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

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Abstract

No region of the United States fared worse over the post-war period than the "Rust Belt," the heavy manufacturing zone bordering the Great Lakes. We argue that a lack of competition in labor and output markets in the Rust Belt's main industries 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 half the decline in the Rust Belt's manufacturing employment share. Industry evidence support the model's predictions that investment and productivity growth rates were relatively low in the Rust Belt.

Keywords: Rust Belt, competition, productivity, unionization, hold up

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1. Introduction

No region of the United States fared worse over the post-war period than the area known as the "Rust Belt." While there is no official definition of the Rust Belt, it has come to mean the heavy manufacturing zone bordering the Great Lakes, and including such cities as Detroit and Pittsburgh. By any number of metrics, the Rust Belt's share of aggregate economic activity declined dramatically 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 powerful labor unions that dominated the majority of the Rust Belt's manufacturing industries. In output markets, many of these same industries were run 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.

We formalize the theory in a dynamic general-equilibrium model in which the extent of competition is what 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 a labor union that demands the competitive wage for 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 growth. 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 from estimates of markups in key Rust Belt industries. We find that the model explains roughly half the decline in the Rust Belt's manufacturing employment share.

We conclude by presenting several types of evidence supporting the theory's predictions. First, we show that investment and productivity growth in prominent Rust Belt industries were lower than those of the rest of the economy, as predicted by the theory. Second, we present historical evidence that productivity growth and technology adoption rates for Rust Belt producers tended to lag behind their foreign counterparts for much of the postwar period. Finally, we provide evidence that competitive pressure picked up substantially in the Rust Belt in the 1980s, and show that the Rust Belt's decline slowed and its productivity growth increased in the 1980s. This is just as our theory predicts.

Our paper builds on 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 firms innovate in order to "escape the competition," such as 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 to block new 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), Feyrer, Sacerdote, and Stern (2007) and Kahn (1999), 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 the finding of Blanchard and Katz (1992) 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 well as other papers in the literature, such as that of Borjas and Ramey (1995) and that of Taschereau-Dumouchel (2012), is the link between inequality and unionization, which is absent from the current paper.

2. Decline of the Rust Belt: Evidence

In this section we present four basic facts which characterize the Rust Belt's economic performance over the post-war period. The first fact fact is the slow, secular decline in the Rust Belt's share of U.S. employment. The second fact is the high relative wages paid to workers in the Rust Belt. The third is the relatively low productivity growth in industries located predominantly in the Rust Belt. The fourth is the turnaround of the 1980s, where the Rust Belt's decline slowed, its wage premium fell and productivity growth increased.

Definition and Data Sources

We begin by defining the term "Rust Belt." Our benchmark definition of the Rust Belt is the region comprising Illinois, Indiana, Michigan, New York, Ohio, Pennsylvania, West Virginia and Wisconsin. These definition is meant to represent the heavily manufacturing area bordering the great lakes, which is consistent with previous use of the term (see e.g. Blanchard and Katz (1992) and Feyrer, Sacerdote, and Stern (2007) and the references therein.) Figure 1 displays the Rust Belt on a map of the United States.

Our main source of data is the decadal U.S. Censuses of 1950 through 2000, available through the Integrated Public Use Microdata Series (IPUMS). The only sample restriction is to focus only on 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.

Fact 1: Decline in Rust Belt's Employment Share

Figure 2 plots the Rust Belt's share of employment from 1950 through 2000 according to three different time series. The figure shows that, according to all three series, the Rust Belt's share exhibited a slow secular decline over the period. The aggregate employment share of the Rust Belt (blue line) began at 43 percent in 1950, and declined to 27 percent in 2000. The manufacturing share of the Rust Belt (green dashed line) began at 51 percent in 1950 and ended at 34 percent. The aggregate share of employment in states other than the "Sun Belt" states of Arizona, California, Florida, New Mexico and Nevada was 49 percent in 1950 and 36 percent in 2000.

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 dashed green line in Figure 2 clearly shows that the Rust Belt's share of employment declined *even within the manufacturing sector*. Thus, while the manufacturing sector may have been shrinking relative to services in the aggregate, within the manufacturing sector the trend was for employment to shift from the Rust Belt to the rest of the country.[2]

The fact that the Rust Belt's share of employment in states other than the Sun Belt declined so much shows that the Rust Belt's decline is not simply due to the rise of the Sun Belt. That is, the Rust Belt's decline is not simply due to a rise in the availability of air conditioning, making warmer southern locales more attractive. Even among states where air conditioning was arguably no more or less useful than in the Rust Belt, employment moved out of the Rust Belt states and into other non Sun Belt states.[3]

We also find that the Rust Belt's share of value added declined slowly and secularly since 1950. The Rust Belt's share of aggregate value added and manufacturing value added in 1950 were 45 percent and 56 percent, and fell to 27 percent and 32 percent by 2000. This amounts to declines of 18 and 24 percentage points, respectively. Thus, the Rust Belt's decline is slightly more pronounced for value added than for employment.

Fact 2: Higher than Average Wages in Rust Belt

Figure 3 plots two measures of the relative wages earned by manufacturing workers in the Rust Belt. We focus on manufacturing because our theory is arguably most applicable there; Table 2 shows that the patterns are similar when we include all workers. The first (solid line) is the ratio of average wages of manufacturing workers in the Rust Belt to average wages of all other U.S. manufacturing workers. This ratio is above one for the entire period 1950 through 2000, indicating that wages in the Rust Belt were higher than elsewhere in manufacturing. The magnitude of the wage premium was in the range of 10 percent to 15 percent in the period 1950 to 1980, and lower afterwards.

The second measure (dotted line) is the Rust Belt wage premium among manufacturing workers when adding controls for schooling, potential experience, race and sex. In other words, what is plotted is the coefficient of a Rust Belt dummy variable interacted with the year in a Mincer type regression. These coefficients are above one for the entire period as well, hovering around 13 percent between 1950 and 1980, and falling afterwards (though still remaining positive.) Thus,

[2] We find this pattern within several prominent manufacturing sectors as well. For example the share of U.S. employment in steel, autos and rubber tire manufacturing located in the Rust Belt was 75 percent in 1950 and 55 percent in 2000.

