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Transportation and Development: Insights from the U.S. 1840–1860*

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Abstract

We study the effects of large transportation costs on economic development. Since reliable data for developing countries are hard to come by, we go back in time to the Midwest and the Northeast of the U.S. This is a natural case to study because starting from 1840 decent data is available showing that the two regions shared key characteristics with today's developing countries and that transportation costs were large and then came way down. To disentangle the effects of the large reduction in transportation costs from those of other changes that happened during 1840–1860, we build a model that speaks to the distribution of people across regions and across the sectors of production. We find that the large reduction in transportation costs was a quantitatively important force behind the settlement of the Midwest and the regional specialization that concentrated agriculture in the Midwest and industry in the Northeast. Moreover, we find that it led to the convergence of the regional per capita incomes measured in current regional prices and that it increased real GDP per capita. However, the increase in real GDP per capita is considerably smaller than that resulting from the productivity growth in the nontransportation sectors.

Keywords: regional income convergence; settlement; structural transformation; transportation costs.
JEL classification: O11; O18; O41.

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1 Introduction

Many observers have argued that large transportation costs are an important problem of developing countries; see for example Booth et al. (2000) and the references therein. However, it challenging to quantify the effects of large transportation costs because reliable data from these countries are hard to come by. In this paper, we argue that the Midwest and the Northeast of the U.S. before the Civil War provide a natural case to study. Starting from 1840 decent data are available showing that in 1840 transportation costs were very large and that the majorities of the two regional labor forces worked in agriculture, as is the case in today's developing countries. In the twenty years between 1840 and 1860, transportation costs then came way down as a result of the construction of the railways.[1] During the same time period, real GDP per capita grew strongly and the distributions of people across the two regions and across the sectors of production changed considerably. Specifically, the northeastern labor force moved from agriculture to industry and services ("structural transformation") and the midwestern labor force grew very strongly ("settlement").

While the large reduction in transportation costs is likely to be an important force behind these changes, we cannot directly infer from the data how important it actually was. The simple reason is that, in addition to it, labor productivity grew strongly in the non–transportation sectors, the total labor force exploded, and the available western farm land increased by a lot. To disentangle the effects of the large reduction in transportation costs from those of these other changes, we build a model of the Midwest and the Northeast. Naturally, we require our model to account for the stylized facts reported above, and so it needs to speak to the distributions of people across the two regions and across the sectors of production within each region. Off–the–shelves models cannot deliver this because they only look at one of these dimensions. For example, economic geography models only look at the distribution of people across locations and structural

[1] Taylor (1964), Fishlow (1965), and North (1965) provide detailed accounts of the transportation revolution that happened in the U.S. before the civil war.

transformation models only look at the distribution of people across sectors.

Our model has the following key features. First, the Midwest has a comparative advantage in agriculture and the Northeast has a comparative advantage in industry, reflecting that farm land 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 and the size of transportation costs determines how much they actually trade with each other. Second, people are ex–ante identical and without paying a cost they choose in which region to locate and in which sector to work. In equilibrium, the wages in the different sectors of each region will be equalized and the regional living standards will be equalized as well. 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 on. As in Kongsamut et al. (2001), this leads to structural transformation when GDP grows.

We restrict our model to be consistent with the key facts from 1840, in particular that transportation costs were large. We then establish that it delivers the structural transformation in the Northeast and the settlement of the Midwest when we feed in the large reduction in transportation costs together with the changes that happened outside of transportation during 1840–1860. This gives us confidence that we have build a reasonable model of the Midwest and the Northeast during 1840–1860 from which we can learn about the effects of large transportation costs.

Feeding into our model the large observed reduction in transportation costs alone while keeping everything else the same, we find that it has two main effects. First, the large observed reduction in transportation costs is a quantitatively important force behind the structural transformation in the Northeast and the settlement of the Midwest. Specifically, it increases industrial production in the Northeast, it shifts agricultural production to the midwestern farm land, and it draws the labor force from the Northeast to the Midwest. Second, the large reduction in transportation costs affects per capita income in two important ways. Specifically, it leads to the convergence of the regional per capita incomes measured in current regional prices and it increases real GDP per capita. However, the increase in real GDP per capita is considerably less than that resulting from the labor productivity growth in the nontransportation sectors. This leads us to be skeptical about whether cross–country differences in transportation costs can account for the observed large cross–country disparities in real GDP per capita.

The intuition for the effects on the distributions of people across regions and sectors of production comes from international trade theory. Specifically, the principle of comparative advantage implies that as transportation costs fall each region specializes in its comparative advantage, that is, agriculture in the Midwest and industry in the Northeast. Since people can choose in which region to live, we have an additional effect here that is absent in international trade theory: as transportation costs fall, the vast midwestern farm land becomes more accessible and both the labor force and the agricultural production shift even more to the Midwest.

The intuition for the effects on income is somewhat more involved. We start with the level effects of large transportation costs on regional per capita incomes. Our model matches the fact that in 1840 midwestern income per capita measured in current regional prices was about half of that in the Northeast [Easterlin (1960)]. At first sight this seems to contradict the fact that in the equilibrium of our model utility is equalized across the two regions and in terms of purchasing power regional per capita incomes are the same.[2] However, there is no contradiction because the dollar income needed in the Midwest to buy a given utility is much lower than in the Northeast. The reason is that food is the main consumption good and food is much cheaper in the Midwest. This comes about because the Midwest exports exports food and transportation costs are large. These arguments also imply that as transportation come down, the difference in regional prices disappears and measured in current regional prices regional incomes per capita converge to each other.

