The Decline of the U.S. Rust Belt: A Macroeconomic Analysis

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January 24, 2013

Abstract

The region of the United States that arguably fared worst over the post-war period is the "Rust Belt," the heavy manufacturing zone near the Great Lakes. In this paper we argue that a lack of competition in labor and output markets in the Rust Belt were responsible for much of the region's decline. We formalize this theory in a dynamic general equilibrium model in which productivity growth and regional employment shares are determined by the extent of competition. When plausibly calibrated, the model explains roughly one third of the decline in the Rust Belt's employment share. Evidence from prominent Rust Belt industries support the model's predictions that investment and productivity growth rates were relatively low in the Rust Belt. In addition, evidence from the cross-section of metropolitan areas shows that areas that paid workers the highest wage premiums in 1950 had the lowest employment growth from 1950 to 2000, supporting the theory.

Keywords: Rust Belt, competition, productivity, unionization, monopoly

JEL codes: E24, E65, J3, J5, L16, R13

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1. Introduction

While the United States as a whole saw robust increases in economic activity over the postwar period, the economic performance of regions within the country was highly unequal. The region that arguably fared worst of all is the portion of the Midwest and Northeast known as the "Rust Belt." While there is no standard definition of the Rust Belt, it has generally come to mean the heavy manufacturing zone near the Great Lakes that includes cities such as Detroit, Cleveland and Pittsburgh. The salient characteristic of the region is that its share of economic activity has declined steadily since the end of World War II.

We argue that the Rust Belt declined in large part due to a lack of competition in labor and output markets in its most prominent industries, such as steel, automobile and rubber manufacturing. The lack of competition in labor markets was closely linked to the behavior of the powerful labor unions that dominated each of the major Rust Belt industries for much of the postwar period. In output markets, the major Rust Belt industries were each dominated by a small set of oligopolists who, according to numerous sources, actively stifled competition for decades after the end of WWII. We argue that this lack of competition served to depress investment and productivity growth, which led to a movement of economic activity out of the Rust Belt and into other parts of the country (notably the "Sun Belt" in the U.S. South.)

We formalize the theory in a dynamic general equilibrium model in which the extent of competition determines productivity growth. There is a continuum of goods in the economy, with some fraction produced in the "Rust Belt" and the rest produced in the "Sun Belt." The two regions differ only in the extent of competition they face. Rust Belt producers must hire workers through competitive bargaining with a labor union, which demands the competitive wage per each worker plus some fraction of the surplus from production. Sun Belt producers pay only the competitive wage. In output markets, both regions face a competitive fringe with whom they engage in Bertrand competition. We assume that Rust Belt producers can "block" the fringe to some extent, while Sun Belt producers cannot. Firms in both regions have the ability to undertake investment which, at a cost, increases the productivity of any workers hired.

The main prediction of the theory is that the lesser the extent of competition in either labor or output markets in the Rust Belt, the lower its investment and productivity. We first illustrate this result qualitatively in a simple static version of the theory. We show there are two effects which drive the theory's prediction. The first effect is a "hold up problem" which arises through the collective bargaining process. Firms in both regions make costly investments to upgrade technology. Unlike Sun Belt firms, however, Rust Belt firms must share the benefits from the technology upgrade with the union. As a result, Rust Belt firms optimally choose to invest less ex-ante than they otherwise

would. The second effect comes from differences in output market competition. The inability of Sun Belt producers to block the competitive fringe gives them a stronger incentive to invest in order to "escape the competition" (as in the work of Acemoglu and Akcigit (2011) and Aghion, Bloom, Blundell, Griffith, and Howitt (2005), among others.) This incentive is less prevalent among Rust Belt producers, and hence they invest less.

We then embed this simple static framework in a richer dynamic model in which productivity and the employment share in each region evolve endogenously over time. Because goods are gross substitutes, employment and output tend to move to the region with the highest productivity growth, as in the model of Ngai and Pissarides (2007). The main quantitative experiment takes the extent of competition over time as exogenous and computes the model's predicted shares of manufacturing employment in the Rust Belt. Discipline on the extent of competition over time comes from estimates of the Rust Belt workers' wage premiums and by estimates of markups in key Rust Belt industries. We find that the model explains at least one-third of the Rust Belt's decline, and in some specifications explains more than one-half.

We conclude by presenting several types of evidence supporting the theory's predictions. First, we show that direct measures of TFP growth in prominent Rust Belt industries were lower than those of the rest of the economy. Second, we present historical evidence that productivity growth and technology adoption rates for Rust Belt producers tended to lag behind their counterparts in Europe and Asia for much of the postwar period. Finally, we provide evidence from the cross-section of metropolitan areas in the United States that the wage premiums earned by workers in 1950 – one sign of limited competition – are highly negatively correlated with employment growth from 1950 to 2000.

Our paper relates closely to a recent and growing literature linking competition and productivity. As Holmes and Schmitz (2010), Syverson (2011) and Schmitz (2012) argue, there is now a substantial body of evidence linking greater competition to higher productivity. As one prominent example, Schmitz (2005) shows that in the U.S. Iron Ore industry there were dramatic improvements in productivity following an increase in competitive pressure in the early 1980s, largely due to efficiency gains made by incumbent producers. Similarly, Bloom, Draca, and Van Reenan (2011) provide evidence that European firms most exposed to trade from China in recent years were those that innovated more and saw larger increases in productivity. Pavcnik (2002) documents that after the 1980s trade liberalization in Chile, the producers facing new import competition saw the largest gains in productivity, in part because of efficiency improvements by existing producers. A common theme with these papers and ours is that competition reduced rents to firms and workers and forced them to improve productivity. Along these lines, our work also relates closely to that of Cole and Ohanian (2004), who argue that policies that encouraged non-competitive behavior in the

industrial sector during the Great Depression depressed aggregate economic activity even further.

From a modeling perspective, our work builds on several recent studies in which model firms innovate in order to "escape the competition," such as in the work of Acemoglu and Akcigit (2011) and Aghion, Bloom, Blundell, Griffith, and Howitt (2005). The common theme is that greater competition in output markets encourages incumbent firms to innovate more in order to maintain a productivity advantage over potential entrants. Our model also relates to those of Parente and Prescott (1999) and Herrendorf and Teixeira (2011), in which monopoly rights reduce productivity by encouraging incumbent producers from blocking new productivity-enhancing technologies.

Our paper also complements the literature on the macroeconomic consequences of unionization. The paper most related to ours in this literature is that of Holmes (1998), who uses geographic evidence along state borders to show that state policies favoring labor unions greatly depressed manufacturing productivity over the postwar period. Our work also resembles that of Taschereau-Dumouchel (2012), who argues that even the threat of unionization can cause non-unionized firms to distort their decisions so as to prevent unions from forming, and that of Bridgman (2011) who argues that a union may rationally prefer inefficient production methods so long as competition is sufficiently weak.[1]

To the best of our knowledge we are the first to explore the role of competition in understanding the Rust Belt's decline. Our work contrasts with that of Yoon (2012), who argues that the Rust Belt's decline was due (in part) to rapid technological change in manufacturing, and Glaeser and Ponzetto (2007), who argue that the declines in transportation costs eroded the Rust Belt's natural advantage in shipping goods via waterways. Our paper also differs from the work of Blanchard and Katz (1992) and Feyrer, Sacerdote, and Stern (2007), who study the long-term consequences of the Rust Belt's decline in employment (rather than the root causes of the decline.) Our model is consistent with their finding that employment losses sustained by Rust Belt industries led to population outflows rather than persistent increases in unemployment rates.

[1]While our model takes the extent of competition in labor markets as exogenous, several recent studies have modeled the determinants of unionization in the United States over the last century. Dinlersoz and Greenwood (2012) argue that the rise of unions can be explained by technological change biased toward the unskilled, which increased the benefits of their forming a union, while the later fall of unions can be explained by technological change biased toward machines. Relatedly, Acikgoz and Kaymak (2012) argue that the fall of unionization was due instead to the rising skill premium, caused (perhaps) by skill-biased technological change. A common theme in these papers, as in the work of Taschereau-Dumouchel (2012), is the link between inequality and unionization, and the union's role in reducing inequality, which is absent from the current paper.

2. Decline of the Rust Belt

In this section we present the basic fact to be explained: the decline of the Rust Belt. We show that, by a number of metrics, the Rust Belt's share of aggregate economic activity declined substantially over the post-war period.

2.1. The Rust Belt: Our Definition

While there is no widely agreed upon definition, most users of the term "Rust Belt" use it to refer to the heavy manufacturing area near the Great Lakes (see e.g. Blanchard and Katz (1992) and Feyrer, Sacerdote, and Stern (2007) and the references therein.) For the purposes of this paper, we define the Rust Belt to be the region encompassing Illinois, Indiana, Michigan, New York, Ohio, Pennsylvania, West Virginia and Wisconsin. This definition keeps the essence of previous use of the term and, in addition, allows us to aggregate various data sources in a consistent way.

2.2. Measuring the Decline

Our main source of data are the decadal U.S. Censuses of 1950 through 2000, available through the Integrated Public Use Microdata Series (IPUMS). In each year we restrict attention to private-sector workers who are not primarily self-employed. We also draw on state-level employment data from 1970 and onward from the U.S. Bureau of Economic Analysis (BEA), and state-level value added and wage data from 1963 and onward, also from the BEA.

Figure 1 plots the Rust Belt's share of aggregate employment (grey dashed line) and share of manufacturing employment (solid black line). Both time series consist of estimates from the census data for 1950 and 1960 plus BEA state-level data in subsequent years (the census and BEA provide almost identical estimates in overlapping years). The Figure shows that by both metrics, the Rust Belt's share declined dramatically. The Rust Belt employed 43 percent of aggregate employment in 1950, and just 27 percent in 2000. In terms of manufacturing employment, the Rust Belt share was over one-half in 1950 – 51 percent to be exact – and fell to one-third in 2000. Notably, the decline is much more dramatic from 1950 to 1980 than since 1980, in which the Rust Belt's shares of aggregate and manufacturing employment declined by only a few percentage points.