[3] 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 (since the end of WWII) than their counterparts on the other side of the border. 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, such as right-to-work laws.

even after controlling for standard observables, manufacturing workers in the Rust Belt earned substantially more than other workers in the remainder of the country.

Fact 3: Lower than Average Productivity Growth in Rust Belt Industries

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 by comparing estimates of productivity growth in industries that were prominent in the Rust Belt region over the 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.[4] 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 the Rust Belt in each year. We define "Rust Belt industries" as all those industries with employment shares in the Rust Belt greater than one standard deviation above the mean in both 1950 and 2000. The industries turn out to be Blast Furnaces and Steel Mills, Engines and turbines, Iron and Steel Foundries, Metal forgings and stampings, Metalworking machinery, Motor Vehicles and equipment, Photographic Equipment, and Screw machine products. In the Appendix, we consider a broader set of Rust Belt industries, and find that similar patterns hold there as well.

Table 3 reports productivity growth rates for the Rust Belt industries and their averages. Productivity growth is measured as the growth in double-deflated value added per worker.[5] The first data column reports productivity growth in each industry, and the Rust Belt average, for the period 1958 to 1980. On average, productivity growth rates were 1.6 percent per year in the Rust Belt industries, and almost a full percentage point higher at 2.5 percent per year in all manufacturing industries. Productivity growth rates are also lower in the Rust Belt in the period 1980 to 1997 (2.7 percent compared to 3.1), and over the entire period (2.1 percent to 2.8 percent).

One limitation of these data is that what we define as Rust Belt industries include a lot of economic activity that does not take place in the Rust Belt. This is particularly true in the later period of the sample, when the Rust Belt's share of activity had fallen substantially. For the auto industry, we address this concern (at least in part) by computing the rate of growth of automobiles produced per worker for the Big Three auto makers, who had the majority of their auto production in the Rust Belt region, using company annual reports. We find that GM, Ford and Chrysler had average

[4] A detailed description of the data, and the data themselves, are available here: http://www.nber.org/nberces/.

[5] Specifically, we deflate the value of output in each industry by the price deflator for output, and deflate the value of material purchases in each industry by the price deflator for materials. We then calculate the growth rate of double-deflated value added per worker as the growth rate of deflated output per worker minus the the growth rate of deflated materials per worker, where the latter is weighted by the materials cost share of total reveue.

annual productivity growth rates of 1.1 percent, 1.3 percent and 1.8 percent respectively.[6] As these growth rates are all lower than the manufacturing average of 2.5 percent per year, they suggest that Rust Belt automobile productivity growth was indeed relatively low over this period.

For the steel industry, Collard-Wexler and De Loecker (2012) (Table 10) report TFP growth by two broad types of producers: the vertically integrated mills, most of which were in the Rust Belt, and the minimills, most of which were in the South. They find that for the vertically integrated mills, TFP growth was very low from the period 1963 to 1982, and in fact negative for much of the period. From 1982 to 2002 they report very robust TFP growth in the vertically integrated mills, totaling 11 percent 1982 and 1987, and 16 percent between 1992 to 1997. This supports the claim that Rust Belt steel productivity growth was relatively low over the period before the 1980s, and picked up only afterwards.

A second limitation of the productivity evidence of Table 3 is that it compares Rust Belt industries to other industries that may have differed in "potential productivity growth." In other words, in part it compares newer industries, such as computers, where there is a large scope for productivity growth, than in more-established industries, such as steel and autos. To address this potential limitation, we compare productivity growth in the U.S. steel and auto industries to foreign steel and auto industries. The idea is that comparing the key Rust Belt industries to similar industries abroad, one can see how the Rust Belt fared compared to other producers with similar scope for productivity growth.

For the auto industry, Fuss and Waverman (1991) compare the performance of the United States industry to that of Japan. They calculate that between 1970 and 1980, TFP growth in the Japanese auto manufacturing industry averaged 4.3 percent per year. In the U.S. auto industry, in contrast, TFP growth averaged just 1.6 percent.[7] For the steel industry, Lieberman and Johnson (1999) (Figure 8) compute that TFP in the U.S. vertically integrated mills was roughly constant from 1950 to 1980. Over the same period, TFP in the Japanese steel industry roughly *doubled.* Thus, in both the auto and steel industry, evidence suggests that the Rust Belt producers experienced productivity growth substantially below that of the foreign producers in their same industries.

Fact 4: Turnaround of the 1980s

The fourth salient fact about the Rust Belt's performance since WWII is its turnaround of the 1980s. After around 1980, the Rust Belt's employment share decline slowed, its wage premium

[6] The company reports are all publicly available from the companies themselves. The exact years used differ slightly across the three companies due to data availability. The data for GM, Ford and Chrysler begin in 1954, 1955 and 1950, respectively.

[7] Norsworthy and Malmquist (1983) find slightly lower numbers for an earlier period, but still find lower TFP growth for the U.S. auto industry than for the Japanese auto industry.

fell, and its productivity growth picked up in a number of important industries.

Figure 2 shows that the decline in the Rust Belt's employment share slowed after 1980. In the aggregate, for example, the decline from 1950 to 1980 was about 12 percentage points, whereas the decline was just 3 percentage points afterwards. In manufacturing, the decline was about 15 percentage points until 1980, about about 3 percentage points from 1980 to 2000.

Table 2 plots the Rust Belt wage premium in 1950 and 2000 according to several other metrics. Each row presents the coefficient from the Rust Belt dummy in a Mincer regression in 1950 and 2000, where the regression controls or sample restrictions differ. The first row shows, as described above, that manufacturing workers had wage premiums of around 13 percent in 1950 and just 2 percent in 2000. For all workers, the premium was 17 percent in 1950 and just 1 percent in 2000. For full-time workers the premium was also 17 percent in 1950 and was 4 percent in 2000. When including more detailed race controls, including dummies for all race categories present in the census, the premium was 16 percent in 1950 and 3 percent in 2000. When including in addition dummies for each possible school attainment, the premium is 14 percent in 1950 and zero in 2000.

