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 region'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 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 includes foreign production and international trade. Foreign production 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 by way of 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 manufacturing value added, 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 10 percentage points, compared to 18 percentage points in the data. Thus, the model accounts for about 55 percent of the region's decline. Furthermore, the model is 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. The model also matches the evolution of labor's share of value added in manufacturing. The decline in the 1980s is brought about by the emergence of more cooperative labor-management relations and hence shrinking rents paid to unionized workers in the Rust Belt.

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 1 percentage point, which amounts to 5 percent of the drop observed in 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.

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) and Farber et al. (2021) examine the relationship between unions and income inequality. None of these papers, however, relate labor conflict to the decline of the Rust Belt.

The focus of our model on unionized labor markets builds on a growing literature that connects lack of competition to poor economic performance (see e.g. Pavcnik 2002; Aghion et al. 2005; Cole et al. 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 by introducing foreign competition as an alternative source of the region's decline. Section 5 discusses the parameterization and analyzes the model quantitatively. Section 6 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 line), 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 employment

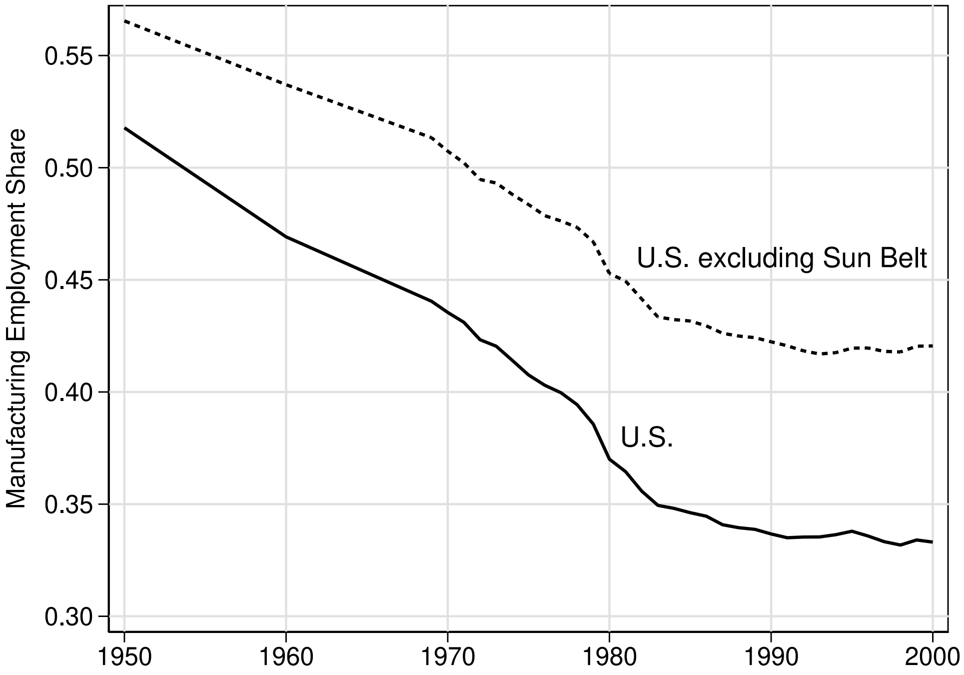

Figure 1: The Rust Belt's Manufacturing Employment Share

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 line) 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. He finds faster employment growth in counties located in Right-to-Work states relative to nearby counties located in ”No-Right-to-Work” states.

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 located in the Rust Belt. Moreover, manufacturing employment in every single Rust Belt state dropped relative to the rest of the country.

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 2, 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 4.6 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 1.4 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 line. This simple wage premium started out at 13 percent in 1950, stayed between 12 and 16 percent through 1980, and then fell to 5 percent by 2000.

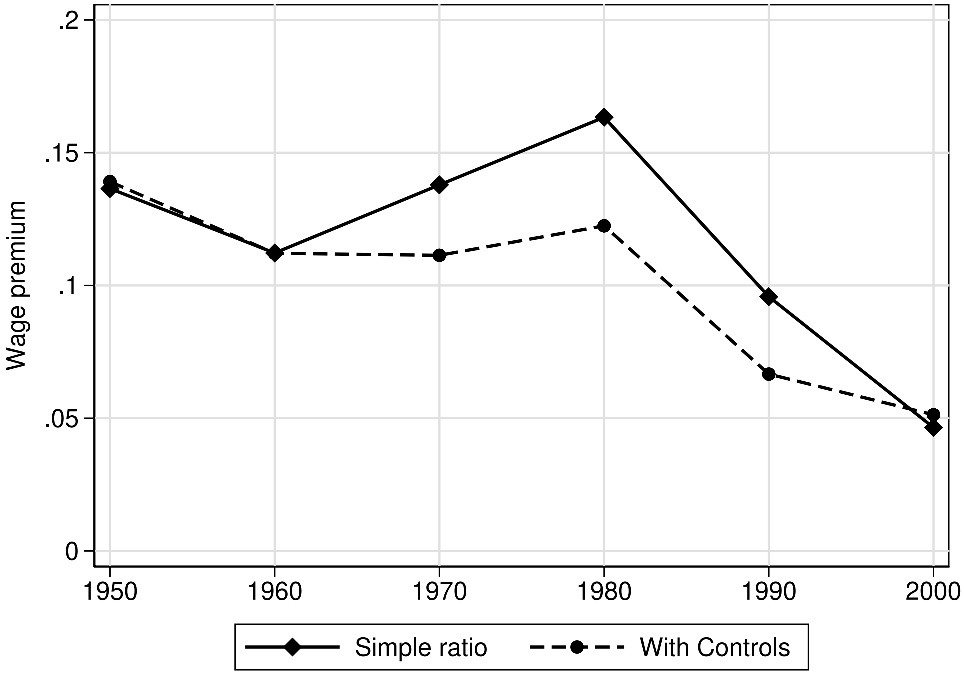

Figure 2: Wage Premium in Rust Belt Manufacturing

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 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 during this period.

Another possible factor affecting the wage premium is that the cost of living was higher 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 Online 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. In his survey chapter on union behavior, Farber (1986) characterizes unions as organizations that bargain over industry rents in the form of wage premia. Moreover, they ration scarce, high-paying union jobs in order to sustain these 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.

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 between 1979 and 1986. The strike rate stayed low permanently after 1986.

This change in labor relations and the drop in the Rust Belt wage premium discussed in section 2.3 reflect the political economy of organized labor during this time. Legislation and judicial decisions gradually reduced union bargaining power. The Taft Hartley Act of 1947 allowed states to operate as "Right-to-Work" states, in which union membership is not a requirement for employment. States outside the Rust Belt gradually adopted "Right-to-Work" laws, which turned these states into lower-cost locations for production.

The Supreme Court's 1965 *Textile Workers vs. Darlington Manufacturing* decision also contributed to the reduction in labor's bargaining power. Darlington closed one of its busi-

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[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 2002). 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).

