INTERNATIONAL ECONOMIC REVIEW
Vol. 53, No. 3, August 2012

THE ROLE OF TRANSPORTATION IN U.S. ECONOMIC DEVELOPMENT: 1840–1860*

BY BERTHOLD HERRENDORF, JAMES A. SCHMITZ, JR., AND ARILTON TEIXEIRA[1]

Arizona State University, U.S.A.; Federal Reserve Bank of Minneapolis, U.S.A.; Fucape, Brazil

We return to two questions concerning the 19th century U.S. transportation revolution. First, to what extent were transportation improvements responsible for the large changes in the regional distribution of population in the United States and, within regions, for the changes in industry structure? Second, how important were transportation improvements for welfare gains? We find that transport improvements were the key factor driving where people lived and what industry they worked in. We also find that transport improvements were important for welfare gains: Gains over 1840–1860 would have been only half as large if there had been no transportation improvements.

1. INTRODUCTION

It is hard to exaggerate the improvements in 19th century U.S. inland transportation. At the start of the century, inland transportation of goods was limited to wagons and boats (on rivers and lakes). And if goods were moved upriver, the boats were typically pulled. Within two decades, steamboats were being used on rivers, so upriver and downriver rates were now much closer. Next came canals, offering a new possibility to carry goods. And finally, railroads were developed, a mode that came to dominate much of the industry.

It is not surprising that these events have been called a transportation revolution, and that economic historians have devoted considerable effort to study this revolution's impact on U.S. economic development. One big issue of study has been the extent to which transportation improvements were responsible for the large changes in the distribution of population in the United States (as the country moved westward, and which we will call the "settlement of the Midwest") and, within regions, for the changes in industry structure (as, for example, the Northeast shifted from agriculture to manufacturing, and which we will call the "structural transformation of the Northeast"). Most historians, notably North (1965), have argued that transportation improvements drove these changes.[2] But note that there are other competing hypotheses for population movements, like the safety-valve hypothesis of Turner (see discussion below).

Another issue has been assessing the welfare impact of transport improvements. Notable here is the work of Fogel (1979) estimating the welfare loss if the United States had not developed

*Manuscript received September 2009; revised April 2011.

[1] We thank two referees whose detailed comments led to a significantly improved article. We also thank Richard Rogerson for many suggestions, Guillaume Vandenbroucke for sharing some of his data with us, and Sanghoon Lee for excellent research assistance. We have received helpful comments from Yan Bai, Francesco Caselli, Pedro Cavalcanti, Roozbeh Hosseini, Belén Jerez, Alexander Monge, Edward Prescott, Ákos Valentinyi, and the audiences at ASU, the 2007 Development Conference at Pittsburgh, Illinois, the 2007 ITAM Summer Camp in Macro, the 2008 NBER Conference on Time and Space in Philadelphia, Penn State, the 2006 and 2008 SED Conferences, Toronto, and UBC. The views expressed herein are those of the authors and not necessarily those of the Federal Reserve Bank of Minneapolis or the Federal Reserve System. Please address correspondence to: Berthold Herrendorf, Department of Economics, Arizona State University, W.P Carey School of Business, 350 East Lemon Street, Tempe, AZ 85287-3806. Phone: (480) 965-1462. Fax: (480) 965-0748. E-mail: *berthold.herrendorf@asu.edu*.

[2] North starts his paper with the sentence, "The timing and pace of the development of North America was basically influenced by transportation and the way in which transportation systems developed."

railroads in the 19th century but rather employed the other available transportation modes (like steamboats, canals, and so on). Fogel argued that not having railroads, and instead having to rely on canals, rivers, and so on, would have raised transportation costs on the order of around 5% of GDP.

We return to both of these issues in this article. We examine these issues over the period 1840–1860. Below, we describe why we limit ourselves to this period. Our analysis differs in two respects from the literature. First, we use different tools or methods to address the issues. In particular, we develop a simple quantitative general equilibrium model. Second, we ask some different questions. In particular, in assessing welfare gains, we ask: "What were the welfare gains of the *combined* transportation improvements (including new canals, railroads, etc.) over 1840–1860?" By contrast, Fogel's counterfactual (in our period 1840–1860) was: "What would the welfare losses have been if the United States had employed all the transport improvements over 1840–1860 *except* railroads?"

Before discussing our results, let us briefly describe our model. The model has two regions: the Midwest and the Northeast. It has three goods: agriculture and manufacturing, which are traded across regions, and services, which is not. Our model has three other key features. First, the Midwest has a comparative advantage in agriculture and the Northeast a comparative advantage in manufacturing, reflecting that farmland is much more fertile in the Midwest than in the Northeast. Hence, there is a motive for interregional trade. However, transportation between the two regions is costly. Second, people are ex ante identical and choose in which region to locate and in which sector (i.e., agriculture, manufacturing, and services) to work. We assume for simplicity that there is no cost of moving between regions. In equilibrium, the utilities of households in different regions are equalized, though incomes will differ across regions (since prices do). Third, preferences are nonhomothetic such that the income elasticity of agricultural goods is smaller than one and the income elasticity of nonagricultural goods is larger than one. As in Kongsamut et al. (2001), this leads to structural transformation when GDP grows.

We restrict our model to be consistent with key facts from 1840, such as large transportation costs between regions and large agricultural productivity differences between regions. We then ask how well the model matches key U.S. time series statistics over 1840–1860. We do this by feeding into the model *four* of the key changes over this period: large gains in transport productivity, large gains in nontransport productivity (i.e., in manufacturing, agriculture, and services), large increases in population, and large increases in (improved) farmland. We show that the time series produced by the model matches well the settlement of the Midwest (the Midwest share of population grew from 31% to 43% over these two decades) and the structural transformation in the Northeast (where the share of agriculture in the labor force went from 54% to 33% over the same period). That the model does a good job matching key U.S. statistics over 1840–1860 gives us confidence in using the model to perform counterfactuals regarding the impact of the transportation revolution.

Turning to our results, we first return to the issues studied by North and use the model to examine what forces were behind the settlement of the Midwest and structural transformation of the Northeast. One exercise we run is to change each one of the four forces above separately. If we feed into the model *only* the nontransportation total factor productivity (TFP) gains over 1840–1860, we see that this shifts population from the Midwest to the Northeast (the model implies that the Midwest share of population would fall from 31% to 14%). Of course, this is the opposite of what happened to population. If we feed in *only* population growth, this does shift the population to the Midwest (the model implies that the Midwest share of population would increase from 31% to 52%), but there is no structural transformation in the Northeast (and, in fact, its opposite). But if we feed in transportation improvements alone, we see that the model matches well both the shift of the population to the Midwest and the structural transformation in the Northeast.

Another related exercise is to change all four factors *except* the transport improvements. We find in this case that there is little change in the share of the population in the Midwest. We conclude from these exercises that transportation improvements were indeed the main force driving shifting population and structural transformation, confirming what North had argued.

That transport improvements had significant impacts on the distribution of population and, within region, on industry distribution does not mean that it led to large welfare gains (a point emphasized by Fogel). We next ask how the transport revolution influenced welfare. We first ask: What are the welfare gains between 1840 and 1860 from all four changes (i.e., improvements in transport TFP, improvements in nontransport TFP, increased land endowments, and increased population)? In particular, we ask: What additional income would an 1840 household need (in 1840) to achieve the new, higher utility level with all four changes? Then we ask: What are the welfare gains if instead we made all four changes *except* that transport TFP stayed at 1840 levels? Without the transport improvements over 1840–1860, welfare gains would have been only about 50% of what they were in the first case. We also ask: What are the welfare gains if instead we increased *only* transport TFP to 1860 levels (and did not make the other three changes)? Welfare gains with only transport improvements would have been about 33% of what they were with all factors changing.

We conclude then that transport improvements were a big part of welfare gains over 1840–1860.[3] However, we do not want to overstate the importance of transport improvements. As we show below, welfare gains from nontransport TFP improvements, and from the increase in improved farmland, were larger than those from transport improvements.

Finally, we decompose the overall welfare gains from transportation improvements into the *direct* gains and the *general* equilibrium gains. The direct gains consist of the reduced spoilage of goods that results if no decisions are changed (that is, if no household changes location, and no household changes the sector in which they work). The general equilibrium gains consist of those that follow from allowing these decisions to be changed. Perhaps the main contribution of this article is, in fact, our ability to calculate the gains coming from general equilibrium effects that follow transportation improvements. We find that the gains from general equilibrium effects are sizable, ranging between a third and one half of the overall welfare gains.

The remainder of the article is organized as follows: In the next section, we review related literature. In Section 3, we describe the model. In Section 4, we define the equilibrium. In Section 5, we restrict our model parameters so as to match key features of the Midwest and the Northeast in 1840. In Section 6, we ask how well the model (calibrated to 1840) matches time series statistics from 1840 to 1860. Sections 7 and 8 present the counterfactuals (on the structural transformation and welfare, respectively), and Section 9 concludes.

2. RELATED LITERATURE

There are at least three large literatures that are related to our work: analyses of structural transformations in open economies; analyses of the westward movement of population in the 19th century United States; and analyses of economic development and transportation. We briefly discuss these in turn.

A notable study of structural transformation in an open economy is Caselli and Coleman (2001). They show that over the century following the Civil War, per capita income in the U.S. South converged to that of the U.S. Northeast. The U.S. South underwent a major structural transformation, moving from agricultural production to manufacturing production. Caselli and Coleman show that reductions in the costs of human capital accumulation over the century account for the convergence of southern income to northeastern income.[4]

[3] Fogel (1979) himself conjectured that *combined* 19th century U.S. transportation improvements were likely an important part of welfare gains (though he never dealt with this question directly). His famous argument was that the extra benefits that railroads provided over canals (and all the other improvements) were not great. In other words, he argued that canals (and the rest) were good substitutes for railroads.

[4] More recent models of structural transformation in open economies include Matsuyama (2009) and Yi and Zhang (2010). In contrast to Caselli and Coleman and our model, these papers do not allow labor mobility between

Regarding the literature on the westward movement of the U.S. population, it was long recognized that people moved from the Northeast to the Midwest even though income per capita in the Midwest was only half that in the Northeast. This is sometimes called the “Easterlin Paradox” in economic history; see Kim and Margo (2004) for a review of this literature.