The fact that the Rust Belt's share of manufacturing employment dropped by so much suggests that the decline of the Rust Belt is not a simple story about structural change. That is, the Rust Belt's decline was not simply because the United States' manufacturing sector declined, and the Rust Belt happened to be intensive in manufacturing. The solid black line in Figure 1 clearly shows that the Rust Belt's share of employment declined *even within the manufacturing sector*. Figure A.1, in the Appendix, shows that in absolute levels, manufacturing employment in the Rust Belt

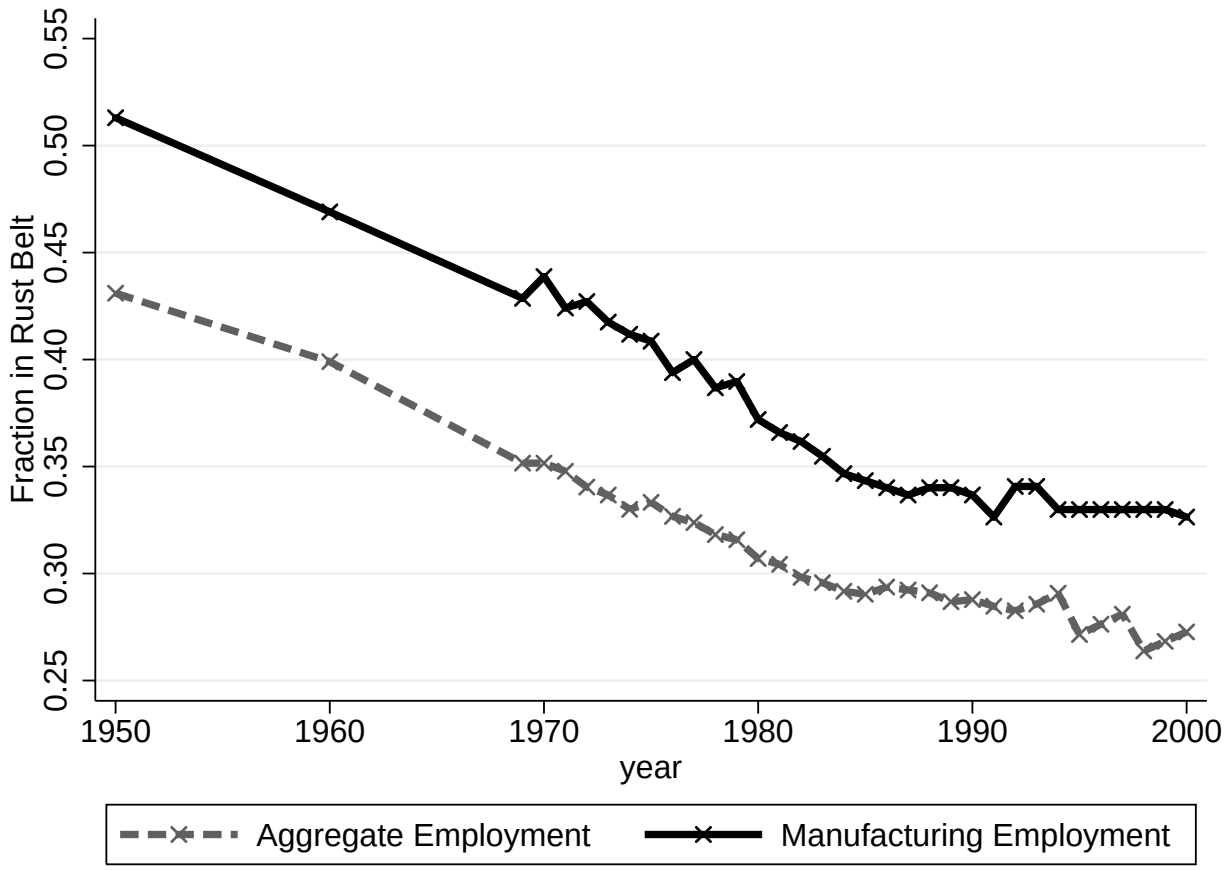


Figure 1: Fraction of Employment and Manufacturing Employment in the Rust Belt

stayed roughly constant over this period while manufacturing employment outside the Rust Belt roughly doubled. What was happening, these figures suggest, is that manufacturing employment was moving from the Rust Belt to elsewhere in the country.

Table 1 quantifies the decline of the Rust Belt by several other metrics and cuts of the data. Each row describes the Rust Belt's share of U.S. economic activity in 1950 and 2000 for one particular metric, and the percentage point decline from 1950 to 2000. The first two row reproduce the information in Figure 1 for convenience; the Rust Belt's share of aggregate employment and manufacturing employment declined by 16 percentage points and 19 percentage points, respectively.

The third row shows the decline only looking at the industries that were most prominent in the Rust Belt in the 1950s, namely steel, automobile and rubber manufacturing. The Rust Belt employed 75 percent of workers in these industries in 1950, which fell to 55 percent by 2000, for a drop of 20 percentage points. This shows that the Rust Belt's decline was not simply a compositional change within United States manufacturing, with heavy industries such as steel, autos and rubber

Table 1: Decline of the Rust Belt by Various Metrics

	Fraction in Rust Belt		Difference
	1950	2000	1950 - 2000
Aggregate Employment	0.43	0.27	-0.16
Manufacturing Employment	0.51	0.33	-0.18
Steel, Autos and Rubber Employment	0.75	0.55	-0.20
Employment in "Cold States"	0.73	0.62	-0.11
Aggregate Value Added	0.45	0.27	-0.18
Manufacturing Value Added	0.56	0.32	-0.24

Employment shares are computed using decennial census data from IPUMS and state-level data from the BEA. Industries are classified according to IPUMS 1990 industry codes. "Cold States" are states whose average temperature is below the state average. Aggregate and manufacturing value added are imputed for 1950-1962 and 1997-2000 using annual changes in the share of wage payments by region.

declining while other manufacturing industries (e.g. high tech) rising elsewhere in the country. To the contrary, employment in steel, automobiles and rubber moved out of the Rust Belt, and even more dramatically than for manufacturing as a whole.

The fourth row of the table shows the Rust Belt's employment share among "Cold States," which are defined to be all states whose average temperature is below average (all Rust Belt states make the cut as Cold States.) The Rust Belt's employment share among Cold States fell from 73 percent to 62 percent, for a drop of 11 percentage points. This suggests that a simple story about the advent of air conditioning making the warmer states more suitable for production is not likely to be a central factor in determining the Rust Belt's poor economic performance over the period. Even among states where air conditioning was no more or less useful than in the Rust Belt, employment was moving out of the Rust Belt states and into cold non-Rust-Belt states.[2]

The final two rows show the Rust Belt's share of aggregate value added and manufacturing value added. The shares in 1950 were 45 percent and 56 percent, and fell to 27 percent and 32 percent in 2000, which amount to declines of 18 and 24 percentage points. The conclusion from these data is that the decline in the fraction of value added in the Rust Belt was even more pronounced than the decline in employment.

[2]This finding is consistent with the work of Holmes (1998), who looks at counties within 25 miles of the border between right-to-work states and other states and finds that countries in the right-to-work states had much higher employment growth rates than their counterparts on the other side of the border. Between 1947 and 1992, the counties in right-to-work states averaged 101% growth in manufacturing employment; over the same period, counties on the other side of the borders averaged just 62% manufacturing employment growth. Given that there are essentially no differences in temperature between these sets of counties, Holmes (1998) argues that the differences in outcomes must be due to differences in state policies.

3. Lack of Competition in the Rust Belt

In this section we show that one salient characteristic of the Rust Belt was a relatively low degree of competition in labor and output and markets for several decades after the end of WWII. Labor markets in the Rust Belt were dominated by powerful labor unions in most of the prominent Rust Belt industries. Output markets were characterized by close-knit oligopolists in many industries that, by many metrics, faced very low competitive pressure from the outside. Around the 1980s, however, competitive pressure increased, as output markets drew new competition from abroad and new entrants at home, and labor markets witnessed a drop in the influence of unions.

3.1. Lack of Competition in Labor Markets

It is widely known that unions dominated labor markets in many Rust Belt manufacturing industries. The two largest and most powerful unions in the United States at the time were the United Steelworkers (USW) and United Auto Workers (UAW). Roughly two thirds of all auto workers were members of the UAW, while an only slighter smaller fraction of steel workers were members of the USW.[3] The majority of steel and auto workers were employed in the Rust Belt for decades after the end of WWII. According to the U.S. Bureau of Labor Statistics, of the top ten most unionized states in 1974, seven were Rust Belt states, as were four of the top five (Michigan, West Virginia, New York and Pennsylvania.)[4]

It is also well established that these unions extracted great concessions from their employers and enjoyed substantial rents. Figure 2 shows one simple metric of the premiums: the ratio of average wages in the Rust Belt to average wages in the rest of the country. The dashed gray line shows the relative wages for all workers, and the solid black line shows the relative wages for manufacturing workers. From 1950 to 1980 the average wage was at least 10 percent higher in the Rust Belt than in the rest of the country, and reached 15 percent (among manufacturing workers) by 1980.[5]

Industry histories provide more direct evidence of the types of rents enjoyed by workers in these unions. Ingrassia (2011) and Vlasic (2011) provide numerous examples of various concessions extracted from the"Big Three" auto producers of Ford, General Motors and Chrysler from WWII through the 1970s. By 1973, a UAW worker could earn "princely sums" working on production

[3]These figures are for 1970 and come from BLS Bulletin 1937 Appendix D. The UAW and USW also had large membership rates in a diverse set of other manufacturing industries (Goldfield, 1987).

[4]BLS Bulletin 1865 and BLS Bulletin 1370-12. Unionization rate are the percent of all non-agricultural employment that is covered under a collective bargaining agreement.

[5]The ratio of average wages, while a crude measure of wage premiums, is similar to the estimated "Rust Belt" dummy we find when regressing individual-level wages on education, potential experience and other controls. More generally, the ratio of average wages is in the same range as the estimated union wage premium documented in a long literature (see e.g. Blanchflower and Bryson (2004) for a review.)