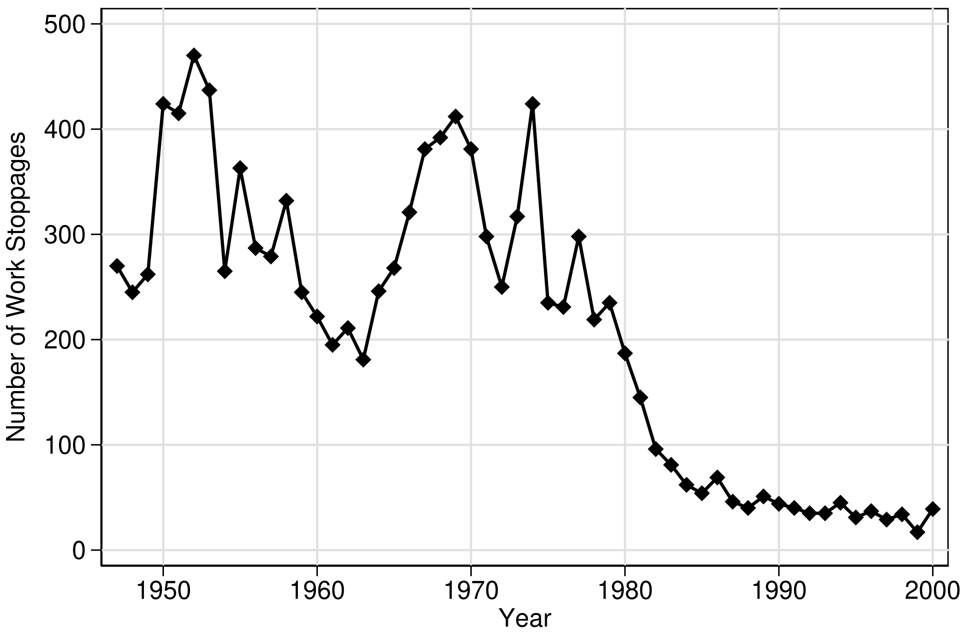

Figure 3: Major Work Stoppages in the United States

nesses (a single plant) after the plant's workers opted for union representation. The Supreme Court held that a business could legally shut down operations, even if the proximate reason was union animus, and even if the plant's owner was the owner of multiple plants. In doing so, the Supreme Court upheld an Appellate Court ruling that reversed a National Labor Relations Board decision, which characterized Darlington's shutdown as an unfair labor practice. The decision gave rise to an implicit threat of shutdown in response to union organization or union actions that management did not support.

Perhaps the single most important political economy change was President Reagan's decision to fire striking aircraft controllers in 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). It is widely agreed 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. While the retention of replacement workers had been a fair labor practice since the Supreme Court's 1938 decision in *NLRB vs. MacKay Radio*, it was not widely used until the 1970s. The Reagan administration's decision in 1981 solidified the practice and was viewed as a substantial blow to labor unions. 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.

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.[2] This is also consistent with our theory that the Rust Belt's wage premia were related to labor conflict since the decline in bargaining power coincides with the dwindling of the wage premium from 12 percent in 1980 to around 5 percent by 2000 (see Figure 2).

All of these political economy developments motivate our interpretation of the changes in the Rust Belt's strike frequency and relative wages as reflecting legal and institutional shifts, which we build into the quantitative model and analysis in Sections 4 and 5.

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 1 presents a set of five regressions that explore the correlates of state-industry employment growth rates. The main outcome of interest is the log of employment growth 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 is -0.86 and it is statistically significant at the one-percent level. The coefficient is economically significant as well: one more work stoppage per year is equivalent to 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,

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[2] Direct evidence corroborates this interpretation. 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).

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 0.178, up from 0.035 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 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 0.378, 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 1 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.[3]

The evidence so far establishes a robust correlation between labor conflict and employment growth but does not prove a causal relationship. In particular, it does not rule out the possibility that the prospect of future job losses prompted unions to unionize more aggressively or to go on strike more frequently. To address this potential reverse-causality concern we consider an alternative measure of conflict that long predated post-war employment growth, namely strikes that occurred between 1927 and 1934, in Online Appendix A.3. We compiled this measure of early labor conflict 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.

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[3] Online 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.

3. Simple Model of Labor Conflict and Regional Decline

In order to highlight the role of unionized 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.

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 σ is the elasticity of substitution. By assumption, these intermediates are gross substitutes ($\sigma > 1$). Intermediate firms are indexed by i and use labor to produce a single intermediate good:

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

where $n_t(i)$ is labor input, $z_t(i)$ is the productivity level of the firm producing good i, 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 regard 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 λ 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 retained current profits to increase its productivity in the following period. The remainder is disbursed to the households in the form of dividends.[4] 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 α 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.

This cost function delivers balanced growth when the two regions have symmetric labor markets and there is no labor conflict. The relative productivity term, $\left(\frac{z_t(i)}{\mathcal{Z}_t}\right)^{\sigma-1}$, implies that firms with lower than average productivity can catch up to the technological frontier at lower cost. This catch-up effect is exactly offset by the fact that low-productivity firms generate less profit. Together with the catch-up effect, this market-size effect implies that the growth rate of $x_t(i)$ is independent of the firm's productivity level $z_t(i)$ and growth is balanced, in expectation.

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[4] A previous version of the paper considered fully dynamic firm investment decisions (see Alder, Lagakos, and Ohanian 2014). 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.

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

Let us first characterize the problem of a firm in the Rest-of-the-Country, where labor markets are competitive. This firm chooses a price $p_t(i)$, output $y_t(i)$, and labor input $n_t(i)$ to maximize 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 over marginal cost:

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

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 $X_t = \frac{\sigma}{\sigma-1}$. The final good price is given by the ideal price index $P_t = \left(\int_0^1 p_t\left(i\right)^{1-\sigma} di\right)^{\frac{1}{1-\sigma}}$.

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 equals the sum of w_t and 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 to do so (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 exogenous share is denoted $\phi \in (0, 1]$. In terms of output, employment, and prices, the occurrence of a strike is isomorphic to a multiplicative productivity shock $(1-\kappa)$ and the post-strike profit is given by $\underline{\pi}_t(i) = \left(\frac{\sigma}{\sigma-1}\frac{w_t}{P_t}\frac{1}{(1-\kappa)e^{\varepsilon_t(i)}z_t(i)}\right)^{1-\sigma}\frac{X_t}{\sigma}$. Following the arbiter's decision, the strike ends, production takes place using the remaining time available $(1 - \kappa)$, and the period ends. The union receives $\phi\underline{\pi}_t(i)$ and the firm retains $(1 - \phi)\underline{\pi}_t(i)$.[5]

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, which implies that some Rust Belt firms experience strikes in a given period while others do not. Firms in the Rest of the Country do not have strikes.

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

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[5] 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.

in the competitive labor market. The union distributes $R_t(i)$ or $\phi\underline{\pi}_t(i)$, depending on whether a strike takes place, equitably among the $n_t(i)$ workers at firm i.

It follows that Rust Belt workers in the model earn the competitive wage plus a "union premium" while Rest-of-the-Country workers earn the competitive wage only. Clearly, workers strictly prefer union jobs and we specify how workers apply for union membership in the next section.