In sum, we find that although there is no difference in regional purchasing power, large

[2] 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.

transportation costs lead to large differences in regional incomes per capita measured in current regional prices. This illustrates the importance of purchasing power corrections. While other researchers have also pointed out that purchasing power corrections are important, they typically focus on cross sections of countries and they find that differences in the relative prices of nontradables, in particular services, are key. In contrast, we focus on a cross section of regions and we find that differences in the relative prices of tradables, in particular agricultural goods, are key.

We finish with providing intuition for the effects on real GDP. There are two channels through which the large reduction in transportation costs increases real GDP per capita: fewer resources get used for transporting goods between the regions and agricultural labor productivity increases when agricultural production shifts to the more fertile midwestern farm land. Quantitatively, these two effects remain relatively small though. The reasons are that interregional trade flows are relatively small and that even in agriculture the land share is less than fifty percent. Note that the first statement is a general equilibrium version of the finding of Fogel (1979) that the social savings from the railways are small and the second statement is a version of the result from international trade theory that the static gains from reductions in transportation costs – or tariffs – are small.

The remainder of the paper is organized as follows. In the next section, we review the most closely related literature. In Section 3, we describe the model and define the equilibrium. In Section 4, we restrict our model parameters so as to match key features of the Midwest and the Northeast in 1840. In Section 5, we report our findings on the effects of the large reduction in transportation costs. We conclude in Section 6.

2 Related Literature

To begin with, our work is related to the economic history literature about the settlement of the West. For example, Vandenbroucke (2008) provides a quantitative general equilibrium model which focuses on the settlers' investments in clearing and improving the vast areas of unimproved western farm land. Vandenbroucke 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, agricultural labor productivity, and real GDP.

Our work is also related to the economic history literature that asks why people settled in the Midwest although income per capita was only half of what it was in the Northeast. This is sometimes called the "Easterlin Paradox" in economic history; see Kim and Margo (2004) for further discussion. We emphasize that in our model there is no paradox at all. As we have argued above, regional standards of living are equalized although measured in current regional prices income per capita in the Midwest is only half of what it is in the Northeast.

Our work is also related to that of Caselli and Coleman (2001), who argue that during the hundred years after the civil war falling costs of human capital accumulation account for structural transformation in the South and the catch up of southern with northeastern per capita income. In contrast, we consider the Midwest and the Northeast in the twenty years before the civil war. Since during this period, transportation costs were much larger than afterwards, we therefore focus on them instead of human capital accumulation. One important implication is that in our model regional income convergence occurs only if income is measured in current regional prices. In contrast, in the model of Caselli and Coleman regional income convergence occurs in terms of purchasing power.

Lastly, our work is related to that Adamopoulos (2005), who finds large effects of cross–country differences in infrastructure on GDP per capita. 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 the observable regional price differences to infer how large transportation costs within the U.S. must have been. We emphasize that the 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. In contrast to Adamopoulos, we find that the large observed reduction in transportation costs during 1840–1860 has relatively modest effects on real GDP per capita.

3 Model

Our environment shares key features with standard dual–economy models. In particular, it disaggregates the economy into agriculture and non–agriculture and it introduces two asymmetries between these two sectors: only agriculture uses the fixed factor land and agricultural goods have an income elasticity that is smaller than one whereas nonagricultural goods have an income elasticity that is larger than one.[3] Our environment has two key features that are new. First, there are two regions and the transportation of goods between them is costly. Second, without paying a cost households choose in which region to work and consume. In contrast, in standard dual–economy models households all consume in a hypothetical central location, implying that they all face the same purchase prices.

3.1 Regions

There are two regions indexed by $j \in \mathcal{J} \equiv \{0, 1\}$. We think of region 0 as the Northeast and of region 1 as the Midwest. Region j is endowed with L_j units of land where land is improved land that is ready for farming instead of unimproved land that could be used for farming if it was cleared, broken, and fenced. This difference will turn out to be important when we calibrate the model in Section 4 below.

[3] Lewis (1954) and Jorgenson (1961) developed the first dual–economy models while Harris and Todaro (1970) is the most well known example.

3.2 Preferences and endowments

In each region there are three goods: an agricultural good, an industrial good, and services. The goods are indexed by their type $g \in \mathcal{G} \equiv \{a, i, s\}$ and by their region $j \in \mathcal{J}$. So, c_{a0}, for example, denotes the agricultural good in the Northeast.

There is a measure $N > 0$ of ex ante identical households. Households value the consumption of the three goods according to the utility function:

$$u(c_a, c_i, c_s) = \omega_a \log(c_a - \underline{c}) + \omega_i \log(c_i) + \omega_s \log(c_s), \tag{1}$$

where $\underline{c} > 0$, $\omega_a, \omega_i, \omega_s \in (0, 1)$, and $\omega_a + \omega_i + \omega_s = 1$. The constant term $\underline{c}$ implies that the income elasticity of agricultural goods is less than one ("Engel's law") and the income elasticities of the other two goods are larger than one.[4]

Each household has an endowment of one unit of labor and of an equal share of the land of its region. Thus, if N_j households choose to live in region j, then each one of them gets endowed with L_j/N_j units of region j's land. This implies that the regional GDPs are equal to the regional incomes, which will be convenient later on when we calibrate the model.

