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Abstract

Regional income inequality within countries is an important contributor to global income inequality. I investigate its relationship with structural change and growth using the historical experience of the United States since 1880. Specifically, I modify an existing multi-sector general equilibrium growth model and highlight two important forces: (1) structural change, which disproportionately benefit poor agricultural regions; and (2) transport cost reductions, which shrinks regional price and wage differences. Consistent with existing research, structural change accounts for the Southern states' convergence to the Northeast. In contrast, I find reductions in transport costs offset the nominal income gains from structural change for the Midwestern states. The Midwest case is of greater relevance for developing countries, given their high internal transportation costs. These results suggest growth in developing countries may not significantly reduce global income inequality.

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1 Introduction

Income inequality within countries is an important and persistent contributor to global income inequality [Bourguignon and Morrisson, 2002]. Geographic and spatial differences, in particular between rural and urban or inland and coastal areas, are for many countries a key source of within-country differences.[1] Recent research may suggest an inverse relationship between within-country regional income inequality and overall economic growth.[2] As growth proceeds, structural change involves farm workers moving to higher productivity non-agricultural activities and rising relative agricultural wages. Both channels will disproportionately benefit average incomes in poorer agriculturally-intensive regions. Caselli and Coleman [2001] confirm this is a dominant driver of convergence between the Southern and Northeastern United States since 1880. In this paper, I examine an alternative US region - the Midwest - that shares an important feature with many developing countries that the US South does not: high transportation costs between the poor agricultural region to the non-agricultural core. I find transportation cost reductions dampen the convergence effect of structural change and growth.

The development experience of the United States provides a good case study, since a long time-series of sectoral and regional employment and earnings data is not available for current developing countries. The United States has high-quality sectoral and regional earnings and employment data available since 1880. The Southern and Midwestern regions also provide two alternative environments in which to study the impact of structural change on regional convergence.[3] The high transport costs between the Midwest and Northeast is similar to many developing countries, where high transport costs are a severe problem for poor, rural, and agriculturally-intensive regions [Gollin and Rogerson, 2010]. In contrast, the Southern states are endowed with extensive river networks and coastal access, significantly lowering the cost of transporting goods. These two regions experienced very different development paths. Table 1 highlights the rapid growth of relative

[1] See, e.g. Kanbur and Zhang [2005], for China; Sahn and Stifel [2003], for Africa; or Heshmati [2004] for a good summary.

[2] See, e.g., Paci and Pigliaru [1997] or Caselli and Coleman [2001].

[3] See Figure 1 for a graphical depiction of each region of the United States.

Table 1: Relative Earnings and Employment Shares, by Region, 1880 and 1980

	Southern States		Midwestern States	
	1880	1980	1880	1980
Ag. Employment Share	0.73	0.03	0.55	0.04
Ag. to Nonag. Relative Wage	0.34	0.72	0.43	0.65
Expressed as Fraction of Overall Average Wage in Northeastern States				
Overall Wage	0.43	0.92	0.81	1.00
Nonagricultural Wage	0.83	0.93	1.18	1.01
Agricultural Wage	0.28	0.60	0.51	0.76

Own calculations using data from Lee et al. (1957) and Caselli and Coleman (2001). Illustrates large differences between the South and the Midwest in average wage convergence to Northeast, despite similarities in terms of agriculture's initial employment and relative wage.

Southern incomes and comparatively lower growth for the initially richer Midwest. These patterns are puzzling in light of two facts: (1) agricultural wages in both regions were initially low relative to other sectors; and (2) agriculture initially dominates employment in both regions and both undergo rapid structural change. As employment moves into higher-paying non-agricultural sectors, income in agricultural regions should rise. The Caselli and Coleman [2001] framework, which works very well for the South, cannot quantitatively match the Midwest experience - in particular, the Midwest's initially high nominal income and comparatively low subsequent growth.

High transport costs between the Midwest and the Northeast, but not between the South and the North, is clear in the data. The 1887 Report of the Senate Committee on Transportation Routes, for example, finds transport costs for a bushel of wheat sent between Atlantic ports to Great Lake ports by rail averaged 21 cents. This is a significant charge, given the average price of a bushel of wheat was 104 cents in the 1870s [US Census Bureau, 1878]. Harley [1980] compiles additional evidence on wheat and freight prices. Depending on the route, the per bushel rate to ship wheat from Chicago to New York in 1880 ranged between 8 to 15 cents. Further west, there was an additional cost to ship from Kansas City to Chicago of 11 cents. The farm price of a bushel of wheat was 118 cents in New York, 101 in Indiana, 93 in Wisconsin, 82 in Iowa, and 73 in Kansas. The further west one is of New York, the higher the transportation costs and the lower the wheat price. While land-route rates between Southern and Northeastern locations is not provided, the rate to ship from Odessa, TX or New York to Liverpool, UK were nearly identical (10.4 versus 8.6 cents, respectively). This suggests ocean shipping rates from Southern ports to Northeastern ones were *substantially* lower than land-based routes available to the Midwest. Indeed, wheat prices in Odessa and New York were very similar, with the wholesale bushel price at 112.[4] Over time transport costs decline dramatically - Glaeser and Kohlhase [2004] points to nearly a 90% decline in transport costs over the century.

