Harley (2008) shows that 19th century freight rates on grain became very low between New York and Liverpool in part because grain was used as ballast on ships transporting live cattle. Ballast is necessary because it gives stability to the ship. Usually ballast is transported for free or at very low freight rates, because they enable the more valuable good to be shipped. The implication is that absent the live meat trade, and the need for ballast, freight rates on grain would have been much higher.

Overall, the case of shipping suggests that large-scale technological changes were moments of discontinuous productivity advances, but they were often equaled by many incremental changes. Arguably a similar statement applies to productivity growth more generally. In that sense transport is not different from manufacturing and some services.

2. Transport improvements, market integration, and trade

Greater market integration is one consequence of the transport revolution. Market integration relates to the co-movement of prices in different markets as defined in the law of one price. The law states that the price difference for a commodity in two markets should be smaller or equal to transport and transaction costs, the so-called no-arbitrage gap. If the price difference is greater than the gap, trade will occur (commodities will move from the low to the high price market) and the price differences will shrink to the gap. The so-called 'speed of adjustment' is the rate at which prices converge to the gap (Federico and Persson, 2006).

Perhaps the most striking evidence of integration is the 19th century wheat market. AS an illustration, Harley (1980) documents the difference in wheat prices between Britain and Chicago between 1850 and 1913 (see figure 2). The wheat price difference was high in the 1850s and 60s (around 50 cents a bushel). By the 1890s and through 1913 the price difference was negligible (around 5 cents a bushel). There was a large growth in trade between the US and the Britain accompanying the greater integration of wheat markets. In fact, global trade grew so much that historians have dubbed the late 19th century the first 'era of globalization.' Based on the wide diffusion of railroads and steam ships in the late 19th century, it would appear they were the main drivers of this market integration and international trade.

Figure 2: Wheat prices in Britain and Chicago, 1850-1913
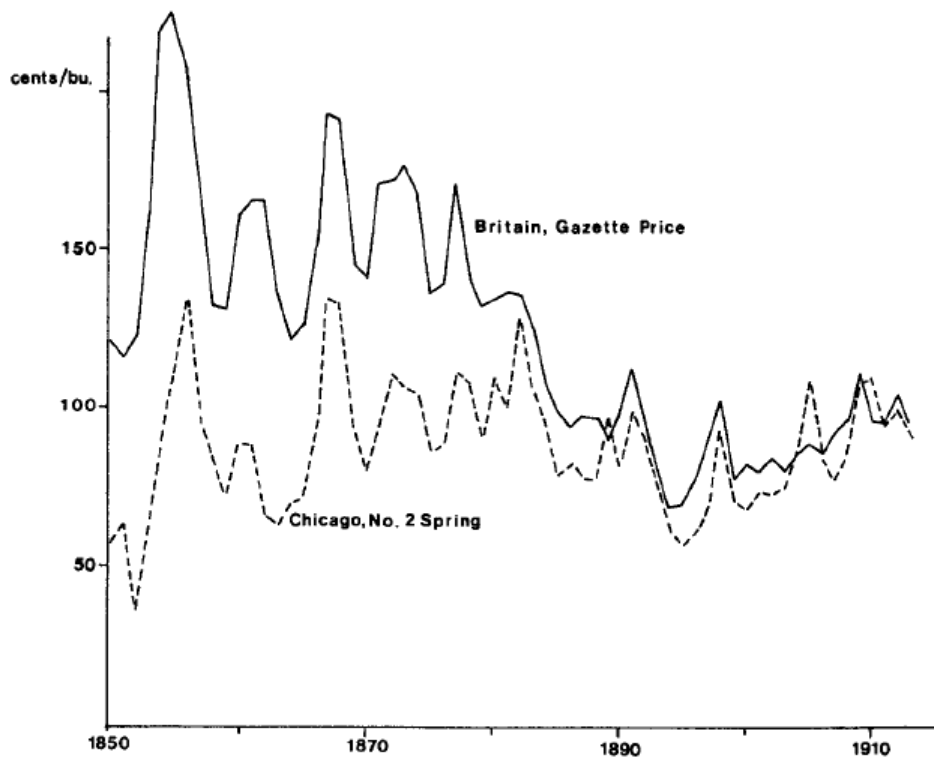
Source: Harley (1980).

But in cliometrics reasonable theories are not always supported by the data. Jacks (2006) provides evidence that railroads and canals were not the main drivers of integration. This important paper aims to quantify the contribution of various factors to market integration. It proposes an empirical model to explain integration in wheat markets. The model has variables for technological factors, like railroads and canals, and institutional variables, like tariffs and common monetary regimes. The main specification is the following:

$$\text{market integration}_{ijt} = \alpha \cdot \text{technology}_{ijt} + \beta \cdot \text{institutions}_{ijt} + \eta \cdot x_{ij} + \delta_t + \varepsilon_{ijt}$$

where market integration$_{ijt}$ is the estimated transaction costs or speed of adjustment between city pair i and j in year t, technology$_{ijt}$ and institutions$_{ijt}$ include the key explanatory variables. The remaining variables are controls including year fixed effects, distance, and common borders. Jack's finds a striking conclusion: institutional factors were more important in explaining the decline in price gaps. For example, having a railroad connection reduced the transaction cost by 0.02 standard deviations, while shared adherence to the gold standard reduced the transaction cost by 0.22 standard deviations. In short, institutional variables were the key driver of market integration during the late 19th century according to this model.

This essay will return to the topic of institutions later, but it is worth noting that other studies continue to argue that transport was an important driver of market integration and trade. For example, Pascali (2017) argues that the steamship had a major impact on global trade from 1850 to 1900. The introduction of the steamship led to an asymmetric change in trade costs among countries. Before this invention, trade costs depended on wind patterns, and some countries were favorably located. But wind patterns mattered much less after the steamship was introduced. Pascali uses this fact to identify large effects of steamships on trade. Donaldson (2018) reaches a similar conclusion for railways in colonial India using different data and a different identification strategy.