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.

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

The proof is in Online Appendix B.2. Here we outline the main properties of the model leading to Proposition 1 and the intuition for the results.

We solve the union problem by backward induction. Let $\tilde{R}_t(i)$ denote the union's offer that makes the firm indifferent between acceptance and rejection at the final stage of the bargaining protocol. Formally, $\tilde{R}_t(i)$ is such that $\pi_t(i) - \tilde{R}_t(i) = (1-\phi)(1-\kappa)^{\sigma-1}\pi_t(i)$. Recall that $\pi_t(i)$ is a function of the idiosyncratic productivity shock $\varepsilon_t(i)$ and we can characterize the offer that satisfies the firm's indifference condition as a function of this shock: $\tilde{R}_t(i) \equiv \mathcal{R}\left(\varepsilon_t\left(i\right)\right)$.

Note that $\mathcal{R}$ is increasing in $\varepsilon_t(i)$ and according to equation (24) in Online Appendix B.1, the probability of a strike associated with a particular offer $R_t(i)$ is given by:

$$\begin{aligned} \tilde{F}\left(R_t\left(i\right)\right) &\equiv \Pr\left(R_t\left(i\right) > \tilde{R}_t\left(i\right)\right) \\ &= \frac{\mathcal{R}^{-1}\left(R_t(i)\right) - \underline{\varepsilon}}{\overline{\varepsilon} - \underline{\varepsilon}}. \end{aligned} \tag{10}$$

Aggressive offers are more likely to lead to a strike, and equation (10) captures this relationship. At the offer stage, the union will propose a rent $R_t(i)$ that maximizes its payoff *ex ante*. Formally, the union solves:

$$\max_{R_t(i)} \left(1 - \frac{\mathcal{R}^{-1}\left(R_t(i)\right) + \overline{\varepsilon}}{\overline{\varepsilon} - \underline{\varepsilon}}\right) R_t(i) + \frac{\mathcal{R}^{-1}\left(R_t(i)\right) + \overline{\varepsilon}}{\overline{\varepsilon} - \underline{\varepsilon}} \phi(1-\kappa)^{\sigma-1} \int_{-\overline{\varepsilon}}^{\mathcal{R}^{-1}(R_t(i))} \pi_t(i) f(\varepsilon_t(i)) d\varepsilon_t(i), \tag{11}$$

The first-order condition with respect to $R_t(i)$ yields the union's optimal offer:

$$R_t^*(i) = \left(1-(1-\phi)(1-\kappa)^{\sigma-1}\right)\frac{X_t}{\sigma}\left(\frac{\sigma-1}{\sigma}\frac{P_t}{w_t}z_t(i)e^{\bar{\varepsilon}}\right)^{\sigma-1} e^{-\frac{1-(1-\kappa)^{\sigma-1}}{1-(1-\phi)(1-\kappa)^{\sigma-1}}}, \quad (12)$$

where we take into account that $\varepsilon_t(i)$ is distributed uniformly on $[-\bar{\varepsilon}, \bar{\varepsilon}]$. According to (12), the equilibrium rent is increasing in the union's bargaining power ϕ. Unions extract bigger rents for themselves when they expect to get more in the event of a work stoppage, which is resolved by arbitration.

In equilibrium, one can show that the probability of rejection, and hence, a strike, is given by:

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

Equation (13) implies that the work stoppage rate does not depend on the firm's productivity $z_t(i)$. Moreover, the strike frequency is increasing in the union's bargaining power ϕ. Proposition 1 thus provides an equilibrium link between union bargaining power in the model and two observables in the data: wage premia and strikes. This link forms the basis for the parameterization of the quantitative model in sections 4 and 5.

Now that we have a sharp characterization of $R_t^*(i)$ in equation (12) and $\tilde{F}\left(R_t^*\right)$ in equation (13) we can describe the union membership application process.

Thanks to the wage premium associated with union membership, workers strictly prefer Rust Belt jobs over jobs elsewhere. The union, however, restricts membership to workers who will actually be employed by Rust Belt firms in order to maximize their members' wage premium. The size of this rent and hence the rent *per worker* at a particular firm i depends on the size of the firm and 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.

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

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

where ε^* is the value of the transitory shock given by $\varepsilon^* = \mathcal{R}^{-1}\left(R_t^*(i)\right)$. If the realized productivity is below this threshold, the firm rejects the union's offer and the union calls a strike.

Recall that according to (13), the probability of a strike is equalized across firms. Let this probability be $\tilde{F}$. In addition, it is straightforward to show that $\frac{R_t^*(i)}{E(n_t(i)|\varepsilon_t(i)\geq\varepsilon^*)}$ is equalized across firms. $R_t^*(i)$ and expected employment are both proportional to $z_t(i)^{\sigma-1}$ and the result follows immediately. A detailed proof is available in Online Appendix B.3. Let this constant *per worker* rent be denoted by r^*. Moreover, the constant markup-up-over-marginal-cost rule implies that $\frac{\phi E(\pi_t(i)|\varepsilon_t(i)<\varepsilon^*)}{E(n_t(i)|\varepsilon_t(i)<\varepsilon^*)} = \frac{\phi}{\sigma-1}$. Clearly, the union wage premium is equalized *ex ante* across all Rust Belt firms.

If the queue of job applicants $q_t(i)$ is longer than the number of available jobs at firm i, the union will select workers at random. Workers who miss out on a union job can instead accept a non-union job immediately, but they suffer a disutility $\bar{u}$ from queuing in vain. In equilibrium, the length of the queue at firm i is given by:

$$q_t(i) = E\left(n_t\left(i\right)\right)\left(1 + \frac{\left(1-\tilde{F}\right)r^* + \tilde{F}\frac{\phi}{\sigma-1}}{\bar{u}}\right). \tag{14}$$

Clearly, higher wage premia lead to longer queues and higher utility costs associated with a failed bid for admission to the union will shorten the queue. As long as the wage premium is positive, however, the queue is always longer than the expected number of available jobs at each firm (see Online Appendix B.4 for more details).

3.6. Equilibrium Employment Dynamics

The model also links labor conflict to regional employment dynamics and we formalize this relationship in a second proposition.

Proposition 2 *Expected investment is lower in Rust Belt firms than in Rest-of-the-Country firms. The aggregate employment share of Rust Belt firms is falling provided* $\phi \in (0, 1]$.