Table 3 shows the productivity pickup of the 1980s. In the largest single Rust Belt industry, namely Blast furnaces & steel mills, productivity growth was just 0.8 percent per year pre 1980, and rose dramatically to 5.5 percent per year after 1980. Large productivity growth increases after 1980 are also present in Metalworking machinery, Motor vehicles & equipment, and Screw machine products. Of course not all Rust Belt industries had these increases, such as Railroad equipment, which had a productivity growth decrease over this period. But on the whole, the region did see productivity increases. The average productivity growth rate was 1.6 percent year from 1958 to 1980, and a full percentage point higher at 2.7 percent per year after 1980.

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, according to several sources, faced low competitive pressure in the decades after the end of WWII. 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.[8] 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.)[9]

It is also well established that these unions extracted great concessions from their employers and enjoyed substantial rents. Figure 3 shows one simple metric of these rents: 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.[10]

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.

[8]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).

[9]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.

[10]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.)

By 1973, a UAW worker could earn "princely sums" working on production or other union-created jobs, such as serving on the plant "recreation committee." In many cases workers could 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, and points to this premium as evidence that steel workers earned rents (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 on the first day of deer hunting season (see e.g. Hoerr (1988)).

Figure 3 also provides an indication that union power began to decline during the 1980s. Relative wages in the Rust Belt fell from roughly 12 percent above other workers to just 4 percent above by 2000. Not coincidentally, union membership dropped steadily over this period. In the Appendix, we plot that 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.

Evidence on work stoppages suggest that union power fell dramatically around the early 1980s. Figure 4 plots the BLS's data series on work stoppages affecting at least one thousand workers. In the period before 1980, they are variable but average around 250 per year. Around 1980 they begin to fall dramatically, and average less than 50 per year in the period from 1980 onward. If work stoppages are a measure of union power to hold up their employers, the 1980s ushered in a period of dramatically less hold up of firms by labor unions.

3.2. Lack of Competition in Output Markets

In output markets served by the 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 virtually the entire domestic market right after WWII and at least half the country's total steel capacity from the end of 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.[11]

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 unchal-

[11] 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."

lenged 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. That the big steel producers appeared to cooperate in pricing is echoed in numerous other industry studies as well.[12] 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.[13]

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).[14] 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.[15] In the auto industry, the U.S. Justice Department at different points 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 each of the steel, auto and rubber industries, concentration ratios fell substantially starting in the 1970s and 1980s. In autos, the Big Three' currently have less than half the domestic market, with even lower figures 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 the steel industry (most of which was in the Rust Belt).[16] In the period since 1987 their

[12]Hudson and Sadler (1989) for example write that "in 1948 the industry .. [began] a system whereby all firms automatically followed US Steel's lead in pricing. During this era, therefore, companies were assured of a comfortable profit margin and faced little incentive to seek out new, more profitable, locations; nor did they do so."

[13]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."

[14]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).

[15]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.

[16]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.

estimated markups averaged just 13 percent.[17]

4. Model

In this section we present a simple model which formalizes the link between competition, productivity and regional employment shares. We use the model to relate the lack of competitive pressure in the Rust Belt to the four facts presented above, and to understand the decline in the Rust Belt's share of U.S. employment over the post-war period.

4.1. Households and Regions

Time is discrete, and time periods are indexed by t. There a unit measure of households who have preferences over a single consumption good:

$$\sum_{t=0}^{\infty} \delta^t C_t \tag{1}$$

where their discount factor δ satisfies $\delta \in (0,1)$. The households are each endowed with one unit of labor in each period, and supply their labor inelastically to the market.

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

$$Y_t = \left(\int_0^1 q_t(j)^{\frac{\sigma-1}{\sigma}} dj \right)^{\frac{\sigma}{\sigma-1}} \tag{2}$$

where $q_t(j)$ is the quantity of intermediate j used in production of the final good, and σ is the elasticity of substitution between any two varieties. We assume that $\sigma > 1$, meaning that any two varieties are gross substitutes.

The final good can either be consumed or used for investment. Intermediates $j \in [0,\lambda)$ are produced in the "Rust Belt," and intermediates $j \in [\lambda,1]$ are produced in the "Rest of the Country." The two regions differ in the nature of their competition in labor markets and output markets (described below). We use subscripts R for the Rust Belt and S for the Rest of the Country.

[17] The evidence of Schmitz (2005) and Dunne, Klimek, and Schmitz (2010) shows that the early 1980s were a time when competitive pressure in the United States increased substantially in at least two important industries: iron ore and cement. In both industries one impetus for the increased competition was a lowering of transportation costs for foreign competitors.

4.2. Intermediate Production and Investment

Each intermediate can be produced by either an incumbent firm or a competitive fringe. For ease in exposition we will omit the j index for intermediates. At the beginning of each period, incumbent firms in both regions begin with some productivity level z_t, and the competitive fringe enters with a productivity level lower than z_t.

In the Rest of the Country, if the incumbent enters with productivity $z_{S,t}$, then the fringe enters with productivity $\phi z_{S,t}$ with $\phi \in (0,1)$. In the Rust Belt, if the incumbent enters with productivity $\phi z_{R,t}$, the fringe enters with productivity $(1-\mu_t)\phi z_{R,t}$ where μ_t stands for the degree of "monopoly power" the firm has in output markets. A higher value of μ_t means that the fringe enters with a lower productivity relative to the incumbent. Note that μ_t is time dependent, and taken as given by all firms. One can think of μ_t as arising from policies which protect incumbent producers, such as emphasized by Parente and Prescott (1999) and Herrendorf and Teixeira (2011), though we interpret μ_t broadly as capturing any factor which raises the operating costs of incumbent firms' immediate competitors.

There are two stages in each period: investment and production. In the investment stage, the incumbent chooses x_t, the percent by which they will improve their productivity. Upgrading productivity by x_t requires a cost $I(x_t, Z_t)$, where $Z_t = \{z_t(j)\}_{j=0}^{1}$ is the set of productivity levels of all producers, and $I(x_t, Z_t)$ is convex in x_t. Importantly, the technology upgrade is irreversible once it has been made, and hence the investment is sunk. After investment, the productivity of the incumbent becomes $z_t(1+x_t)$, and the production function becomes

$$y_t = z_t(1+x_t)\ell_t \tag{3}$$

where y_t and ℓ_t represent the leader's output and labor input. One can think of z_t as technology capital, using the language of McGrattan and Prescott (2010), and $I(x_t, Z_t)$ as the investments themselves (made in units of the final good).