There is another study which also shows the importance of transport policies, but the effects are towards market disintegration. There is evidence for disintegration of markets in the inter-war period between 1920 and 1940. For example, Federico and Sharp (2013) show there was considerable disintegration of agricultural markets in the US. They argue that disintegration

was largely due to an increase in railroad freight rates. Why did that happen? According to Federico and Sharp, freight rates rose because of the 1920 Transportation Act and legislation that followed. There was a shift from a generally pro-competitive policy among US regulators to one in which railroad companies were subsidized through high regulated rates and were protected from competition by the emerging trucking sector. Matters were exacerbated by the price deflation occurring in the 1930s and the failure of regulators to lower rail rates as input prices fell. Arguably, it was the lobbying pressure of the railroad companies that kept the rates high. This case provides an excellent illustration of regulatory capture in transport. More generally, this study and the previous ones suggest that more research is needed to understand the complex relationship between transport, market integration, and trade.

3. **Transport improvements and income gains**

Dramatic reductions in transport costs have potentially large implications for incomes and living standards. Many historians in the early 20th century assumed transport improvements, like railroads, were indispensable to the growth in incomes during the 19th century. Several decades later some of the most famous cliometricians questioned whether this was true. Fogel (1964) and Fishlow (1965) approached this issue using the "social-savings" methodology. The social savings are approximated by the formula: $(P_w - P_r)*Q_r$, where P_w is the price of transport using the old technology, P_r is the price of transport with railroads, and Q_r is the quantity or ton-miles shipped by railroads. The social savings are meant to approximate the consumer surplus created by railroads at some benchmark date (see figure 3). The price P_r is

the marginal cost of delivering railroad services and P_w is the marginal cost of some alternative

technology like wagons. The marginal costs equal the prices charged under the assumption of

perfect competition in transport markets. The shaded region is the social savings, which is (P_w −

P_r)*Q_r after a correction for the elasticity of demand. Notice that a more elastic demand (i.e. a

smaller slope for curve D) implies a lower social savings. A similar methodology has been used

to calculate time savings from transport. Leunig (2006) provides one example for British

railways.

Figure 3: The social savings of railroads depicted as a measure of consumer surplus.
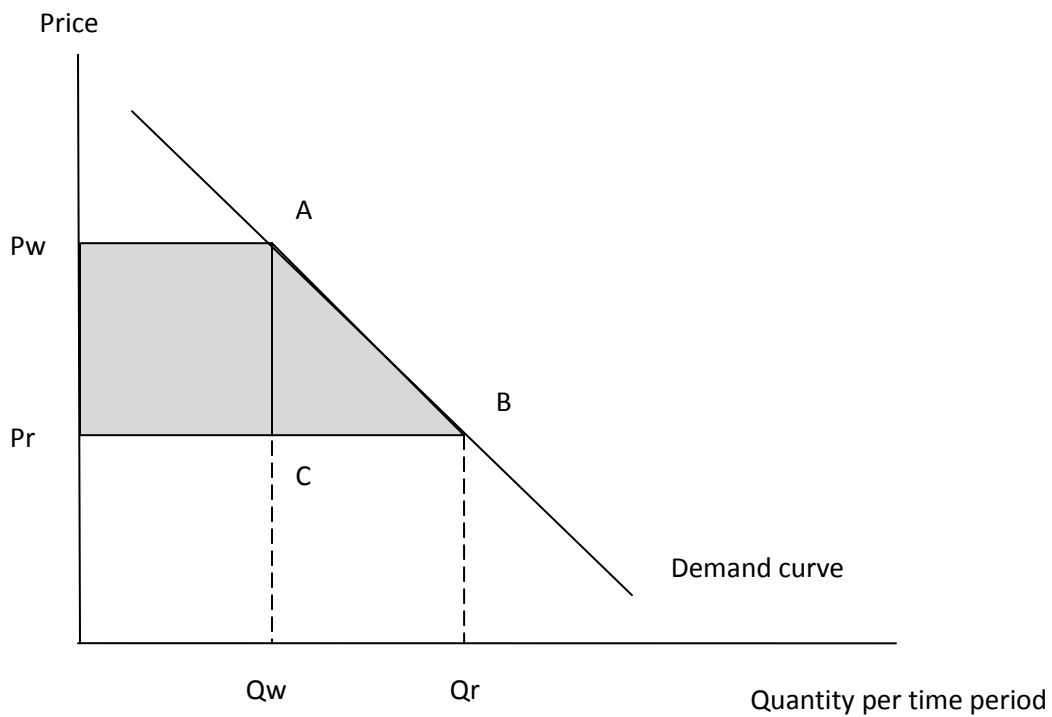
Source: Author's design.

The social savings from railroads are often compared with national income to assess the quantitative significance. Fogel and Fishlow estimated that national income in the United States would have been only 3 to 4% lower in 1860 or 1890 without railroads. In other words, railroads accounted for only a small portion of the income gains between 1840 and later decades. Many cliometricians have followed in their footsteps. For example, Summerhill (2005) and Herranz-Loncan (2014) provides a summary of social savings estimates for railways in Latin America. The savings equal about 25% of total GDP in Argentina, Mexico and Brazil by 1910-1913. These are huge effects, and much larger than the US. However, Herranz-Loncan (2014) finds that the social savings were less than 5% in Uruguay, Peru, and Columbia. In the case of Peru and Columbia, their railway networks were small, and their services were poor in quality.

The social savings methodology has some virtues. Ease of calculation is one. All that is needed are aggregate traffic volumes and estimates of average freight rates or speeds. For railroads, the social savings can be estimated in most economies by 1913 because national statistics are usually available by that date. This allows for cross-county comparisons of the gains from railroads and investigation of the factors that led to different impacts.

