Globalization, unions and robots: The effects of automation on the power of labor and policymaking

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Abstract

International competition has led to the increasing adoption of labor-replacing technology. What are the consequences of this development for international integration? I posit that robots can make workers more productive, increasing the opportunity cost of rent-seeking behavior via union activities. Consequently, the political influence of unions falls in response to robot adoption, with important implications for domestic and international politics and policy. Using data from the U.S. (2004-2014) and leveraging quasi-exogenous variation in international competition in the exposure to robots at the congressional district level, I show that an increase in robot adoption reduces substantively the likelihood that congresspeople vote with unions' interests—especially regarding policy that compensates the losers from international competition. This effect is larger in areas with larger shares of skilled workers, lending support to the hypothesized opportunity-cost mechanism. Reductions in union activities, political contributions, and lower support for cosmopolitanism and for taxation explain this finding.

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1 Introduction

One of the fundamental global economic shifts of the last 50 years has been the automation of work. This development has raised many concerns thanks to machines' ability to replace human labor; e.g., Frey (2019) estimates that machines are projected to take over millions of jobs across the world. In the U.S., for instance, exposure to manufacturing robots has already been responsible for important reductions in employment and wages in the private sector (Acemoglu and Restrepo, 2020). Scholars have also found links between automation and political polarization, the rise of the radical-right and anti-globalization sentiment, as workers seek to protect their livelihoods from global economic change by endorsing economic nationalism (Gallego and Kurer, 2022).

The surge in anti-trade and anti-migration sentiment across the developed world spurred renewed interest in the political consequences of deindustrilization. The evidence indicates that international economic competition is, indeed, one of the main causes behind the recent wave of populism and economic nationalism (Colantone and Stanig, 2018; Baccini and Weymouth, 2021). Importantly, the field of International Political Economy has recognized for decades that the best way to address these problems is to compensate those individuals that lose from globalization via unemployment programs, retraining programs, and public spending more generally. However, the world has moved from an emphasis on the *welfare state*—where governments try to guarantee universal economic and social well-being—into an era of fiscal responsibility and austerity, weakening societies' ability to address the backlash against global integration (Mansfield and Rudra, 2021). What are the implications of automation for sustaining international integration?

I contribute to answering this question in two important ways: First, I argue that labor unions are a key social group that allow society to sustain the redistributive commitment that supports international integration, despite the observed decline in unions' strength over recent decades.[1] Second, I also contribute to the literature on the determinants of international integration by propos-

[1] A similar argument was made by Garrett (1998) in the 90s, and concurrently by Balcazar (2023*b*,*a*) and Becher and Stegmuller (2024) in the case of import competition.

ing a novel mechanism linking automation with union decline and policymaking. I show, using unique data on unions and policymaking, that automation has important consequences for both domestic and international politics and policy through its effect on unions. Specifically, I posit that automation owning to international competition, diminishes the incentives of employed individuals to unionize, reduces campaign donations from workers, and it reduces cosmopolitanism and support for taxation among voters, as well as unions' political power and their capacity to sway public policy in their favor. I also show that the potentially negative effect of automation on employment—while important—is not the main driving force in union-strength decline.[2] Moreover, I also demonstrate that these findings are robust to the competing effect of import competition.

Theories of political participation emphasize the role of labor unions: Unions act as grassroots movements that help voters, both union members and nonmembers, acquire costly political knowledge (Ahlquist and Levi, 2013); they also coordinate voters and get them registered and then delivered to the polls, increasing the turnout of low- and middle-income individuals; they facilitate pooling resources from workers, which are often used for making campaign donations and for lobbying, to further the collective interests of organized labor (Bennett and Kaufman, 2007; Rosenfeld, 2014); strong unions are important because they are a counterbalance to private political interests, by advocating for redistributive policies in favor of workers, and by promoting legislation aimed at improving working conditions and job security in the face of international competition (Frank R. Baumgartner and Leech, 2010; Western and Rosenfeld, 2011; Schlozman, Verba and Brady, 2012). Strong unions are more than the sum of their parts given their capacity for social mobilization. When unions are weak, legislators can afford to ignore unions' for policymaking, otherwise doing so entails meaningful political costs.

