Can the New Economic Geography explain Inequality Between the Great Plains and Great Lakes?

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Abstract: Explanations for cross-country or regional inequality and how inequality may be reversed are perennially important questions for political economists. Paul Krugman's new economic geography, which argues that geographically and historically influenced economic factors can explain the rise of divergence and the possibilities for convergence, is unique. Though well known, this non-linear theory has received little to no empirical testing to date. This paper begins to fill this vacuum with a comparative analysis of Great Plains and Great Lakes states over an eighty year period ending in 2000. This paper finds that the new economic geography can aide our understanding of the causes of inequality, though not being empirically verified in its entirety.

Introduction

Few issues animate political scientists as much as inequality and convergence. The questions animating this paper are: “Why do poor regions exist *within* rich countries, especially democratic ones?” and “How can inequality be reduced and can this be politically brokered?” The domestic mystery may be greater than the international one because standard growth theories predict that free flows of labor and capital will cause wages to converge between regions, and in democracies such as the United States, institutions often protect labor and capital mobility.

The new economic geography introduced by Paul Krugman (1991a, 1991b, 1991c) offers an alternative explanation for poor regions in a rich country. It asserts that wage advantages correlate positively with advantages in regional industrial and population concentration. Because of the theory’s novelty and subject matter, it is often cited by political economists, but to date few have tested it empirically, even though Krugman (1988) has called for it.

In this paper I seek to fill this gap, at least in part, by testing Krugman’s theory through an examination of comparative wage behavior between the agricultural Great Plains and the industrial Great Lakes regions of the United States. Unlike standard growth theories, Krugman’s theory predicts sustained inequality between these regions. The manufacturing wage data in Figure 1 shows that the theory predicts correctly -- divergence occurred and, surprisingly, grew from 1930 to 2000. However, as this paper will show, the factors that the theory alleges would cause this divergence, only partially explain it.

FIGURE 1 ABOUT HERE.

Political Importance of Domestic Analyses

One can hardly overemphasize the political importance that trends in inequality and industrial agglomeration have to domestic policy makers. Wage inequality trends play a huge role in welfare policies, trade policies, and political contests in democratic states. Industrial agglomeration, and its consequent job creation, plays a key role in domestic migration as workers move from less to more fecund regions. This dynamic in turn affects welfare policies, the dispersion of government grants to regions, states, or cities, and ultimately alters legislative regional representation in democracies that do not have nation-wide proportional representation.

Germany is one example of where domestic inequality, a core-periphery dynamic, a specter of divergence, and a wish for convergence, are vital political concerns. Since its unification in 1990, Germany has invested billions of deutsche-marks in the new Länder (the former East Germany) to help the 'east' catch up economically with the 'west', and to prevent mass migration of German workers from eastern to western Länder and cities. Yet eastern Länder remain far behind western ones and migration continues. Italy is another example. It has a rich northern industrial core while the south remains a less wealthy periphery. Government interventions have not been able to bring about convergence. In the United States, scholars and journalists have written about population and industrial growth centers for many years. More recently they have been writing about the declining and emptying heartland – America's grain and ranch region.[1] One journalist has argued that because of the emptying heartland, the Senate, with its equal representation of states, should be discarded as undemocratic (Rosenfeld, 2004).

These examples show how domestic inequality and divergence raise perplexing political questions, questions that cannot be answered by cross-country studies that examine national averages while leaving turbulent inner dynamics hidden.

Inequality Theories

Domestic inequality and divergence are puzzling from classical economic perspectives,

[1] For example: "Amid Dying Towns of Rural Plains …" *The New York Times*. 1 Dec 2003, A1. and "Change of Heartland: America's rural interior …" *National Geographic.* May 2004, 2-29.

which predict convergence. Political economists have offered various explanations for divergence. The new economic geography differs from these.

Romer (1994) has written that the standard growth model, which falls short in explaining comparative economic growth in the world, may need to supplanted by an endogenous growth theory. It explains growth by internal policies, that is, by “private and public sector choices.” (Romer 1994, 1). For example decisions by Italian policy-makers to create institutions strengthening the credibility of trading systems during the Renaissance were important developments that have since helped Western style economies grow (North 1991, Avner, 1994). By contrast, Collier and Gunning (1999) write that bad policies, such as overly large public sectors and slow adoption of new technologies, have stymied economic growth in Africa.

Contrasting with these ‘policy’ driven arguments about economic growth are ‘destiny’ arguments. Gallup and Sachs (1999) argue that geography matters, citing such factors as the deleterious effects of malaria and the sparsity of coastal populations and landlockedness, which increase product distribution costs. Others have argued that colonial legacies and the institutions they left behind have caused inequalities. (Acemoglu, Johnson, Robinson, 2000, 2001).

Other scholars have written that freer trade can cause economic growth and reduce inequality presenting evidence that free-trading countries do better than protectionist countries on average. (Lindert and Williamson, 2001, Dollar and Kraay 2002, Frankel and Romer 1999)

Others, following Rogowski's lead and noting the Stolper-Samuelson theorem, have suggested that freer trade can increase inequality in some economic sectors though fostering gains and convergence in others (Rogowski, 1989). The Stolper-Samuelson theorem asserts that freer trade causes the owners of relatively abundant factors to experience an increased return on their investments and gains in their real incomes, while owners in the relatively scarce factors experience decreased returns and losses. Three political and economic groups – capitalists, landowners, and workers – are associated with the main factors of production – capital, land, and labor. Countries do not have comparative advantages in all three factors – two at most – so at least one group will suffer by more liberalized trade. O’Rourke and Williamson's (1999) study of the 19th century Atlantic economy presented evidence of this dynamic.

The new economic geography differs from these. But just as the inequality theories above have been empirically tested, so should the new economic geography. To that I will now turn.

Part I: The New Economic Geography

The new economic geography as Krugman describes it is a "genre" and a "style of analysis" that moves broadly "in two directions" (1998, 164 & 168). Both directions suggest explanations for the spatial location of an industrial core versus a non-industrial periphery, inequality between these regions, whether these dynamics are in equilibrium, and how wealth divergence can occur followed by convergence. One direction considers the *cross-country* or "international trade" case, the other considers the *within-country* or "location theory" case – the key difference between them being that the latter allows for migration of workers while the former does not (Krugman and Venables 1995). My interest in this paper is only in the within-country or domestic case, but I will nevertheless refer to it in this paper with the more encompassing rubric of new economic geography.

The new economic geography describes an economic and spatial *progression*. The stylized version of the new economic geography begins with manufacturing dispersed throughout two (or more) regions. Three domestic factors, and subsequent changes in them, predict the progression according to the theory. High *transportation costs* make exports from one region expensive in the other region, fostering a dispersed manufacturing equilibrium. Low *economies of scale* contribute to high prices of goods that in turn causes low sales volumes of goods with highly elastic demand (i.e., price sensitivity). A low *mobile proportion* of the workforce, that is, a low proportion of people working in manufacturing versus agriculture, equalizes the regional market sizes because the predominantly agricultural workforce maintains population dispersion. As long as these three interrelated conditions persist, a dispersed, rather than a core-peripheral, manufacture of goods will occur. Because no region enjoys significant competitive or market advantages, manufacturing wage rates should be similar.

However, if these three factors change to opposite levels, then an equilibrium tipping point can be reached that causes the two economies to diverge. One will then observe population shifts to one region, an increasing concentration of manufacturing in that region, and higher wages there than in the other region due to a "home market effect," a rubric for when wages "tend to be higher in the larger market" (Krugman 1991b, 491). As economies of scale increase to *high* levels in the manufacturing region, largely from a larger local market for intermediate goods, the cost of producing a unit of goods becomes far lower than in the other region where economies of scale do not improve. These cost savings help offset transportation costs. When transportation costs then decline to *low* levels, due to such things as technological advances that increase fuel efficiency, the manufacturing region can ship competitively priced goods to the other region. Because the other region's manufacturing cost structures remain high and its local market small, the outside competition will put many of its local firms out of business. If the proportion of the national workforce that is mobile increases to *high* levels, the population and output of the manufacturing region will become large because its jobs attract people. The result is a lopsided population distribution greatly favoring the manufacturing region. We have, therefore, divergence in both location of manufacturing and in wages – a domestic core-periphery situation that may be in equilibrium.