Nevertheless, the social savings methodology is controversial. Critics point to several problems (see McClelland 1972). First, it is not clear what the price of the alternative transport would have been in the absence of railways (P_w in the formula $(P_w - P_r)* Q_r$). Congestion would have likely increased on wagon roads and canals if it had to handle the traffic volume associated with railways. The cost of using alternative transport modes is arguably

underestimated as a result. Second, the social savings calculation omits backward and forward linkages. Railways increased demand for iron and steel as inputs and thus they fostered the development of these important industries. There are also changes in economic geography to consider. Lower transport costs can lead to agglomeration, which has positive effects on productivity.

Recently, cliometrics has used new data and methods to analyze the contribution of transport improvements to income. One good example is Atack and Margo (2011), who study the link between railroads and land values in the US. Land values are informative because most externalities, like agglomeration, should be reflected in land income as it is the fixed factor of production. Atack and Margo's railroad data is derived from digitized 19th century maps and census materials revealing farm outcomes like land area, land which has been improved, and values in dollars. They cleverly employ Geographic Information Software (GIS) to generate spatial variables of interest. Similar GIS data are also employed to study European railways (see Martí-Henneberg 2013).

Atack and Margo use a difference-in-differences estimator (DID) to measure the impact of the railroad. In this case, DID compares the change in farm outcomes between 1850 and 1860 in a treatment group of counties—identified as those getting railroads during the period—versus a control group that did not. Their estimating equation is similar to the following:

log land improved$_{it}$ = $\alpha \cdot$Railroad$_{it}$ + η_i + δ_t + ε_{it}

where the dependent variable is the natural log of acres of improved farmland in county i, η_i is a fixed effect for the county, δ_t is a fixed effect for the census year (1860), railroad$_{it}$ is an indicator equal to 1 if county i has a railroad in year t, and ε_{it} is the error term. Through the county fixed effects, this specification controls for unobservable factors that are specific to a county across time, and through the 1860 fixed effect it controls for factors specific to all counties in that decade relative to 1850. There is an issue, however, in that railroads were anticipated some years in advance. Farmers in counties that would get railroads may have started to improve their lands prior to railroad arrival. More generally, counties that would get railroads are likely to be different from other counties. For example, they could have a more skilled population and be more likely to develop even if railroads did not arrive. Thus, the assumption that the railroad indicator variable is 'as good as random' conditional on the fixed effects is questionable.

Atack and Margo address endogeneity using an instrumental variables (IV) strategy. The idea is to find a variable that predicts railroad access but does not affect land values in any way except through railroad access. Railroad plans from the early 1820s and 1830s are used to identify likely starting and endpoints for future railroads. The starting and end points are often places of economic or military significance. Atack and Margo then use GIS to create straight lines connecting the start and end points. Counties on this line have no special characteristics except that they are located on a favorable route for building a railroad between places of significance. They estimate a much larger effect of railroads on improved land using their IV strategy compared to ordinary least squares (OLS). They argue that railways were anticipated,

leading to a downward bias in the estimated treatment effect. The upshot is that Atack and

Margo create a new estimate for railroads' impact on agricultural improvement. Their

estimates imply that in the 1850s there was a 13.8% increase in improved farmland due to

gains in rail access, which is nearly all the increase in improved farmland during that decade.

Atack and Margo's findings imply that Fishlow's social savings estimate under-states the

contribution of railroads. Fishlow argued that railroads could account for only a small portion of

total economic growth between 1840 and 1860.

The DID approach to measuring the effects of transport improvements has received

some criticism. Recall that DID compares the change in outcomes in a treatment group of

counties—identified as those getting transport access—versus a control group that did not. But

one might argue that a rail "yes or no" classification does not incorporate network effects.

Spatial general equilibrium trade models suggest that a railroad linking a farmer to a major

market should have a greater effect than a railroad linking a farmer to a minor market. In the

former case, the farmer will get cheaper or better manufactured goods because the major

market has more competition and variety. Also, the farmer will get more land rent because it

can more easily sell in a market with high demand and hence high agricultural prices. In the

language of trade models, a railroad linking a farmer to a major market will provide greater

'market access.'

The baseline formulation of market access is the following: $MA_i = \Sigma_{j=1, \neq i}\ pop_j / tc_{ij}$, where

MA_i is the market access of location i, pop_j is the population of any other location j, and tc_{ij} is

the transport cost from i to j, and $\Sigma_{j=1, \neq i}$ is the sum over all other locations j except i. Notice that

market access is high when there are low transport costs to more populous locations (i.e. tc_{ij} is low and pop_j is high). This implies that getting close to a railroad line will have different effects depending on its connections. If the railroad creates lower transport costs to large centers, then market access will increase more than if the railroad creates lower transport costs to small or medium centers. It also implies that railroads can have effects on locations very far away through the network structure.

There are several works in the historical literature estimating market access. One of the most well-known is Donaldson and Hornbeck (2016). It is worth examining their approach because it reassesses the effects of railroads on American agricultural development. They build their analysis from a trade model. They derive an expression for equilibrium land rental rates, which are log-linear in one endogenous economic variable, market access, and several exogenous variables like fixed land productivity. This implies that with panel data one can estimate the equation:

$$\log \text{ land value}_{it} = \alpha \cdot MA_{it} + \eta_i + \delta_t + \varepsilon_{it}$$

where MA_{it} is market access of county i in year t, η_i and δ_t are fixed effects for the county and census year. Notice the similarity with Atack and Margo's model. The key difference is that Donaldson and Hornbeck use market access rather than the indicator variable for the county having any railroad. As they point out, one can include both variables in the same specification and compare their effects. Another feature worth noting is that endogeneity is less of a concern for market access variables compared to an indicator variable for having a railroad in a county.

Market access is largely determined by network structure, which in many contexts is driven by decisions beyond the county under consideration.

