# Labor Market Conflict and the Decline of the Rust Belt

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**Abstract**

No region of the United States fared worse over the postwar period than the "Rust Belt," the heavy manufacturing region bordering the Great Lakes. This paper hypothesizes that the decline of the Rust Belt was due in large part to the persistent labor market conflict that was prevalent throughout the Rust Belt's main industries. We formalize this thesis in a multi-sector dynamic general equilibrium model in which labor market conflict leads to strikes and wage premia in equilibrium. These result in lower investment and productivity growth, which causes employment to move from the Rust Belt to the rest of the country. The model also features rising foreign competition as an alternative source of the Rust Belt's decline. Quantitatively, labor conflict accounts for around half of the decline in the Rust Belt's share of manufacturing employment. Consistent with the data, the model predicts that the Rust Belt's employment share stabilizes by the mid 1980s, once labor conflict subsides. Rising foreign competition plays a more modest role quantitatively, and its effects are concentrated in the 1980s and 1990s, after most of the Rust Belt's decline had already occurred.

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# 1. Introduction

No region of the United States fared worse over the postwar period than the "Rust Belt," the heavy manufacturing region bordering the Great Lakes. In 1950, just over half of U.S. manufacturing employment was located in the Rust Belt. A half century later, in 2000, the Rust Belt employed just one third of U.S. manufacturing workers. Similar declines also occurred for the share of manufacturing value added, aggregate value added and aggregate employment.

This paper proposes and quantifies a theory of the Rust Belt's decline based on persistent *labor market conflict* between the region's manufacturing workers and firms. A large microeconomic literature has empirically studied Rust Belt labor markets at the industry and firm level and concluded that conflicted labor relations significantly depressed Rust Belt competitiveness and productivity. This literature, which we summarize in Section 2, cites strikes – and the threat of strikes – as important channels depressing Rust Belt productivity. Our analysis represents a natural evolution of this microeconomic literature to a macroeconomic setting and is the first study to quantify the link between labor conflict and the decline of the Rust Belt's share of U.S. economic activity.

Our theory is motivated by four observations that we present in detail below. First, labor market conflict in the United States – proxied by rates of major work stoppages – was largely concentrated in Rust Belt manufacturing industries. Second, Rust Belt manufacturing wages, even after controlling for observables, were substantially higher than wages in the rest of the country. Third, there is a strong negative association at the state-industry level between rates of work stoppages and employment growth between 1950 and 2000. Finally, both work stoppage rates and the Rust Belt manufacturing wage premium fell significantly during the 1980s, and this corresponded to a time when the Rust Belt's decline stabilized relative to previous years.

To study how labor market conflict affected the Rust Belt, we develop a dynamic general-equilibrium growth model with two domestic regions: the Rust Belt and the rest of the country. We begin with a simple version of the model that can be characterized analytically. Both regions produce manufactured goods that are gross substitutes in the production of a final consumption good. The two regions differ in that the labor market in the Rust Belt features conflict between workers and firms, whereas labor markets in the rest of the country are competitive. Labor conflict is modeled as arising from imperfect information, which is the standard modeling choice in the literature on strikes (see e.g. Kennan, 1986; Farber, 1986; Cramton and Tracy, 1992). In our setting, the imperfect information is over a productivity shock that is observed by the firm, but not by the workers, at the beginning of each period. A union makes a take-it-or-leave-it offer to the firm of a rent to be paid to the workers. If the firm accepts the offer, production takes place under the terms of the agreement. If the firm rejects the offer, the union calls a strike, during which point production is idle. The strike is resolved by binding arbitration, and a fraction of output is awarded to workers in proportion to a union bargaining weight. Whether or not there is a work stoppage, the firms invest a fixed fraction of profits, which determines their expected productivity levels next period.

The model predicts that the higher the union bargaining weight, the higher are the workers' average rents and rates of work stoppages in equilibrium. This prediction ties the unobservable worker bargaining power in the model to two observables in the data: the Rust Belt's wage premium and work stoppage rate. We also show that a higher union bargaining weight leads to lower average rates of investment and productivity growth by Rust Belt firms relative to firms in the rest of the country. Because goods are gross substitutes in production, employment moves over time from the Rust Belt to the rest of the country (as in Ngai and Pissarides, 2007). This represents the dynamic link between labor conflict and the regional employment patterns that the paper seeks to explain.

In order to quantify the importance of labor conflict for the Rust Belt's decline, we parameterize a version of the model that is enriched to include a foreign sector and international trade. The foreign sector is important because it allows us to compare the labor conflict channel to the alternative hypothesis that a rise in foreign competition in precisely the industries that were concentrated in the Rust Belt was responsible for the region's decline. We model international competition using a simple Ricardian trade structure in which each intermediate good is a CES aggregate of a domestic and a foreign variety as in Atkeson and Burstein (2008) and Edmond, Midrigan, and Xu (2015). We model rising foreign competition as an exogenous productivity boost each period for producers of foreign varieties of Rust Belt goods. We also add a time-varying union bargaining power that governs the extent of labor conflict, and allows the model to match the high rate of conflict earlier in the period and the fall in work stoppage rates during the 1980s.

We parameterize the model to match twelve key moments of the data, which we show are each relevant in identifying some aspect of the model's quantitative behavior. The quantitative importance of labor conflict in the model is disciplined largely by matching the size of the Rust Belt's wage premia, the average rate of work stoppages, and the slope coefficient of a regression of employment growth on work stoppages using simulated data from the model. We match this last statistic using indirect inference, using the same regressions as in the motivating facts discussed above. The importance of rising foreign competition for Rust Belt firms is informed mostly by import shares in predominantly Rust Belt industries, which are higher than average. The extent to which labor conflict and foreign competition lead to changes in regional employment shares are governed in large part by the elasticities of substitution between domestic goods and between home and foreign varieties of each good. We show that these are disciplined by multiple moments, most notably the labor share of income, the Rust Belt wage premium, and the coefficient of conflict on employment growth in the model regressions.

Quantitatively, the model predicts a decline in the Rust Belt's manufacturing employment share of around 11 percentage points, compared to around 18 percentage points in the data. Thus, the model accounts for about 59 percent of the region's decline. Furthermore, the model is also consistent with the *timing* of the decline observed in the data, with more than 90 percent of the loss in the region's employment share materializing by the mid 1980s in both the model and data. In the model, this relative stabilization mirrors the decline in the union's bargaining power, which is disciplined by the lower frequency of work stoppages later in the period.

We then simulate the counterfactual effects of the labor conflict channel on its own, shutting down any differential foreign competition. In this counterfactual experiment, we find that the model predicts a decline of around 9 percentage points, or roughly *half* of the observed decline. The timing is also consistent with the data, with virtually all the employment changes occurring prior to 1990. In a second counterfactual experiment where foreign competition is the only source of differential employment growth, the model generates a modest regional decline of just 2 percentage points, which amounts to 11 percent of the data. Furthermore, the timing of this counterfactual is at odds with the data. Rising imports have virtually no employment effect until the mid-1970s, and the losses are concentrated in the 1980s and 1990s. This suggests that international forces at best played a supporting role in the Rust Belt's decline in the latter part of the time period, and likely had little to do with the large secular decline in the region's employment share that occurred in the first three decades after the end of World War II.

We conclude by providing qualitative evidence in support of our model's prediction that rates of investment and productivity growth were lower in Rust Belt manufacturing industries than in other industries. Industry-level time series of output per worker show that labor productivity growth was lower on average in industries predominantly based in the Rust Belt. The gap in productivity growth was particularly large before 1985, when rates of conflict were particularly high, as our theory predicts. We also cite evidence from historical industry studies that rates of technology adoption were relatively low in Rust Belt industries, particularly in the earlier periods when labor conflict was most prevalent.

Few prior papers have attempted to explain the root causes of the Rust Belt's decline. Yoon (2017) argues, in contrast to our work, that the Rust Belt's decline was due to rapid technological change in manufacturing. Several other papers are implicitly related to the Rust Belt's decline. Glaeser and Ponzetto (2007) theorize that the drop in transportation costs over the postwar period may have caused the decline of U.S. regions whose industries depended on being close to their customers, of which the Rust Belt is arguably a good example. Similarly, Desmet and Rossi-Hansberg (2009) argue that the declining importance of knowledge spillovers led formerly concentrated industries to spread out through space, and Duranton and Puga (2009) emphasize the declining costs of communication. None of these theories emphasize labor market conflict, however, as we do. A number of papers have studied the macroeconomic consequences of unionization, (see e.g. Borjas and Ramey, 1995; Bridgman, 2015; Taschereau-Dumouchel, 2020; Dinlersoz and Greenwood, 2016; Acikgoz and Kaymak, 2014), though none have related labor conflict to the decline of the Rust Belt.

The focus of our model on non-competitive labor markets builds on a growing literature that connects lack of competition with poor economic performance (see e.g. Pavcnik, 2002; Aghion, Bloom, Blundell, Griffith, and Howitt, 2005; Cole, Ohanian, Riascos, and Schmitz Jr., 2005; Schmitz, 2005; Holmes and Schmitz, 2010; Syverson, 2011; Peters, 2020), though our emphasis on labor conflict has not received much prior attention in this literature. Our model's integration of depressed productivity growth with regional decline is related to models of structural change, in which differential employment dynamics and differential sectoral productivity growth go hand-in-hand (see e.g. Ngai and Pissarides, 2007; Buera and Kaboski, 2009; Herrendorf, Rogerson, and Valentinyi, 2014).

The rest of the paper is organized as follows. Section 2 summarizes the facts regarding the Rust Belt's decline, and the history behind the region's conflicted labor relations. Section 3 introduces a simple model that analytically characterizes how labor conflict led to lower employment shares in the Rust Belt over time. Section 4 enriches the model to include international trade, and Section 5 conducts the quantitative analysis of the model. Section 6 presents qualitative supporting evidence that rates of productivity growth and technology adoption were particularly low in Rust Belt industries. Section 7 concludes.

## 2. Decline of the Rust Belt: The Facts

We start by presenting a set of facts that characterize the Rust Belt's decline. First, the Rust Belt's share of manufacturing employment declined secularly from 1950 to 2000. Second, manufacturing industries in the Rust Belt had higher rates of work stoppages than other U.S. industries. Third, manufacturing industries in the Rust Belt paid substantial wage premia. Fourth, all these empirical patterns changed significantly during the 1980s, as labor conflict ebbed, wage premia fell, and the region's decline slowed down. Finally, data at the state-industry level show a strong negative correlation between rates of work stoppages and the pace of employment growth from 1950 to 2000. This correlation is stronger for the period before 1990 than afterward. We also discuss the history of labor conflict in the region, and the political and legal underpinnings of the decline in union power during the period.

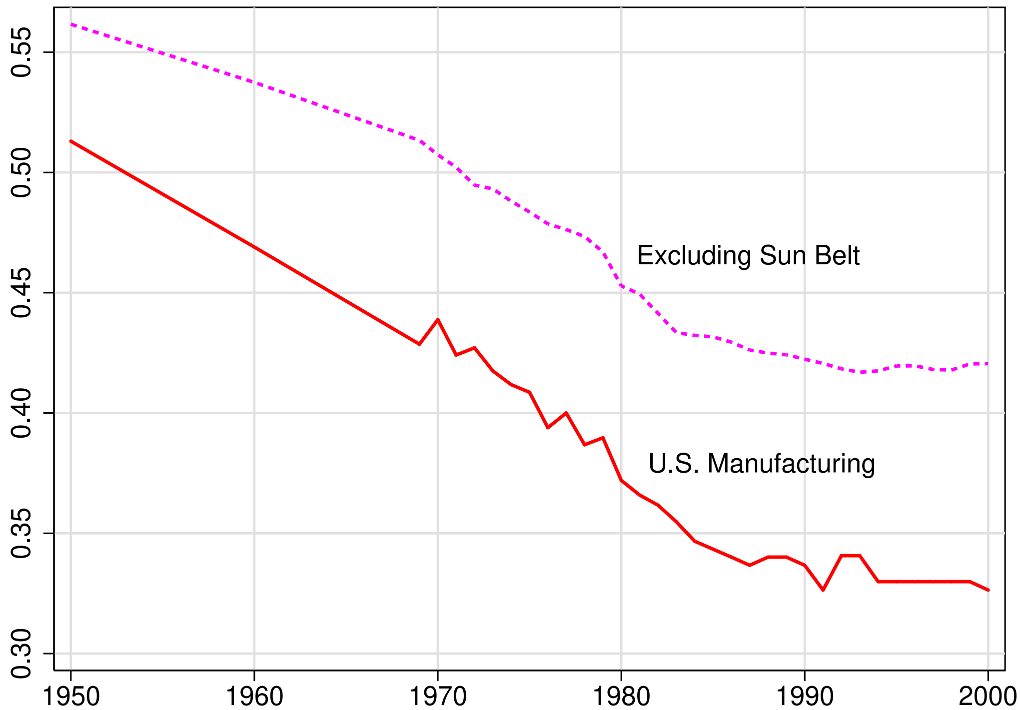
### 2.1. Decline of the Rust Belt's Employment Share

We begin with the basic fact that motivates this paper: the Rust Belt's share of employment decreased secularly over the postwar period. We define the Rust Belt as the states of Illinois, Indiana, Michigan, New York, Ohio, Pennsylvania, West Virginia and Wisconsin. This definition encompasses the heavy manufacturing area bordering the Great Lakes, and is similar to previous uses of the term (see, e.g., Blanchard and Katz (1992), Feyrer, Sacerdote, and Stern (2007) and the references therein). Our main data sources are the U.S. Censuses of 1950 through 2000 and the Current Population Surveys, available through the Integrated Public Use Microdata Series (IPUMS). Throughout, we focus on private-sector wage workers.

Figure 1 plots the Rust Belt's share of employment from 1950 through 2000 by two different metrics. The first is the share of U.S. manufacturing employment located in the Rust Belt (solid red), which began at 51 percent in 1950 and declined to 33 percent by 2000. Note that this decline represents a shift in employment within the U.S. manufacturing sector from the Rust Belt to the rest of the country, rather than the well-studied movement of employment from the manufacturing sector into services (see e.g. Buera and Kaboski, 2012). Furthermore, the decline of the Rust Belt's share of manufacturing employment is broad-based, affecting nearly all of the Rust Belt's industries. For example, the Rust Belt's share of U.S. employment in steel, autos, and rubber tire manufacturing fell from 75 percent in 1950 to 55 percent in 2000.

The second metric we consider is the Rust Belt's share of U.S. manufacturing employ-

Figure 1: The Rust Belt's Manufacturing Employment Share




Note: This figure plots the share of U.S. manufacturing employment located in Rust Belt states (red line) and the share of manufacturing employment in the United States – excluding the Sun Belt states of Arizona, California, Florida, New Mexico and Nevada – located in Rust Belt states (dashed purple line).

ment excluding the "Sun Belt" states of Arizona, California, Florida, New Mexico and Nevada (Blanchard and Katz, 1992). The share of manufacturing employment in states other than the Sun Belt states (dotted purple) was 56 percent in 1950 and 42 percent in 2000. This shows that the Rust Belt's decline is not accounted for by movements, possibly related to weather, of workers to the Sun Belt. The Rust Belt's employment share declined substantially even after excluding these states. This is consistent with the work of Holmes (1998), who studies U.S. counties within 25 miles of the border between right-to-work states (most of which are outside the Rust Belt) and other states, and finds much faster employment growth in the right-to-work state counties next to the border than in counties right across the state border.

More broadly, no region of the United States declined as much as the Rust Belt. Of the seven states with the sharpest declines in manufacturing employment from 1950 to 2000, five are in the Rust Belt. Finally, taken individually, every single Rust Belt state experienced a substantial fall in manufacturing employment relative to the rest of the country.

Table 1: Major Work Stoppage Rates by Region and Sector

| | Percent of Years with a Major Work Stoppage | | |
|---|---|---|---|
| | Manufacturing Industries | Service Industries | Overall |
| Rust Belt | 19.2 | 3.2 | 9.7 |
| Rest of the Country | 2.7 | 0.9 | 1.6 |

Note: The percentages report the average percent of years in which there was at least one major work stoppage (involving 1,000 workers or more) by region and broad sector. The average is taken across all 3-digit manufacturing and service industries. The data cover the years 1958 to 1977 and come from the BLS.

### 2.2. Major Work Stoppages

Next, we present patterns of labor conflict in the United States, and show that the highest rates of conflict from the 1950s to the late 1970s were in manufacturing industries located in the Rust Belt. We focus on work stoppages, defined as those involving 1,000 or more workers, as our measure of labor conflict.

In Table 1, we summarize data collected by the BLS in a consistent way from 1958 to 1977. The dataset contains work stoppages by state and 3-digit SIC code. It includes the number of private-sector workers involved in each stoppage, and we focus on major stoppages, involving at least 1,000 workers. The table reports averages of the state-industry data at the region and sector levels (e.g. manufacturing and services). A work stoppage could be initiated by workers, in the form of a strike, or by management, in the form of a lockout. In either case, it is a clear symptom of conflicted labor-management relations.

Rust Belt manufacturing industries report by far the highest rates of work stoppages in the U.S. On average, 19.2 percent of years involved a major work stoppage. This rate of roughly one strike every five years is consistent with historical studies of labor relations in the Rust Belt's main manufacturing industries, such as steel and autos (see e.g. Richter, 2003). Rust Belt services had far lower rates of major work stoppages, at 3.2 percent per year, as did manufacturing in the rest of the country, at 2.7 percent per year, and services in the rest of the country, at 0.9 percent per year.

Work stoppages are usually associated with labor unions, and Rust Belt manufacturing industries had relatively high rates of unionization. Yet unionization rates by themselves are quite imperfect measures of labor conflict. Between the years 1973 and 1980, for example, CPS data show that 48.1 percent of workers were union members in Rust Belt manufacturing, compared to 28.4 percent among manufacturing workers in the rest of the country. So while unionization rates in manufacturing were around twice as high in the Rust Belt as outside, rates of work stoppages were about *seven* times higher in the Rust Belt. In other words, labor relations were particularly fraught among unions concentrated in the Rust Belt (see also Lodge, 1986; Nelson, 1996).

A natural question is why the Rust Belt manufacturing industries in particular had so much conflict between workers and firm owners. Historical industry studies generally agree that the conflict began with the violent union organizations of these industries in the 1930s (Kennedy, 1999; Millis and Brown, 1950). For example, a 1982 National Academy of Sciences project on the U.S. auto industry argues that the violent union organizations and sit-down strikes of the late 1930s defined an "adversarial and bitter relationship between labor and management" (Clark, 1982). Numerous other studies, including Barnard (2004), Katz (1985), Kochan, Katz, and McKersie (1994), Kuhn (1961), Serrin (1973) and Strohmeyer (1986), also describe how the organizational conflicts of the 1930s and 1940s evolved into chronically conflicted relations in which the strike threat dominated labor negotiations in many Rust Belt industries after World War II.

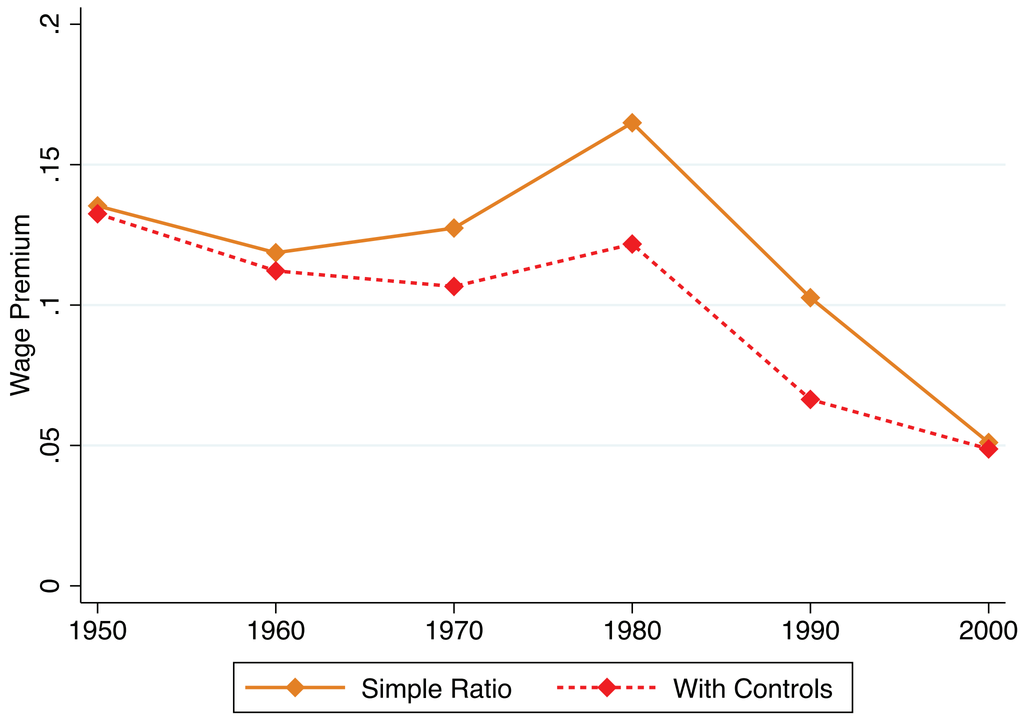
### 2.3. Wage Premia in Rust Belt Manufacturing

This section turns to data on relative wages of manufacturing workers in the Rust Belt. We focus on manufacturing workers because the evidence in the previous section points to conflict as being primarily within the Rust Belt's manufacturing sector. Figure 2 plots two different measures of the wage premium earned by manufacturing workers in the Rust Belt relative to manufacturing workers in the rest of the country. The first is the sample ratio of average manufacturing wages (minus one), plotted as a solid orange line. This simple wage premium started out at 13 percent in 1950, stayed between 12 and 16 percent through 1980, and then fall to 5 percent by 2000.

We address the possibility that the wage premium reflects better educated or more experienced workers by computing the residual wage premium after controlling for education, age, age squared and a sex dummy. This wage premium with controls is plotted as the dashed red line in Figure 2. It is very similar to the simple wage premium. The wage premium with these controls is 13 percent in 1950, it remains between 11 and 13 percent through 1980, and falls about to 6 percent in 2000. Thus, even with these controls, manufacturing workers in the Rust Belt earned substantial wage premia over this period.

Another possible factor affecting the wage premium is that the cost of living was higher

Figure 2: Wage Premium in Rust Belt Manufacturing




Note: This figure plots the ratio of average wages for manufacturing workers in the Rust Belt relative to manufacturing workers in the rest of the United States (orange line) and the dummy variable from a regression of log wages on a Rust Belt dummy variable and other controls, described in the text.

in the Rust Belt than elsewhere. While time series on regional costs of living in the United States do not exist, the BLS did calculate city-level cost of living in a sample of 39 cities in one year, 1966, in the middle of our time period (U.S. Bureau of Labor Statistics, 1967). These data show that the average cost of living difference in Rust Belt cities in 1966 is only about two percent or less, and is statistically insignificant (see Appendix D). Moreover, the premium earned by manufacturing workers in the Rust Belt was not shared by service workers located in the Rust Belt. For example, these non-manufacturing workers earned about 97 percent of the national average wage in 1950, and substantially less than Rust Belt manufacturing workers.

Given that standard human capital controls and regional cost-of-living differences do not account for these premia, we pursue an interpretation of them based on labor conflict. There is considerable evidence that the high unionization and work stoppage rates presented in the previous subsection are driving the wage premium earned by Rust Belt manufacturing workers. Farber (1986)'s survey chapter on union behavior shows that the standard view of unions is that of an organization that bargains over industry rents in the form of wage premia, and that rations scarce, high-paying union jobs in order to preserve those premia.

Models of union labor markets and job rationing are the focus of the large literature on insider-outsider models of unions developed by Lindbeck and Snower (1988), Blanchard and Summers (1986) and Cole and Ohanian (2004), in which unions restrict their membership to maximize rents per worker. These studies cite considerable evidence of union rents and union job rationing. More broadly, Dickens and Lang (1985, 1988) present evidence from CPS data that supports job rationing. Using CPS data from the early 1980s, they find a significant union wage premium after controlling for race, marital status, education, and experience. Moreover, they find evidence that jobs were rationed among white males.