The last part of the new economic geography's progression shows how wage convergence can follow divergence. Krugman offers two scenarios in the 'location' version of the new economic geography where this may happen. The first scenario involves only wage convergence. Manufacturing remains diverged. As transportation costs decline and become smaller portions of buyers' product costs, *real* wages (the buying power of wages) converge as the difference in buyers' cost for goods between the two regions approaches zero. In manufacturing, however, the core-periphery *will persist* because firms enjoy increasing returns in the core region that they cannot obtain in the periphery region. This dynamic runs counter to conventional wisdom that holds that low transportation costs make manufacturing locations irrelevant. This maintains pressure on *nominal* wages to differ. Thus as transportation costs decline, wages will tend to converge, but will not fully converge.

The second scenario allows for convergence in both manufacturing and wages. A retreat from a manufacturing core-periphery equilibrium may occur if certain new combinations of transportation costs, economies of scale, and mobile proportion of the workforce make it profitable for firms to defect or relocate from the manufacturing-core region to the peripheral region. When and if this occurs, then the core-periphery equilibrium's tipping point has been hurdled. When firms relocate to the periphery, wages there will increase and tend toward convergence with the core. I will discuss these combinations in detail in the prediction section.

In the *cross-country* or international trade direction of new economic geography, Krugman presents another possibility for convergence. The lack of workforce mobility keeps the labor supply high in the periphery while job growth remains stagnant, so in time labor costs decline to where it is profitable for manufacturers to move operations there. He does not offer this as a reason for firm relocation in the domestic scenario because he assumes perfect worker mobility. However, we should keep it in mind because it is part of the larger 'genre' of the new economic geography and Krugman claims the international model can be applied to interregional cases.

A key question this theory raises is: why would firms migrate to or stay in the higher-wage manufacturing region when they could pay lower wages for comparable jobs in a peripheral region? The new economic geography's answer is that regional agglomeration is a result of increasing returns, and therefore differs from other growth models that assume either constant or diminishing returns. The general idea of increasing returns is that if inputs are doubled, then economic output is more than doubled. Alfred Marshall (1920) theorized that firms generate increasing returns by locating near other like-firms because of (a) an increased *labor pool*, which provides firms with a skilled workforce, (b) increased intra-industry trade in *intermediate goods*, which provides locally-produced subassemblies of finished goods and an industry-support infrastructure, and (c) increased technical or knowledge *spillovers*, which can speed the rate of innovation and problem solving. This would help explain why firms prefer more costly investments in core areas over less costly ones in peripheral areas: they may yield bigger returns.

Predictions for the Great Plains and Great Lakes

Identifying where this Great Plains and Great Lakes case lies within the theory's progression is the starting point for determining its predictions for our test case. In short, this case, which covers 1930 to 2000, is in the end of the second stage of the progression where the two regions are strongly diverged in a core-periphery alignment. This can be shown in several ways.

First, the Industrial Revolution, which bloomed in the latter 1800s in the United States, resulted in much of the nation's manufacturing locating to Great Lakes states. The Great Lakes states in this paper consist of Wisconsin, Illinois, Indiana, Ohio, Michigan, and Pennsylvania. The Great Plains by contrast were still being settled during this time, especially the northern plains and Oklahoma whose population growths did not level off until 1920. The Great Plains states in this paper are Oklahoma, Kansas, Nebraska, South and North Dakota, and Montana. In 1929 there was minimal manufacturing in the Great Plains states – 1.75% of the population were manufacturing workers – and the population was primarily rural or agricultural – only 33% of the population was urban. By contrast, the Great Lakes states were 67% urban, had 10.2% of its people working in manufacturing, and had much larger populations. Thus the starting conditions of the theory's first stage – dispersed population and manufacturing – do not fit this case. Instead it has the core-periphery orientation of the second stage.

We can observe further evidence of divergence, or the theory's second stage, by looking at regional industrial specialization (or concentration), where high specialization suggests divergence. From 1860 to 1987 both the Hoover and Krugman regional specialization indexes show that U.S. regional specialization was near its highest level in 1930 – amidst a plateau from 1914 to the early 1940s after which it began to decline (Kim 1995, 891, 895).

Last we can consider the relative values of the three factors. The second stage of the theory assumes low transportation costs. Before 1850, transportation costs were high in the United States because horse-and-wagon was the principal mode of overland transporting of goods and information. After the Civil War costs fell dramatically. Railroad track mileage increased from 30,626 miles in 1860 to its peak quantity of 429,883 in 1930. Telegraph mileage in the United States increased from "50,000 miles to 19,382,000 miles between 1860 and 1890" (Kim, 1995). From about 1800 to 1910, overland transport costs declined more than 90% (Bairoch 1990, 142). By 1930, therefore, transportation costs were low. The second stage also assumes high economies of scale. Economies of scale improved dramatically as industrial expertise improved in the latter nineteenth century and when Henry Ford introduced the moving assembly line in the early twentieth century. In 1930, economies of scale were high relative to 1850 levels. Last, the second stage assumes high workforce mobility. The urbanization of America steadily increased through the nineteenth century. Around 1895, urban population exceeded rural population for the first time. Rural dwellers, most of whom were in agriculture, were less mobile because of their tie to the land. Thus, in 1930 the workforce was much more mobile than in the 1800s.

Since our starting point is the second stage, or divergence, two logically possible scenarios for 1930 to 2000 can follow from the new economic geography's principles: continued divergence or progress toward convergence. The theory allows for either scenario depending upon changes to and levels of the three factors. Krugman has modeled the possibilities in a defection or relocation equation that is appropriate for this test case because it assumes divergence as its starting point. If we take his mathematical model seriously, it allows us to obtain a divergence or convergence prediction about the Great Plains and Great Lakes after 1930. Relocation here means firms moving from the manufacturing core to the periphery region.

The relocation equation is a function of three variables that correspond to the three factors discussed in the stylized account of the theory. The transportation cost from one region to the other is represented by its inverse and is symbolized by the variable t. Krugman's proportion of the aggregate population that is mobile and consequently "engaged in manufacturing" is p (1991a, 18).[2] The industry-aggregate economy of scale is represented by an elasticity of demand variable s where a "higher elasticity of substitution … implies smaller economies of scale"(1991b, 497 [and 1991a, 113]). Either firm size or volume of output can represent this. The "profitable to defect"(1991a, 108) or relocation equation[3] takes the form of

$$K = f(t, p, s) = \tfrac{1}{2} t^{ps} \, [(1+p)^{s-1} + (1-p)^{-(s-1)}]$$

where K is a relocation index. When $K < 1$, firms cannot profit by relocating from the core to the periphery, so core-periphery remains the equilibrium. When $K > 1$, firms can profit by relocating from the core to the periphery, so the equilibrium tipping point has been crossed. The mobile share of the population (p) can range from 0 to 1 where '1' means everyone is mobile. Demand is assumed elastic, so $s > 1$. The inverse transportation cost follows Samuelson's (1954, 268) 'iceberg' model: the further a product ships the more 'melts away' so t can range from 0 to 1 where '1' means no loss due to transportation costs.

FIGURE 2 ABOUT HERE.

Figure 2 shows an interpretative graph of this equation. The four lines of the graph are where $K = 1$ and are the divergence-convergence boundaries for four fixed population mobility (p) values. The p values are proxied by the cumulative urban share of the population for the 12 states, satisfying Krugman's urban-rural dichotomy requirement. The urban values represent the proportion of workers who are mobile in the 12 states. Values of the relocation index (K) to the right of a boundary, where $K > 1$, represent the combination of economies of scale and transportation costs that encourage relocation, thus eventual convergence of both wages and manufacturing locations between the regions, for that boundary's value of p. Values to the left of a boundary, where $K < 1$, suggest sustained divergence.

[2] Krugman equates mobile share of the population, or workers in manufacturing, to the "share of expenditures that falls on [or is received by] manufacturers"(1991a, 102)

Figure 2 shows us that divergence is more likely as urban rates, in an urban-rural dichotomy, rise. The heavy solid line represents $K = 1$ in 1930 when p was 0.607 for the 12 states. The dashed line to its immediate right represents the boundary for 2000 when urbanization was higher at 0.757. As urban share or worker mobility (p) increases from 1930 to 2000 levels, the divergence becomes more likely and convergence less likely.