The proof is in Online Appendix B.3. To see how labor-management bargaining and strikes reduce investment in Rust Belt firms, let us first consider 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 reduced by $R_t(i)$. Since investment is a fixed fraction of profits, it follows that investment is lower for a Rust Belt firm that accepts the union's offer than for a similar Rest-of-the-Country firm 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:

$$x_t(i) = \begin{cases} \left(s\pi_t(i)\frac{\mathcal{Z}_t^{\sigma-1}}{\alpha z_t(i)^{\sigma-1}}\right)^{1/2} & \text{if the firm faces no union,} \\ \left(s\big(\pi_t(i) - R_t^*(i)\big)\frac{\mathcal{Z}_t^{\sigma-1}}{\alpha z_t(i)^{\sigma-1}}\right)^{1/2} & \text{if the firm accepts,} \\ \left(s(1-\phi)(1-\kappa)^{\sigma-1}\pi_t(i)\frac{\mathcal{Z}_t^{\sigma-1}}{\alpha z_t(i)^{\sigma-1}}\right)^{1/2} & \text{if the firm rejects.} \end{cases} \tag{15}$$

Equation (15) 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 intermediate goods are gross substitutes, final good producers choose to substitute away from higher cost intermediates toward lower cost ones. Over time, this leads to a shift in labor demand from regions with low productivity growth to those with high productivity growth, as in models of structural change (Herrendorf, Rogerson, and Valentinyi 2014). Proposition 2 states that the relatively low investment rates in the model's Rust Belt give rise to the relocation of production and employment to other regions.

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 foreign production 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 ϕ, is constant over time. In order to account for the regional variation in labor conflict reported in Table 2 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. Online Appendix C. contains the complete equations of the model.

4.1. International Trade

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 country 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:

$$y(i) = \left(y^H(i)^{\frac{\rho-1}{\rho}} + y^F(i)^{\frac{\rho-1}{\rho}} \right)^{\frac{\rho}{\rho-1}}, \tag{16}$$

where ρ 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:

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

$$\tau y^{*H}(i) = (1 - k(i))\, z^H(i) e^{\varepsilon^H(i)} n^{*H}(i), \tag{18}$$

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:

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

$$y^{*F}(i) = z^F(i) n^{*F}(i). \tag{20}$$

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:

$$p^H(i) = \frac{\varepsilon^H(i)}{\varepsilon^H(i) - 1} \frac{1}{z^H(i) e^{\varepsilon(i)}}, \tag{21}$$

where

$$\varepsilon^H(i) \equiv \left(\omega^H(i)\frac{1}{\sigma} + (1 - \omega^H(i))\frac{1}{\rho}\right)^{-1} \tag{22}$$

and

$$\omega^H(i) \equiv \frac{p^H(i)y^H(i)}{p(i)y(i)}. \tag{23}$$

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 (23) 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.

4.2. Labor Market, Bargaining, and Strikes

To capture the evolution of work stoppages in Table 2 and Figure 3, we add two time-varying parameters that govern the extent of labor conflict in each region: ϕ_t^R is the union's bargaining power in the Rust Belt at time t and ϕ_t^S is its counterpart elsewhere at the same time. This implies that *all* workers earn a premium over the competitive wage. Rust Belt workers earn an *excess* premium provided $\phi_t^R > \phi_t^S$, which is the empirically relevant case here. Thanks to this excess premium, workers have a preference for Rust Belt jobs and the number of applicants will again exceed the number of available jobs at each firm. Just like in the simple model, the union randomly selects workers from the queue of applicants and those who fail in their bid for membership will be employed by a Rest-of-the-Country firm.

In equilibrium, firms hire the amount of labor that maximizes their expected profits taking into account that the markup they can charge is a function of the firm's market shares at home and abroad. The bargaining protocol mirrors the procedure in section 3.4 with three exceptions: (1) labor inputs are now chosen *before* the idiosyncratic productivity shock $\varepsilon_t(i)$ is realized, (2) the shock $\varepsilon_t(i)$ is distributed normally rather than uniformly, and (3) the parameter that splits the surplus at the arbitration stage varies across regions and over time.[6] In this quantitative version of the model with variable markups, we can

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[6] 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 multiplicative 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.

no longer characterize the union's offer $R_t(i)^*$ analytically. We can, however, show that the optimal offer is unique (see Online Appendix C.).

Domestic investment, and the evolution of the firms' productivity is identical to the simple economy in Section 3. The law of motion is again 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 next period.

5. Quantitative Analysis

We now parameterize the quantitative version of the model and use it to assess the 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 one force at a time.

5.1. Parameterization and Model Validation

We choose a model period to represent one year since most of our data are available at the 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 we run comparable regressions in the model and in the data. We set the duration of a work stoppage, κ, to 0.12 in order to match the average duration of 43.7 days in the Kennan (1986) data 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: (1) the Rust Belt's share of manufacturing employment in 1950, which is 51.3 percent; (2) the variance of state-industry log employment in 1950, which is 3.2; (3) the average investment-to-value added ratio in the U.S. corporate non-financial sector from 1950 to 2000, which is 16 percent; and (4) the average growth rate of real labor productivity in U.S. manufacturing, which is 2.8 percent per year. The first two are based on our own calculations. The third is from the U.S. Federal Reserve (see Online Appendix Figure A.1) and the fourth is from the NBER-CES productivity database.

The next three moments relate to international trade in manufactured goods: (1) the import-to-sales ratio in the Rust Belt in 1958 (4.5 percent), (2) the same ratio in 1990 (58.7 percent), and (3) the *aggregate* U.S. import-to-sales ratio 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 the stylized fact that import shares were uniformly low at first and then rose significantly over the period, and particularly so in the 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: (1) the average labor share of value added in manufacturing from 1950 to 1980, which is 71 percent and taken from the BLS; (2) the average Rust Belt wage premium of 12 percent from 1950 through 1980 (as in Figure 2); (3) the rate of work stoppages in manufacturing in the Rust Belt from 1958 to 1977 (19.2 percent, reported in Table 2), (4) the same rate of stoppages in the rest of the country (2.6 percent); and (5) 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 1.

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 1. 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, all reported in Table 4, are: λ, the share of goods produced in the Rust Belt; σ_z^2, the standard deviation of log initial firm productivities across goods; α, the linear term in the investment cost function in equation (5); s, the fraction of firm profits invested; τ_0, the initial value of the iceberg trade cost; δ_τ, the annual growth factor of the trade cost; ζ_R, the productivity growth boost in foreign varieties of Rust Belt goods; ϕ_R and ϕ_S, the unions' bargaining power at the arbitration stage in the Rust Belt and in the rest of the country; σ_ε^2, the variance of the firm productivity shocks, $\varepsilon(i)$; σ, the elasticity of substitution between goods; and ρ, 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. The 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 ϕ_R and ϕ_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, ζ, 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 1.14. This is required to match 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 4 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 ϕ_R = 0.44 and ϕ_S = 0.02. This large differential is important because it governs the quantitative importance of the labor conflict channel in the model.

Two parameter values that naturally invite comparison to the previous literature are σ, the elasticity of substitution between goods, and ρ, the elasticity of home and foreign varieties of each good. Our calibrated values of σ = 2.54 and ρ = 2.76 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.

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, with all twelve moments matched to within one decimal place.[7]

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[7] In Appendix C. we provide a detailed discussion of how we view each parameter as being identified from the data. To do so we compute the numerical elasticity of each moment with respect to each model parameter starting from the calibrated parameter values. In short, the moments that are most responsive to each parameter are, for λ, the initial Rust Belt employment share; for α, the average growth; for s, the investment-to-VA ratio; for σ_ε, the variance of firm productivity shocks, for σ_z, the initial variance in employment across goods; for σ, the labor share of GDP; for ρ, the cross-sectional regression coefficient; for ϕ_R and ϕ_S, the work stoppage rate in the Rust Belt and the rest of the country.