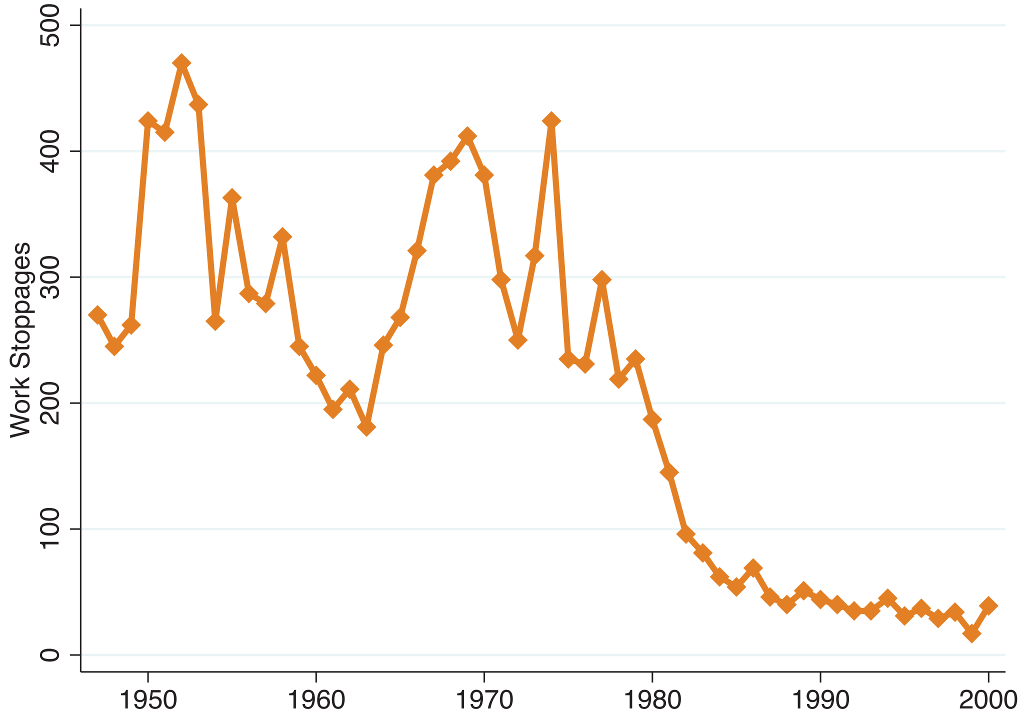
Meier and Rudwick (1979) and Hinshaw (2002) provide detailed studies of the U.S. auto and steel industries, which were concentrated in the Rust Belt, and confirm Dickens and Lang (1985, 1988)'s finding that an important component of job rationing was sharply restricting union jobs offered to women and minorities. Another mechanism in rationing union jobs was nepotism in new hiring. Kupfberg (1999) describes discrimination lawsuits in which unions de facto discriminated against minority candidates by accepting new members who were referred by existing union workers, typically through family or friendship connections.[1]

### 2.4. Changes of the 1980s and the Political Economy of Union Decline

The three facts described above – the secular decline in the Rust Belt's manufacturing employment share, its high rates of labor conflict, and its wage premium – all changed significantly during the 1980s. Figure 1 shows that the decline in the Rust Belt's employment share slowed after around 1986. Specifically, the Rust Belt's share declined by about 16 percentage points between 1950 and 1985, but declined by only two additional percentage points from 1986 to 2000.

[1] A natural question is whether firms tried to escape labor market conflict by substituting other inputs for labor or relocating their production. In fact, many firms in the Rust Belt did try to escape labor market conflict by substituting capital for labor (see e.g. Serrin, 1973; Meyer, 2004). However, organized labor generally resisted these attempts, and explicitly limited capital-labor substitution as part of their collective bargaining agreements (Strohmeyer, 1986; Rose, 1998; Barnard, 2004; Steigerwald, 2010). Firms did also attempt to escape conflict by re-locating their production outside of the Rust Belt. For example, the auto industry developed a relocation plan that was known as the "Southern Strategy" in the 1960s and 1970s, which involved moving auto production to southern states where unions were less prevalent. However, this approach did not achieve what management had hoped. Nelson describes that "the UAW was able to respond (to the Southern Strategy) by maintaining virtually 100 percent organization of production workers in all production facilities" (see Nelson (1996), p 165).

Figure 3: Major Work Stoppages in the United States




Note: This figure plots the number of work stoppages in the United States affecting 1,000 or more workers each year from 1947 to 2000.

Labor relations in the Rust Belt began to change in the 1980s. A large literature describes how Rust Belt union-management relationships began to shift to more cooperation and efficiency around this time, with a significant fall in the use of the strike threat (see e.g. Beik, 2005; Katz, 1985; Kochan, Katz, and McKersie, 1994). The change in labor relations is seen clearly in Figure 3, which shows the number of major work stoppages (involving at least one thousand workers) per year from the end of World War II through the end of the century. The number of major work stoppages fell by almost 90 percent during the period 1979 to 1986, with a permanently lower strike rate afterwards.

The large differences in rates of work stoppages before and after the mid 1980s are consistent with the political economy of organized labor over this period, in which judicial decisions and interpretations, and other legal changes, significantly reduced union power. One key change was President Reagan's decision to fire the striking aircraft controllers in late 1981. This decision, which occurred just as strikes were beginning to decline, is noted as among the most important labor events of the 20th century (see McCartin, 1986; Cloud, 2011, and the references therein).

Academic studies as well as industry participants conclude that the firing of the air traffic controllers and the decertification of their union led to much wider use of permanent replacement workers during strikes. This in turn reduced the power of the strike threat by unions. In particular, the Supreme Court's previously little-noted 1938 decision in NLRB vs. MacKay Radio, in which the Court ruled that using replacement workers during a strike, and keeping those workers on after the strike was settled, was not an unfair labor practice, was viewed as a substantial blow to unions.[2] Empirically, Cramton and Tracy (1998) provide support for the increased use of replacement workers during this period as an important factor in explaining the fall in work stoppage rates.

Another factor weakening union bargaining power was 1947's Taft-Hartley Act, which allowed states to operate as "right to work" states, in which union membership is not a requirement for employment. A growing number of states outside the Rust Belt pursued "right to work" in the 1950s and afterwards, which ultimately turned these states into more attractive locations for production. These developments discussed in this subsection motivate our interpretation of changes in the Rust-Belt's wage premia and strike rates as reflecting legal changes, and will lead us to conduct quantitative experiments in which we exogenously change union bargaining power.

While data on conflict by region and industry are not available after 1977, the fact that the vast majority of work stoppages were in the Rust Belt manufacturing industries beforehand suggests that the largest decline in work stoppage rates must have been in Rust Belt manufacturing.[3] Consistent with the theory that the Rust Belt's wage premia were related to their labor conflict, the decline in worker bargaining power coincides with the declining wage premium. As shown in Figure 2, the wage premium we estimate for Rust Belt manufacturing workers fell from 13 percent in 1950 to around 5 percent by 2000. We also find that the Rust Belt wage premium falls from 1980 to 1990 (and then further from 1990 to 2000) when including dummies for more detailed race and education categories.

[2] A related change was the Supreme Court's 1965 decision in Textile Workers Union vs. Darlington Manufacturing, in which the court ruled that while a company threatening to close a plant if workers were to unionize was an unfair labor practice, a company could close a plant if the workers did unionize. This decision thus made the implicit threat of closure de facto legal.

[3] Direct evidence also suggests that this is the case. For example, Clark (1982), Hoerr (1988), Kochan, Katz, and McKersie (1994) and Strohmeyer (1986) describe how management and unions in autos and steel changed their bargaining relationships in the 1980s, including changing work rules that impeded productivity growth, in order to increase the competitiveness of their industries. Similarly, the United Steelworkers President Lloyd McBride described steel industry labor relations in 1982 as follows: "The problems in our industry are mutual between management and labor relations, and have to be solved. Thus far, we have failed to do this" (see Hoerr, 1988, page 19).

### 2.5. Disaggregate Evidence on Work Stoppages and Employment Growth

If labor conflict was an important cause of the Rust Belt's decline, we would expect to see a negative association between conflict and employment growth in more disaggregate data on manufacturing. In this subsection we ask whether such an association is present at the state-industry level. This requires that we aggregate the BLS micro data on major stoppages such that observations represent state-industries, e.g. motor vehicles in Michigan or metal mining in Alabama. We then merge the work-stoppage data with census data from IPUMS, state-level temperature and climate statistics, and other variables.

Table 2 presents a set of five regressions that explore the correlates of state-industry employment growth rates. The main outcome of interest is the log employment growth rate from 1950 to 2000. Column (1) regresses state-industry employment growth on the number of major work stoppages per year and a set of industry fixed effects. The estimated coefficient on major work stoppages turns out to be -0.86, and is statistically significant at the one-percent level. The coefficient is economically significant as well: one more work stoppage per year is like moving from two standard deviations below the mean to two standard deviations above.

Column (2) adds controls for three state climate characteristics: the average temperature, the within-year standard deviation of monthly temperature, and the average precipitation level. State climate differences have been put forth as determinants of cross-state employment and population dynamics by Rappaport (2007), among others, and the advent of air-conditioning clearly played an important role in the population increases in Sun Belt states like Arizona and Florida. We compute all three variables using data from the five years before and after 1950, though the variables are highly correlated across years. Column (2) also adds the percent of workers that are college graduates in 1950, which may proxy for skill-biased technical change, a potentially important predictor of employment growth at this level of aggregation.

As one might expect, industries in states that had lower temperatures, more variable temperatures within the year, or more rainfall on average, had lower employment growth from 1950 to 2000, all else equal. With these climate variables in the regression, the $R^2$ rises to 0.469, up from 0.325 in Column (1). Thus, the temperature controls substantially increase the explanatory power of the regression. The coefficient on work stoppages remains quite similar in magnitude, however, at -0.63, and remains statistically significant at the one-percent level. On the other hand, the college graduate percent in 1950 is statistically insignificant, suggesting that state-industry skill levels, over and above industry

Table 2: Work Stoppages and State-Industry Employment Growth

| | (1) 1950-2000 | (2) 1950-2000 | (3) 1950-2000 | (4) 1950-1990 | (5) 1990-2000 |
|---|---|---|---|---|---|
| Work Stoppages/Year | -0.86*** | -0.63*** | -0.46*** | -0.40*** | -0.061* |
| | (0.25) | (0.19) | (0.14) | (0.11) | (0.033) |
| State Average Temperature | | 0.044*** | | | |
| | | (0.0046) | | | |
| State Std. Dev. Temperature | | -0.012 | | | |
| | | (0.013) | | | |
| State Average Precipitation | | -0.025*** | | | |
| | | (0.0021) | | | |
| Percent College Grad, 1950 | | -0.20 | -0.084 | 0.017 | -0.10 |
| | | (0.23) | (0.20) | (0.15) | (0.12) |
| Constant | 0.49*** | -0.62 | 0.97*** | 0.57*** | 0.40*** |
| | (0.16) | (0.46) | (0.18) | (0.15) | (0.092) |
| Observations | 2,087 | 1,777 | 1,793 | 1,790 | 1,790 |
| $R^2$ | 0.325 | 0.469 | 0.588 | 0.575 | 0.410 |
| Industry Fixed Effects | Y | Y | Y | Y | Y |
| State Fixed Effects | N | N | Y | Y | Y |

Note: The dependent variable in specifications (1), (2) and (3) is log employment growth from 1950 to 2000. The dependent variables in specifications (4) and (5) are log employment growth from 1950 to 1990, and log employment growth from 1990 to 2000, respectively. Observations are at the state-industry level. The first independent variable is the number of work stoppages affecting 1,000 or more workers per year over the period 1958 to 1977. The second, third and fourth independent variables are state-level weather variables. The fifth independent variable is the percent of workers in the state-industry in 1950 that are college graduates. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

fixed effects, is not an important correlate of employment changes over this period.

Column (3) adds a state fixed effect (but removes the other state variables) to capture any other state conditions potentially relevant for employment growth outcomes. For example, Desmet and Rossi-Hansberg (2009) argue that initial state industry concentration is an important predictor of subsequent state manufacturing growth. Adding state fixed effects raises the $R^2$ further to 0.588, meaning that other state factors explain a substantial portion of the variance in employment growth. Still, the coefficient on work stoppages remains large in magnitude, at -0.46, and statistically significant. Thus, employment growth since 1950 is strongly related to work stoppages at the state-industry level, even after controlling for industry and state fixed effects.

The last two columns of Table 2 run the same specification as Column (3), but focus on employment growth over different time periods. Column (4) focuses on the period 1950 to 1990, while Column (5) focuses on 1990 to 2000. The census year 1990 is a natural cutoff point to consider since, as we argued above, the Rust Belt's decline – and rate of work stoppages – was more most pronounced in the period before the mid 1980s than afterwards. To the extent that work stoppages were an important driver of employment dynamics in the aggregate, one would expect to see a tighter link at a disaggregate level between work stoppages and employment growth in the period before 1990.

Columns (4) and (5) show that in fact the association with work stoppage rates is instead stronger for employment changes before 1990 than for employment changes afterward. The coefficient on work stoppages from 1958 to 1977 is -0.40 for employment growth through 1990, and statistically significant at the one percent level. The same coefficient in the regression of employment growth post 1990 is -0.061, and statistically significant at the ten percent level. This is consistent with our story that work stoppages were mainly relevant for employment changes during the earlier part of our period.[4]

## 3. Simple Model of Labor Conflict and Regional Decline

In order to highlight the role of non-competitive labor markets we first introduce a simple analytical two-region growth model with labor-management conflict in one of them, the Rust Belt. The model can be solved in closed form and we show that the presence of more powerful unions increases the probability of strikes, depresses investment and productivity growth, and lowers the share of aggregate employment in the Rust Belt over time. This tractable model forms the basis for a richer version in Section 4, which we will use in our quantitative analysis in Section 5.

[4] Appendix A explores sensitivity to various modeling assumptions and sample selection choices made in the regressions above. We find that the coefficient on work stoppages is statistically and economically significant when using alternative definitions of major work stoppages, and when including services and agriculture in addition to manufacturing. We find a similar negative association between unionization and employment declines. We also consider an alternative measure of conflict that long predated post-war employment growth: strikes occurring between 1927 and 1934, compiled from data archived by the U.S. Bureau of Labor Statistics. These data show that strikes occurring between 1927 and 1934 are significantly negatively associated with employment growth from 1950 to 2000, which indicates a role for conflict in leading to low employment growth, rather than the reverse.

### 3.1. Preferences and Technologies

Time is discrete and periods are indexed by $t$. There is a unit measure of workers who have linear preferences over a single final consumption good:

$$U = \sum_{t=0}^{\infty} \beta^t C_t, \tag{1}$$

where $0 < \beta < 1$ is the discount factor, and the workers are endowed with one unit of labor each period, which they supply inelastically. The single final good can be used for consumption or investment, which increases a firm's productivity next period. The final good is produced from a continuum of intermediates according to the constant elasticity of substitution (CES) production function:

$$Y_t = \left( \int_0^1 y_t(i)^{\frac{\sigma-1}{\sigma}} di \right)^{\frac{\sigma}{\sigma-1}}, \tag{2}$$

where $y_t(i)$ is the output of a firm producing a single intermediate good and $\sigma$ is the elasticity of substitution. By assumption, these intermediates are gross substitutes ($\sigma > 1$). The production technology for firm $i$ combines labor with the firm's productivity level:

$$y_t(i) = e^{\varepsilon_t(i)} z_t(i) n_t(i). \tag{3}$$

The term $z_t(i)$ is the *productivity level* of the firm producing good $i$, $n_t(i)$ is labor input, and $\varepsilon_t(i)$ is a *productivity shock* that is uniformly distributed, i.e. $\varepsilon_t(i) \sim U(-\bar{\varepsilon}, \bar{\varepsilon})$. The shock $\varepsilon_t(i)$ is observed privately by each firm $i$. This creates a private information problem that, as we show below, leads to labor-management conflict and strikes in equilibrium. In this dimension we follow the literature on strikes closely (see e.g. Kennan, 1986). We discuss the information structure and its implications in more detail in Section 3.4.

A fraction $\lambda$ of intermediate producers is located in the Rust Belt. The remaining $(1 - \lambda)$ intermediate firms are located in the Rest-of-the-Country. Rust Belt firms bargain with a labor union while firms in the Rest-of-the-Country hire labor in a competitive labor market and pay a wage, $w_t$. For simplicity, we assume that goods can be traded across the two regions at no cost.

### 3.2. Investment

Every firm invests an exogenous fraction $s \in (0,1)$ of their retained current profits to increase their productivity in the following period. The remainder is paid to households.[5] The law of motion for the firm's productivity is given by:

$$z_{t+1}(i) = z_t(i)\left(1 + x_t\left(i\right)\right), \tag{4}$$

where $x_t\left(i\right)$ is the rate of productivity growth between $t$ and $t+1$. Productivity growth requires an investment and the cost of $x_t(i)$ is given by:

$$C(x_t\left(i\right), z_t\left(i\right), \mathcal{Z}_t) = \frac{\alpha x_t\left(i\right)^2 z_t\left(i\right)^{\sigma-1}}{\mathcal{Z}_t^{\sigma-1}}, \tag{5}$$

where $\alpha$ is a positive scale parameter governing the average cost of productivity enhancements. The term $\mathcal{Z}_t = \left(\int_0^1 z_t\left(i\right)^{\sigma-1} di\right)^{\frac{1}{\sigma-1}}$ is a geometric average of all firm productivities that takes the elasticity of substitution between different producers into account. The ratio $\left(\frac{z_t(i)}{\mathcal{Z}_t}\right)^{\sigma-1}$ characterizes the firm's productivity relative to average productivity.

We choose this cost function since it delivers balanced growth when the two regions have symmetric labor markets and there is no labor conflict. Similarly, it implies that the growth rate of $x_t(i)$ is independent of $z_t(i)$, holding everything else constant. The convexity in $x_t(i)$ means that larger productivity increases are more costly, all else equal. The relative productivity term, $\left(\frac{z_t(i)}{\mathcal{Z}_t}\right)^{\sigma-1}$, implies that firms with lower than average productivity terms can catch up to the technological frontier at lower cost. In Section 4 we consider our model's quantitative performance under alternative cost functions.

As we show below, differences in investment across firms result from differences in the firms' current profits. Firm profits are functions of productivity levels, $z_t(i)$, idiosyncratic shocks, $\varepsilon_t(i)$, and whether or not the firm is located in the Rust Belt.

### 3.3. The Firms' Problem in the Rest of the Country

We begin with the problem of a firm in the Rest-of-the-Country, where labor markets are competitive, since it is more standard. This firm chooses its price $p_t(i)$, output $y_t(i)$, and

[5] A previous version of the paper considered fully dynamic firm investment decisions (see Alder, Lagakos, and Ohanian, 2017). That model gave rise to quantitatively similar regional investment patterns as the current model, and explained a similar fraction of the Rust Belt's decline. In Section 5 we extend the current model to consider a secular increase in firm investment rates over time. That extension also makes a similar predictions for investment rates by region, and for the magnitude of the Rust Belt's decline.

labor input $n_t(i)$ to maximize its profits:

$$\pi_t(i) = p_t(i)y_t(i) - w_t n_t(i), \tag{6}$$

subject to the downward-sloping demand curve implied by (2). The firm's optimal price is the standard markup:

$$p_t(i) = \frac{\sigma}{\sigma - 1} \frac{w_t}{e^{\varepsilon_t(i)} z_t(i)}. \tag{7}$$

The corresponding output is:

$$y_t(i) = \left(\frac{p_t(i)}{P_t}\right)^{-\sigma} \frac{X_t}{P_t} = \left(\frac{\sigma}{\sigma - 1} \frac{w_t}{P_t} \frac{1}{e^{\varepsilon_t(i)} z_t(i)}\right)^{-\sigma} \frac{X_t}{P_t}, \tag{8}$$

where $X_t$ is aggregate expenditure and $P_t$ is the price of the final good. The firm's period equilibrium profits are:

$$\pi_t(i) = \left(\frac{p_t(i)}{P_t}\right)^{1-\sigma} \frac{X_t}{\sigma} = \left(\frac{\sigma}{\sigma - 1} \frac{w_t}{P_t} \frac{1}{e^{\varepsilon_t(i)} z_t(i)}\right)^{1-\sigma} \frac{X_t}{\sigma}. \tag{9}$$

We choose labor to be the numeraire, so that $w_t = 1$ in all periods. Since there is a unit measure of workers and thanks to the constant mark-up rule, it is straightforward to show that $X_t = \frac{\sigma}{\sigma-1}$.

### 3.4. The Firms' and Union's Problems in the Rust Belt

As in the rest of the country, Rust Belt firms pick their price and labor input to maximize profits. In addition, they bargain with an atomistic union over the size of a rent, $R_t(i)$, to be paid by the firm. If the firm accepts the union's take-it-or-leave-it offer $R_t(i)$, it is split evenly among the workers and labor compensation is equal to the sum of $w_t$ plus the per-worker rent payment.

The union knows the distribution of $\varepsilon_t(i)$, but does not know its realized value when it makes the offer. The firm, on the other hand, *does* know the realized value of $\varepsilon_t(i)$. This imperfect information specification captures an important feature of labor relations in the Rust Belt: unions regularly demanded that firms reveal details about their profitability, and firms regularly refused (see e.g. Clark, 1982).

The union's bargaining power is captured by a parameter $\phi \in [0, 1]$, which will come into play in the event of no agreement between the union and the firm. The bargaining protocol is as follows.

1. At the beginning of period $t$, both the firm and union observe $z_t(i)$.

2. The shock $\varepsilon_t(i) \sim U(-\bar{\varepsilon}, \bar{\varepsilon})$ is revealed to the firm, but not to the union.

3. The union makes a take-it-or-leave-it offer $R_t(i)$ to be paid from the firm's profits.

4.*a*. If the firm accepts the union's offer, production occurs, each worker receives $w_t$ plus a per-worker share of $R_t(i)$ and the firm keeps $\pi_t(i) - R_t(i)$. The firm makes an investment of $s(\pi_t(i) - R_t(i))$ and pays a dividend $(1-s)(\pi_t(i) - R_t(i))$. Dividend payments are disbursed to a fully diversified mutual fund of which each household owns a single share. The period ends.

4.*r*. If the firm rejects the union's offer of $R_t(i)$, the workers strike and the firm is idled for a fraction $\kappa \in (0,1)$ of the available production time. An "arbiter" then issues a binding decision on the share of the post-strike profits that the union receives. This share is denoted $\phi \in (0,1]$. The firm's post-strike profit is denoted by $\underline{\pi}_t(i)$. Following the arbiter's decision, the strike ends, production occurs, using the remaining time available $(1-\kappa)$, and the period ends. The union receives $\phi\underline{\pi}_t(i)$ and the firm retains $(1-\phi)\underline{\pi}_t(i)$.[6]

In the equilibrium of the model, the unions choose $R_t(i)$ to maximize their expected payoffs. Firms choose to accept or reject the union offers to maximize their expected profits. In equilibrium, some Rust Belt firms experience strikes each period while others do not. Firms in the rest of the country do not have strikes. Rust Belt workers in the model earn rents over the competitive wage, while workers in the rest of the country do not. We assume that workers must queue for union jobs, which entails a cost. In equilibrium, the cost of queuing equals the expected wage premium, making all workers indifferent between a union job and a non-union job. We spell out these conditions in Appendix C. In reality, workers rationed union jobs in other ways, as we argued in Section 2, though this is not crucial for our argument.

### 3.5. Equilibrium Strikes and Wage Premia

We now characterize how union bargaining power relates to work stoppages and to wage premia in equilibrium. Specifically, the model implies the following link between them.