3.3 Technologies

Waterpower was an essential input into early 19th century manufacturing, and it was abundant only in the Northeast [Hunter (1979)]. Large–scale manufacturing was therefore done almost only in the Northeast while manufacturing in the Midwest was limited to low–scale production of clothes, basic tools and the like, which mostly took place at home.[5] To capture this in the simplest possible way, we assume that industrial good can

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

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

be produced in the Northeast only. The production function is:

$$Y_{i0} = A_{i0} N_{i0}, \tag{2}$$

where A_{i0} and N_{i0} are total factor productivity (TFP henceforth) 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 has the largest land share by far. We capture this in a stylized way by assuming that agriculture is the only sector that uses land. The production function in region $j \in \mathcal{J}$ is:

$$Y_{aj} = A_{aj} Z_j^{\theta_z} N_{aj}^{\theta_n} L_j^{\theta_l}, \tag{3}$$

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:

$$Y_{sj} = A_{sj} N_{sj}, \tag{4}$$

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 industrial goods can be transported subject to an iceberg cost. Specifically, if B_j units of one of these two goods are boarded in region j, then

$$D_{j'} = \mathcal{T}_{jj'} B_j$$

units are delivered to region $j' \neq j$ where $\mathcal{T}_{jj'} \in (0,1)$ is the TFP of transporting goods from region j to j'. Note that we do not impose the restriction $\mathcal{T}_{jj'} = \mathcal{T}_{j'j}$ because transportation costs may differ depending on which goods are transported on the two different routes.

We assume that there are no costs of transporting households between the two regions. This is a natural benchmark that will simplify matters greatly. We should mention that this eliminates a margin that would be helpful when we ask our model to match the observed distribution of people between the two regions. This will not be crucial, however, because we can adjust the service TFPs in the two regions instead. To see this, 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 then just need to reduce the service TFP in the Midwest.

3.4 Equilibrium

We want to study interior equilibrium, so the agricultural TFPs have to be sufficiently large such that the economy can produce $c_{aj} > \underline{c}$ for both regions. Households will then consume all goods because our utility function satisfies the Inada conditions. This implies that at least one agricultural technology, the manufacturing technology, and both service technologies are operated in equilibrium. Since land in each region is a given fixed factor, the other agricultural technologies will be operated too.

We start with the market clearing conditions. For labor, land, and services they are straightforward. In particular, in each region, rented labor equals the number of households living there and rented land equals the land endowment there. Moreover,

$$c_{sj} N_j = A_{sj} N_{sj}, \tag{5}$$

where

$$N_0 \equiv N_{a0} + N_{i0} + N_{s0},$$
$$N_1 \equiv N_{a1} + N_{s1}.$$

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

$$N_0 c_{a0} = A_{a0} Z_0^{\theta_z} N_{a0}^{\theta_n} L_0^{\theta_l} + D_0, \tag{6}$$
$$N_1 c_{a1} + B_1 = A_{a1} Z_1^{\theta_z} N_{a1}^{\theta_n} L_1^{\theta_l}, \tag{7}$$
$$N_0 c_{i0} + Z_0 + B_0 = A_{i0} N_{i0}, \tag{8}$$
$$N_1 c_{i1} + Z_1 = D_1. \tag{9}$$

(6) and (7) say that in each region the total agricultural consumption plus the boarded quantities (left–hand side) equals the production plus the deliveries from the other region (right–hand side). (8) says that in region 0 the total industrial consumption plus the intermediate goods plus the boarded quantities (left–hand side) equal the production (right–hand side). (9) says that in region 1 the total industrial consumption plus the intermediate goods (left–hand side) equal the deliveries from region 0 (right–hand side).

We assume that there is perfect competition in all sectors. The profit maximization problems of the competitive goods producers are familiar, so we skip them here. The profit maximization problems of the competitive transportation firms may not be so familiar, so we spend some time on them now. Consider first a representative firm that transports agricultural goods from region 1 to region 0. Given prices, it maximizes the revenue from delivered quantities minus the costs from boarded quantities subject to the transportation technology. Choosing the agricultural good in region 0 as the numeraire, this problem can be written as:

$$\max_{B_1,D_0} D_0 - p_{a1}B_1 \quad s.t. \quad D_0 = \mathcal{T}_{10}B_1. \tag{10}$$

Similarly, a representative firm that transports industrial goods from region 0 to region 1 solves:

$$\max_{B_0,D_1} p_{i1}D_1 - p_{i0}B_0 \quad s.t. \quad D_1 = \mathcal{T}_{01}B_0. \tag{11}$$

The first–order conditions to these problems imply that

$$p_{a1} = \mathcal{T}_{10}p_{a0}, \tag{12}$$

$$p_{i0} = \mathcal{T}_{01}p_{i1}. \tag{13}$$

This implies that $p_{a1} < p_{a1}$ and $p_{i0} < p_{i1}$, as Figure 1 in Appendix C illustrates.