I expand on Caselli and Coleman [2001] by introducing regions and transportation costs between regions into the model. Structural change and growth in the poor agricultural region is fueled by reductions in learning costs for agricultural workers to acquire the skills necessary for non-agricultural employment. Goods transported from one region to another will face a cost, which raises the consumer price of importable goods and lowers the price of exportable goods. For the Midwest, this will result in higher manufactured goods prices and lower agricultural goods prices. Since agricultural goods constitute a smaller fraction of consumer spending at the time (approximately 30%), a higher wage for Midwestern workers is necessary to prevent emmigration. As transport costs decline, the relative manufactured goods prices, and therefore the compensating differential to nominal earnings, decline as well. This may offset the convergence achieved from structural change.

I will demonstrate that transportation cost reductions are sufficient to match data in cases where there is much structural change along with comparatively lower nominal income growth, such as the Midwestern states. If transport costs were held at their 1880 level, the income growth in the Midwest resulting from structural change would be 30% larger than actually observed. If transport costs were not incorporated into the model, then overall Midwestern wages would not have been as high as in the data and the degree of income differences difficult to account for.

[4]The farm price was not available for Odessa at this time, so I use the wholesale price. The New York wholesale price, at 120 in Winter and 117 in Spring, is nearly identical to the annualised average farm price of 118, which suggests this is an acceptable approximation.

Initially high and declining transport costs reconciles the modest initial earnings differential, low relative agricultural wage, and high agricultural employment share with high overall wage levels in the Midwest. Simply put, transport cost improvements occurred as structural change proceeded and the two channels had effects of similar magnitude but opposite direction on regional income differences. The the role of transport costs for the Midwest may be informative about the future evolution of regional earnings differences in many developing countries. Global income differences may therefore decline less than one might expect from considering the structural change channel alone.

This paper contributes to the structural transformation and growth literature and, in particular, joins research dealing with frictions within a two-sector, multi-region framework. Broadly speaking, this literature examines the strong negative relationship between the share of output and employment commanded by the agricultural sector and the overall level of economic activity - a phenomenon known as the "Kuznets fact" of growth. Recently, a variety of models have been developed to explain these facts. These include: increasing consumer goods variety [Greenwood and Uysal, 2005, Foellmi and Zweilmueller, 2006]; preference non-homotheticities [Kongsamut et al., 2001]; differential sectoral productivity growth [Ngai and Pissarides, 2007]; and, capital deepening [Acemoglu and Guerrieri, 2006].[5] While capturing the output and employment facts quite well, these models cannot match regional income differences or the rising agricultural wages we observe. To capture rising agricultural wages, Caselli and Coleman [2001] incorporate labour market frictions between agriculture and non-agriculture to show that improved ability of workers to acquire manufacturing skills can capture the rise in relative agricultural wages. Herrendorf et al. [2009] investigate goods market frictions between regions, finding large reductions in transportation costs between regions are an important driving force behind westward settlement patterns in the mid-1800s. Neither paper examines the role of transport costs between regions for income convergence and structural change.

[5]A concise review of the issues involved may be found in Matsuyama [2005].

2 A Regional Growth Model

The model is dynamic, with two regions (the core, c, and the periphery, p) and two sectors (agriculture and a manufactured good). As in Kongsamut et al. [2001], and others, the agricultural good faces a subsistence requirement, and therefore has an income elasticity below unity. The manufactured good may be consumed or invested to accumulate capital. Each region can trade either good with the other region by incurring an iceberg transportation cost, with a fraction ($\Delta < 1$) of the original shipped goods arriving at the destination. Workers may select either sector to work in, but must receive manufacturing skills in order to become employed in the manufacturing sector.

2.1 Firms

There are two types of perfectly-competitive firms: goods producing firms and transportation firms.

2.1.1 Goods Producing

An agricultural sector, a, and a manufacturing sector, m, exist in each of the two regions, populated by perfectly competitive firms. Each produces output using land, labour, and capital with constant returns to scale. To ensure a balanced growth path exists, I assume a unit elasticity of factor substitution.[6] Thus, for each region $i \in \{p,c\}$ and sector $s \in \{a,m\}$,

$$Y_{st}^{i} \quad = \quad A_{st}^{i} {T_{st}^{i}}^{\gamma_s} {L_{st}^{i}}^{\alpha_s} {K_{st}^{i}}^{(1-\gamma_s-\alpha_s)}. \tag{1}$$

Y, T, L, and K, respectively denote output, land, labour, and capital. I assume total factor productivity (A) is such that $A_{mt}^{p} = A_{mt}^{c}$ and $A_{at}^{p} > A_{at}^{c} = 0$ for all $t = [0,..,\infty)$. The comparative advantage of the core, c, is thus in manufacturing and it will completely specialise. To simplify notation, the periphery's agriculture is selected as the numeraire ($P_{at}^{p} = 1$). Manufacturing sector output may be consumed or invested in

[6] See Kongsamut et al. [2001]. For an alternative specification involving more general CES preferences, see Ngai and Pissarides [2007].

new capital goods, the stock of which depreciates at rate δ. Agricultural goods may only be consumed and are not storable. Regional land endowments are exogenously set, with the periphery's fraction of the total denoted by ω. Including land in the production function ensures a deterministic distribution of manufacturing production between the regions by creating diminishing returns to scale in the regionally mobile factors (labour and capital). Firms may use land and capital in either sector and both factors can be costly converted from use in one sector to another. In contrast, labour may only move between sectors if it possesses the necessary manufacturing skills, the accumulation of which I present in Section 2.2.1.