[6] This arbitration process, while stylized, does capture some of the key features of major Rust Belt strikes, such as when President Truman intervened in the major steel strikes of 1952, and when Vice President Nixon became the de facto arbitrator between steel producers and the United Steel Workers in the strikes of 1959 (Clark, 1985).

**Proposition 1** *The equilibrium wage premum, $R_t^*(i)$, and the probability of a strike are both strictly increasing in union bargaining power, $\phi$.*

The proof is presented in Appendix B.2. Here we outline the main properties of the model leading to Proposition 1 and the intuition for the results. The union problem of what offer to make is solved by backward induction. At the offer stage, the union will propose a rent $R_t(i)$ that maximizes its payoff *ex ante*. The union's optimal offer can be shown to be:

$$R_t^*(i) = \left(1 - (1-\phi)\left(1-\kappa\right)^{\sigma-1}\right) \frac{X_t}{\sigma} \left(\frac{\sigma-1}{\sigma}\frac{P_t}{w_t} z_t e^{\bar{\varepsilon}}\right)^{\sigma-1} e^{-\frac{1-(1-\kappa)^{\sigma-1}}{1-(1-\phi)(1-\kappa)^{\sigma-1}}}. \tag{10}$$

The union's optimal offer trades off the higher rents from a larger accepted offer with the lower probability that the offer will be accepted. From (10), one can verify that rents are higher when bargaining power, $\phi$, is higher. This is intuitive, since unions propose larger rents for themselves when they expect to get more in the event of a work stoppage that is resolved by arbitration.

Firms maximize profits when they reject union offers that are above a threshold. Specifically, given the productivity shock $\varepsilon_t(i)$, the firm is indifferent between accepting and rejecting the union's take-it-or-leave-it offer if it satisfies:

$$\tilde{R}_t(i) = \pi_t^*(i) - (1-\phi)\underline{\pi}_t^*(i). \tag{11}$$

The threshold, $\tilde{R}_t(i)$, is a function of $\varepsilon_t(i)$ since it depends on realized profits in the agreement and non-agreement outcomes. Let $\tilde{R}_t(i) \equiv g\left(\varepsilon_t(i)\right)$ denote this function. One can show that:

$$g\left(\varepsilon_t(i)\right) = e^{\varepsilon_t(i)(\sigma-1)} \left(\frac{\sigma}{\sigma-1}\frac{w_t}{P_t}\frac{1}{z_t(i)}\right)^{1-\sigma} \frac{X_t}{\sigma}\left(1-(1-\phi)\left(1-\kappa\right)^{\sigma-1}\right). \tag{12}$$

The firm's profit-maximizing behavior is to reject union offers that are above $g\left(\varepsilon_t(i)\right)$, and to accept offers that are below. The profit-maximizing behavior of unions and firms gives rise to the equilibrium rate of work stoppages. In particular, one can show that the probability of rejection, and hence, a strike, is given by:

$$\tilde{F}\left(R_t^*(i)\right) \equiv \frac{g^{-1}\left(R_t^*(i)\right) + \bar{\varepsilon}}{2\bar{\varepsilon}} = 1 - \frac{1-(1-\kappa)^{\sigma-1}}{1-(1-\phi)(1-\kappa)^{\sigma-1}}\frac{1}{2\bar{\varepsilon}(\sigma-1)}. \tag{13}$$

From (13), one can show that work stoppage rates are increasing in union bargaining power, $\phi$. Proposition 1 thus provides an equilibrium link between union bargaining power in the model and two observables in the data: wage premia and strikes. Looking ahead, this link will form the basis for the parameterization of the model to follow.

### 3.6. Equilibrium Employment Dynamics

The model also links labor conflict to regional employment dynamics, which we formalize in a second proposition:

**Proposition 2** *Expected investment is lower in Rust Belt firms than in firms in the rest of the country. The aggregate employment share of Rust Belt firms is falling as long as $\phi \in (0,1]$.*

The proof is also in Appendix B.2. To see how bargaining and strikes reduce investment in Rust Belt firms, it is easiest to begin with the case of a firm $i$ that accepts the union's offer, $R_t(i)$. Since this rent is a lump-sum transfer to the union, the profit-maximizing labor input is independent of $R_t(i)$. In this case the Rust Belt firm's problem is identical to the problem of a firm in the Rest-of-the-Country. The optimal price, output, and profit are the analogues of equations (7), (8), and (9) that characterize these solutions for a Rest-of-the-Country firm – though with profits lower by $R_t(i)$. Since investment is a fixed fraction of profits, it follows that investment is lower tor a Rust Belt firm that accepts the union's offer than for a similar firm in the rest of the country that does not face a union.

Of course, the firm does not always accept the union's offer. To see how labor conflict is linked to employment dynamics more generally, recall that investment $x_t(i)$ is an exogenous fraction of retained earnings, net of rents and arbitration awards. In particular:

$$x_t(i) = \begin{cases} \left(s\pi_t(i)\frac{\mathcal{Z}_t^{\sigma-1}}{\alpha z_t(i)^{\sigma-1}}\right)^{1/2} & \text{if the firm faces no union,} \\ \left(s\big(\pi_t(i) - R_t^*(i)\big)\frac{\mathcal{Z}_t^{\sigma-1}}{\alpha z_t(i)^{\sigma-1}}\right)^{1/2} & \text{if the firm accepts,} \\ \left(s(1-\phi)(1-\kappa)^{\sigma-1}\pi_t(i)\frac{\mathcal{Z}_t^{\sigma-1}}{\alpha z_t(i)^{\sigma-1}}\right)^{1/2} & \text{if the firm rejects.} \end{cases} \tag{14}$$

Equation (14) illustrates how investment is lower in the event of a strike than in the case of a firm with a similar productivity level, $z_t(i)$, but facing no union. It is also true, as we argued above, that investment is lower in the case that the firm accepts the union's offer than in the case where a firm does not face a union. In summary, both actual strikes – and the threat of strikes – reduce investment in the model, consistent with the historical evidence cited in Section 2.

The decline in the Rust Belt's employment share, which forms the second part of Proposition 2, stems from the assumption that intermediate goods are gross substitutes in production. When goods are gross substitutes, final goods producers choose to substitute away from higher cost intermediates and toward lower cost ones. Over time, this leads to shifts in employment demand from regions with lower productivity growth to those with higher productivity growth, as the literature on structural change (see e.g. Herrendorf, Rogerson, and Valentinyi, 2014). Proposition 2 states that the relatively low investment rates in the model's Rust Belt lead, over time, to production and employment moving into the rest of the country.

## 4. Quantitative Open-Economy Version of the Model

The simple model in the previous section establishes a direct link between the frequency of work stoppages, the magnitude of wage premia, and the secular decline in the Rust Belt's share of employment. The model has an analytical solution but does not accommodate alternative explanations of the region's undoing.

Most notably, the model abstracts from foreign competition, which may have contributed to the Rust Belt's decline. To account for this alternative or complementary channel we add a foreign sector and international trade to the simple model. In addition, our treatment of unions in Section 3 is stark in the sense that none of the jobs outside the Rust Belt are unionized and labor's bargaining power, parameterized by $\phi$, is constant over time. In order to account for the regional variation in labor conflict reported in Table 1 and the evolution of work stoppages over time shown in Figure 3 we augment the quantitative model with two separate and time-varying parameters that govern the union's bargaining power in each region.

Rather than describing this version in full detail, we focus on the additional features that are needed to connect the model to the empirical evidence on international trade and the progression of work stoppages in the Rust Belt and in the rest of the country. Appendix C contains the complete equations of the model.

The quantitative model captures the possibility that international forces, beyond the control of the firms in the Rust Belt, may have prompted a gradual shift in the region's comparative advantage. Such a shift would disproportionally increase competitive pressure on Rust Belt producers compared to firms and industries located elsewhere in the U.S. Conceivably, this gradual erosion of the region's comparative advantage could be the driving force behind the reallocation of economic activity from the Rust Belt to the rest of the economy as domestic consumers shift from goods produced locally to similar products imported from abroad. By the same token, the shift in comparative advantage leads to increased demand – and exports – from foreign consumers for domestic goods produced outside the Rust Belt. Both forces tend to reduce the Rust Belt's share of U.S. output and employment, and our quantitative model can account for this alternative mechanism of the region's decline.

To formalize the spirit of this story we assume that each intermediate good $i$ is now a composite made from two distinct varieties. One variety is produced domestically and labeled $H$ (*Home*). The second variety is produced abroad and labeled $F$ (*Foreign*). The final goods are still produced using the same CES production over intermediate goods as in equation (2).

The two varieties of each good are combined according to:

$$y(i) = \left( y^H(i)^{\frac{\rho-1}{\rho}} + y^F(i)^{\frac{\rho-1}{\rho}} \right)^{\frac{\rho}{\rho-1}}, \tag{15}$$

where $\rho$ is the substitution elasticity between the two varieties. We follow Atkeson and Burstein (2008) and Edmond, Midrigan, and Xu (2015) by assuming that $1 < \sigma < \rho < \infty$. This means that the elasticity of substitution across varieties of the same good $i$ is higher than the elasticity across goods. A *Home* firm hires labor to produce output for the domestic and export markets:

$$y^H(i) = (1 - k(i)) z^H(i) e^{\varepsilon^H(i)} n^H(i) \tag{16}$$

$$\tau y^{*H}(i) = (1 - k(i)) z^H(i) e^{\varepsilon^H(i)} n^{*H}(i), \tag{17}$$

where asterisks denote labor input and the corresponding output for final use in *Foreign*, $z^H(i)$ is the start-of-period productivity level of the firm (regardless of the destination of output), $e^{\varepsilon(i)}$ is the privately observed idiosyncratic productivity shock with $\varepsilon(i) \sim N(0, \sigma_\varepsilon^2)$, $n^H(i)$ and $n^{*H}(i)$ are the labor inputs for domestic sales and exports, respectively, and $k(i) \in \{0, \kappa\}$ captures the potential output loss associated with a strike, in which case $k(i) = \kappa \in (0, 1)$.

International trade involves standard iceberg costs $\tau \geq 1$. In order to deliver $y^{*H}(i)$ units of the domestic variety to its destination abroad, the firm has to produce and ship $\tau y^{*H}(i)$ units. We require that trade be balanced each period after taking into account trade costs.

We model rising foreign competition for Rust Belt producers as an exogenous productivity boost each period for producers of foreign varieties of Rust Belt goods. In particular, we assume that the productivity of these producers is increased by an exogenous factor $\zeta_R > 1$ each period. For simplicity, we assume that the foreign sector does not face a productivity shock, though this does not affect our results in a substantive way. The production function for foreign producers selling in domestic and export markets are:

$$\tau y^F(i) = z^F(i)n^F(i) \tag{18}$$

$$y^{*F}(i) = z^F(i)n^{*F}(i). \tag{19}$$

We assume that the *Home* and *Foreign* producers of good $i$ engage in head-to-head Cournot quantity competition. This implies that prices are no longer characterized by a constant markup-over-marginal-cost rule. In particular, it can be shown that the equilibrium prices are characterized by market share-adjusted markups over marginal cost:

$$p^H(i) = \frac{\epsilon^H(i)}{\epsilon^H(i) - 1}\frac{1}{z^H(i)e^{\varepsilon(i)}}, \tag{20}$$

where

$$\epsilon^H(i) \equiv \left(\omega^H(i)\frac{1}{\sigma} + (1 - \omega^H(i))\frac{1}{\rho}\right)^{-1} \tag{21}$$

and

$$\omega^H(i) \equiv \frac{p^H(i)y^H(i)}{p(i)y(i)}. \tag{22}$$

The *Foreign* producer selling in the *Home* market has an analogous set of conditions. Note that there is no closed-form solution for the optimal prices since the market shares in equation (22) are equilibrium objects. It can be shown, however, that markups and thus prices are increasing functions of a firm's share in the market for good $i$. In practice, this means that firms with a larger productivity advantage over their foreign rivals charge larger markups, as do firms with higher productivity than the domestic average.

To capture the evolution of work stoppages in Table 1 and Figure 3, we add two time-varying parameters that govern the extent of labor conflict in each region: $\phi_t^R$ is the union's bargaining power in the Rust Belt at time $t$ and $\phi_t^S$ is its counterpart elsewhere at the same time. This extension enables us to account for the key labor market facts at a more granular level.

In equilibrium, firms hire the amount of labor that maximizes their expected profits taking into account the markups they can charge. The bargaining protocol is as in the simple model, though labor inputs are now chosen before the shock is realized and the parameter that splits the surplus at the arbitration stage varies across regions and over time.[7]

[7]In Section 3, firms hired labor once the idiosyncratic uncertainty was resolved. In a nutshell, this timing convention implied that firms subject to a strike were isomorphic to firms suffering a temporary mul-

The workers' queuing problem, and hence their location choice, mirrors the steps in the simple model and we omit a detailed discussion here. Domestic investment, and the evolution of the firms' productivity is identical to the simple economy in Section 3. The law of motion is given by (4) and the cost function is defined in equation (5). At the end of each period, firms invest a constant fraction $s$ of retained profits and the cost function describes how this investment is transformed into higher productivity.

## 5. Quantitative Analysis

We now parameterize the quantitative version of the model and use it to assess the quantitative importance of labor conflict in the Rust Belt's decline. As a frame of reference, we also consider the rise in foreign competitive advantage in producing varieties of goods predominantly made in the Rust Belt. Our strategy is to calibrate the model to include both forces, and then to simulate the effects of counterfactually shutting down each force one at a time.

### 5.1. Parameterization and Model Validation

We choose a model period to represent one year since most of our data is available at an annual frequency. Moreover, the majority of all strikes were concluded within one year (Kennan, 1986). We set the number of goods (indexed by $i$) to be 1,793, which equals the number of state-industry observations in the regressions of Section 2. This choice assures that when we run similar regressions in the model, the model and data regressions have the same number of observations. We set the duration of a work stoppage, $\kappa$, to be 0.12 so as to match the average duration of 43.7 days in the data of Kennan (1986) on strikes in U.S. manufacturing.

Our calibration strategy for the remaining twelve parameters is to choose them to minimize the distance between twelve moments of the data and their counterparts generated by the model. These moments are reported in Table 3, and we discuss them each briefly here. The first four moments relate to initial conditions and average firm growth rates. They are: the Rust Belt's share of manufacturing employment in 1950, which is 51.3 percent; the variance of state-industry log employment in 1950, which is 3.2; the average investment-to-value added ratio in the U.S. corporate non-financial sector from 1950 to

tiplicative productivity shock $(1-\kappa) \in [0,1]$. This simplification enabled us to derive sharp closed-form characterizations of all endogenous variables. In reality, the firms' workforce is less flexible in the sense that firms cannot instantaneously downsize employment in the event of a strike, and the quantitative version of the model captures this feature.

2000, which is 16 percent; and the average growth rate of real labor productivity in U.S. manufacturing, which is 2.8 percent per year. The first two on our own calculations, while the third comes from the U.S. Federal Reserve (see Appendix Figure E.1), and the fourth comes from the NBER productivity database.

The next three moments relate to international trade. They are: the import-to-sales ratios in the Rust Belt in 1958 and 1990, which are 4.5 percent and 58.7 percent, and the import-to-sales ratio in the U.S. manufacturing sector in 1990, which is 25.8 percent. The data come from the industry-level import data of Feenstra (1996). Import-to-sales ratios in the Rust Belt are computed as a weighted average of the top twenty industries by employment concentration in the Rust Belt. The three target moments succinctly capture that import shares started at a low level and rose significantly over the period, rising even faster in manufacturing industries that were concentrated in the Rust Belt.

The last five moments relate more closely to labor conflict and labor's share of income. These are: an aggregate labor income share from 1950 to 1980 of 64 percent (Elsby, Hobijn, and Şahin, 2013); the average Rust Belt wage premium of 12 percent from 1950 through 1980 (as in Figure 2); the rate of work stoppages in manufacturing in the Rust Belt (19.2 percent) and the rest of the country (2.6 percent) from 1958 to 1977, as in Table 1; and the slope coefficient from the regression of log employment growth from 1950 to 2000 on rates of work stoppages from 1958 to 1977, as reported in Table 2.

We match this last moment by indirect inference. In particular, we run good-level regressions of log employment growth from 1950 and 2000 on work stoppage rates between 1958 and 1977, and match a value of -0.46, as in the third regression of Table 2. Note that this is the most conservative choice of the four regressions in that the others (that cover the period 1950 to 2000) have larger estimated coefficients, and hence stronger negative links between work stoppages and employment growth. One challenge in comparing the model and actual regressions is that the underlying data on work stoppages are at the firm level, whereas model work stoppages represent outcomes at the state-industry level. In the data, in periods where there is at least one work stoppage at the state-industry level, the average number of firms involved is 3.3 per stoppage. We therefore multiply all our model work stoppages by 3.3 in our model regressions.

The parameters we calibrate, reported in Table 4, are: $\lambda$, the share of goods produced in the Rust Belt; $\sigma_z^2$, the standard deviation of log initial firm productivities across goods; $\alpha$, the linear term in the investment cost function in equation (5); $s$, the fraction of firm profits invested; $\tau_0$, the initial value of the iceberg trade cost; $\delta_\tau$, the annual growth factor of the trade cost; $\zeta_R$, the productivity growth boost in foreign varieties of Rust Belt goods;

Table 3: Targeted Moments in the Model and Data

| Moment | Model | Data |
|---|---|---|
| Initial employment share of Rust Belt | 51.3 | 51.3 |
| Initial variance of state-industry log employment | 3.2 | 3.2 |
| Average labor productivity growth | 2.8 | 2.8 |
| Average investment-to-VA ratio | 15.9 | 16.0 |
| Import share, Rust Belt (1958) | 4.5 | 4.5 |
| Import share, Rust Belt (1990) | 58.7 | 58.6 |
| Imports share, U.S. manufacturing (1990) | 25.5 | 25.8 |
| Labor share of GDP (1950-1980) | 64.0 | 64.0 |
| Rust Belt wage premium (1950-1980) | 12.0 | 12.0 |
| Work stoppage rate in Rust Belt (1958-1977) | 19.2 | 19.2 |
| Work stoppage rate outside Rust Belt (1958-1977) | 2.6 | 2.7 |
| Slope coefficient: log empl. growth on stoppages | -0.49 | -0.46 |

Note: This table reports the twelve moments targeted in the calibration and their values in the calibrated model.

$\phi_R$ and $\phi_S$, the unions' bargaining power at the arbitration stage in the Rust Belt and in the rest of the country; $\sigma_\varepsilon^2$, the variance of the firm productivity shocks, $\varepsilon(i)$; $\sigma$, the elasticity of substitution between goods; and $\rho$, the elasticity of substitution between the home and foreign varieties of each good.

We solve the model assuming that labor conflict is high only before 1979, following the evidence presented above, and Figure 3 in particular. That figure shows that work stoppages averaged 305.5 per year before 1979 and 39.5 after 1985, with a steady decline in between. In other words, rates of work stoppages fell by 87 percent from 1979 to 1985. We model this decline in work stoppages by multiplying $\phi_R$ and $\phi_S$ by a factor 0.71 each year starting in 1979 and ending in 1985, which yields a cumulative decline in bargaining power of 87 percent. We also assume that the foreign productivity growth boost in the foreign Rust Belt, $\zeta$, is present only until 1986. This is consistent with the rise in imports relative to output in the Rust Belt being faster than that of the rest of the country only until 1986 (see Figure 5).

Table 4 reports the values of the parameters that minimize the sum of squared distances between the model moments and their counterparts in the data. Since most are hard to interpret directly, several observations are worth making. First, there is large variation in initial productivity across goods, with a log variance of 1.16. This is required to match

Table 4: Calibrated Parameters

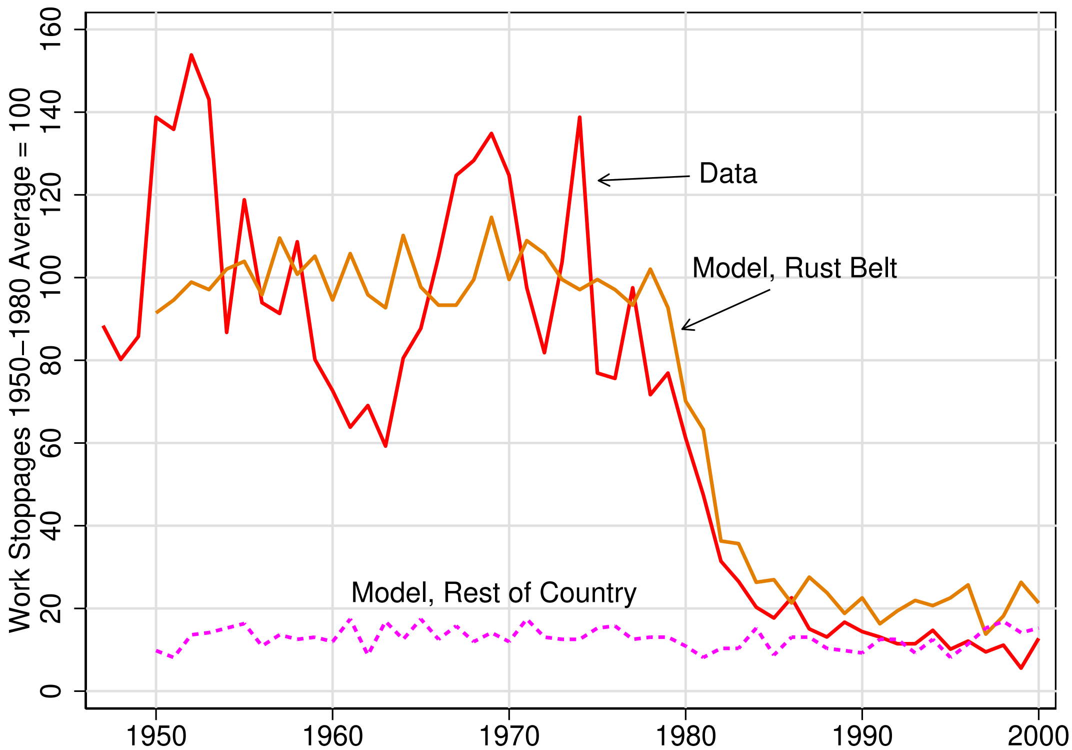
| Parameter | Moment | Value |
|---|---|---|
| $\lambda$ | share of goods produced in Rust Belt | 0.47 |
| $\sigma_z^2$ | variance of initial firm productivities | 1.16 |
| $\alpha$ | linear term in investment cost function | 0.16 |
| $s$ | investment rate | 0.40 |
| $\tau_0$ | initial trade cost | 8.9 |
| $\delta_\tau$ | annual growth factor of trade cost | 0.97 |
| $\zeta_R$ | productivity boost for *Foreign* Rust Belt | 1.03 |
| $\phi_R$ | labor bargaining power in Rust Belt | 0.42 |
| $\phi_S$ | labor bargaining power outside Rust Belt | 0.01 |
| $\sigma_\epsilon^2$ | variance of intra-period productivity shocks | 0.09 |
| $\sigma$ | elasticity of substitution between goods | 2.48 |
| $\rho$ | elasticity of substitution between $H$ and $F$ varieties | 3.12 |

Note: This table reports the twelve parameters in the model and their calibrated values.

the large observed variance in employment shares across state-industry pairs in 1950. Second, initial trade costs are high in 1950 and then fall by around 3 percent per year. This is required to match the low but then rising import shares in manufacturing, as we discuss further below. Third, the exogenous productivity boost for foreign Rust Belt varieties is about 3 percent per year. This is broadly consistent with the relatively high growth rates of GDP in Japan, Germany and other parts of Europe and Asia since the end of World War II (see e.g. Baily, Bosworth, and Doshi, 2020). Finally, labor bargaining power is substantially higher in the Rust Belt than in the rest of the country, with $\phi_R$ = 0.42 and $\phi_S$ = 0.01. This large differential is important because it drives the quantitative importance of the labor conflict channel in the model.