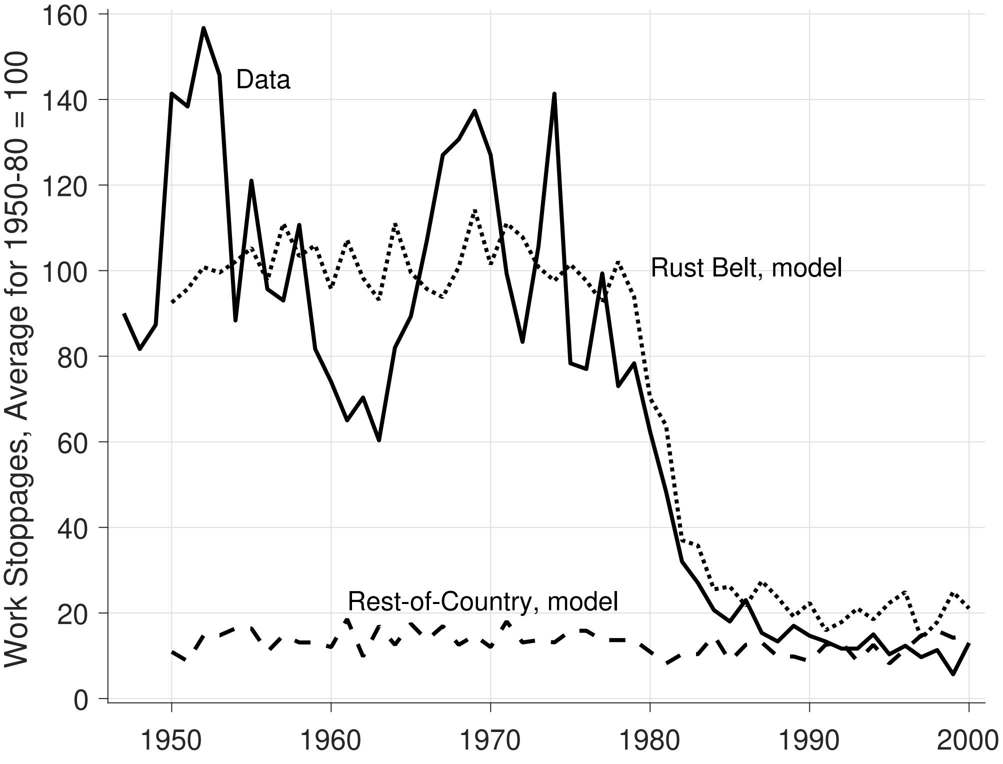

Figure 4: Work Stoppages in Model and Data

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 predicts that virtually all of the decline comes from the Rust Belt. Given that the vast majority of all work stoppages before 1980 occurred in the Rust Belt (see Table 2), a decline in the data of the magnitude shown in Figure 4 must be driven by a drop in that region empirically.

Figure 5 displays the import-to-sales ratios in the model and data. The solid line plots the import share for the manufacturing sector as a whole, and the dotted line plots the import share for the Rust Belt. The calibrated import shares generated by the model are shown by the dashed line (for U.S. manufacturing) and the dash-dotted line (for Rust Belt manufacturing). Our calibration strategy with respect to imports matches the data fairly

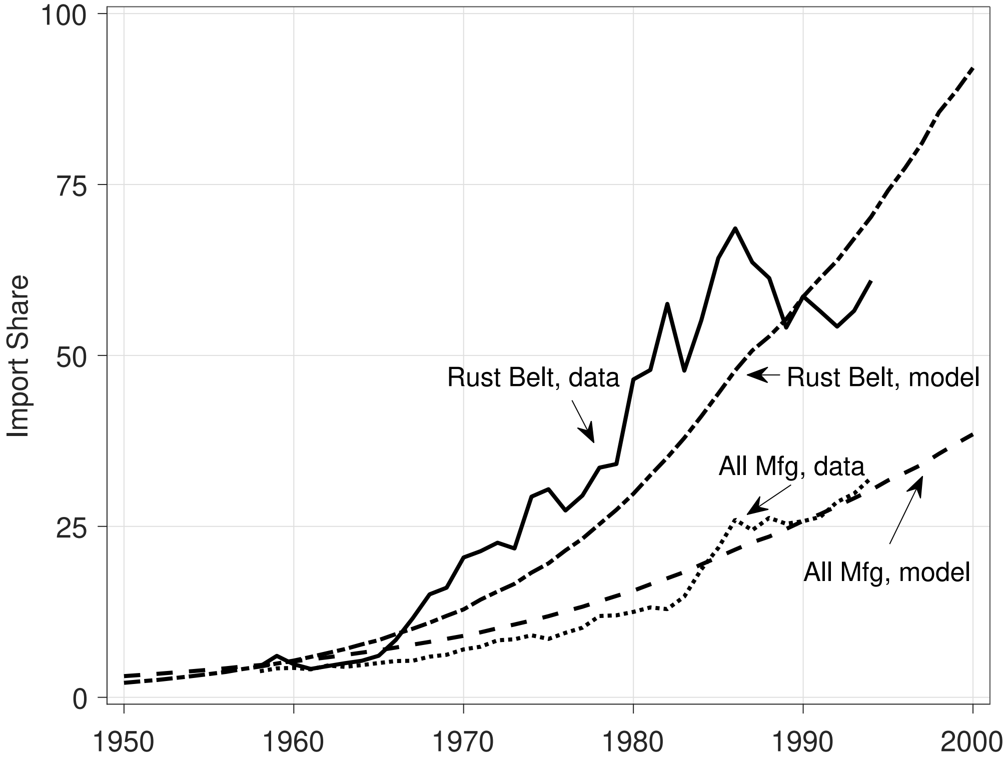

Figure 5: Import Shares in Model and Data

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 underpredicts the Rust Belt's import share somewhat until 1990, overpredicts 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 1.6 percent. This elasticity is well within the (wide) range suggested by the trade literature, and close to the range of estimates in a recent study by Boehm, Levchenko, and Pandalai-Nayar (2020). They report long-run elasticities of around -1.8 to -2.3.