Each firm exists in a competitive environment and, therefore, takes output prices, P^i_{st}, as given. In addition, factor markets are competitive and land rents, wages, and capital rents - respectively, q_t, w_t, and r_t - are also exogenous to each firm. They each use the production technology from Equation (1) to maximize profits,

$$\Pi^i_{st} = P^i_{st}Y^i_{st} - w^i_{st}L^i_{st} - q^i_{st}T^i_{st} - r^i_{st}K^i_{st} \quad \forall\, i = p, c \text{ and } s \in \{a, m\}.$$

2.1.2 Transportation

Transportation firms earn profits by arbitraging goods price differences across regions. Goods bought by a transport firm in one region may be transported to consumers in another region by incurring an iceberg-cost, Δ, similar to Herrendorf et al. [2009]. Formally, if D^i_{st} and B^i_{st} represent the quantity of good s delivered to and bought from region i, it must be the case that $D^i_{st} = \Delta B^j_{st} \quad \forall i, j = p, c, i \neq j$. For $\{i, j\} \in \{\{p, c\}, \{c, p\}\}$ and $s \in \{a, m\}$ the transport firm's maximization problem is

$$\max_{D^i_{st}, B^i_{st}} \pi_t = P^i_{at}D^i_{at} + P^i_{mt}D^i_{mt} - p^j_{at}B^j_{at} - p^j_{mt}B^j_{mt}.$$

Complete specialization of the core in manufacturing ensures $D^p_{at} = D^c_{mt} = B^p_{mt} = B^c_{at} = 0$.

Specifically, to deliver one unit of manufactured goods to the periphery, earning P^p_{mt} in revenue, the transport firm must purchase $1/\Delta$ units of the good in the core, costing $\left(\frac{1}{\Delta}\right) P^c_{mt}$. A zero profit condition on transport firms means for each unit revenue and costs must equal. The same hold for agricultural goods in the opposite direction. Overall, this implies,

$$\Delta_t P^p_{mt} = P^c_{mt}, \tag{2}$$

$$P^c_{at} = 1/\Delta_t. \tag{3}$$

2.2 Households

Each region contains one household and a continuum of agents within each. The total national population is normalized to one. As is standard in models of structural change, each agent is endowed with preferences that treat consumer goods asymmetrically, with agricultural goods contributing to utility only above a subsistence level, $\bar{a}$. This results in an income inelastic demand for agricultural goods, which causes agriculture's share of consumption and employment to decline with income. An agent's wealth is given by the present value of labour and non-labour income. Each agent selects a region of residence and each regional household determines the allocation of agents across sectors. That is, individual agents are sovereign in every respect but for their choice of occupation. To ensure individual agents are indifferent between occupations, household consumption, denoted c, is evenly divided among its members. Finally, non-labour income from land and capital rents is generated by ownership stakes available to all agents regardless of residency.[7]

Formally, the household of region $i \in \{p, c\}$ faces the following problem

$$\max_{\{c^i_{at}, c^i_{mt}, L^i_{at}, L^i_{mt}, i\}^\infty_{t=0}} \sum_{t=0}^{\infty} \beta^t \left[\tau \log(c^i_{at} - \bar{a}) + (1-\tau)\log(c^i_{mt})\right]$$

subject to

$$\begin{aligned} \sum_{t=0}^{\infty} (P^i_{at} c^i_{at} + P^i_{mt} c^i_{mt}) &\leq \sum_{t=0}^{\infty} (L^i_{at} w^i_{at} + L^i_{mt} w^i_{mt}) + A_t \\ &\equiv L^i_{at} H^i_{at} + L^i_{mt} H^i_{mt} + A_t, \end{aligned}$$

where (H^i_{at}, H^i_{mt}) and A_t are, respectively, the present value of lifetime labour and

[7] Land and capital rents will equalize across regions.

non-labour earnings for region i from time t onwards. Optimal allocations between consumption goods are such that the marginal rate of substitution equals the output price ratio,

$$\frac{U_m(c_{at}^i, c_{mt}^i)}{U_a(c_{at}^i, c_{mt}^i)} = \frac{1-\tau}{\tau}\frac{c_{at}^i - \bar{a}}{c_{mt}^i} \quad = \quad \frac{P_{mt}^i}{P_{at}^i} \quad \forall\, i \in \{p, c\}. \tag{4}$$

In equilibrium, to ensure agents are indifferent between regions of residence, total household utility is identical between regions; that is,

$$\tau \log(c_{at}^p - \bar{a}) + (1-\tau)\log(c_{mt}^p) \quad = \quad \tau \log(c_{at}^c - \bar{a}) + (1-\tau)\log(c_{mt}^c). \tag{5}$$

