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Mark Stelzner and Enzo Cerrutti

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Workers and Technological Change in the United States

By Mark Stelzner¹ and Enzo Cerrutti²

Abstract: *In this paper, we put forward a theoretical framework for understanding a positive relationship between labor laws and innovation and rigorously test it against both historical and empirical data. We show how several periods in the economic history of the United States – like the increase in slave-field hand productivity in cotton picking in the Antebellum South, the transition in the North from artisanal shops to nonmechanized factories, the increase in productivity in mechanized textile factories in the Northeast in the late Antebellum period, and the increase in productivity in sharecropping after the Civil War – can be understood, at least partially, through our theoretical framework. To build further support for the framework, we empirically analyze how change in labor laws during the early twentieth century affect patent issuance by state. And we also look at how changes in worker power, as proxied by strike activity, affected patent issuance by industry between the early twentieth century and 1980.*

Keywords: Technological change, labor laws, worker power, inequality

JEL codes: N31, N32, N41, N42, K31, O14

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What is the relationship between legislative support for workers, worker power, and technological change? Do laws that support workers promote technological change and thus growth? Or can we only hope to empower workers at the expense of technological change and growth? While such questions are central for optimally structuring the economy, the answers are not clear. To be sure, workers, employers, politicians, and social scientists alike have discussed such issues for centuries. However, no broad historical or empirical evidence has been put forward to answer these questions. In this paper, we seek to do exactly this by systematically exploring the relationship between labor legislation, worker power, and innovation across states and industries in the United States over the last two centuries.

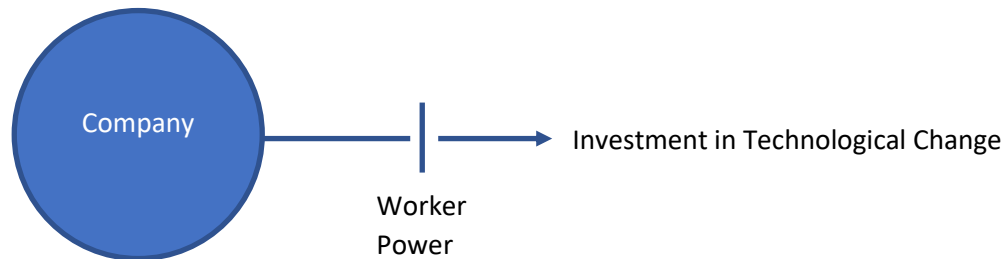
1. The Literature

Workers have long had ambiguous views on technological change. For example, William Heighton (1827), a shoemaker in Philadelphia, voice of the early nineteenth century labor movement, and founder of the *Mechanics' Free Press*, acknowledged that technology could ease the burden of workers. However, Heighton also argued that it is a “source of the most abject poverty, wretchedness and starvation.” Technological change throws laborers out of work and reduces those who remain employed “to the very lowest term.” The antagonistic side of labor’s views on innovation have, at times, led to collective action against technological change. For example, in the mid twentieth century, after technology had eliminated the need for wood or coal to power trains, railroad unions fought to keep firemen employed (Lichtenstein, 2013). And in 1996, workers at General Motors (GM) went on strike because of GM’s push to incorporate design-for manufacturing production techniques – projected to reduce labor needs by 25 to 30 percent.

Economists have often focused on such negative sentiments and argued theoretically that laws that protect workers would inhibit technological change. For example, Greenspan (2000) and Feldstein (2001) posit that whenever new technology is adopted companies need to reorganize production – which includes firing redundant workers. Laws that protect workers hinder employers’ flexibility and thus decreases incentives for companies to adopt new technologies. This basic dynamic is depicted in Figure 1 – a one dimensional road to innovation. While simple, this idea is credited with explaining many differences in growth across countries and time. Indeed, Greenspan argues that Europe grew slower than the United States in the

1990s, because more protective labor laws in Europe reduced the adoption of technology compared to the United States.

Figure 1: Road to Innovation



Source: author.

This framework has widespread support in economics. For example, in the basic Solow growth model, workers’ collective activity and progressive labor legislation that increases the cost of labor would decrease demand for labor creating unemployment. The resulting increase in capital per unit of labor would decrease the returns to capital investment and thus reduce growth. If innovation stems from human capital investment (like in Romer (1990), Grossman and Helpman (1991) and Aghion and Howitt (1992)), then a reduction in growth would reduce investment in human capital and therefore also reduce technological change – having a further negative impact on growth. Basic neoclassical growth models highlight the same general relationship between worker power and investment in technological change as depicted in Figure 1.

While logically appealing, it is not clear if antidotal evidence, like the case of GM in 1996, supports such contentions. For example, workers at GM charged that the design-for manufacturing techniques were merely a way to speed up and stretch out production – forcing GM employees to work faster and creating a regime of permanent overtime (McAlinden, 1997). Furthermore, Lichtenstein (2013) argues that “unionists who have defended an outmoded or redundant organization of work might temporarily win a battle, but they almost always lost the war, both ideological and occupational.” So, it seems unclear if all strategies labeled as technological change are such and if workers have the power to effectively block technological

change other than in select cases in the very short run. Because they lack broad based historical or empirical evidence to support their theoretical claims, neither Greenspan (2000), Feldstein (2001), Romer (1990), Grossman and Helpman (1991), or Aghion and Howitt (1992) can answer such contentions.

Gust and Marquez (2004) look at the statistical relationship between labor legislation and investment in information technology as a percentage of gross domestic product (GDP) across advanced industrialized countries in the 1990s. In accordance with Figure 1, Gust and Marquez conclude that employment protection legislation inhibits investment in information technology. However, their results hold only when controlling for spending on education and the size of the service sector by country. When they control for other variables like the real interest rate, stock market capitalization, availability of venture capital, investment as a percentage of GDP, other changes over time, or the regulatory burden on startups their statistical evidence for a negative relation between support for workers and innovation evaporates.