Using (10)–(11), we can eliminate boarded and delivered quantities from (6)–(9). This leads to the aggregate feasibility constraints for the two goods:

$$\mathcal{T}_{10}^{-1}N_0c_{a0} + N_1c_{a1} = \mathcal{T}_{10}^{-1}A_{a0}Z_0^{\theta_z}N_{a0}^{\theta_n}L_0^{\theta_l} + A_{a1}Z_1^{\theta_z}N_{a1}^{\theta_n}L_1^{\theta_l}, \tag{14}$$

$$(N_0c_{i0} + Z_0) + \mathcal{T}_{01}^{-1}(N_1c_{i1} + Z_1) = A_{i0}N_{i0}. \tag{15}$$

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

Definition 1 *A competitive equilibrium is a list of*

- *prices of final goods, rental rates of labor and land in each region,* $p_{a1}, \{p_{ij}, p_{sj}, p_{nj}, p_{lj}\}_{j\in\mathcal{J}}$,[6]

- *consumption in each region,* $\{c_{aj}, c_{ij}, c_{sj}\}_{j\in\mathcal{J}}$,

- *location choices (with* N_j *households choosing region* j*),*

- *labor in each region,* $\{N_{a0}, N_{i0}, N_{s0}\}$ *and* $\{N_{a1}, N_{s1}\}$

- *intermediate goods and land in each region,* $\{Z_j, L_j\}_{j\in\mathcal{J}}$

- *boarded and delivered quantities in each region,* $\{B_j, D_j\}$

such that

- *given prices and regions, households' consumption choices maximize their utilities*

- *given prices*

  - *households choices of region maximize their indirect utilities*

  - *firms' choices maximize profits*

- *markets clear*

- *the labor forces in each region add up to the region's population*

- *the populations of the two regions add up to the total population*

In Appendix A, we derive the conditions for an interior equilibrium in which all technologies are operated. Although we have kept our model as simple as possible, it does not have a closed–form solution. We therefore calibrate it in the next section. Afterwards, we will solve it numerically to study the effects of the large reduction in transportation costs.

[6]We do not list the price of intermediate goods, because in equilibrium $p_{ij} = p_{zj}$.

4 Restricting the Model Parameters

We now restrict the parameters of our model such that it is consistent with the fact that in 1840 the Midwest and the Northeast shared key characteristics with today's developing countries.

4.1 Basic definitions and normalizations

We follow the Census and identify the Northeast with New England and Middle Atlantic and the Midwest with East and West North Central. Figure 2 in Appendix C shows which states belong to these Census regions.[7]

We need to calibrate the following parameters: the preference parameters $\underline{c}, \omega_a, \omega_i, \omega_s$; the technology parameters $A_{i0}, A_{a0}, A_{a1}, A_{s0}, A_{s1}, \mathcal{T}_{01}, \mathcal{T}_{10}$ and $\theta_z, \theta_n, \theta_l$; the endowments L_0, L_1 with land (where land means improved land that is ready for farming); the size N of the total labor force where total means Midwest plus Northeast. These are seventeen parameters.

Several normalizations reduce the number of parameters to ten. To begin with, recall that $\omega_a + \omega_i + \omega_s = 1$ 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: $A_{a0} = A_{i0} = A_{s0} = L_0 = N = 1$. 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 ten parameters to calibrate:

$$\underline{c}, \omega_a, \omega_i; \quad A_{a1}, A_{s1}, \mathcal{T}_{01}, \mathcal{T}_{10}, \theta_z, \theta_n; \quad L_1.$$

[7] 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. Moreover, the Midwest and the Northeast traded much more with each other than each of them traded with the South [Fishlow (1964)].

4.2 Parameters we calibrate individually

We start with the calibration of L_1, that is, midwestern land that was farmed in 1840. Gallman (1996) reported that this was 54% of northeastern farmed land. Given the normalization $L_0 = 1$, we therefore set $L_1 = 0.54$.

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 share cropping 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 share croppers used. Moreover, share cropping 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 fifty percent, which seems reasonable.[8]

We turn to the calibration of the transportation TFPs $\mathcal{T}_{jj'}$. Recall that in equilibrium

$$p_{a1} = \mathcal{T}_{10} p_{a0},$$

$$p_{i0} = \mathcal{T}_{01} p_{i1}.$$

To calibrate $\mathcal{T}_{10}$, we use data about regional differences in the prices of agricultural goods. In Tables B-2, Easterlin (1960) reported regional average price data from Tucker for 1840–1843 and Seaman for 1840–1846. These data imply large regional price differences: the prices in the Midwest relative to the Northeast were 0.4–0.57 for wheat and 0.24–0.4 for corn. Easterlin (1960) also reported that according to the Patent Office, in 1848 the regional prices of pork relative to the Northeast were 0.4–0.45 in Indiana/Illinois and 0.36–0.4 in Iowa/Missouri. Since theses numbers are averages over 1840–1848 when

[8] 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)].

transportation costs were falling rapidly, the actual price differences in 1840 were larger still. We therefore choose $\mathcal{T}_{10}$ for 1840 such that the implied regional price differences are at the high end of the reported range: $\mathcal{T}_{10} = 0.35$. This implies that the food price in the Northeast is around three times larger than in the Midwest.

Unfortunately, we do not have similarly detailed price information for industrial goods. All we know is that transporting industrial goods was less costly than agricultural goods (grains rot more than nails rust and livestock may die altogether). We capture this by choosing $\mathcal{T}_{01} = 0.5$ in 1840. We emphasize that our findings are not sensitive to this particular choice of $\mathcal{T}_{01}$. The reason is that the share of industrial goods in GDP was small in 1840.