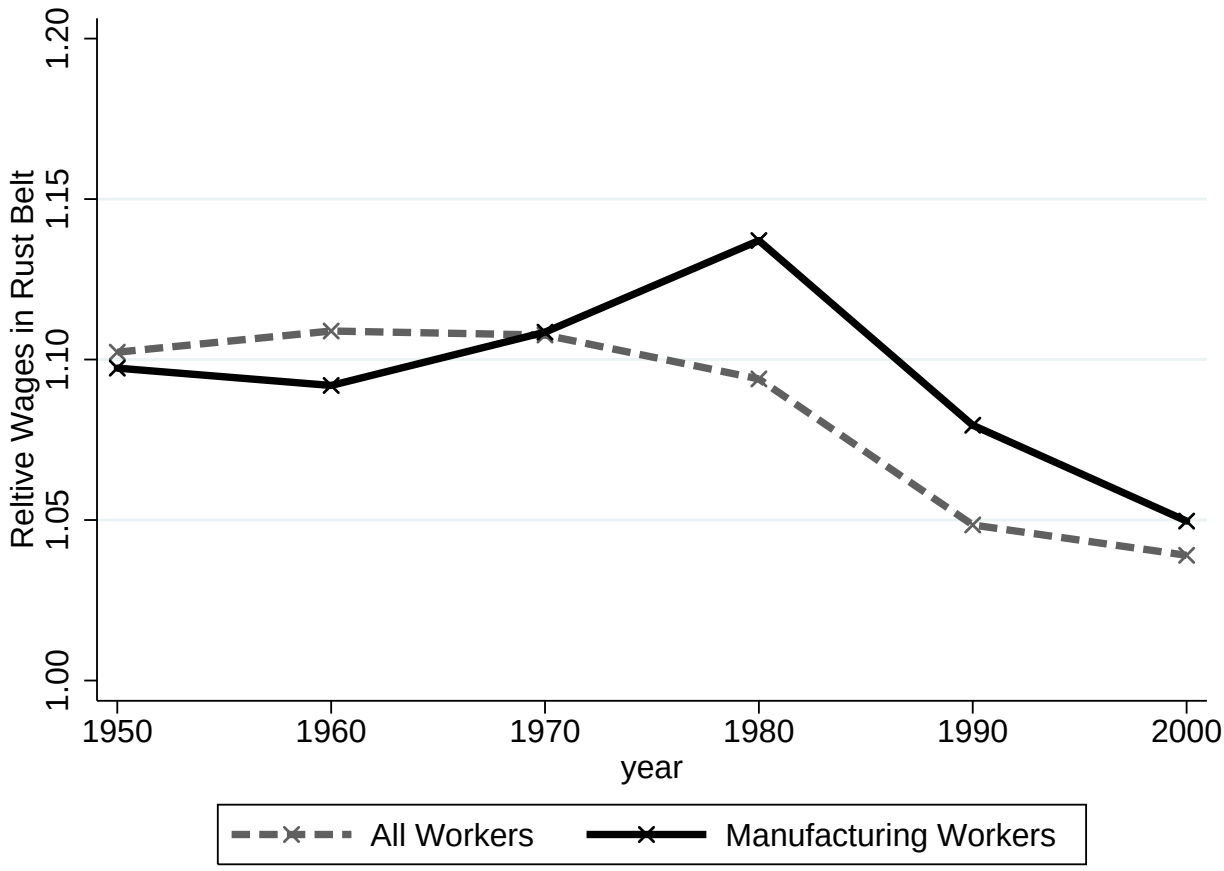


Figure 2: Relative Wages of Rust Belt Workers

or other union-created jobs, such as serving on the plant "recreation committee", and then retire with full benefits as early as age 48 (Ingrassia, 2011, pp. 46, 56). In steel, Tiffany (1988) states that in 1959, average hourly earnings for steel workers were more than 40 percent higher than the all-manufacturing average in the United States (p. 178). Evidence of non-wage rents in steel abound, such as clauses in various steelworker contracts that guaranteed that the steel mills would be shut down during the first few days of deer hunting season.

The figure also shows that union power declined over this period, taking a particularly large drop in the 1980s. Relative wages in the Rust Belt fell from between 10 and 15 percent above those of other workers to just 4 percent above most recently. More broadly, union membership dropped steadily over this period. Figure A.2 (in the Appendix) shows the unionization rate for the country as a whole using data from Goldfield (1987), and in the Rust Belt, using the state-level unionization database of Hirsch and Macpherson (2003)). In 1980, the first year of available disaggregated data, 30 percent of the Rust Belt workforce was unionized. By 2000, the unionization rate in the Rust Belt was below 20 percent.

3.2. Lack of Competition in Output Markets

In output markets for several prominent Rust Belt industries, production was dominated by just a few firms for most of the postwar period. The largest three steel producers – U.S. Steel, Bethlehem Steel, and National Steel – had at least half the U.S.'s total steel capacity from the end of WWII through 1980 (Crandall, 1981; Tiffany, 1988). The Big Three auto producers accounted for 90 percent of automobile sales in the United States in 1958, and at least 75 percent until around 1980 (Klier, 2009). A similar dominance pertained to the four largest rubber tire producers, who had at least 90 percent of the market in every year from 1950 to 1970.[6]

In each of these industries, there is evidence that the few producers behaved non-competitively. Adams and Brock (1995, p. 94) describe the big Steel producers as having had "virtually unchallenged control of a continent-size market," which led to a "well-honed system of price leadership and follower-ship" (with U.S. Steel as the leader). Similarly, Ingrassia (2011, p. 29) describes the automobile industry as being a "model of corporate oligopoly" throughout the 1950s, 1960s and 1970s, with General Motors playing the role of the price leader.[7]

Both steel and autos, as well as rubber, were accused on multiple occasions of explicit collusion. In 1959, the Federal Trade Commission (FTC) charged fifteen rubber manufacturers with agreeing on common list prices and discounting policy (French, 1991).[8] Tiffany (1988) describes several similar instances in Steel, and on several occasions management at the big steel firms were called in front of congress to explain their lack of competition in pricing.[9] In the auto industry, the U.S. Justice Department charged Ford and GM with collusion and charged the Big Three with conspiring to eliminate competition (Adams and Brock, 1995, p. 87).

Several types of evidence suggest that competitive pressure picked up starting in the 1970s and 1980s, as the cost of imports from abroad plummeted and new firms entered the domestic markets for goods formerly supplied almost exclusively by Rust Belt producers. In the steel, auto and

[6] These four were Goodyear, Firestone, U.S. Rubber and Goodrich. All four were located in Akron, Ohio, once known as the "Rubber Capital of the World."

[7] Adams and Brock (1995, p. 78) write that "the prices adopted by the Big Three [auto manufacturers] appear at times to represent the outcome of a tacit bargain arrived at through a delicate process of communication and signaling.... Once they have revealed their hands to one another, then they announce their final prices, which, not surprisingly, tend to be quite similar."

[8] The FTC claimed that the rubber manufacturers had revived the cooperative policies granted to them in the 1930s by the National Industrial Recovery Act (which was later outlawed). The manufacturers agreed to "cease and desist" without admitting any wrongdoing. See French (1991, p. 95).

[9] For example, in 1957 the Senate's antitrust committee directly accused the steel industry of anticompetitive pricing behavior, and called industry leaders to testify for six days. In a telling exchange between Senator Estes Kefauver and U.S. Steel chairman Roger Blough, Kefauver asked why all the major steel companies had the same price. Blough responded: "...if we offer to sell steel to a customer at the same price as a competitor offers to sell to the customer, that is very definitely a competitive price." According to Tiffany (1988), Kefauver and the rest of committee were thoroughly unconvinced, yet no punishment was ever sought for any steel producer.

rubber industries for example, concentration ratios have fallen dramatically since the 1970s and 1980s. In autos, the Big Three' now have less than half the domestic market, with a similar trends in steel and rubber (Tiffany, 1988; French, 1991). Estimates of markups paint a similar picture, at least where such estimates exist. In the steel industry, Collard-Wexler and De Loecker (2012) estimate markups of on average 25 percent over the period 1967 through 1987 for the integrated segment of steel industry (most of which was in the Rust Belt).[10] In the period since 1987 their estimated markups averaged just 13 percent.

4. Simple Model

In this section we present a simple model which illustrates the main components of the theory. The model links the extent of competition in labor and output markets to investment and hence productivity growth. The model predicts that less competition in either market leads to lower productivity growth.

4.1. Environment

There is a continuum of intermediates, indexed by j, which are combined to produce a final good. The production function for the final good is given by

$$Y = \left(\int_0^1 y(j)^{\frac{1}{2}} di \right)^2 \tag{1}$$

where any two intermediates have elasticity two between them. The final good can either be consumed or used for investment. Intermediates $j \in [0, \frac{1}{2})$ are produced in the "Rust Belt," and intermediates $j \in [\frac{1}{2}, 1]$ are produced in the "Sun Belt." These two regions differ in the nature of their competition in labor markets and output markets (as described below). Each good i is produced by an industry that has a single "lead" producer and, in the Sun Belt region, a competitive fringe.

Production of intermediates takes place in two stages. In the first stage, each leader firm enters with productivity level z and chooses their "technology upgrade," x. Upgrading technology by x requires a cost $I(x)$, where $I(\cdot)$ is strictly convex and is such that $I(0) = 0$. One can think of z as "technology capital", using the language of McGrattan and Prescott (2010), which they define as the "accumulated know-how from investments in R&D, brands and organizations," and $I(x)$ as the investments themselves.

[10] These numbers are consistent with estimated markups in the auto industry over this period. Berndt, Friedlaender, and Chiang (1990) estimate markups for Ford, GM and Chrysler over the period 1959 through 1983. Taking an average of the three firms and the years in their sample, their estimated markups are 21 percent.

After investment, the productivity of leader j becomes $z(1+x(j))$, and the production function becomes

$$y(j) = z[1+x(j)]\ell(j) \tag{2}$$

where $y(j)$ and $\ell(j)$ represent the leader's output and labor input.

In the second stage, firms decide how much labor to hire and what price to charge, given their production function, (2). In the Sun Belt, leader firms must Bertrand compete with the competitive fringe. Thus, leader firms there pick the optimal price taking into consideration the fringe. In the Rust Belt, we assume the leader firms get to "block" the fringe from operating. Thus, leaders firms in the Rust Belt face no competition from the fringe and set an optimal monopolist markup.