We can determine whether $K < 1$ in 1930 and later years – a core-periphery equilibrium – by estimating s and t. We can estimate s by calculating backwards from Krugman's "constant markup" quotient of $s/(s-1)$. (1991a, 104) The markup quotient reflects how much a producer can markup the price of a good over its cost based on the inelasticity (price sensitivity) of the product.[4] Markups for a product that is highly inelastic or price sensitive (s is high), must be small for the product to sell. Assuming the product cost in its fixed and variable components contains all of the costs of doing business, the aggregate markup of a firm's products will be roughly equal to its profit margin. United States corporations as a whole had full-year after-tax profit margins between 3.98% and 7.09% from 1940 to 2000, as shown in Table 1. Thus, the range of elasticity of demand (s) from 1940 to 2000 is $15.1 < s < 26.1$.[5] In 1930, the first year of the Great Depression, aggregate corporate margins dropped to 1.14%, so s jumped to an anomalous and high 89.1.

TABLE 1 ABOUT HERE.

We can estimate t, the "inverse of transportation costs" as 1 divided by the quotient of the price plus transportation costs over the price, for an aggregate set of goods.[6] (Krugman 1991b, 489) Using the prices of diverse samples of 45 goods from 1930 to 1990 Sears Roebuck catalogs, and the advertised costs to ship the goods 750 to 1000 miles, we obtain the estimates

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[3] The two terms in the brackets represent the profits a firm in the periphery region could earn shipping product to the core region (1st term) and its own region (2nd term). The term in front of the brackets is a multiplier for the wage premium firms must pay to attract workers.

[4] When inelasticity or price sensitivity is high, say 30, then the producer can charge a price of 30/(30-1) or 1.03 times the product's cost. This may be true of generic athletic socks. When inelasticity is low, say 2, then the producer can charge a price of 2/(2-1) or 2 times the products cost. This may be true of perfume.

[5] Net Profit $P = s/(s-1)$, so $s = P/(P-1)$. Thus, the s for 1990 is calculated as $1.0398 \div (1.0398-1) = 26.1$. Satisfying Krugman's requirement that $s > 1$, P is the relative breakeven point '1', plus the profit margin.

[6] The 'inverse' (t) is 1 / ([price + transportation costs] ÷ price). If the price of a good is 1 and transportation costs are 13.2% of the price, then the buyer's cost is 1.132 of the price. The inverse is 1/1.132 or 0.883.

for t shown in Table 1. Here we see that the transportation costs as a proportion of the buyer's cost varied little and, surprisingly, increased a little over time. The inverse transportation costs (t) stayed within a tight range of 0.911 to 0.956.

With these estimated ranges of elasticity of demand (s) and the inverse of transportation costs (t) we can determine, from Figure 2, the new economic geography's predictions for the Great Plains and Great Lakes interregional dynamics after 1930. The ellipse in the upper center of the chart represents the predictions. It contains the values of s and t calculated above from 1940 to 2000. The ellipse shows that the relocation index (*K*) values are less than '1' for all urban population and transportation cost combinations and that the tipping point for convergence, the $K = 1$ line, moves further away over time.

This yields the following predictions, which meet the standard falsifiability requirements (Chalmers 1999; King, Keohane, and Verba 1994).

a. The most salient prediction is that the core-periphery dynamic (divergence) will be in equilibrium from 1930 to 2000, thus will persist. The progression will remain, consequently, in the second stage and will not progress to the third stage where convergence can occur.
b. As urban proportion of the population (p) increases over time, divergence will strengthen because the relocation index's distance to its equilibrium tipping point (*K* = 1) increases.
c. The low transportation costs (adding 10% to the buyer's cost for goods) will strongly sustain the core-periphery (divergence) equilibrium. To approach the tipping point, t must approach 0.65 which means adding 55% to the buyer's cost for goods, which is highly unlikely based on historical costs.
d. The high and relatively immutable range of elasticity values (s) after 1930 also suggests a sustained core-periphery, particularly as the urban proportion of the population increases.

These predictions of continued divergence suggest these quantifiable predications:

e. Increased (or sustained) higher wages in Great Lakes versus Great Plains states.
f. Higher (or sustained high) regional specialization indexes, meaning the Great Lakes will largely remain the manufacturing core region and relocation will be minimal.
g. The number of manufacturing workers in the Great Lakes states will continue to dwarf those in the Great Plains.

Part II: Evaluating the theory

In the remainder of this paper I will evaluate whether the new economic geography correctly predicts the dynamics and causes of divergence (or inequality) between the Great Plains and Great Lakes regions from 1930 to 2000. I will discuss changes in divergence over time, and then evaluate the effects of these changes *on wages* by analyzing *regional* and then *state* data.

Changes in Divergence Over Time

Divergence in the new economic geography is manifested in two ways: wage differences and manufacturing concentration (or numbers). The theory asserts these correlate positively by the 'home market effect'. From 1920 to 2000 manufacturing workers' nominal wages in the Great Plains states trended increasingly below those in the Great Lakes states as shown in Figure 1. On this count, the new economic geography predicts correctly: divergence strengthens after 1930.

TABLE 2 ABOUT HERE.

However, in manufacturing concentration, the results are more ambiguous. On the one hand, regional specialization indexes and proportion of people in manufacturing suggest convergence is occurring. As noted above, regional specialization indexes declined after 1940. Regional specialization decreased from a plateau of about "43 percent" in 1939 to "23 percent in 1987."(Kim 1995, 887) A declining index signifies that industries are becoming more geographically dispersed. Kim (1995, 887) states this trend has been described by Hoover (1971), Krugman (1991a), and Scott (1988), "among others." One could argue that while these data show increasing dispersion on a national level, it is not necessarily reaching the Great Plains. Yet, as Table 2 shows, manufacturing increased in the Great Plains states on a proportion-of-population basis while it declined in the Great Lakes states. At the present trends, the proportions will converge around 2025. In numbers of manufacturing workers, the Great Plains states grew from 179 to 425 thousand from 1950 to 2000, whereas the Great Lakes shrank from 4675 to 3439 thousand.

On the other hand, divergence is still occurring. In 2000 the Great Lakes proportion of manufacturing workers was still higher than the Great Plains by 43%, and the total number of workers was still eight times higher. Thus, the trend might not be toward convergence, but toward a steady state condition where divergence will persist. Consequently, on manufacturing concentration, the theory incorrectly predicts that the core-periphery will remain as strong as it has been because it has instead weakened. However, the theory is correct that divergence would persist. Thus we cannot conclude that the new economic geography predicts wrongly or rightly here. We can say, however, that the 'home market effect' – an assumption of the theory – does not hold, since manufacturing concentration and wages correlate negatively.

Since the theory assumes that manufacturing concentration raises wages and the manufacturing gap between the regions is shrinking, it is puzzling that wages have continued to diverge. The remainder of this paper will investigate this and evaluate whether Krugman's theoretical causal mechanisms can explain wage divergence.

Test Variables

My test variables represent the three factors of the new economic geography – mobile proportion of the population, economies of scale, and transportation costs – which I call the explanatory variables, and six control variables. The data is comprised of 96 observations – 12 states for 8 years – six Great Plains and six Great Lakes states for 1930, 1940, and so on to 2000. The regional analysis, which follows, divides each year's observations into two regions. The state analysis, utilizing statistical methods, uses the observations as is.

The proportion of each state's population that is mobile (p) is represented by a proxy, the proportion of *urban* population in an urban-rural dichotomy. It can range from 0 (all rural) to 1 (all urban). Economies of scale is represented by *elasticity of demand* (s), which Krugman states moves opposite to economies of scale. Elasticity of demand is proxied using Krugman's equation, noted above, of $s = P/(P - 1)$, where P is relative to the breakeven revenue (i.e., P is '1' plus profit margin). The aggregate profit margin of states' manufacturing are comprised from 'value added by manufacturing' less 'salaries and wages', divided by the 'value of manufacturing shipments'. I used these estimates rather than the more precise data of state's profit margins because the latter data is not available.

Transportation cost is the most complex variable. I utilized a new variable to reflect states' differences in distance to markets – a transportation cost gradient (*TCG*) in gallons per mile. This variable is a *relative* indicator of the cost to reach a given market size from a state.

Busch and Reinhardt's (1999) geographic concentration calculation was informative for the *TCG*. Their *GEOCON* variable provides a relative indicator of the geographic concentration of an industry by determining an employee weighted national geographic centroid for the industry. While their variable cannot directly be made into an indicator of transportation cost, their idea of a weighted sum of geographic distances using latitude and longitude data is useful.

To visualize a *TCG*, imagine a rotating radius expanding from a home state until the geographic area covered by the resultant circle contains a given proportion of the U.S. market. The gradient's size will be large for states far from markets, and small for states close to markets.