2.2.1 Occupational Choice

Occupational choice enters the household problem only through its effect on lifetime wealth. A household selects agents to acquire manufacturing skills only if the expected present discounted value of lifetime manufacturing earnings are sufficient to compensate for the foregone labour earnings while learning takes place. Following Caselli and Coleman [2001], each agent is endowed with an intellectual handicap, which determines the length of time required to acquire manufacturing skills. This handicap is the product of a population wide parameter (ξ_t) and an individual component (ζ_{jt}). The former captures the overall costs in training labour while the latter captures person-specific costs of learning. The product, $\zeta_{jt}\xi_t$, represents the fraction of a period necessary to receive training. The cost of switching sectors for person j at time t is $\zeta_{jt}\xi_t w_{mt}$ and the benefits are the increased labour earnings in manufacturing. Finally, given that the core region perfectly specializes in manufacturing, human capital decisions take place in the periphery. The peripheral household selects agent-j to engage in manufacturing production at time-t if and only if

$$\begin{aligned} H_{mt}^p - H_{at}^p &\geq \zeta_{jt}\xi_t w_{mt}^p, \\ \Rightarrow \bar{\zeta}_t &= \frac{1}{\xi}\frac{H_{mt}^p - H_{at}^p}{w_{mt}^p}, \end{aligned} \tag{6}$$

where $\bar{\zeta}_t$ is the cutoff value for an individual's learning handicap. Those with individual learning costs above this trenshold ($\zeta_{jt} > \bar{\zeta}_t$) will select remain in agriculture. To ensure a steady-state exists where at least some individuals are without manufacturing skills, an exogenous survival rate λ is assumed. Dying agents are replaced by an equal number of newborn agents without any skills in the periphery.

The lifetime value of labour earnings in each sector $s \in \{a,m\}$ can be written recursively as the current period earnings plus the expected discounted next-period value,

$$H^p_{st} = w^p_{st} + \frac{c^p_{at} - \bar{a}}{c^p_{a(t+1)} - \bar{a}} \beta \lambda H^p_{s(t+1)}. \tag{7}$$

where $\frac{c^p_{at}-\bar{a}}{c^p_{a(t+1)}-\bar{a}}\beta = \frac{\beta U_a(c_{a(t+1)}, c_{m(t+1)})}{U_a(c_{at}, c_{mt})}$ is the value of period-$(t+1)$ peripheral agricultural goods (the numeraire) in terms of period-t goods.

Given this structure, it is possible to derive the labour supply equations for each sector. Denote with l_s the average time (in terms of fraction of a period) a given generation spends in sector s. As in Caselli and Coleman [2001], I assume $f(\zeta_j) = 3\zeta_j^2$ is the distribution function of individual handicap parameters. The population average time spent acquiring skills is then simply the mean value of $\zeta_{jt}\xi_t$ for those individuals who opted to switch. Given that, the time spend in the manufacturing sector is simply whatever time is left after acquiring skills. Mathematically, this may be represented by

$$l^p_{et} = \int_0^{\bar{\zeta}_t} \xi_t \zeta_j f(d\zeta_j) = (3/4)\xi \bar{\zeta}_t^4, \tag{8}$$

$$l^p_{mt} = \int_0^{\bar{\zeta}_t} (1 - \xi_t \zeta_j) f(d\zeta_j) = \bar{\zeta}_t^3 - l^p_{et}. \tag{9}$$

In aggregate, the number of individuals in agriculture is the fraction of the previous period's agricultural labour force that is still alive plus the newborn individuals who do not switch. If all learning is complete within a model period (a decade), the average number of individuals in training is the fraction of newborns who switch.

That is,

$$L_{at}^{p} = (1-L_{a(t-1)}^{p})(1-\lambda)l_{at}^{p} + L_{a(t-1)}^{p}\lambda, \quad (10)$$
$$L_{et}^{p} = (1-L_{a(t-1)}^{p})(1-\lambda)l_{et}^{p}. \quad (11)$$

Manufacturing labour, given that is it able to move across borders, will be uniquely determined through equilibrium in the labour market and equality of utility between regions.

2.3 Competitive Equilibrium

A competitive equilibrium in this economy is characterized by, for all $i \in \{p,c\}$ and $s \in \{a,m\}$, allocations $\{c_{st}^{i}, L_{st}^{i}, l_{st}^{i}, T_{st}^{i}, K_{st}^{i}, Y_{st}^{i}\}_{t=0}^{\infty}$, output prices $\{P_{st}^{i}\}_{t=0}^{\infty}$, factor prices $\{q_t, r_t, w_{st}^{i}\}_{t=0}^{\infty}$, and occupational choice variables $\{H_{st}, \bar{\zeta}_t\}_{t=0}^{\infty}$ such that: given output and factor prices, households maximize utility and firms maximize profits; households are indifferent between residing in either region; and both input and output markets clear.