The fundamental role of a union is to bargain for better wages and job conditions for its members (Freeman and Medoff, 1984). When this bargaining process breaks down, unionized workers strike, generating a cost for their employer by reducing output in the firm. They also generate a

[2]This contrasts the view that deglobalization due automation is driven by unemployment concerns (Wu, 2018).

cost for themselves because *strike pay* is lower than workers' wages.[3] Automation affects the cost of union activity, especially in the private sector, because when tasks are automated, strikes become less costly for the employer since machines replace manual labor, thereby reducing unions' bargaining power.[4] As a result, the benefits from joining a union versus working fall. Thus the *opportunity cost* of union versus productive activities increases because workers are better of by investing their effort working rather than rent-seeking.

I theorize that the extent to which automation affects union strength depends on the composition of the workforce. The tasks performed by skilled labor are harder to automate unlike the tasks performed by unskilled labor, which are more routinary (Owen, 2020; Belloc, Burdin and Landini, 2023). Therefore while automation may substitute unskilled individuals' labor, it can act as a complement to skilled labor, increasing its productivity. Higher productivity in turn offsets the benefits from striking. This reduces the incentives of skilled labor to unionize because unions compress the wages between skilled and unskilled labor through bargaining.This in turn reduces unions' bargaining power and makes unionization more costly for workers as automation increases. Hence a higher supply of skilled labor can further reduce unionization and union activities in response to automation.[5]

As unionization falls, unions' resources for political participation, especially manpower, diminish. Thus unions become less effective at trading grassroots mobilization, contributions to politicians and lobbying, for political influence in the policy-making process. Consequently, legislators responsiveness to unions' interests declines in response to automation—especially where the supply of skilled labor is high—with consequences for domestic and international policy.

I test the previous claims using data from the U.S. from 2004-2014, which allows me to analyze

[3]Workers pay a union fee which is used to pay union members during strikes to incentivize their participation. Calculations using data from the Bureau of Labor Statistics in the US, shows that workers pay \$2,300 USD on average (2009=100) in union fees a year (about 5% of their wage); only 15% pay a fix share (on average 3.5%) of their wages.

[4]Automation is less likely to affect unions in the public sector because tasks in this sector cannot be easily automated given that they have a lower routine-task content.

[5]The process of deskilling, related to the task-approach to automation, wherein automation reduces the marginal productivity of skilled labor, is analyzed in Section A.6.1. I show that this process has contrasting implications.

numerous mechanisms in the causal chain from automation to policymaking: I analyze the impact of exposure to robots on government responsiveness to unions' interests using the American Federation of Labor and Congress of Industrial Organizations (AFL-CIO) legislative scorecard, which measures how lawmakers vote on issues that are important for workers.[6] Further, I investigate the causal impact of automation on a number of mechanisms mapping the causal chain from automation to policy responsiveness: unionization rates, union activities such as collective bargaining and strikes; political expenditures from unions; workers' political attitudes regarding redistribution and cosmopolitanism; and also political participation from workers via campaign donations.[7]

Since workers and policy makers can strategically react to the prospect of automation in firms to forestall or promote robot adoption, causality may actually run in the opposite direction. To address this problem as well as omitted variable bias, I use a shift-share design to leverage exogenous variation coming from improvements in technology in the private sector to instrument exposure to robots in the US. The shift-share corresponds to the exposure to robots in European countries that are ahead of the U.S. in robotics (*the shift*), weighted by *the shares* of private industries in total local employment. These improvements increase the level of competition between firms at a global scale, forcing local firms to automate.

The identification assumption requires that those areas in the U.S. adopting more robots, do so in response to technological innovations that increase the level of competition amongst firms. Moreover, robot usage in European countries that are ahead of the U.S. in robotics should not be caused by economic trends affecting U.S. industries. Acemoglu and Restrepo (2020) seminal work on automation demonstrates that these assumptions have both theoretical and empirical support.[8] Further, I control for a battery of confounding variables to address any concerns with the identifi-

[6]The AFL-CIO is the largest and most important federation of workers in the US. It advocates for social welfare policies in industries affected by global economic change. It represents both public and private sector unions, and millions of workers in manufacturing, where automation has had big impacts (AFL-CIO, 2019).