Two parameter values that naturally invite comparison to the previous literature are $\sigma$, the elasticity of substitution between goods, and $\rho$, the elasticity of home and foreign varieties of each good. Our calibrated values of $\sigma$ = 2.48 and $\rho$ = 3.12 are comparable to the range of estimates of Broda and Weinstein (2006), for example, who estimate median elasticities between 2.7 and 3.6, depending on the time period and degree of aggregation. In fact, our estimated elasticities are conservative in the sense that values at the higher end of their range would predict even larger declines of the Rust Belt than our benchmark calibration.

Figure 4: Work Stoppages in Model and Data

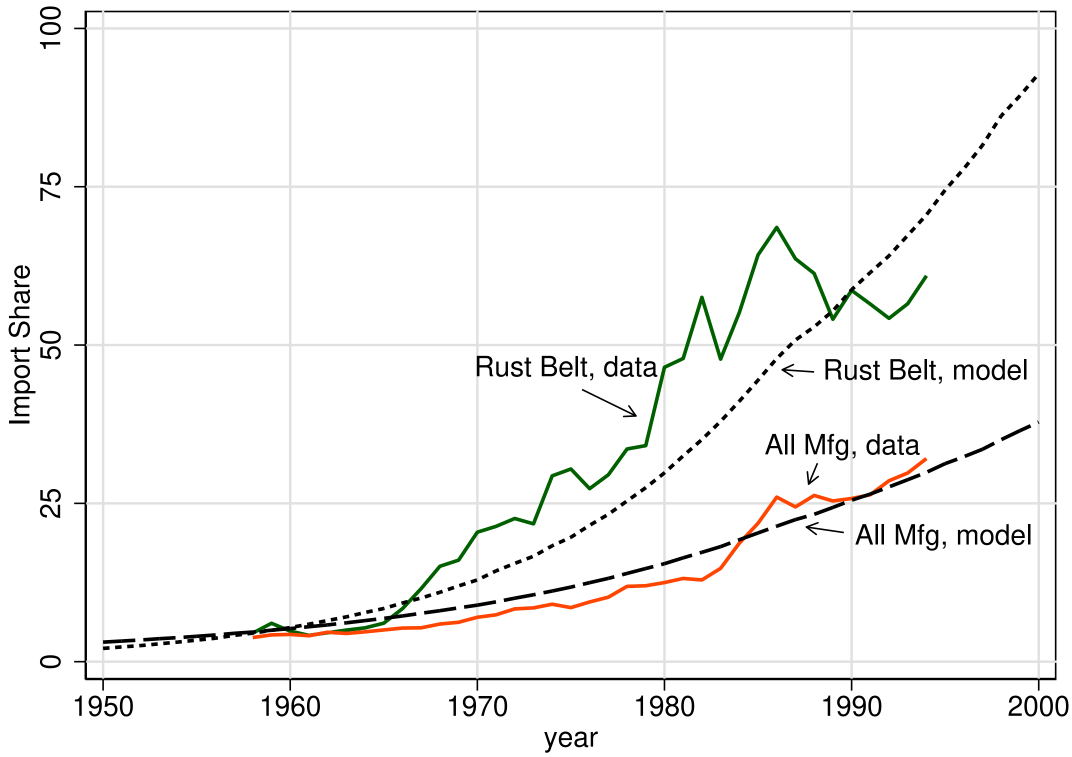



Note: This figure plots major work stoppages in the U.S. economy, using data from the BLS, and work stoppage rates in the model by region. It normalizes work stoppages in the data so that the average in the period 1950 to 1980 is 100, and normalizes work stoppage rates in the model so that the average in the Rust Belt for the period 1950 to 1980 is 100.

Table 3 reports the values of the moments targeted in the calibration in both the model and data. Overall, the model fits the data well, and eight of the twelve moments are matched to within one decimal place. The average difference between model and data moments is well under one percent. The moment with the largest difference between model prediction and data is the slope coefficient, though these are still fairly close, at -0.49 in the model to -0.46 in the data.

To better illustrate the model's consistency with the evidence on labor conflict, Figure 4 plots the model's rate of work stoppages by region, and the total number of work stoppages in the data (from Figure 3). Each is normalized in such a way that the average pre 1980 is equal to 100, since the levels are not directly comparable (the data include strikes in the service sector and public sector, whereas the model includes only manufacturing). As Figure 4 shows, the work stoppage behavior in the model largely mimics the data: both have high average values until 1979, then decline steadily until the mid 1980s and stay low afterwards. We cannot split the aggregate stoppage data by region, but the model

Figure 5: Import Shares: Model and Data




Note: This figure plots import shares in the U.S. manufacturing sector (green line) and in the industries most prevalent in the Rust Belt (red line), plus the model's predictions for each (short and long dashed black lines). Import shares are defined as imports divided by the total value of industry shipments and come from Feenstra (1996).

predicts that virtually all of the decline comes from the Rust Belt. It seems clear that this is the case in the data as well, since the vast majority of all work stoppages before 1980 occurred in the Rust Belt.

Figure 5 displays the import-to-sales ratios in the model and data. The red solid line is the import share for the manufacturing sector as a whole, and the solid green line is the import share for the Rust Belt. The model's calibrated import shares in the model are displayed in Figure 5 as the two dashed lines. Our calibration strategy with respect to imports matches the data fairly well. In particular, the import-to-sales ratios are low through the mid 1960s, and then rise afterwards, particularly in the Rust Belt. The model under-predicts the Rust Belt's import share somewhat until 1990, over-predicts it afterwards, and (by construction) hits the target share in the year 1990.

One moment of interest in many studies of international trade – and not targeted in our calibration strategy – is the elasticity of imports to trade costs. We calculate that a one-percent increase in trade costs in 1950 in our model leads to a decrease in imports of

Table 5: Elasticity of Moments to Parameters

| | $\lambda$ | $\sigma_{z,0}$ | $\alpha$ | $s$ | $\sigma$ | $\phi_R$ | $\sigma_\epsilon$ | $\phi_S$ | $\rho$ |
|---|---|---|---|---|---|---|---|---|---|
| Initial employment share of Rust Belt | **2.1** | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| Initial variance of state-ind. log empl. | 0.0 | **2.1** | 0.0 | 0.0 | 3.0 | 0.0 | 0.0 | 0.0 | 0.3 |
| Average labor productivity growth | -0.1 | 0.5 | **-0.5** | 0.4 | 0.3 | -0.1 | 0.0 | 0.0 | -0.1 |
| Average investment-to-VA ratio | -0.3 | 0.1 | 0.0 | **1.0** | -1.2 | -0.1 | 0.0 | 0.0 | -0.1 |
| Labor share of GDP | 0.3 | 0.0 | 0.0 | 0.0 | 0.4 | 0.1 | 0.0 | 0.0 | 0.0 |
| Rust Belt wage premium | 1.2 | 0.1 | 0.0 | 0.0 | **-3.1** | **1.0** | -0.7 | 0.0 | -0.1 |
| Work stoppage rate in Rust Belt | 0.3 | 0.0 | 0.0 | 0.0 | 0.1 | 0.9 | **1.2** | 0.0 | 0.0 |
| Work stoppage rate outside Rust Belt | -0.7 | 0.0 | 0.0 | 0.0 | 0.4 | 0.0 | 1.1 | **0.2** | 0.0 |
| Regression coeff.: $\Delta$ empl. on conflict | -0.6 | -0.4 | -0.2 | 0.6 | -3.5 | 1.0 | 0.0 | 0.0 | **2.4** |

Note: This table reports the elasticity of each moment to each parameter, calculated from one-percent numerical derivatives of each parameter starting from the calibrated parameter values. The largest elasticity (in absolute value) in each column is printed in bold faced. The largest elasticity (in absolute value) in each row is printed in underline. The table excludes the elasticities of $\tau_0$, $\zeta_R$ and $\delta_\tau$ and the three import-share moments, which are presented in Appendix A.

1.6 percent. This elasticity is well within the (wide) range suggested by the trade literature, and close to the range of estimates in the recent study by Boehm, Levchenko, and Pandalai-Nayar (2020), who report long-run elasticities of around -1.8 to -2.3.

### 5.2. Identification

Given the fairly large number of moments and targets in our calibration, it is useful to provide a systematic analysis of how each parameter is identified from the data. To that end, we compute the elasticity of each moment in the model to each parameter, starting from the calibrated parameter values. This amounts to re-solving the model one additional time for each parameter, each time increasing the value of one parameter by one percent while leaving all other parameters the same. Table 5 reports the values of these elasticities for nine of the twelve parameters and moments in the calibration. For expositional purposes we relegate the trade parameters $\tau_0$, $\delta_\tau$ and $\zeta_R$, and the trade moments, to the Appendix, and we instead discuss those informally here. We print the largest elasticity in each *column* in bold face, to highlight which moments are most sensitive to each parameter, and we underline the largest elasticity in each *row* to illustrate which parameter has the largest effect on each moment.

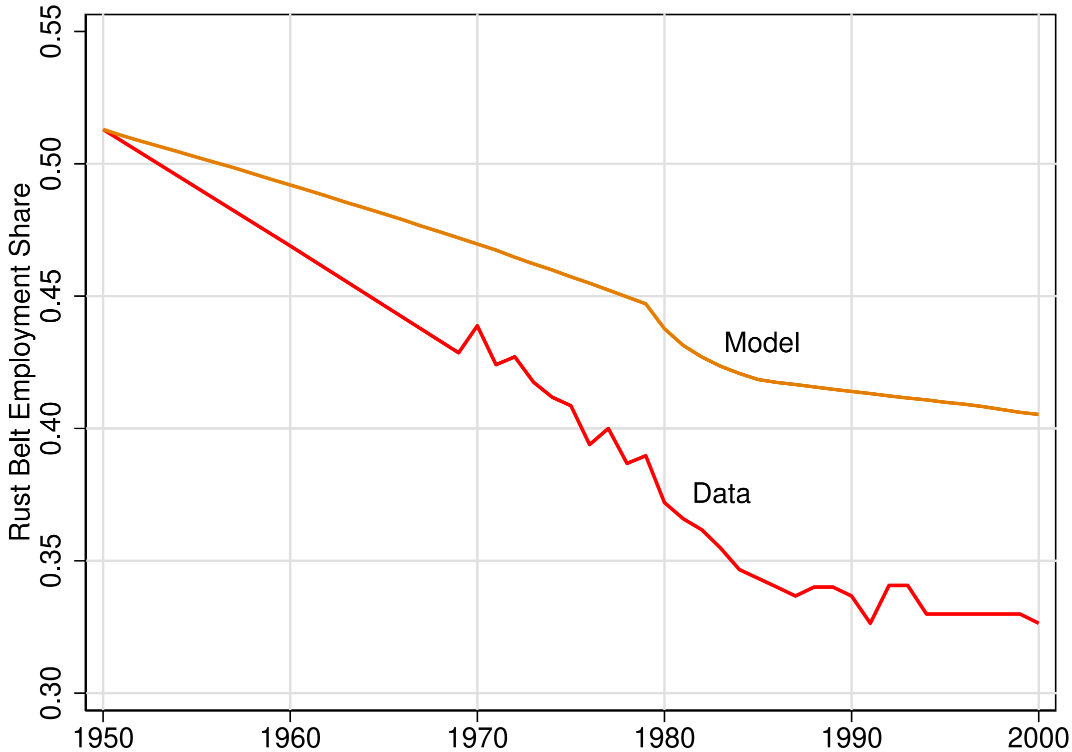
As Table 5 shows, several of the moments and parameters are tightly linked to one another. The Rust Belt's initial employment share is most responsive to $\lambda$, and vice versa. The same is true of the average productivity growth and $\alpha$ (the scale parameter in the investment cost function), and of the work stoppage rate and $\sigma_\epsilon$ (the variance of firm productivity shocks).

In other cases the mapping between parameters and moments is somewhat more intricate. The parameter $\sigma_{z,0}$ most strongly affects the initial variance in employment across goods (i.e. the elasticity of 2.1 in the second row, second column), though this moment also responds strongly to the elasticity of substitution, $\sigma$ (i.e. the elasticity of 3.0 in the second row, fifth column). Similarly, the savings parameter $s$ has the largest effect on the investment-to-VA ratio, though this moment also responds most strongly to $\sigma$. The parameter $\sigma$ also has the largest impact on the labor share of GDP. In fact, this moment responds to little else. Intuitively, this is because $\sigma$ largely controls the average markup in the economy, and hence the economy's non-labor income share.

The labor bargaining parameters, $\phi_R$ and $\phi_S$, have the largest impacts on the Rust Belt wage premium and work stoppage rate in the rest of the country. The former also has a substantial impact on the work stoppage rate in the Rust Belt, and the conflict coefficient in the regression of log employment growth on work stoppage rates. This regression coefficient is informed by several parameters, with the largest responses being to the elasticities of substitution $\sigma$ and $\rho$, and $\phi_R$ also playing an important role. A larger value of $\sigma$ leads to a less negative slope since it reduces the size of the average surplus and hence the scope for conflict. A larger value of $\rho$ leads to a more negative slope since it increases the substitution from home to foreign varieties of Rust Belt goods, and – since trade is balanced – from foreign to home varieties of goods made in the rest of the country. A higher $\phi_R$ raises rates of conflict and wage premia in the Rust Belt, which results in a larger negative impact of conflict on employment.

The trade parameters have intuitive mappings to the data (see Appendix Table E.1). Changes in $\tau_0$, the initial trade cost, have the largest impact on the 1958 import share in the Rust Belt. Naturally, $\tau_0$ also affects import shares in later years in both regions. Changes in $\zeta_R$, the productivity boost for foreign varieties of Rust Belt goods, have the largest impact on the 1990 import share in the Rust Belt. The parameter $\delta_\tau$, which governs the annual decline in trade costs, also has the largest impact on the Rust Belt's import share in 1990, though it also has a substantial impact on the manufacturing sector's import share in 1990.

Figure 6: Rust Belt's Decline: Model vs Data



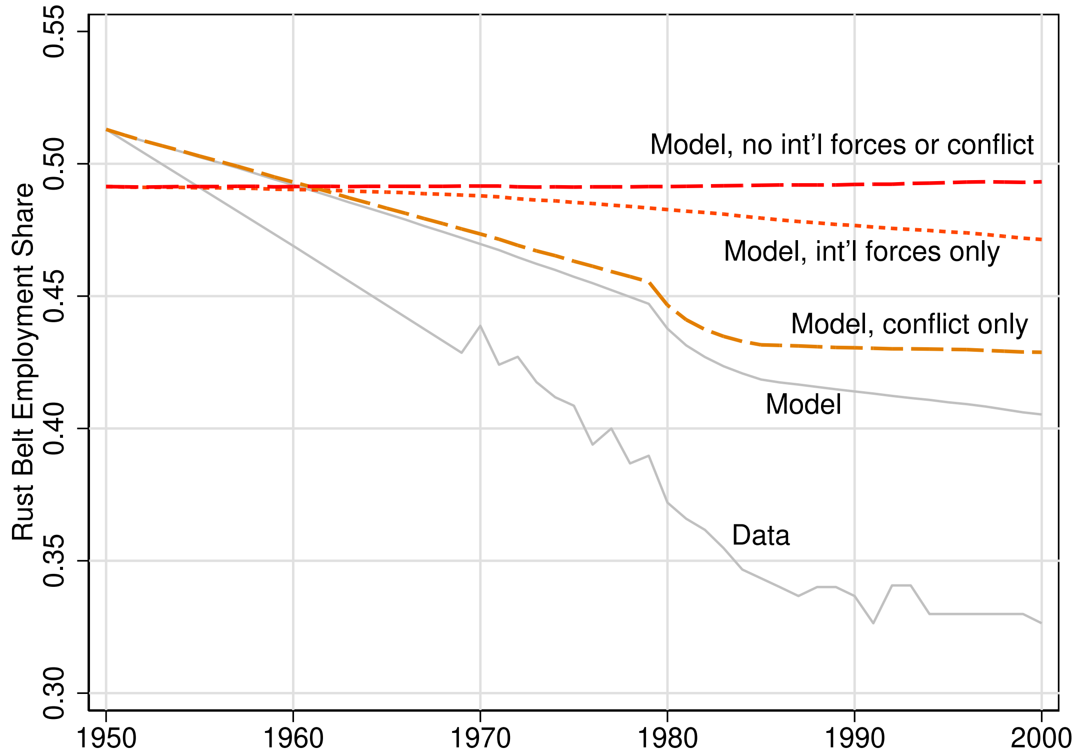

Note: This figure plots the share of U.S. manufacturing employment located in the Rust Belt (solid red line) and the model's prediction for this share (solid orange line).

### 5.3. Model's Predictions for Rust Belt's Decline

The model's main prediction of interest, which is not targeted in any way, is the path of the Rust Belt's share of manufacturing employment from 1950 to 2000. Figure 6 plots the model's prediction for this share (orange line) and its empirical counterpart (red line). Like the data, the model predicts a large secular decline of the Rust Belt's employment share. For the entire time period, the model predicts a drop of 10.8 percentage points, compared to 18.3 percentage points in the data. Thus, the model accounts for 58.9 percent of the overall decline in the data.

The model is also largely consistent with the timing of the Rust Belt's decline. Both in the model and data, the decline is steeper before the mid 1980s than afterwards. The model predicts a drop of 9.5 percentage points until 1985, compared to 16 percentage points in the data. From 1986 on, the model generates an additional decline of around one percentage point, compared to two percentage points in the data. The productivity growth rate in the model is 0.2 percentage points lower per year on average in the Rust

Figure 7: Decomposing the Rust Belt's Decline




Note: This figure plots the Rust Belt's share of U.S. manufacturing employment under three counterfactual simulations of the model. The first, labelled "Model, conflict only," has labor conflict but no international forces, meaning $\zeta_R$ is set to one (long dashed orange line). The second, labelled "Model, int'l forces only," has international forces but no labor conflict, meaning $\phi_R$ is set to $\phi_S$ (short dashed orange-red line). The third, "Model, no int'l forces or conflict" sets $\zeta_R$ to one and sets $\phi_R$ to $\phi_S$ (dashed red line). The data and benchmark model's predictions are plotted as grey lines.

Belt before 1985. Afterward, productivity growth rates are nearly identical in the two regions. As we argue further below, the lower productivity growth rates in the Rust Belt before 1985 are qualitatively consistent industry productivity data.

To better understand the reasons behind the Rust Belt's decline, we conduct three counterfactual simulations. In the first, we leave only the labor conflict channel, and shut off any changes in international comparative advantage that could have reduced the Rust Belt's share of employment within the United States. To do so we re-solve the model setting $\zeta_R$, the productivity boost for the foreign Rust Belt, to one (meaning no productivity boost each period). Thus, any resulting decline in the Rust Belt from this counterfactual is driven by the difference between $\phi_R$ and $\phi_S$, which leads to higher rates of work stoppages and wage premia in the model's Rust Belt, and hence lower rates of investment and productivity growth.

The dashed red line in Figure 7, marked "Model, conflict only," plots the Rust Belt's employment share under this counterfactual. From conflict alone, the model predicts that the Rust Belt's share of employment would have declined by 8.4 percentage points. This amounts to 46 percent of the overall decline in the data. Virtually all of the decline occurs before the 1980s, which is again consistent with the timing of the decline in the data. As a frame of reference, the figure also re-produces the predictions from the main calibration. As one can see from the figure, the model with only labor conflict does nearly as well as the full model in explaining the Rust Belt's decline.

The second counterfactual simulation adds back the rise in foreign comparative advantage but shuts down the differential in labor-market conflict. That is, this counterfactual sets $\phi_R = \phi_S$ = 0.01, but returns $\zeta_R$ to its value of 1.03 in the main calibration. This counterfactual is plotted as the short-dashed purple line in Figure 7 labeled "Model, int'l forces only." Three features of this counterfactual are noteworthy. First, the initial employment share of the Rust Belt is now lower than in the main calibration. This is due to decreased demand for labor by firms in the Rust Belt now that strikes are largely eliminated. When strikes are more likely, firms prefer larger workforces to avoid costly lost production if a strike actually occurs. The second noteworthy feature of this counterfactual is that the Rust Belt's decline is modest in magnitude. The model's employment share drops by just 2 percentage points from 1950 to 2000, amounting to only 11 percent of the decline observed in the data. Finally, the timing of the decline under only international forces is inconsistent with the data: most of the decline in this counterfactual happens after the mid 1970s, whereas most of the decline in the data materializes before that time. This is simply because most of the rise in import shares occurred after the mid 1970s in the data.[8]

All in all, this counterfactual suggests that international forces are unlikely to explain much of the Rust Belt's decline. Neither the timing nor magnitudes of the changes in foreign comparative advantage suggest that the Rust Belt was mostly a victim of global changes outside their control. International forces may play a supporting role in understanding why the Rust Belt's recovery was not faster in the later part of the period. Yet for the first three decades after the end of World War II – where outflows from the Rust Belt were most acute – international trade was more of a footnote than a headline factor in accounting for the region's decline.

[8] Autor, Dorn, and Hanson (2013a) document that regions in U.S. industries that were more exposed to imports from China since 1990 experienced substantially worse labor market outcomes relative to other regions. Since imports from China were only 2 percent in 1990 and negligible before that, imports from China are quite unlikely to have played an important role in the Rust Belt's decline from 1950 to 1990. Furthermore, most of the affected regions were located outside the Rust Belt (see Autor, Dorn, and Hanson, 2013b, Figure 1B).

The third counterfactual shuts down both labor market conflict and the rise in comparative advantage for foreign producers of varieties of Rust Belt goods. We do this by setting $\phi_R = \phi_S$ = 0.01 and $\zeta_R$ = 1. All other parameter values are kept unchanged. The result is depicted as the dashed orange line on Figure 7 labeled "No int'l forces or labor conflict." In this counterfactual, the Rust Belt's share of employment stays roughly constant from 1950 to 2000, rising 0.2 percent. The implication is that the Rust Belt's share of employment would not have changed much on its own without these two forces. In reality, other factors could certainly have affected the Rust Belt's share of economic activity; the point here is that the model is not hardwired to deliver declines in the Rust Belt for reasons other than conflict and international changes in comparative advantage.

One noteworthy prediction of the last two counterfactuals is that *aggregate* labor productivity growth would have been higher in the absence of labor conflict in the Rust Belt. In the benchmark calibration, productivity growth for the average manufacturing firm is 2.8 percent. When labor conflict is shut off, average productivity growth rises to 3.0 percent. Cumulatively, average manufacturing productivity would have been 8.6 percent higher in 2000 had labor conflict been the same low level in the Rust Belt as in the rest of the country. Thus, the Rust Belt's economic conditions didn't just reallocate economic activity from one region to another, but resulted in lower long-run levels of aggregate productivity.

### 5.4. Sensitivity Analysis

To better understand how sensitive the quantitative results are to other model features, we re-calibrate the model under several alternative assumptions. These sensitivity analyses are summarized in Table 6. The first row of the table reproduces the predicted decline of the model Rust Belt in the benchmark calibration, and the percent of the data explained by the model. The second row presents the same numbers when we re-calibrate the model to match a lower strike duration of 38 days rather than the 43.8 days, which is about half a standard deviation lower than the average in Kennan (1986)'s strike data. To do so, we re-calibrate the model with $\kappa$ = 0.105 rather than $\kappa$ = 0.12. In this calibration, the model predicts a 9.7 percentage-point decline in the Rust Belt's manufacturing employment share, or 53.1 percent of the data. This is lower than the 58.9 percent in the benchmark calibration, which highlights how the model's quantitative predictions are sensitive to the duration of work stoppages that result from labor conflict.