The labor market in the Rust Belt is dominated by a single labor union that is the sole supplier of labor services. In order to produce any output, Rust Belt firms must not only pay each worker hired the competitive wage (normalized to one), but must also pay a fraction of their surplus to the labor union. The fraction of the surplus paid to the union is determined by Nash Bargaining, with the union's bargaining weight given by β. The labor market in the Sun Belt is competitive, in contrast, and each worker earns the competitive wage.

The household has a unit measure of members, each of which with one unit of time that they supply inelastically to the labor market. Jobs in the Rust Belt are rationed, and only a fraction of household members (chosen at random by the firms) may supply labor to the Rust Belt. The household pools workers' labor earnings plus profits from the firms, and spends all its income on the final good. Formally, the household's budget constraint is

$$P \cdot C = 1 + R + \int_0^{\frac{1}{2}} \Pi_R(j)dj + \int_{\frac{1}{2}}^1 \Pi_S(j)dj \tag{3}$$

where P is the price of the final good, C is the quantity of the final good purchased for consumption, $1+R$ is the labor earnings plus the rents earned by workers in the Rust Belt, and $\Pi_R(j)$ and $\Pi_S(j)$ are profits earned by intermediate firms in the Rust Belt and Sun Belt.

4.2. Sun Belt Producer's Problem

In the Sun Belt, the first-stage (investment) problem of producer i is given by

$$\Pi_S(j) = \max_{x_S(j)} \left\{ \tilde{\pi}_S(x_S(j)) - I(x_S(j)) \right\} \tag{4}$$

where $\tilde{\pi}_S(x_S(j))$ represents the *quasi-rents* earned in the second stage. The second-stage problem is to pick prices and labor input to maximize these quasi rents:

$$\tilde{\pi}_S(x_S(j)) = \max_{p_S(j),\, \ell_S(j)} \Big\{ p_S(j) y_S(j) - \ell_S(j) \Big\} \tag{5}$$

subject to

$$y_S(j) = z[1 + x_S(j)]\ell_S(j), \quad \text{and}$$
$$y_S(j) = X \cdot P \cdot [p_S(j)]^{-2}, \tag{6}$$

where equation (6) is the standard demand function associated with a CES production function. Variables X and P represent the (endogenous) total spendjng on all goods by the household and firms, and the aggregate price index, respectively:

$$X = \int_0^{\frac{1}{2}} p_R(j) y_R(j) dj + \int_{\frac{1}{2}}^1 p_S(j) y_S(j) dj \quad \text{and}$$
$$P = \Big[\int_0^{\frac{1}{2}} p_R(j)^{-1} dj + \int_{\frac{1}{2}}^1 p_S(j)^{-1} dj \Big]^{-1}.$$

Since Sun Belt leaders must Bertrand compete with the competitive fringe, it follows that they limit price the fringe, charging a price of $p_S(j) = 1/z$.[11]

To understand better how the Sun Belt producers operate, it is useful to rewrite their first-stage problem after incorporating the optimal limit-pricing behavior. It is

$$\Pi_S(j) = \max_{x_S(j)} \Big\{ x_S(j) \ell_S(x_S(j)) - I(x_S(j)) \Big\} \tag{7}$$

where $\ell_S(x_S(j)) = X \cdot P \cdot z[1 + x_S(j)]^{-1}$. One can then see how investment is key to earning any profits at all; if the leader doesn't invest, she cannot price below the fringe, and hence earns no profits. Thus, the Sun Belt leaders rationale for investing is the escape-the-competition effects of e.g. Acemoglu and Akcigit (2011) and Aghion, Bloom, Blundell, Griffith, and Howitt (2005).

4.3. Rust Belt Producer's Problem

The Rust Belt producers' problem differs from the Sun Belt producers' problem in two ways. First, in output markets, the Rust Belt gets to block the competitive fringe and set a standard monopolist markup. Second, in labor markets, the Rust Belt must hire labor through a union with collective

[11] If investment among Sun Belt producers is sufficiently high in equilibrium, specifically if $x_S(j) > 1$, then Sun Belt producers choose a standard monopolistic markup. For expositional purposes we focus here on the case where $x_S(j) \leq 1$.

bargaining rights. The union supplies labor in exchange for the competitive wage plus a share of the producers' profits.

4.3.1. Collective Bargaining

Consider first the second-stage problem, once the investment decision $x_R(j)$ has been decided. The quasi-rents of firm j are

$$\tilde{\pi}_R(x_R(j)) = \max_{p_R(j),\ell_R(j)} \Big\{ p_R(j) y_R(j) - \ell_R(j) \Big\} \quad \text{where} \tag{8}$$

$$y_R(j) = z[1 + x_R(j)]\ell(j), \quad \text{and}$$

$$y_R(j) = X \cdot P \cdot [p_R(j)]^{-2}. \tag{9}$$

These quasi-rents are defined identically to those of the Sun Belt producers. The difference is that Rust Belt firms must bargain over the quasi-rents with the union. We assume that the union and each producer split the surplus according to Nash Bargaining, with the unions' bargaining weight represented by $\beta \in [0,1]$. The solution to the bargaining problem yields the standard result that the union receives a share β of the quasi-rents, with the firm taking the other $1-\beta$.

4.3.2. Investment and Production

Now consider the profit maximization problem of the Rust Belt producer. Given the bargaining solution above, the problem becomes:

$$\Pi_R(j) = \max_{x_R(j)} \Big\{ (1-\beta)\tilde{\pi}_R(x_R(j)) - I(x_R(j)) \Big\}. \tag{10}$$

In other words, firms pick investment to maximize their share of the quasi-rents minus their cost of investment. One can easily show that the first-order condition characterizing a Rust Belt producer's choice of investment is

$$(1-\beta)\tilde{\pi}'_R(x_R(j)) = I'(x_R(j)). \tag{11}$$

This equation shows that investment is lower the higher is β. This result arises because the bargaining problem involves a quintessential *hold-up problem.* Since the investment decision cannot be reversed once it has been made, the workers can hold up the firm and extract a larger share of the surplus ex-post.[12] This effect is not present in the Sun Belt since producers there bear do not

[12] Van Reenen (1996) provides concrete evidence that workers do in fact capture some of the surplus from innovations by their firms. Using a rich panel of firms of the United Kingdom, he shows firms that innovate tend to pay higher wages with a lag of roughly three years after innovating. He estimates that workers in innovating firms capture on average 20% to 30% of the quasi-rents generated by innovation.

bargain with a union.

A second key difference is that Rust Belt producers do not face a competitive fringe and simply choose their optimal price (taking prices of the other goods as given.) As is standard, these firms choose a price which gives them a constant markup (in this case of 100 percent) over marginal cost:

$$p_R(j) = 2(z[1+x_R(j)])^{-1}. \tag{12}$$

It is useful to re-write the Rust Belt producer's first-stage (investment) problem incorporating their optimal price as

$$\Pi_R(j) = \max_{x_R(j)} \left\{ (1-\beta) \cdot \ell_R(j) - I\big(x_R(j)\big)] \right\} \tag{13}$$

subject to $\ell_R(x(j)) = X \cdot P \cdot z[1+x_R(j)]^{-1}$. Here, the firm earns a constant $1-\beta$ units of output per unit of labor input hired, reflecting the constant markup over marginal cost charged by the Rust Belt firm. Unlike the Sun Belt's equivalent problem in (7), the escape competition effect is absent. The Rust Belt firms' rationale for innovation is that a more efficient production technology increases demand for their variety.

4.4. Optimal Investment in Equilibrium

An equilibrium of the economy is a set of quantities and prices such that households and producers solve their problems taking prices (other than their own) as given, all firms in each region choose the same prices and quantities, and markets clear. We will drop the i index for equilibrium objects for convenience, and to distinguish equilibrium quantities with the choice variables of a single producer. One can show that the following is true in equilibrium.

Proposition 1 *Equilibrium investment is lower in the Rust Belt region.*

The proof is in the Appendix. To gain some intuition for the result, consider first the case when parameters are such that $x_S > 1$. One can think of this as being the case when investment costs are "sufficiently low." In this case, the Sun Belt producers are so much more productive than the competitive fringe that they choose to set a standard monopoly markup, just like Rust Belt producers.[13] One can combine the firms' first order conditions to show that optimal investment in equilibrium must satisfy the following equation:

$$I'(x_R) = (1-\beta)\, I'(x_S). \tag{14}$$

[13] Bernard, Eaton, and Jensen (2003) have a similar result, where the most productive producer either sets a standard monopolist markup if it is much more productive than other firms, or limit prices the second most productive if the two have more similar productivty levels.

It follows therefore that $x_R < x_S$, since $\beta > 0$ and $I(\cdot)$ is convex. Here, the difference in innovation results only from the fact that labor manages to extract a fraction of the surplus (positively related to β) from Rust Belt producers. Absent this non-competitive behavior in labor markets, i.e. when $\beta = 0$, investment is identical in the two regions.

Consider next the case when parameters are such that $x_S < 1$. One can think of this as the case when investment costs are sufficiently high. Now Sun Belt producers limit price the competitive fringe, while Rust Belt firms choose the standard monopolist markup. In addition, Rust Belt firms still must bargain with labor over the surplus. Combining the firms' first order conditions this time yields:

$$I'(x_R) = (1-\beta)\left(\frac{1+x_S}{2}\right)^2 I'(x_S). \tag{15}$$

In this case it also must be true that $x_R < x_S$. There are now two reasons for the difference in equilibrium investment. As before, the $1-\beta$ term arises from the fact that the Rust Belt firms get to keep less than the total proceeds from investment. In addition, the $\left(\frac{1+x_S}{2}\right)^2$ term arises from the differences in output market competition, and this term is less than one as long as $x_S < 1$ in equilibrium, which is true if and only if the Sun Belt firms are actually limit pricing in equilibrium. If so, Rust Belt firms get to charge a higher markup even when innovating relatively less, while Sun Belt firms innovate more to escape the competition.