In the production stage, incumbent firms decide how much labor to hire and what price to charge, given their production function. In both regions, the incumbents must Bertrand compete with the fringe. Incumbents also complete with other varieties, which are gross substitutes. Hence incumbents face a downward-sloping demand for their good. We present their problem in detail below.

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_t, and the union's share of the surplus (rents) denoted R_t. The labor market in the rest of the country is competitive, in contrast, and each worker earns the competitive wage.

Because of the presence of the union, jobs in the Rust Belt are rationed. Each period, the Rust Belt firms issue "permits" to some measure of workers allowing them to supply labor in the Rust Belt and earn the union premium. The measure is chosen by the firms given their labor demand, which in turn is given by prices and their expectations of other firms' actions. These permits represent a crude but simple way to capture the fact that union jobs were rationed.[18]

The households pool workers' labor earnings plus profits from the firms, and spend all their income on the final good. Formally, the households' budget constraint is

$$P_t \cdot C_t = 1 + R_t + \int_0^\lambda \Pi_{R,t}(j)dj + \int_\lambda^1 \Pi_{S,t}(j)dj \tag{4}$$

where P_t is the price of the final good, C_t is the quantity of the final good purchased for consumption, $1+R_t$ is the labor earnings plus the rents earned by workers in the Rust Belt, and $\Pi_{R,t}(j)$ and $\Pi_{S,t}(j)$ are profits earned by intermediate firms in the Rust Belt and Rest of Country.

4.3. Extent of Competition

We define the *extent of competition* to be the state variable $\theta_t \equiv (\beta_t, \mu_t)$. The extent of competition captures the distortions in labor markets, β_t, and output markets, μ_t, and evolves exogenously over time, taking on one of three values. Formally, $\theta_t \in \{\theta_H, \theta_L, \theta_C\}$, 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.

	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.

[18] In reality, rationing was more complicated. In some instances, immigrants or members of minority groups were given lower preference. In other instances, sons of union workers were given priority in hiring. We abstract from these complications for simplicity, and since the distribution of union rents across households is not crucial for our theory.

4.4. Static Firm Problem

The firms' static profit maximization problem is as follows. 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 period profits. Clearly, forward-looking producers anticipate the period profits in stage two associated with any given investment decision. So let us describe the firm's problem starting with the production stage.

Consider a Rest-of-Country firm (dropping t subscripts) who enters the period with productivity z_S and has chosen technology upgrade x_S. Assume that all the other Rest-of-Country 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:

$$\tilde{\pi}_S(Z_S, X_S; \theta) = \max_{p_S,\, \ell_S} \left\{ p_S y_S - \ell_S \right\} \tag{5}$$

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. The variables X and P represent total spending on all goods by the household and the aggregate price index, respectively:

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

Since Rest-of-Country incumbents must Bertrand compete with the competitive fringe, it follows that they limit price the fringe and charge $p_S(i) = \frac{1}{\phi z_S}$.[19]

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 Rest-of-Country producers have productivity $\tilde{z}_S$ and have chosen investment $\tilde{x}_S$. 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

$$\tilde{\pi}_R(Z_R, X_R; \theta) = \max_{p_R,\, \ell_R} \left\{ p_R y_R - \ell_R \right\} \tag{6}$$

[19] For expositional purposes we focus on the case where investment in equilibrium is "sufficiently low" such that it is optimal for incumbents 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.

subject to $y_R = z_R[1+x_R]\ell_R$ and $y_R = X \cdot P^{\sigma-1} \cdot p_R^{-\sigma}$.

4.5. Dynamic Firm Problem

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

$$V_S(Z_S;\theta) = \max_{x_S} \left\{ \tilde{\pi}_S(Z_S, X_S) - I(x_S, Z_S) + \delta \mathbb{E}\left[V_S\big(Z_S;\theta'\big) \right] \right\} \tag{7}$$

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 Rest-of-Country producer picks the amount of investment each period to maximize "quasi rents" (period profits) minus investment costs plus the expected discounted value of future profits.

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

$$V_R(Z_R;\theta) = \max_{x_R} \left\{ (1-\beta)\tilde{\pi}_R(Z_R, X_R, \theta) - I(x_R, Z_R) + \delta \mathbb{E}\left[V_R\big(Z_R';\theta'\big) \right] \right\} \tag{8}$$

where $Z_R' = \big(z_R(1+x_R), \tilde{z}_R(1+\tilde{x}_R), \tilde{z}_S(1+\tilde{x}_S)\big)$. 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 $1-\beta$.

Finally, letting $i \in \{R,S\}$ denote the region, we assume that the investment cost function is

$$I(x_i, Z_i) = x_j^{\gamma} \frac{\overline{c}\, z_i^{\sigma-1}}{\lambda \tilde{z}_R^{\sigma-1} + (1-\lambda)\tilde{z}_S^{\sigma-1}} \tag{9}$$

for $Z_i = (z_i, \tilde{z}_i, \tilde{z}_{-i})$, $\gamma > 1$, and $\overline{c} > 0$. 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.

4.6. 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 there is no imperfect competition in either region. 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. First, x is given as the solution to a single equation in one unknown.

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.

4.7. Dynamics under Imperfect Competition

We now consider when the state of competition 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 elsewhere. One can show that if investment is lower in the Rust Belt than in the rest of the country 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's goods rises, and because goods are gross substitutes consumers demand relatively more of the cheaper Rest-of-Country goods. Thus, as in Ngai and Pissarides (2007), employment flows out of the Rust Belt.

The distortion in labor markets, β, has an adverse effect on investment because of a *hold-up problem*. Because firms bear all the costs of investment, but later split the surplus with the labor union, firms invest less ex-ante than they otherwise would. Thus, this distortion leads Rust Belt firms to invest less than firms in the rest of the country, all else equal. By itself, this force leads to a decline in the share of employment located in the Rust Belt.