One potential explanation for this paradox would be that the individuals moving to the Midwest had lower education, abilities, and so on as compared to those who stayed in the Northeast. This would be consistent with the “safety-valve” theory of western movement of Frederick Jackson Turner, who argued that the western frontier was an escape for urban workers, particularly the unskilled. Most of the large literature on Turner’s hypothesis has not found support for it (see Ferrie, 1997). However, Ferrie argues that perhaps there should be a reevaluation of the criticisms.

In our model, there are, in fact, large regional income differences. In 1840, in our calibrated model, midwestern income per capita is about half of Northeast per capita income. In the model, income is lower in the Midwest because food is the main consumption good and food is much cheaper in the Midwest (since the Midwest exports food and transportation costs are large). Hence, the dollar income needed in the Midwest to buy a given utility is much lower than in the Northeast. Although incomes are different, utilities are equalized. In our model, then, there is no paradox.[5]

Regarding models of westward expansion, our article is related to Vandenbroucke (2008) and Mourmouras and Rangazas (2009). As opposed to the structural transformation models above, these papers have one-sector, or one-good, models.

Vandenbroucke (2008) provides a quantitative general equilibrium model that focuses on settlers’ investments in clearing and improving the vast areas of unimproved western farmland. He models transportation costs in a stylized way by assuming that they apply only to the shipment of intermediate goods from the East to the West. As we do, he finds that a reduction in transportation costs draws people to the West. In contrast to us, his model does not speak to the effects of lower transportation costs on regional specialization, regional income differences, and agricultural labor productivity.

Mourmouras and Rangazas (2009) examine the transition from the use of a traditional technology to produce the single good in their model, a technology that uses land, to a modern technology (which does not use land). In this sense, they are looking at the movement from farming to manufacturing and not the westward movement per se. In their model, those individuals who use the traditional technology earn lower wages than those in the modern sector, though they earn similar incomes (since they receive rents from the land). This matches key U.S. statistics for the 19th century.

Finally, our work is related to analyses of economic development and transportation. A first example is Adamopoulos (2005), who finds large effects of cross-country differences in transportation infrastructure on GDP per capita. The model of Adamopoulos (2005) builds on that developed in an earlier version of this paper, Schmitz (2003). The difference from our work is that he attempts to measure transportation costs directly by using measures of infrastructure (e.g., miles of roads per inhabitant), whereas we use observed regional price differences to infer transportation costs between U.S. regions. Infrastructure of a country is only one of the determinants of transportation costs. Other determinants are how competitive the transportation sector is, how well the infrastructure is maintained or laid out, and where the population lives. Our indirect measure captures these additional determinants. A second example from the literature on the development effects of transportation costs is the nice paper by Donaldson (2009), who studied the effects of the construction of the railroad network in colonial India. He finds that this huge infrastructure project reduced transportation costs considerably and increased real income by 18% in the regions served by the new railroads.

regions. Moreover, these papers have not attempted (at least not yet) to quantitatively match some key episodes of structural transformations.

[5] Coelho and Shepherd (1976) and Margo (1999) provide evidence that in terms of purchasing power, midwestern income per capita indeed was similar to northeastern income per capita.

In our model, there are direct effects of improved transportation, and then general equilibrium effects. Lagakos (2009) presents a model where improvements in transportation also lead to secondary productivity effects. In particular, improvements in transportation can lead to adoption of more efficient retail technologies, as better transport spurs adoption of larger and more efficient retail formats.

3. MODEL

For simplicity, we study a static model. There is a measure $N > 0$ of ex ante identical households. At the start of the period, households (costlessly) decide in which of two regions to live (that is, consume and work). The two regions are indexed by $j \in \mathcal{J} \equiv \{E, W\}$, E denoting the Northeast and W the Midwest. Region j has L_j units of land. Land means improved land that is ready for farming (instead of unimproved land that needs to be cleared, broken, and fenced).[6]

3.1. *Endowments.* Each household has an endowment of one unit of labor. The household also receives an endowment of land. In particular, if N_j households choose to live in region j, then each one of them receives an endowment of L_j/N_j units of region j's land.[7]

3.2. *Preferences.* There are three goods: an agricultural good, a manufactured good, and services. The goods are indexed by their type $g \in \mathcal{G} \equiv \{a, m, s\}$. Households in region j value the consumption of the three goods according to the utility function

$$u(c_{aj}, c_{mj}, c_{sj}) = \omega_a \log(c_{aj} - \underline{c}) + \omega_m \log(c_{mj}) + \omega_s \log(c_{sj}), \tag{1}$$

where c_{gj} is the consumption of good g in region j, $\underline{c} > 0$, $\omega_a, \omega_m, \omega_s \in (0, 1)$, and $\omega_a + \omega_m + \omega_s = 1$. The constant term $\underline{c}$ implies that the income elasticity of agricultural goods is less than 1 ("Engel's law") and the income elasticities of the other two goods are larger than 1.[8]

3.3. *Technologies.* Waterpower was an important input into early 19th century U.S. manufacturing, and it was abundant only in the Northeast (Hunter, 1979). Large-scale manufacturing was located almost entirely in the Northeast, whereas manufacturing in the Midwest was limited to low-scale production of clothes, basic tools, and the like, which mostly took place at home.[9] To capture this in the simplest possible way, we assume that manufactured goods can be produced in the Northeast only. This assumption simplifies the analysis considerably. And it is a reasonable approximation only for the period before the Civil War, and is the main reason we focus on the 1840–1860 period.

The production function we assume is

$$Y_{mE} = A_{mE} N_{mE},$$

[6] This environment shares features with dual-economy models. Lewis (1954) and Jorgenson (1961) developed the first dual-economy models, whereas Harris and Todaro (1970) is the most well-known example.

[7] Regarding ownership of land, one assumption we could make is that all households share the land equally (regardless of where households move). Another assumption is that all households in a given region share the land of that region equally (the assumption we use). And a third assumption is that all households that work in agriculture in a region share the land of that region equally. Although the choice we make would influence, for example, wages (under the last assumption, agricultural wages would be smaller than nonagricultural wages in a region), it would not influence our quantitative findings regarding, for example, the welfare gains from transportation improvement. In particular, the quantitative findings we discuss in Table 6 (on welfare gains) below would not change.

[8] Mundlak (2005) provides a review of the supporting evidence.

[9] Slaughter (2001), for example, documented for 1850 that in 5 out of 14 manufacturing industries, all midwestern states reported zero manufacturing output.

where A_{mE} and N_{mE} are TFP and labor in manufacturing. Note that we assume constant returns in manufacturing although the economic geography literature typically assumes increasing returns; see Fujita et al. (1999) for a review of this literature. Our reason here is that we take as given the existence and location of the whole manufacturing sector and that the empirical evidence suggests that returns for the whole manufacturing sector are close to constant (Basu and Fernald, 1997).

Agriculture can be produced in both regions. Agriculture has by far the largest land share, which we capture in a stylized way by assuming that it is the only sector that uses land. The agricultural production function in region $j \in \mathcal{J}$ is

$$Y_{aj} = A_{aj} Z_j^{\theta_z} N_{aj}^{\theta_n} L_j^{\theta_l},$$

where A_{aj} is TFP, Z_j are intermediate inputs that are produced in manufacturing, N_{aj} is labor, and L_j is land in region j. Moreover, $\theta_z, \theta_n, \theta_l \in (0, 1)$ (with $\theta_z + \theta_n + \theta_l = 1$) are the shares of intermediate goods, labor, and land.

Services can be produced in both regions. The production function in region $j \in \mathcal{J}$ is

$$Y_{sj} = A_{sj} N_{sj}, \tag{2}$$

where A_{sj} and N_{sj} are TFP and labor in the service production of region j.

Services have to be consumed where they are produced. In contrast, agricultural and manufactured goods can be transported subject to an iceberg cost. Specifically, if $B_{g,j}$ units of good g are boarded in region j , then

$$D_{g,j'} = T_{g,jj'} B_{g,j}$$

units of good g are delivered to region $j' \neq j$, where $T_{g,jj'} \in (0, 1)$ is the TFP of transporting good g from region j to j'. Note since it will be the case that agricultural goods move from W to E, and manufactured goods move from E to W, there are only two parameters to be determined, $T_{a,WE}$ and $T_{m,EW}$. Moreover, we can also drop the good g subscript, and we have the two parameters T_{WE} and T_{EW}. We assume that $T_{WE} < T_{EW}$ since spoilage is greater for agricultural goods.

One might wonder why we model services at all. There are two reasons for this. First, given that we have confined manufacturing production to the Northeast, having services implies that midwestern workers have a choice of sector and do not necessarily need to work in agriculture. This is essential below when we match the regional labor shares in agriculture. Second, having services is useful when we ask our model to match the observed distribution of the labor forces between the two regions. For example, suppose that in the model, the share of people in the Midwest is larger than what it was in the data. To make living in the Midwest less attractive, we can reduce the TFP of the nontradable good in the Midwest.

4. EQUILIBRIUM

We are interested in studying equilibrium where all technologies are used, that is, the manufacturing technology in the Northeast, both agricultural technologies, and both service technologies.

We start with the market clearing conditions. For land, rented land in a region equals the land endowment of the region. For labor, rented labor in a region equals the number of households living there, in particular,

$$N_E = N_{aE} + N_{mE} + N_{sE},$$
$$N_W = N_{aW} + N_{sW},$$

and the number of households in both regions equals total population, $N_E + N_W = N$.