Controlling for some of these variables seems vital. Almost a century ago, Keynes (1936) explained that imperfect information about demand and supply in the future forces businesses to make decisions about investment based on current market conditions. During times when the economy is depressed, investment will be low because individuals, extrapolating their present situation, will worry about profitability. This dynamic surely holds for investment in technology. If the current state of the economy is weak and thus overall investment is low, it is unlikely that business will adopt new technology or invest in technological innovation. Thus, there are theoretical reasons to expect a strong positive relationship between expenditure on technology and the current state of the economy. As stated above, Gust and Marquez's statistical evidence for a negative relation between support for workers and innovation evaporates when controlling for investment as a percentage of GDP – a proxy for the current state of the economy. Thus, the results they use to support their conclusion seem to stem from omitted variable bias. Once controlled for, their results no longer hold.

Furthermore, Gust and Marquez (2004) only cover a handful of years, and during those years, there was a huge bubble in technology in the United States. Between December 1996 and December 1999, the market value of NASDAQ stocks increased by 315 percent. Dot.com, e-commerce, fiber optic, server, chips, software, IT, and telecom companies were almost exclusively traded on NASDAQ. Despite sky rocking stock values, many of these companies

had little or no earnings. Indeed, even Alan Greenspan said there was ‘irrational exuberance’ in the stock market in 1996 (Kindleberger, 2005). This ‘irrational exuberance’ in new technology companies in the United States, which became even more irrational after 1996, must have distorted Gust and Marquez’s results. Because the United States protected workers much less than Europe or Japan during the 1990s, the bubble in technology companies in the United States, which Gust and Marquez do not control for, would bias their results in a negative direction – potentially changing the sign of their identified relation between labor laws and technological change. Again, it seems like other variables are driving Gust and Marquez’s results.

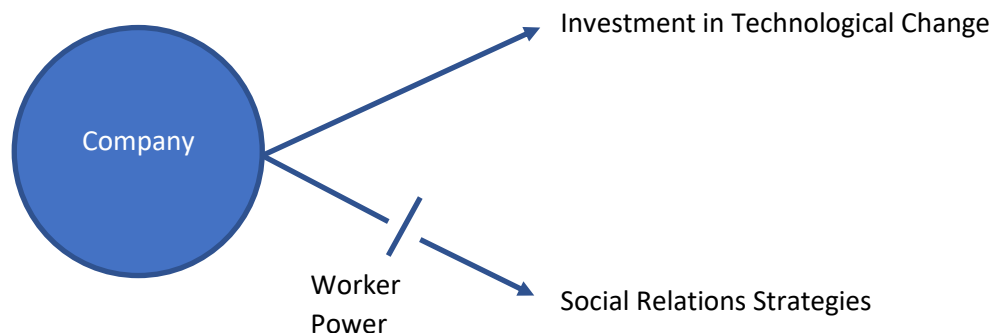
In the economic history literature, Brown and Philips (1986) argue that in the decades after the Civil War, because workers had a relatively high degree of intrafirm power, cannery operators in Baltimore pursued a strategy of technological innovation designed to reduce costs through weakening the control of craft workers. Thus, Brown and Philips identify, at least in this specific case, a positive relationship between worker power and technological change. If capping and processing workers were not empowered, cannery operators would not have pursued technological change when they did. While intriguing, Brown and Philips do not systematically test the relationship between worker power and technological innovation across industry and over a time. They only look at canning manufacturing in Baltimore in the decades after the Civil War. Nor do they explore the consequences of a positive relationship between worker power and innovation.

In this paper, we seek to fill the void in the literature. In the follow section, we put forward a theoretical framework to understand a positive relationship between progressive labor laws, worker power, and technological change. To give a historical backing to the framework, we connect it with several periods in the economic history of the United States. In the third section, we systematically look at data on patents, labor legislation, strike activity, and several other controls to see how labor legislation and worker power has shaped technological growth over time and across states and industries in the United States throughout the twentieth century. In the fourth section, we conclude.

2. Theoretical Framework in a Historical Context

Companies face a multi-dimensional array of strategy choices. However, not all the choices are both privately and socially beneficial.³ When it comes to cost reduction, companies can move in two general directions.⁴ As depicted in Figure 2, one strategy option open to employers is to invest in technological change. While an uncertain strategy in the short term, technological change offers the possibility of cheaper production in the future which can be monopolized for a time, either through a patent or as a trade secret. Furthermore, this strategy has positive spillover effects for the rest of society when the technology disseminates and thus adds to public knowledge.

Figure 2: Fork in the Road: cost reduction strategies for business



Source: author.

Companies can also follow social relations strategies; strategies to push their employees to work harder.⁵ They can do this through speeding up the pace of work or stretching out total work time. The classic example of the former is increasing the speed of an assembly line in a plant and forcing workers to adjust. When applied to salaried workers in health care or any other industry, speeding up work can also have a stretch out effect as workers seek to fulfill increased requirements through working longer, uncompensated hours. If the political climate is

³ In economic models of perfect competition, it is assumed that companies *cannot* act in ways that are not socially beneficial. These models give theoretical support to ideas of laissez faire. However, many of the understanding these models impart and the policy prescriptions that stem from them are highly contingent on their assumptions.

⁴ Negative externalities, like pollution, would be a third option. We do not explore this strategy here. However, following such a strategy would have effects like those that stem from social relations strategies. The only difference with externalities is that the cost would affect economic agents not party to the transaction. With social relations strategies, workers, who are party to the economic transaction, are essentially feeling an increased cost.

⁵ The term “social relations strategies” comes from Lazonick and Brush (1985).

conducive, such strategies are more certain in the short run. However, they don't have the same positive spillover effects as investment in innovation. Furthermore, social relations strategies bring with them other negatives. For example, speeding up or stretching out work can cause stress and deterioration of employees' health.⁶

The more socially desirable cost reduction strategy is technological innovation. Indeed, this is the path that much of human betterment has been based on. However, there has also been long periods where increased productivity stems from social relations strategies. For example, between 1800 and 1860, productivity per field hand in cotton farming in southern United States increased by more than 400 percent. Over the period, there was no change in machine technology used in cotton farming (Olmstead and Rhode, 2008). Baptist (2014) argues that this dramatic increase in productivity, which kept pace with the Industrial Revolution in England, was largely due to systematic torture which was ratcheted up as demand for cotton increased – a social relations strategy in the extreme. Through this system of torture, norms on suitable ages and gender for working in the field were set aside. Men, women, and children labored side by side in the same tasks for longer hours and at a faster pace.