Arithmetically, each state's *TCG* is the quotient of an Opportunity Gradient (*OG*) divided by the cost of fuel in dollars per gallon. The *OG* is the sum of incomes of the states surrounding a home state, and the home state's income, divided by the sum of distances to those states and the average internal distance of the home state. States' incomes reflect the market size. The cost of fuel is represented by the wellhead cost of petroleum normalized in constant 1930 dollars (1930 = 1). The *OG* is similar to Tinbergen's (1962) gravity model. The distance portion of the *OG*, by being the denominator, is similar to Samuelson's (1954, 268) iceberg model. The distance from one state to another is calculated as geographic center to geographic center in terms of latitude and longitude using the Haversine formula (Sinnott 1984, 159). Geographic centers were chosen because they don't move, they reasonably calculate income centers of most states, and the data are easier to find than income centers. Because Michigan's geographic center is many miles northwest of its income center due to the sparse Upper Peninsula, I use instead a latitude and a longitude slightly east of Lansing for it approximates Michigan's income center based on population distribution. The distance to transport goods within a state is estimated as the average distance between two randomly and uniformly distributed points in the state (Gaboune, Laporte, and Soumis, 1993, 516). The equations for the *OG*, the distance between two points on the globe in latitude and longitude, and the distance within a state are presented in the Appendix.

I use five *control* variables, which are potential alternative explanations for wage behavior. A higher *education level* – indicating higher average human capital – often means higher wages. I use the proportion of the population in each state that has earned a college degree as a proxy for worker education levels. A higher *ratio of women to men* in manufacturing means lower wages because women have historically been paid less than men. As a proxy for this ratio, I use the ratio of men and women in the general workforce. Increased *ages of workers* – another form of higher human capital – tends toward higher wage rates, so I include the median age of the state as a proxy for the age of workers. Some political economists assert that high tax burdens drive businesses from high-tax states to low-tax states causing job losses to high-tax states and a weakening of wages. Others assert that high taxes are relatively benign citing high European and U.S. growth with high taxes from 1950 to 1980. This paper takes the former view so I include two state tax variables. I use a state *tax rate* variable – per capita state tax revenues divided by per capita income – and a *tax revenue* variable – per capita state revenues divided by the 12-state population-weighted average of tax revenues.[7] I omit federal taxes because federal tax rates are the same for all states. Last, I use a *union density* variable – the proportion of the workforce who are union members – because union agreements often drive wages up.

All the variables were normalized in some fashion to ensure direct relative comparisons over time. For example, the *OG* and *TCG* were normalized by using state incomes as *proportions* of total U.S. income. Education levels, median age, gender, tax revenue, and wage rates were calculated as ratios of states' data divided by the population-weighted average of the twelve states. A C++ program calculated the *OG* values. Its inputs were the geographic centers of the 50 states (in latitude and longitude), incomes of the U.S. and the 50 states for the 8 observation years, and the rectangular or circular dimensions of my 12 states (for internal distances).

Analysis at the Regional Level

This section discusses regional comparisons and results. It first evaluates whether the differences between the two regions' new economic geography variables explain wage behavior as predicted. It then briefly examines whether the control variables, at the regional level, appear to be contributing factors to wage behavior. The regional analysis is important because it can illuminate a dynamic that the state (i.e., statistical) analysis cannot – whether the regional explanatory variables converge even though wages, as shown above, remain diverged. This dynamic if present will help corroborate the theory's prediction of a core-periphery equilibrium.

Let us first consider the theory's mobile portion of the population, which is proxied by urban rates. In 1930 about 33% of the Great Plains states and 67% of the Great Lakes states were urban. By 2000 those figures increased to 63% and 78%. Thus the Great Plains states had lower urban rates than Great Lakes states, but the difference decreased over time. Graphically, this is shown – along with wages and the other explanatory variables – in Figure 3: Explanatory Variables' Differences. Thus, even as the regions' mobile portion of the population trended toward convergence, wage divergence persisted. Since cumulative urban rates increased, this

[7] A potential endogeneity problem exists between state taxes and wages. Higher tax revenues may be sign of a higher tax burden, but can also be a result of higher incomes or wages. Tax rates as revenue divided by wages may fix this, but since most states have graduated tax schedules, a higher tax rate may also be an indicator of higher wages.

result is consistent with the new economic geography's predictions.

FIGURE 3 ABOUT HERE.

The differences in the elasticities of demand between the two regions also decreased from 1930 to 2000, as Figure 3 shows, suggesting a trend of convergence in how much firms can mark up products, thus earn in profits and pay in wages. Great Plains states had nearly 42% lower aggregate elasticities of demand than Great Lakes states in 1930, but averaged only about 12% less from 1970 to 2000. However, despite the smaller difference in elasticities in demand over time, wage differences continued to grow suggesting again a core-periphery equilibrium.

The differences in the regional transportation cost gradients show the greatest differences of the explanatory variables between the regions. This can be seen in Figure 3, which contains all four variants of the *TCGs.* While the *TCG* differences decrease over time – a result of U.S. population shifts south and west – thereby reducing pressure on wages to differ, they remain large – greater than 45% for all variants for all years. At the state level, TCG_{25} in 1930 varied from a best of 1.936 gallons/kilo-mile for Pennsylvania to a worst of 0.398 for Montana; in 1980 when the real price of oil was nearly four times 1930 levels, TCG_{75} ranged from a high of 0.699 in Pennsylvania to 0.202 gallons/kilo-mile in Montana. Figure 3 also shows us that the smaller the market shares the higher are the differences between regions. This suggests that embryonic Great Plains firms have a severe competitive disadvantage with comparable Great Lakes firms. Krugman's theory predicts that the Great Plains and Great Lakes are in a core-periphery equilibrium due to assiduously low *absolute* transportation costs (i.e., low nationally) – as we saw in Table 1 – so even if differences in transportation costs decline, wage divergence should persist and it does. Increasing returns, as Krugman suggests in his theory, may be a contributing dynamic to this behavior.

The control variables have mixed correlations to wage behavior. Figure 4, less the tax rates, show the differences in control variables at the regional level relative to the regional wage differences. The median age between the two regions shows a slightly younger Great Plains region catching up with the Great Lakes region by 1970 and remaining about the same age thereafter. The reduced age difference over time – from 1930 to 1970 – suggests that age might correlate negatively with wages – opposite what we expect. Thus, age does not appear to explain wage behavior.

FIGURE 4 ABOUT HERE.

The education data shows that, people in the Great Plains states had proportionally more 4-year college degrees than did people in the Great Lakes states for most years, but education differences do not trend up nor down, and they vary over time near zero so they do not appear to correlate with or explain wages.

The regional differences in the ratio of women to men in the workforce trended upward throughout the time period, while wages trended downward. In 1930 the *ratio of women to men* in the workforce was 22.0% lower in the Great Plains than in the Great Lakes states while in 2000 this ratio was 4.0% higher. This is what we would expect if the gender of workers explains wages. Thus gender appears to have an effect on wages.

Throughout the time period of 1930 to 2000 the Great Plains states had significantly lower union densities than the Great Lakes states. This should greatly contribute to the former states having lower wages than those of the latter states.

State tax rates differences, which are not on Figure 4, varied considerably from 1930 to 2000, roller-coastering downward from 1930 to 1970, then remaining around zero in trending upward from 1970 to 2000. In 1930 Great Plains tax rates were almost 90% higher than in the Great Lakes states. In 1940 and 1950 the differences were about 15% and 40% respectively. The mixed directions of tax rate differences relative to wage differences suggest that tax rates do not explain wages. State per capita tax revenue differences, which are on Figure 4, also fluctuated substantially from 1930 to 2000, but unlike tax rates, they trended downward, as do wage differences, during the whole period. This correlation is opposite what we would expect if higher tax revenues are ultimately causing businesses to flee states driving wages lower. So tax revenues do not appear to explain wage divergence.

In summary, these regional analyses seem to offer support for the new economic geography since a divergence equilibrium persists despite trends in the explanatory variables that might suggest less wage inequality. Some control variables can additionally explain wages, but most appear to not do so. In the next section, I will explore whether the Krugman variables continue to explain wage divergence when examined at the state level.

Statistical Analysis and Results

For state level analysis, I use an Ordinary Least Squares (OLS) framework. The variables are shown in Table 3: Summary of Variables. We are testing the ability of the theory's three variables – urban share of the population, elasticity of demand, and transportation cost – to explain manufacturing wage behavior. There are six control variables – education level, median age, worker gender, tax rates, tax revenues, and union density. In general, Krugman's theory will be empirically supported if his variables statistically explain manufacturing wages when control variables are included in the model.