4.3 Parameters we calibrate jointly

At this point, we are left with five parameters to calibrate: $\omega_a, \omega_i, \underline{c}, A_{a1}, A_{s1}$. 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) the shares of the northeastern and the midwestern labor forces in agriculture as reported by Weiss (1987);[9] (iii) midwestern over northeastern GDP per worker in current regional prices as reported by Easterlin (1960); (iv) midwestern over northeastern real agricultural labor productivity, which we calculated from the data reported by Parker and Klein (1966).[10]

Table 1 shows that we hit the targets well. In particular, as in the data, the Midwest

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

[10] The data in Parker and Klein 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 Parker and Klein report in each grain for the end of the nineteenth 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

	Data	Model
	1840	
Share of tot. LF in MW	0.31	0.31
Share of NE LF in agr.	0.54	0.53
Share of MW LF in agr.	0.77	0.77
GDP per worker in MW rel. to NE	0.52	0.51
Agr. lab. prod. in MW rel. to NE	1.3	1.32

in the model has much lower income per capita than the Northeast measured in current regional prices. There are two reason for this: food is the main consumption good for which a typical household spent most of its budget; food is much cheaper in the Midwest than in the Northeast, because the Midwest exports it to Northeast and transportation costs are large. To buy the same living standard, an average midwestern worker then needs a much lower dollar income that an average northeastern worker.

We emphasize that by construction the regional income differences our model generates do not at all reflect differences in the regional standards of living. This is consistent with the evidence presented by Coelho and Shepherd (1976) and Margo (1999). Studying monthly civilian payroll data for U.S. army posts, they found that dollar wages of selected occupations were considerably lower in the Midwest while purchasing power adjusted wages were slightly higher.

Beyond the relevance for our calibration, it is important to realize that large transportation costs can lead to large differences in regional incomes per capita measured in regional prices although measured in terms of purchasing power there are no income differences whatsoever. While many researchers have stressed the importance of purchasing power corrections, they typically focus on cross sections of countries instead of cross sections of regions of a country. These researchers find that differences in the relative prices of nontradables, in particular services, are key. In contrast, we find that differences in the relative prices of tradables, in particular agricultural goods, are key.

Table 2 shows the calibrated parameter values other than the five normalizations. Two parameter values are noteworthy. First, A_{a1} comes out 55% higher than A_{a0}. This reflects that land in the Midwest is of much 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_{s1} comes out at only 18% of A_{s0}. This low value is likely to capture 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.

Table 2: Calibrated parameter values

$\underline{c}$	ω_a	ω_i	ω_s	A_{a1}	A_{s1}	$\mathcal{T}_{10}$	$\mathcal{T}_{01}$	θ_z	θ_n	θ_l	L_1
0.65	0.17	0.44	0.39	1.55	0.18	0.35	0.5	0.2	0.5	0.3	0.54

4.4 Generating the midwestern settlement and the northeastern structural transformation

Before we study the effects of the large reduction in transportation costs in isolation, we show that our model can generate the settlement of the Midwest and the structural transformation of the Northeast. To this end, we need to feed in the

the strong labor productivity growth in the non–transportation sectors, the large increase in the total labor force exploded and in the available western farm land. We start by quantifying these changes.

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 reduced transportation costs further [Holmes and Schmitz Jr. (2001)]. Chart IV in North (1965) illustrates the large resulting drop in inland freight rates on the railways.

To quantify how large the reduction in transportation costs between the Midwest and the Northeast was, we use information about the change in the regional prices. To begin with, Berry (1945) documents the price of agricultural goods relative to nonagricultural goods both in Cincinnati and New York. He finds that relative price between these two locations converged considerably between 1840 and 1860. While this is indicative, it does not help us to quantify the reduction in transportation costs, because Cincinnati is located in the Ohio valley. That implies that it had been accessible by river transport long before the railways came. Moreover, as Mak and Walton (1972) document, the major improvement in the TFP of river transport happened way before 1840 when the steamboat was introduced in the 1820s.

More relevant for our purpose here are the price differences between New York City and locations west of Cincinnati that Table 1.A. of Harley (1980) reports. In particular, in the middle of the 1850s the wheat prices on the midwestern farms relative to the New York farm prices 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, we set $\mathcal{T}_{10}(1860) = 0.55$. Since again we do not have comparable price data for industrial goods, we assume that transportation TFP improved by the same amount in both directions, so we set $\mathcal{T}_{01}(1860) = 0.70$.

We continue by quantifying the strong labor productivity growth in the non–transportation sectors and the large increases in the total labor force and the available western farm land. Gallman (1992) estimates that aggregate TFP increased by 0.82% per year during 1840–1860, or 18% over the whole period. Denoting by $A_{gi}(1840)$ and $A_{gi}(1860)$

the TFPs in the nontransportation sectors, we have:[11]

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

The Census reports that as a result of large immigration flows into the U.S. the labor force of the Midwest and the Northeast more than doubled during 1840–1860:

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

Lastly, Gallman (1996) estimates that the area of improved farm land increased somewhat in the Northeast and a lot in the Midwest:

$$\frac{L_0(1860)}{L_0(1840)} = 1.32, \qquad \frac{L_1(1860)}{L_1(1840)} = 3.27.$$

Table 3: The effects of all changes on where people live and where agricultural production is done