The system of equations characterising such an equilibrium is given by the Equations governing production, (1); output prices, (2) and (3); human capital acquisition, (6) and (7); labour supply, (8-11); consumption, (4); residency, (5); the following input market clearing conditions

$$T_{mt}^{c} = 1-\omega, \quad (12)$$
$$T_{at}^{p} + T_{mt}^{p} = \omega, \quad (13)$$
$$L_{at}^{p} + L_{mt}^{p} + L_{et}^{p} + L_{mt}^{c} = 1; \quad (14)$$

the Euler equations, one for each region,

$$\frac{c_{m(t+1)}^{i}}{c_{mt}^{i}} = \beta\left[\frac{\partial Y_{mt}^{i}}{\partial K_{mt}^{i}} + 1 - \delta\right] \quad \forall\, i \in \{p,c\}; \quad (15)$$

and agricultural and manufacturing goods markets clearning

$$L_{mt}^{c} c_{at}^{c} = D_{at}^{c},$$

$$
\begin{aligned}
(1-L_{mt}^c)c_{at}^p + B_{at}^p &= Y_{at}^p, \\
L_{mt}^c c_{mt}^c + K_{m(t+1)}^c + B_{mt}^c &= Y_{mt}^c + (1-\delta)K_{mt}^c, \\
(1-L_{mt}^c)c_{mt}^p + K_{a(t+1)}^p + K_{m(t+1)}^p &= Y_{mt}^p + D_{mt}^p + (1-\delta)(K_{mt}^p + K_{at}^p).
\end{aligned}
$$

where, since the total population is normalized to one, the core and peripheral populations are, respectively, L_{mt}^c and $(1-L_{mt}^c)$.

3 Effects of Transportation Costs

This section presents derivations highlighting the underlying channels through which transportation costs affect the model's equilibrium.

Perfectly competitive input and output markets imply output prices equal marginal costs of production. For the manufacturing sector of region i,

$$
P_m^i = \frac{1}{A_m}\left[\left(\frac{w_m^i}{\beta_L}\right)^{\beta_L}\left(\frac{a}{\beta_T}\right)^{\beta_T}\left(\frac{r}{1-\beta_T-\beta_L}\right)^{1-\beta_T-\beta_L}\right].
$$

Since manufacturing productivity is identical across regions, the ratio of marginal costs depends only on the ratio of manufacturing wages. That is,

$$
\begin{aligned}
\frac{MC_m^p}{MC_m^c} = \left(\frac{w_m^p}{w_m^c}\right)^{\beta_L} &= \frac{P_m^p}{P_m^c}, \\
&= \Delta^{-1}, \\
\Rightarrow \frac{w_m^p}{w_m^c} &= \Delta^{-1/\beta_L} \qquad (16)
\end{aligned}
$$

where the second line follows from the nature of the transportation technology: $\Delta P_m^p = P_m^c$. The region importing manufactured goods faces a higher price for those goods due to the transportation cost. This higher price will encourage entry unless wages rise to ensure zero profit once again.

Alternatively, one could investigate the impact of transport costs on migration decisions. Since living standards are identical across regions by assumption, incomes must rise if the costs of a achieving a certain level of utility rises. Thus, if reductions in transportation costs lower regional average price dispersion then it will also lower regional income dispersion. To see this, the equality of utility levels between residents of each region - Equation (5) - may be combined with optimal consumption allocation conditions - Equation (4) - and regional pricing conditions - Equations (2) and (3) - to arrive at the relative expenditure on each good for each region. That is,

$$\frac{P_a^c(C_a^c-\bar{a})}{P_a^(C_a^p-\bar{a})} = \frac{P_m^c C_m^c}{P_m^p C_m^p} \quad = \quad \Delta^{1-2\tau}, \tag{17}$$

For simplicity, first consider the case of zero agricultural subsistence consumption ($\bar{a}=0$). The budget constraint for a manufacturing worker in region $i \in \{c,p\}$ is

$$P_a^i C_a^i + P_m^i C_m^i = w_m^i + r + a \equiv Z^i$$

Taking the ratio between regions, and utilizing Equation (17), yields

$$\begin{aligned} \frac{Z^p}{Z^c} &= \frac{\Delta^{1-2(1-\tau)} + \frac{1}{\Delta^{1-2\tau}}\frac{P_m^c C_m^c}{P_a^c C_a^c}}{1+\frac{P_m^c C_m^c}{P_a^c C_a^c}} \\ &= \frac{\Delta^{1-2(1-\tau)} + \frac{1}{\Delta^{1-2\tau}}\frac{1-\tau}{\tau}}{1+\frac{1-\tau}{\tau}} \\ &= \frac{1}{\Delta^{1-2\tau}} \end{aligned} \tag{18}$$

where the second equality follows from the standard result that optimal expenditure shares equal $(1-\tau)/\tau$. Note that for $\Delta = 1$ we have $Z^p = Z^c$ (which implies $w_m^p = w_m^c$) and for $\Delta < 1$ we have $Z^p > Z^c$ ($w_m^p > w_m^c$). Moreover, if we ignore land and capital rent,

$$\frac{\partial\left(\frac{w_m^p}{w_m^c}\right)}{\partial(1-\Delta)} = -\frac{\partial\left(\frac{w_m^p}{w_m^c}\right)}{\partial\Delta} = \frac{1-2\tau}{\Delta^{2\tau}} > 0.$$

Thus, as transportation costs fall ((1-Δ) ↓) peripheral manufacturing wages also fall relative to the core ($w_m^p/w_m^c \downarrow$).

Table 2: Calibration of Common, Time-Invariant, Model Parameters

Parameter	Description	Target	Value
α_a, α_m	Labour's Share of Output	Literature	0.6
γ_a	Farm Land Share	Caselli and Coleman [2001]	0.19
γ_m	Non-Farm Land Share	Caselli and Coleman [2001]	0.06
τ	Ag. Preference Weight	Expenditure Shares	0.01
λ	Survival Probability	40 year working life	0.75
δ	Depreciation Rate	4% annual rate	0.36
β	Discount Factor	5% annual discount rate	0.60

Displays calibrated parameters that are constant through time and common across regions. Jointly calibrated parameters are listed separately with results in Table 4*b*.