The measurement of market access is another innovation of Donaldson and Hornbeck's study. They calculate the lowest county-to-county freight rate for all combinations of county pairs (tc_{ij} in the market access formula). The calculation relies on three components. Each are worth commenting on. The first uses transportation cost parameters that apply to a given unit length of each transportation mode (railroad, waterway, and wagon). The transport cost parameters consist of freight rates per mile. These are often reported in the literature, but one might wonder about their accuracy. Stated freight rates could be based on a small number of observations or locations. Practically speaking, freight rates could be mis-measured, leading to biases in the estimates.

The second step in calculating market access uses a transportation network GIS database that maps where freight could move along each transportation mode. The GIS data are highly detailed and offer tremendous potential. However, there is an issue in geo-rectifying railroad and waterway maps, which are the under-lying data. As Atack (2013) shows the sources are not always consistent, and researcher choices need to be made. The third step involves the computation of lowest-cost freight routes along the network for given cost parameters. The computation comes from network analysis software. Computation time can be a problem if there are large numbers of counties and many transport modes, although this problem is quickly diminishing with better computing power.

In their analysis, Donaldson and Hornbeck find large effects of railroads on market access and on agricultural land values. Their counterfactual estimates imply that in the absence of railroads, agricultural land values would have decreased by 60% in 1890. In terms of income lost, their estimates imply that Gross National Product (GNP) would be 3.22% lower in 1890. Donaldson and Hornbeck's estimated impact is larger than Fogel (1964), who argued that without railroads the loss in agricultural land values would total 2.7% of GNP in 1890. While this may sound like a small difference, consider that the loss of *all* agricultural land income could at most lower US GNP by 5.35% in 1890. Therefore, the impact of railroads is capped at 5.35% of GNP in the approach focusing on agricultural land. Future research may shed light on the urban land values or capital and labor income. Perhaps the main lesson is that the 'market-access' approach offers new insights and is a useful tool for evaluating the effects of transport improvements on income.

4.   Transport improvements and external effects

There is a large historical literature examining what can be termed 'external' effects of transport improvements. It considers the effects of using new transportation services on changing residence from a rural to urban area, on participating in new trade, or exposure to pollution to name a few. Several interesting papers examine external effects and are worth discussing in some detail.

Greater urbanization was a feature of many advanced economies in the 19th and 20th century. Urbanization was associated with increased consumption opportunities and is considered a good measure of living standards. Urbanization also had effects on productivity through agglomeration. In theory, as more people locate and work in urban areas, the productivity of the average worker increases, leading to higher incomes. There are compelling reasons to think that transport improvements increased the concentration of economic activity for most economies up to the mid-20th century. In economic geography models with increasing returns, agglomeration forces are stronger when transport costs change from high to intermediate (Krugman and Venables 1995). In the intermediate range, food is shipped more cheaply, consumers spend more on manufactured goods, which are more productively made in a single location, and workers tend to locate in a single location. The implication is that with better transport innovations, like the railroad, urbanization should have increased.

Several papers examine the effects of transport improvements on urbanization. One example is Hornung (2015), who studies railroads and urbanization in Prussia. In Prussia, urbanization increased significantly between 1841 and 1871. This was quite early by international standards. The other cases of early urbanization were Great Britain and the Netherlands. Prussia was also an early adopter of railroads. Most up to 1850 were built between large cities. This feature was likely due to most early railroad projects being privately owned, financed, and operated. After 1850 the Prussia government began to subsidize railroad construction and the network extended. The reasons for Prussian government involvement are complex. National defense was one key factor.

What were the effects of railroads on Prussian urbanization? Hornung studies many cities and employs various specifications to answer this question. One specification involves a panel regression of log city-population on an indicator for having railroad access. Endogeneity is addressed using straight lines which connect important cities through the railroad network. Hornung's instrument is very similar to the one used by Atack and Margo (2011). The rationale is that lines were mostly built linearly due to high construction costs. Consequently, ordinary cities located on a direct line between important cities gained access to the railroad more by chance. In contrast, cities whose location deviated from the straight line could gain access only for reasons potentially endogenous to the city's growth. Hornung's conclusion is that gaining railroad access increased a Prussian city's population by approximately 15% after 15 years.

Did railroads have a similar effect on urbanization elsewhere? Berger and Enflo (2017) study a similar issue in 19th century Sweden. They found that early railroad access increased city population by 25 to 30% over several decades. Interestingly, the specifications and data in these two studies on Prussia and Sweden are quite similar, yet the estimated effects of railroads are different. As one reads through several papers of this kind, it becomes clear that the effects of railroads generally differ. A better understanding of heterogeneity is a subject that deserves greater attention in future research.

Another outstanding issue in this area concerns 'reorganization' effects, where transport improvements increase population in one area at the expense of lowering it elsewhere. The suburbanization process in the United States during the mid-20th century provides a good example of reorganization. Baum-Snow (2007) shows that the aggregate

population of US central cities declined by 17% between 1950 and 1990, despite population

growth of 72% in metropolitan areas as a whole. Why did this happen? At this time the US

Federal Government funded a massive highway expansion, known as the inter-state highway

program. The 1956 Interstate Highway Act committed the federal government to pay 90% of

the cost of construction for the 41,000-mile highway system. The rest was financed by state and

local governments. National defense is one of the main reasons the US Federal Government

increased its contribution. Many interstate highways passed through the central business

districts (CBDs) of major cities. In 1956, the CBDs were densely populated in part due to the

construction of railroads a century earlier. As highways passed through the CBD, they made it

easier for households to live at the edge of the city and to commute to the CBD for work. Baum-

Snow estimates that one new highway passing through a central city area reduced its

population by 18%. A counterfactual estimate implies that central city population would have

grown by about 8% had the interstate highway system not been built. These estimates imply

large effects of highways on population reorganization. Similar impacts have been found in

Europe. For example, Garcia-López, et al (2015 find that each highway caused an 8 to 9%

decline in central city population between 1960 and 2011.