	1840		1860	
	Data	Model	Data	Model
Share of tot. LF in MW	0.31	0.31	0.43	0.43
Share of NE LF in agr.	0.54	0.53	0.33	0.24
Share of MW LF in agr.	0.77	0.77	0.62	0.67

Table 3 reports what happens when we feed into our model the large reduction in transportation costs together with the other three changes. The first two columns repeat Table 1 for comparability. Column 3 reports the 1860 values of the first three targets from Table 1 (we dropped the last two targets because we do not have data on them for 1860). Column 4 shows that our model does a good job at generating the settlement

[11]Gallman's estimate of TFP includes the transportation sector. We ignore this and assume that Gallman's numbers apply also to the sectors other than transportation. Our justification is that the transportation was small in the antebellum period. For example, Broadberry and Irwin (2006) reported that it had around 2% of the labor force. In Appendix B, we offer some robustness analysis to show that our principal conclusions do not depend on this simplification.

of the Midwest and the structural transformation in Northeast. We should mention that compared to the data the model puts too few people into northeastern agriculture and too many people work into midwestern agriculture. The likely reason is that, for simplicity, we have abstracted from small–scale midwestern manufacturing and from the investments required for clearing and improving midwestern farm land. Compared to the data, these abstractions drive somewhat too many people towards northeastern industry and midwestern agriculture.

5 The Development Implications of Large Transportation Costs

We are now ready to study the effects of the large reduction in transportation costs for the development of the Midwest and the Northeast during 1840–1860. We start with its effects for the distributions of people across the two regions and across the sectors of production within each region. Table 4 shows that if we feed in the large reduction in transportation costs while keeping the other variables unchanged, the share of the labor force in the Midwest increases to 0.41. Moreover, the share of the northeastern labor force in agriculture decreases to 0.38 while the share of the northeastern labor force in agriculture hardly changes.

The intuition for these effects comes in three parts. First, the large reduction in transportation costs makes the economy richer. Since the income elasticity of agricultural goods is smaller than one, the consumption share spent on food goes down and agricultural production becomes less important. Second, the large reduction in transportation costs lets the two regions specialize in their area of comparative advantage, that is, the Northeast specializes in manufacturing and the Midwest specializes in agriculture. This is the same effect as that from the reduction in tariffs in international trade theory. Third, since people can move between regions, there is an additional channel that is absent in international trade theory. The reduction in transportation costs makes it cheaper to transport industrial intermediate inputs and manufactured consumption goods to the Midwest. This shifts the labor force and agricultural production even more to the Midwest.

Table 4: The effects of the large reduction in transportation costs on where people live and where agricultural production is done

	1840		1860	
	Data	Model	Data	$\Delta\mathcal{T}_{jj'}$
Share of tot. LF in MW	0.31	0.31	0.43	0.41
Share of NE LF in agr.	0.54	0.53	0.33	0.38
Share of MW LF in agr.	0.77	0.77	0.62	0.76

Although the effects of the other three changes are not the focus of our paper, it is interesting in its own right to understand how they change where people live and where agricultural production is done. Column 4 of Table 5 reports that increasing the TFPs of the nontransportation sectors decreases the shares of the labor force in the Midwest to 0.14 and the shares of the regions' labor forces in agriculture to 0.48 and 0.65, respectively. The reason is that it makes all sectors more productive, so the economy becomes richer. Given nonhomothetic preferences, the consumption share spent on food goes down and the labor force in agriculture and in the Midwest falls. Column 5 of Table 5 reports that increasing the total labor force increases the share of the labor force in the Midwest to 0.52 and the shares of the regions' labor forces in agriculture to 0.60 and 0.96, respectively. The reason is that increasing the total labor force increases the ratio of the labor force to land, which makes the economy poorer. The resulting effects are exactly opposite to previous ones. Column 6 of Table 5 reports that increasing the land endowments decreases the shares of the regions' labor forces in agriculture to 0.42 and 0.68, respectively. This comes about because increasing the land endowments increases agricultural labor productivity and makes the economy richer. Moreover, increasing the land endowments increases the share of the labor force in the Midwest to 0.33. This comes about because most of the new land is in the Midwest. Perhaps surprisingly, these effects remain fairly modest because the land gets raised by the land share of 0.3. This is important to keep in mind for the what we will find about the effects of the large reduction in transportation costs on real GDP per capita.

Table 5: The effects of the changes outside of transportation on where people live and where agricultural production is done

	1840		1860			
	Data	Model	Data	ΔA_{gi}	ΔN	ΔL_j
Share of tot. LF in MW	0.31	0.31	0.43	0.14	0.52	0.33
Share of NE LF in agr.	0.54	0.53	0.33	0.48	0.60	0.42
Share of MW LF in agr.	0.77	0.77	0.62	0.65	0.96	0.68

We continue with the effects of the large reduction in transportation costs on the regions' per capita incomes measured in current regional prices. The evidence reported by Easterlin (1960) suggests that during the second part of the 19th century midwestern income per capita converged considerably to that in the Northeast.[12] We find that in our model transportation costs are an important force behind regional income convergence: the large reduction in transportation costs increases the ratio of the midwestern to north-eastern income per capita from 0.51 to 0.78. The reason for this convergence in regional incomes is that as transportation costs fall the regional prices of tradable goods converge to each other. We stress that there is only convergence if income is measured in current regional prices. In contrast, measured in terms of purchasing power, the regional incomes per capita are equal in our model.