The second alternative calibration adds a modest secular time trend in the firm investment rate, which is observed in the data (see Appendix Figure E.1). The benchmark cali-

Table 6: Sensitivity Analysis

| | Change in Rust Belt's Employment Share | Percent of Data Explained |
|---|---|---|
| Benchmark calibration | -10.8 | 58.9 |
| Lower strike duration ($\kappa = 0.105$) | -9.7 | 53.1 |
| Time trend in investment rate | -10.3 | 56.0 |
| Alternative cost function ($\rho$ in place of $\sigma$) | -10.1 | 55.2 |
| Additional decade of conflict | -12.5 | 68.2 |

Note: This table reports the decline in the Rust Belt's share of U.S. manufacturing employment under alternative parameterizations of the model.

bration assumes a constant investment rate of 16 percent over the entire period, whereas investment rises from an average of 13.6 as a percent of value added in the 1950s to 17.4 percent in the 1990s. Here we calibrate the model to match all the moments in the benchmark calibration plus the secular rise in investment observed in the data. This leads to a fairly small change in most parameters, and a fairly small change in the model's predicted decline of the Rust Belt, to 10.3 percentage points, or 56 percent of the actual decline. The gradual increase in investment rates observed in the data thus has only a modest impact on our results.

The third alternative calibration considers a variation of the investment cost function, namely:

$$C(x_t(i), z_t(i), \mathcal{Z}_t) = \frac{\alpha x_t(i)^2 z_t(i)^{\rho-1}}{\mathcal{Z}_t^{\rho-1}}, \tag{23}$$

which substitutes $\rho - 1$ for $\sigma - 1$ as the power on firm productivity (in the numerator) and the weighted average of all firms' productivity (in the denominator) in the cost function used in the benchmark calibration. The rationale for the original specification is that it leads to balanced growth when the economy is closed and there is no labor conflict. As the economy becomes more open and firms are competing more with their foreign counterparts, the "effective" substitution elasticity shifts from $\sigma$ toward $\rho$. To account for this effect, we re-calibrate the model using this alternative specification of the cost function. We find that re-calibrating the model with this alternative cost function results in little difference in practice on either the behavior of the model's growth rates or its predictions for the Rust Belt's decline. The re-calibrated model predicts a 10.1 percentage point decline in the Rust Belt, which is 55.2 percent of the actual value, and only modestly lower than the 58.9 percent explained in the benchmark calibration.

In the final sensitivity analysis we add an additional decade of conflict. We consider this scenario because even though rates of conflict began declining in 1979, the wage premia paid in the Rust Belt were still substantial in 1990 (see Figure 2). If we were to calibrate our model to match the decline in the wage premium, rather than the decline in work stoppage rates, this would suggest around an extra decade of labor conflict in our model. In this scenario, our model predicts a decline of 12.5 percentage points in the Rust Belt, which amounts to 68.2 percent of the region's actual decline. The point here is that the model's main calibration may be somewhat conservative in its assumptions about when the effects of labor conflict actually subsided.

### 5.5. Extension with Services

A natural extension to our model is to include a service sector. The benchmark calibration ignored the service sector and assumed that the entire economy was based on manufacturing. Clearly this is false, though: the U.S. service sector grew in secular fashion from about 70 percent of the workforce in 1950 to almost 90 percent by 2000. This begs the question: to what extent would the model's quantitative conclusions change if it were to include a service sector in addition to manufacturing?

To help answer this question, consider a simple extension of the model that includes both manufacturing and service sectors, with structural change from the former to the latter over time. Let there be a representative firm that produces final goods in region $j$ from tradable manufactured goods and non-tradable services. Let the final-goods production technology in region $j$ be:

$$Y^j = \left(\mu^{\frac{1}{\theta}} {Y_m^j}^{\frac{\theta-1}{\theta}} + (1-\mu)^{\frac{1}{\theta}} {Y_n^j}^{\frac{\theta-1}{\theta}}\right)^{\frac{\theta}{\theta-1}}, \tag{24}$$

where $Y_m^j$ and $Y_n^j$ denote the amount of manufacturing goods and services used to produce the final good, $\theta$ denotes the elasticity of substitution between the manufactured good and local service, and $\mu$ is a weight parameter on manufacturing. Let the non-tradable services be produced by a representative firm in each region with the linear technology $Y_n^j = z_n^j l_n^j$, where $z_n^j$ is the labor productivity of services in region $j$, and $l_n^j$ is the amount of labor employed in region $j$ for services production.

The literature on structural change has largely agreed that the elasticity of substitution between manufactured goods and services, $\theta$, is close to zero (see e.g. Herrendorf, Rogerson, and Valentinyi, 2014; Garcia-Santana, Pijoan-Mas, and Villacorta, 2016). In our model, this would mean that $Y_m$ and $Y_n$ are strong complements. As a result, when manufacturing activity moves out of a region, there would little scope for consumers to simply substitute to services. Instead, service activity would move out of the region almost one-for-one with manufacturing activity. This suggests that adding a service sector will be unlikely to change the model's quantitative predictions for the Rust Belt's decline. Indeed, this is consistent with what we found in a previous version of the current model that explicitly featured a service sector (Alder, Lagakos, and Ohanian, 2017). For this reason we prefer to abstract away from a service sector in the quantitative model.

## 6. Supporting Evidence

In this section we provide additional supporting evidence for the model's prediction that investment and productivity growth rates were lower in Rust Belt industries. We first examine labor productivity growth rates in U.S. manufacturing industries, and find that industries predominantly located in the Rust Belt had lower than average productivity growth on average. We also find that the growth differentials were largest in the period before the mid 1980s, when labor conflict was most predominant. Second, we present historical industry evidence on technology adoption. This evidence points to lower rates of adoption for key technologies in the Rust Belt.

### 6.1. Low Productivity Growth in Rust Belt Manufacturing Industries

We begin by examining labor productivity growth patterns for U.S. manufacturing industries. The main challenge we face is that direct measures of productivity growth by region are not available for many industries. Therefore, our approach is to focus on measures of productivity growth in a broad set of industries by matching productivity data by industry to census data containing the geographic location of employment for each industry. This allows us to compare productivity growth in the industries most common in the Rust Belt to other industries.

To identify which industries are predominantly located in the Rust Belt, we match NBER industries (by SIC codes) to those in the IPUMS census data (by census industry codes). In each industry, we then compute the fraction of employment located in the Rust Belt. We define "Rust Belt industries" to be those whose employment share in the Rust Belt is more than one standard deviation above the mean. In practice, this turns out to be a cutoff of at least 68 percent of industry employment located in the Rust Belt.

Table 7 reports productivity growth rates for the Rust Belt industries and their average over time. Productivity growth is measured as the growth in real value added per worker,

Table 7: Labor Productivity Growth in Rust Belt Industries

| | Annualized Growth Rate, % | | |
|---|---|---|---|
| | 1958-1985 | 1985-1997 | 1958-1997 |
| Blast furnaces, steelworks, mills | 0.9 | 7.6 | 2.8 |
| Engines and turbines | 2.3 | 2.9 | 2.5 |
| Iron and steel foundries | 1.5 | 2.3 | 1.7 |
| Metal forgings and stampings | 1.5 | 2.8 | 1.9 |
| Metalworking machinery | 0.9 | 3.5 | 1.6 |
| Motor vehicles and motor vehicle equipment | 2.5 | 3.8 | 2.9 |
| Photographic equipment and supplies | 4.7 | 5.1 | 4.9 |
| Railroad locomotives and equipment | 1.6 | 3.1 | 2.0 |
| Screw machine products | 1.2 | 1.1 | 1.2 |
| Rust Belt weighted average | 2.0 | 4.2 | 2.6 |
| Manufacturing weighted average | 2.6 | 3.2 | 2.8 |

Note: Rust Belt Industries are defined as industries whose employment shares in the Rust Belt region in 1975 are more than one standard deviation above the mean of all industries. Labor Productivity Growth is measured as the growth rate of real value added per worker. Rust Belt weighted average is the employment-weighted average productivity growth rate for Rust Belt industries. Manufacturing weighted average is the employment-weighted average productivity growth across all manufacturing industries. Source: Authors' calculations using NBER CES productivity database, U.S. census data from IPUMS, and the BLS.

using industry-level price indices as deflators. The first data column reports productivity growth in each industry, and the Rust Belt weighted average, for the period 1958 to 1985. On average, productivity growth rates were 2.0 percent per year in Rust Belt industries and 2.6 percent in all manufacturing industries. Productivity growth rates in the Rust Belt were much higher between 1985 and 1997 than before, averaging 4.2 percent per year, compared to 3.2 percent for all manufacturing industries. For the whole period, the Rust Belt industries had slightly lower productivity growth (2.6 percent) than all manufacturing industries (2.8 percent).

Productivity growth in Rust Belt industries picked up after 1985. In the largest single Rust Belt industry, blast furnaces & steel mills, productivity growth averaged just 0.9 percent per year before 1985 but rose substantially to an average of 7.6 percent per year after 1985. Large productivity gains after 1985 are also present in all but one of the nine industries most common in the Rust Belt. We also find that investment rates increased substantially in most Rust Belt industries after 1985, rising from an average of 4.8 percent to 7.7 percent per year.

One potential limitation of the productivity measures of Table 7 is that they do not directly measure productivity by region. However, these productivity patterns are consistent with a study that does measure productivity by region directly, using plant-level data. For the steel industry, Collard-Wexler and De Loecker (2015) measure labor productivity growth and 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 1963 to 1982 and, in fact, negative for much of the period. In contrast, they report robust TFP growth post-1982 in the vertically integrated mills: TFP improved by 11 percent from 1982 to 1987 and by 16 percent between 1992 and 1997.

### 6.2. Low Rates of Technology Adoption in the Rust Belt

Numerous types of historical evidence corroborate the model's prediction that rates of productivity-enhancing investment were particularly low in the Rust Belt. 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. 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. Even though U.S. steel producers had ample opportunity to adopt these technologies, they nonetheless were laggards in adopting them (Adams and Brock, 1995; Adams and Dirlam, 1966; Lynn, 1981; Oster, 1982; Tiffany, 1988; Warren, 2001). 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." In continuous casting, adoption rates lagged as well. Only 15 percent of U.S. steel capacity by 1978 involved continuous casting, compared to 51 percent in Japan, 41 percent in Italy, 38 percent in Germany, and 28 percent in France.

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

> Inadequate capital formation in any industry produces meager gains in productivity, upward pressure on prices, sluggish job creation, and faltering eco-

> nomic 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 though Michelin drastically increased its U.S. market share during that time. In auto manufacturing, the sluggish rate of technology adoption is widely acknowledged by industry historians and insiders, such as Adams and Brock (1995), Ingrassia (2011) and Vlasic (2011).[9]

## 7. Conclusion

This paper develops a quantitative aggregate theory of the Rust Belt's decline, with a focus on four observations: (1) the conflicted relations between Rust Belt firms and workers, featuring high rates of work stoppages; (2) the Rust Belt's significant wage premium; (3) the negative correlation between work stoppages and employment growth at the U.S. state-industry level; and (4) the shift in all of these patterns during the 1980s, when the region's decline slowed, and its wage premium and rate of work stoppages fell sharply.

In summary, our theory is that the Rust Belt's decline was driven by labor market conflict that manifested itself in strikes and wage premia and reduced investment in the region's main industries. This lack of investment led to the movement of manufacturing employment out of the Rust Belt and into the rest of the country. Following several legal

[9] A related type of evidence comes from expenditures on research and development (R&D). Though many of the investments in new technologies made by U.S. manufacturers over this period would not have been newly developed by the firms themselves, but rather purchased from a third party. Still, 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.

and political shifts that substantially reduced union bargaining power in the 1980s, labor conflict declined, leading to higher rates of investment and productivity growth and the region's stabilization, albeit at a much lower level than before. Our analysis indicates that these losses were in large part self-inflicted by management and union leaders who were not able to create more cooperative relationships until more recently, much as unions and management in other parts of the United States and Europe have been able to do more successfully.

Why were union-management negotiations so inefficient in the Rust Belt, with the failure to be more cooperative ultimately decimating economic activity in the region? A large literature has concluded that the remarkably violent unionizations of the Rust Belt's main industries in the late 1930s and early 1940s, in which many workers died, created an environment of dislike and mistrust that persisted for decades (see Strohmeyer, 1986; Hoerr, 1988). This view is summarized clearly by former United Auto Workers (UAW) President Robert King, who stated "The 20th-century UAW fell into a pattern with our employers where we saw each other as adversaries rather than partners. Mistrust became embedded in our relations (...) [and this] hindered the full use of the talents of our members and promoted a litigious and time-consuming grievance culture" (Walsh, 2010).

Had King's predecessors – and the predecessors of the management teams in the Rust Belt – been more cooperative, the location of workers, capital, and production across the United States might have been quite different today. Future research should focus more on why it took much of the region's undoing for workers and firms to establish more cooperative relationships. Future research should also explore other theories of this enormous reallocation, accounting for why the decline began when it did, why it lasted so long, and why the Rust Belt ultimately stabilized.

## References

ACIKGOZ, O. T., AND B. KAYMAK (2014): "The Rising Skill Premium and Deunionization," *Journal of Monetary Economics*, 63, 37–50.

ADAMS, W., AND J. BROCK (eds.) (1995): *The Structure of American Industry*. Prentice-Hall, Inc.

ADAMS, W., AND J. B. DIRLAM (1966): "Big Steel, Invention, and Innovation," *Quarterly Journal of Economics*, 80(2), 167–189.

AGHION, P., N. BLOOM, R. BLUNDELL, R. GRIFFITH, AND P. HOWITT (2005): "Competition and Innovation: An Inverted U Relationship," *Quarterly Journal of Economics*, 120(2), 701–728.

ALDER, S. D., D. LAGAKOS, AND L. E. OHANIAN (2017): "Labor Market Conflict and the Decline of the Rust Belt," NBER Working Paper 20538.

AMERICAN IRON AND STEEL INSTITUTE (1980): "Steel at the Crossroads: The American Steel Industry in the 1980s," .

ATKESON, A., AND A. BURSTEIN (2008): "Pricing-to-Market, Trade Costs, and International Relative Prices," *American Economic Review*, 98(5), 1998–2031.

AUTOR, D. H., D. DORN, AND G. H. HANSON (2013a): "The China Syndrome: Local Labor Market Effects of Import Competition in the United States," *American Economic Review*, 103(6), 2121–2168.

——— (2013b): "The Geography of Trade and Technology Shocks in the United States," *American Economic Review: Papers & Proceedings*, 103(3), 1–8.

BAILY, M. N., B. BOSWORTH, AND S. DOSHI (2020): "Productivity Comparisons: Lessons from Japan, the United States, and Germany," Economic Studies of Brookings.

BARNARD, J. (2004): *American Vanguard: The United Auto Workers During the Reuther Years, 1935-1970*. Oxford University Press, Detroit, MI.

BEIK, M. (2005): *Labor Relations*. Greenwood Press, Westport, CN.

BLANCHARD, O., AND L. KATZ (1992): "Regional Evolutions," *Brookings Papers on Economic Activity*, 1992(1).

BLANCHARD, O., AND L. SUMMERS (1986): "Hysteresis and the European Unemployment Problem," *NBER Macroeconomics Annual*, pp. 15–77.

BOEHM, C., A. A. LEVCHENKO, AND N. PANDALAI-NAYAR (2020): "The Long and Short (Run) of Trade Elasticities," NBER Working Paper No. w27064.

BORJAS, G. J., AND V. A. RAMEY (1995): "Wage Inequality and Trade," *Quarterly Journal of Economics*, 110, 1075–1110.

BRIDGMAN, B. (2015): "Competition, Work Rules and Productivity," *Journal of Economic Dynamics and Control*, 52, 136–149.

BRODA, C., AND D. WEINSTEIN (2006): "Globalization and the Gains from Variety," *Quarterly Journal of Economics*, 121(2).

BUERA, F. J., AND J. P. KABOSKI (2009): "Can Traditional Theories of Structural Change Fit the Data?," *Journal of the European Economic Association*, 7(2-3), 469–477.

——— (2012): "The Rise of the Service Economy," *American Economic Review*, 102(6), 2540–69.

CLARK, J. P. (1985): *The Competitive Status of the U.S. Steel Industry: A Study of the Influences of Technology in Determining International Industrial Competitive Advantage*. National Academy Press, Washington, D.C.

CLARK, K. B. (1982): *The Competitive Status of the U.S. Auto Industry: A Study of the Influences of Technology in Determining International Industrial Competitive Advantage*. National Academy Press, Washington, D.C.

CLOUD, D. L. (2011): *We are the Union: Democratic Unionism and Dissent at Boeing*. University of Illinois Press, Champaign, IL.

COLE, H. L., AND L. E. OHANIAN (2004): "New Deal Policies and the Persistence of the Great Depression: A General Equilibrium Analysis," *Journal of Political Economy*, 112(4), 779–816.

COLE, H. L., L. E. OHANIAN, A. RIASCOS, AND J. A. SCHMITZ JR. (2005): "Latin America in the Rearview Mirror," *Journal of Monetary Economics*, 52(1), 69–107.

COLLARD-WEXLER, A., AND J. DE LOECKER (2015): "Reallocation and Technology: Evidence from the U.S. Steel Industry," *American Economic Review*, 105(1), 131–171.

CRAMTON, P. C., AND J. S. TRACY (1992): "Strikes and Holdouts in Wage Bargaining: Theory and Data," *American Economic Review*, 82(1), 100–121.

——— (1998): "The Use of Replacement Workers in Union Contract Negotiations: The U.S. Experience, 1980-1989," *Journal of Labor Economics*, 16(4), 667–701.

DESMET, K., AND E. ROSSI-HANSBERG (2009): "Spatial Growth and Industry Age," *Journal of Economic Theory*, 144, 2477?2502.

DICKENS, W. T., AND K. LANG (1985): "A Test of Dual Labor Market Theory," *Review of Economics and Statistics*, 75(4), 792–805.

——— (1988): "Labor Market Segmentation and the Union Wage Premium," *Review of Economics and Statistics*, 70(3), 527–530.

DINLERSOZ, E., AND J. GREENWOOD (2016): "The Rise and Fall of Unions in the United States," *Journal of Monetary Economics*, 83, 129–146.

DURANTON, G., AND D. PUGA (2009): "From Sectoral to Functional Urban Specialisation," *Journal of Urban Economics*, 57(2), 343–370.

EDMOND, C., V. MIDRIGAN, AND D. Y. XU (2015): "Competition, Markups, and the Gains from International Trade," *American Economic Review*, 105(10), 3183–3221.

ELSBY, M. W., B. HOBIJN, AND A. ŞAHIN (2013): "The Decline of the U.S. Labor Share," *Brookings Papers on Economic Activity*, 2, 1–63.

FARBER, H. S. (1986): "The Analysis of Union Behavior," in *Handbook of Labor Economics*, ed. by O. Ashenfelter, and D. Card., vol. 2, chap. 35.

FEENSTRA, R. C. (1996): "NBER Trade Database, Disk1: U.S. Imports, 1972-1994: Data and Concordances," NBER Working Paper no. 5515.

FEYRER, J., B. SACERDOTE, AND A. D. STERN (2007): "Did the Rust Belt Become Shiny? A Study of Cities and Counties That Lost Steel and Auto Jobs in the 1980s," *Brookings-Wharton Papers on Urban Affairs*, pp. 41–102.

FRENCH, M. J. (1991): *The U.S. Tire Industry*. Twayne Publishers, Boston.

GARCIA-SANTANA, M., J. PIJOAN-MAS, AND L. VILLACORTA (2016): "Investment Demand and Structural Change," CEPR Working Paper 11636.

GLAESER, E. L., AND G. A. PONZETTO (2007): "Did the Death of Distance Hurt Detroit and Help New York?," in *Agglomeration Economics*, ed. by E. L. Glaeser, chap. 10. University of Chicago Press, Chicago.

HERRENDORF, B., R. ROGERSON, AND A. VALENTINYI (2014): "Growth and Structural Transformation," in *Handbook of Economic Growth*, ed. by P. Aghion, and S. N. Durlauf, vol. 2B. Elsevier.

HINSHAW, J. H. (2002): *Steel and Steelworkers: Race and Class Struggle in 20th Century Pittsburgh*. State University of New York Press, Albany, NY.

HOERR, J. (1988): *And the Wolf Finally Came*. University of Pittsburgh Press, Pittsburgh, PA.

HOLMES, T. J. (1998): "The Effect of State Policies on the Location of Manufacturing: Evidence from State Borders," *Journal of Political Economy*, 106(4), 667–705.

HOLMES, T. J., AND J. A. SCHMITZ (2010): "Competition and Productivity: A Review of Evidence," *Annual Review of Economics*, 2, 619–642.

INGRASSIA, P. (2011): *Crash Course*. Random House, New York.

KATZ, H. C. (1985): *Shifting Gears: Changing Labor Relations in the U.S. Automobile Industry*. MIT Press, Cambridge, MA.

KENNAN, J. (1986): "The Economics of Strikes," in *Handbook of Labor Economics*, ed. by O. Ashenfelter, and R. Layard, pp. 1091–1137. North-Holland.

KENNEDY, D. (1999): *Freedom from Fear*. Oxford University Press, New York, NY.

KOCHAN, T. A., H. C. KATZ, AND R. B. MCKERSIE (1994): *The Transformation of American Industrial Relations*. ILR-Cornell University Press, Ithaca, NY.

KUHN, J. W. (1961): *Bargaining in Grievance Settlement: The Power of Industrial Work Groups*. Columbia University Press, New York, NY.

KUPFBERG, S. (1999): "Civil Rights Law and Breaking Down Patterns of Segregation: The Case of Nepotism," *Hofstra Labor and Employment Law Journal*, 16(2), 792–805.

LINDBECK, A., AND D. J. SNOWER (1988): *The Insider-Outsider Theory of Employment and Unemployment*. MIT Press, Cambridge, MA.

LODGE, G. (1986): *The American Disease*. NYU Press, New York, NY.

LYNN, L. (1981): "New Data on the Diffusion of the Basic Oxygen Furnace in the U.S. and Japan," *Journal of Industrial Economics*, 30(123-135).

MCCARTIN, J. (1986): *Ronald Reagan, the Air Traffic Controllers, and the Strike that Changed America*. Oxford University Press, New York, NY.

MEIER, A., AND E. RUDWICK (1979): *Black Detroit and the Rise of the UAW*. Oxford University Press.

MEYER, S. (2004): "An Economic Frankenstein: UAW Workers Response to Automation at the Ford Brook Park Plant in the 1950s," in *Automobile in American Life and Society*, ed. by C. R. Hulten. University of Michigan Press, Dearborn, MI, Case Study Number 4.

MILLIS, H., AND E. C. BROWN (1950): *From the Wagner Act to Taft-Hartley: A Study of National Labor Policy and Labor Relations*. University of Chicago Press, Chicago, IL.

NELSON, D. (1996): "The Political Economy of U.S. Automobile Protection," in *The Political Economy of American Trade Policy*, ed. by A. O. Kreuger. University of Chicago Press, Chicago, IL.

NGAI, R. L., AND C. A. PISSARIDES (2007): "Structural Change in a Multisector Model of Growth," *American Economic Review*, 97(1).

OSTER, S. (1982): "The Diffusion of Innovation among Steel Firms: The Basic Oxygen Furnace," *Bell Journal of Economics*, 13(1), 45–56.

PAVCNIK, N. (2002): "Trade Liberalization, Exit and Productivity Improvement: Evidence from Chilean Plants," *Review of Economic Studies*, 69(1), 245–276.

PETERS, M. (2020): "Heterogeneous Mark-Ups, Growth and Endogenous Misallocation," *Econometrica*, 88(5), 2037–2073.

RAJAN, R. G., P. VOLPIN, AND L. ZINGALES (2000): "The Eclipse of the U.S. Tire Industry," in *Mergers and Productivity*, ed. by S. N. Kaplan, pp. 51–92. University of Chicago Press.

RAPPAPORT, J. (2007): "Moving to Nice Weather," *Regional Science and Urban Economics*, 37, 375–398.

RICHTER, I. (2003): *Labor's Struggles, 1945-150: A Participant's View*. Cambridge University Press.

ROSE, J. D. (1998): "The Struggle over Management Rights at US Steel, 1946-1960: A Reassessment of Section 2-B of the Collective Bargaining Contract," *Business History Review*, 72(3), 446–477.

RUGGLES, S. J., T. ALEXANDER, K. GENADEK, R. GOEKEN, M. SCHROEDER, AND M. SOBEK (2010): "Integrated Public Use Microdata Series: Version 5.0," [Machine-readable database]. Minneapolis: University of Minnesota.