TABLE 3 ABOUT HERE.

Transportation costs are represented by two variables – *TCG* and *OG*. Fuel costs significantly decreased the *TCGs* in 1980, 1990, and 2000 compared to the *OGs* because of sharply higher fuel costs. From 1925 to 1970 wellhead prices of crude oil remained between 0.9 and 1.5 times 1930 costs (in constant dollars). In 1980, they were about 3.7 times 1930 levels, and about 2.2 times in 1990 and 2000. Since the composition of transportation costs entails more than just fuel costs, these stark increases in fuel prices may exaggerate changes in transportation costs. So I added the *OG* because it reflects transportation costs as a function of only distance.

The general results of the statistical analysis for the theory's three variables are that the transportation cost variables had an effect on wage rates in the manner the theory predicts with well over 99% statistical significance. Urban rates also affected wages as predicted, but with a moderate level of significance at 87%. Elasticity-of-demand failed to meet predictions. In the remainder of this section I will explain the statistical analysis and then discuss these results and those of the control variables in more detail.

The statistical analysis involved several steps. There were several pre-analysis steps meant to check and improve the credibility of the statistics. Then there were the analysis steps – those associated with running the regressions.

The first pre-analysis step checked for variables' conformity with the Gauss-Markov assumptions via boxplots, histograms, and other tools in Data Desk. The variables transformed to improve the normality of their distributions are the following. The *TCG*, *OG*, and tax revenue variables were transformed with natural logs; education was transformed as *e* to the education power, age as 16 to the age power, gender as 10 to the gender power, and urban rates as 6 to the urban-rate power. Elasticity of demand was Box-Cox transformed using a slider value of -1.4.

The next pre-analysis step checked for serial correlation, a possibility for time-series data. Serial correlation can violate the Gauss-Markov criteria for uncorrelated errors. The regressions' Durbin-Watson statistics ranged from 1.90 to 2.10 indicating a 95% confidence level of no serial correlation. Previously I had run regressions with a lagged dependent variable – a common check on serial correlation – and found it attenuated the regression coefficients by 25-75 percent destroying statistical significance (Achen, 2000), so I omitted the lagged variable.

The last pre-analysis step of importance involved checking for outliers. Cook's diagnostics indicates that one observation – 1980 Montana – has a large influence, and has more than twice the influence than the next most influential variable. Why is this? Montana has the lowest *TCGs* for all market sizes and years suggesting it should have the lowest manufacturing wages. Yet in 1980 Montana had the second highest wages of all 12 states. Historically a large proportion of Montana's 'manufacturing' is in mining and logging, unlike the other states. From 1970 census data, this proportion for Montana was about 70%. Montana also has strong labor unions at its copper mines driving wages up. In 1980 the prices of precious metals skyrocketed. Copper prices rose to levels that, since then, have not been matched in constant dollars. Therefore, I excluded the 1980 Montana observation by giving it a dummy variable.

The analysis steps began with running Amelia on 16 models comprised of different combinations of the variables. Each model used one of the two tax variables – tax revenue or tax rates – and each model used one of eight transportation cost variables resulting in the 16 models. The eight transportation cost variables arose from using four variants for each of the *TCG* and *OG* variables – one reaching 25% of the U.S. market, then 50%, 75%, and 95% – because of my uncertainty over an appropriate market size in considering transportation costs. Each model included all of the remaining variables. The analysis steps were run in GAUSS programs.

The analysis needed Amelia because the elasticity of demand variable is missing data for 1950 and 1960 (King, et al, 2001). Value of shipments data, used to estimate it, are not available for 1950 and 1960. The first of Amelia's three processes outputted 25 datasets for each of the 16 models imputing values for the missing data. The Amelia runs included U.S. profit data (NIBT) to improve missing data estimations. Draws were set at 40 (_AMsn=40) to satisfy the Central Limit Theorem. The second process entailed OLS regressions on each of the 400 imputed datasets. I also did a Durbin-Watson check and ran a likelihood calculation on each regression result. The third Amelia process combined the 25 regression results for each of the 16 models producing one set of regression coefficients and variances for each model. I then averaged each set of 25 likelihoods so each of the 16 models had only one.

The last analysis step amalgamated the regression coefficients and variances from the 16 models into one set of coefficients and variances using Bayesian Averaging (Bartels 1997, 645 and Hoeting et al 1999, 383). Bayesian Averaging uses the likelihood of each model at their maximum likelihood estimate (MLE) to permit the data to tell the user how much weight to apply to each model's coefficients and variances (Pawitan 2001, 151 and King 1998, 65). The sum of the weights is 1.00 or 100%. The Appendix contains the Bayesian Average equations.

TABLE 4 ABOUT HERE.

The weights of the models ranged from 0.2% of the whole to 30.9%. The eight models with tax revenues accounted for about 94% of the weighting versus 6% for the eight with tax rates suggesting that models with tax revenues statistically explain much more than those with tax rates. Similarly, the eight models with the *OG* variables accounted for about 70% of the weighting versus about 30% for eight models with the *TCG* variables.

Table 4 shows the final regression statistics. The top half contains the control variables while the bottom half contains Krugman's three explanatory variables. The middle columns contain results. For *union density*, a 1 unit increase results in a 0.0306 unit increase in wages (i.e., wage ratio). Since the wage ratio is normalized around 1, this can be stated as a 3.06 percentage point increase in wages. For *age*, which was transformed, a 1 unit increase in 16-to-the-age-power results in a 0.00887 unit, or a 0.887 percentage point, decrease in the wage ratio. A 1 milli-unit increase in $ln\ TCG_{75}$, increases the wage ratio by 5.20 percentage points.

The confidence levels show the statistical significance of the variables, derived from t-scores and the degrees of freedom. The *OGs* and *TCGs* – representing transportation costs – are highly significant for all eight variants, with confidence levels well above 99 percent. We can be more than 99% confident, therefore, that transportation cost's true effect on wages is not zero. Union density is also significant above a 99% level. Education and tax rates are statistically insignificant, thus their true effect on wages is likely to be near zero.

The right columns evaluate the results. The 5-95 effects, which ignore outliers, are calculated by multiplying the variables' coefficients by their range of values from the 5th to the 95th percentile. The 5-95 range of $ln\ OG_{75}$ is –0.0297 to 0.1004, or 0.1301 dollars per kilo-mile and its coefficient is 0.1150, thus the 5-95 effect of $ln\ OG_{75}$ is a wage increase of 15.0%. The robustness assessments – Low, Medium, or High – are based on the confidence levels. The last column shows whether the sign of the regression coefficients met the expectations outlined in Table 3.

These results suggest that Krugman's theory explains in part. Of all the variables, the theory's transportation costs (*OGs* and *TCGs*) affect wages the most, in the direction the theory predicts, and in a highly robust manner. Their 5-95 effects averaged 12.9% and ranged from 10.3% to 16.7%. Urban rates also affected wages as predicted. It had the second greatest effect of all variables at 10.8%, but with moderate robustness. Krugman's third variable – elasticity of demand – fails to explain, correlating to wages opposite what the theory predicts.

Of the control variables, several affected wages as predicted. Union density correlated positively with wages, as expected, having a 5-95 effect of 9.8% with very high robustness. Gender's 5-95 effect on wages was -7.4% with high robustness. Tax rates and education have meager effects with negligible robustness. *Age* has a reasonable affect on wages, at -6.6%, but in a direction opposite what we expected. Why this occurs requires further inquiry.

Tax revenues have a large affect on wages and is highly robust, but it also moves opposite expectations. I suspect this is due to wages driving tax revenues rather than tax revenues driving wages – the potential endogeneity problem warned about earlier in this paper. Because endogeneity may be present, I ran regressions without tax revenues and this did not meaningfully change the results of the theory's three variables. Thus tax revenue's affect on Krugman's variables is benign.

Conclusion

In light of these results – the regional comparisons and the statistical outcomes – what can we conclude about the new economic geography and its ability to explain inequality between the Great Lakes and Great Plains regions and states? Additionally, what can we say more generally about the prospects for wage convergence between these regions?