5.2. 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 (dashed line) and its empirical counterpart (solid 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 10.0 percentage points,

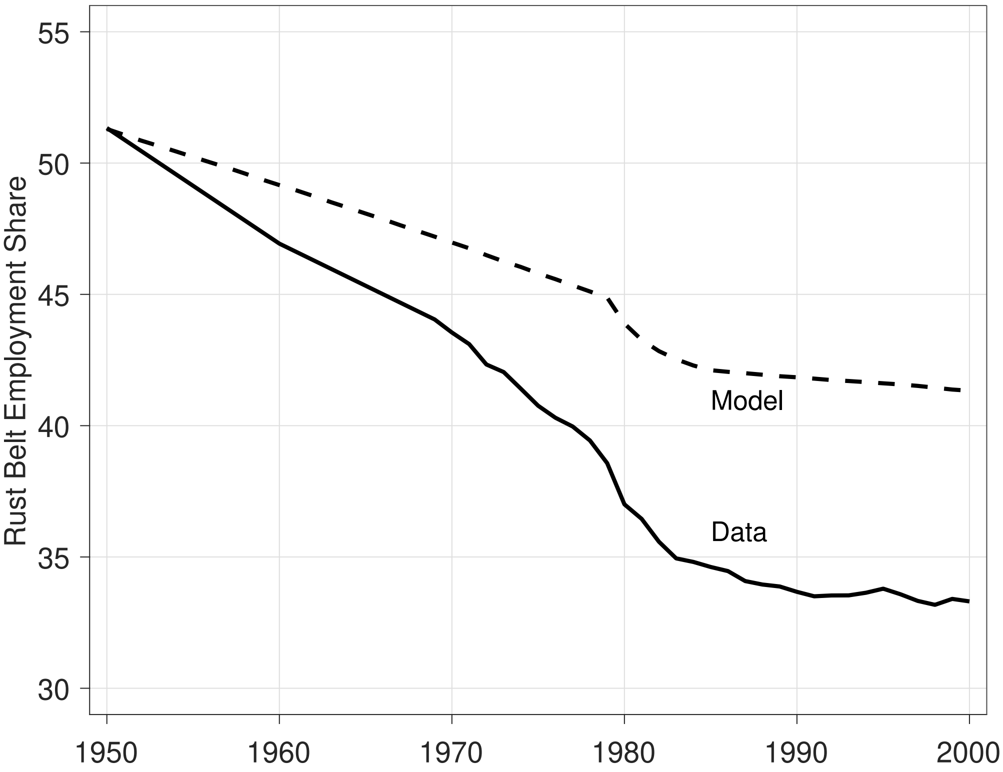

Figure 6: Rust Belt's Decline in Model and Data

compared to 18.3 percentage points in the data. Thus, the model accounts for 54.6 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 9.2 percentage points until 1985, compared to 16 percentage points in the data. From 1986 on, the model generates an additional decline of around 0.8 percentage point, compared to two percentage points in the data. The productivity growth rate in the model is 0.3 percentage point lower per year, on average, in the Rust Belt before 1985. After 1985, the extent of labor market conflict is similar across the two regions and the average productivity growth rates are nearly identical. This is why the Rust Belt's employment share stabilizes around this time.[8] As we argue further below, the lower productivity growth rates in the Rust Belt before 1985 are qualitatively consistent

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[8] Our cost function, equation (5), has the property that firms in the two regions grow at the same rate, on average, when $\phi_R = \phi_S$ and there is no international trade. In the open economy version here, the variable markups associated with Cournot competition between domestic and foreign producers imply that growth is not necessarily balanced. However, since the values of σ and ρ are fairly close, this market size effect on firm growth rates is quantitatively small and firms in the two regions grow at similar rates once ϕ_R falls in the 1980s.

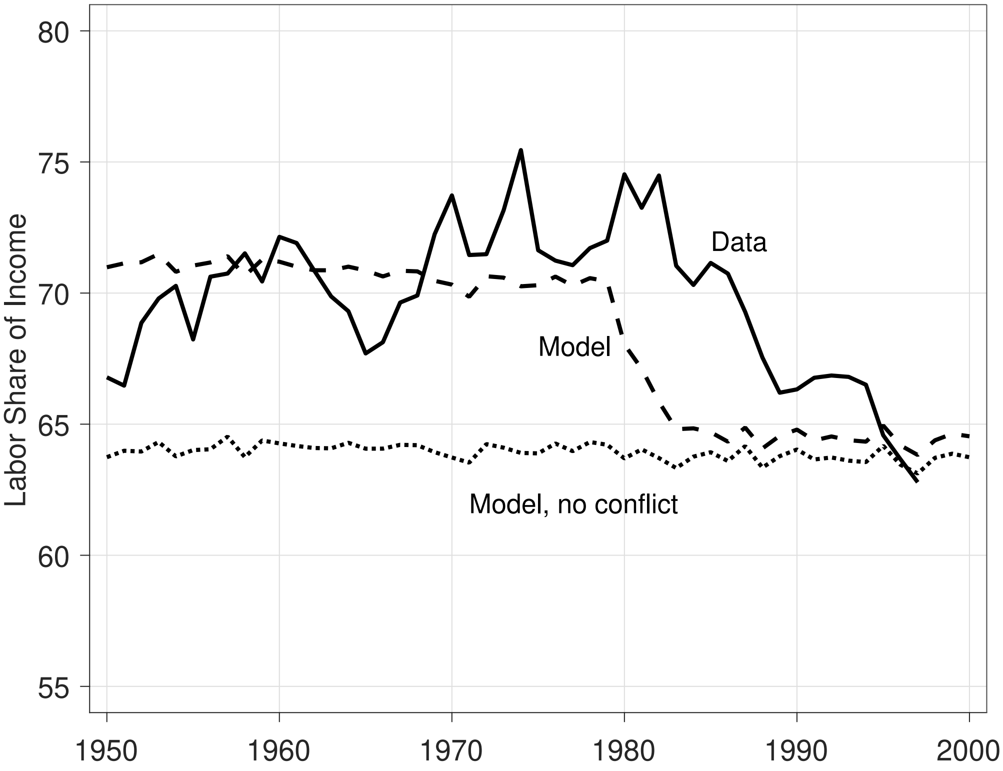

Figure 7: Labor's Share of Value Added in Manufacturing

with the empirical evidence on industry productivity.

Our model also makes predictions for labor's share of value added in the manufacturing sector, measured as total compensation of manufacturing workers divided by value added in the manufacturing sector. Figure 7 plots this labor share in the data (solid line) and in the benchmark calibration (dashed line). The model matches the average level of 70.7 percent from 1950 to 1980 by construction, with annual variation in the model determined by the productivity (and strike) realizations of the model industries. The share starts to decline in the 1980s thanks to a drop in labor conflict and levels off at around 64 percent afterwards. In the data, the share also declines substantially after the 1980s, though somewhat later than in the model, and it ends at 63 percent in 1997.