5. Dynamic Model

We now embed the main features of the simple static model into a richer dynamic model, that can be used for quantitative counterfactual experiments. The dynamic model differs in several main ways from the static model. First, firm productivity and employment by region evolve endogenously over time. Second, the extent of competition in output markets results in two opposing effects: the escape-competition effect described in the simple model, and a *Schumpeterian effect*, which leads to more investment the lower is the extent of competition in output markets. Finally, the model is more flexible in ways that allow for quantitative experiments.

5.1. Environment

There is a stand-in household whose preferences are given by

$$U = \sum_{t=0}^{\infty} \delta^t C_t \tag{16}$$

where δ is the discount factor and C_t is consumption of a final good. The final good is produced using the CES production function

$$Y = \left(\int_0^1 q(j)^{\frac{\sigma-1}{\sigma}} dj \right)^{\frac{\sigma}{\sigma-1}} \tag{17}$$

where σ is the substitution elasticity between any pair of intermediates in the economy. We assume that $\sigma > 1$, which implies that the intermediates are gross substitutes. As before, the final good can be used for both consumption and investment, and each intermediate is produced by a competitive monopolist located in one of two regions, the Rust Belt or the Sun Belt. The exogenous measure of Rust Belt goods is $\lambda \in (0,1)$, while the measure of goods in the Sun Belt is $1-\lambda$. Just as in the simple model the production of each good requires a single input, labor, and the wage is normalized to unity each period.

Each period is divided into two stages. In the first stage, the intermediate firms decide how much to upgrade their technology. We assume that a technology upgrade x requires investment, as will be laid out below. In the second stage, the firm decides how much labor to hire, what price to charge, and possibly splits proceeds with the union. As before, we assume Rust Belt producers bargain with unions over their second-stage profits with bargaining weight β for the union and $1-\beta$ for the firm.

Producers in both regions face a competitive fringe each period. In the Sun Belt, the fringe enters with productivity ϕz_S, where z_S is the initial productivity among Sun Belt producers, and the

parameter $\phi > 0$ governs how effectively the fringe catches up to the leader firms each period. In the Rust Belt, the fringe begins the second stage with productivity $\phi z_R(1-\mu_t)$. The parameter μ stands for the extent of "monopoly power" in output markets, and captures the ease with which incumbents can block entry by potential challengers. One can think of this as arising from policies which protect incumbent producers, such as emphasized by Parente and Prescott (1999) and Herrendorf and Teixeira (2011).

The extent of competition each period is governed by state $\theta \equiv (\beta, \mu)$, which takes on one of three values. Formally, $\theta \in \{\theta_H, \theta_L, \theta_C\}$, where θ_H represents a *high-distortion* state, θ_L represents a *low-distortion* state, and θ_C stands for a *competitive* state. The transition from one state to another is governed by the following transition matrix.

Table 2: Transition Probabilities Between States

	θ_H	θ_L	θ_C
θ_H	$1-\varepsilon$	ε	0
θ_L	0	$1-\varepsilon$	ε
θ_C	0	0	1

From either the high-distortion or low-distortion states, with probability ε the economy transitions to a more competitive state. With probability $1-\varepsilon$ the economy states in the same state. The competitive state θ_C is absorbing.

5.2. Static Firm Problem

The firms' static profit maximization problem is similar to the one laid out in the simple static model of the previous section. Still, we spell it out completely here for clarity. In the first stage, the firm decides how much to invest. In the second stage, the firms decides what price to set and how much labor to hire in order to maximize their quasi-rents. Clearly, forward-looking producers anticipate the quasi-rents in stage two associated with any given investment decision. So let us describe the firm's problem starting with stage two.

Consider a Sun Belt firm who enters the period with productivity z_S and has chosen technology upgrade x_S. Assume that all the other Sun Belt firms have productivity $\tilde{z}_S$ and have chosen upgrade $\tilde{x}_S$, which could be equal to z_S and x_S (and will be in equilibrium). Finally, assume that all Rust Belt producers have productivity $\tilde{z}_R$ and have chosen $\tilde{x}_R$. To keep the notation tidy, we define $Z_S \equiv (z_S, \tilde{z}_S, \tilde{z}_R)$ and $X_S \equiv (x_S, \tilde{x}_S, \tilde{x}_R)$. Whenever possible, we also drop the firm label $j \in [0,1]$.

The static profit maximization problem of the Run Belt firm is to maximize the quasi-rents:

$$\tilde{\pi}_S(Z_S, X_S) = \max_{p_S,\, \ell_S} \Big\{ p_S y_S - \ell_S \Big\} \tag{18}$$

subject to $y_S = z_S[1+x_S]\ell_S$ and $y_S = X \cdot P^{\sigma-1} \cdot p_S^{-\sigma}$, which are the production function and standard demand function under CES preferences. As before, X and P represent total spending on all goods by the household and the aggregate price index, respectively:

$$X = \int_0^{\lambda} p_R(j) q_R(j) dj + \int_{\lambda}^{1} p_S(j) q_S(j) dj$$
$$P = \Big[\int_0^{\lambda} p_R(j)^{1-\sigma} dj + \int_{\lambda}^{1} p_S(j)^{1-\sigma} dj \Big]^{\frac{1}{1-\sigma}}.$$

Since Sun Belt leaders must Bertrand compete with the competitive fringe, it follows that they limit price the fringe and charge $p_S(i) = \frac{1}{\phi z_S}$.[14]

Now consider a Rust Belt firm who enters the period with productivity z_R and has chosen investment level x_R, while all other Rust Belt producers have productivity $\tilde{z}_R$ and investment $\tilde{x}_R$. Assume that all Sun Belt producers have productivity $\tilde{z}_S$ and have chosen investment $\tilde{x}_S$. As we did for the Sun Belt, let us define $Z_R \equiv (z_R, \tilde{z}_R, \tilde{z}_S)$ and $X_R \equiv (x_R, \tilde{x}_R, \tilde{x}_S)$. Quasi-rents of the Rust Belt are given by

$$\tilde{\pi}_R(Z_R, X_R; \mu) = \max_{p_R,\, \ell_R} \Big\{ p_R y_R - \ell_R \Big\} \tag{19}$$

subject to $y_R = z_R[1+x_R]\ell_R$ and $y_R = I \cdot P^{\sigma-1} \cdot p_R^{-\sigma}$. The additional argument in the Rust Belt producer's profit function, μ, reflects the difference in the limit price compared to a Sun Belt producer.

5.3. Dynamic Firm Problem

We now consider the dynamic problem of the firms. The Bellman equation that describes a Sun Belt producer's problem is:

$$V_S(Z_S; \theta) = \max_{x_S} \Big\{ \tilde{\pi}_S(Z_S, X_S) - I(x_S, Z_S) + \delta \mathbb{E}\Big[V_S\big(Z_S; \theta'\big) \Big] \Big\} \tag{20}$$

where $Z_S' = \big(z_S(1+x_S), \tilde{z}_S(1+\tilde{x}_S), \tilde{z}_R(1+\tilde{x}_R)\big)$, and the expectations are over θ', tomorrow's state of competition. The Sun Belt producer picks the amount of investment each period to maximize quasi rents minus investment costs plus the expected discounted value of future profits.

[14] For expositional purposes we focus on the case where investment in equilibrium is "sufficiently low" such that it is optimal for Sun Belt producers to limit price the fringe. More generally, they either limit price or set a standard monopolist markup, depending on how much investment they undertake in equilibrium.

Analogously, the Rust Belt producer's Bellman equation is:

$$V_R(Z_R;\theta) = \max_{x_R}\left\{(1-\beta)\tilde{\pi}_R(Z_R,X_R,\theta) - I(x_R,Z_R) + \delta\mathbb{E}\left[V_R\left(Z_R';\theta'\right)\right]\right\} \tag{21}$$

where $Z_R' = \left(z_R(1+x_R), \tilde{z}_R(1+\tilde{x}_R), \tilde{z}_S(1+\tilde{x}_S)\right)$. The Rust Belt producer picks its technology upgrade to maximize its share of quasi rents minus investment costs, plus the expected discounted value of future profits. Its share is $1-\beta$, which is determined by the Nash bargaining.

Finally, we assume that the investment cost function is

$$I(x_i,Z_i) = x_j^{\gamma}\frac{\overline{c}\, z_i^{\sigma-1}}{\lambda\tilde{z}_R^{\sigma-1} + (1-\lambda)\tilde{z}_S^{\sigma-1}} \tag{22}$$

for $Z_i = (z_i, \tilde{z}_i, \tilde{z}_{-i})$, $\gamma > 1$, $\overline{c} > 0$ and $i \in \{R,S\}$. One desirable property of this cost function is that investment costs are increasing and convex in x. Moreover, the further the firm lags the "average" productivity level in the economy the cheaper it is to upgrade the current technology z_i. A second desirable property, as we show later, is that this cost function delivers balanced growth when distortions in labor and output markets are shut down.

5.4. Dynamics in the Competitive State

In the competitive state, $\beta = \mu = 0$ for the current period and all future periods. Analyzing the competitive state is convenient for gaining intuition, as the dynamics are particularly clean when both β and μ are zero. To see this, define the balanced growth path to be a situation where $x_R = x_S = x$ each period. Then, one can show that three things are true along the balanced growth path (all proofs are relegated to the Appendix). First, x is given as the solution to a single equation in one unknown (presented in the Appendix.) Second, the ratio z_R/z_S is constant from one period to the next. Third, the Rust Belt's employment share is constant from one period to the next.

These properties of the balanced growth path are useful for several reasons. First, they illustrate that in the competitive state, both regions grow at the same rate. This implies that the decline of the Rust Belt can only come about in the model from imperfect competition there (and not, simply differences in the productivity states of the two regions). Second, the properties are useful in calibrating the model, as the properties of the model in the competitive state can largely be solved by hand. This makes the long run properties of the model transparent and tractable.