Next, consider market clearing for goods markets. For services, we have the consumption in a region equals the production in the region, that is,

$$c_{sj} N_j = A_{sj} N_{sj}.$$

The market clearing conditions for agricultural and manufacturing goods in each region are more involved, as they need to account for the boarded and delivered quantities. In equilibrium, the Northeast exports manufacturing goods to the Midwest and the Midwest exports agricultural goods to the Northeast. We therefore assume that the Northeast boards only manufacturing goods and the Midwest boards only agricultural goods. This allows us to write the market clearing conditions for agricultural and manufacturing goods as

$$N_E c_{aE} = A_{aE} Z_E^{\theta_z} N_{aE}^{\theta_n} L_E^{\theta_l} + D_E, \tag{3}$$

$$N_W c_{aW} + B_W = A_{aW} Z_W^{\theta_z} N_{aW}^{\theta_n} L_W^{\theta_l}, \tag{4}$$

$$N_E c_{mE} + Z_E + B_E = A_{mE} N_{mE}, \tag{5}$$

$$N_W c_{mW} + Z_W = D_W. \tag{6}$$

Equations (3) and (4) say that in each region, the total agricultural consumption plus the boarded quantities (left-hand side) equal the production plus the deliveries from the other region (right-hand side), where D_E are the deliveries of agricultural goods in the Northeast and B_W the boardings of the goods in the Midwest. Equation (5) says that in region E, the total manufacturing consumption plus the intermediate goods used in agriculture plus the boarded quantities (left-hand side) equal the production (right-hand side). Equation (6) says that in region W, the total manufacturing consumption plus the intermediate goods (left-hand side) equal the deliveries from region E (right-hand side).

We assume that there is perfect competition in all sectors (agriculture, services, manufacturing, and transportation). The profit maximization problems of the goods producers are familiar, so we skip them here. The profit maximization problems of the transportation firms may not be so familiar, so we discuss them. Consider first a representative firm that transports agricultural goods from region W to region E. Given prices, it maximizes the revenue from delivered quantities minus the costs from boarded quantities subject to the transportation technology. This problem can be written as

$$\max_{B_W, D_E} p_{aE} D_E - p_{aW} B_W \quad \text{s.t.} \quad D_E = T_{WE} B_W,$$

where we will use the agricultural good in region E as the numeraire (that is, $p_{aE} = 1$). Similarly, a representative firm that transports manufactured goods from region E to region W solves

$$\max_{B_E, D_W} p_{mW} D_W - p_{mE} B_E \quad \text{s.t.} \quad D_W = T_{EW} B_E.$$

The first-order conditions to these problems imply that

$$p_{aW} = T_{WE} p_{aE}, \tag{7}$$

$$p_{mE} = T_{EW} p_{mW}. \tag{8}$$

This implies that $p_{aW} < p_{aE}$ and $p_{mE} < p_{mW}$.

Using $D_E = T_{WE} B_W$ and $D_W = T_{EW} B_E$ in (3)–(6), we can eliminate boarded and delivered quantities. This gives the aggregate feasibility constraints for agricultural and manufacturing goods:

$$T_{WE}^{-1}N_E c_{aE} + N_W c_{aW} = T_{WE}^{-1}A_{aE}Z_E^{\theta_z}N_{aE}^{\theta_n}L_E^{\theta_l} + A_{aW}Z_W^{\theta_z}N_{aW}^{\theta_n}L_W^{\theta_l}, \tag{9}$$

$$(N_E c_{mE} + Z_E) + T_{EW}^{-1}(N_W c_{mW} + Z_W) = A_{mE}N_{mE}. \tag{10}$$

The left-hand sides list the total consumptions and use of intermediate goods, and the right-hand sides list the total productions.

A *competitive equilibrium* is a list of (i) prices of final goods, rental rates of labor and land (in each region), p_{aW}, $\{p_{mj}, p_{sj}, p_{nj}, p_{lj}\}$, $j \in \mathcal{J}$, (ii) consumption in each region, $\{c_{aj}, c_{mj}, c_{sj}\}$, $j \in \mathcal{J}$, (iii) location choices (with N_j households choosing region j), (iv) labor choices in each region, $\{N_{aE}, N_{mE}, N_{sE}\}$ and $\{N_{aW}, N_{sW}\}$, (v) choices of intermediate goods and land in each region, $\{Z_j, L_j\}$ $j \in \mathcal{J}$, and (vi) boarded and delivered quantities in each region, $\{B_j, D_j\}$ $j \in \mathcal{J}$, such that

1. For a household in region j, given prices, household consumption choices maximize utility.
2. Household choices of location maximize utility.
3. Firm choices maximize profits.
4. Markets for goods clear.
5. Markets for labor clear.
6. The populations of the two regions sum to the total population.

Although we have kept our model as simple as possible, it does not have a closed-form solution.

5. RESTRICTING THE MODEL PARAMETERS IN 1840

We now restrict the parameters of our model such that it is consistent with statistics from the Midwest and the Northeast in 1840.[10] In particular, we abstract from the southern United States. So, when we talk about total labor force, we mean the sum of the labor forces in the Midwest and the Northeast.[11] Note that we sometimes use the term labor force and sometimes the term population. But, in fact, we will calibrate our model to labor force data.

5.1. *Basic Definitions and Normalizations.* Now we need to calibrate the following parameters: the preference parameters $\underline{c}$, ω_a, ω_m, ω_s; the technology parameters A_{mE}, A_{aE}, A_{aW}, A_{sE}, A_{sW},T_{EW},T_{WE}, and θ_z, θ_n, θ_l; the land endowments L_E, L_W (where land means improved land that is ready for farming); and the size N of the total labor force. There are 17 parameters.

Several normalizations reduce the number of parameters to 10. To begin with, recall that $\omega_a + \omega_m + \omega_s = 1$ and $\theta_z + \theta_n + \theta_l = 1$. Moreover, we normalize the TFPs in northeastern production, the area of northeastern land, and the total labor force in 1840: $A_{aE} = A_{mE} = A_{sE} = L_E = N = 1$. The first three normalizations are just choices of units for the three final goods. The normalization of the total labor force is more tricky because our model is not homogeneous. We can make it nonetheless because, given a choice of N, we can adjust $\underline{c}$ in such a way that per capita variables remain unchanged.

At this point, we are left with 10 parameters to calibrate:

$$\underline{c}, \omega_a,\ \omega_m;\quad A_{aW},\ A_{sW},\ T_{EW},\ T_{WE},\ \theta_z,\ \theta_n;\quad L_W.$$

[10] We use U.S. Census definitions of the Northeast, which includes the New England states (Maine, Vermont, New Hampshire, Massachusetts, Connecticut, and Rhode Island) and the Middle Atlantic states (New York, New Jersey, and Pennsylvania). The Midwest consists of East North Central (Michigan, Wisconsin, Indiana, Illinois, and Ohio) and West North Central (North Dakota, South Dakota, Minnesota, Iowa, Nebraska, Missouri, and Kansas).

[11] One may wonder why we abstract from the South entirely. The reason is that the two most dramatic changes—the shift in the relative labor forces and the structural transformation—happened in the Midwest and the Northeast.

5.2. *Parameters We Calibrate Individually.* We start with the calibration of L_W, that is, midwestern land that was farmed in 1840. Gallman (1996) reported that this was 54% of northeastern farmed land. Given the normalization $L_E = 1$, we therefore set $L_W = 0.54$.

We continue with the share parameters in the agricultural production function, θ_l, θ_z, and θ_n. We start with the share of intermediate goods. Since we do not have capital in our model, we treat capital income as part of intermediate goods income. Following Mundlak (2005), we set $\theta_z = 0.2$. We continue with the share of land. Mundlak (2005) documented that 19th century sharecropping arrangements provided the landlord with around half of the crop. This is an upper bound on the land share because landlords often owned capital such as houses, barns, stables, and tools that the sharecroppers used. Moreover, sharecropping arrangements do not include livestock production, which has a lower land share than crop production. We therefore set $\theta_l = 0.3$. Given constant returns to scale in agriculture, this implies a labor share of 50%, which seems reasonable.[12]

We turn to the calibration of the transportation TFPs, $T_{jj'}$. There are two ways to proceed. One is to use evidence on regional price differences. For example, recall that in equilibrium

$$p_{aW} = T_{WE} p_{aE},$$

so that we can calibrate T_{WE} using

$$T_{WE} = \frac{p_{aW}}{p_{aE}}. \tag{11}$$

Another approach is to use direct measures of transportation cost to calibrate the parameters. If the dollar costs of transporting agricultural products from the Midwest to the Northeast is c, then in terms of physical units, the cost is c/p_{aW}. In the model, in order to transport a ton, more than a ton must be boarded, namely, $(1/T_{WE})$. So, the cost of transportation in physical units is $[(1/T_{WE}) - 1]$. Hence, we can calibrate T_{WE} from

$$[(1/T_{WE}) - 1] = \frac{c}{p_{aW}},$$

or in particular

$$T_{WE} = \frac{1}{1 + (c/p_{aW})}. \tag{12}$$

What data would we want to calibrate $T_{WE}(1840)$ using (11)? For relative prices, that is, p_{aW}/p_{aE} in (11), it would be ideal to know the ratio of the price received by the farmer (the farm-gate price) and the delivered price (like the wholesale price in the city where the food is consumed). What data are available? As for relative prices p_{aW}/p_{aE}, there are some data available on the ratio of wholesale prices of agricultural goods between cities (like Chicago and New York). There are also data available on the ratio of farm-gate prices between farms in various regions (like between Ohio and New York). Neither type of data is exactly what we want, but the best datum for calibrating $T_{WE}(1840)$ is the ratio of regional farm-gate prices.

What data would we want to calibrate $T_{WE}(1840)$ using (12)? For the cost of transportation (relative to the price of the farm good), that is, c/p_{aW}, it would be ideal to know the ratio of the transportation cost (from the farm to the wholesale market in the city of consumption) and the price received by the farmer (the farm-gate price). There are data on the transportation cost of wheat, that is, c, between Chicago and New York. However, these data only start in the late

[12] To avoid confusion, we should mention that these share parameters do not apply to the second half of the 20th century when the share of land was smaller and the share of intermediates and capital was larger (Valentinyi and Herrendorf, 2008).

1850s. Moreover, it is not the cost of transporting wheat from the farm to New York. Other data on transportation costs are found in North (1965). These are not costs along given routes, but "rough" estimates of the time path of cents per ton mile (an estimate of c) for different transportation modes for the decades before the Civil War.

In summary, the data available on transportation costs are not sufficient to calibrate $T_{WE}(1840)$. However, when we discuss how the transportation TFP parameters changed between 1840 and 1860, we can use the data on transportation costs to assess our relative price procedure.

Let us now turn to calibrating T_{WE} for 1840 using the data available on the ratio of farm-gate prices across various regions. Easterlin (1960, Table B.2) reports regional farm-gate price data from Tucker (which are averages of two years, 1840 and 1843). These data imply large regional price differences. Tucker reports that prices received by farmers in the central United States (Ohio, Indiana, Michigan, Illinois, Iowa, and Kentucky) for wheat were 40% of the prices received by New England farmers. For corn, central U.S. farmers received between 0.27 and 0.42 of New England farmers (Tucker presents a range).