[7]Unemployment is another potential mechanism. I don't investigate the effect of automation on the former mechanism because it has been examined elsewhere (Acemoglu and Restrepo, 2020). However, in Section 8 I indicate that the effects of automation are only partly explained by unemployment and mostly driven by unionization.

[8]See also an analysis of robustness to Rottemberg weights in this type of design by Becher and Stegmuller (2024), following Goldsmith-Pinkham, Sorkin and Swift (2020).

cation assumption, and perform several robustness tests to reassure the reader about my findings.

I demonstrate that automation has important political implications by reducing public policy to unions interests among other political outcomes. I find that an increase in one standard deviation in robot adoption—about 600 robots: i) Reduces the number of social welfare bills a member of congress votes in accordance to unions' interests by almost 2 bills per year. ii) Is related to a 0.14 percentage point reduction in the number of unionized workers, and a 0.03 percentage points reduction in the share of unionized workers—or more than 50% of the yearly decline in unionization—and to a drop in approximately 35 workers in collective bargaining agreements. iii) Reduces political donations from workers, especially skilled workers, by about 2 percentage points—or a tenth of their likelihood to donate. iv) Reduces cosmopolitanism among workers by 7 percentage points, and reduces support for taxation by 1%, especially among unskilled individuals. The effects are stronger when there is a more educated labor force, consistent with the hypothesized opportunity-cost mechanism.

The findings herein contribute mainly to the following literatures: First, to the vast literatures on the political economy of unions and of automation (Wu, 2018; Gallego, Kurer and Schöll, 2018; Anelli, Colantone and Stanig, 2018; Thewissen and Rueda, 2019; Owen, 2020; Milner and Solstad, 2021; Chaudoin and Mangini, 2022). I show that automation affects public policy responsiveness to the interests of organized labor through their negative impact on unionization, union activity, political participation from workers and voters' political attitudes—especially when the opportunity cost of unionization is high. Second, it contributes to the literature concerned to understanding the backlash against globalization (Walter, 2021; Colantone, Ottaviano and Stanig, 2022; The Niehaus Center, 2022). I demonstrate that automation has structural political ramifications on both domestic and international public policy through unions, that manifest in expressions against taxation, cosmopolitanism and policies that compensate the losers from international competition. My findings echo the notion that economic change affect interests groups that are essential in policymaking, and to sustain international integration.

2 The problem of union decline

Unionization rates have declined from approximately 35% to 17% between 1970 and 2014 in OECD countries, and although unions represent more than 100 million workers in OECD countries, their decline has been politically consequential (Garrett, 1998; Bennett and Kaufman, 2007; Schlozman, Verba and Brady, 2012). Becher, Stegmueller and Käppner (2018), for instance, show for the U.S., that in congressional districts where unionization rates in the private sector are lower, labor contributions to congresspeople decline, and members of congress are less likely to vote in accordance with the official preferences of organized labor. Indeed, unions are the institutions where workers interact with each other on a regular basis, in the workplace and after work, and these interactions create strong foundations for the political mobilization of workers (Olson, 1965). Unions are grassroots organizations that pool resources to participate in politics; they also help voters acquiring political knowledge, coordinate them and mobilize them to the polls (Bennett and Kaufman, 2007; Rosenfeld, 2014; Ahlquist, 2017). Thus when unions are weak, legislators are less willing to trade influence in their legislative agendas for grassroots mobilization and campaign support from unions.

Union decline is also consequential for social welfare because when unions weaken, poverty and inequality increase (Farber et al., 2018). Unions advocate for policies that improve workers' well-being and reduce inequality, such as more redistribution through taxes; increased public spending; improved working conditions and job security; and retraining programs for industries affected by international economic competition. Union grassroots activities also shape the consciousness of workers toward supporting more social egalitarianism and cosmopolitanism (Kim and Margalit, 2017; Frymer and Grumbach, 2021). (See also Figure A1.) Further, unions also advocate for a broad range of policies with international implications, including but not limited to: migration, tariffs, international finance, among many other (Table A1). Thus strong unions fulfill an essential role in society, helping workers to overcome collective actions issues for participating in politics, for improving social welfare and for influencing politics and policy.