SCHMITZ, J. A. (2005): "What Determines Productivity? Lessons from the Dramatic Recovery of the U.S. and Canadian Iron Ore Industries Following Their Early 1980s Crisis," *Journal of Political Economy*, 113(3), 582–625.

SERRIN, W. (1973): *The Company and the Union*. Alfred A. Knopf, New York, NY.

STEIGERWALD, D. (2010): "Walter Reuther, the UAW, and the Dilemmas of Automation," *Journal of Labor History*, 51(3), 429–453.

STROHMEYER, J. (1986): *Crisis in Bethlehem*. Adler and Adler, Bethesda, MD.

SYVERSON, C. (2011): "What Determines Productivity?," *Journal of Economic Literature*, 49(2), 326–365.

TASCHEREAU-DUMOUCHEL, M. (2020): "The Union Threat," *Review of Economic Studies*, 87(6), 2859–2892.

TIFFANY, P. A. (1988): *The Decline of American Steel*. Oxford University Press.

U.S. BUREAU OF LABOR STATISTICS (1967): "City Worker's Family Budget, for a Moderate Living Standard, Autumn 1966-Bulletin No. 1570-1," U.S. Government Printing Office.

VLASIC, B. (2011): *Once Upon a Car: The Fall and Resurrection of America's Big Three Auto Makers–GM, Ford, and Chrysler*. Harper Collins.

WALSH, D. (2010): "UAW's Bob King Offers up Auto Workers as Fodder for Exploitation," https://www.wsws.org/en/articles/2010/08/king-a04.html.

WARREN, K. (2001): *Big Steel: The First Century of the United States Steel Company, 1901-2001*. University of Pittsburgh Press.

YOON, C. (2017): "Estimating a Dynamic Spatial Equilibrium Model to Evaluate the Welfare Implications of Regional Adjustment Processes: The Decline of the Rust Belt," *International Economic Review*, 58(2), 473–497.

# Appendix (for Online Publication Only)

## A. Alternative Measures of Labor Conflict and Employment Growth

In section 2.5 we analyzed the relationship between major work stoppages, defined as stoppages involving at least 1,000 workers, and employment growth. In the following three subsections we conduct several robustness checks using alternative proxies for labor market conflict.

### A.1. Alternative Size Thresholds for Work Stoppages

Table A.1 reports coefficient estimates of a regression of employment growth on work stoppages similar to those in Table A.3. Each row represents the results of an alternate specification. The dependent variable is the log employment change between 1950 and 2000 and the observations are state-industry pairs. The other independent variables are identical to specifications (1) - (4) in Table A.3.

Table A.1: Robustness of State-Industry Regressions

| | Regression Specification | | | |
|---|---|---|---|---|
| Alternative Regression | (1) | (2) | (3) | (4) |
| Work Stoppages/Year, 1,000+ workers | -0.41*** | -0.30*** | -0.29*** | -0.27*** |
| | (0.071) | (0.063) | (0.058) | (0.056) |
| Work Stoppages/Year, 2,000+ workers | -0.67*** | -0.50*** | -0.48*** | -0.44*** |
| | (0.12) | (0.11) | (0.10) | (0.092) |
| Work Stoppages/Year, 500+ workers | -0.17*** | -0.12*** | -0.11*** | -0.10*** |
| | (0.046) | (0.038) | (0.035) | (0.036) |
| Work Stoppages/Year, 0+ workers | -0.019** | -0.012* | -0.011** | -0.0080* |
| | (0.0090) | (0.0062) | (0.0055) | (0.0048) |
| Percent of Workers in Stoppages | -0.13*** | -0.11*** | -0.090*** | -0.068*** |
| | (0.020) | (0.017) | (0.020) | (0.021) |
| Sample Restriction: Only Manufacturing | -0.39*** | -0.23*** | -0.22*** | -0.22*** |
| | (0.073) | (0.059) | (0.054) | (0.056) |

**Note:** The dependent variable in all regressions is log employment growth from 1950 to 2000. All else as in Table **??** except where indicated. Coefficients on all other independent variables are omitted for brevity. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

As a frame of reference, the first row of Table A.1 reproduces the benchmark results of Table A.3, where the independent variable of interest is work stoppages affecting 1,000 or more workers. The second row uses work stoppages affecting 2,000 workers or more, and keeps all else the same. Coefficients on work stoppages are larger in this case, and still everywhere statistically significant. The third and fourth rows consider lower thresholds on work stoppages, in particular 500 or more workers and 0 or more workers. These coefficients are smaller in magnitude but still statistically significant. In terms of economic magnitude, these regressions confirm the strong relationship between work stoppages and employment growth at the industry-state level. The negative relationship between the threshold number of workers involved and the magnitude of the coefficient is largely driven by the fact that the number of work stoppages increases as the threshold declines. In the case of work stoppages affecting any positive number of workers, the standard deviation rises to 3.9 from 0.9 in the benchmark. Thus, moving from two standard deviations below the mean to two standard deviations above will lead to a 13 percent decline in employment. This is comparable in magnitude to the estimate in the benchmark regression specification. We conclude that our results are not artefacts of the exact thresholds for workers affected by work stoppages.

The fifth row takes as its main independent variable the number of workers involved in work stoppages from 1958 to 1977 divided by total employment (summing over all the years) over this period. In other words, the dependent variable is the percent of workers involved in a work stoppage. Thus, instead of choosing a particular cutoff for workers involved, this alternative variable takes a more continuous measure of conflict. This independent variable also shows up with a large estimated coefficient that is statistically significant in all four specifications. Our results are also robust to this more continuous measure of work stoppages.

In the final two rows of Table A.1 we revert to the independent variable from our benchmark specification (stoppages affecting at least 1,000 workers), but we change the dependent variable and sample selection. The final row of the table is the same regression as the others but restricts the sample to only manufacturing industries. The estimated coefficient is still large and statistical significant. We conclude that an earlier timeframe for employment growth and restriction to just manufacturing still leave our conclusions from Section 2 intact.

Table A.2: Unionization Rates by Region and Sector

| | Fraction of Unionized Workers (Percent) | | |
|---|---|---|---|
| | Manufacturing | Services | Overall |
| Rust Belt | 48.1 | 22.5 | 30.9 |
| Rest of Country | 28.4 | 14.4 | 18.1 |

### A.2. Unionization Rates, 1973 to 1980

Next, we explore if the relationship between labor conflict and employment growth is robust to using a different proxy: the unionization rate. Unions have historically been related to labor conflict, though as a comparison of Tables 1 and A.2 reveals, unionization rates are not perfectly correlated with work stoppages. Adversarial labor-management relations and hold-up problems, for instance, can arise even in the absence of strikes.

A limitation of our unionization measure is that data at the individual level on union participation is only available in the CPS starting in 1973, and the data are only comparable up to 1980. As in the measure of work stoppages, we aggregate the data to the state-industry level, to be at a comparable level of aggregation as our other variables. The CPS reports state-data in groups until 1978. We allocate workers to state within each group according to the state population shares in later years, where data is reported for each individual state. Note that our data are highly correlated with CPS unionization data from 1983 to 1992, which tend to be more widely used.

Table A.3 reports the results of four regressions of log employment growth from 1950 to 2000 on unionization and the same set of other correlates as Table A.3. In particular, all observations are again at the state-industry level, and all regressions include an industry fixed effect. The first column shows that unionization rates are highly negatively related to employment growth. The coefficient on unionization is -0.74, meaning that moving the unionization rate from zero to one hundred percent is associated with 74 log points lower employment growth compared to the same industry in other states. The percent college graduate is again positive but insignificant. Adding controls for population, manufacturing employment share and the employment concentration paints a similar picture, and again leaves the coefficient on unionization large, negative, and statistically significant, at -0.56. Adding controls for climate variables lowers the coefficient on unionization to

Table A.3: Unionization Rates and Employment Growth

| Independent Variables | Dep. Var: Log Employment Growth 1950-2000 (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Unionization Rate | -0.74*** | -0.56*** | -0.34*** | -0.30*** |
| | (0.076) | (0.077) | (0.075) | (0.072) |
| Percent College Grad, 1950 | 0.076 | 0.061 | -0.022 | -0.031 |
| | (0.094) | (0.093) | (0.086) | (0.074) |
| Log State Population, 1950 | | -0.071*** | -0.12*** | |
| | | (0.014) | (0.015) | |
| State Mfg Employent Share, 1950 | | -1.83*** | -0.85*** | |
| | | (0.12) | (0.15) | |
| State Empl. Herfindahl Index, 1950 | | -2.41*** | -1.24*** | |
| | | (0.37) | (0.36) | |
| State Average Temperature | | | 0.014*** | |
| | | | (0.0027) | |
| State Std. Dev. Temperature | | | -0.060*** | |
| | | | (0.0070) | |
| State Average Precipitation | | | -0.014*** | |
| | | | (0.0013) | |
| Constant | -1.49*** | -0.83*** | -0.39 | -1.45*** |
| | (0.096) | (0.10) | (0.25) | (0.13) |
| Observations | 4,691 | 4,691 | 4,628 | 4,691 |
| $R^2$ | 0.611 | 0.637 | 0.694 | 0.747 |
| Industry Fixed Effects | Y | Y | Y | Y |
| State Fixed Effects | N | N | N | Y |

Note: The dependent variable in all regressions is log employment growth from 1950 to 2000. Observations are at the state-industry level. The first independent variable is unionization rate over the period 1973 to 1980, and the second is the percent of workers in the state-industry in 1950 that are college graduates. All other independent variables are measured at the state level in 1950. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

-0.34, and adding a state fixed effect leads to a unionization coefficient estimate of -0.30. Still, estimated coefficients on unionization are statistically significant at the one-percent level and economically large. We conclude that using unionization to proxy for work stoppages leads to a very similar picture as using work stoppages.

### A.3. Strikes from 1927 to 1934

While the results of Tables 2 and A.3 are certainly consistent with our theory that labor conflict reduced employment growth, an alternative hypothesis is that the employment decline caused the conflict. In particular, one could worry that once workers realized that their firms or industries were declining, they responded by unionizing or striking.

To address this potential reverse causality story, we draw on data on labor conflict that long pre-dated the postwar employment outcomes that are the dependent variables in Tables 2 and A.3. In particular, we draw on strikes data collected by the BLS in the 1920s and 1930s. The earliest data we found at the state-industry level were from 1927 to 1936, though we focus on the period 1927 to 1934, since this pre-dated the Wagner Act of 1935, which greatly increased the ability of workers nationwide to form collective bargaining arrangements. These early measures of conflict are likely related to the deep-seated distrust between workers and firms that began in this period, but is unlikely to be caused by any employment outcome starting two decades later.

Note that these data have some clear limitations. In particular, they are the two-digit industry level, which makes the mapping to the three-digit industries in the more recent data somewhat crude. Moreover, the data are only reported in states that had at least twenty five total strikes over this period. Thus, we are forced to drop states with few strikes, and this amounts to dropping around half the states and 30 percent of the total population represented by the data. These limitations make it harder to find associations between our dependent variables and our measure of strikes from 1927 and 1934.

Table A.4 presents the results of regressions of log employment growth from 1950 to 2000 on strikes from 1927 to 1934 and the same independent variable as Tables 2 and A.3. Using the same set of regression controls as above, strikes from 1927 to 1934 are significantly negatively related to employment growth from 1950 to 2000. With just the percent college graduate (and the industry fixed effects) as controls, the coefficient on strikes is -0.040. Adding the state controls for initial population and economic structure lower the coefficient to -0.019, and adding state climate controls lowers the strikes estimate to -0.018. Adding state fixed effects further lowers the strikes coefficient to -0.012, though in all cases strikes are statistically significant at the one-percent level.

How does the economic significance of strikes from 1927 to 1934 relate to that of the postwar work stoppages variable? The standard deviation of strikes from 1927 to 1934 is 32, so moving from one standard deviation below the mean to one standard deviation above is associated – in regression (4) – with around 77 log points lower employment growth. This

Table A.4: Strikes Per Year from 1927 to 1934 and Postwar Employment Growth

| Independent Vars | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | Dep. Var: Log Employment Growth 1950-2000 | | | |
| Strikes 1927-1934 | -0.040*** | -0.019*** | -0.018*** | -0.012*** |
| | (0.0045) | (0.0040) | (0.0040) | (0.0039) |
| Percent College Grad, 1950 | 0.087 | 0.10 | 0.033 | 0.024 |
| | (0.13) | (0.12) | (0.12) | (0.11) |
| Log State Population, 1950 | | -0.093*** | -0.096*** | |
| | | (0.020) | (0.023) | |
| State Mfg Employent Share, 1950 | | -2.68*** | -2.05*** | |
| | | (0.14) | (0.18) | |
| State Empl. Herfindahl Index, 1950 | | 3.85*** | 4.51*** | |
| | | (0.68) | (0.72) | |
| State Average Temperature | | | -0.0050 | |
| | | | (0.0033) | |
| State Std. Dev. Temperature | | | -0.057*** | |
| | | | (0.0082) | |
| State Average Precipitation | | | -0.012*** | |
| | | | (0.0020) | |
| Constant | -1.54*** | -0.70*** | 0.72** | -1.33*** |
| | (0.16) | (0.18) | (0.33) | (0.19) |
| Observations | 2,834 | 2,834 | 2,834 | 2,834 |
| $R^2$ | 0.663 | 0.712 | 0.721 | 0.745 |
| Industry Fixed Effects | Y | Y | Y | Y |
| State Fixed Effects | N | N | N | Y |

Note: The dependent variable in all regressions is log employment growth from 1950 to 2000. Observations are at the state-industry level. The first independent variable is the average number of strikes from 1927 to 1934, and the second is the percent of workers in the state-industry in 1950 that are college graduates. All other independent variables are measured at the state level in 1950. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

suggest an economically large effect of conflict on employment outcomes, as in Tables 2 and A.3.

Overall, the results of Table A.4 provide evidence against a reverse-causality story running from industry decline to conflict. Instead, the results suggest that the causality runs from strikes to employment growth, which corroborates the thesis of this paper.

# B. Section 3 Appendix

## B.1. Derivation of Strike Probability

$$\tilde{F}\left(R_t\left(i\right)\right) \equiv \Pr\left(R_t\left(i\right) > \tilde{R}_t\left(i\right)\right) = \Pr\left(\frac{\ln\left(\frac{R_t(i)\sigma}{X_t\left(1-(1-\phi)(1-\kappa)^{\sigma-1}\right)}\left(\frac{\sigma}{\sigma-1}\frac{w_t}{P_t}\frac{1}{z_t(i)}\right)\right)}{\sigma-1} > \varepsilon_t(i)\right)$$

$$= \frac{\frac{\ln\left(\frac{R_t(i)\sigma}{X_t\left(1-(1-\phi)(1-\kappa)^{\sigma-1}\right)}\left(\frac{\sigma}{\sigma-1}\frac{w_t}{P_t}\frac{1}{z_t(i)}\right)\right)}{\sigma-1} - \underline{\varepsilon}}{\overline{\varepsilon} - \underline{\varepsilon}}$$

$$= \frac{g^{-1}\left(R_t(i)\right) - \underline{\varepsilon}}{\overline{\varepsilon} - \underline{\varepsilon}}. \tag{25}$$

## B.2. Proofs of Propositions in Section 3

**Proof** of Proposition 1.

$$\frac{\partial R_t^*(i)}{\partial \phi} = \underbrace{(1-\kappa)^{\sigma-1}\left(1 + \frac{(1-\kappa)^{\sigma-1}}{\left(1-(1-\phi)\left(1-\kappa\right)^{\sigma-1}\right)^2}\right)}_{>0}$$
$$\times \underbrace{\frac{X_t}{\sigma}\left(\frac{\sigma-1}{\sigma}\frac{P_t}{w_t}z_t e^{\bar{\epsilon}}\right)^{\sigma-1}}_{>0}\underbrace{e^{-\frac{1-(1-\kappa)^{\sigma-1}}{1-(1-\phi)(1-\kappa)^{\sigma-1}}}}_{>0}$$
$$> 0 \quad \forall \phi \in (0,1) \text{ and } \sigma > 1$$

$$\frac{\partial \tilde{F}\left(R_t^*\left(i\right)\right)}{\partial \phi} = \frac{1-(1-\kappa)^{\sigma-1}}{\left(1-(1-\phi)\left(1-\kappa\right)^{\sigma-1}\right)}\frac{(1-\kappa)^{\sigma-1}}{2\bar{\epsilon}(\sigma-1)}$$
$$> 0 \quad \forall \phi \in (0,1) \text{ and } \sigma > 1$$

Q.E.D.

**Proof** of Proposition 2.
The proof proceeds in two parts.

1. Let $i$ denote a firm in the Rust Belt and $j$ a firm elsewhere. According to equation

(14) we have:

$$
\begin{aligned}
E[x_t(j)] &= E\left[\left(s\pi_t(j)\frac{\mathcal{Z}_t^{\sigma-1}}{\alpha z_t(j)^{\sigma-1}}\right)^{\frac{1}{\gamma}}\right] \\
&= \left(\frac{s\mathcal{Z}_t^{\sigma-1}}{\alpha}\right)^{\frac{1}{\gamma}} E\left[\left(\frac{\pi_t(j)}{z_t(j)^{\sigma-1}}\right)^{\frac{1}{\gamma}}\right] \\
&= \left[\frac{s\mathcal{Z}_t^{\sigma-1}}{\alpha}\left(\frac{\sigma-1}{\sigma}\frac{P_t}{w_t}\right)^{\sigma-1}\frac{X_t}{\sigma}\right]^{\frac{1}{\gamma}} E\left[e^{\varepsilon_t(j)\frac{\sigma-1}{\gamma}}\right] \\
&= \left[\frac{s\mathcal{Z}_t^{\sigma-1}}{\alpha}\left(\frac{\sigma-1}{\sigma}\frac{P_t}{w_t}\right)^{\sigma-1}\frac{X_t}{\sigma}\right]^{\frac{1}{\gamma}} \frac{\gamma}{2\bar{\varepsilon}(\sigma-1)}\left(e^{\bar{\varepsilon}\frac{\sigma-1}{\gamma}} - e^{-\bar{\varepsilon}\frac{\sigma-1}{\gamma}}\right)
\end{aligned}
$$

and

$$
\begin{aligned}
E[x_t(i)] =&(1-\tilde{F}(R_t^*(i)))E\left[\left(s(\pi_t(i)-R_t^*(i))\frac{\mathcal{Z}_t^{\sigma-1}}{\alpha z_t(i)^{\sigma-1}}\right)^{\frac{1}{\gamma}}\right] \\
&+\tilde{F}(R_t^*(i))E\left[\left(s(1-\phi)(1-\kappa)^{\sigma-1}\pi_t(i)\frac{\mathcal{Z}_t^{\sigma-1}}{\alpha z_t(i)^{\sigma-1}}\right)^{\frac{1}{\gamma}}\right] \\
<&(1-\tilde{F}(R_t^*(i)))E\left[\left(s\pi_t(i)\frac{\mathcal{Z}_t^{\sigma-1}}{\alpha z_t(i)^{\sigma-1}}\right)^{\frac{1}{\gamma}}\right] \\
&+\tilde{F}(R_t^*(i))E\left[\left(s\pi_t(i)\frac{\mathcal{Z}_t^{\sigma-1}}{\alpha z_t(i)^{\sigma-1}}\right)^{\frac{1}{\gamma}}\right] \\
=&E\left[\left(s\pi_t(i)\frac{\mathcal{Z}_t^{\sigma-1}}{\alpha z_t(i)^{\sigma-1}}\right)^{\frac{1}{\gamma}}\right] \\
=&\left[\frac{s\mathcal{Z}_t^{\sigma-1}}{\alpha}\left(\frac{\sigma-1}{\sigma}\frac{P_t}{w_t}\right)^{\sigma-1}\frac{X_t}{\sigma}\right]^{\frac{1}{\gamma}} \frac{\gamma}{2\bar{\varepsilon}(\sigma-1)}\left(e^{\bar{\varepsilon}\frac{\sigma-1}{\gamma}} - e^{-\bar{\varepsilon}\frac{\sigma-1}{\gamma}}\right) \\
=&E[x_t(j)]
\end{aligned}
$$

2. Let $\theta^R$ and $\theta^S$ denote the employment shares of the Rust Belt and the Rest-of-the-Country, respectively. The optimal labor input of a firm located outside the Rust

Belt or of a Rust Belt firm not subject to a strike is given by

$$n_t(i) = \left(\frac{\sigma-1}{\sigma}\frac{P_t}{w_t}\right)^{\sigma} \left(e^{\varepsilon_t(i)} z_t(i)\right)^{\sigma-1} \frac{X_t}{P_t} \tag{26}$$

and

$$\underline{n}_t(i) = \left(\frac{\sigma-1}{\sigma}\frac{P_t}{w_t}\right)^{\sigma} \left((1-\kappa)e^{\varepsilon_t(i)} z_t(i)\right)^{\sigma-1} \frac{X_t}{P_t}, \tag{27}$$

respectively. Using (26) and (27) we can characterize $\theta^S$ and $\theta^R$ by

$$\begin{aligned}
E[\theta_t^S] &\equiv E\left[\int_\lambda^1 n_t(j)dj\right] \\
&= \int_\lambda^1 E\left[n_t(j)\right] dj \\
&= \int_\lambda^1 \left(\frac{\sigma-1}{\sigma}\frac{P_t}{w_t}\right)^{\sigma} \frac{X_t}{P_t} \frac{e^{\bar{\varepsilon}(\sigma-1)} - e^{-\bar{\varepsilon}(\sigma-1)}}{2\bar{\varepsilon}(\sigma-1)} z_t(j)dj \\
&= \left(\frac{\sigma-1}{\sigma}\frac{P_t}{w_t}\right)^{\sigma} \frac{X_t}{P_t} \frac{e^{\bar{\varepsilon}(\sigma-1)} - e^{-\bar{\varepsilon}(\sigma-1)}}{2\bar{\varepsilon}(\sigma-1)} \int_\lambda^1 z_t(j)dj
\end{aligned}$$

and

$$\begin{aligned}
E[\theta_t^R] &\equiv E\left[\int_0^\lambda n_t(i)di\right] \\
&= \int_0^\lambda E\left[n_t(i)\right] di \\
&= \int_0^\lambda \left[\int_{e^{-\bar{\varepsilon}}}^{e^{\tilde{\varepsilon}}} \underline{n}_t(i) de^{\varepsilon_t(i)} + \int_{e^{\tilde{\varepsilon}}}^{\bar{\varepsilon}} n_t(i) de^{\varepsilon_t(i)}\right] di \\
&= \left(\frac{\sigma-1}{\sigma}\frac{P_t}{w_t}\right)^{\sigma} \frac{X_t}{P_t} \left[(1-\kappa)^{\sigma-1} \frac{e^{\tilde{\varepsilon}(\sigma-1)} - e^{-\bar{\varepsilon}(\sigma-1)}}{2\bar{\varepsilon}(\sigma-1)} + \frac{e^{\bar{\varepsilon}(\sigma-1)} - e^{\tilde{\varepsilon}(\sigma-1)}}{2\bar{\varepsilon}(\sigma-1)}\right] \int_0^\lambda z_t(i)di,
\end{aligned}$$

where $\tilde{\varepsilon}$ denotes the realization of the productivity shock that makes the firm indifferent between accepting and rejecting the union's request $R_t^*(i)$. According to equation (60) this threshold value does not depend on the Rust Belt firms' productivity $z_t(i)$.

We can write the ratio of expected employment shares as

$$\frac{E[\theta_t^R]}{E[\theta_t^{RC}]} = M \frac{\int_0^\lambda z_t(i)di}{\int_\lambda^1 z_t(j)dj} \tag{28}$$

where

$$M \equiv \frac{(1-\kappa)^{\sigma-1}\frac{e^{\tilde{\varepsilon}(\sigma-1)}-e^{-\bar{\varepsilon}(\sigma-1)}}{2\bar{\varepsilon}(\sigma-1)}+\frac{e^{\bar{\varepsilon}(\sigma-1)}-e^{\tilde{\varepsilon}(\sigma-1)}}{2\bar{\varepsilon}(\sigma-1)}}{\frac{e^{\bar{\varepsilon}(\sigma-1)}-e^{-\bar{\varepsilon}(\sigma-1)}}{2\bar{\varepsilon}(\sigma-1)}}$$

is constant.