Two opposing forces govern the link between competition in output-market and investment in the model. The first is what the literature has called the *escape-competition* effect (see e.g. Aghion, Bloom, Blundell, Griffith, and Howitt (2005) and the references therein.) All else equal, the stronger is the competitive fringe today (i.e. the lower is μ_t), the more incentive leader firms have to invest today to lower their costs. The second effect is now the so-called *Schumpeterian Effect*. This effect says that the greater is the catch-up of the competitive fringe tomorrow (i.e. the lower is μ_{t+1}), the *less* incentive leader firms have to invest today, since they will get to enjoy the benefits of having lower costs for fewer periods. Which effect dominates is not predetermined in the model, but will be determined by the data used in the parameterization procedure (and the procedure itself) in the section to follow.

More generally, we would like to assess how important are the labor-market distortions and output-market distortions are together for understanding the Rust Belt's decline. We turn to this question next.

5. Quantitative Analysis

We now turn to a quantitative analysis of the dynamic model, where we ask how large of a decline in the Rust Belt's manufacturing employment share the model predicts over the period from 1950 to 2000. We calibrate the extent of competition faced by Rust Belt producers using evidence on wage premiums and markups. We find that the model explains approximately half the drop in the Rust Belt's manufacturing employment compared to the data.

5.1. Parameterization

We set a model period to be five years. We set the discount rate to $\delta = 0.96^5$ so as to be consistent with a 4 percent annual interest rate. For the elasticity of substitution we set $\sigma = 3$ based on the work of Broda and Weinstein (2006), who estimate substitution elasticities between a large number of goods at various levels of aggregation. We note that ours is a conservative choice relative to their median estimated elasticities in that higher values of σ will lead to an even greater predicted decline in the Rust Belt's employment share. Next, we set the initial productivity states to be $z_S = z_R = 1$, and set the initial state of competition to be θ_H, reflecting the evidence (of Section 3) that competitive pressure was at its lowest in the 1950s.

We calibrate the remaining parameters jointly. These are: ϕ, which governs the catch-up rate of the fringe; λ, which pins down the share of goods produced in the Rust Belt; γ, which is the curvature parameter in the investment-cost function; and $\bar{c}$, which is the (linear) scale parameter in the cost function.

We choose these values to match four moments of the data. The first is an average markup of 18 percent in the Sun Belt, which is consistent with what Collard-Wexler and De Loecker (2012) estimate for the period since 1980 among minimill steel producers (most of which were located outside the Rust Belt.) The second is an initial employment share of 51 percent in the Rust Belt, to match the manufacturing employment share in the data in 1950. The third is an investment-to-GDP ratio of 5 percent, which McGrattan and Prescott (2010) report as the average sum of investments in R&D, advertising and organization divided by GDP. The fourth and final moment is a long-run growth rate (in the competitive state) of 2 percent per year.

We also match values of μ and β in states θ_H and θ_L jointly in the calibration procedure. These are chosen to match the estimated markups over the period described in Section 3, and the estimated wage premiums plotted in Figure 3. The targets are listed in Table **??**. The targets for θ_H are supposed to capture the values from the period between 1950 to 1980, while the targets for θ_L are supposed to represent the period afterwards, when competitive pressure rose.

Targeted Wage Premiums and Markups

	Wage Premium	Markup
θ_H	0.12	0.32
θ_L	0.02	0.26

For the probability of a switch in the state of competition, we choose a value of $\varepsilon = 1/6$. This is consistent with an expected stay in the high-distortion state for thirty years. Thus, in 1950, firms in the model expect competitive pressure to pick up around 1980, roughly when it did in the data.

In our baseline experiment, we impose that the economy moves from θ_H to θ_L in 1985, consistent with evidence of Section 3, and then from θ_L to θ_C in 2000. The idea is that, regardless of what firms expected, competitive pressure did pick up in 1985. The choice of moving to the competitive state in 2000 is based in part on the data, which show the lowest markups and wage premiums at the end of the period, and in part based on convenience: what we assume post 2000 has little baring on the model's predictions for 1950 to 2000, and the model is most tractable in the competitive state.

The parameter values implied by the calibration (under the pessimistic scenario) are $\phi = 0.954$, $\lambda = 0.609$, $\gamma = 1.7$ and $\bar{c} = 4.16$. The bargaining power parameters are $\beta_H = 0.320$ and $\beta_L = 0.168$ in 1985. The monopoly power parameters are $\mu_H = 0.141$ and $\mu_L = 0.071$ (update these values).

5.2. Quantitative Results

Figure 5 displays the model's predictions for the manufacturing employment share in the Rust Belt from 1950 to 2000. Several points are worth noting from the figure. Most importantly, the model predicts a large secular decline in the Rust Belt's employment share. The model predicts a drop of around 7 percentage points overall, compared to a 16 percentage decline in the data. Thus the model predicts just under half the decline observed in the data.

Second, the model's predicted decline is more pronounced between 1950 and 1980, as in the data. The model predicts a drop of 8 percentage points until 1980, compared to a 12 percentage point drop in the data. In the subsequent two decades, from 1980 to 2000, the Rust Belt's employment share declined just three percentage points in the data. The model also predicts even a modest increase in the Rust Belt's hare over this period.

Why does the model predict a sharper decline in the earlier part of the period? There are two reasons. First, competitive pressure is weaker in the earlier part of the period, and hence the gap in productivity growth between the two regions is largest then. This leads to a relatively large increase in the relative price of the Rust Belt goods, and households substituting into the cheaper goods of the Sun Belt. Once competitive pressure picks up, the decline slows. Second, higher competitive pressure in the later period leads to a sharp drop in the markup of Rust Belt producers, and hence a sharp drop in the relative price of their goods. In the model this leads to the spike in the Rust Belt's employment share in 1985. In reality, presumably, the increase in competition did not hit all Rust Belt industries exactly at the same time. Thus, the more favorable prices of Rust Belt goods resulting from competition might have played out more smoothly over time in reality than in the model.

5.3. Investment and Productivity Growth

What do the model's predictions for investment and relatively productivity growth look like? The model predicts that investment expenditures average 3.3 percent of value added in the Rust Belt, compared to 6.5 percent in the Sun Belt. Thus, investment rates are substantially lower in the Rust Belt than in the remainder of the economy.