2.1 Why unions decline?

Unions are primarily rent-seeking organizations and secondarily grassroots movements. The main job of a union is to bargain for better wages and job conditions with firms' managers and owners (Freeman and Medoff, 1984). To this end, unions use the threat of strike to force their counterparts to the bargaining table in a process called *collective bargaining*.[9] The threat of strike is effective if a work stoppage can reduce substantially a firm's output, because if workers can generate a high cost for employers with a strike, the latter would be more willing to accommodate unions' demands. Hence unions can obtain a higher *union membership premium* when they have more bargaining power, increasing costs for firms.

The literature on labor unions posits four main explanations behind union decline: First, the *institutional thesis* stresses the role of legislation governing unions, in union decline. Employers, private interest groups and policy makers have incentives to reduce unionization to cut firms' production costs, prevent strikes, and boost economic growth (Bennett and Kaufman, 2007). Right-to-Work Laws (RWLs) are classic examples of this: RWLs have been adopted by 28 states in the U.S., seeking to prohibit union security agreements between employers and labor unions, which require employees who are not union members to contribute to the costs of union representation. Backers of these laws claim that these laws protect workers against being forced to join a union. However, these laws have instead undermined unions' bargaining strength by creating a free rider problem, whereby workers don't contribute union fees but benefit from union activities (Feigenbaum, Hertel-Fernandez and Williamson, 2018).

Second, the *structural thesis* emphasizes that union decline is explained by shifts in employment away from occupations, industries, and regions where union density has traditionally been high—e.g., manufactures—toward sectors with lower density such as the service sector, where organization is more expensive. Indeed, manufacturing has shed employment over the past decades,

[9] A process of negotiation between employers and union representatives. The collective agreements reached in these negotiations set out working conditions and rights to participate in company affairs.

which has shifted toward service-providing industries. Unionization in the services sector is more difficult vis-á-vis the manufacturing sector thanks to decentralized bargaining, where the firm may negotiate with individual employers; a low degree of corporatism because atomized bargaining can eliminate the benefits of collective bargaining; and lower benefits to labor organization because shop floors are smaller and often prohibit union access (Visser et al., 2019; Schnabel, 2020).

Third, the *networks thesis* sustains that union strength requires a high level of workplace social capital towing union recognition (Naidu, 2022). Despite unions remain highly popular, anchoring union collective action from workers is a "militant minority" who are extremely attached and loyal to their coworkers and the labor movement and who work to strengthen unions despite little in the way of personal benefits; i.e., the networks' centers. These individuals form crucial ties between unions and their (potential) members, constituting shop stewards, canvassers, etc., in union shops, which matter for sustaining norms of solidarity that facilitate collective action. However, private-sector co-worker interactions outside of work and their friendships, and thus their sense of identity at work, have declined markedly (e.g., The Social Capital Project 2017), affecting these networks.

Finally, the *market competition* thesis states that firms prosper as long as their competitors face similar production costs. Since unions rent-seeking activities impose higher labor costs on firms, their competitors can produce at lower costs and sell at lower prices. Hence firms with unions need to find a way to cut costs to sustain the demand for their products. The problem is that unions cannot credibly commit to not rent-seek to reduce labor costs because their primary purpose is to do exactly that, thus firms have incentives to reduce labor costs by laying off workers (Kochan et al., 2013); or by relocating shops to places where unionization is more difficult;[10] or by reducing workers' incentives to unionize by undermining union's bargaining power. Otherwise, market forces can push firms to closing shop, reducing the number of unionized workers through a negative effect on employment.