4 Calibration

To evaluate the quantitative importance of structural change and transport cost improvements for the evolution of regional income differences, the model must be calibrated to key features of the data. I first set the parameters (τ, β, δ, γ_a, γ_m, α_a, α_m, λ, Δ_{1880}, Δ_{1980}) individually from existing literature or data. Their values are presented in Table 2. Many of the parameter values are identical to those common in the literature. Factor shares in production, which are land shares γ_a and γ_m and labour shares α_a and α_m, are set following Jorgenson and Gollop [1992] and Caselli and Coleman [2001]. Given an expected 40 years of life beyond a typical agent's education decision, and using a decade as the model period, the probability of dying, λ, is set at 0.75. Finally, the transportation cost parameters in 1880 are set to match available price data. As noted in the introduction, the rate to transport wheat from Kansas City to New York ranges, depending on the route, from one-quarter to one-third of the bushel's final value. Thus, $\Delta_{1880} = 0.75$. To determine Δ_{1980}, data from Glaeser and Kohlhase [2004] points to nearly a 90% decline in transport costs over the century, which implies $\Delta_{1980} = 0.97$. I set agriculture's share of consumer expenditures, (c_a/c), to 0.31, following Caselli and Coleman [2001].[8]

The remaining parameters, (ω, ξ_{1880}, ξ_{1980}, $\bar{a}$, K_0^p, K_0^c, $L_{a,-1}^p$), have no directly observable counterparts in data so I set them jointly to target certain model outcomes, which are observable, with data. Since the precise values depend on the regional group and experiment being conducted, I display these parameters along with results in Section 5 but describe their calibration here. With constant learning costs ($\xi_{1880} = \xi_{1980}$) the targets are: (1) agricultural consumption share in 1880; (2) relative agricultural wages in 1880; (3) relative regional wages in 1880; (4), constant marginal product of capital in each region;[9] and (5) 1880 agricultural labour shares.[10] When I allow learning costs to decline over time, ($\xi_{1880} > \xi_{1980}$) I also target (6) relative regional wages in 1980.

For clarity, I list here the jointly determined parameters and what statistic is most sensitive to each. First, ω denotes the share of productive land allocated to the peripheral region. Increasing this parameter will primarily increase the relative share of peripheral average income, (w^p/w^c). Second, ξ is the population-wide learning time parameter, with a higher value indicating greater difficulty for all agents in acquiring non-agricultural skills. This results in lower relative agricultural earnings, (w_a/w_m). Third, $\bar{a}$ represents the subsistence parameter that influences the food consumption share, (c_a/c). This influence is strongest in the initial period due to the low level of overall income, and hence a high level of relative food consumption. Fourth, (K_0^p, K_0^c) are the initial capital stocks in each region. They are adjusted to ensure capital's marginal product is idential in the initial period to the steady-state value, consistent with the Kaldor fact of no trend in capital returns. Finally, $L_{a,-1}^p$ is the 1870 agricultural employment share in Equation (10) for 1880 ($t = 0$), it is calibrated such that $L_{a,0}^p$ matches data.

[8]The consumption of food and kindred products relative to all consumption expenditures in 1880 from the *Historical Statistics of the United States* (Series Cd378-410) is 0.29. Caselli and Coleman [2001], however, provide an estimate of agriculture's share of GDP net of gross investment - also using data from the *Historical Statistics* in addition to Maddison [1991].

[9]Capital returns are equalized across regions.

[10]Using data collected by Lee et al. [1957], with values of 0.485 and 0.38 respectively for the South and the Midwest.

5 Results

I use the fully calibrated model to show declining transportation costs offset the effect of structural change on regional convergence.

5.1 The Southern States

This section will briefly repeat the experiments of Caselli and Coleman [2001] to demonstrate the adjusted model replicates their results when transportation costs are ignored ($\Delta = 1$). This section will also highlight that declining learning costs facilitates structural change and can drive regional convergence.

Table 3a displays the results for the Southern states for two scenarios. When costs to accumulating non-agricultural skills remain constant through time, the model fails to capture the declining agricultural labour share, rising relative agricultural wage, and rising average incomes in the South. With declining learning costs, however, the relative agricultural wage increases dramatically. Declining learning costs also facilitated the movement of labour out of agriculture and in increased Southern average overall wages. Intuitively, this represents a reduction in the supply of farm workers. Thus, improvements in the ability of workers to accumulate non-agricultural skill can drive structural change, increase agriculture's relative wage, and increase incomes of agriculturally intensive regions. For the Midwestern States, however, this channel alone is insufficient to match the data.