Some do not agree with Baptist (2014). For example, Hilt (2017) claims that biological innovation in cotton seeds are “known to be among the primary drivers” of productivity gains in cotton picking in the Antebellum South. His source of certainty, Olmstead and Rhode (2008) base their conclusion on finding no statistical evidence for increased plantation size or managerial experience interacted with plantation size driving the increase in field hand productivity across plantations and over time. However, at no point do Olmstead and Rhode control for the different varieties of upland cotton seeds. Nor do they ever control for work intensity. Thus, their conclusion is one of default with minimal effort to falsify other explanations. Yet, their default explanation seems specious. Indeed, Rhode (2015) shows that many contemporaries in the United States and England believed that the vast majority of the new

⁶ The separation between social relations strategies and technological change is not always so binary in real life. For example, technological change that increases efficiency at one point in the production chain can be used to speed up production everywhere else. Thus, such a strategy would have both social relations and technological change aspects. Indeed, many economists have highlighted the control element of some technologies (for example see Braverman and Stiglitz (1985), Skott and Guy (2007), and Stiglitz (2014)). To a certain degree, this point blurs the dichotomy in Figure 2. However, as we shall see, the theory laid out here is still important for understanding many episodes in the economic history of the United States. Also, the ability for employers to use technology as a social relations strategy can be constrained by worker power in the same way as pure social relations strategies.

seed varieties created after the initial introduction of Upland cotton were scams which took advantage of the huge degree of asymmetric information in the cotton seed market. For example, in 1839, Edmond Ruffin of the *Farmer's Register* explained that “dupes are continually made by the vilest and grossest impositions [in the cotton seed market] that can be imagined.”⁷ And in 1847, the *American Agriculturist* reported that many farmers claimed that *Mastodan*, another new seed, was a “gross humbug on the planting interest.”⁸ Despite these ubiquitous contemporary views, Rhode (2015) goes on to argue that the many new seeds were actually more productive. However, the only evidence he provides is the increase in productivity per field hand itself.

Given the historical evidence presented by Baptist (2014), the lack of evidence supporting the seed hypothesis, and the complete lack of political and legal rights of enslaved cotton field hands, it is hard to understand why some find it so hard to accept the possibility that the increase in productivity in cotton picking stemmed from increased exploitation of enslaved cotton workers. To be sure, there are many other episodes in the economic history of the United States where productivity increased without technological change.

For example, between 1820 and 1850 in northern United States, nonmechanized factories started to replace artisanal shops. There were no technological differences between the two forms of organization in many industries; however, nonmechanized factories were more profitable than artisanal shops. In his study of this transition, Sokoloff (1984) concludes that the higher profitability of the nonmechanized factories could have come from forcing laborers to work harder through a stricter discipline regime and utilizing more vulnerable workers (women and children) – a social relations strategy. And in the mechanized textile factories in northeastern United States between 1835 and 1855, there were dramatic increases in productivity per weaver. However, during this period, there were no changes in technology. While David (1973, 1975) argues that learning by doing was the sole source of the productivity gains in textile manufacturing, he offers no evidence to support such claims. On the other hand, Lazonick and Brush (1985) statistically analyze data from Lawrence Textile Mill #2 in Massachusetts on

⁷ *Farmer's Register* 7, no. 4 (30 April 1839), p. 252; also reprinted in *Southern Agriculturist* 12, no. 6, (June 1839), p. 318.

⁸ *American Agriculturist* 6, no. 7 (July 1847), p. 227.

output per weaver and find that social relations strategies were central to understanding the increase in productivity in cotton textile mills in the 1840s and 1850s.

Likewise, real cotton production per worker in the South after the Civil War increased by 45 percent between the late 1860s and the late 1890s. Almost a decade later, cotton production had increased by another 9 percent. By the end of the first decade of the twenty first century, real output per worker was around 82 percent of what it had been before the Civil War – when production was centered around slavery (Ransom and Sutch, 2001). However, until the 1940s and 1950s, both on small farms and large plantations, cotton was still farmed using the same labor-intensive planting, cultivating, and harvesting techniques as had been used a half a century earlier (Freedman, 2013). Thus, these productivity gains might have also come from social relations strategies – strategies that moved labor relations in southern agriculture back towards slavery.

In sum, there are many periods in the economic history of the United States where productivity gains seem to, or could have, stemmed from social relations strategies. Surely there are many more incidents where the drivers of changes in productivity are less clear. While some economists would contest such explanations, none has put forward substantial evidence against the possibility of social relations strategies. Indeed, many that have sought to understand the events described above in other ways seem to base their understandings on the assumption that social relations strategies cannot take place – even under slavery.

Given the two directions and their divergent social implication, it is important that we ask: how does an employer choose which of the two strategies to follow? It seems, everything else equal, employers typically choose the strategy that is more certain. As mentioned above, pursuing technological innovation is very uncertain in the short run for an individual firm. Costs increase at present with the hope of increasing productivity in the future through some new method or machine that does not yet exist. On the other hand, social relations strategies are much more certain in the short run. There are potential increases in costs initially – for example, like hiring more supervisors. However, per unit costs will very likely decrease in the short run through increased productivity per production worker. As depicted in Figure 2, the only potential road block to such a strategy is worker power.

Worker power is a function of many variables: worker solidarity, labor laws and institutions, the social context, etc. These variables are often interconnected. Worker solidarity

makes possible political backing for laws that support labor and a social context that accepts a role for collective labor activities. At the same time, given a set of labor laws and social climate, workers' collective actions are more successful, and thus more likely, when laws and institutions support workers. For example, Stelzner (2017a) shows that strike activity by state in the United States between 1883 and 1934 was largely determined by state laws. When and where labor laws were harsher, workers struck less. When and where laws were more supportive of labor, workers struck more. Likewise, Stelzner (2017b) shows that the reduction in strike activity since the early 1980s in the United States is, to a large extent, a result of a change in adjudication and administration of the main federal labor law, the National Labor Relations Act, and a change in social context. Other scholars have found similar results. For example, Friedman (1998) shows that strike activity in France and the United States between the 1880s and early twentieth century was largely a function of the supportiveness of government.