As a result, productivity growth rates are substantially lower in the Rust Belt. The model's average annualized productivity growth rate for Rust Belt producers is 1.4 percent; in the Sun Belt this figure is 2.3 percent. Worth noting is that predicted productivity growth is lowest in the early period in the Rust Belt, at 1.3 percent per year from 1950 to 1980, and rises to 1.6 percent per year after 1980. In the Sun Belt, productivity growth is 2.4 percent per year before 1980 and falls slightly to 2.1 percent afterwards. Thus, the difference in productivity growth rates converged somewhat over the period. After 2000, in the competitive state, the model predicts that productivity growth rates are both exactly two percent per year (as per the calibration.)

6. Supporting Evidence on Investment and Productivity Growth

In this section we present additional evidence on the model's predictions for investment and productivity growth. In particular, we consider evidence on R&D expenditures, TFP growth, and technology adoption rates. While each has its limitations, taken together they support the model's prediction that investment and productivity growth were relatively low in Rust Belt industries for most of the post-war period.

6.1. R&D Expenditures

The first piece of evidence we consider is on R&D expenditures by industry. Expenditures on R&D provides a nice example of costly investments that are taken to improve productivity, as in the model.

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 percent 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 percent, 12.4 percent and 11.6 percent of total sales, respectively. Auto manufacturing, rubber and plastics manufacturing, and "ferrous metals," which includes steelmaking, had R&D expenditures of just 2.1 percent, 1.2 percent and 0.4 percent 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.[20]

6.2. Technology Adoption

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 **??** 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 percent of its capacity produced using continuous casting methods, compared to a high of 51 percent 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.[21]

[20] 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). "

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

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."[22]

The view that technology adoption in the U.S. steel industry was inefficiently low is in fact confirmed by the producers themselves. In their 1980 annual report, the American Iron and Steel Institute (representing the vertically integrated U.S. producers) admit that:

> Inadequate capital formation in any industry produces meager gains in productivity, upward pressure on prices, sluggish job creation, and faltering economic growth. These effects have been magnified in the steel industry. Inadequate capital formation ... has prevented adequate replacement and modernization of steelmaking facilities, thus hobbling the industry's productivity and efficiency (American Iron and Steel Institute, 1980).

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.

The sluggish rate of technology adoption by the auto industry seems to be widely acknowledged by industry historians and insiders, such as Adams and Brock (1995), Ingrassia (2011) and Vlasic (2011). As one example, 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

(2012) and the references therein.

[22] As just one example, Ankl and Sommer (1996) report 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.)

> was introduced, to the late seventies, the cars remained remarkably the same. What innovation there was came almost reluctantly (p. 244).

To summarize the results of this section, investment and productivity growth seemed to be lower among Rust Belt industries than other U.S. industries, and lower than they could have been given available investment opportunities, particularly before the 1980s. This supports the model's predictions that Rust Belt investment and productivity growth rates were low, and particularly so before the 1980s when competition was at its lowest.

7. Conclusion

While the U.S. economy as a whole experienced robust economic growth over the postwar period, there was substantial variation in the economic performance of regions within the country. No region fared worse than the Rust Belt, the heavy manufacturing zone bordering the Great Lakes. The Rust Belt's share of employment and value added fell drastically over this period, both overall and within the manufacturing sector.

Our theory is that a lack of competition was behind the Rust Belt's poor economic performance. We formalize our theory in a dynamic general equilibrium model in which productivity growth is driven by the strength of competition in labor and output markets. Non-competitive labor markets lead to a hold-up problem between workers and firms, which discourage firms from investing. Non-competitive output markets reduce 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. These predictions are borne out in several types of evidence from prominent Rust Belt industries.

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Figure 1: The U.S. Rust Belt