The Baum-Snow analysis takes other factors into account, namely the effects of income

levels and inequality on suburbanization. The estimates suggest that greater income reduces

central city population, which makes sense because households want to buy more housing

space with higher income and space is cheaper in the suburbs. Baum-Snow also finds that

greater income inequality reduced central city population. This would make sense if rich

households wanted to isolate themselves from poor households leading to large differences in schooling and other amenities.

Building on these results, one might wonder how reorganizing the population in space affects welfare. On the one hand, if transport innovations led to more racial segregation, as in the US case, there might be negative welfare consequences. It could also lead to dispersion in production, reducing agglomeration benefits. On the other hand, moving population to suburban areas allowed more housing consumption which is clearly desired by many families. Not surprisingly, the welfare effects are quite complicated and depend on a range of pecuniary and non-pecuniary externalities.

There is a growing interest in the negative externalities associated with transport. Pollution is one of the largest concerns in the 21st century and many of the emissions come from transportation vehicles (Winston 2013). The historical literature has begun to examine this issue. Britain was perhaps the most polluted economy before World War I. Significant amounts of coal were burned for home, industrial and transportation activities. Were the amounts significant enough to cause poor health? This is a difficult question to answer because air pollutants were not measured before the 20th century. However, innovative research by Beach and Hanlon (2016) infers pollution using local industrial structure and coal usage by industry in Britain during the 19th century. They estimate that a one standard deviation increase in coal use raised infant mortality by 6 to 8%. As it turns out, transport was not the main consumer of coal in mid-19th century Britain. It was the home and manufacturing sectors. This would suggest that railroads were not a direct driver of pollution related health problems in this setting.

This conclusion may not hold elsewhere however. Tang (2017) focuses directly on the negative health effects of railroads in the late 19th century. An example provides an illustration. In 1886, a cholera epidemic swept through Japan and killed 108,405 people, accounting for 1 out of 9 deaths that year. Strikingly, prefectures with railroad access in 1886 had a higher incidence of mortality, 336 deaths per 100,000, compared to the 245 deaths in prefectures without rail access. Many factors could potentially explain the railroad-mortality connection, but Tang is able to isolate the effects of railroads using matching and DID regression models. The specification has similarities to studies examining the effects of railroads on land values.

$$\text{mortality rate}_{it} = \alpha \cdot \text{Railroad}_{it} + \eta_i + \delta_t + \varepsilon_{it}$$

where the dependent variable is deaths per 100,000 people in prefecture i in year t, Railroad$_{it}$ is an indicator for prefecture i having a rail connection in year t, and the remaining variables are fixed effects. Tang estimates that rail access accounts for a 5.5% increase in mortality between 1884 and 1893. Moreover, rail-associated mortality represents about 66% of the total increase in mortality pre and post adoption of railroads. He also uses official causes of death to show that 75% of rail-associated deaths were due to communicable diseases, like tuberculosis and influenza. The implications of this finding are large. One of the benefits of transport improvements is to increase urbanization and productivity. In fact, in another paper (2014), Tang demonstrates that railroads contributed to industrialization in Japan. But as Tang (2017) shows, in some circumstances greater communication can also lead to disease transmission and higher mortality. The field of cliometrics needs more research on the negative health consequences of transport, as they loom large in the 21st century.

5. Persistence and long-run impacts of transport

Most of the analysis thus far has focused on the short-run effects of transport improvements. For example, the contribution of railways to increasing land values and urbanization in the 19th century. But there are theoretical reasons to argue that the impact of railroads and other transport innovations matter over the long-run. The channel is through persistence of locational choices. If a population settles in an area because of some natural or human-made advantage in the past, then the population may become 'locked-in' for the future. Lock-in could persist even as the original natural or human advantage which determined the settlement becomes largely irrelevant.

Transportation advantages are one of the main factors identified in the persistence literature. Bleakley and Lin (2012) provide one of the classic studies on persistence and the role of transport in creating lock-in. They focus on portage sites in the US during the early 1800s. Much overland transport went by lakes and rivers at this time. There were some sections of rivers that were not navigable, which meant that traders had to stop and carry their products and canoes along the river until navigation could resume. At portage sites commercial services were provided. Thus, population density tended to be higher at portage sites. Transportation options in the US clearly changed during the 19th and 20th centuries making river transportation far less important. One might imagine that early portage sites would gradually lose population to locations which had other advantages. Bleakley and Lin show this did not happen. They analyze the following model

$$\text{Log(population in 2000}_i) = \alpha \cdot \text{portage site}_i + \beta \cdot x_i + \varepsilon_i$$

where $\text{Log(population in 2000}_i)$ is the log of 2000 population in a geographic unit like a county or census tract, portage site_i is an indicator for whether the unit was a portage site in the early 19th century, and x_i is a set of city-level controls. Note that portage is defined as a fall line or river intersection. The use of the geographic variables to identify portage makes this specification akin to a reduced form regression, in which endogeneity is not a concern. Bleakley and Lin estimate that portage units have 90 logs points higher population density in 2000. That is equivalent to 145% increase in population density. One might think that portage sites were about 145% larger in the 19th century when portage was most valuable. However, this is not true. Nearly half of the population advantage of portage sites emerged between 1900 and 2000, which is long after canoes became a hobby vessel.

There are other papers which document persistence in outcomes associated with early transport investment. Jedwab and Moradi (2016) study colonial railroads in Ghana, where the British built railroads linking the coast to sparsely populated mining areas and the hinterland. Using a data set on cities, they look at the effects railroads had on the distribution of population from 1891 to 2000. Jedwab and Moradi first establish the importance of railways for initial urban location. They estimate the following model:

$$\text{Urban population in 1931}_i = \alpha \cdot \text{Railroad in 1918}_i + \beta \cdot x_i + \varepsilon_i$$

where 1931 urban population in a location is regressed on indicators for having rail access in 1918 plus controls x_i. Instruments are introduced to address endogeneity for railroads and are

ignored for the present discussion. Jedwab and Moradi estimate that the urban population in

1931 was significantly higher if the location had a railroad in 1918. They argue that the

decrease in internal trade costs encouraged the local cultivation of cocoa, which became a

leading export in Ghana. Rural populations increased along the lines as cocoa cultivation

required more labor in cocoa-producing villages. Urban populations then increased because

villages used the towns as trading stations.