Social relation strategies are only possible if laws disempower workers and the social climate is supportive of employers' prerogatives. In such a situation, worker power is weak, and there is no barrier to adopting social relation strategies. This was clearly the case under slavery. There were no real statute checks on slave owners that prohibited them from forcing their slaves to work harder through torture. Although slaves engaged in a continuous struggle with their owners through such methods as slowing the pace of work when overseers were not looking, they clearly had very little power as workers. Slave owners were only inhibited in the application of tougher social relations strategies by their personal squeamishness towards torture and potentially social norms on the treatment of slaves – both of which higher profits seemed to conquer easily.

Likewise, Montgomery (1972) and Laurie (1989) show that the political and social coalition that supported workers in northeastern United States in the late 1820s and 1830s fell apart in the depression of 1837 through 1843. Class solidarity was replaced by politics based on nativism and religious sectarianism leaving workers relatively unprotected. This change in the political context and the resulting change in worker power made possible social relations strategies adopted in both nonmechanized factories and mechanized textiles mills in Massachusetts. Indeed, Lazonick and Brush (1985) show that the introduction of Irish weavers, who were more vulnerable than their Yankee counterparts, to Lawrence Mill #2 was a central social relations strategy used to divide weavers and force them to work harder.

A similar story took place in the South after the Civil War. Through overt calls of racism, southern Democrats redeemed seats in state legislatures and governorships in the 1870s breaking the nascent political collation between poor whites and the newly freed slaves. Virginia's democratic platform in 1874 proclaimed a "race against race" in order to win over poor southern whites, and Louisiana's Democratic platform asserted: "We, the white people of Louisiana,... [pronounce] a war of races" imminent (Foner, 2011). After victory at the polls, Southern states remade laws such to regain control of southern labor. Through controlling workers' ability to quit, making it a crime not to work, and giving an employer property rights in his employee vis-à-vis other employers, southern legislatures, supported by state courts, dramatically changed intrafirm power dynamics to the detriment of the newly freed men and women and workers in general (Stelzner, 2017a). These changes in the political context and thus worker power would have made possible increased productivity gains through social relations strategies – potentially explaining the lack of technological change in cotton farming for more than half a century after the Civil War.

Conversely, when worker power is stronger, social relations strategies are more likely to be blocked. As a result, employers are more likely to follow the socially optimal strategy of investing in technological change. This is the essential dynamic highlighted by Brown and Philips (1986). Craft canary workers in Baltimore had a relatively large degree of worker power. Brown and Philips argue that this was because of specific skills needed in cooking and canning food. However, it could have also stemmed, to some degree, from the general political climate after the Civil War which was, at least for a time, supportive of workers. Canary operators pursued a strategy of technological innovation, because social relations strategies were not possible.

Likewise, the post-Civil War sharecropping system of cotton production was not remade until the 1930s, 1940s, and 1950s. During the New Deal and World War II, the political context changed dramatically. For example, in the 1930s urged on by actions of the new federal government, an interracial agriculture union was created along the shore of the Mississippi. Through forming locals, calling strikes, and demanding support from the federal government, the Southern Tenant Farmers' Union (STFU) invigorated new assertiveness among black agricultural laborers. In the mid-1940s, over disputes on pay in the Mississippi Delta, field hands refused to work leaving around 40 percent of the cotton in the fields according to H. L. Mitchell,

founder of the STFU. For southern agricultural laborers, this was a revolution of worker power not seen since Radical Reconstruction in the late 1860s and early 1870s. Dorothy Lee Black, the secretary-manager of the Delta Council, a white planters' organization, stated on January 1, 1943 that the STFU's "increasing agitation and activity among the negroes of the Delta seriously threatens the unity as well as the economy of this area" (Woodruff, 1994). The change in political context, the extreme shortage of workers from the war, and the war itself empowered workers and likely pushed southern cotton farmers to finally adopt strategies of technological innovation.

3. *An Empirical Test*

We have now outlined a theoretical framework for understanding a positive relationship between worker power and technological change. And we have shown that this framework helps understand certain moments in the economic history of the United States. However, does this relationship hold more generally? In this section, we seek to answer this question by systematically analyzing the empirical relationship between labor legislation, worker power and technological change over time and across states and industries in the United States. Using OLS, we first look at the following relationship between labor legislation and technological change:

$$TECH_{st} = a + bLABORLAWS_{st} + cSTATE_s + dYEAR_t + eTREND + u_{st} \quad (1)$$

$TECH_{st}$ stands for technological change and spans across states, s , and years, t .

$LABORLAWS_{st}$ is a vector that represents two state level labor law variables. The $STATE_s$ and $YEAR_t$ independent variables represent vectors of controls for states and years, respectively, and $TREND$ stands for time trend.

As a proxy for technological change, we use data on patents by state and year from Petralia et al. (2016). Using patents as a proxy for innovation has several problems. First, a patent is not an invention. It is a grant by government which secures the inventor or his/her agent an exclusive right to produce and sell the invention. Many times, companies obtain numerous patents on slightly differentiated devices to block competitors from copying technology in a somewhat different form. This would inflate the number of patents compared to inventions. Second, all patents do not represent the same level of technological change. Some

patents pertain to technology which dramatically reshapes an industry while others pertain to technology that is never widely adopted (Merton, 1935). However, the two potential problems for using patents as a proxy for innovation mentioned above tend to cancel each other out. If a patent represents a significant technological change, it is likely that a company will seek many slightly differentiated patents for the same technology; such activity is incentivized because the innovation and the edge it allows on competitors is so profitable. Conversely, if an innovation is patented and never widely adopted, it is very unlikely to be patented multiple times in differentiated forms. Thus, the peculiarities of the system self-calibrate, to some degree, the importance of a given technology.