5.5. Dynamics under Imperfect Competition

We now consider when the state is either θ_H or θ_L. As will be documented quantitatively in the following section, when plausibly calibrated, the model in either of these states predicts that investment (and productivity growth) is lower in the Rust Belt than the Sun Belt. One can show that if investment is lower in the Rust Belt than the Sun Belt in the current period, then the employment share in the Rust Belt declines between the current and following period. The reason is simple. Less investment means that the relative price of the Rust Belt goods' rises, and because goods are gross substitutes consumers demand relatively more of the cheaper Sun Belt goods. Thus, as in Ngai and Pissarides (2007), employment flows to the Sun Belt.

6. Quantitative Analysis

[TO BE ADDED SHORTLY]

7. Supporting Evidence

This section assesses the model's predictions that rates of investment and productivity growth were systematically lower in Rust Belt industries than those located elsewhere.

7.1. Investment and Technology Adoption

In the model, investments represent expenditures that lead to productivity increases in the future. One reasonable proxy for such investments are expenditures on research and development (R&D). Evidence from the 1970s suggests that R&D expenditures were lower in key Rust Belt industries, in particular steel, automobile and rubber manufacturing, than in other manufacturing industries. According to a study by the U.S. Office of Technology Assessment (1980), the average manufacturing industry had R&D expenditures totaling 2.5% of total sales in the 1970s. The highest rates were in communications equipment, aircraft and parts, and office and computing equipment, with R&D representing 15.2%, 12.4% and 11.6% of total sales, respectively. Auto manufacturing, rubber and plastics manufacturing, and "ferrous metals," which includes steelmaking, had R&D expenditures of just 2.1%, 1.2% and 0.4% of total sales. These data are qualitatively consistent with the model's prediction that investment rates were lower in the Rust Belt than elsewhere in the United States.[15]

Another proxy for productivity-enhancing investment activity is the rate of adoption of key productivity-enhancing technologies. For the U.S. steel industry before 1980, the majority of which was in the Rust Belt, there is a strong consensus that adoption rates of the most important technologies lagged far behind where they could have been (Adams and Brock, 1995; Adams and Dirlam, 1966; Lynn, 1981; Oster, 1982; Tiffany, 1988; Warren, 2001). The two most important new technologies of the decades following the end of WWII were the basic oxygen furnace (BOF) and the continuous casting method. Figure A.3 shows adoption rates of continuous casting methods in the United States, Japan and several other leaders in steel production. Two things are worth noting from this figure. First, the United States was a laggard, with only 15% of its capacity produced using continuous casting methods, compared to a high of 51% in Japan, by 1978. Second, this was the period where large integrated steel mills of the Rust Belt dominated production. Putting these two observations together implies that the Rust Belt lagged far behind in the adoption of one important technology over the period.[16]

[15] Several sources explicitly link the lack of innovation back to a lack of competition. For example, about the U.S. steel producers Adams and Brock (1995) state that "their virtually unchallenged control over a continent-sized market made them lethargic bureaucracies oblivious to technological change and innovation. Their insulation from competition induced the development of a cost-plus mentality, which tolerated a constant escalation of prices and wages and a neglect of production efficiency (page 93). "

[16] In the 1980s and afterward, the U.S. steel industry made large investments in a new technology, the minimill,

There is also agreement that the U.S. steel industry had ample opportunities to adopt the new technologies and chose not to do so. For example Lynn (1981) states that "the Americans appear to have had more opportunities to adopt the BOF than the Japanese when the technology was relatively new. The U.S. steelmakers, however, did not exploit their opportunities as frequently as the Japanese." Regarding the potential for the U.S. Steel Corporation to adopt the BOF, Warren (2001) describes the 1950s and 1960s as "a period of unique but lost opportunity for American producers to get established early in the new technology."[17]

Similar evidence can be found for the rubber and automobile manufacturing industries. In rubber manufacturing, Rajan, Volpin, and Zingales (2000) and French (1991) argue that U.S. tire manufacturers missed out on the single most important innovation of the postwar period, which was the radial tire, adopting only when it was too late (in the mid 1980s). The big innovator of the radial tire was (the French firm) Michelin (in the 1950s and 1960s). According to French (1991), most of the U.S. rubber tire producers hadn't adopted radials even by the 1970s, even as Michelin drastically increased its U.S. market share.[18]

About the automobile industry, Halberstam (1986) writes

> Since competition within the the [automobile manufacturing] industry was mild, there was no incentive to innovate; to the finance people, innovation not only was expensive but seemed unnecessary... From 1949, when the automatic transmission was introduced, to the late seventies, the cars remained remarkably the same. What innovation there was came almost reluctantly (p. 244)

The lack of innovation by the auto industry is noted also by e.g. Adams and Brock (1995), Ingrassia (2011) and Vlasic (2011).

7.2. Productivity Growth

Direct measures of productivity growth by region do not exist unfortunately. Nevertheless, we can assess the model's predictions for productivity growth in the Rust Belt and Sun Belt by comparing

which used an electric arc furnace to turn used steel products into raw steel for re-use. Virtually all of these adoptions were made outside of the Rust Belt region, and in the U.S. South in particular. See Collard-Wexler and De Loecker (2012) and the references therein.

[17] According to Ankl and Sommer (1996), an engineer at the U.S. Steel Company visited the Austrian Linz BOF plant in 1954 and brought back a favorable report on the prospects of the BOF. Management at U.S. Steel vetoed this line of research and reprimanded the engineer for making an unauthorized visit to the Austrian firm (pp 161-162.)

[18] Interestingly, French (1991) claims that all the new radial plants, when they were eventual built, were built in the Midwest and South. Akron, "the Rubber City," stopped making passenger automobile tires in 1978, truck tires in 1984 and aircraft tires in 1987.

Table 3: TFP Productivity Growth by Individual Rust Belt Industries

	Annualized Growth Rate, %		
	1958-1980	1980-2000	1958-2000
Iron and Steel Foundries	0.0	0.5	0.2
Machinery, Misc	−0.4	−0.1	−0.2
Motor Vehicles	1.0	0.2	0.6
Railroad Equipment	1.0	−0.3	0.3
Rubber Products	−0.2	2.5	1.1
Steel Mills	0.4	0.9	0.7
Rust Belt Average	0.3	0.6	0.4
U.S. Economy	2.0	1.4	1.8

Note: Rust Belt Industries are defined as those industries whose employment shares in the Rust Belt MSAs are more than one standard deviation higher than the mean in both 1950 and 2000. Source: Author's calculations using NBER CES productivity database, U.S. census data from IPUMS, and the BLS.

estimates of productivity growth in industries that were prominent in the Rust Belt region over period 1950 to 2000 to productivity growth in the rest of the economy.

Concrete estimates of productivity growth by industry are available from the NBER CES database.[19] By matching their industries (by SIC codes) to those available to us in our IPUMS census data (by census industry codes), we are able to compute the fraction of all employment in each industry that is located in Rust Belt MSAs in each year. We define ''Rust Belt industries" as all those industries with employment shares in Rust Belt MSAs greater than one standard deviation above the mean in both 1950 and 2000. The industries that make the cut are Iron and Steel Foundries, Machinery (Misc), Motor Vehicles, Railroad Equipment, Rubber Products, and Steel Mills.

Table 3 provides estimates of total-factor productivity (TFP) growth per year in these industries over several time horizons. As a frame of reference, we compute TFP for the U.S. economy as a whole as the Solow Residual from a Cobb-Douglas production function with labor share two-thirds and aggregate data from the BEA. The right-most column shows the entire period of data availability, namely 1958-2000. TFP growth was lower in every Rust Belt industry than for the U.S. economy as a whole. The highest growth was in Rubber Products, which grew at 1.1% per year, while the lowest was in Machinery, which grew at -0.2% per year. The U.S. economy, on the

[19] Data and a detailed description of the data are available here: http://www.nber.org/nberces/.

other hand, had far higher TFP growth of 1.8% per year over this period.

The first and second two columns show TFP growth by industry in the periods 1958-1980 and 1980 to 2000. We chose this breakdown because we observed that productivity in several of these industries increased after around 1980. Furthermore, the evidence of Schmitz (2005) and Dunne, Klimek, and Schmitz (2010) suggests that the early 1980s were a time when competitive pressure in the Great Lakes region may have increased substantially.[20]

The first two columns show that in four of the six industries – Iron and Steel Foundries, Machinery, Rubber Products, and Steel Mills – there is evidence that productivity increased in the period after 1980. This is consistent with the productivity pickup found in the model in the latter part of the period.

For the automobile industry, international evidence also supports the idea that productivity growth was lower than it otherwise might have been. Table **??** shows a simple measure of productivity – vehicles produced per worker – for the big three U.S. auto producers and two prominent Japanese producers, Nissan and Toyota. On average, the U.S. producers increased output per worker by about 25% over the period 1960 to 1983. Over the same period, the Japanese producers increased output per worker by over 300%. For example General Motors went from 8 cars per worker in 1960 to 11 in 1983, while Nissan went from 12 to 42. These productivity estimates are crude at best given that they ignore capital, differences in the size and quality of vehicle and so forth. Nevertheless, they show dramatic differences in output per worker over the period, with the U.S. far behind in terms of apparent productivity growth.

7.3. Evidence from Cross-Section of MSAs

In this section we provide some additional evidence that supports our mechanism. Specifically, we look beneath the surface of the regional aggregates focused on until now, and consider the cross-section of Metropolitan Statistical Areas (MSAs) within the United States. The basic question we ask if whether MSAs that had the lowest employment growth over the period 1950 to 2000 were those that had the least competitive environments in 1950. We find this indeed the case using one measure of competition: the wage premium earned by workers on average.

The data we use for this analysis is the decennial census micro data available from IPUMS. The unit of geography is, as mentioned above, the MSA, which corresponds roughly to a city plus its surrounding suburbs. We report MSA-level statistics for all MSAs in the country that are above a certain size threshold, usually around 100,000 people. The place of residence is excluded for

[20] Both of these papers argue that transportation costs for foreign competitors (in the iron ore and cement industries) may have increased in the early 1980s. The papers also both show evidence of a dramatic increase in productivity starting in the early 1980s.

confidentiality reasons in smaller MSAs or rural areas. We also focus attention to 3-digit MSAs as defined by IPUMS, as these have changed definition relatively infrequently over time (unlike the 4-digit MSAs.)