After the 1970s rail transport in Ghana was far less important. Railroad tracks were not

maintained, and road transport increased. Did this mean that areas close to railroads lost

population? The answer is no. Jedwab and Moradi estimate a second set of regressions.

$$\text{Urban population in 2000}_i = \alpha \cdot \text{Railroad in 1918}_i + \beta \cdot x_i + \varepsilon_i$$

$$\text{Urban population in 2000}_i = \alpha \cdot \text{Railroad in 1918}_i + \eta \cdot \text{Urban population in 1931}_i + \beta \cdot x_i + \varepsilon_i$$

The first regression identifies whether railroads in 1918 affected urban population in 2000. This

would represent a persistent effect because railroads had lost their original significance in

transport. The second equation examines whether railroads' effect runs through the urban

population in 1931, a lagged dependent variable. Jedwab and Moradi show that railroads in

1918 had a strong effect on 2000 population, but the coefficient on the rail indicator is small

once the urban population in 1931 is included in the specification. In other words, the spatial

equilibrium became stable after railroads were built. Subsequent transportation technologies

(i.e. trucks) did not relocate population from near railroads. The Ghanan case is quite striking

because the end of colonialism represented a large economic and political change, but it was not sufficient to wipe out the persistent effects of railroads.

How are these persistence patterns understood? Bleakley and Lin (2012) propose a simple model where an individual's utility is a function of the population density at their location. Two factors affect the utility according to density. One is the strength of congestion. Congestion increases with density and lowers the utility of the individual. The second is the strength of agglomeration. Agglomeration increases with density and raises the utility through greater productivity. Natural advantages, like portage sites, are another factor in the model. They increase the utility of locating in one place versus another. Thus, natural advantages can be crucial at some point in time, leading to a density in one location. If the natural advantage disappears, say because of general technological progress, then an individual might leave a location because it is congested. However, when the agglomeration forces are strong it may be optimal to stay. Is the strength of agglomeration sufficiently powerful to lock-in locations? While compelling, there are cases like post-war Japan where cities were wiped out by bombs and yet they came back to their original size (Davis and Weinstein 2002). If agglomeration was strong then these cities should not have remerged. No doubt, the issue of lock-in is far from settled.

6. **Institutions and transport development**

Much of the existing literature on transport analyzes its effects on income and development. But there is a broader question one could ask. What makes some societies effective in delivering transport services? This is closely related to the broader question of what makes some societies rich and others poor. One popular view is that institutions are a fundamental cause of economic development. Institutions are the humanly devised constraints that structure political, economic and social interaction. In their formal sense, institutions are constitutions and legal systems, but less formally they include norms and beliefs. As originally emphasized by North (1991), institutions matter because they affect transaction costs and hence incentives to invest and innovate. Extending this logic to transport, one might imagine that institutions affect transport infrastructure investment. Here there are large fixed costs, raising the risk of expropriations or misallocation.

In the literature, there is some evidence that transport infrastructure became more developed in countries with stronger democratic institutions and with greater state capacity. A comparison of England and France in the 18th century provides one illustration. In England, road infrastructure was provided through a mixture of local initiative and parliamentary oversight. Local groups submitted petitions requesting the right to form a 'turnpike-trust' and improve a stretch of road in their area. Parliament usually granted these requests and named the petitioners as trustees with the authority to levy tolls and improve the road. Parliament set the maximum tolls and gave local officials powers to settle disputes between property owners and trustees. Turnpikes were established on all highways linking London with major provincial cities (Bogart 2005). France had a different approach to their highways. The crown designated

some highways as primary roads (royal routes) and others as secondary roads. The primary

roads received some funding from the central government in Paris and were constructed and

maintained by the Ponts-et-Chaussees, an elite engineering school. Secondary roads were

maintained by French communes, generally through the use of corvee labor.

How did these different paths affect the size and efficiency of road networks in England

and France? The data suggest that England had more km of paved roads per capita than

France. England also had faster travel speeds (Szostak 1991). One reason is that English

political institutions placed significant limits on the ability of parliament or the crown to

arbitrarily change tolls or to substantially reduce the rights of turnpike trusts. This high degree

of regulatory commitment encouraged trustees and private groups to make investments in the

road because they expected that parliament would uphold their rights (Bogart 2011). It is

unlikely the French crown could make such commitments, and thus private investors would

have hesitated in making such investments. A second reason is that the English parliament

devised mechanisms for compensating landowners when their land was taken. Parliament

empowered juries who had local knowledge. They also gave county Justices of the Peace

powers to oversee juries in case they were too generous to landowners. Thus, local knowledge

was combined with checks and balances. France had no such system before the French

Revolution and it struggled to overcome local resistance (Rosenthal 2009).

France further developed its road network after the French Revolution. The central

government increased its funding of national routes. There was also substantial change in the

funding and organization of secondary roads. A French law of 1836 gave communes the right

to levy 5 percent surtax from the four main direct taxes in their jurisdiction. It also allowed

departmental councils to impose financial contributions on communes located along roads of

regional importance (Price 2017). The changes following the French Revolution provide further

testimony to the importance of institutions.

The financing of railways also illustrates the importance of institutions. Railway

construction often required financial support from governments. However, many relied on tax

revenues collected from trade, which often depended on railways. Bignon, Esteves, and

Herranz-Loncan (2015) argue there was a two-way feedback between government revenues

and railways, with a potential for multiple equilibria. In other words, countries could end up in a

'poverty-trap' with few railways and little revenue.