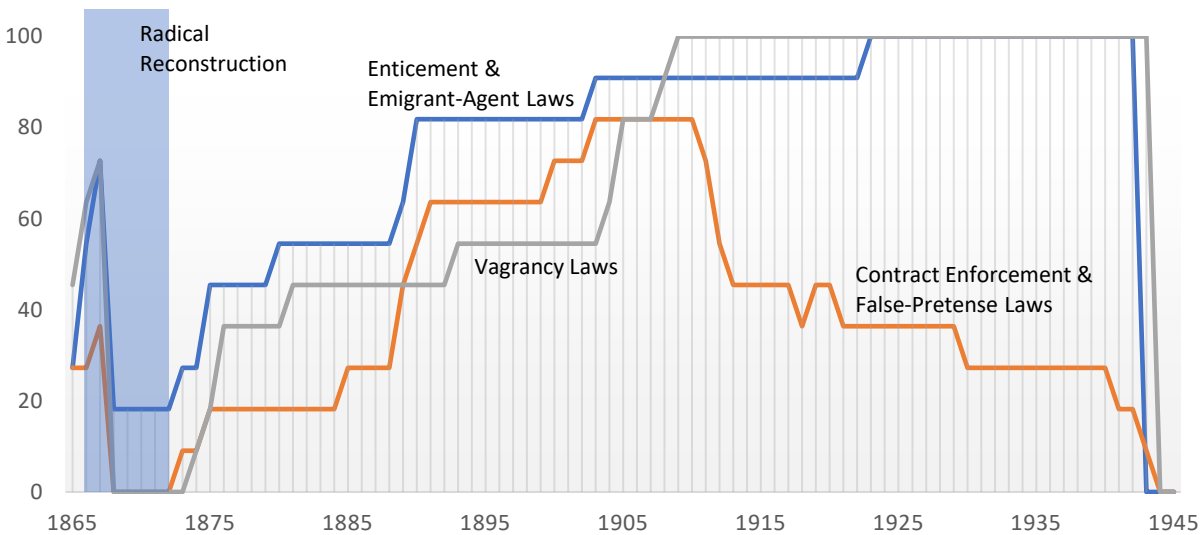
In analyzing the relationship depicted in Figure 2, we want data on patents on technology that reduces the cost of production – not patents on technology that is utilized by the final consumer. The later would not fall under the same cost reduction calculus. To roughly distinguish between the two, we merge Petralia et al. (2016) patent data with data on industry of use from the United States Office of Patents and Trademarks (USOPT).⁹ We then eliminate patent data for technology that would most likely be used by the final consumer. In the first statistical test, we include patent data from agriculture, food, textile, material production and handling, metal working, husbandry, and apparel (NBER subcategory codes 11, 51, 52, 61, and 63). Because NBER codes only start in 1911, our statistical tests of equation (1) also begins in 1911.

The main independent variables are a state level index on laws that created peonage (debt slavery) and labor injunctions as a percentage of strike activity from Stelzner (2017a). The state level index on peonage is a combination of state level data on contract enforcement, false-pretense, enticement, emigrant-agent, and vagrancy laws which were created in the South after Redemption and were only finally torn down during World War II. Contract labor laws made it illegal to break a labor contract without good and sufficient cause. False pretense laws had the same effect as contract labor laws – to constrain workers. However, these laws were less blatantly unconstitutional. Instead of outright prohibition of breaking a labor contract, false pretense laws restricted workers' ability to quit by making it possible to charge quitting workers with fraud. Enticement laws punished employers who lured away labor already under contract.

⁹ Patent data from USOPT can be found at <https://www.uspto.gov/learning-and-resources/electronic-data-products/historical-patent-data-files>.

Emigrant agent laws served a similar purpose as enticement laws but were aimed to constrain out of state employers. Vagrancy laws constrained the movement of unemployed workers and those who choose to absent themselves from the labor market by making it a punishable offense to be caught not working.

Figure 3: Percent of Southern States with Labor Law

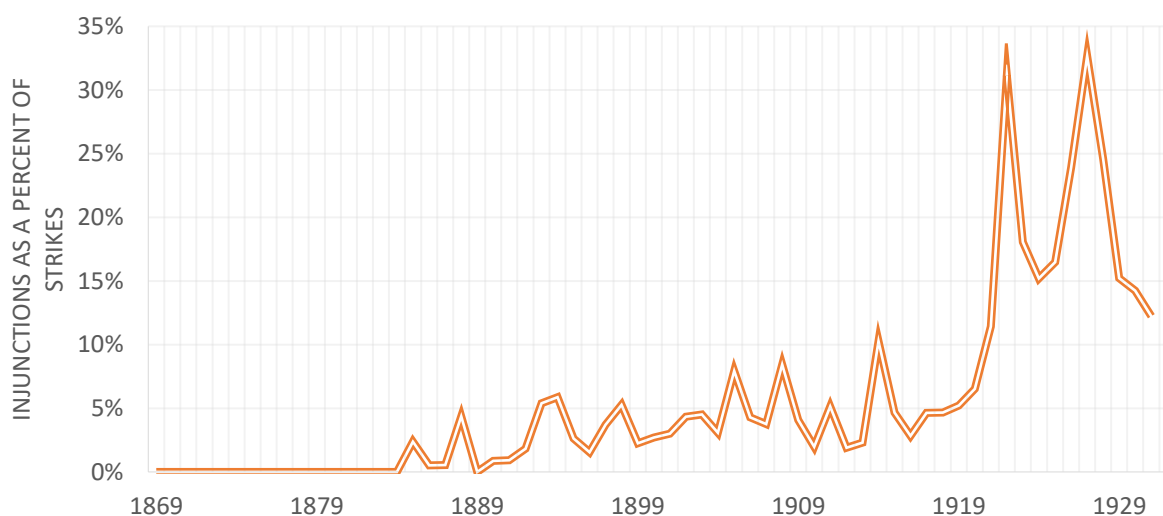


Source: Stelzner (2017a). The three series above show the percentage of eleven southern states (Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Texas, and Virginia) that had contract enforcement or false-pretense laws, enticement or emigrant-agent laws, and vagrancy laws.

In Figure 3, we present data on the percentage of eleven southern states (Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Texas, and Virginia) that had contract enforcement or false-pretense laws, enticement or emigrant-agent laws, and vagrancy laws. For the contract enforcement and false-pretense series and the enticement and emigrant-agent series, a state is counted as having the law if it has one or the other or both. A state is counted as not having such a law when it is repealed by the state legislature or struck down by the state or federal Supreme Court. As can be seen in Figure 3, the percent of southern states that had such laws increased over the Gilded Age. By the beginning of the twentieth century, almost all southern states had moved labor relations back towards slavery by reducing the freedom of the newly freed men and women, and workers in general.