This paper has shown that the new economic geography is somewhat right in this test case in the divergence-to-convergence (or possibility for convergence) portion of the theory. In short, the theory predicts the regions are in an equilibrium that maintains divergence. By divergence, the theory refers to both manufacturing concentration (or numbers) and wages. On the former item, the proportion of the population working in manufacturing is converging between the two regions, though the numbers of manufacturing workers in the Great Lakes regions continues to dwarf those in the Great Plains. Thus, the theory gets mixed marks on this count. On the latter item, divergence in wages is sustained and growing, so the theory predicts correctly in this.

The theory also predicts that the divergence dynamic is caused by three variables – transportation costs, economies of scale, and proportion of the population that is mobile. The regional analysis, comparing the regional differences of the variables to wage behavior, suggests that the theory predicts reasonably well – that transportation cost and urban rates are contributing to wage divergence, economies of scale might be contributing, *and* the core-periphery is in equilibrium because wage divergence did not reverse as differences shrunk. The statistical results, however, do not corroborate the theory in its entirety. Transportation costs and mobile proportion of the population explain much of the wage behavior, but economies of scale (observed via the elasticity of demand variable) affects wages in a direction opposite what the theory predicts though its significance is notably low So overall, we can say that the new economic geography is correct only in part.

As for the control variables, they provided interesting results. Union densities, long known as important economic determinants in the European setting, are shown here to also be important in the U.S. by contributing strongly to wage behavior (Hanson 2005). The gender of the workforce is also shown to affect wage rates as expected.

Criticisms could possibly be levied against these results or this study. I will discuss two that I consider more serious. One is that the new economic geography applies to individual industries rather than industries in aggregate as I investigated above. A problem with this view, however, is that concentration of an industry still requires intermediate goods and 'infrastructure' goods that are common to many industries and require economies of scale to maximize efficiencies and thus costs. Therefore industries tend to clump together. Lone ranger industries are rare. Furthermore to evaluate a single industry, one would have to show that agents in that industry sedulously considered locating in the periphery as a viable option and this is probably not possible to do. Aggregate analysis avoids this problem because there will always be some firms, at the aggregate level, that will be considering investment in the periphery region.

A second potential criticism is that the statistical analysis does not show the persistence of the core-periphery equilibrium – it only shows variables' effects on wages. One response to this is that the traditional method of examining persistence is to use a lagged dependent variable. However, as was mentioned above, this maneuver suppresses the regression coefficients of the other variables to insignificance. It may be that further advances in statistical methods are needed before persistence can be examined without shrinking the effects of the other variables.

What might these results suggest for future wage convergence between the Great Plains and Great Lakes regions? While the results of this case study show a stubborn core-periphery dynamic, I believe there are reasons to believe convergence may be occurring now. We should note that convergence in employment is occurring. In both proportions of workers who are in manufacturing and in absolute numbers of manufacturing workers, the Great Plains and Great Lakes regions are converging. Job creation often leads to higher future wages, so employment convergence may be a harbinger of wage convergence.

Some additional reasons for us to anticipate convergence is that urbanization of the Great Plains states is increasing, the cost of land for businesses is relatively low, and the cost of housing is low. These conditions may eventually offset the increasing-returns comparative advantage currently enjoyed by the Great Lakes states. Furthermore, peripheral regions, or states, overcoming divergence is possible. The South in the United States is much more industrialized today than in, say, 1920. China has developed regional industrial centers where industry was previously weak, and South Korea is no longer a peripheral or global 'South' country, to cite a few examples.

This analysis has shown us that domestic core-periphery analyses can give us important results. Economic growth and divergence continue to be major areas of research because our understanding of their causes is still wanting. Traditional models fail to explain all economic growth patterns in the world. The neo-classical model predicts convergence between rich and poor regions yet convergence often does not always happen. Though O'Rourke and Williamson (1999) found convergence between North Atlantic countries in the 1800s, a North-South divergence continues for much of the world (Pritchett, 1997). Divergence also still occurs *within* countries. Some rich countries have poor regions, especially if they are large and diverse geographically. The new economic geography presents a theory for why divergence occurs and persists built on the presumption of increasing returns and the role of transportation costs, size of the mobile workforce, and economies of scale. This study suggests that the intuition behind this has merit, at least based on the wage results. But the theory is also deficient in respects leaving a space for future theoretical improvements.

A summary of the data sources, the data, the TCGs *and* OGs *for all 50 states, and copies of the GAUSS programs for replication or other purposes are available from the author upon request.*

Appendix: Equations.

The Opportunity Gradient:

For some state *h*,

$$OG = \frac{i_h}{d_{hh}} + \sum_{k=1}^{m} \frac{i_k}{d_{hk}} \text{ ; with } m \text{ such that } \left(i_h + \sum_{k=1}^{m-1} i_k \right) < s < \left(i_h + \sum_{k=1}^{m} i_k \right) \quad \text{where}$$

h ≈ the *home* state.
k ≈ the k^{th} state, where k = 1 the nearest state, k = 2, the next, etc.
d_{hk} ≈ the *distance* from the home state to the k^{th} state.
i_k ≈ the total *income* of the k^{th} state
s ≈ the threshold market size.
m ≈ the *threshold* state, inclusive.

Distance – *d* – between two points on the earth (Haversine formula)

$$d = 2 \times R \times \text{arctan2}(\text{sqrt}[1\text{-}a], \text{sqrt}[a]), \qquad \textit{given}$$

$$a = \{\sin(\frac{lat1 - lat2}{2})\}^2 - \{\cos(lat1) \times \cos(lat2) \times [\sin(\frac{lng1 - lng2}{2})]^2\}$$

$lat1$, $lat2$ ≈ the latitude of the 1st and 2nd states' geographic center (in radians)
$lng1$, $lng2$ ≈ the longitude of the 1st and 2nd states' geographic center (in radians)
R ≈ the *radius* of the earth. (3956 miles)

The average distance between two random and uniformly distributed points.

For a (state approximated as a) rectangle where a = one side, and b = the other side:

$$AD_R = \frac{1}{3}(a^2 + b^2)^{1/2} + \frac{a^2}{6b}\ln\left(\frac{b + (a^2 + b^2)^{1/2}}{a}\right) + \frac{b^2}{6a}\ln\left(\frac{a + (a^2 + b^2)^{1/2}}{b}\right) - \frac{(a^2 + b^2)^{5/2}}{15a^2b^2} + \frac{a^5 + b^5}{15a^2b^2}$$

For a (state approximated as a) circle where r = the radius: $AD_C = r \times \frac{128}{45p}$

The Likelihood equations -- at the MLE – for a Normal linear model

the *variance*: $\hat{s}^2 = \frac{1}{n}\sum_{i=1}^{n}(y_i - x_i'\hat{b})^2$, where $\hat{b}$ = vector of regression coefficients

the *likelihood*: $L(\hat{b}, \hat{s}^2 \mid y) = \prod_{i=1}^{n}(2p\hat{s}^2)^{-1/2} e^{-z_i}$, where $z_i = \frac{(y_i - x_i\hat{b})^2}{2\hat{s}^2}$

y_i = the vector of the observations for the dependent variable (i.e. wages)
x_i = the matrix of observations for the independent variables.
p = the constant 3.1415 …
the variance = a scalar value.

The Bayesian average mean and variance of a set of linear regression models

. $E(ß \mid \mathbf{X}, \mathbf{y}) \equiv \bar{\mathbf{b}} = \sum_{j=1}^{n} r_j \mathbf{b}_j$ *the mean*

$V(ß \mid \mathbf{X}, \mathbf{y}) = \sum_{j=1}^{n} r_j V(\mathbf{b}_j) + \sum_{j=1}^{n} r_j (\mathbf{b}_j - \bar{\mathbf{b}})^2$ *the variance*

where $n =$ number of models containing the regression coefficient
$r_j =$ the proportion of the likelihood of model *j* relative to the other models, a scalar.
$\mathbf{b}_j =$ regression coefficient vector of model *j*
$\bar{\mathbf{b}} =$ the vector of Bayesian averages for the coefficients
$V(\mathbf{b}_j) =$ the vector of variances for each coefficient in the coefficient vector.