According to Part 1. of the proof, we know that the expected growth rates of firm productivities are equalized across firms within the same region (Rust Belt and Rest-of-the-Country). Moreover, the expected growth rates for Rust Belt firms are uniformly lower. Therefore, the ratio of employment shares in (28) is decreasing over time, i.e. the employment share of Rust Belt firms is declining over time. Q.E.D.

### B.3. Union Rent per Worker

In equilibrium, the union rent *per worker* does not depend on the firm's productivity $z_t(i)$. In section B.4 we show that each worker receives $\frac{\phi}{\sigma-1}$ in addition to the competitive wage $w_t$ in the event of a strike.

What is less obvious is that $r_t \equiv \frac{R_t^*(i)}{E(n_t(i)|\varepsilon_t(i)\geq\tilde{\varepsilon})}$ is also equalized across firms.

Recall that according to equation (10), the optimal offer is

$$\begin{aligned} R_t^*(i) &= \left(1-(1-\phi)\left(1-\kappa\right)^{\sigma-1}\right)\frac{X_t}{\sigma}\left(\frac{\sigma-1}{\sigma}\frac{P_t}{w_t}z_t(i)e^{\tilde{\varepsilon}}\right)^{\sigma-1}e^{-\frac{1-(1-\kappa)^{\sigma-1}}{1-(1-\phi)(1-\kappa)^{\sigma-1}}} \\ &\equiv \kappa_{t,R}z_t(i)^{\sigma-1} \end{aligned}$$

Using equation (26) and the notation $n_t(i,\varepsilon)$ to highlight the dependence of labor input on the realization of $\varepsilon$ we can show that

$$\begin{aligned} E\left(n_t\left(i,\varepsilon\right)|\varepsilon_t(i)\geq\varepsilon^*\right) &= \int_{\tilde{\varepsilon}}^{\bar{\varepsilon}} n_t(i,\varepsilon)de^{\varepsilon_t(i)} \\ &= \left(\frac{\sigma-1}{\sigma}\frac{P_t}{w_t}\right)^{\sigma}\frac{X_t}{w_t}z_t(i)^{\sigma-1}\frac{e^{\bar{\varepsilon}(\sigma-1)}-e^{\tilde{\varepsilon}(\sigma-1)}}{2e^{\bar{\varepsilon}(\sigma-1)}} \\ &\equiv \kappa_{t,n}z_t(i)^{\sigma-1} \end{aligned}$$

It follows immediately that

$$\frac{R_t^*(i)}{E\left(n_t\left(i\right)|\varepsilon_t(i)\geq\tilde{\varepsilon}\right)} = \frac{\kappa_{t,R}}{\kappa_{t,n}}\frac{z_t(i)^{\sigma-1}}{z_t(i)^{\sigma-1}} = \frac{\kappa_{t,R}}{\kappa_{t,n}}$$

is equalized across firms indexed by $i$ at time $t$.

### B.4. Labor Markets and the Union

In addition to the competitive wage $w_t \equiv 1$, each worker employed by a Rust Belt firm $i \in [0, \lambda]$ receives a portion of the rents. If the union's take-it-or-leave-it offer is accepted, each worker gets an equal share of $R_t^*(i)$ given by (10). If the offer is rejected and a strike takes place, each worker receives an equal share of $\phi \underline{\pi}_t(i)$.

We assume that workers hired by a Rust Belt firm must be union members. This captures the "closed shop" nature of the labor contracts that were typical in Rust Belt industries. This arrangement implies that firms cannot bypass the union in order to recruit workers in the competitive labor market.

At the beginning of each period, workers decide whether to apply for a union job at one of the Rust Belt firms. These jobs are desirable since they pay the competitive wage plus a union rent. The size of this rent at a particular firm $i \in [0, \lambda]$ depends on whether a strike takes place, which workers do not know when they apply for a job. Instead, they decide whether to apply for a job at a particular firm based on the rent they can *expect* to earn.

Given firm $i$'s productivity $z_t(i)$, prospective workers know that the union will propose the rent $R_t^*(i)$ according to equation (10) and that the probability of rejection, which leads to a strike at that firm is given by $\tilde{F}\left(R_t^*\left(i\right)\right)$ in equation (60).

It follows that, in expectation, a worker hired by a Rust Belt firm $i \in [0, \lambda]$ will be paid

$$\underbrace{1}_{\text{competitive wage}} + \left(1 - \tilde{F}\left(R_t^*\left(i\right)\right)\right) \underbrace{\frac{R_t^*(i)}{E\left(n_t\left(i\right)|\epsilon_t(i) \geq \epsilon^*\right)}}_{\textit{per capita} \text{ rent without strike}} + \tilde{F}\left(R_t^*\left(i\right)\right) \underbrace{\frac{\phi E\left(\pi_t(i)|\epsilon_t(i) < \epsilon^*\right)}{E\left(n_t\left(i\right)|\epsilon_t(i) < \epsilon^*\right)}}_{\textit{per capita} \text{ profit share with strike}},$$

where $\epsilon^*$ is the threshold value of the transitory shock that solves equation (11). If the realized productivity is below the threshold, the firm rejects the union's offer and the union calls a strike.

According to equation (60), the probability of a strike does not depend on the firm's $z_t(i)$ and is constant over time. Let $\tilde{F}^* \equiv F\left(R_t^*\left(i\right)\right)$ denote this probability. Moreover, it is straightforward to show that $\frac{\phi E(\pi_t(i)|\epsilon_t(i)<\epsilon^*)}{E(n_t(i)|\epsilon_t(i)<\epsilon^*)} = \frac{\phi}{\sigma-1}$. Finally, using (10) and (9) it can be shown that $\frac{R_t^*(i)}{E(n_t(i)|\epsilon_t(i)\geq\epsilon^*)}$ does not depend on $z_t(i)$ either and remains constant over time. Let $r \equiv \frac{R_t^*(i)}{E(n_t(i)|\epsilon_t(i)\geq\epsilon^*)}$ be this per-worker rent in the no-strike case.

Clearly, arbitrage equalizes the *ex ante* value of a union job application across Rust Belt firms. The *ex ante* value is also constant over time, which has implications for the workers' decision to apply for union jobs. Since workers are not solving an intertemporal consumption-savings problem and have linear flow utility according to (1), the *ex ante* utility flow value of a job equals total expected, discounted income associated with that job.

The expected value of a Rust Belt job is given by:

$$E(v^R) = 1 + \left(1 - \tilde{F}^*\right) r + \tilde{F}^* \frac{\phi}{\sigma - 1} + E(D), \tag{29}$$

where $E(D)$ is the expected per capita dividend income. Every worker in this economy owns a single share of a fully diversified mutual fund and the firms' dividend payments are rebated to the funds' shareholders. In expectation, total dividends collected by the fund are given by:

$$\begin{aligned} E(D) =&(1-s)\Bigg( \int_0^\lambda \left(1 - \tilde{F}^*\right) \left(E\left(\pi_t(i)|\epsilon_t(i) \geq \epsilon^*\right) - R_t^*(i)\right) \\ &+ \tilde{F}^*(1-\phi) E\left(\pi_t(i)|\epsilon_t(i) < \epsilon^*\right) di + \int_\lambda^1 E\left(\pi_t(i)\right) di \Bigg) \end{aligned} \tag{30}$$

Since the economy is populated by a unit measure of households, total dividends equal per capita dividends, in expectation, and each worker receives $E(D)$ in addition to income for labor services and union rents.

The expected value of a Rest-of-the-Country job is given by:

$$E(v^S) = 1 + E(D). \tag{31}$$

Since $E(v^R) > E(v^S)$, workers strictly prefer to be employed by a Rust Belt firm. Rust Belt jobs, however, are in scarce supply and workers need to decide whether to queue up at some firm $i \in [0, \lambda]$. If the queue at firm $i$ is longer than the number of available jobs, workers are selected at random from the queue. *Ex post*, the number of workers hired by firm $i$ depends on the realization of $\epsilon_t(i)$ since, for given $z_t(i)$, firms with higher productivity shocks (1) hire more workers and (2) avoid the production time losses triggered by a strike.

If a worker queues up for a union job, but is not hired at time $t$, she can take a Rest-of-the-Country job immediately but suffers an exogenous utility cost $\bar{u}$.

*Ex ante*, the probability of being offered a job is given by:

$$\Pr\left(\text{hired by } i\right) = \frac{(1-\tilde{F}^{*})E\left(n_t(i)|\epsilon_t(i) \geq \epsilon^{*}\right) + \tilde{F}^{*}E\left(n_t(i)|\epsilon_t(i) < \epsilon^{*}\right)}{q_t(i)} = \frac{E\left(n_t\left(i\right)\right)}{q_t(i)}, \quad (32)$$

where $q_t(i)$ is the length of the queue at firm $i$ and time $t$.

Workers queue at firm $i$ if the expected payoff from doing so exceeds the payoff associated with taking a Rest-of-Country non-union job:

$$\frac{E\left(n_t\left(i\right)\right)}{q_t(i)}E(v^R) + \left(1 - \frac{E\left(n_t\left(i\right)\right)}{q_t(i)}\right)\left(E(v^S) - \bar{u}\right) \geq E(v^S) \quad (33)$$

Since the values of jobs don't depend on $i$, the probability of getting a union job is identical at all Rust Belt firms in equilibrium and is given by:

$$\frac{E\left(n_t\left(i\right)\right)}{q_t(i)} = 1 + \frac{E(v^R - v^S)}{\bar{u}} \quad (34)$$

This implies that $q_t(i)$ is proportional to the firm's productivity $z_t(i)$. The proportionality with respect to $z_t(i)$ is due to the constant probability of a strike across Rust Belt firms. In equilibrium, the constant *ex ante* probability of being offered a union job, conditional on queuing for one, is given by:

$$\frac{E\left(n_t\left(i\right)\right)}{q_t(i)} = \left(1 + \frac{E(v^R - v^S)}{\bar{u}}\right)^{-1} \leq 1. \quad (35)$$

## C. Section 4 Appendix

### C.1. Quantitative Version of the Model

In this subsection, we provide the full set of equations used in the quantitative version of the model.

**Production Functions and Final Goods Sector.** The *Foreign* counterparts of production functions (2) and (15) are:

$$Y_t^* = \left(\int_0^1 y_t^*(i)^{\frac{\sigma-1}{\sigma}} di\right)^{\frac{\sigma}{\sigma-1}}$$
$$y^*(i) = \left(y^{*H}(i)^{\frac{\rho-1}{\rho}} + y^{*F}(i)^{\frac{\rho-1}{\rho}}\right)^{\frac{\rho}{\rho-1}}.$$

There is free entry into the market for producing the final good. The representative producer in *Home* is a price-taker in both input and output markets and solves:

$$\max_{\{y(i)\}_{i\in[0,1]}} \Pi = PY - \int_0^1 p(i)y(i)di,$$

where perfect competition implies

$$P = \left(\int_0^1 p(i)^{1-\sigma} di\right)^{\frac{1}{1-\sigma}}.$$

Similarly, the representative *Foreign* firm solves:

$$\max_{\{y^*(i)\}_{i\in[0,1]}} \Pi^* = P^*Y^* - \int_0^1 p^*(i)y^*(i)di,$$

where

$$P^* = \left(\int_0^1 p^*(i)^{1-\sigma} di\right)^{\frac{1}{1-\sigma}}.$$

**Firm Profit Maximization.** Firms maximize total expected profits:

$$E\left(\Pi^H(i)\right) = E\left(\pi^H(i)\right) + E\left(\pi^{*H}(i)\right),$$

where

$$E\left(\pi^{H}(i)\right) = \max_{n^{H}(i)} E\left(p^{H}(i)y^{H}(i)\right) - wn^{H}(i), \tag{36}$$

$$E\left(\pi^{*H}(i)\right) = \max_{n^{*H}(i)} E\left(p^{*H}(i)y^{*H}(i)\right) - wn^{*H}(i). \tag{37}$$

The quantities $y^{H}(i)$ and $y^{*H}$ are given by equations (16) and (17), respectively. The expectation is over all possible realizations of $\varepsilon(i)$ and whether a strike occurs, which determines the value of $k(i) \in \{0, \kappa\}$.

Similarly, the *Foreign* firm has productivity $z^{F}(i)$ and maximizes the expected profit $E\left(\Pi^{F}(i)\right)$:

$$E\left(\Pi^{F}(i)\right) = E\left(\pi^{*F}(i)\right) + E\left(\pi^{F}(i)\right),$$

where

$$E\left(\pi^{*F}(i)\right) = \max_{n^{*F}(i)} E\left(p^{*F}(i)y^{*F}(i)\right) - w^{F}n^{*F}(i), \tag{38}$$

$$E\left(\pi^{F}(i)\right) = \max_{n^{F}(i)} E\left(p^{F}(i)y^{F}(i)\right) - w^{F}n^{F}(i). \tag{39}$$

For a given realization of $\varepsilon(i)$ and labor inputs $n^{H}(i)$, $n^{*H}(i)$, $n^{*F}(i)$ and $n^{F}(i)$, the quantities $y^{H}(i)$, $y^{*H}(i)$, $y^{*F}(i)$ and $y^{F}(i)$ are determined by equations (16)-(19). For given $P$, $P^{*}$, $Y$ and $Y^{*}$, the prices that clear all four markets simultaneously are given by equations (40)-(43) below.:

$$y^{H}(i) = \left(\frac{p^{H}(i)}{p(i)}\right)^{-\rho}\left(\frac{p(i)}{P}\right)^{-\sigma} Y, \tag{40}$$

$$y^{F}(i) = \left(\frac{\tau p^{F}(i)}{p(i)}\right)^{-\rho}\left(\frac{p(i)}{P}\right)^{-\sigma} Y, \tag{41}$$

$$y^{*H}(i) = \left(\frac{\tau p^{*H}(i)}{p^{*}(i)}\right)^{-\rho}\left(\frac{p^{*}(i)}{P^{*}}\right)^{-\sigma} Y^{*}, \tag{42}$$

$$y^{*F}(i) = \left(\frac{p^{*F}(i)}{p^{*}(i)}\right)^{-\rho}\left(\frac{p^{*}(i)}{P^{*}}\right)^{-\sigma} Y^{*}, \tag{43}$$

where the prices of the composite intermediate goods $y(i)$ and $y^{*}(i)$ are given by

$$p(i) = \left(p^{H}(i)^{1-\rho} + \left(\tau p^{F}(i)\right)^{1-\rho}\right)^{\frac{1}{1-\rho}} \tag{44}$$

and

$$p^*(i) = \left(\left(\tau p^{*H}(i)\right)^{1-\rho} + p^{*F}(i)^{1-\rho}\right)^{\frac{1}{1-\rho}}. \tag{45}$$

The terms $\left(\frac{p(i)}{P}\right)^{-\sigma} Y$ and $\left(\frac{p^*(i)}{P^*}\right)^{-\sigma} Y^*$ describe the final good producers' demand for $y(i)$ and $y^*(i)$ in *Home* and *Foreign*, respectively. The price ratios in the first term on the right hand side of equations (40)-(43) govern the market shares of the *Home* and *Foreign* producer in the domestic and export markets for good $i$, the importance of which we discuss in more detail below.

The *Foreign* producer selling in the *Home* market charges:

$$p^F(i) = \frac{\epsilon^F(i)}{\epsilon^F(i) - 1} \frac{w^F}{z^F(i)}, \tag{46}$$

$$\epsilon^F(i) \equiv \left(\omega^F(i)\frac{1}{\sigma} + (1 - \omega^F(i))\frac{1}{\rho}\right)^{-1} \tag{47}$$

$$\omega^F(i) \equiv \frac{\tau p^F(i) y^F(i)}{p(i)y(i)} = 1 - \omega^H(i) \tag{48}$$

Producers selling in the *Foreign* market (identified by *) will charge:

$$p^{*H}(i) = \frac{\epsilon^{*H}(i)}{\epsilon^{*H}(i) - 1} \frac{1}{z^H(i)} \tag{49}$$

$$p^{*F}(i) = \frac{\epsilon^{*F}(i)}{\epsilon^{*F}(i) - 1} \frac{w^F}{z^F(i)}, \tag{50}$$

where $\epsilon^{*H}(i)$ and $\epsilon^{*F}(i)$ are the analogues of (21) and (47) in the *Foreign* market.

Using the demand functions (40)-(43) together with the optimal prices in (44)-(20), (46), (49), and (50), we can characterize the maximal profit of a *Home* firm for any realization of $\{\varepsilon(i)\}_{i\in[0,1]}$ by

$$\begin{aligned}\Pi^H(i) \equiv& \pi^H(i) + \pi^{*H}(i) \\ =& z^H(i)^{\rho-1}\Big[\epsilon^H(i)^{-\rho}\left(\epsilon^H(i) - 1\right)^{\rho-1} p(i)^{\rho-\sigma} E\left(P^\sigma Y\right) \\ &+ \epsilon^{*H}(i)^{-\rho}(\epsilon^{*H}(i) - 1)^{\rho-1} p^*(i)^{\rho-\sigma} E\left(P^{*\sigma} Y^*\right)\Big].\end{aligned} \tag{51}$$

Similarly, we have

$$\begin{aligned}\Pi^F(i) \equiv& \pi^{*F}(i) + \pi^F(i) \\ =& \left(\frac{z^F(i)}{w^F}\right)^{\rho-1} \Big[\epsilon^{*F}(i)^{-\rho}(\epsilon^{*F}(i)-1)^{\rho-1}p^*(i)^{\rho-\sigma}P^{*\sigma-1}E\left(P^{*\sigma}Y^*\right) \\ &+ \epsilon^F(i)^{-\rho}\left(\epsilon^F(i)-1\right)^{\rho-1}p(i)^{\rho-\sigma}P^{\sigma-1}E\left(P^\sigma Y\right)\Big]\end{aligned} \tag{52}$$

for a *Foreign* intermediate producer of good $i$.

Importantly, $P$, $P^*$, $Y$ and $Y^*$ depend on the realizations of *all* $\{\varepsilon(i)\}_{i\in[0,1]}$, not just $\varepsilon(i)$. This implies that individual firms form expectations over these aggregate variables, and since the economy is populated by a continuum of firms indexed by $i \in [0,1]$, these expectations must be confirmed *ex post*.

**Bargaining Protocol in the Quantitative Version** For simplicity, we characterize the protocol for a single good $i$ with two producers – *Home* and *Foreign* – who take the productivities and hiring decisions of all other firms producing goods $j \neq i$ as given.

1. At the beginning of each period, everyone observes the idiosyncratic productivities $\{z^H(i), z^F(i)\}_{i\in[0,1]}$, the two firms hire labor inputs $n^H(i)$, $n^{*H}(i)$, $n^{*F}(i)$, and $n^F(i)$ to maximize $E\left(\Pi^H(i)\right)$ and $E\left(\Pi^F(i)\right)$, where $\Pi^H(i)$ and $\Pi^F(i)$ are given by (51) and (52), respectively. Once the number of workers has been chosen, the firms can no longer adjust the size of their workforce for the remainder of the period.

2. The productivity shock $\varepsilon^H(i)$ is revealed to the *Home* firm, but not to the union.

3. The union makes a take-it-or-leave-it offer of $R(i)$, net of the competitive wage, to be paid out from the profits of the firm.

4.a. If the firm **accepts**, it produces using the workers it chose in 1., transfers $R(i)$ to the union and retains $\Pi^H(i) - R(i)$. The union splits $R(i)$ evenly among its $n^H(i)+n^{*H}(i)$ workers. The period ends.

4.r. If the firm **rejects**, the union calls a strike and production idles for fraction $\kappa \in (0,1)$ of time. Workers are not paid during the strike.

As in the simple model, a fictitious arbiter allocates the fraction $\phi(i) \in (0,1)$ of post-strike profits, denoted $\hat{\Pi}^H$, to the union. We assume that $\phi(i) = \phi^R$ for all $i \in [0,\lambda]$ (i.e. firms in Rust Belt) and $\phi(i) = \phi^S$ for all $i \in [\lambda, 1]$ (i.e. firms in Rest-of-Country). Unions in the Rust Belt have greater bargaining power that is captured by setting

$\phi^R > \phi^S$. Arbitration is binding. The union distributes its share of post-strike profits to the workers on payroll. The period ends.

The union selects $R(i)$ to maximize its expected payoff. The problem can be solved by backward induction.

**Union's Problem in the Quantitative Model.** At stage 4. of the bargaining protocol, all labor inputs have been chosen and the productivity shocks have been revealed. There is no uncertainty and the prices $p^H(i)$, $p^F(i)$, $p^{*H}(i)$, $p^{*F}(i)$ solve equations (40)-(43). The firm has to decide between accepting or rejecting $R(i)$ by comparing the payoffs associated with 4.a. and 4.r. It accepts the request if

$$\Pi^H\left(\varepsilon^H(i)\right) - R(i) \geq (1-\phi(i))\,\hat{\Pi}^H\left(\varepsilon^H(i)\right) \tag{53}$$

and rejects otherwise. We write profits as a function of $\varepsilon^H(i)$ to highlight that *ex post* profits depend on the realization of the productivity shock. Given $R(i)$, there is a cutoff value of $\varepsilon^H(i)$, denoted by $\tilde{\varepsilon}^H(i)$ that solves

$$\Pi^H\left(\tilde{\varepsilon}^H(i)\right) - R(i) = (1-\phi(i))\,\hat{\Pi}^H\left(\tilde{\varepsilon}^H(i)\right). \tag{54}$$

The union knows that the firm accepts if $\varepsilon^H(i) \geq \tilde{\varepsilon}^H(i)$ and rejects otherwise.

In Appendix C.2 we show that $\Pi^H(\varepsilon^H(i))$ increases in $\varepsilon(i)$ strictly faster than $\hat{\Pi}^H(\varepsilon^H(i))$ does. This implies there exists a strictly increasing one-to-one correspondence between $R(i)$ and $\tilde{\varepsilon}^H(i)$, which we denote as

$$\tilde{\varepsilon}^H(R) : \mathbb{R}^+ \mapsto \mathbb{R}^+. \tag{55}$$

The union maximizes total rents plus wage income for its affiliated workers:

$$\begin{aligned} R^*(i) = \arg\max_{R(i)} & \int_{\tilde{\varepsilon}^H(R)}^{\infty} \left[n^H(i) + n^{*H}(i) + R(i)\right] f(\varepsilon^H(i))d\varepsilon^H(i) \\ & + \int_0^{\tilde{\varepsilon}^H(R)} \left[(1-\kappa)\left(n^H(i) + n^{*H}(i)\right) + \phi(i)\hat{\Pi}^H\left(\varepsilon^H(i)\right)\right] f\left(\varepsilon^H(i)\right) d\varepsilon^H(i), \end{aligned} \tag{56}$$

where $f(\varepsilon^H(i))$ is the probability density function for the shock $\varepsilon^H(i)$. The first integral takes into account realizations of $\varepsilon^H(i)$ where the firm accepts $R(i)$; the second integral is over shocks that lead to a rejection and hence a strike.