The labor injunction was invented during the Gilded Age in the North, and it became the central method for regulating labor relations in many states until the Norris-LaGuardia Act of 1932 made labor injunctions illegal. Labor injunctions also moved law in a regressive direction by abrogating workers' rights through an expanded judicial understanding of property which made even peaceful collective action illegal. Also, labor injunctions replaced jury trials in labor hearings, common in the decades before and immediately after the Civil War, with equity court hearings void of juries. The net result was differential treatment of combinations by capital, which increased dramatically over this period, and labor. In Figure 4, we present data on the percent of strikes enjoined by year in the United States between the late 1860s and the early 1930s.

Figure 4: the Rise of the Labor Injunction



Source: Stelzner (2017a).

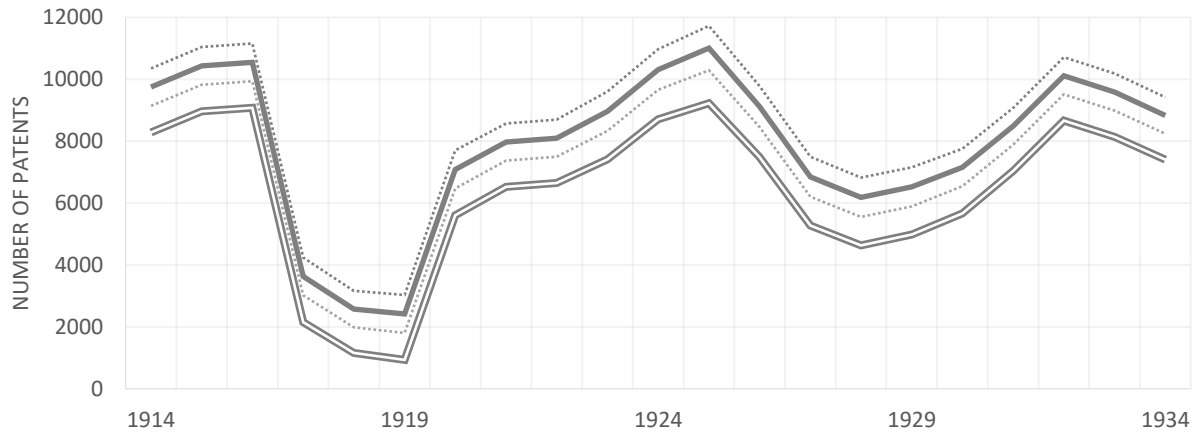
In columns 1.A through 1.C in Table 1, we display the results from three different specifications of equation (1). In the first regression which is reported in 1.A, we control for population by state – denoted as $POPULATION_{st}$, total primary and secondary education spending at the local, state, and federal level as a percent of GDP by year – denoted as $EDUCATION_t$, and year fixed effects. In the following two specifications, we also control for state fixed effects and a time trend. Data on education spending comes from the Historical Statistics of the United States and Snyder et al. (2016) and is lagged

to account for the delayed effect of educational spending on technological change. Year and state fixed effects are not listed to save space. The year fixed effects variable captures such elements as Keynesian investor sentiment and other government spending factors that might influence innovation across time. The state fixed effects variable captures state specific differences in preferences or organization of production that might influence the initial level of technological change and patent issuance across state.

As we can see, there is a strong negative relationship between labor laws that created a state of peonage and technological change and between labor injunctions as a percentage of strikes and technological change; regressive labor legislation reduced worker power making it possible for employers to reduce costs through social relation strategies. Thus, in states with more regressive legislation, there is less technological change. For example, southern states that had labor laws that restricted employees' ability to quit, punished individuals for not working, and prohibited employers from bidding away employed workers, passed around 170 fewer patents per year than like states without such laws. This result is astonishing because 170 patents per year surpasses the year-state mean across the sample, and because almost all southern states had such regressive labor laws in the beginning of the twentieth century. Likewise, northern states that more intensely used labor injunctions relative to strike activity experienced less technological change than like states which were less oppressive towards labor.

In Figure 5, we show the effect of regressive labor legislation on technological change at the national level. The double grey line is the actual number of patents passed per year nationally in agriculture, food, textile, material production and handling, metal working, husbandry, and apparel (NBER subcategory codes 11, 51, 52, 61, and 63). The single grey line is what patents per year would have been, according to the results from column 1.C, if the labor injunction wasn't used in the North and false pretense, contract labor, vagrancy, emigrant-agent, and enticement laws never took root in the South. The dotted grey lines are the standard error. As we can see, technological change throughout the period would have been significantly larger if the laws that created peonage and the change in understanding of laws by the courts which created the labor injunction had never taken root.

Figure 5: Effect of Regressive Labor Legislation on Technological Change



Source: Author – see text. Double grey line represents actual patents passed per year nationally in agriculture, food, textile, material production and handling, metal working, husbandry, and apparel. The single grey line represents estimated patents per year if regressive labor legislation never took root, and dotted lines represent the confidence interval.

To test the robustness of these findings, we re-specify our model by looking directly at the relationship between worker power and technological change over time and across industry in the United States:

$$TECH_{it} = a + bWPOWER_{it} + cINDUSTRY_i + dYEAR_t + eTREND + u_{it} \quad (2)$$

$TECH_{it}$ stands for technological change and spans across industry, i , and year, t .

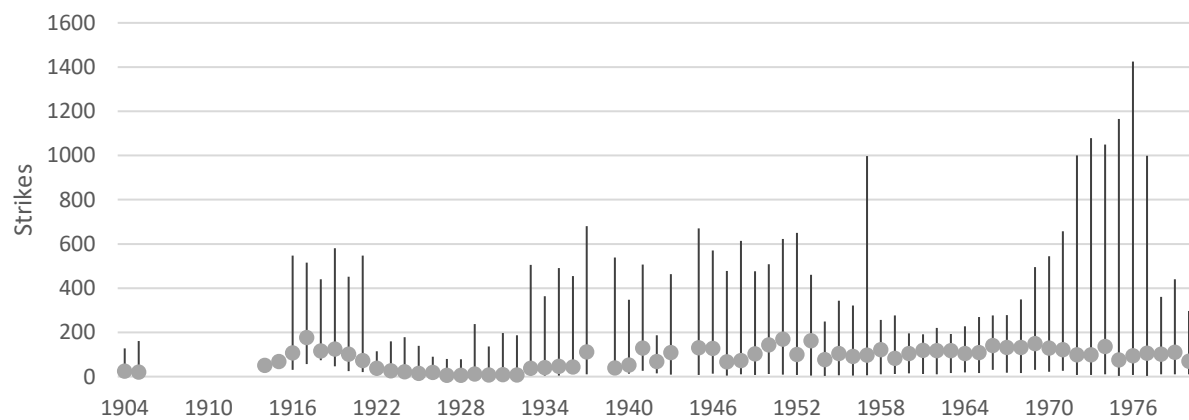
$WPOWER_{it}$ stand for worker power and also spans industry, i , and year, t . The

$INDUSTRY_i$ and $YEAR_t$ independent variables represent vectors of controls specific to the industry and years, respectively, and $TREND$ stands for time trend.