If we used the corn prices to calibrate $T_{WE}(1840)$, we would obviously get lower values than if we used wheat prices. Here, we will use the wheat prices, which again averaged 0.40 for the two years 1840 and 1843. The 1840 price ratio is presumably smaller than this average, than 0.40. Here, we will calibrate the model to a "low" value, namely, 0.35, and then to a "high" value, namely, 0.40. Our initial or baseline calibration is to the ratio 0.35.

Unfortunately, we do not have similarly detailed price information for manufactured goods. All we know is that transporting manufactured goods was less costly than transporting agricultural goods (grains rot more than nails rust and livestock may die altogether). We capture this by choosing $T_{EW} = 0.5$ in 1840. We emphasize that our findings are not sensitive to this particular choice of T_{EW}. The reason is that the share of manufactured goods in GDP was small in 1840.

5.3. *Parameters We Calibrate Jointly.* At this point, we are left with five parameters to calibrate: $\omega_a, \omega_m, \underline{c}, A_{aW}, A_{sW}$. We choose them such that our model replicates key statistics of the Midwest and the Northeast in 1840. Specifically, we target (i) the share of the total labor force in the Midwest as reported by the Census; (ii) and (iii) the shares of the northeastern and the midwestern labor forces in agriculture as reported by Weiss (1987)[13]; (iv) midwestern GDP per worker relative to Northeast GDP per worker in current regional prices as reported by Easterlin (1960); and (v) midwestern agricultural labor productivity relative to northeastern agricultural labor productivity. Agricultural labor productivity in the Midwest and the Northeast is derived from data reported by Parker and Klein (1966).[14]

These five statistics or targets are presented in the first column of Table 1. The second column of Table 1 reports the statistics in the model economy given the calibrated parameters (which are presented in Table 2). The model economy statistics are very close to the corresponding statistics for the U.S. economy in 1840. In particular, in the model, income per capita in the Midwest is much lower than in the Northeast. There are two reasons for this: Food is the main consumption good for which a typical household spent most of its budget and food is much

[13] Weiss improved upon the Census numbers, and so we use his numbers here; see also Weiss (1992).

[14] The data in Parker and Klein (1966) imply that in 1839, labor productivity in bushels per man-hour in the Midwest relative to the Northeast is 1.1 for wheat, 1.2 for oats, and 1.8 for corn. To calculate the aggregate relative labor productivity from these three numbers, we use the total hours worked in each grain crop by region and the prices of each grain by region. This calculation implies an aggregate labor productivity in midwestern relative to the northeastern agriculture of 1.3. Two comments are in order. First, if one looks at the labor productivity ratios that Parker and Klein report in each grain for the end of the 19th century, one finds that the Midwest's advantage over the Northeast gets much larger. This is due in large part to the fact that, as the century progressed, more distant and better farmland was used in the Midwest. Second, the three main grain crops did not obviously comprise the other major components of agricultural production, which is livestock. There are no studies of livestock productivity, but a key intermediate input into livestock production is grain, in particular, oats and corn. Since they were far cheaper in the Midwest than the Northeast, it must have been the case that raising livestock was also more productive in the Midwest.

TABLE 1
CALIBRATION TARGETS AND CORRESPONDING MODEL STATISTICS

	Data	Model
	1840	
Share of total labor force in Midwest	0.31	0.31
Share of Northeast labor force in agriculture	0.54	0.53
Share of Midwest labor force in agriculture	0.77	0.77
GDP per worker in Midwest relative to Northeast	0.52	0.51
Agricultural labor productivity in Midwest relative to Northeast	1.30	1.32

TABLE 2
CALIBRATED PARAMETER VALUES

Preference parameters	$\underline{c} = 0.65$, $\omega_a = 0.17$, $\omega_m = 0.44$, $\omega_s = 0.39$
Technology parameters	$A_{aW} = 1.55$, $A_{sW} = 0.18$
	$T_{WE} = 0.35$, $T_{EW} = 0.50$
	$\theta_z = 0.2$, $\theta_n = 0.5$, $\theta_l = 0.3$
Endowments	$L_W = 0.54$

TABLE 3
SETTLEMENT OF MIDWEST AND STRUCTURAL TRANSFORMATION IN NORTHEAST, 1840–1860, U.S. DATA VERSUS MODEL PREDICTIONS

	Data		Model	
	1840	1860	1840	1860
Share of total labor force in Midwest	0.31	0.43	0.31	0.43
Share of Northeast labor force in agriculture	0.54	0.33	0.53	0.24
Share of Midwest labor force in agriculture	0.77	0.62	0.77	0.67

cheaper in the Midwest than in the Northeast, because the Midwest exports it to the Northeast and transportation costs are large. To achieve the same utility, a Midwest household then needs a much lower dollar income than a Northeast household.

Table 2 shows the calibrated parameter values other than the five normalizations. Two parameter values are noteworthy. First, our calibrated agricultural TFP parameter A_{aW} is 1.55 times greater than A_{aE}. This reflects that land in the Midwest is of higher quality than in the Northeast. Since Gallman's land measures do not adjust for this, the differences in quality show up in differences in the TFPs of the regions' agriculture. Second, A_{sW} is only 18% of A_{sE}. This low value likely captures that there were costs of moving to the Midwest from which we have abstracted. As a result, living in the Midwest becomes more attractive in the model than it was in the real world. Having a lower TFP in midwestern services reduces the attractiveness of living in the Midwest, and so it helps us to match the midwestern share of the labor force.

6. HOW WELL DOES THE MODEL "EXPLAIN" THE 1840–1860 PERIOD?

In this section, we ask how well the model "explains" U.S. statistics for the period 1840–1860. We first ask how well it explains the shift of population from the Northeast to the Midwest and the significant structural transformation in the Northeast from agriculture to nonagriculture. We then ask how well it explains interregional trade flows. If the model does a reasonable job, then this will give us confidence in exploring counterfactuals on the role of transportation improvements in the next section.

Table 3 presents the share of population in each region and the share of the labor force in each region in agriculture in 1840 and 1860 (columns 1 and 2, respectively). Over these two decades, the share of the labor force in the Midwest increased from 31% to 43%. This shift we refer to as the “settlement of the Midwest.” The share of the Northeast labor force in agriculture dropped from 54% to 33% over 1840–1860. This shift we refer to as the “structural transformation in the Northeast.”

To see if the model can explain these shifts, we feed into the model four significant changes that occurred over the period 1840–1860. These significant changes were (1) major gains in transportation productivity, (2) major gains in the productivity of the nontransportation sectors, (3) a large increase in the amount of improved farmland, and (4) a large increase in population.

The increase in the labor force is obtained from Weiss (1987). He reports that the labor force of the Midwest and the Northeast more than doubled during 1840–1860. In particular, we have that

$$\frac{N(1860)}{N(1840)} = 2.10.$$

Such a huge labor force increase is very unusual in only 20 years and is driven in part by immigration into the United States.

The increase in improved farmland is obtained from Gallman (1996). He estimates that the area of improved farmland increased dramatically in the Midwest and to a much lesser degree in the Northeast. In particular, we have

$$\frac{L_E(1860)}{L_E(1840)} = 1.32, \quad \frac{L_W(1860)}{L_W(1840)} = 3.27.$$

Estimates for productivity growth in the nontransportation sectors are obtained from Gallman (1992). He estimates that aggregate TFP increased by 0.82% per year during 1840–1860, or 18% over the whole period. Denoting by $A_{gj}(1840)$ and $A_{gj}(1860)$ the TFPs in the nontransportation sectors, we have[15]

$$\frac{A_{gj}(1860)}{A_{gj}(1840)} = 1.18, \quad g \in \mathcal{G}, \quad j \in \mathcal{J}.$$

Finally, we turn to estimates of gains in transportation productivity. The main reason for the large reduction in transportation costs during 1840–1860 was the massive expansion of the railways. Taylor (1964, p. 79) gives a sense of the immense speed with which this happened: During 1840–1860, the total railroad mileage increased from 1,657 to 8,946 in the Northeast and from 199 to 10,247 in the Midwest. Fishlow (1965) documents that as a result, railroad TFP increased considerably during 1840–1860. The railways also increased the competition in the transportation sector, which further reduced transportation costs (Holmes and Schmitz, 2001).

How can we quantify the reduction in transportation costs between the Midwest and the Northeast? We start with information about the change in regional farm-gate prices. Then, we will discuss data on transportation charges.

Harley (1980) reports that in the middle of the 1850s, the wheat prices on the midwestern farms relative to the New York farms were 0.52 in Iowa, 0.57 in Wisconsin, and 0.61 in Indiana. Since the Midwest was settled from East to West, the more western observations are likely to be more relevant for the location decisions we are interested in here. Therefore, using regional price data, we set $T_{WE}(1860) = 0.55$. Hence, we have that

$$\frac{T_{WE}(1860)}{T_{WE}(1840)} = \frac{0.55}{0.35} = 1.57.$$

[15] Gallman’s estimate of TFP includes the transportation sector. We ignore this for now. Below, we offer some robustness analysis to show that our principal conclusions are not sensitive to other reasonable choices for nontransport TFP growth.

Since, again, we do not have comparable price data for manufactured goods, we assume that transportation TFP improved by the same amount in both directions, so we set $T_{EW}(1860) = 0.70$. Hence, we have that

$$\frac{T_{EW}(1860)}{T_{EW}(1840)} = \frac{0.70}{0.50} = 1.40.$$

We next turn to using the limited data on transportation costs. There are not enough data on transportation charges to calibrate our transport parameters. However, we can use the data to see if our numbers are in the ballpark.

As mentioned, a time series on the costs of transporting wheat between Chicago and New York City is available from the late 1850s onward. From these data and the wholesale price of wheat in Chicago, we can estimate $T_{EW}(1860)$ for the Chicago to New York City route.