To better understand the forces driving the Rust Belt's decline, we conduct four counterfactual simulations. In the first, we keep the labor conflict channel but eliminate the exogenous shift of the international comparative advantage that could have reduced the Rust Belt's share of employment within the United States. To do so, we solve the model with a value of ζ_R equal to one. This implies that changes in the Rust Belt's comparative advantage are entirely self-inflicted since they are solely driven by the difference between ϕ_R and ϕ_S, which leads to higher rates of work stoppages and wage premia in the model's

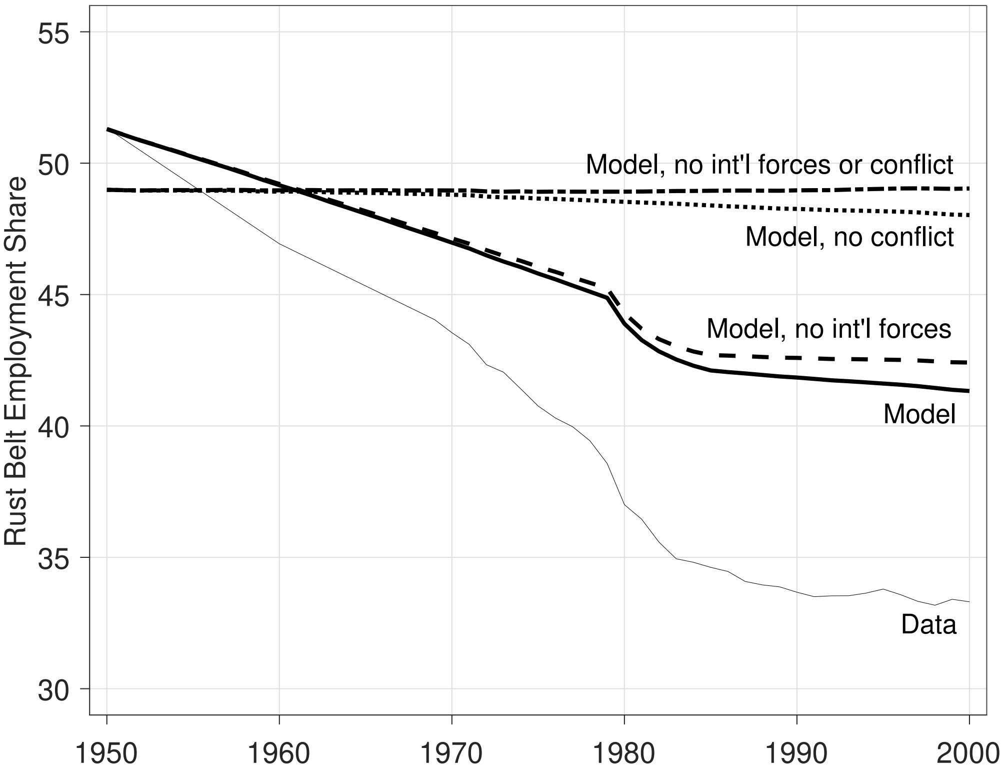

Figure 8: Decomposing the Rust Belt's Decline

Rust Belt, and hence lower rates of investment and productivity growth.

The dashed line in Figure 8, marked "Model, no int'l forces," 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 8.9 percentage points. This amounts to 49 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 (solid line, labeled "Model") and the empirical employment share (thin solid line, labeled "Data"). Clearly, the model featuring 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 eliminates the labor-market conflict gap. That is, this counterfactual sets $\phi_R = \phi_S$ = 0.02, but returns ζ_R to a value of 1.04, the same as in the main calibration. This counterfactual is plotted as the dotted line in Figure 8 labeled "Model, no conflict." 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 when strikes are largely eliminated. What is the intuition for this result? When strikes are (more) likely, firms hire additional workers to minimize the cost of lost production in terms of reduced market share and lower markup over marginal cost when 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 1 percentage point from 1950 to 2000, amounting to only 5 percent of the decline observed in the data.

Furthermore, the timing of the decline driven by international forces alone 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.[9]

Finally, this counterfactual predicts a fairly constant labor income share of 64 percent across the five decades (dotted line in Figure 7), which is counterfactually low for the period before the 1980s, during which labor's share was approximately 7 percentage points higher, on average. In our model, this gap – which is equivalent to about 10 percent of labor income – mostly reflects the value of lost rents for Rust Belt workers.

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 fell victim to global changes outside its control. International forces may have muted the strength of the recovery 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.

The third counterfactual shuts down both labor market conflict and the exogenous rise in comparative advantage for foreign producers of varieties of Rust Belt goods. We do this by setting $\phi_R = \phi_S = 0.02$ and $\zeta_R = 1$. All other parameter values are kept unchanged. The result is depicted as the dash-dotted line in Figure 8 labeled "No int'l forces or labor conflict." In this counterfactual, the Rust Belt's share of employment increases marginally by 0.1 percentage points between 1950 and 2000. The key implication is that the Rust Belt's share of employment would not have changed much on its own without

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[9] Autor, Dorn, and Hanson (2013a, 2013b) 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).

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 in the Rust Belt been the same 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.

The fourth, and final, counterfactual experiment captures the implications of a scenario where the Taft-Hartley Act of 1947 is never passed by Congress and unions in the Rest-of-the-Country gradually catch up to their Rust Belt counterparts in terms of the bargaining power ϕ_S. Formally, we assume that ϕ_S increases from 0.02 in 1950 to 0.22 in 2000, which is the halfway point between the original value of ϕ_S and ϕ_R (0.44), as in Figure A.3 in Online Appendix G. This process limits the firms' ability to escape the Rust Belt unions by relocating production to a "Right-to-Work" state and potentially lowers the pace of the Rust Belt's decline between 1950 and 2000.

The Rust Belt's employment share drops to approximately 42 percent by 2000 in this counterfactual simulation, which is similar in magnitude to the decline in the benchmark parameterization (see Figure A.4 in Online Appendix G.). The reason for this result is that firms outside the Rust Belt begin to stockpile more labor as the unions' bargaining power increases in order to minimize the loss of market share in the event of a strike. This rise in "featherbedding" largely offsets the effects of a narrower investment gap. The income share of labor in manufacturing associated with this experiment gradually rises from 71 percent in 1950 to 74 percent by 2000 (see Figure A.5 in Online Appendix G.), which is at odds with the empirical evidence.

Even though the Rust Belt's decline in this counterfactual is similar to the benchmark experiment, the implications for aggregate productivity growth are substantively different. The average annual rate of productivity growth in this experiment is 2.6 percent between 1950 and 2000, compared to 2.8 percent in the benchmark calibration. Aggregate productivity, which captures the cumulative effect of the annual 0.2 percentage point growth gap, is 9.3 percent lower in 2000.

5.3. Sensitivity Analysis

To better understand how sensitive the quantitative results are to other model features, we calibrate the model under several alternative assumptions. These sensitivity analyses are summarized in Table 5. 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 9.9 percentage-point decline in the Rust Belt's manufacturing employment share, or 54.3 percent of the data. This is only slightly lower than the 54.6 percent in the benchmark calibration, which highlights how the model's quantitative predictions are robust 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 Online Appendix Figure A.1). The benchmark calibration 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 10.1 percentage points, or 55.3 percent of the actual decline. The gradual increase in investment rates observed in the data thus has only a modest impact on our results.

In the final sensitivity analysis we add an additional decade of conflict. We consider this scenario because even though rates of conflict began to decline 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 an extra decade of labor conflict in our model, approximately. In this scenario, the model predicts an 11.7 percentage point decline in the Rust Belt's employment share, which amounts to 64.1 percent of the region's actual losses. Since the benchmark calibration assumes a fairly early improvement in labor-management relations it may underestimate the magnitude of the region's decline that is due to labor conflict.

5.4. Regional Productivity & Investment Evidence

Our model predicts that investment and productivity growth rates were lower in Rust Belt industries, particularly before the 1980s, when labor conflict was most severe. Unfortunately, there are no comprehensive data on investment and productivity by region and industry that allow us to test this model prediction directly.[10] There is, however, supportive evidence for individual industries.