We finish with the effect of the large reduction in transportation costs on real GDP per capita and real agricultural labor productivity. Both variables are weighted averages over the two regions with the respective weights being the relative labor forces and the relative agricultural labor forces. We compute each real variable via the chain index with regional prices in 1840 and 1860 as predicted by our model. To put the effects of transportation costs into perspective, we also report what the changes outside transportation do to the

[12]Unfortunately, Easterlin only reports numbers for 1840 and 1880, but not for 1860.

real variables.

Table 6 shows our findings on real effects. We can see that the large reduction in transportation costs, the increase in the TFP of the non–transportation sectors, and the increase in land all increase real GDP per capita and real agricultural labor productivity. Moreover, the effects of the large reduction in transportation costs pale in comparison to those of the two other changes. We also see that the increase in the population decreases real GDP per capita and real agricultural labor productivity.

The large reduction in transportation costs increases real GDP for two reasons: fewer resources get used for transporting goods between the regions and agricultural productivity increases when production shifts to the more fertile midwestern farm land. Quantitatively, these two effects don't get very large though. The first reason is that interregional trade flows are relatively small. In our model, for example, the Northeast exports only 8.9% of its 1840 GDP to the Midwest. This is a general equilibrium version of the finding of Fogel (1979) that the social savings of the railways are small. The second reason is that even in agriculture the land share is considerably less than fifty percent. This is similar to why the large cross–country differences in the capital stocks translate into relatively small differences in GDP per capita only. This is also similar to the result from international trade theory that the static gains from reductions in tariffs are small.

Table 6: The real effects of the four changes (in growth factors)

	$\Delta\mathcal{T}_{jj'}$	$\Delta\mathcal{A}_{ij}$	ΔL_j	ΔN
GDP per capita	1.06	1.34	1.20	0.77
Agricultural labor productivity	1.01	1.37	1.26	0.64

We should mention that for two reasons the effects of transportation costs may be larger than what we have just reported. As we saw above, the large reduction in transportation costs is one of the major forces behind the settlement of the Midwest, which in turn is closely linked to the expansion of midwestern farm land. One may therefore argue that we should add the real effects of the increase in land to those of the large reduction in transportation costs. If we do this in our model, then real GDP per capita and real agricultural labor productivity increase by factors of 1.20 and 1.32, respectively. While these increases are still smaller than those resulting from the increase in the nontransportation TFPs, they are getting close. The second reason why the effects of transportation costs can be larger than what we reported above is that transportation costs did not fall enough during 1840–1860. We therefore use model to measure what happens when we reduce transportation costs all the way to zero. We find that real GDP per capita increases by a factor 1.29 and real agricultural labor productivity increases by a factor 1.17. Now the effect of transportation costs on real GDP is about the same as that of the increase in the TFPs of the nontransportation sectors. However, it is still orders of magnitude smaller than the observed cross–country disparities in real GDP per capita. This leads us to be skeptical about the importance of cross–country differences in transportation costs for cross–country disparities in real GDP per capita.

6 Conclusion

We have studied the effects of large transportation costs on economic development. Since data for developing countries is limited, we have gone back in time to the Midwest and the Northeast of the U.S. during 1840–1860 when decent data becomes available. We have argues that this is a natural case to study because there was a large reduction in transportation costs and because the two regions shared key characteristics with today's developing countries. To disentangle the effects of the large reduction in transportation costs from those of other important changes that happened during 1840–1860, we have built a model that speaks to the distributions of people across the regions and the sectors of production. We have found that the large reduction in transportation costs was a quantitatively important force behind the settlement of the Midwest and the regional specialization that concentrated the agricultural production in the Midwest and the industrial production in the Northeast. Moreover, we have found that the large reduction in transportation costs led to the convergence of the regional per capita incomes measured in current regional prices. Lastly, we have found that the large reduction in transportation costs increased real GDP per capita, but that this increase was considerably smaller than that resulting from the productivity growth in the nontransportation sectors.

One selling point we have not yet explores is that our model is a fully articulated general equilibrium model that allows us to evaluate welfare and to ask counterfactual questions. An interesting example would be to measure the returns on the large investments that the U.S. government made in the transportation sector before the Civil War. A prominent example is the construction of the Erie canal. We plan to address this issue in future research.

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Appendix A: Characterization of Competitive Equilibrium

To begin with, we have the following 5 feasibility constraints:

$$N_0 = N_{a0} + N_{i0} + N_{s0}, \quad N_1 = N_{a1} + N_{s1}, \quad N = N_0 + N_1, \tag{16}$$

$$c_{s0} N_0 = A_{s0} N_{s0}, \quad c_{s1} N_1 = A_{s1} N_{s1}, \tag{17}$$

$$\mathcal{T}_{10}^{-1} N_0 c_{a0} + N_1 c_{a1} = \mathcal{T}_{10}^{-1} A_{a0} Z_0^{\theta_z} N_{a0}^{\theta_n} L_0^{\theta_l} + A_{a1} Z_1^{\theta_z} N_{a1}^{\theta_n} L_1^{\theta_l}, \tag{18}$$

$$(N_0 c_{i0} + Z_0) + \mathcal{T}_{01}^{-1} (N_1 c_{i1} + Z_1) = A_{i0} N_{i0}. \tag{19}$$