The cost of transporting a bushel of wheat, by rail, was about 35 cents a bushel in the late 1850s (Tunell, 1897). The wholesale price of wheat in Chicago varied quite a bit in the late 1850s, with a value of about 70 cents a bushel at the end of the decade. Using the formula (12) above, and $c/p_{aW} = 1/2$, gives $T_{WE}(1860) = 2/3 = 0.67$, which is greater than $T_{WE}(1860) = 0.55$.

But recall that we want the technology for transporting wheat from the *farm* to New York, not *Chicago* to New York. To get this technology, we would have to add local transport costs (i.e., from the farm to Chicago) to the cost c above. Local transport costs are often large. We would also use the farm-gate price for p_{aW} (which was likely lower than the Chicago wholesale price). So, we think this calculation shows we are in the ballpark.

As far as how transport costs changed over the 1840–1860 period, there is some rough information provided by North (1965). In Chart IV, p. 222, North presents his estimates of transportation rates by mode over the 19th century (which are recorded in Df17-21, pp. 4–781, *Historical Statistics of the United States*, millennial ed., vol. 4). He presents rates only for selected years. For railroads, he reports 6.20 cents per ton mile in 1833, 5.50 cents per ton mile in 1848, and 2.80 cents per ton mile in 1860.

What do these data imply about the time path of T_{EW}? One thing we can do is estimate the technology parameter for the Chicago to New York trip in 1848, $T_{WE}(1848)$, and compare it to its value in 1860, $T_{WE}(1860) = 0.67$. To do this, suppose that the transportation charges between Chicago and New York between 1848 and 1860 behaved as those reported by North for rail between 1840 and 1860. Then, we can calculate the transportation charge between Chicago and New York for 1848, call it x, using

$$\frac{x}{35} = \frac{5.50}{2.80},$$

where $x/35$ is the ratio of transport charges in 1848 and 1860 for Chicago to New York (where recall the 1860 transport charge, 35, is given above), and 5.5/2.8 is the ratio for this period from North (1965). We calculate $x = 68.76$. Wheat prices in Chicago in 1848 were about $p_{aW} = 60$, so that we have $x/p_{aW} = 1.15$ and hence $T_{WE}(1860) = 0.46$. So, there was a significant gain in technology in this 1848–1860 period. Again, we think this calculation shows we are in the ballpark.

Table 3 reports what happens when we feed into our model the four changes above. Again, the first two columns present the data for 1840 and 1860, respectively, whereas columns 3 and 4 present the model values for these years. The table shows that our model generates the settlement of the Midwest that was observed, its share of population increasing from 31% to 43%.

The model also generates a structural transformation in the Northeast, though it predicts an even larger decline in Northeast agriculture than was seen, from 53% to 24% of the labor force. By contrast, the decline in agriculture in the Midwest was smaller than observed, only from 0.77% to 0.67%. The reason that the structural transformation in the Northeast is greater than observed is likely because we have abstracted from the investments required for clearing and improving midwestern farmland and from investments in migration.

As a check on the robustness of our findings, we explore another estimate of growth rates of nontransport TFP. In particular, we consider what happens when we use Greenwood and Seshadri's (2002) estimates of the growth rates of TFP during the 19th century in agriculture (0.49% per year) and nonagriculture (0.73% per year). Using these growth rates over the 1840–1860 period, we find that our results are little changed. In particular, the share of the population in the Midwest in 1840 is now 0.48, and the share of the labor force in agriculture is 0.24 and 0.70 in the Northeast and the Midwest, respectively.

Another interesting way to "test" the model is to ask how the "size" of the transportation sector in the calibrated model compares to the actual size of the sector in the U.S. data. One way to measure size is to use a sector's share of employment, or its share of value-added. Given that we have modeled transportation as an iceberg technology, there is no employment in the sector, and there is no value-added in the sector. But we can measure the size of shipments (relative to some measure, like GDP) made by the sector.

Data on interregional trade flows are available from Fishlow (1964). Let us first discuss the trade flows from the Northeast to the Midwest. In 1840, the shipments from the Northeast to the Midwest were, according to Fishlow (1964), 19.7 million dollars (in Northeast prices).[16] Northeast income in 1840 was, according to Easterlin (1960), 576 million dollars. Hence, Northeast exports to the Midwest relative to Northeast income was 3.4%. In the model, the corresponding value is 4.4%. So, the model does a reasonable job matching the 1840 export share of the Northeast to the Midwest.

What about the trade flows from the Midwest to the Northeast? Fishlow (1964) estimates that in 1840, the Midwest shipped 16.5 million dollars of goods to the Northeast for its consumption. These included exports that went from the Midwest directly to the Northeast for consumption (7.1 million) and exports sent south through New Orleans for consumption in the Northeast (9.4 million). Midwest income in 1840 was, according to Easterlin (1960), 157 million dollars. Hence, Midwest exports to the Northeast relative to Midwest income was 10.5%. In the model, the corresponding value is 13.6%. So, the model also does a reasonable job matching the 1840 export share of the Midwest to the Northeast.

Unfortunately, we are not able to calculate the export ratios for 1860, as Easterlin does not calculate 1860 regional incomes.

These exercises have given us confidence in the model, and so we turn to some counterfactual exercises with transportation TFP.

7. THE ROLE OF TRANSPORTATION IN THE U.S. ECONOMY: STRUCTURAL TRANSFORMATION

In this section, we ask whether transportation improvements played a central role in the settlement of the Midwest and the structural transformation of the Northeast (as argued by North).

One way to answer this question is to ask what the model predicts for the distribution of population across locations, and across industries, if we individually changed each of the four factors. For example, would there have been a settlement of the Midwest and a structural transformation of the Northeast if there had *only* been improvements in transportation? If there had *only* been an increase in improved farmland? And so on.

We first feed into the model the large reduction in transportation costs while keeping the other variables *unchanged*. Table 4 reports the results of this exercise. For ease in comparing the model predictions to the data, we repeat the U.S. statistics in columns 1 and 2. We present the model predictions in columns 3 and 4.

The predictions of the model, that is, the *changes* between columns 3 and 4, are fairly close to the *changes* observed in the data. There is an increase in the share of population in the Midwest,

[16] Note that Fishlow uses the term "North" for Northeast and "West" for Midwest.

TABLE 4
SETTLEMENT OF MIDWEST AND STRUCTURAL TRANSFORMATION IN NORTHEAST, 1840–1860
(WHEN ONLY TRANSPORT TFP INCREASES)

	Data		Model	
	1840	1860	1840	1860
Share of total labor force in Midwest	0.31	0.43	0.31	0.41
Share of Northeast labor force in agriculture	0.54	0.33	0.53	0.38
Share of Midwest labor force in agriculture	0.77	0.62	0.77	0.76

TABLE 5
SETTLEMENT OF MIDWEST AND STRUCTURAL TRANSFORMATION OF NORTHEAST, 1840–1860 (WHEN ONLY NONTRANSPORT TFP CHANGES, ONLY POPULATION CHANGES, AND ONLY LAND CHANGES)

	Data		Model (Other TFPs Increase)		Model (Population Increases)		Model (Land Increases)	
	1840	1860	1840	1860	1840	1860	1840	1860
Share of total labor force in Midwest	0.31	0.43	0.31	0.14	0.31	0.52	0.31	0.33
Share of Northeast labor force in agriculture	0.54	0.33	0.53	0.48	0.53	0.60	0.53	0.42
Share of Midwest labor force in agriculture	0.77	0.62	0.77	0.65	0.77	0.96	0.77	0.68

from 0.31 to 0.41, and there is a structural transformation of the Northeast, as the share of its labor force in agriculture goes from 0.53 to 0.38. In the Midwest, the share falls slightly from 0.77 to 0.76.

As for the sensitivity of this result to different changes in transportation TFP, we ask what happens when we change T_{WE} from 0.35 to 0.50 (instead of from 0.35 to 0.55), and change T_{EW} from 0.50 to 0.65 (instead of from 0.50 to 0.70). When we use these smaller increases in transport TFPs, we find that there is a smaller increase in the share of population in the Midwest (it goes from 0.31 to 0.39), and a smaller decrease in the share of the Northeast's labor force in agriculture (which falls from 0.53 to 0.42). The share of the Midwest's labor force in agriculture falls to 0.76 (just as it did in the original exercise). So, the results do not change much.

In sum, then, if there had only been a large improvement in transportation productivity, the movement of population and the specialization by industry would have looked fairly similar to what was observed. But this would not be the case if we changed (on their own) any of the other three factors discussed above. To see this, in Table 5, we ask what happens when we change each of the other three factors. Again, for ease in comparing the model predictions to the data, we repeat the U.S. statistics in columns 1 and 2. The model predictions if we changed *only* the productivity of the nontransportation sectors are given in columns 3 and 4. This change leads to some implications that are qualitatively at odds with the observed history. In particular, the share of the workforce in the Midwest decreases, going from 0.31% to 0.14%. As all sectors become more productive, the economy becomes richer. Given nonhomothetic preferences, the consumption share spent on food, and the labor force in agriculture, goes down. The Midwest shrinks.

Increasing the total labor force alone (columns 5 and 6) leads to an increase in the share of population in the Midwest. But notice that it also leads to some implications that are qualitatively at odds with the observed history. In particular, the share of the labor force in the Northeast that is in agriculture increases from 0.53 to 0.60. Increasing the total labor force increases the ratio of the labor force to land, which makes the economy poorer.

Increasing the land endowments (columns 6 and 7) decreases the share of the labor force in agriculture in each region, from 0.53 to 0.42 in the Northeast and from 0.77 to 0.68 in the Midwest. However, in contrast to the observed history, increasing the land endowments does not lead to much of an increase in the share of the labor force in the Midwest (it increases from 0.31 to 0.33).

As a final exercise, which is not reported in Table 5, we change all factors except transportation improvements. In this case, the model predicts that the share of the population in the Midwest goes from 0.31 to 0.34, the share of the Northeast labor force in agriculture goes from 0.53 to 0.43, and the share of the Midwest labor force in agriculture goes from 0.77 to 0.69.[17] Hence, if transport improvements did not occur (but all the other changes did), there would not have been much of an increase in the Midwest's share of population.

This analysis confirms North's view that transportation improvements played the central role in the movement of people and development of industry (at least in our period of study).