Collard-Wexler and De Loecker (2012) draw on plant-level census data to measure TFP growth in the steel industry. It was dominated by vertically integrated mills located primarily in the Rust Belt. Minimills, on the other hand, were concentrated in the U.S. South. The authors find that TFP growth from 1963 to 1982 was actually *negative* in the U.S. steel industry, falling by a cumulative 11 percent. In contrast, TFP in minimills was growing at a rate of 19 percent over the same period. After 1982, TFP growth for the steel sector as a whole rebounded sharply, rising a cumulative 37 percent through 2002. In this period, TFP in the minimills increased by 18 percent, suggesting that most of the growth in U.S. steel manufacturing productivity took place in the integrated mills (see Table 10). This is consistent with the model's predictions that Rust Belt producers had lower productivity growth than their counterparts in other parts of the country before the 1980s, with relatively faster growth afterwards.

Historical accounts of the steel industry attribute at least some of this lackluster productivity growth to the slow adoption of arguably the two most important new technologies in the decades after WWII: the basic oxygen furnace and the continuous casting method (see, for instance, Lynn 1981; Oster 1982; Tiffany 1988; Adams and Brock 1995; Warren 2001). Lynn (1981) argues, for instance, that "the Americans appear to have had more opportunities to adopt the basic oxygen furnace 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

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[10] Industry-level data on productivity growth are available for this time period from the NBER productivity data base, though these are not broken down by region. In Online Appendix E. we show that manufacturing industries with the highest proportion of workers in the Rust Belt region had lower average productivity growth than other manufacturing industries, particularly before the 1980s.

percent in Japan, 41 percent in Italy, 38 percent in Germany, and 28 percent in France.[11,12]

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[11] The view that technology adoption in the U.S. steel industry was inefficiently low was also taken 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 economic growth. These effects have been magnified in the steel industry. Inadequate capital formation ... has prevented adequate replacement and modernization of steelmaking facilities, thus hobbling the industry's productivity and efficiency (*Steel at the Cross Roads: The American Steel Industry in the 1980s* 1980)."

[12] Similar accounts can be found for the rubber tire and automobile manufacturing industries, which were also among the Rust Belt's largest industries. In rubber tire manufacturing, Rajan, Volpin, and Zingales (2000) and French (1991) argue that U.S. tire manufacturers, which were concentrated in Ohio, 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, concentrating on the U.S. south. In auto manufacturing, the sluggish rate of technology adoption among the main producers, which were largely located in Michigan, is acknowledged by industry historians and insiders, such as Ingrassia (2011) and Vlasic (2011).

6. 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.

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 and political shifts that substantially reduced union bargaining power in the 1980s, labor conflict declined, leading to higher rates of 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 fairly recently. This contrasts with more cooperate union-management relations in other parts of the U.S. and Europe, for instance.

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 respective management teams – been more cooperative, this study indicates that the location of workers, capital, and production across the United States would be quite different today, with far fewer economic losses within the Rust Belt. Our findings also suggest new avenues for future research, including analyzing why labor and management fought for so long, and endured such massive losses, before finally resolving their destructive conflict.

Code replicating the tables and figures in this article can be found in Alder, Lagakos, and

Ohanian (2022) in the Harvard Dataverse, https://doi.org/10.7910/DVN/TBMUWR.

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Table 1: 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)	(0.18)	(0.13)	(0.11)	(0.034)
State Average Temperature		0.044***			
		(0.014)			
State Std. Dev. Temperature		-0.012			
		(0.039)			
State Average Precipitation		-0.025***			
		(0.0054)			
Percent College Grad, 1950		-0.20	-0.084	0.017	-0.10
		(0.22)	(0.20)	(0.13)	(0.14)
Observations	2,087	1,777	1,793	1,790	1,790
R^2	0.035	0.178	0.378	0.369	0.079
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. Standard errors are clustered at the state level and reported in parentheses.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 2: 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	4.6	10.3
Rest of the Country	2.7	1.4	1.9

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.

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	16.0	16.0
Import share, Rust Belt (1958)	4.5	4.5
Import share, Rust Belt (1990)	58.6	58.6
Imports share, U.S. manufacturing (1990)	25.5	25.8
Labor share of VA, U.S. manufacturing (1950-1980)	70.7	70.7
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)	2.7	2.7
Slope coefficient: log empl. growth on stoppages	-0.46	-0.46

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

Table 4: Calibrated Parameters

Parameter	Moment	Value
λ	share of goods produced in Rust Belt	0.46
σ_z^2	variance of initial firm productivities	1.14
α	linear term in investment cost function	0.19
s	investment rate	0.44
τ_0	initial trade cost	9.0
δ_τ	annual growth factor of trade cost	0.97
ζ_R	productivity boost for *Foreign* Rust Belt	1.04
ϕ_R	labor bargaining power in Rust Belt	0.44
ϕ_S	labor bargaining power outside Rust Belt	0.02
σ_ε^2	variance of intra-period productivity shocks	0.09
σ	elasticity of substitution between goods	2.54
ρ	elasticity of substitution between H and F varieties	2.76

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

Table 5: Sensitivity Analysis

	Change in Rust Belt's Employment Share	Percent of Data Explained
Benchmark calibration	-10.0	54.5
Lower strike duration ($\kappa = 0.105$)	-9.9	54.3
Time trend in investment rate	-10.1	55.3
Additional decade of conflict	-11.7	64.1

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

Note for Figure 1

This figure plots manufacturing employment located in Rust Belt states relative to the U.S. (solid line) and relative to the United States but excluding the “Sun Belt” states of Arizona, California, Florida, New Mexico and Nevada (dashed line).

Note for Figure 2

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 (solid line) and the dummy variable from a regression of log wages on a Rust Belt dummy variable and other controls (dashed line), which is described in the text.

Note for Figure 3

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

Note for Figure 4

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.

Note for Figure 5

This figure plots import shares in the U.S. manufacturing sector (dotted line) and in the industries most prevalent in the Rust Belt (solid line), plus the model’s predictions for each (dashed line for U.S. manufacturing and dash-dotteded line for Rust Belt manufacturing). Import shares are defined as imports divided by the total value of industry shipments and come from Feenstra (1996).

Note for Figure 6

This figure plots the share of U.S. manufacturing employment located in the Rust Belt (solid line) and the model’s prediction for this share (dashed line).

Note for Figure 7

This figure plots labor's share of value added in U.S. manufacturing in the data, in the model and in the counterfactual simulation with no labor conflict.

Note for Figure 8

This figure plots the Rust Belt's share of U.S. manufacturing employment under three counterfactual simulations of the model. The first, labelled "Model, no int'l forces," has labor conflict but no international forces, meaning ζ_R is set to one (dashed line). The second, labelled "Model, no conflict," has international forces but no labor conflict, meaning ϕ_R is set to ϕ_S (dotted line). The third, "Model, no int'l forces or conflict" sets ζ_R to one and sets ϕ_R to ϕ_S (dash-dotted line). For reference, the data and the predictions generated by the benchmark calibration are plotted as solid lines.