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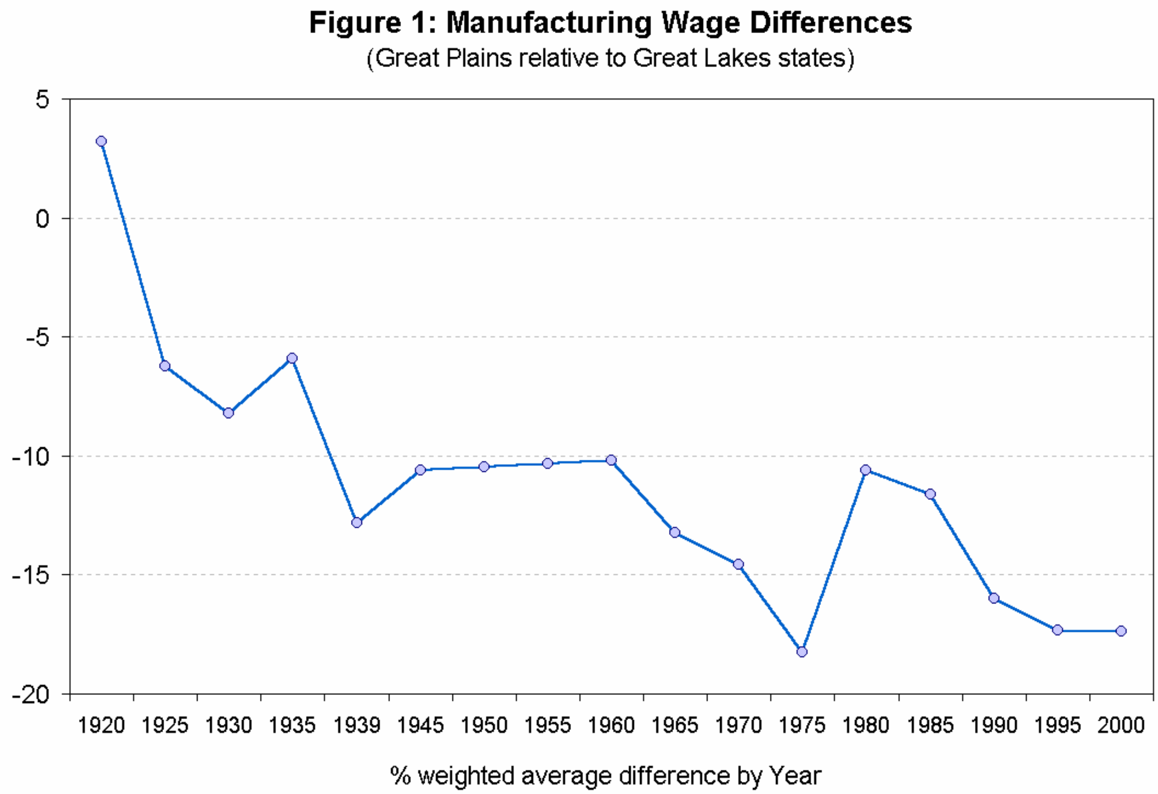
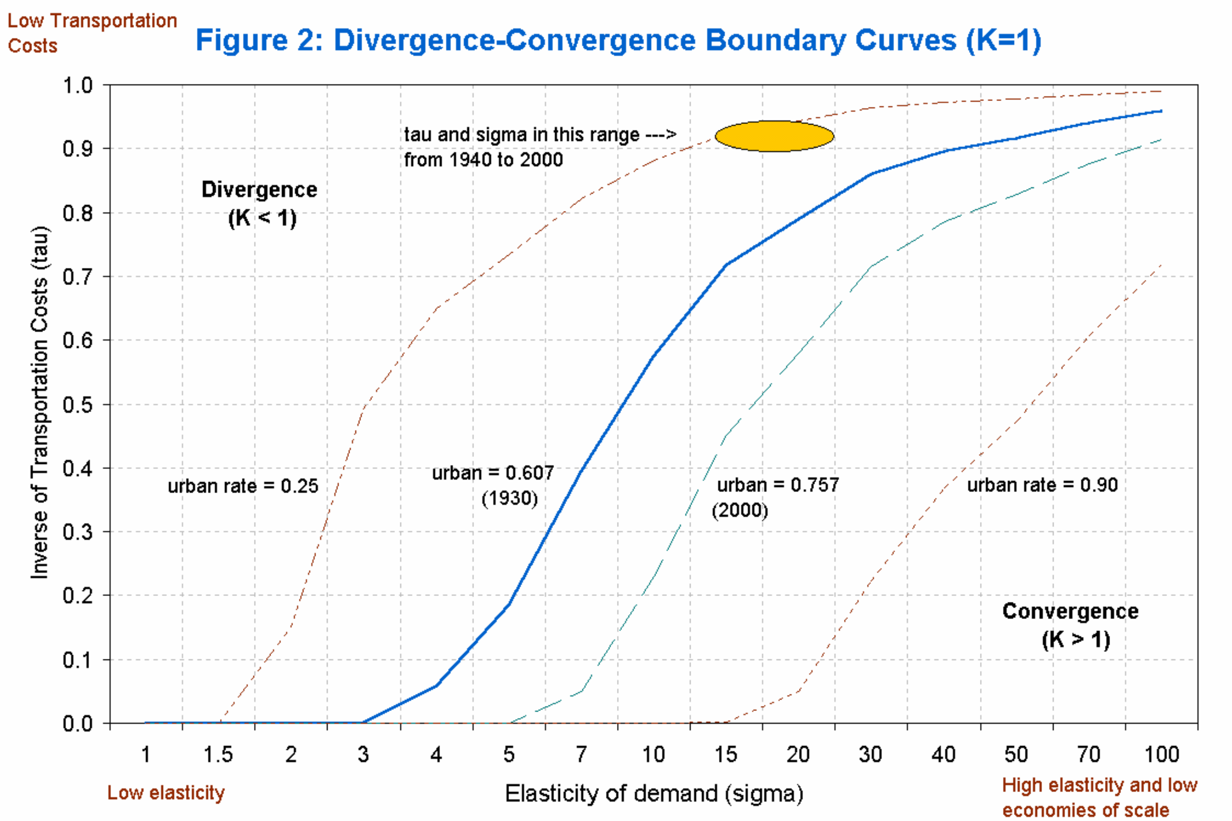


Figure 1: Manufacturing Wage Differences
(Great Plains relative to Great Lakes states)
5
0
-5
-10
-15
-20
1920 1925 1930 1935 1939 1945 1950 1955 1960 1965 1970 1975 1980 1985 1990 1995 2000
% weighted average difference by Year

Figure 2: Divergence-Convergence Boundary Curves (K=1)