It is possible to give some intuition for the forces at play in the model when we increase transportation TFP alone. First, the large reduction in transportation costs lets the two regions *increase* their specialization in production. One way to gauge this increased specialization is to compare the regional differences in the share of the labor force in agriculture *in the model* in 1840 and 1860. Again looking at Table 4, the regional difference in 1840 is 0.24, that is, 0.77 (in the Midwest) minus 0.53 (in the Northeast). The regional difference in 1860 is 0.38, that is, 0.76 minus 0.38. Hence, the difference *increases*, reflecting an increase in specialization. This is the same effect as that from the reduction in tariffs in international trade theory.

Second, the large reduction in transportation costs makes the economy richer. Since the income elasticity of agricultural goods is smaller than 1, the consumption share spent on food goes down and agricultural production becomes less important. This is a force for agriculture's share of the labor force to decline in both regions.

Third, there are forces acting to make the agricultural sector bigger in the Midwest. In particular, since households can move, and since lowering transportation costs makes it cheaper to transport manufactured intermediate inputs and manufactured consumption goods to the Midwest, there is a force acting to increase the size of the Midwest. The second and third forces offset each other, and there is essentially no decline in the share of the agricultural labor force in the Midwest (it declines from 0.77 to 0.76).

Finally, we mention that when we increase transport TFP (alone), the difference in per capita income narrows considerably. In particular, the ratio of the midwestern to northeastern income per capita changes from 0.51 (in 1840) to 0.78 (in 1860). The reason for this convergence in regional incomes is that as transportation costs fall, the regional prices of tradable goods converge to each other.[18]

8. THE ROLE OF TRANSPORTATION IN THE U.S. ECONOMY: WELFARE GAINS

In this section, we will explore the impact of transportation improvements on welfare. We consider two methods to calculate the welfare consequences of various improvements. First, we consider the welfare *gains* of adopting improvements. Second, we consider the welfare *losses* of dropping improvements. This last approach was followed by Fogel (1979), so we examine it as well.

8.1. *Welfare Gains from Adopting Improvements.* What were the household welfare gains over 1840–1860 (i.e., from changing all four sets of parameters, namely, the transport improvements, the nontransportation TFP gains, the increased land endowments, and the population increase)? And how important were the improvements in transportation to the welfare gains? To answer these questions, we calculate and compare various types of welfare gains.

In order to describe these welfare calculations, let us first introduce some notation. In particular, we will denote various parameter configurations of the model by Λ_j. The first two

[17] This exercise, then, produces essentially the same changes as did the exercise when we increased the land endowment.

[18] Again, this is consistent with the evidence presented on regional incomes by Easterlin (1960), though he only reports numbers for 1840 and 1880, and not for 1860.

TABLE 6

WELFARE GAINS FROM ADOPTING IMPROVEMENTS: BASELINE RESULTS (PERCENTAGE INCREASE IN INCOME AN 1840 HOUSEHOLD WOULD NEED TO ACHIEVE UTILITY IN EQUILIBRIUM WHERE WE ADOPT THE FOLLOWING IMPROVEMENTS)

	Adopt All Improvements	Adopt All Improvements Except Transportation	Adopt Only Transport TFP	Adopt Only Nontransport TFP	Adopt Only Land	Adopt Only Population
Northeast	18	10	6	15	9	−11
Midwest	59	31	19	47	29	−35

are

$$\Lambda_1 = \text{ 1840 parameter vector,}$$
$$\Lambda_2 = \text{ 1860 parameter vector,}$$

where Λ_1 is simply the parameters listed in Table 2. Λ_2 is obtained from Λ_1 by changing the transport TFP parameters, the nontransport TFP parameters, the land parameters, and the population parameter to 1860 levels. To isolate the impact of transport TFP, we also consider

$$\Lambda_3 = \text{ 1860 parameter vector,} \quad \textit{except} \text{ 1840 transport parameters,}$$
$$\Lambda_4 = \text{ 1840 parameter vector,} \quad \textit{except} \text{ 1860 transport parameters,}$$

where the third vector Λ_3 is obtained from Λ_1 by changing the nontransport TFP parameters, the land parameter, and the population parameter, but not the transport TFP parameter. The fourth vector Λ_3 is obtained from Λ_1 by changing only the transport TFP parameters. In order to make comparisons to the transport TFP changes, we consider three other vectors, namely,

$$\Lambda_5 = \text{ 1840 parameter vector,} \quad \textit{except} \text{ 1860 nontransport parameters,}$$
$$\Lambda_6 = \text{ 1840 parameter vector,} \quad \textit{except} \text{ 1860 land parameters,}$$
$$\Lambda_7 = \text{ 1840 parameter vector,} \quad \textit{except} \text{ 1860 population parameter.}$$

Now, imagine we are in 1840 and ask: What are the welfare gains of adopting all four improvements, that is, moving from Λ_1 to Λ_2?[19] Let $p_E(\Lambda_1)$ and $p_W(\Lambda_1)$ denote the vector of equilibrium prices in each region given the equilibrium with Λ_1. Let $y_E(\Lambda_1)$ and $y_W(\Lambda_1)$ denote the equilibrium income levels in each region. Finally, let $u_E(\Lambda_1)$ and $u_W(\Lambda_1)$ denote the level of utility in each region in 1840, where, of course, $u_E(\Lambda_1) = u_W(\Lambda_1)$.

Changing the parameter vector from Λ_1 to Λ_2 results in a new equilibrium, with utility levels $u_E(\Lambda_2)$ and $u_W(\Lambda_2)$, where again $u_E(\Lambda_2) = u_W(\Lambda_2)$. We ask: What income would a person have to receive in 1840 (again, in the equilibrium with Λ_1) so that the person would achieve the higher utilities $u_E(\Lambda_2) = u_W(\Lambda_2)$? These incomes will depend on region, and we call them $\widetilde{y}_E$ and $\widetilde{y}_W$. The households of 1840 would then need a percentage increase in income of

$$\frac{\widetilde{y}_E - y_E(\Lambda_1)}{y_E(\Lambda_1)} \times 100 \quad \text{and} \quad \frac{\widetilde{y}_W - y_W(\Lambda_1)}{y_W(\Lambda_1)} \times 100, \tag{13}$$

where note that we multiply by 100.

In Table 6, we present the ratios in (13) in column 1. In the Northeast, households would need an 18% increase in income to achieve the 1860 utility level, whereas those in the Midwest would need a 59% increase. The gains in the Midwest are much larger than in the Northeast.

[19] Note that, of course, only the first three changes, namely, transport improvements, nontransport TFP improvements, and increased land endowments, will increase welfare. For brevity, we will call the changes in population an "improvement."

Before we explain the reason for this difference, let us describe the rest of the numbers in the table.

The next calculation is to change the parameter vector from Λ_1 to Λ_3 (by changing all the parameters *except* the transportation parameters). We then have a new utility level, $u_E(\Lambda_3) = u_W(\Lambda_3)$. We then have new income levels that would be needed in 1840 to achieve these utility levels, where we again denote them by $\widetilde{y}_E$ and $\widetilde{y}_W$. And we calculate new ratios in (13). In the Northeast, we calculate 10, and for the Midwest 31.

We next change the parameter vector from Λ_1 to Λ_4 (by changing *only* the transportation parameters). In the Northeast, we calculate 6, and for the Midwest 19. Similarly, columns 4–6 present the welfare gains when we change *only* the nontransportation TFP parameters (Λ_1 to Λ_5), *only* the land endowments (Λ_1 to Λ_6), and *only* the population (Λ_1 to Λ_7).

We next discuss two issues: Why are the gains in the Midwest bigger than those in the Northeast, and how important were transportation improvements in the gains?

Let us first describe the intuition for the different regional welfare effects when we only change the transportation TFP parameters (i.e., column 3). In 1840, food was much cheaper in the Midwest than in the Northeast, and manufactures and services were more expensive. Hence, households in the Midwest consumed more food and less manufactures than households in the Northeast.

The increase in transport TFP does two things. First, it makes the economy "richer." Hence, with nonhomothetic preferences, this means that more manufacturing goods are consumed in 1860 relative to 1840. Second, it leads to price convergence. For now, let us imagine that it led to complete convergence. Then, in 1860, households in the Midwest and the Northeast would consume the same bundle of goods (as incomes would be the same).

Hence, we know (1) the 1840–1860 increase in consumption of manufactured goods is more for an 1840 Midwest household than for an 1840 Northeast household and (2) the 1840 price of manufactures is bigger in the Midwest than in the Northeast. Both forces mean that an 1840 Midwest household needs a greater increase in income than an 1840 Northeast household to achieve the 1860 utility level.

There was not complete price convergence by 1860 (of course), so the claim that "the 1840–1860 increase in consumption of manufactured goods is more for an 1840 Midwest household than for an 1840 Northeast household" cannot be made with a simple theoretical argument once price convergence is not complete. But it is quantitatively true for the parameters here.

This is the intuition for column 3.[20] How about the other columns (except the last)? The intuition is essentially the same: In each of these cases, the changes make the economy richer, and hence households increase purchases of nonagricultural goods. These prices are higher for midwestern households.

Now, were transportation improvements an important part of welfare gains? Though household welfare gains depend on region, there are important conclusions we can reach that do not depend on region. In particular, comparing columns 1 and 2, we see that if there had been no transport improvements (but the other three changes), welfare gains would have been only a bit more than half the welfare gains from all four changes (10% as compared to 18% for Northeast households, or 55%, and 31% as compared to 59% for Midwest households, or 52%). These estimates indicate that transportation improvements were important for welfare.

Although transportation improvements were important, we do not want to overstate them. In another exercise (not reported in Table 6), we ask, "How much would welfare have increased if we had all the improvements except the increases in nontransport TFP?" Welfare would have increased by 6 and 19 in the Northeast and Midwest, respectively. Welfare gains would have

[20] A referee suggested an alternative view or intuition for why the Midwest households need a greater increase in income than Northeast households. Northeast households consume less food than Midwest households in 1840 (since food is relatively expensive in the Northeast); hence, they are closer to the subsistence constraint $\underline{c}$. The closer is the initial consumption to the subsistence level, the larger is the impact of a given increase in income on total utility. Hence, to achieve a given increase in utility from, say, an improvement in transportation, the households in the Northeast need a smaller increase in income than households in the Midwest.