As a proxy for technological change, we use data on patents by industry of use by year from the USOPT. For reasons discussed above, we only look at patents in industries where technology is more likely to be used in the production process and exclude patents in industries where technology is more likely to be used by the final consumer. Thus, in the follow statistical tests of equation (2), we use patents for use in twelve industries: agriculture, mining, electrical industrial equipment, chemicals, ships, ferrous metals, nonferrous metals, fabricated metals, food and tobacco, textiles, paper, and wood.

As a proxy for worker power, we use strikes by industry by year between 1901 and 1980. While strikes can sometimes represent desperation, they more often represent solidarity between workers. For any individual worker, there are many selfish reasons not to participate in a strike. Thus, when workers come together and collectively voice a grievance through stopping work, it represents a high level of solidarity and worker power. Strike data comes from several sources: The Twenty-First Annual Report of the Commissioner of Labor (1906), The Monthly Labor Review (1929), Peterson (1938), and the U.S. Bureau of Labor Statistics. In Figure 6, we present the maximum, minimum, and mean strikes per year across the twelve industries mentioned above. For years where data on strike activity in an industry is missing, the year is dropped for the respective industry.

Figure 6: Strikes per Industry per Year

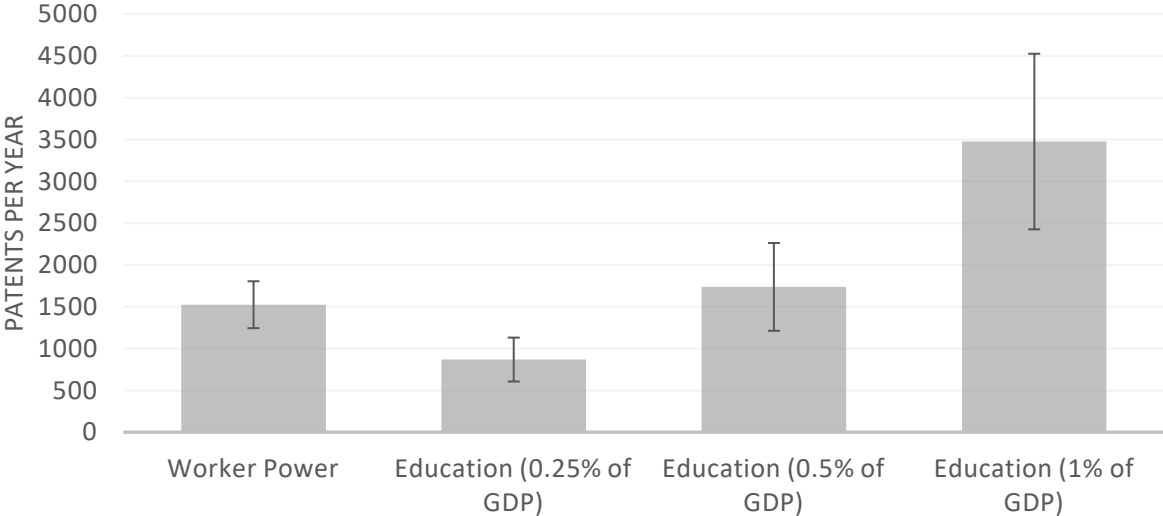


Source: the Twenty-First Annual Report of the Commissioner of Labor (1906), The Monthly Labor Review (1929), Peterson (1938), and the U.S. Bureau of Labor Statistics.

In columns 2.A through 2.D in Table 1, we display the results four different specifications of equation (2). In 2.A, we only control for total primary and secondary education spending at the local, state, and federal level as a percent of GDP by year and year fixed effects. In columns 2.B and 2.D, we control for year and industry fixed effects, year and industry fixed effects and a time trend, and year and industry fixed effects and an industry specific time trend. The industry fixed effects variable captures industry specific differences that might influence the initial level of technological change and patent issuance across industry. The industry specific time trend captures difference in how industries change over time.

As we can see, the worker power variable remains positive and highly statistically and economically significant across specifications. Indeed, a change in worker power from the 50th to the 85th percentile of the sample has a comparable effect to an increase in public spending on primary and secondary education by 0.5 percent of GDP. To visualize this result, in Figure 7, we display data on the effect of a change in worker power on innovation. The thick bar on the left represents the increase in patents passed per year as a result of increasing worker power variable from the 50th to the 85th percentile in the sample. The three thick bars on the right represents a change in primary and secondary education spending at the federal, state, and local level by 0.25, 0.5, and 1.0 percent of GDP – according to results depicted in column 2.B from Table 1. The thin bars above the values for worker power and educational spending represent the confidence interval. As we can see, the effect of increasing worker power from the 50th to the 85th percentile is on par with the effect of increasing public spending on primary and secondary public education by 0.5 percent of GDP.

Figure 7: Effect of Worker Power on Technological Change by Industry



Source: Author – see text. The thick bar on the left represents the increase in patents passed per year due to increasing worker power from the 50th to the 85th percentile in the sample. The three thick bar on the right represents a change in primary and secondary education spending at the federal, state, and local level by 0.25, 0.5, and 1.0 percent of GDP – according to results depicted in column 2.B from Table 1. The thin bars above the values for worker power and education represent the confidence interval.