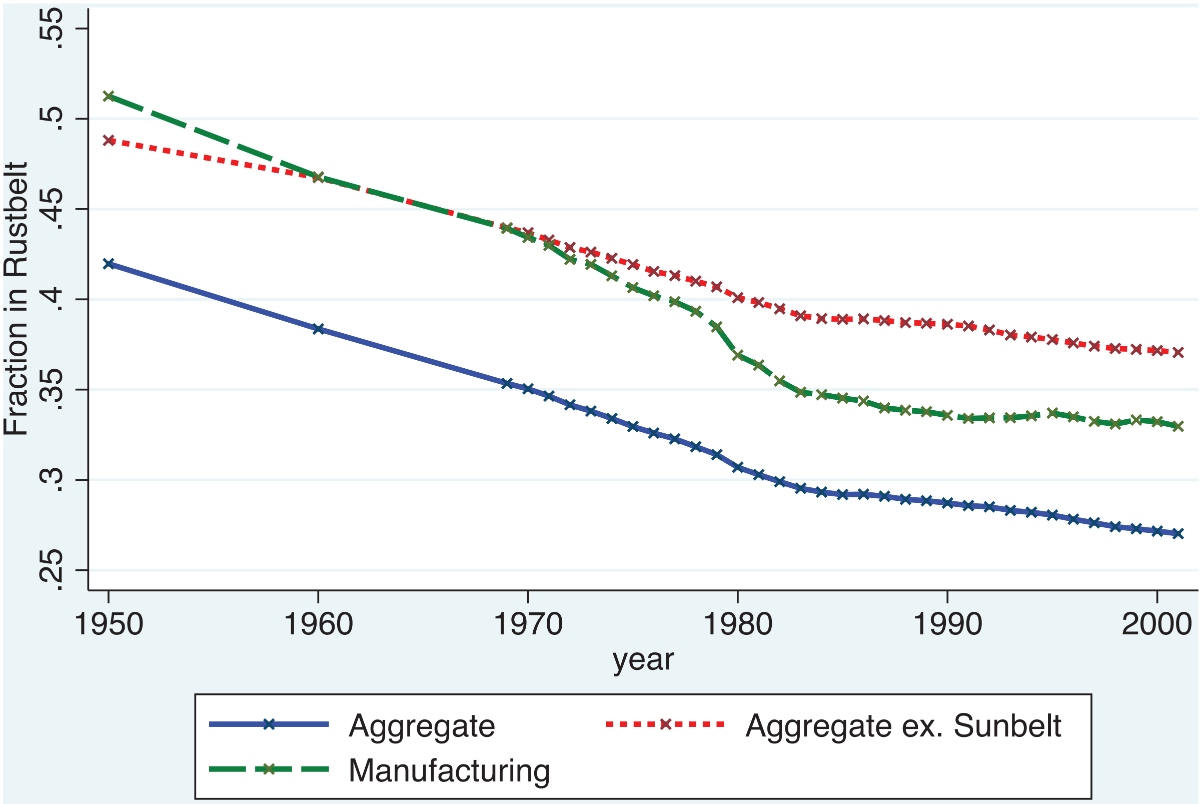

Figure 2: Employment Shares in the Rust Belt

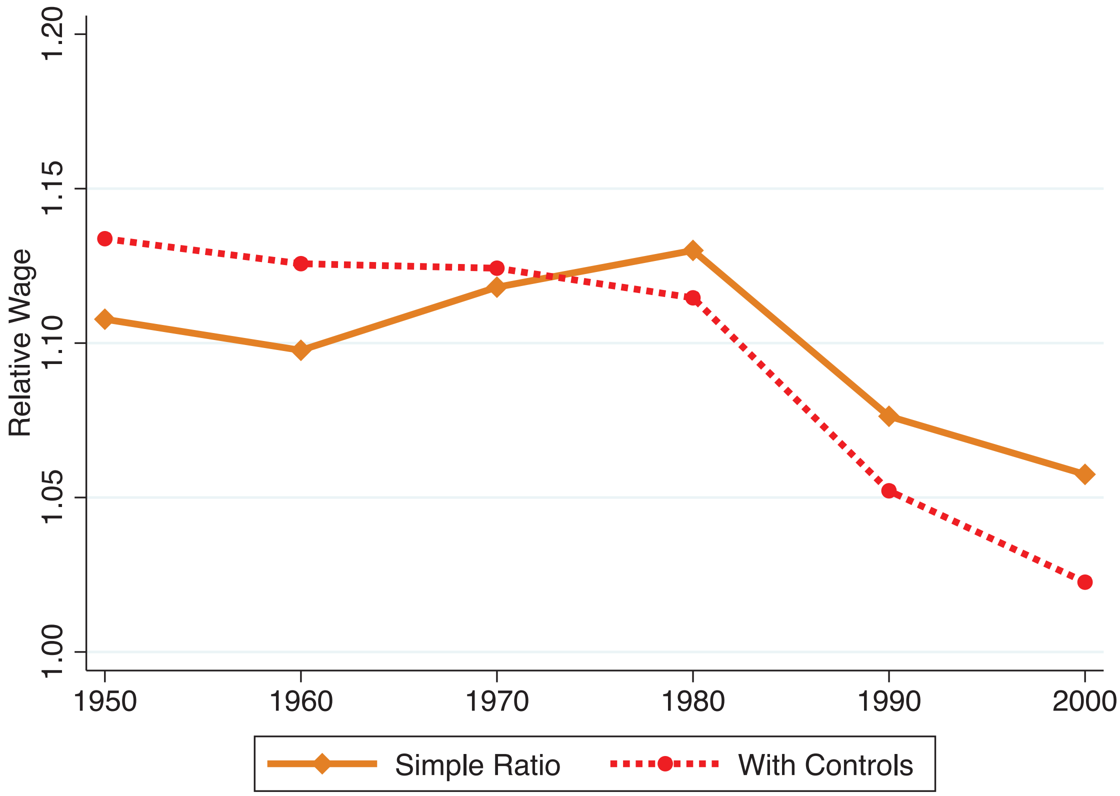

Figure 3: Relative Wages of Rust Belt Workers

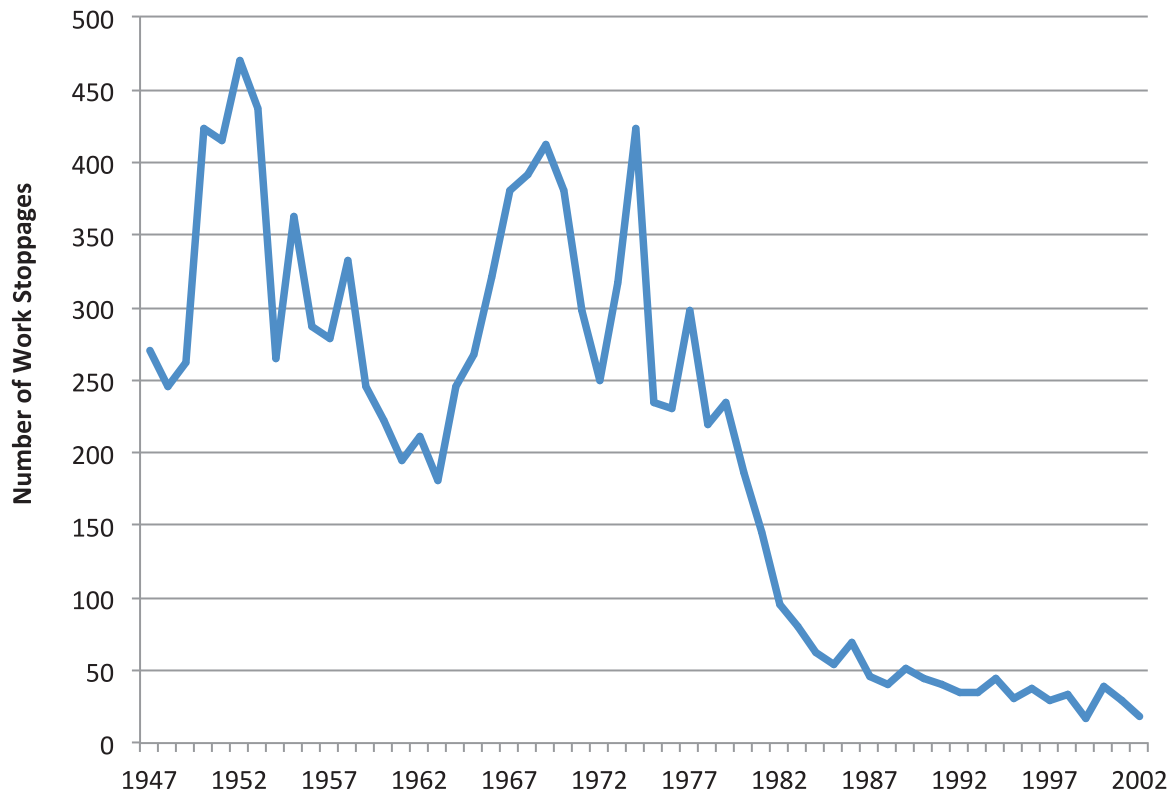

Figure 4: Work Stoppages Affecting More Than One Thousand Workers

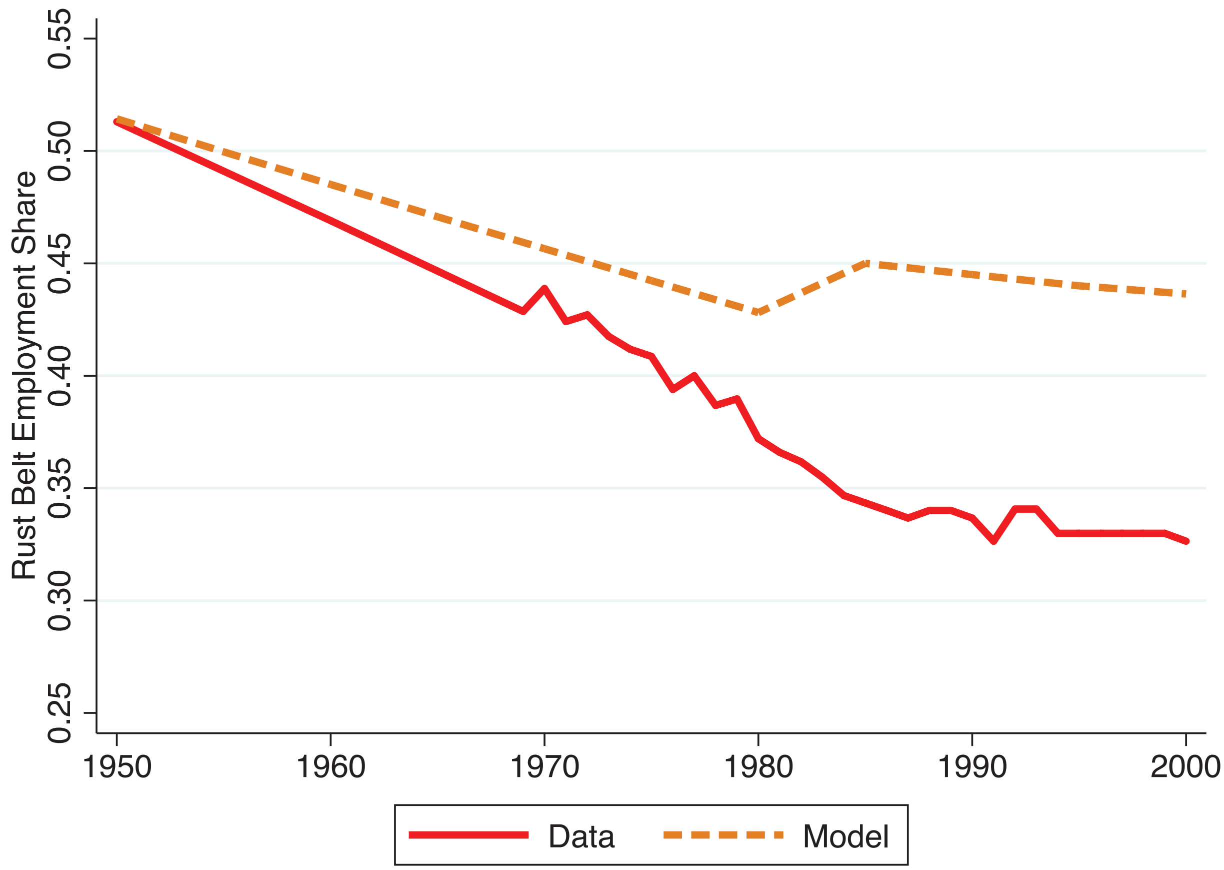

Figure 5: Fraction of Manufacturing Employment in Rust Belt: Model and Data

Table 2: Relative Wages of Rust Belt Workers

	Relative Wages	
	1950	2000
Manufacturing workers	1.13	1.02
All workers	1.17	1.01
Full-time workers	1.17	1.04
All Workers + more detailed race controls	1.16	1.03
All Workers + more detailed race & schooling controls	1.14	1.00

Note: Relative Wages are defined as one plus the coefficient in a Mincer-type log-wage regression of a dummy variable taking the value of 1 for workers living in the Rust Belt, and 0 otherwise, interacted with years 1950 and 2000. The controls in the regression are educational attainment dummies, a quartic polynomial in potential experience, and dummies for full-time status, immigrant status, nonwhite status, sex, year, and year X Rust Belt interaction terms.

Table 3: Labor Productivity Growth in Rust Belt Industries

	Annualized Growth Rate, %		
	1958-1980	1980-1997	1958-1997
Blast furnaces & steel mills	0.8	5.5	2.8
Engines and turbines	2.4	2.3	2.3
Iron and steel foundries	1.3	2.2	1.7
Metal forgings and stampings	1.9	1.6	1.8
Metalworking machinery	0.8	2.8	1.6
Motor vehicles & equipment	2.0	4.8	3.2
Photographic equipment	4.9	4.8	4.9
Railroad equipment	3.2	0.4	2.0
Screw machine products	0.4	2.2	1.2
Rust Belt average	1.6	2.7	2.1
Manufacturing Sector average	2.5	3.1	2.8

Note: Rust Belt Industries are defined as industries whose employment shares in the Rust Belt region are more than one standard deviation above than the industry mean. Labor Productivity Growth is measured as the growth rate of real value added per worker. Rust Belt Average is the employment-weighted average growth rate for Rust Belt industries. Manufacturing Average is the employment-weighted average growth in the all manufacturing industries. Source: Author's calculations using NBER CES productivity database, U.S. census data from IPUMS, and the BLS.