Bignon *et. al.* develop their argument for Latin America. They document that railway

and fiscal development were low in some Latin American countries, like Columbia and Ecuador,

and high in others, like Argentina and Uruguay. They propose a system of equations to account

for the co-evolution between railways and tax revenues. A discussion of their model is useful

because it speaks to dynamic effects. The first system models government revenues as a

function of trade.

government revenues$_{it}$ = $\alpha \cdot$trade$_{it}$ +$\beta \cdot$x$_{it}$ +η_i + d$_t$ + ε_{it}

where government revenues$_{it}$ is the log of tax revenue of country i in year t, trade$_{it}$ is the log

value of trade, x$_{it}$ is a vector of controls and the rest are country and year fixed effects. The

variable trade$_{it}$ is endogenous and Bignon *et. al.* use railways to instrument for trade. The effect

of railways on trade is plausible, but do railways affect government revenues in other ways?

The authors argue they do not because no taxes were directly levied on railways. There could

be indirect effects of railroads, which violates the exclusion restriction for an instrumental

variable. Nevertheless, some assumption is needed to identify the effect of trade and railways

are a plausible instrument.

The second equation in their model specifies the target size of the rail network

measured in the natural log of rail track miles. The equation is:

$$\text{rail*}_{it} = b \cdot \text{government revenues}_{it} + c \cdot x_{it} + \eta_i + d_t + \mu_{it}$$

where rail*_{it}, the target network size, is a function of government revenue, control variables

specific to the country, and fixed effects. Bignon *et. al.* argue for a dynamic equation to

describe rail development because the target is never achieved in any period. The growth of

the rail network from t-1 to t is the difference between the target and the reality in the

previous period.

$$(\text{rail}_{it} - \text{rail}_{it-1}) = \delta(\text{rail*}_{it-1} - \text{rail}_{it-1})$$

In the last step, they substitute the target rail network rail*_{it} into the dynamic equation to get

the following specification.

$$(\text{rail}_{it} - \text{rail}_{it-1}) = \delta \cdot \text{rail}_{it-1} + \delta \cdot b \cdot \text{govt. revenues}_{it-1} + \delta \cdot c \cdot x_{it-1} + \delta \cdot \eta_i + \delta \cdot d_{t-1} + \delta \cdot \mu_{it-1}$$

Their aim in this equation is to estimate the effect of government revenue and lagged rail

network size on the growth of rail networks. With these two estimates they can recover the

structural parameter b. Importantly, government revenue is endogenous according to their

framework. They instrument for revenues with each country's total level of diplomatic

representation abroad and an index of legislative effectiveness. Here the authors feature the

role of institutions explicitly. Legislative effectiveness is a measure of institutional quality, which

arguably leads to more taxation. This assumption is supported by much research on state

capacity (e.g. Dincecco 2015).

Bignon *et. al.'s* estimation yields insightful results (Figure 4). They find evidence for a

two-way feedback between railways and government revenues. Their estimates are shown in

the following graph for the average Latin American country. More railway mileage is estimated

to increase government revenue (the solid line). Also more tax revenues are estimated to

increase railway mileage (the dotted line). The equilibrium is reached where these two lines

intersect. Notably for history, the equilibrium can change if there is an exogenous shock to

either railways or tax revenues. For example, suppose legislative effectiveness improves due to

political changes in a country. This would lead to more revenues and more rail infrastructure

(imagine the solid line shifting up). More generally, this analysis illustrates how better

institutions can help countries escape a poverty trap through more transport infrastructure.

Figure 4: Estimated relationship between tax revenues and railway miles in Latin America
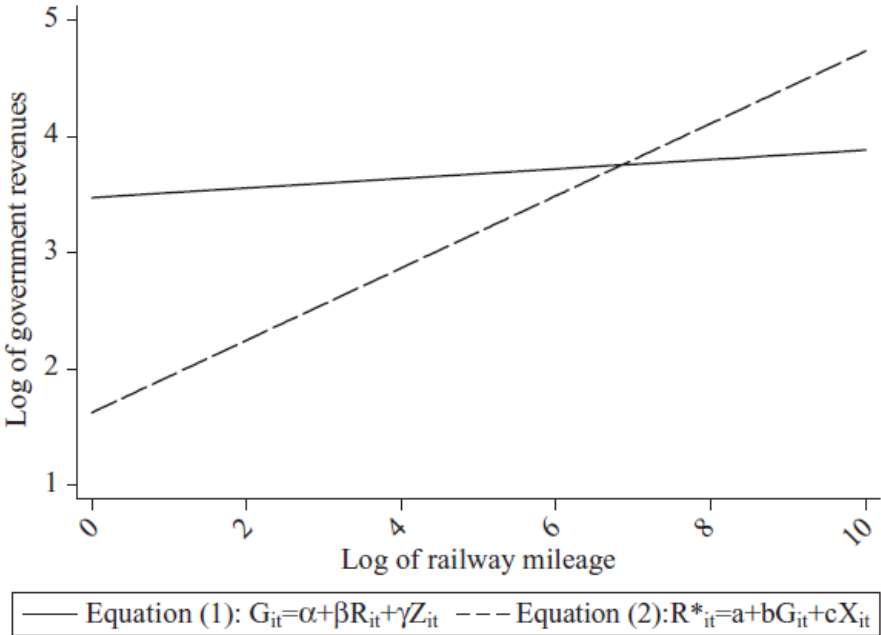
Source Bignon, Esteves, and Herranz-Loncan (2015)

7. Public and private sector involvement

Historically both the public and private sectors have been deeply involved in the transport sector. Various scholars have tried to explain the duality (see Newberry 2002, Milward 2005). One view sees some level of public provision as necessary because the private sector would fail to provide the efficient quantity of transport services. One reason is the natural monopoly features of transport. Very large fixed costs, like building a port or railroad, imply that total costs are minimized if there is one supplier in the market. But the one supplier can charge monopoly prices, which is inefficient. A government owner of transport would not

necessarily charge the monopoly price however, because governments generally consider more than just profits when making decisions. There is an alternative view that private provision is generally preferred because of government 'failure.' Interest groups are a potent source of such failure because they can appeal to various layers of government to support socially undesirable infrastructure projects or to kill desirable policy reforms (Winston 2013). Ultimately it is an empirical question whether public or private provision has been beneficial or not.