5.2 The Midwestern States

To match the Midwest experience, I incorporate transportation costs that decline through time ($\Delta_{1880} < \Delta_{1980} < 1$). I report the results for the counterfactual exercises in Table 4a and the set of calibrated parameters in Table 4b. The baseline specification matches the declining share of agricultural employment and relative regional incomes. The subsistence parameter value of 0.18 implies 31% of consumer expenditures are spent on food, to match data. The Midwest is also allocated 71% of the land between the two regions. In the data, not adjusting for land quality differences, Midwestern states have 78% of land. The remaining three panels

Table 3: Various Model Simulations, South and Northeast

(a) Comparing Model Output to Data

	Data		Model	
	1880	1980	1880	1980
(i) Constant Learning Costs				
Ag. Employment Share	0.48 *	0.02	0.48	**0.41**
Ag. to Nonag. Relative Wage	0.34 *	0.72	0.34	**0.02**
Overall Wage Relative to Northeast	0.43 *	0.92	0.43	**0.38**
(ii) Declining Learning Costs				
Overall Ag. Employment Share	0.48 *	0.02	0.48	0.07
Southern Ag. to Nonag. Relative Wage	0.34 *	0.72 *	0.34	0.72
Southern Wage Relative to NE	0.43 *	0.92	0.43	0.96

(b) Jointly Calibrated Parameters

Model Parameter	Description	Scenario: Constant Learning Costs	Scenario: Declining Learning Costs
$\bar{a}$	Food Subsistence	0.23	0.23
ω	Southern Land	0.63	0.63
ξ_{1880}	1880 Learning Cost	2.08	1.92
ξ_{1980}	1980 Learning Cost	2.08	0.50
Δ_{1880}	1880 Transport Cost	1.00	1.00
Δ_{1980}	1980 Transport Cost	1.00	1.00

[*] denotes calibration target. Panel (a) displays results of various model simulations. Parameter values displayed in Panel (b).

of Table 4a illustrate the impact of neglecting transport costs ($\Delta = 1$) or imposing constant costs through time ($\Delta_{1880} = \Delta_{1980} < 1$).

In panel (ii), I illustrate the model statistics without transportation costs ($\Delta_t = 1$). The bold cell highlights the income difference between regions is too large, with the Midwest overall income 62% of Northeast rather than 81% as in data. I recalibrate the model in panel (iii) to allow the parameters to try and match the true income differences as well as possible. In this case, nearly all land (99%) is allocated to the Midwest, and learning costs are set extremely low in 1880. Despite these modifications, which only increase the Midwestern income to 73% of the Northeast, the model without transportation costs cannot match the data for 1880. By introducing transportation costs, peripheral earnings rise to compensate for higher manufactured goods prices, and therefore lead to a higher initial relative income for the region.

To illustrate the importance of *declining* transport costs, panel (iv) displays the effect of holding transportation costs at their 1880 value of 0.75. The model predicts the Midwest would have surpassed (by 32%) the Northeast in terms of income. This decline in transport costs eliminates nearly two-thirds of average Midwestern nominal income growth, which rises only 19 percentage points relative to the Northeast instead of the 51 implied by experiment (iv). I conclude the high cost of transport in 1880 that declined to a relatively modest level by 1980 is sufficient to allow the model to match the relative income levels in the data, without unreasonable values for the Midwestern land share or costs of acquiring non-agricultural skills.

5.2.1 Alternative Differences for the Midwest

There are other adjustments one can make to the model to match relative earnings data. In this section, I examine two: higher Midwestern initial capital stock and higher Midwestern initial TFP levels. These adjustments will not match other important aspects of the data or have implausible implications.

First, consider the initial Midwestern capital stock. With additional capital allocated to the region in 1880, wages in both sectors will rise. I find that allocating additional capital reduces agriculture's share of consumer expenditures (since additional income is disproportionately spent on non-agricultural goods) and lowers agriculture's relative wage. To compensate, additional land and higher subsistence

Table 4: Various Model Simulations, Midwest and Northeast

(a) Comparing Model Output to Data

	Data		Model	
	1880	1980	1880	1980
(i) Declining Transportation Costs (Baseline Model)				
Ag. Employment Share	0.39 *	0.03	0.39	0.06
Ag. to Nonag. Relative Wage	0.43 *	0.65 *	0.43	0.65
Overall Wage Relative to Northeast	0.81 *	1.00	0.81	1.00
(ii) No Transportation Costs				
Overall Ag. Employment Share	0.39 *	0.03	0.38	0.06
MW Ag. to Nonag. Relative Wage	0.43 *	0.65 *	0.36	0.65
MW Wage Relative to NE	0.81 *	1.00	**0.62**	0.97
(iii) No Transportation Costs (Recalibrated)				
Overall Ag. Employment Share	0.39 *	0.03	0.39	0.06
MW Ag. to Nonag. Relative Wage	0.43 *	0.65 *	0.43	0.65
MW Wage Relative to NE	0.81 *	1.00	**0.73**	0.97
(iv) Constant Transportation Costs				
Ag. Employment Share	0.39 *	0.03	0.39	0.06
Ag. to Nonag. Relative Wage	0.43 *	0.65 *	0.43	0.65
Overall Wage Relative to Northeast	0.81 *	1.00	0.81	**1.32**