We consider all workers who report being primarily wage earners, as opposed to the self-employed, and only those employed in the private sector. The reason for these restrictions are to limit possible biases in our measurement of wage premiums, as well as to keep our sample as standard as possible. We note that our results carry over to alternative sample restrictions, and discuss some of these in detail below.

We construct our measures of wage premiums as follows. As in many standard macroeconomic models, we assume that under competition, the workers' wage should be proportional to their human capital. Following the tradition of Mincer, we assume that a worker's human capital is a function their schooling and potential work experience. We build on these assumptions by letting a worker's wage depend on where they live, with some regions offering a larger payment per unit of human capital than others. In particular, we assume that the log hourly wage of worker i in region m is

$$\log w_{i,m} = \alpha \cdot SCHOOL_{i,m} + \sum_{j=1}^{4} \beta_j \cdot EXPER_{i,m}^{j} + \sum_{m=1}^{M} D_m \cdot \pi_m + \varepsilon_{i,m} \tag{23}$$

where $SCHOOL_{i,m}$ and $EXPER_{i,m}$ represent years of schooling and potential experience, D_m is a dummy for residing in region m, and $\varepsilon_{i,m}$ is an error term. The coefficients α and β_1 through β_4 capture the returns to schooling and experience while the π_m terms capture the "premium" that a worker earns for living in region m controlling for schooling and experience.

We estimate (23) using the IPUMS micro data (from 1950), and take the π_m terms as our measure of wage premiums by MSA. We emphasize that these measures are best thought of as suggestive due to the crude way in which they are calculated. One limitation for example is that other potentially important MSA-level characteristics are omitted from the regression, such as cost-of-living indices. Another limitation is that schooling and potential experience themselves are imperfect proxies for human capital. Nevertheless, we argue that these wage premium measures are still useful in describing and understanding regional differences in economic performance over the post-war period.

Figure 3 shows the wage premium in 1950 (normalized to 0) plotted against the annualized growth in employment from 1950 to 2000. Rust Belt MSAs are displayed in red, while the rest are black. As can be seen in the figure, there is a negative correlation between the two variables, with regions with the highest premiums in 1950 tending to have the worst subsequent employment growth. The correlation coefficient is -0.44, and is significant at well below the 1% level.

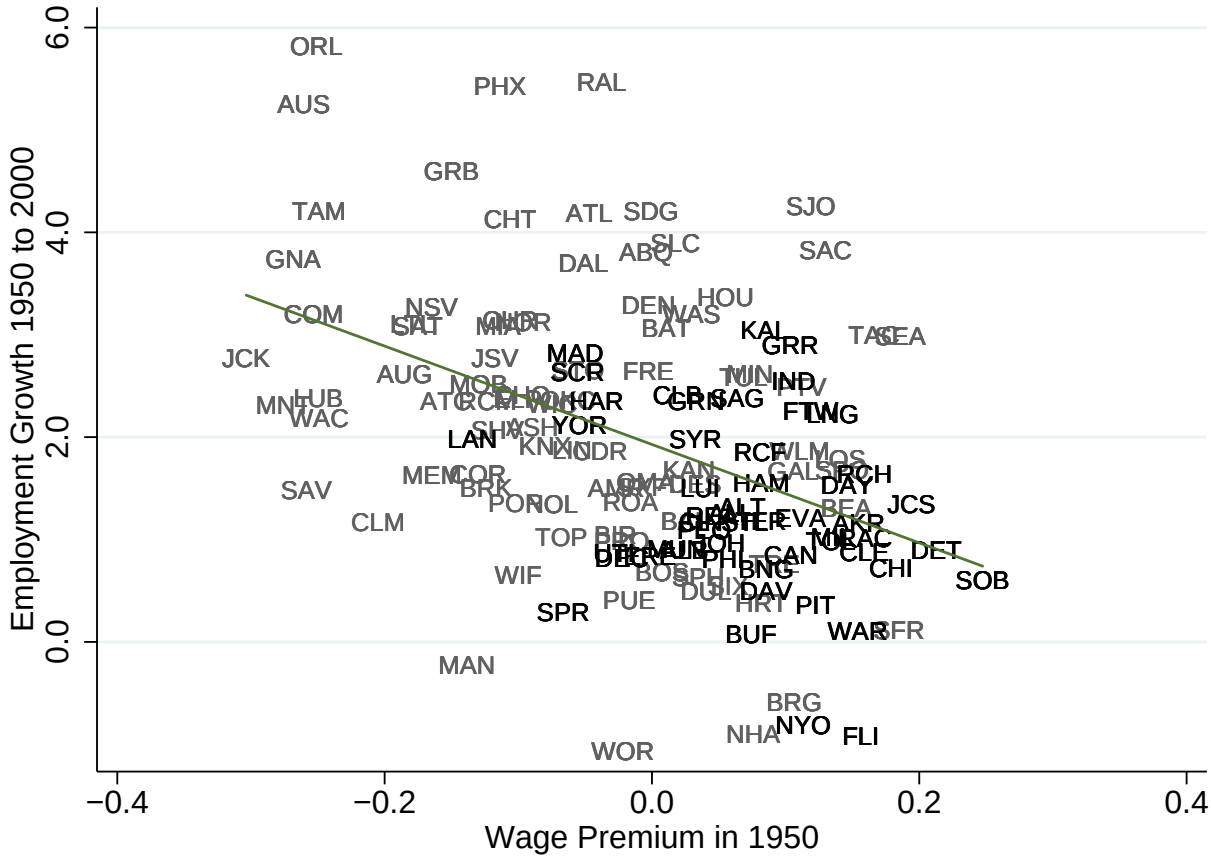


Figure 3: Wage Premiums and Employment Growth across MSAs

Which are the regions on either end of the spectrum? Among the MSAs with high wage premiums are South Bend, IN (SOB), Detroit, MI (DET), Jackson, MI (JCS), Chicago-Gary-Lake, IL (CHI), Pittsburgh, PA (PIT), Youngstown-Warren, OH (WAR), and Flint, MI (FLI). Each of these MSAs was home in 1950 to a major manufacturing center in the automobile or steel industries.[21] Among those with low wage premiums are Orlando, FL (ORL), Austin, TX (AUS), Phoenix, AZ (PHX), Raleigh-Durham, NC (RAL) and Greensboro-Winston Salem-High Point, NC (GRB). These MSAs have all been referred to as being part of the "Sun Belt" (by Blanchard and Katz (1992), among others).

One potential alternative theory of the wage premiums in the Rust Belt is that workers there were of higher than average ability. This could be the case, say, if talented workers in the 1950s tended to be attracted disproportionately to the Rust Belt regions because labor markets there were strong

[21] See e.g. Vlasic (2011) or Ingrassia (2011) on auto manufacturing, and Tiffany (1988) or Crandall (1981) on steel. South Bend, Detroit, Jackson and Flint were major auto producers; Pittsburgh, Youngstown-Warren and Chicago-Gary-Lake were steelmaking centers.

at the time. According to this theory, the interpretation of the above-average wages as premiums is erroneous, and instead the higher than average wages earned by workers in this region simply reflected their higher productivity.

One piece of evidence against this hypothesis is that workers in industries common in the Rust Belt tended to suffer some of the largest wage losses in percent terms after a (plausibly) exogenous displacement, compared to workers in other industries (Carrington and Zaman, 1994; Jacobson, Lalonde, and Sullivan, 1993). Carrington and Zaman (1994) find that displaced workers in the typical industry lost about 10% of their pre-displacement wage when moving to a new job. In contrast, workers in the "primary metal manufacturing" industry lost around 26% of their wages, and workers in "transport equipment manufacturing" and "rubber and plastics manufacturing" lost around 20%. This evidence is more consistent with the hypothesis that these workers were earning wage premiums than with the hypothesis that these workers were disproportionately the most productive workers.

8. Conclusion

While the U.S. economy as a whole experience growth of just under two percent per year over the postwar period, there was substantial variation in growth experiences across regions within the country. In this paper we document that the wage premium earned by a region's workers on average in 1950 is a very good predictor of subsequent growth in wages and employment, with lower growth rates occurring in regions with higher wage premiums in 1950. Furthermore, many of the regions with the highest premiums and worst economic performance are concentrated in what is often called the Rust Belt: the manufacturing zone around the Great Lakes.

We use this fact to build a theory of the decline of the Rust Belt. Our theory is that a lack of competition was behind the Rust Belt's poor economic performance. We argue that the high wage premiums earned by workers in the Rust Belt region reflected non-competitive behavior in labor markets, with powerful labor unions active in many of the major Rust Belt industries, such as steel, automobile and rubber manufacturing. We then cite direct evidence that output markets were non-competitive as well, with just several large dominating each of the major Rust Belt industries.

We formalize our theory in a dynamic general equilibrium model, in which the strength of competition in labor and output markets determines the extent to which firms innovate and increase productivity. Non-competitive labor markets lead to a "hold up" problem, which discourage firms from investing. Non-competitive output markets eliminate the firm's incentive to invest in order to escape the competition. A plausibly calibrated version of the model predicts roughly one-half of the decline found in the data. The model also predicts that the Rust Belt lagged behind in investment in new technologies and productivity growth. Several types of evidence from prominent Rust Belt industries support these predictions.