The first-order condition of the union's problem with respect to $R(i)$ relies on Leibniz's rule:

$$1-F\left(\tilde{\varepsilon}^{H}(R)\right)-\tilde{\varepsilon}^{H\prime}(R)\left[n^{H}(i)+n^{*H}(i)+R(i)\right]f\left(\tilde{\varepsilon}^{H}(R)\right)$$
$$+\tilde{\varepsilon}^{H\prime}(R)\left[(1-\kappa)\left(n^{H}(i)+n^{*H}(i)\right)+\phi(i)\hat{\Pi}^{H}\left(\tilde{\varepsilon}^{H}(R)\right)\right]f\left(\tilde{\varepsilon}^{H}(R)\right)=0,$$

which can be further simplified to

$$1-F\left(\tilde{\varepsilon}^{H}(R)\right)-\tilde{\varepsilon}^{H\prime}(R)\left[\kappa\left(n^{H}(i)+n^{*H}(i)\right)+R(i)-\phi(i)\hat{\Pi}^{H}\left(\tilde{\varepsilon}^{H}(R)\right)\right]f\left(\tilde{\varepsilon}^{H}(R)\right)=0, \quad (57)$$

where $F(\cdot)$ is the c.d.f. corresponding to $f(\cdot)$ and $\tilde{\varepsilon}^{H\prime}(R)$ is given by the total differential of the cutoff rule (54):

$$\begin{aligned}D(\tilde{\varepsilon}^{H}(R)) &\equiv \tilde{\varepsilon}^{H\prime}(R)\\ &= \Bigg(n^{H}(i)p^{H}(\tilde{\varepsilon}^{H}(R))\frac{\epsilon^{H}(\tilde{\varepsilon}^{H}(R))-1}{\epsilon^{H}(\tilde{\varepsilon}^{H}(R))}+n^{*H}(i)p^{*H}(\tilde{\varepsilon}^{H}(R))\frac{\epsilon^{*H}(\tilde{\varepsilon}^{H}(R))-1}{\epsilon^{*H}(\tilde{\varepsilon}^{H}(R))}\\ &\quad -(1-\phi)(1-\kappa)\left[n^{H}(i)\hat{p}^{H}(\tilde{\varepsilon}^{H}(R))\frac{\hat{\epsilon}^{H}(\tilde{\varepsilon}^{H}(R))-1}{\hat{\epsilon}^{H}(\tilde{\varepsilon}^{H}(R))}+n^{*H}(i)\hat{p}^{*H}(\tilde{\varepsilon}^{H}(R))\frac{\hat{\epsilon}^{*H}(\tilde{\varepsilon}^{H}(R))-1}{\hat{\epsilon}^{*H}(\tilde{\varepsilon}^{H}(R))}\right]\Bigg)^{-1}.\end{aligned} \quad (58)$$

where $p^{H}(\tilde{\varepsilon}^{H}(R))$, $p^{*H}(\tilde{\varepsilon}^{H}(R))$, $\hat{p}^{H}(\tilde{\varepsilon}^{H}(R))$, and $\hat{p}^{*H}(\tilde{\varepsilon}^{H}(R))$ are market-clearing prices for the *Home* firm with start-of-period productivity $z(i)$ when the realized intra-period productivity shock is equal to $\tilde{\varepsilon}^{H}(R)$. In particular, $\hat{p}^{H}(\tilde{\varepsilon}^{H}(R))$ and $\hat{p}^{*H}(\tilde{\varepsilon}^{H}(R))$ are the prices when the firm faces a strike. The fractions involving $\epsilon^{H}(\tilde{\varepsilon}^{H}(R))$ and $\epsilon^{*H}(\tilde{\varepsilon}^{H}(R))$ are the inverses of markups when the realized productivity shock is equal to $\tilde{\varepsilon}^{H}(R)$, again with the hat notation denoting cases where strikes are called.

After substituting (54) and (58) into the first-order condition (57) we get

$$1-F\left(\tilde{\varepsilon}^{H}(R)\right)-D(\tilde{\varepsilon}^{H}(R))\left[\kappa\left(n^{H}(i)+n^{*H}(i)\right)+\Pi^{H}(\tilde{\varepsilon}^{H}(R))-\hat{\Pi}^{H}(\tilde{\varepsilon}^{H}(R))\right]f(\tilde{\varepsilon}^{H}(R))=0 \quad (59)$$

so that the union's problem is re-specified in terms of the threshold productivity $\tilde{\varepsilon}^{H}(R)$ that satisfies (59). It is then straightforward to characterize the union's optimal request $R^{*}(i)$ using the $\tilde{\varepsilon}^{H}(R)$ that solves (59) and equation (54).

In Appendix C.3 we show that a unique $\tilde{\varepsilon}^{H}(R)$ and hence $R^{*}(i)$ maximizes the union's objective function. The probability that a firm rejects a request and a strike takes place is given by

$$\Pr(\text{strike}) = \frac{1}{2}\left[1 + \text{erf}\left(\frac{\tilde{\varepsilon}^H(R)}{\sigma_\varepsilon\sqrt{2}}\right)\right]. \tag{60}$$

Firms take the union's $R(i)$ and the corresponding probability of a strike into account when they hire labor inputs in order to maximize the *ex ante* profits in equations (36)-(39).

**Trade Balance.** The trade balance condition is as follows:

$$\int_0^1 \left(p^{*H}(i)\left[\tau y^{*H}(i)\right] - \left[\tau p^F(i)\right] y^F(i)\right) di = 0. \tag{61}$$

Note that $p^H(i)$ and $p^F(i)$ are the f.o.b. ("free on board" or factory gate) prices. The prices of the composite intermediates are based on the c.i.f. ("cost including freight") prices.

### C.2. Firms' *Ex Post* Profits

The profit functions (51) and (52) cannot be solved in closed form. We can, however, show that the firms' profits are strictly increasing in $\varepsilon(i)$ for given $\{\varepsilon(j)\}_{i\neq j}$. We formally show that *Home's* profit in the domestic market is a monotone increasing function of the productivity shock. The characterization of profits generated in the export market is available upon request.

Recall that the market shares of the *Home* and *Foreign* firms are given by

$$\omega^H(i) \equiv \frac{p^H(i)y^H(i)}{p(i)y(i)} = \left(\frac{p^H(i)}{p(i)}\right)^{1-\rho} \tag{62}$$

$$\omega^F(i) \equiv \frac{\tau p^F(i)y^F(i)}{p(i)y(i)} = \left(\frac{\tau p^F(i)}{p(i)}\right)^{1-\rho} = 1 - \omega^H(i). \tag{63}$$

By equation (41), we obtain

$$d\ln p^F(i) = \frac{\rho-\sigma}{\rho} d\ln p(i). \tag{64}$$

By definition of the sector price index, (44), we have

$$d\ln p(i) = \omega^H(i) d\ln p^H(i) + \omega^F(i) d\ln p^F(i). \tag{65}$$

Combining these two equations, we have

$$d\ln p^F(i) = \frac{(\rho-\sigma)\omega^H(i)}{\rho\omega^H(i) + \sigma\omega^F(i)} d\ln p^H(i). \tag{66}$$

Substituting this equation into the result of total differentiating the ratio of (40) and (41), we obtain

$$d\ln y^H(i) - d\ln y^F(i) = -\left(\omega^H(i)\frac{1}{\sigma} + \omega^F(i)\frac{1}{\rho}\right)^{-1} d\ln p^H = -\epsilon^H(i) d\ln p^H. \tag{67}$$

Given the outcome of strikes, the only source of variation in output at the price-setting stage comes from the realization of productivity shock $z^H(i)$. Therefore, holding the strike outcome fixed, $d\ln y^H(i) = d\ln z^H(i)$ and $d\ln y^F(i) = 0$, so that the equation above implies

$$\frac{d\ln p^H(i)}{d\ln z^H(i)} = -\left(\omega^H(i)\frac{1}{\sigma} + \omega^F(i)\frac{1}{\rho}\right) = -\frac{1}{\epsilon^H(i)} > -1 \tag{68}$$

and

$$\frac{d\ln p^H(i)y^H(i)}{d\ln z^H(i)} = \frac{d\ln p^H(i)}{d\ln z^H(i)} + 1 > 0. \tag{69}$$

Since labor cost is fixed, the *ex post* profits without strikes is strictly increasing in the productivity shock. Moreover, this equation also holds under strikes, so that the elasticity of sales to the productivity shock is the same regardless of strikes. Since strikes take out a fraction $\kappa$ of output, the response of the level of sales to productivity shocks is larger when there is no strike. Putting these pieces together, we can write the ex post profits as strictly increasing functions of *Home* firm's productivity, which satisfy

$$\begin{aligned}\frac{d\pi^H(i)(z^H(i))}{dz^H(i)} = \frac{dp^H(i)y^H(i)}{dz^H(i)} &= l^H(i)p^H(i)\left(1 + \frac{z^H(i)}{p^H(i)}\frac{dp^H(i)}{dz^H(i)}\right) \\ &= l^H(i)p^H(i)\frac{\epsilon^H(i) - 1}{\epsilon^H(i)}\end{aligned} \tag{70}$$

and

$$\frac{d\hat{\pi}^H(i)(z^H(i))}{dz^H(i)} = (1-\kappa)l^H(i)\hat{p}^H(i)\frac{\hat{\epsilon}^H(i) - 1}{\hat{\epsilon}^H(i)}, \tag{71}$$

so that

$$\frac{d\pi^H(z^H(i))}{dz^H(i)} > \frac{d\hat{\pi}^H(z^H(i))}{dz^H(i)} > 0 \tag{72}$$

where $\hat{\pi}^H$, $\hat{p}^H$, and $\hat{\epsilon}^H$ denote the corresponding variables in cases where strikes take place.

Analogously, we can derive that the *Home* firm's profits overseas is also strictly increasing in the productivity shock regardless of strikes, and satisfies

$$\frac{d\pi^{*H}(i)(z^H(i))}{dz^H(i)} = l^{*H}(i)p^{*H}(i)\frac{\epsilon^{*H}(i)-1}{\epsilon^{*H}(i)}, \tag{73}$$

$$\frac{d\hat{\pi}^{*H}(i)(z^H(i))}{dz^H(i)} = (1-\kappa)l^{*H}(i)\hat{p}^{*H}(i)\frac{\hat{\epsilon}^{*H}(i)-1}{\hat{\epsilon}^{*H}(i)}, \tag{74}$$

and

$$\frac{d\pi^{*H}(z^H(i))}{dz^H(i)} > \frac{d\hat{\pi}^{*H}(z^H(i))}{dz^H(i)} > 0. \tag{75}$$

Define

$$\Pi^H(z^H(i)) = \pi^H(z^H(i)) + \pi^{*H}(z^H(i)), \tag{76}$$

we have

$$\frac{d\Pi^H(z^H(i))}{dz^H(i)} > \frac{d\hat{\Pi}^H(z^H(i))}{dz^H(i)} > 0. \tag{77}$$

### C.3. Uniqueness of $R(i)$

Let the idiosyncratic productivity shock $\varepsilon^H(i)$ follow a normal distribution with mean $\mu_\varepsilon$ and standard deviation $\sigma_\varepsilon$. Further simplification yields

$$\frac{1-\Phi((\ln\tilde{z}^H-\bar{z})/\sigma_z)}{\varphi((\ln\tilde{z}^H-\bar{z})/\sigma_z)} = D(\tilde{z}^H)\left[\kappa w^H(l^H+l^{*H})+\Pi^H(\tilde{z}^H)-\hat{\Pi}^H(\tilde{z}^H)\right], \tag{78}$$

where $\Phi(\cdot)$ and $\varphi(\cdot)$ denote the CDF and PDF of the standard normal distribution. It is easy to see that the right-hand side of the equation is positive and increasing in $\tilde{z}^H$. The left-hand side is the inverse of the inverse Mill's ratio and is equal to $1/E[W|W > (\ln\tilde{z}^H-\bar{z})/\sigma_z]$ where $W$ is a random variable following standard normal distribution. Therefore, the left-hand side expression is strictly decreasing in $\tilde{z}^H$ and satisfies

$$\lim_{\tilde{z}^H\to 0}\frac{1-\Phi((\ln\tilde{z}^H-\bar{z})/\sigma_z)}{\varphi((\ln\tilde{z}^H-\bar{z})/\sigma_z)} = \infty \tag{79}$$

and

$$\lim_{\tilde{z}^H\to \infty}\frac{1-\Phi((\ln\tilde{z}^H-\bar{z})/\sigma_z)}{\varphi((\ln\tilde{z}^H-\bar{z})/\sigma_z)} = 0. \tag{80}$$

Therefore, for any value of $\sigma > 1$, $\phi \in (0,1)$, and $\kappa \in (0,1)$ There exists a unique solution for $\tilde{z}^H$ that satisfies (78), hence a unique solution of $R$.

## C.4. Numerical Algorithm

Numerical methods are used to compute the solution. In lieu of a continuum, we populate the economy by $2 \times I$ firms, which are indexed by $i \in \{1, \ldots, I\}$. Each $i$ has two producers, one in *Home* and one in *Foreign*. We maintain the assumption that the market for each good $i$ is small, which implies that the two producers of this good take the decisions of all producers $j \neq i$ in *Home* and *Foreign* as given. We choose $I = 1793$, which is the number of U.S. state-industry (manufacturing only) pairs at the 3-digit SIC level in the data.

The state vector of the economy is the set of 3,586 firm productivities $\{z^H(i), z^F(i)\}_{i\in\{1,\ldots,I\}}$. The model's initial period will correspond to the year 1950, which is the first observation in the dataset. The initial period productivities are drawn from a log-normal distribution with normalized mean $\mu = 0$ and variance $\sigma_z^2$.

The period-by-period solution algorithm relies on initial guesses for aggregate expenditures, the foreign wage, the $4 \times I$ matrix of labor inputs, and the $1 \times I$ vector of threshold productivities. These guesses are partitioned into three groups, which are organized hierarchically and this structure is mirrored by the solution algorithm.

Given the total price-adjusted expenditures $P^{\sigma-1}(PY)$ and $P^{*\sigma-1}(P^*Y^*)$ in *Home* and *Foreign*, respectively, the foreign wage $w^F$, and the set of labor inputs $\{n^H(i), n^{*H}(i), n^F(i), n^{*F}(i)\}_{i\in\{1,\ldots,I\}}$, we find the threshold productivities $\tilde{\varepsilon}$ that satisfy equation (59) for each $i$ in step 1 of the algorithm.

Next, given the thresholds $\{\tilde{\varepsilon}\}_{i\in\{1,\ldots,I\}}$, we find the labor allocation $\{n^H(i), n^{*H}(i), n^F(i), n^{*F}(i)\}_{i\in\{1,\ldots,I\}}$ that satisfies the *ex ante* demand equations (44)-(50). This is the second step. We iterate over steps 1 and 2 to convergence of the productivity thresholds and labor inputs.

We then verify if $w^F$ satisfies the trade balance condition and whether the $P$, $P^*$, $Y$, and $Y^*$ implied by the solution in steps 1 and 2 satisfy the labor market clearing condition. This is the third step of the algorithm.

If necessary, we update $P^{\sigma-1}(PY)$, $P^{*\sigma-1}(P^*Y^*)$, and $w^F$ and iterate over the three-step procedure to convergence. In all three steps we use standard numerical methods to solve systems of non-linear equations.

## D. Regional Cost-of-Living Differences

One potential explanation of the Rust Belt's wage premium we document in Section 2 is that the cost of living was higher in the Rust Belt than elsewhere in the United States. To address this hypothesis, we draw on the study of the U.S. Bureau of Labor Statistics (1967) that estimates costs of living across 39 U.S. metropolitan areas and 4 regional averages of urban areas not already included in one of the metropolitan areas. Their estimates are not exactly cost of living differences, since they adjust the expenditure basket in each region to take into consideration e.g. higher heating costs in colder areas. But they do attempt to capture the cost of an average budget for a family of "moderate living standards" in each city in question.

Table D.1: Average Cost of Living in 1966, by U.S. City (U.S. = 100)

| | Region | | |
|---|---|---|---|
| | Rust Belt | Rest of Country | Difference |
| All cities | 100.4 | 99.1 | 1.3<br>(0.28) |
| Excluding non-metro areas | 101.1 | 99.8 | 1.3<br>(0.28) |
| Excluding Honolulu, HI | 101.1 | 98.8 | 2.2<br>(0.12) |
| Excluding New York, NY | 100.3 | 98.8 | 1.5<br>(0.22) |

Note: The table reports the average cost of living in 1966 for cities in the Rust Belt and in the rest of the country, constructed by the BLS (1967). The overall average cost of living in urban areas is set to be 100. The right-hand column is the simple difference between the Rust Belt and the rest of the country, and below that, a $p$-value of the $t$-test that the means are the same. The first row includes 39 cities and averages for 4 non-metropolitan areas, in the northeast, north central, south and west. The second row includes only the 39 cities. The third row excludes Honolulu, and the last excludes Honolulu and New York City.

To compare average costs of living in the Rust Belt and elsewhere, we classify each city as being in the Rust Belt or in the rest of the country. The Rust Belt cities are: Buffalo, NY; Lancaster, PA; New York, NY; Philadelphia, PA; Pittsburgh, PA; Champaign-Urbana, IL; Chicago, IL; Cincinnati, OH; Cleveland, OH; Dayton, OH; Detroit, MI; Green Bay, WI; Indianapolis, IN; and Milwaukee, WI. The other cities are Boston, MA; Hartford, CT; Portland, ME; Cedar Rapids, IA, Kansas City, MO; Minneapolis, MN; St. Louis, MI; Wichita, KS; Atlanta, GA, Austin, TX; Baltimore, MD; Baton Rouge, LA; Dallas, TX; Durham, NC; Houston, TX; Nashville, TN; Orlando, FL; Washington, DC; Bakersfield, CA; Denver, CO; Honolulu, HI; Los Angeles, CA; San Diego, CA; San Francisco, CA; and Seattle, WA.

Table D.1 reports the averages across all 43 cities and non-metropolitan areas, compared to the U.S. average for all urban areas, which is normalized to 100. The Rust Belt has an average cost of 100.4, compared to 99.1 outside of the Rust Belt, for a difference of 1.3 percentage points. The $p$-value of this difference is 0.28, indicating that the difference is statistically insignificant at any conventional significance level. The second row excludes the four non-metropolitan areas. Not surprisingly, the average cost of living is higher in both regions, as larger urban areas tend to be more expensive. The difference is still 1.3 and statistically insignificant. The third row excludes Honolulu, the city with the highest cost of living, at 122. This brings the average cost of living down in the rest of the county, and raise the difference to 2.2 percentage points, though the $p$-value is 0.12. The last row excludes New York City, which has the second highest cost of living, at 111. New York City is in the Rust Belt, according to our definition, but not often thought of as a "Rust Belt" city. The Rust Belt is now 1.5 percentage points more expensive than the rest of the country, with a $p$-value of 0.22.

In summary, in none of the sample restrictions is the Rust Belt more than two percentage points more expensive than the rest of the country, and in all cases the difference is statistically insignificant. This casts substantial doubt on the hypothesis that workers in the Rust Belt earned higher wages in order to compensate them for higher costs of living.

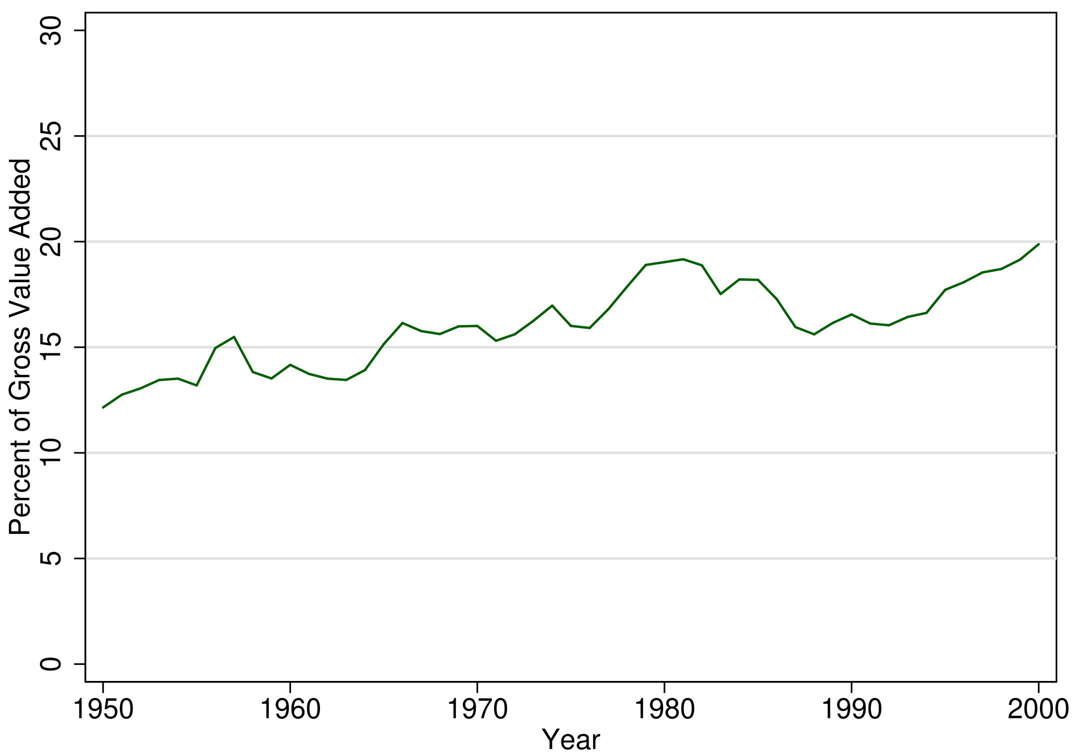
## Additional Tables and Figures

Table E.1: Elasticity of Moments to Parameters – Including Trade Parameters and Moments

| | $\lambda$ | $\sigma_{z,0}$ | $\alpha$ | s | $\tau_0$ | $\zeta_R$ | $\delta_\tau$ | $\sigma$ | $\phi_R$ | $\sigma_\epsilon$ | $\phi_S$ | $\rho$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R.B. initial empl. share | 2.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| Initial var. of log empl. | 0.0 | 2.1 | 0.0 | 0.0 | -0.1 | 0.0 | 0.0 | 3.0 | 0.0 | 0.0 | 0.0 | 0.3 |
| Labor productivity growth | -0.1 | 0.5 | -0.5 | 0.4 | 0.0 | 0.0 | 0.0 | 0.3 | -0.1 | 0.0 | 0.0 | -0.1 |
| Inv-to-VA ratio | -0.3 | 0.1 | 0.0 | 1.0 | -0.3 | 0.1 | -0.2 | -1.2 | -0.1 | 0.0 | 0.0 | -0.1 |
| R.B. import-to-sales, 1958 | -2.2 | -0.1 | 0.0 | 0.0 | -1.7 | 0.2 | -0.3 | -4.3 | 0.0 | 0.0 | 0.0 | -0.8 |
| R.B. import-to-sales, 1990 | -2.4 | -0.1 | -0.2 | 0.2 | -1.4 | 0.8 | -1.1 | -1.9 | 0.2 | 0.0 | 0.0 | -0.1 |
| Mfg import-to-sales, 1990 | 0.1 | 0.3 | -0.1 | 0.1 | -1.3 | 0.4 | -1.0 | -1.5 | 0.1 | 0.0 | 0.0 | -0.2 |
| Labor share | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.1 | 0.0 | 0.0 | 0.0 |
| R.B. wage premium | 1.2 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | -3.1 | 1.0 | -0.7 | 0.0 | -0.1 |
| Rust Belt work stoppages | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 1.2 | 1.3 | 0.0 | 0.0 |
| R.O.C. work stoppages | -0.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.0 | 1.2 | 0.2 | 0.2 |
| Reg. coeff: conflict | -0.6 | -0.4 | -0.2 | 0.6 | -0.2 | 0.6 | -0.2 | -3.5 | 1.0 | 0.0 | 0.0 | 2.4 |

Note: This table reports the elasticity of each moment to each parameter, calculated from one-percent numerical derivatives of each parameter starting from the calibrated parameter values. The largest elasticity (in absolute value) in each column is printed in bold faced. The largest elasticity (in absolute value) in each row is printed in underline. This table is the same as the one in the text but includes the elasticities of $\tau_0$, $\zeta_R$ and $\delta_\tau$ and the three import-share moments.

Figure E.1: Firm Investment-to-Value Added Ratio




Note: This figure plots the ratio of investment to value added in the U.S. corporate non-financial sector. The data come from the Federal Reserve Board's Financial Accounts of the United States.