(b) Jointly Calibrated Parameters

		Scenario			
Model Parameter	Description	Declining Transport Costs (Baseline Model)	No Transport Costs	No Transport Costs (Recalibrated)	Constant Transport Costs
$\bar{a}$	Food Subsistence	0.18	0.18	0.21	0.18
ω	Midwestern Land	0.71	0.71	0.99	0.71
ξ_{1880}	1880 Learning Cost	2.26	2.26	0.89	2.26
ξ_{1980}	1980 Learning Cost	0.62	0.62	0.64	0.62
Δ_{1880}	1880 Transport Cost	0.75	1.00	1.00	0.75
Δ_{1980}	1980 Transport Cost	0.97	1.00	1.00	0.75

* denotes calibration target. Panel (a) displays results of various model simulations. Parameter values displayed in Panel (b).

food requirements are necessary. Overall, the data can be matched with additional capital (roughly 20% more than implied by scenario (iii) in Table 4a) but 95% of land and a high subsistence parameter is necessary. The additional capital also implies an implausibly low marginal product of capital in manufacturing less than one. That is, it implies an additional unit of capital results in less than an additional unit of manufacturing output in the following period. It also leads to a large difference in capital's revenue product. Data from the 1880 Census records, which collects total value of output, intermediates, and capital stocks suggests no differences between the Midwest and the Northeast.

Second, if Midwestern TFP in manufacturing was 6-7% higher than the Northeast then the model would match the relative earnings data. Prices, however, would be equalized across regions. The earlier discussion implies this is not the case, with large price differences existing for a homogeneous good between various Midwestern cities and New York. Even for non-agricultural goods there are price differences. Haines [1989] finds that clothing in Kansas is 29% higher than the national average and furniture in Indiana is 16% above the national average. Taking a simple average across states, Midwestern clothing is over 6% higher than the Northeast, fuel is over 5% higher, and other non-agricultural goods are nearly 8% higher, although no difference exists for furniture. While these price differences are smaller than implied by the model (roughly one-third to half as much in 1890, which is Haines [1989]'s year of study), TFP differences is not likely the entire story.

6 Conclusion

Within-country income differences are an important source of global income inequality. This paper contributes to research that finds declining employment in relatively low-paying agriculture and rising agricultural wages relative to other sectors will disproportionately benefit agriculturally intensive areas, leading to regional convergence. The approach in this paper is to account for transport costs between agricultural and non-agricultural regions, which decline as growth and structural change take place. This feature is common among developing countries, where transportation issues have been a topic of much research. To examine this channel, I augment an established general equilibrium model of structural transformation to incorporate between-region transportation costs. I find reductions in transportation costs offset nominal income gains from structural change, thus limiting convergence. Simply put, if transportation costs between regions are neglected, structural change resulting from improved methods of human capital accumulation will imply too large an increase in earnings for agricultural regions. I empirically evaluate the model with the experience of both the Midwest and the South, matching both cases well. These results suggest the potential for structural change and growth to reduce regional, and therefore global, income inequality is limited.

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Figure 1: US Census Regions

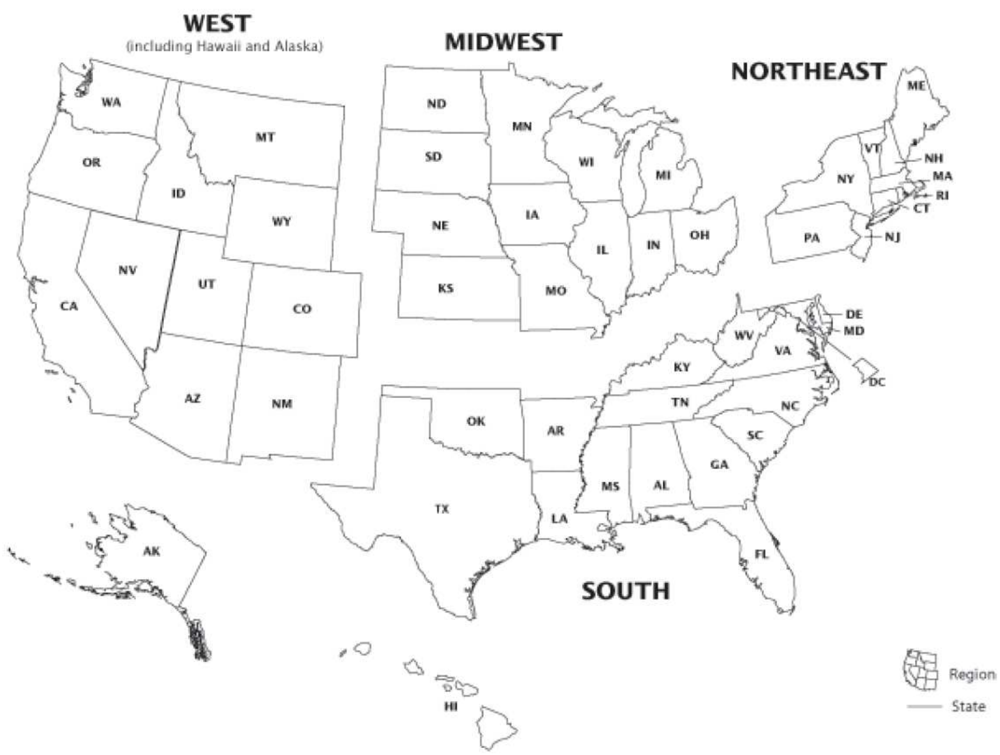

Image produced by the US Bureau of Transportation Statistics; Source: US Census Bureau.