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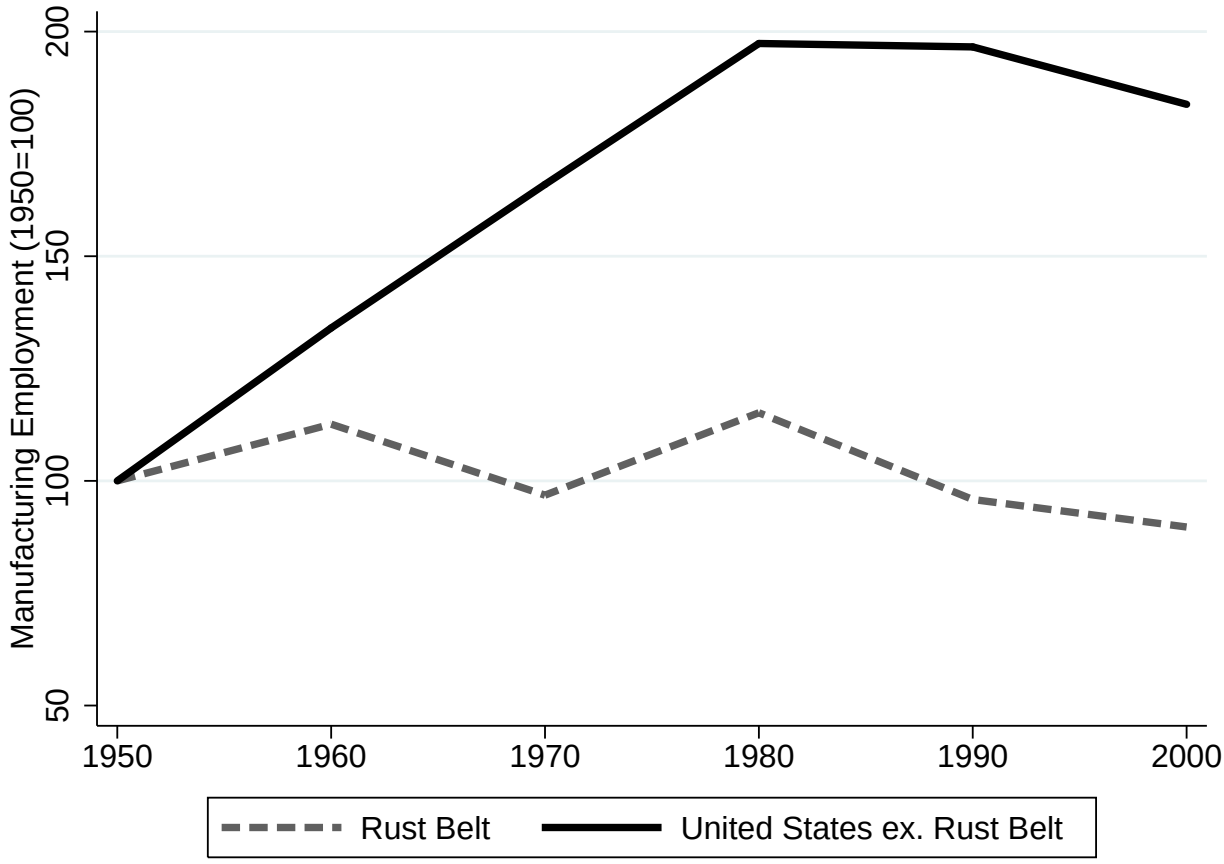


Figure 4: Manufacturing Employment in Rust Belt and Rest of United States

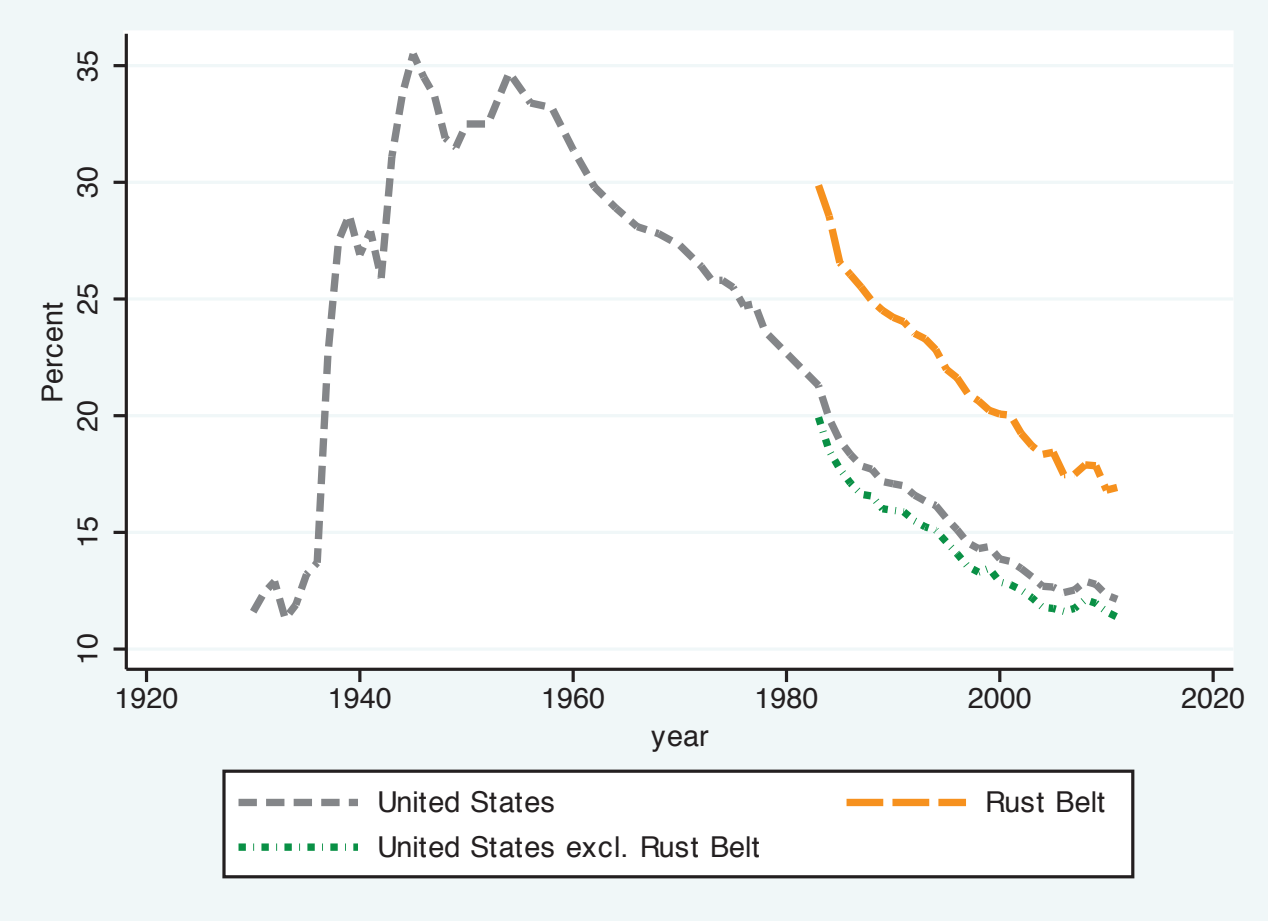


Figure 5: Unionization Rate in the United States and by Region

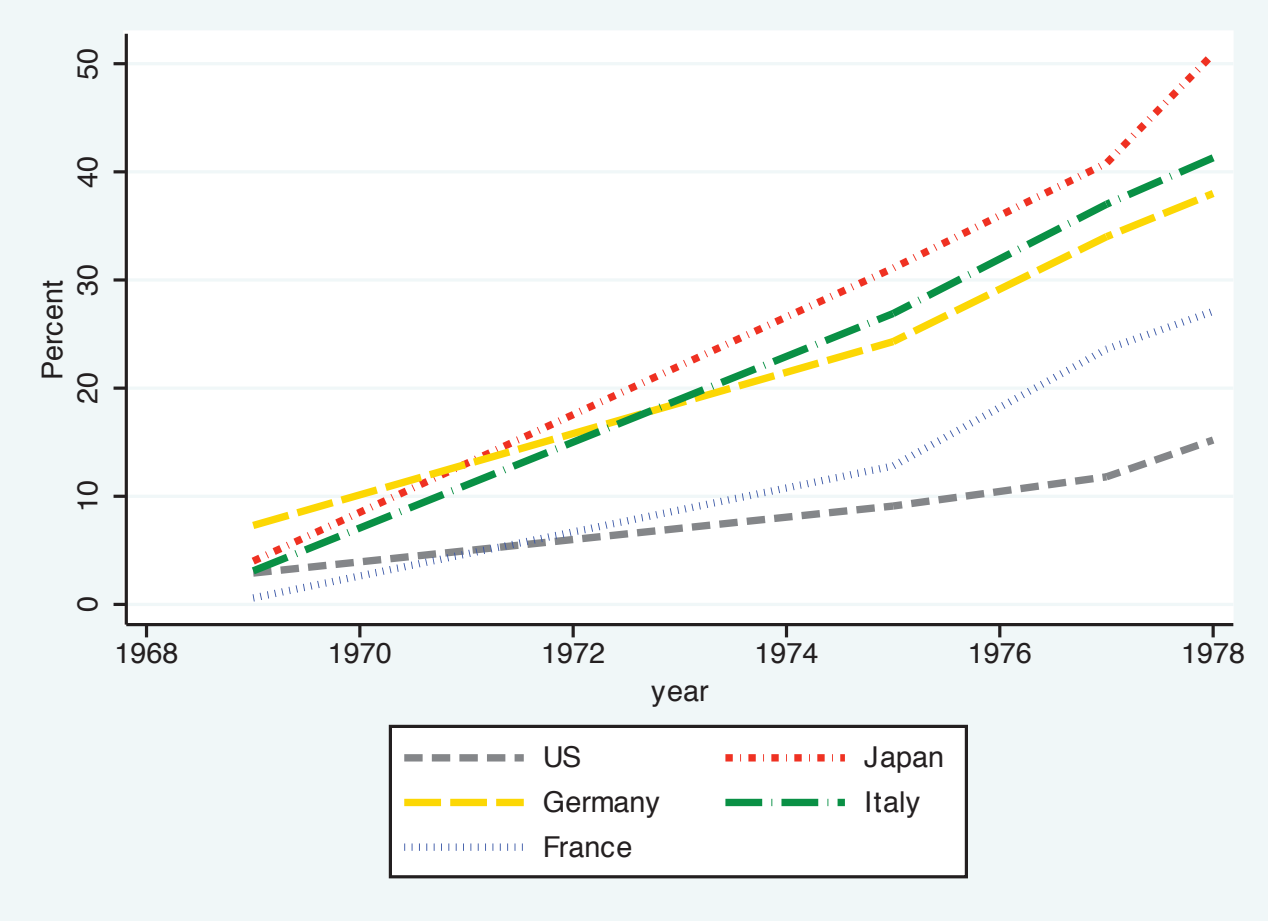


Figure 6: Fraction of Steel Made Using Continuous Casting Process