TABLE 7
WELFARE GAINS FROM ADOPTING IMPROVEMENTS: SMALLER TRANSPORT TFP INCREASES (PERCENTAGE INCREASE IN INCOME AN 1840 HOUSEHOLD WOULD NEED TO ACHIEVE UTILITY IN EQUILIBRIUM WHERE WE ADOPT THE FOLLOWING IMPROVEMENTS)

	Adopt All Improvements	Adopt All Improvements Except Transportation	Adopt Only Transport TFP	Adopt Only Nontransport TFP	Adopt Only Land	Adopt Only Population
Northeast	16	10	4	15	9	−11
Midwest	52	31	14	47	29	−35

been only about one-third the welfare gains from all four changes (6% as compared to 18% for Northeast households and 19% as compared to 59% for Midwest households). So, according to this way of measuring the importance of an improvement to welfare, transportation TFP improvements were important (gains would have been half as much without them), but they were not as important as the gains from nontransport TFP improvements (gains would have been a third as much without them).

In another way to assess welfare, we see that the gains to introducing the transport TFP improvements alone (column 3) are about a third of the welfare gains from all four changes (note in Table 6 that the "6" for Northeast households and the "19" for Midwest households in column 3 are the same numbers calculated in the experiment above, where we changed all factors except nontransport TFP). The gains to introducing the nontransport TFP improvements alone (column 4) are about 80% of the welfare gains from all four changes (15% as compared to 18% for Northeast households and 47% as compared to 59% for Midwest households). Again, transport improvements had a significant impact on welfare, though again not as big as improvements in the other sectors.

We next ask how these welfare results change when we use different values of the transportation TFP parameters. We run two exercises. First, keeping the original calibration for 1840, we use smaller increases in transport TFP for 1840–1860. Second, we recalibrate the model by assuming a larger transport TFP parameter for agriculture in 1840.

In the first exercise, keeping the calibrated parameters in Table 2, we ask what happens to the quantities in Table 6 when we change T_{WE} from 0.35 to 0.50 (instead of from 0.35 to 0.55), and change T_{EW} from 0.50 to 0.65 (instead of from 0.50 to 0.70). Note that in this exercise, only the first and third columns of Table 6 will change.

In Table 7, we report the new quantities in the first and third columns (and repeat the other columns for ease of comparison). When we use these smaller increases in transport TFPs, there is a smaller increase in welfare from the combined improvements, with 16 and 52 in the Northeast and Midwest, respectively. Hence, welfare increases from all improvements are now about 88% of the previous gains in Table 6 (16/18 = 0.89 and 52/59 = 0.88). Comparing columns 1 and 2 in Table 7, we see that if there had been no transport improvements (but the other three changes), welfare gains would have been about 60% of the welfare gains from all four changes (10% as compared to 16% for Northeast households, or 62%, and 31% as compared to 52% for Midwest households, or 60%). In Table 6, the gains without transport improvement would have been about 50% of gains from all four. So, the results are not much different.

How about the increase from improving transport TFP alone? We see that the gains to introducing the transport TFP improvements alone (column 3) are about 25% of the welfare gains from all four changes (4/16 and 14/52). In Table 6, the gains would have been about a third. Hence, the gains are smaller, but transport improvements remain important for welfare.

In the second exercise, we recalibrate the model and then look at welfare gains. In particular, we assume a higher transport TFP in agriculture in 1840 and then recalibrate the model. That is, we assume that $T_{WE}(1840) = 0.40$ (and not 0.35). Recall that there are five parameters that we jointly calibrate, ω_a, ω_m, $\underline{c}$, A_{aW}, and A_{sW}. In the new calibration, they are $\omega_a = 0.07$, $\omega_m = 0.48$, $\underline{c} = 0.67$, $A_{aW} = 1.43$, and $A_{sW} = 0.21$.

TABLE 8

WELFARE GAINS FROM ADOPTING IMPROVEMENTS: NEW CALIBRATION (PERCENTAGE INCREASE IN INCOME AN 1840 HOUSEHOLD WOULD NEED TO ACHIEVE UTILITY IN EQUILIBRIUM WHERE WE ADOPT THE FOLLOWING IMPROVEMENTS)

	Adopt All Improvements	Adopt All Improvements Except Transportation	Adopt Only Transport TFP	Adopt Only Nontransport TFP	Adopt Only Land	Adopt Only Population
Northeast	15	9	4	14	8	−11
Midwest	53	31	15	49	29	−37

TABLE 9

WELFARE LOSSES FROM DROPPING IMPROVEMENTS (PERCENTAGE DECREASE IN INCOME AN 1860 HOUSEHOLD IS WILLING TO SUFFER TO AVOID EQUILIBRIUM WHERE WE ADOPT THE FOLLOWING IMPROVEMENTS)

	Drop All Improvements	Drop Only Transport TFP	Drop Only Nontransport TFP	Drop Only Land Improvement	Drop Only Population
Northeast	17	8	12	11	−12
Midwest	36	17	24	24	−25

With these new parameters, we ask what are the welfare gains from adopting improvements? The parameters in 1860 are as above. In particular, we change T_{WE} from 0.40 to 0.55 and change T_{EW} from 0.50 to 0.70. The results of this exercise are given in Table 8.

We see that if there had been no transport improvements (but the other three changes), welfare gains would have been about 60% of the welfare gains from all four changes (9% as compared to 15% for Northeast households, or 60%, and 31% as compared to 53% for Midwest households, or 58%).

How about the welfare increase from improving transport TFP alone? Welfare increases would have been about 25% of the welfare gains from all four changes (4/15 and 15/53). Again, these are smaller than those in Table 6, but still important.

8.2. *Welfare Losses from Dropping Improvements.* Next, we imagine that we are in 1860 and ask: What are the welfare losses from dropping improvements? We explore this method because it is similar to the exercise conducted by Fogel (1979).

Consider the welfare loss of moving from Λ_2 to Λ_1. Again, Λ_2 denotes the vector of model parameters in 1860, with utility $u_E(\Lambda_2) = u_W(\Lambda_2)$, and prices and incomes $p_E(\Lambda_2)$ and $p_W(\Lambda_2)$, and $y_E(\Lambda_2)$ and $y_W(\Lambda_2)$. Changing the parameter vector from Λ_2 to Λ_1 results in a new equilibrium with utilities $u_E(\Lambda_1) = u_W(\Lambda_1)$. We ask: What (lower) income is an 1860 household willing to accept to avoid the equilibrium with utilities $u_E(\Lambda_1) = u_W(\Lambda_1)$? These incomes will depend on region, and we call them $\widetilde{y}_E$ and $\widetilde{y}_W$. The households are then willing to give up income (in percentage terms)

$$(14) \qquad \frac{\widetilde{y}_E - y_E(\Lambda_2)}{y_E(\Lambda_2)} \times 100 \quad \text{and} \quad \frac{\widetilde{y}_W - y_W(\Lambda_2)}{y_W(\Lambda_2)} \times 100,$$

where these numbers are negative.

In Table 9, we present the absolute values of the ratios in (14) in column 1, which are 17 and 36 for the Northeast and Midwest, respectively. Now, let us drop the transport improvements, that is, move from Λ_2 to Λ_3. This results in a new equilibrium with utilities $u_E(\Lambda_3) = u_W(\Lambda_3)$. We can again calculate the terms in Equation (14). In Table 9, we present the ratios in (14) in column 2. The rest of the table is constructed in a similar way.

How do the welfare gains in Table 6 compare to the welfare losses in Table 9? The welfare losses in Table 9 are smaller than the welfare gains in Table 6. Yet, the conclusion that transportation is important for welfare is similar. If we drop transportation improvements alone (Table 9, column 2), the welfare loss is nearly half of the welfare loss if we dropped all improvements (Table 9, column 1), namely, 8% as compared to 17% for Northeast households and 17% as compared to 36% for Midwest households.

8.3. *Welfare Gains from Transportation Improvements: Direct versus General Equilibrium.* The welfare gains from transportation improvements can be thought of as composed of two parts: the *direct* gains and the *general equilibrium* gains. The direct gains consist of the reduced spoilage of goods that results if no decisions are changed (that is, if no household changes location and no household changes the sector in which members work). The general equilibrium gains consist of those that follow from allowing these decisions to be changed. The *overall* welfare gains, then, are the sum of the direct gains and the general equilibrium gains.

Consider the welfare gains of adopting new transportation technology (by itself), that is, the gains in Table 6, column 3. Again, these are the gains of moving from Λ_1 to Λ_4. We calculate the direct gains as follows: Because there is less wasting of goods, more manufactures arrive in the Midwest than before. Let us assume that all these extra manufactures are consumed. That is, none of it is used as intermediates in the agricultural sector. So, the utility of the households in the Midwest increases since they consume more manufactures (and the same food and services). Call this new utility level $\widehat{u}_W(\Lambda_4)$ (where recall $u_W(\Lambda_4)$ was the utility when we did not restrict household decisions). Similarly, more agricultural goods arrive in the Northeast. So, the utility of the households in the Northeast increases since they consume more agricultural goods (and the same manufactures and services). Call this new utility level $\widehat{u}_E(\Lambda_4)$. These utilities $\widehat{u}_E(\Lambda_4)$ and $\widehat{u}_W(\Lambda_4)$ will not be same.

Now, we ask: How much income would a person need in the original equilibrium with Λ_1 to get the same welfare as in the direct gain case above, that is, $\widehat{u}_E(\Lambda_4)$ and $\widehat{u}_W(\Lambda_4)$? Let us say the answer is $\widehat{y}_W$ and $\widehat{y}_E$. Then they would need a percentage increase of

$$(15) \qquad \frac{\widehat{y}_E - y_E(\Lambda_1)}{y_E(\Lambda_1)} \times 100 \quad \text{and} \quad \frac{\widehat{y}_W - y_W(\Lambda_1)}{y_W(\Lambda_1)} \times 100,$$

where these are the direct gains.

In the Northeast, the direct gain is 3%. The overall gain is 6%. Hence, for households in the Northeast, the general equilibrium gain (the overall welfare gain minus the direct gain) is half of the overall gain. In the Midwest, the direct gain is 13%. The overall gain is 19%. Hence, for households in the Midwest, the general equilibrium gain is 6%, almost a third of the overall gain.