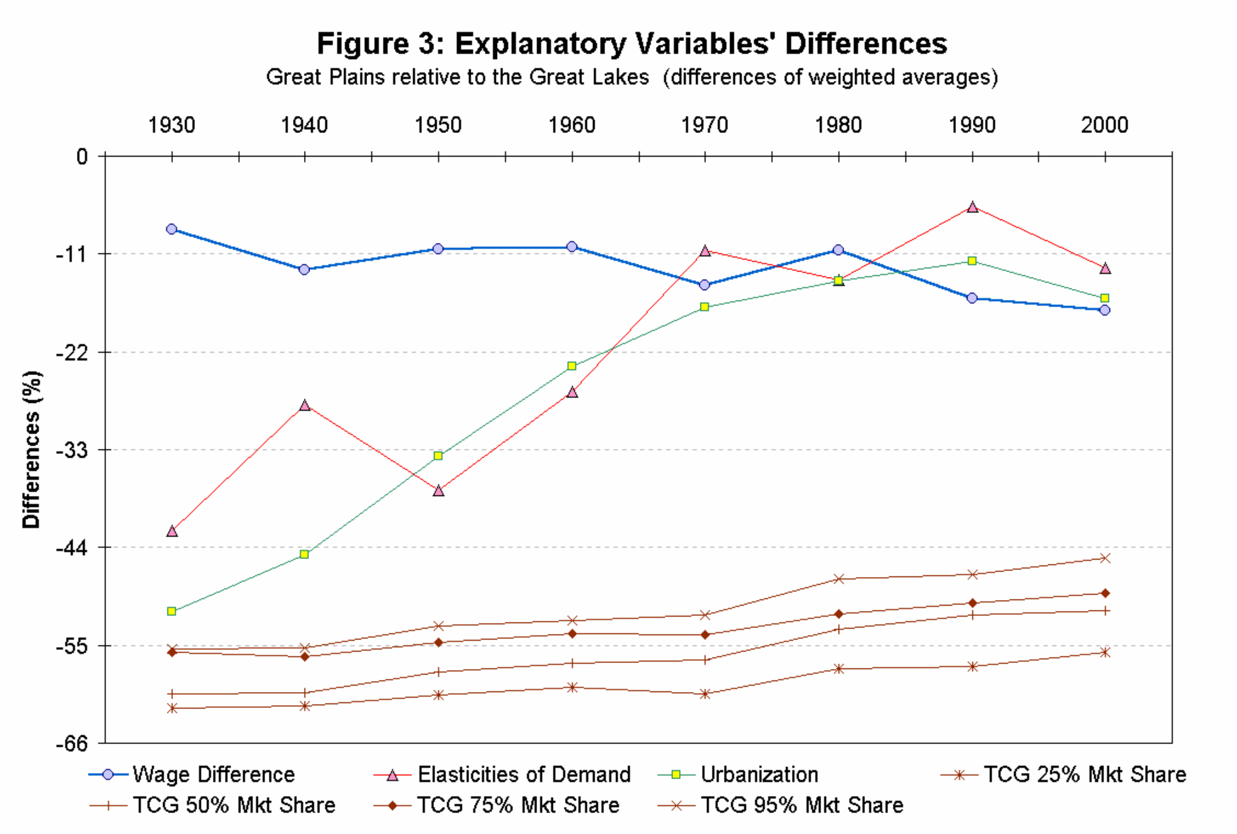


Figure 3: Explanatory Variables' Differences
Great Plains relative to the Great Lakes (differences of weighted averages)
1930
1940
1950
1960
1970
1980
1990
2000
0
-11
-22
-33
-44
-55
-66
Differences (%)
Wage Difference
Elasticities of Demand
Urbanization
TCG 25% Mkt Share
TCG 50% Mkt Share
TCG 75% Mkt Share
TCG 95% Mkt Share

Figure 4: Control Variables' Differences (tax rates not included)
Great Plains relative to the Great Lakes (weighted average differences in %)

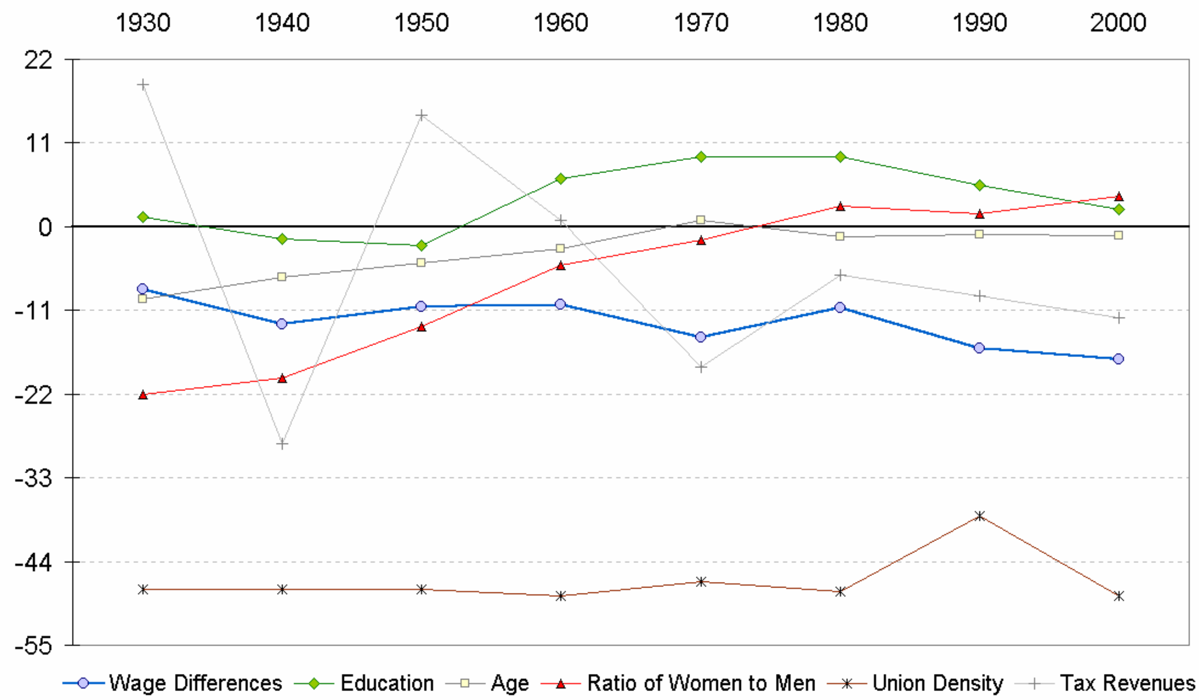


Table 1: Estimated Values of s and t for the Great Plains and Great Lakes from 1930-2000

	1930	**1940**	**1950**	**1960**	**1970**	**1980**	**1990**	**2000**
Profit Margins =	1.14%	6.02%	7.09%	4.40%	4.03%	4.87%	3.98%	6.05%
s **=**	89.1	17.6	15.1	23.7	25.8	21.5	26.1	17.5
Buyer's Cost =	1.048	1.069	1.046	1.070	1.074	1.081	1.098	n/a
Transportation Costs =	4.83%	6.94%	4.56%	6.95%	7.38%	8.07%	9.80%	n/a
t **=**	0.954	0.935	0.956	0.935	0.931	0.925	0.911	n/a

Buyer's cost is relative to advertised prices; the excess over 1 reflects the transportation costs.
Source: Statistical Abstracts of the U.S. various years.

Table 2: Proportion of the populations that are production workers (in %)

	1930†	1940†	1950	1960†	1965	1975	1985	1990	1995	2000
Great Plains	1.8	1.3	2.4	2.8	2.9	3.7	3.6	3.8	4.0	4.2
Great Lakes	10.2	8.3	11.4	9.0	9.4	7.8	6.5	6.3	6.3	6.0

† Production workers data are from 1929, 1939, 1959, populations from 1930, 1940, 1960.

Table 3: Summary of Variables

Variable	***type***	***expected effect on manufacturing wages***	
manufacturing wages	dependent variable	n/a	
urban rates	explanatory variable	as urban rates ↑	wages go up
elasticity of demand	explanatory variable	as e of d ↑ (*econ of s* ↓)	wages go down
TCG	explanatory variable	as *TCG* ↑ (*tr cost* ↓)	wages go up
OG	explanatory variable	as *OG* ↑ (*tr cost* ↓)	wages go up
education of workforce	control variable	as education ↑	wages go up
age of workforce	control variable	as age ↑	wages go up
women in workforce	control variable	as women ↑	wages go down
tax rates	control variable	as tax rates ↑	wages go down
tax revenues	control variable	as tax revenue ↑	wages go down
union density	control variable	as union density ↑	wages go up

Table 4: OLS Results after Bayesian Averaging

The dependent variable is *manufacturing wages*. d.f. = 87.

Variable	**coeff**	**st. error**	**t-score**	**conf level**	**5-95 effects**	**robustness**	**right sign?**
const	0.4085	0.5009	0.82	--	--	--	--
e^education	0.0254	0.0450	0.56	--	2.3 %	negligible	Yes
16^age	–0.00887	0.00593	–1.49	86 %	-6.6 %	M	No
10^women/work	–0.0129	0.00707	–1.83	93 %	-7.4 %	H	Yes
union density	0.0306	0.0101	3.04	> 99 %	9.8 %	VH	Yes
tax rate	–0.00018	0.00667	–0.03	--	-0.1 %	negligible	Yes
ln tax revenue	0.0953	0.0432	2.21	> 95 %	6.4 %	VH	No
MT80 dummy	0.242	0.086	2.80	> 99 %	24.2 %	VH	Yes
6^urban rate	0.0431	0.0286	1.51	87 %	10.8 %	M	Yes
elast of demand *	0.0826	0.0735	1.12	73 %	5.5 %	L	No
ln OG 25	0.1084	0.0287	3.78	> 99 %	16.7 %	VH	Yes
ln OG 50	0.1004	0.0304	3.31	> 99 %	14.1 %	VH	Yes
ln OG 75	0.1150	0.0324	3.56	> 99 %	15.0 %	VH	Yes
ln OG 95	0.1216	0.0345	3.52	> 99 %	14.8 %	VH	Yes
ln TCG 25	0.0519	0.0151	3.44	> 99 %	11.2 %	VH	Yes
ln TCG 50	0.0497	0.0155	3.20	> 99 %	10.4 %	VH	Yes
ln TCG 75	0.0520	0.0159	3.28	> 99 %	10.4 %	VH	Yes
ln TCG 95	0.0519	0.0163	3.19	> 99 %	10.3 %	VH	Yes

* Transformed using a Box-Cox transformation with a slider value of –1.4.