Railway history provides insights on where the boundary between public and private was drawn. Interestingly, most railways built between 1830 and 1880 were owned by private companies. Afterwards there was a trend to more government ownership. In some cases, governments started to build railways and in other cases nationalizations placed large railway assets in public hands.

There are various reasons why railway nationalizations occurred in some countries and not others before 1913. For the sake of brevity and continuity with the previous section, this essay focuses on political and legal factors. In theory, limited government, embodied by strong constraints on the executive, should work against nationalizations. Constraints made it harder for the government to expropriate private property like railroad tracks and rolling stock. Common law legal systems had a similar effect in theory (see La Porta et. al. 2008). In common law countries, courts have traditionally required that expropriations satisfy a "public use" and that owners receive "just compensation." The public use requirement might have made it difficult for public officials to nationalize railroads because they had to explain why government ownership satisfied a public benefit. Moreover, the just compensation clause might have

prevented governments from imposing a low price on companies. In civil law countries, railroad

companies could also appeal to courts, but they may not have been as effective if governments

could intervene and ensure that decisions went in their favor.

Bogart (2009) provides evidence on the role of institutional factors in explaining the

likelihood or extent of nationalizations across countries between 1870 and 1913. The author

creates panel data on the incidence and extent of nationalizations across more than 1200

country-year pairs. This is combined with other cross-country data, including constraints on the

executive branch of government, the degree of democracy, legal origin, and a host of other

variables. Cross-country estimates for 1910 reveal that the incidence of nationalizations (i.e.

exceeding a minimum threshold of nationalized rail mileage) was more likely in countries with

French and German civil law legal systems compared to common law legal systems and

Scandinavian civil law legal systems. Nationalization was also more likely in countries with

weak constraints on the executive branch or with less democracy.

The Swiss case provides some insights on why legal systems mattered for railway

nationalizations (see Bogart 2009). Up to 1890 most of the railways in Switzerland were built

and owned by French companies. The original concessions created a special board of

arbitrators, who would settle disagreements between the French companies and the Swiss

Federal government in the event of a proposed nationalization. The arbitrators were separate

from the Swiss federal court system, and they presumably provided some assurance to French

companies that government policy decisions would be made without political interference. By

the 1890s, foreign ownership of railways became generally unpopular in Switzerland. But there

were public concerns that a government takeover of railways would be quite costly to the Swiss taxpayer because French investors would demand high compensation. In 1896, one year before a major Swiss railway nationalization law was passed, the Federal Council and Assembly passed a law nullifying the authority of arbitrators and requiring that disputes over railways be settled in federal courts. The close timing of the arbitrator law and nationalization suggests they were connected. This example illustrates how government intervention and legal systems interact.

What impact did nationalizations have on the railway sector? Bogart (2010) examines the efficiency of railway operation. In other words, the money an economy spent supplying x ton miles and y passenger miles given wage and fuel prices and stocks of railway capital. The cross-country evidence suggests that the average nationalization lowered the cost efficiency of railway systems. However, there are also some economies where railway nationalizations increased cost efficiency. Colonial India is one interesting example. The initial construction and management of the Indian rail network was done by private British companies operating with a public guarantee. If net earnings (i.e., gross earnings minus working expenses) as a proportion of capital outlay yielded less than the guaranteed return of 5% in any year, the colonial government in India compensated the company with the difference. The guarantees proved costly to the colonial government. Years later it decided to nationalize all formerly private railway lines and become the majority owner. By 1910 the government had nationalized all the private railway companies that built the main trunk lines up to 1880.

Importantly, railway companies in India were nationalized on the 25th or 50th year of their original contract. This fact is useful because the timing of nationalization was determined

by the date of the original concession contract and other exogenous events many decades earlier. Bogart and Chaudhary (2012) exploit this fact when they analyze the effects of Indian railway nationalizations on working expenses (i.e. variable costs). They construct a panel dataset on inputs, outputs and costs for the primary standard and metre gauge railway systems between 1874 and 1912. Regression analysis shows that working expenses were 13% lower on average following a change to colonial government ownership. The cost declines are not driven by firms anticipating takeovers, poor quality, changes in reporting standards, or long run trends. Rather, the evidence suggests the government reduced operational costs by cutting labor costs. These results are surprising given that nationalizations generally raise costs. Bogart and Chaudhary suggest that the colonial government in India had unique incentives to operate railways well. It had weak fiscal capacity and railways were one of the few industries it could tax effectively, provided it had majority ownership. This case points to the value of detailed studies on institutions, which are often missed in the cross-country analysis.

8. Conclusions

In summary, cliometrics has made major advances in the historical analysis of transportation through better measurement, economic modelling, and estimation. This essay surveys several topics and innovative research studies. There are several general conclusions. First, there were revolutionary changes in transport over the last 300 years generating high rates of productivity growth. Macro-inventions, like steam power, were important but many incremental innovations mattered too. Second, there is evidence that transport improvements contributed to greater market integration, urbanization, and aggregate income. There is also

evidence that transport improvements influenced population density long after their original function became obsolete. But there is still disagreement in the literature about the relative importance of transport and there are also some studies which argue that transport improvements contributed to higher mortality. Teasing out the positive and negative effects of transport improvements on welfare is likely to remain an important area of research. Third, institutions were a fundamental factor in determining why transport services were more efficient in some economies. There is evidence that institutions influenced investment in transport networks and the degree of public and private ownership. There is also evidence that ownership mattered for transport efficiency, and in some cases, government ownership improved outcomes. Overall, cliometric research on transport offers many insights on this historically important sector.

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