We can do a similar exercise in the case of welfare losses. Consider dropping the transportation TFP (by itself). Again, these are the losses of moving from Λ_2 to Λ_3. We calculate the direct losses as follows: Because there is more wasting of goods, less manufactures arrive in the Midwest than before. Let us assume that lost manufacturing is taken from consumption. That is, none of it is taken from the intermediates in the agricultural sector. So, the utility of the households in the Midwest falls since they consume less manufactures (and the same food and services). Call this new utility level $\widehat{u}_W(\Lambda_3)$ (where recall $u_W(\Lambda_3)$ was the utility when we did not restrict household decisions). Similarly, less agricultural goods arrive in the Northeast. So, the utility of the households in the Northeast decreases since they consume less agricultural goods (and the same manufactures and services). Call this new utility level $\widehat{u}_E(\Lambda_3)$.

Now, we ask: What lower income would a household be willing to take in the original equilibrium with Λ_2 and still get the same welfare as in the direct loss case above, that is, $\widehat{u}_E(\Lambda_3)$ and $\widehat{u}_W(\Lambda_3)$? Let us say the answer is $\widehat{y}_W$ and $\widehat{y}_E$. Then, they would face a percentage decrease of

$$(16) \qquad \frac{\widehat{y}_E - y_E(\Lambda_2)}{y_E(\Lambda_2)} \times 100 \quad \text{and} \quad \frac{\widehat{y}_W - y_W(\Lambda_2)}{y_W(\Lambda_2)} \times 100,$$

where we take absolute values to put it in loss terms.

First, note that we actually might not be able to make this calculation. For example, it may turn out that the agricultural goods that are shipped from the Midwest to the Northeast may not be large enough to cover the minimum consumption level of Northeast households. Second, note that when we can make these calculations, the direct welfare losses are going to be bigger than the overall welfare losses.

It turns out that we cannot calculate the direct welfare loss in our calibrated model. The agricultural goods that are shipped from the Midwest to the Northeast are not, in fact, large enough to cover the minimum consumption level of Northeast households.[21]

Finally, we are now in a position to describe in more detail the exercise that Fogel conducted. His counterfactual was to imagine dropping some transportation improvements (in particular, railroads). He did not make calculations based on utilities as we did above. Rather, he asked how much extra cost would be involved in making the shipments that were originally made (when all the transport improvements were available) but now using all improvements except railroads. This is similar to the direct loss we defined above, though, again, it was an extra cost calculation (or dollar calculation). Fogel argued that his calculation was an upper bound to the loss.

9. CONCLUSIONS

We returned to two old questions regarding the 19th century U.S. transportation revolution. Using a simple, quantitative general equilibrium model, we have found that transportation improvements were indeed the key force behind the large changes in the distribution of population across U.S. regions and, within regions, for the changes in industry structure (as North, 1965, had argued).

We also explored the welfare gains from the transportation improvements. Fogel (1979) conjectured that *combined* 19th century U.S. transportation improvements were likely an important part of welfare gains. Our analysis provides support for this for the period 1840–1860.[22]

REFERENCES

ADAMOPOULOS, T., "Transportation Costs, Agricultural Productivity, and Cross-Country Income Differences," Mimeo, University of York, Toronto, 2005.

BASU, S., AND J. G. FERNALD, "Returns to Scale in U.S. Production: Estimates and Implications," *Journal of Political Economy* 105 (1997), 249–83.

CASELLI, F., AND W. J. COLEMAN, II, "The U.S. Structural Transformation and Regional Convergence: A Reinterpretation," *Journal of Political Economy* 109 (2001), 584–616.

COELHO, P. R. P., AND J. F. SHEPHERD, "Regional Differences in Real Wages: The United States 1851–1880," *Explorations in Economic History* 13 (1976), 203–30.

DONALDSON, D., "Railroads of the Raj: Estimating the Economic Impact of Transportation Infrastructure," Job Market Paper, 2009.

EASTERLIN, R. A., "Interregional Differences in Per Capita Income, Population, and Total Income, 1840–1950," in *Trends in the American Economy in the Nineteenth Century*, NBER Studies in Income and Wealth (Princeton, NJ: Princeton University Press, 1960).

FERRIE, J., "Migration to the Frontier in Mid-Nineteenth Century America: A Re-Examination of Turner's 'Safety Valve'," Working Paper, Northwestern University, 1997.

FISHLOW, A., "Antebellum Interregional Trade Reconsidered," *American Economic Review* (Papers and Proceedings) 54 (1964), 352–64.

———, *American Railroads and the Transformation of the Antebellum Economy* (Cambridge, MA: Harvard University Press, 1965).

FOGEL, R., "Notes on the Social Savings Controversy," *Journal of Economic History* 39 (1979), 1–54.

[21] We could, of course, calculate the direct loss if there was a "small" enough drop in transport TFP.

[22] Again, Fogel's famous argument was that the extra benefits that railroads provided over canals (and all the other improvements) was not great. In other words, he argued that canals (and the rest) were good substitutes for railroads. Holmes and Schmitz (2001) argued that Fogel underestimated the benefit of the railroads since he ignored that railroads introduced greater competition into the transport industry, which led to lower prices and better technology in the other transportation sectors (mainly transportation by water).

FUJITA, M., P. KRUGMAN, AND A. J. VENABLES, *The Spatial Economy: Cities, Regions, and International Trade* (Cambridge, MA: MIT Press, 1999).

GALLMAN, R. E., "American Economic Growth before the Civil War: The Testimony of the Capital Stock Estimates," in R. E. Gallman and J. J. Wallis, eds., *The Standard of Living in Early 19th Century America* (Chicago: University of Chicago Press, 1992).

———, "The U.S. Capital Stock in the 19th Century," Mimeo, University of North Carolina at Chapel Hill, 1996.

GREENWOOD, J., AND A. SESHADRI, "The U.S. Demographic Transition," *American Economic Review* (Papers and Proceedings) 92 (2002), 153–9.

HARLEY, C. K., "Transportation, the World Wheat Trade, and the Kuznets Cycle, 1850–1913," *Explorations in Economic History* 17 (1980), 218–50.

HARRIS, J. R., AND M. P. TODARO, "Migration, Unemployment and Development: A Two-Sector Analysis," *American Economic Review* 60 (1970), 126–42.

HOLMES, T. J., AND J. A. SCHMITZ, JR., "Competition at Work: Railroads vs. Monopoly in the U.S. Shipping Industry," *Federal Reserve Bank of Minneapolis Quarterly Review* 25 (2001), 3–29.

HUNTER, L., *A History of Industrial Power in the United States, 1780–1930, Vol. 1, Water Power in the Century of the Steam Engine* (Charlottesville, VA: University of Virginia Press, 1979).

JORGENSON, D. W., "The Development of a Dual Economy," *Economic Journal* 71 (1961), 309–34.

KIM, S., AND R. A. MARGO, "Historical Perspectives on U.S. Economic Geography," in J. V. Henderson and J. F. Thisse, eds., *Handbook of Regional and Urban Economics*, Volume 4 (Amsterdam, The Netherlands: Elsevier, 2004).

KONGSAMUT, P., S. REBELO, AND D. XIE, "Beyond Balanced Growth," *Review of Economic Studies* 68 (2001), 869–82.

LAGAKOS, D., "Superstores or Mom and Pops? Technology Adoption and Productivity Differences in Retail Trade," Working Paper, Arizona State University, 2009.

LEWIS, W. A., "Economic Development with Unlimited Supplies of Labour," *Manchester School of Economic and Social Studies* 22 (1954), 139–91.

MARGO, R. A., "Regional Wage Gaps and the Settlement of the Midwest," *Explorations in Economic History* 36 (1999), 128–43.

MATSUYAMA, K., "Structural Change in an Interdependent World: A Global View of Manufacturing Decline," *Journal of the European Economic Association* 7 (2009), 478–86.

MOURMOURAS, A., AND P. RANGAZAS, "Reconciling Kuznets and Habbakuk in a Unified Growth Theory," *Journal of Economic Growth* 14 (2009), 149–81.

MUNDLAK, Y., "Economic Growth: Lessons from Two Centuries of American Agriculture," *Journal of Economic Literature* 43 (2005), 989–1024.

NORTH, D. C., "The Role of Transportation in the Economic Development of North America," paper presented at the International Congress of the Historical Sciences, Vienna, August 1965, and published in *Les grandes voies maritimes dans le monde*, XVe–XIXe siecles (Paris: L'École des Hautes Études en Sciences Sociales, 1965).

PARKER, W. N., AND J. V. KLEIN, "Productivity Growth in Grain Production in the United States, 1840–60 and 1900–10," in D. S. Brady, ed., *Output, Employment, and Productivity in the United States after 1800*, Vol. 30 (New York: National Bureau of Economic Research, 1966).

SCHMITZ, J. A., JR., "Nineteenth Century U.S. Economic Growth: How Important Was the Transportation Revolution?" Mimeo, Federal Reserve Bank of Minneapolis, 2003.

SLAUGHTER, M. J., "Does Trade Liberalization Converge Factor Prices? Evidence from the Antebellum Transportation Revolution," *Journal of International Trade and Development* 10 (2001), 339–62.

TAYLOR, G. R., *The Transportation Revolution, 1815–1860, The Economic History of the United States*, Vol. 4 (New York: Holt, Rinehart, and Winston, 1964).

TUNELL, G. G., "Appendix to the Diversion of the Flour and Grain Traffic from the Great Lakes to the Railroads," *Journal of Political Economy* 5 (1897), 413–20.

VALENTINYI, A., AND B. HERRENDORF, "Measuring Factor Income Shares at the Sectoral Level," *Review of Economic Dynamics* 11 (2008), 820–35.

VANDENBROUCKE, G., "The U.S. Westward Expansion," *International Economic Review* 49 (2008), 81–110.

WEISS, T., "The Farm Labor Force by Region, 1820–1860: Revised Estimates and Implications for Growth," Working Paper 2438, National Bureau of Economic Research, 1987.

———, "U.S. Labor Force Estimates and Economic Growth, 1800–1860," in R. E. Gallman and J. J. Wallis, eds., *The Standard of Living in Early 19th Century America* (Chicago: University of Chicago Press, 1992).

YI, K.-M., AND J. ZHANG, "Structural Change in an Open Economy," Staff Report 456, Federal Reserve Bank of Minneapolis, February 2011.