Then, we have the households' budget constraints in the Northeast and the Midwest:

$$c_{a0} + p_{i0} c_{i0} + p_{s0} c_{s0} = (1 - \theta_z) A_{a0} Z_0^{\theta_z} N_{a0}^{\theta_n - 1} L_0^{\theta_l}, \tag{20}$$

$$p_{a1} c_{a1} + p_{i1} c_{i1} + p_{s1} c_{s1} = (1 - \theta_z) p_{a1} A_{a1} Z_1^{\theta_z} N_{a1}^{\theta_n - 1} L_1^{\theta_l}. \tag{21}$$

Moreover, we have 5 first–order conditions from the household problems:

$$\frac{p_{i0} c_{i0}}{p_{a0}(c_{a0} - \underline{c})} = \frac{p_{i1} c_{i1}}{p_{a1}(c_{a1} - \underline{c})} = \frac{\omega_i}{\omega_a}, \tag{22}$$

$$\frac{p_{i0} c_{i0}}{p_{s0} c_{s0}} = \frac{p_{i1} c_{i1}}{p_{s1} c_{s1}} = \frac{\omega_i}{\omega_s}, \tag{23}$$

$$u(c_{a0}, c_{i0}, c_{s0}) = u(c_{a1}, c_{i1}, c_{s1}). \tag{24}$$

Lastly, we have 7 first–order conditions from the firm problems:

$$p_{i0} = p_{i1}\mathcal{T}_{01}, \tag{25}$$

$$p_{a1} = \mathcal{T}_{10}, \tag{26}$$

$$p_{i0} = \theta_z A_{a0} Z_0^{\theta_z - 1} N_{a0}^{\theta_n} L_0^{\theta_l}, \tag{27}$$

$$p_{i1} = p_{a1}\theta_z A_{a1} Z_1^{\theta_z - 1} N_{a1}^{\theta_n} L_1^{\theta_l}, \tag{28}$$

$$p_{i0}A_{i0} = p_{s0}A_{s0} = \theta_n A_{a0} Z_0^{\theta_z} N_{a0}^{\theta_n - 1} L_0^{\theta_l}, \tag{29}$$

$$p_{s1}A_{s1} = p_{a1}\theta_n A_{a1} Z_1^{\theta_z} N_{a1}^{\theta_n - 1} L_1^{\theta_l}. \tag{30}$$

These are 19 equations. Dropping one equation via Walras Law, we arrive at 18 equations in 18 unknowns that characterize the competitive equilibrium.

Appendix B: Robustness

To demonstrate that the robustness of the fact that our model generates the settlement of the Midwest and the structural transformation in the Northeast, we explore two alternatives to using Gallman's estimates TFP growth rates in agriculture, manufacturing and services. The first alternative uses the estimates of Greenwood and Seshadri (2002) of the average annual growth rates of TFP during for the 19th century: 0.49% in agriculture and 0.73% in non–agriculture. The second alternative uses a lower TFP growth rate in agriculture, manufacturing and services than suggested by Gallman: 0.5% per year. The idea behind doing this is that TFP growth was fastest in transportation. This implies that aggregate TFP growth rates of Gallman are larger than the TFP growth rates of agriculture, manufacturing and services.

As we can see from Table 7, our findings are little affected by replacing the parametrization from the body of the text by either scenario. In particular, with each of the three parametrizations the Midwest gets settled and the Northeast industrializes.

Table 7: Settlement and structural transformation – different estimates for the TFP growth rates in agriculture, manufacturing, and services

	Gallman's estimate	Greenwood–Seshadri's estimate	Lower bound estimate
Share of tot. LF in MW	0.43	0.48	0.48
Share of NE LF in agr.	0.24	0.24	0.24
Share of MW LF in agr	0.67	0.70	0.70

Appendix C: Figures

Figure 1: Regional Specialization and Interregional Tradeflows

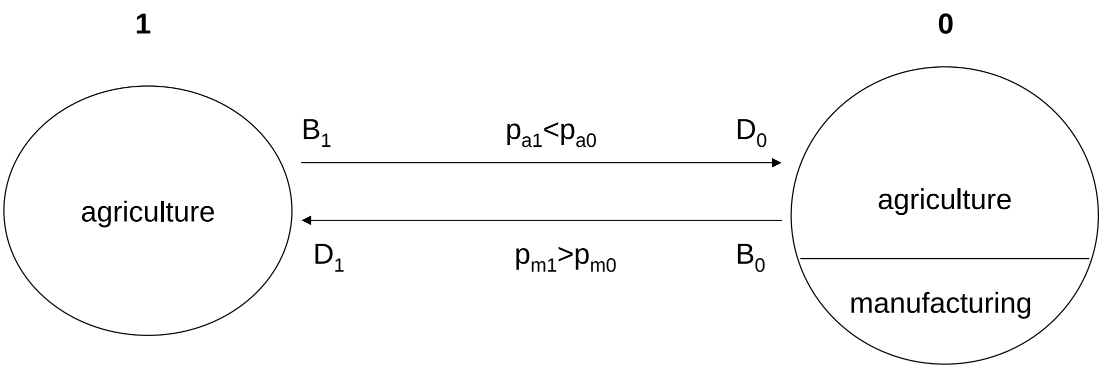

Figure 2: U.S. Geography According to the Census