Table 1: Technological change in the United States – patent issuance by state (1) and industry (2)

	1.A	1.B	1.C	2.A	2.B	2.C	2.D
PEONAGE INDEX _{st}	-171.9*** (11.55)	-169.0** (69.54)	-169.0** (69.54)	---	---	---	---
INJUNCTIONS STRIKES _{st}	-58.53 (51.10)	-114.7*** (39.99)	-114.7*** (39.98)	---	---	---	---
WPOWER _{it}	---	---	---	4.20*** (0.48)	1.82*** (0.335)	1.82*** (0.335)	0.41** (0.166)
POPULATION _{st}	93.05*** (5.12)	160.8*** (22.15)	160.8*** (22.15)	---	---	---	---
EDUCATION _t	51.62*** (18.10)	29.38*** (11.30)	26.01 (278.2)	358.4* (190.6)	289.7*** (87.49)	-2430 (3378)	3.35 (38.25)
TREND	---	---	1.68* (1.02)	---	---	80.56 (102.01)	---
YEAR FIXED EFFECTS	Yes	Yes	Yes	Yes	Yes	Yes	Yes
STATE OR INDUSTRY FIXED EFFECTS	No	Yes	Yes	No	Yes	Yes	Yes
INDUSTRY SPECIFIC TIME TREND	No	No	No	No	No	No	Yes
	(1911-1934) N=805	(1911-1934) N=805	(1911-1934) N=805	(1901 – 1980) N = 692	(1901 – 1980) N = 692	(1901 – 1980) N = 692	(1901 – 1980) N = 692

Source: Author – see text. The injunction, peonage, worker power, and education variables are lagged to capture the delayed effect legislation would have on employers’ decisions to invest in technology and the fruition of such decisions. Robust standard errors in brackets where *, **, and *** indicate statistical significance at the 10, 5, and 1 percent levels, respectively.

In regressions 2.A through 2.D, we also controlled for nonlinear effects of strike activity to check if Figure 2 should also have worker power as a potential road block to investment in technology like assumed in Figure 1. Throughout the different specifications, strikes only start to have a negative effect on patent issuance once they surpass 1,200 strikes per industry-year. These results are revealing because only in one industry-year cell (mining in 1976) of the 960 cells did strikes surpass this value. Thus, as contended by Lichtenstein (2013), there is very little evidence of worker power, as we have experienced it in the United States during the twentieth century, impeding technological change. Because the mid-twentieth century was the peak of worker power in the history of the United States, it seems safe to say that before the twentieth century and during the twenty-first century we have yet to experience such extreme worker power either.

4. *Conclusion*

In this paper, we have put forward both historical and statistical evidence for a positive relationship between labor legislation that supports workers, worker power, and technological change in the United States. In terms of the former, many episodes in the economic history of the United States – like the increase in slave-field hand productivity in cotton picking in the Antebellum South, the transition in the North from artisanal shops to nonmechanized factories, the increase in productivity in mechanized textile factories in the Northeast in the late Antebellum period, and the increase in productivity in sharecropping after the Civil War – can be understood, at least partially, through the dynamic highlighted in Figure 2. Likewise, we have seen through systematically analyzing data on patents by industry of use and data on labor legislation and worker power that in industries and during years where worker power is larger, technological change is greater. And in states and during years where legislation is more supportive of workers, technological change is greater.

This relationship should not be surprising. When a company creates a negative externality, like polluting the environment, a Pigouvian tax increases economic efficiency if it is less than or equal to the value of the negative externality. Likewise, when a company has market power on the selling side, like in the case of a monopolist or oligopolist, a price ceiling or regulation that breaks up the company to increase competition can increase economic efficiency. Like with social relation strategies, negative externalities and market power are assumed away in

perfect competition. However, when these assumptions are not met, when negative externalities, market power on the selling side, or social relations strategies are present in the economy, policy that would hurt the economy if functioning perfectly, in the economic sense, can actually make it function better. Legislation that supports workers and thus increases worker power makes it more likely that social relation strategies are not adopted. Thus, in a world where social relations strategies are possible, worker power brings us closer to a perfectly competitive economy through eliminating the non-socially desirable strategy that is assumed away in most economic models. The avenue left open to business, investing in technological change, has positive spillover effects on the rest of the economy by increasing public knowledge and thus creating sustainable growth. Therefore, there are strong non-normative reasons to embrace workers.

The relationship identified in this paper is important today. Since the early 1980s, there have been dramatic changes in labor law and the social context which have reduced worker power making social relations strategies more accessible to employers. For example, Stelzner (2017b) creates an index on the orientation of the NLRA as adjudicated by the NLRB and the Supreme Court and shows that, starting in the early 1980s, the Board and the Supreme Court began to reinterpret the NLRA to the detriment of employees. Starting around the same time, the NLRB began to increase processing times in decisions on employer violations of the NLRA and certification of bargaining units and union election outcomes – making the labor law that still exists less effective. Stelzner also shows that government actions in 1981 dramatically transformed the social context encompassing employer-employee relations motivating public and private sector employers to increase the frequency in which they hired permanent replacements during strikes. These changes in labor law have decreased worker power – which can be seen in the dramatic decrease in both large and small strikes and the decrease in case intake at the NLRB.

Given the relationship identified in this paper, a reduction in worker power via change in understanding of the NLRA, administration of the NLRB, and a change in social context would infer that social relations strategies are more readily adoptable by employers today. Indeed, there is much evidence that this is the case. For example, compared with the three decades after World War II, business has invested much less in plants, equipment, and research and development since the 1980s (Freeman, 2012; p. 354). Indeed, Lazonick (2014) has shown that a growing percentage of net income of large companies in the United States is spent on stock buy

backs. Between 2003 and 2012, 449 companies in the Standard and Poor's 500 index spent 54 percent of profits, \$2.4 trillion, to buy back their own stock. This clearly leaves less money to be spent on research and development and thus forces business to find productivity gains through other avenues. Indeed, Bivens and Mishel (2015) have shown that while productivity per worker has continued to grow over the last four decades, wage growth for non-management workers have stagnated.

Thus, it seems that we are in another period where social relations strategies are more prominent. As we have seen above, such strategies are done at the expense of investing in technology. Consequently, they make society as a whole worse off. Conversely, this means that if we want to restructure our economy such that it functions better, an effective way to do that is through supporting workers.

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