The competitive thesis is especially relevant. On the one hand, companies naturally operate in

[10]This mechanism translates to laying off workers (Mankiya et al., 2017).

a competitive environment affected by domestic and international pressures, and organized labor need firms to prosper and new jobs to lend themselves to organization. Firms' competitiveness is the underlying driving force shaping firms' incentives to oppose unions, workers' incentives to unionize, and politicians' incentives to regulate unions. Indeed, the evidence shows that sectors of traditional union strength had already contracted before the wave of sharp deunionization started (Pencavel, 2007). Furthermore, the key economic forces undermining unions were already under way when the legal framework turned unfavorably against unions (Bennett and Kaufman, 2007). Hence the competitive thesis precedes the causes mentioned in the alternative theses above.

2.2 International competition, automation and union decline

Under the competitive thesis there are essentially two forces driving union decline: i) Unemployment and ii) A reduction in the incentives to unionize. Scholars have argued that automation has been perhaps one of the most important sources behind these two forces (Kennedy et al., 1982; Gil, 1986; Bennett and Kaufman, 2007). For example, manufacturing unions in the U.S. were strong during the early 70s, despite corporate leaders were seeking to reform labor laws to limit union power. This changed during the late 70s and early 80s, as U.S. experienced unprecedented levels of domestic and international competition owing to the increasing levels of automation in Japan and Western Europe, and also within the U.S.

One prominent example is the automotive industry. Japanese firms had adopted a strong mechanization process of their assembly lines, reducing the production costs of automobiles.[11] As a result, Japanese companies increased their market share from 11% in 1978 to 21% in 1980. These international pressures, also came from within the US. Multinational companies, like Hyundai and Toyota, opened subsidiaries in the U.S., with high levels of automation and strong anti-union stances. The same occurred in other manufacturing industries such as micro-components, light steel manufactures, printing and textiles.

[11] Kennedy et al. (1982) notes that Japan used more than 30% of all robots in the production of manufactures, whereas the U.S. only used 10%.

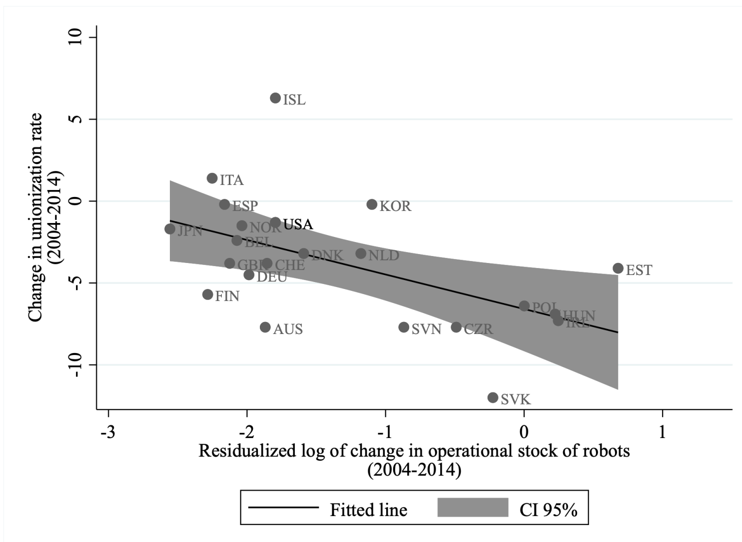
To address increased competition, local companies were forced to retool and restructure their production process, investing in labor-saving technologies. In the manufacturing industry, this process targeted the processes that were friendly towards automation. As a result, mechanization triggered a deskilling process that made many workers dispensable because managers and owners needed machine operators and repairmen to generate output. This process towards automatizing the tasks previously performed by workers, allowed companies to layoff hundreds of thousands of workers over the years (Kennedy et al., 1982). Belloc, Burdin and Landini (2023) finds similar evidence for present-day Europe.

Interestingly, unions generally do not generally oppose the process of automation, and instead negotiate new bargaining agreements with employers to avoid plant closures and layoffs. However, the prospect of automation reduced unions' bargaining power, because firms could automate to replace workers. As a result unions have been forced to accept wage cuts and lower benefits, reducing union membership premiums. Ironically, these concessions have helped subsidizing the introduction of robots in firms' operations, further reducing the need for manual labor, forcing unions to renegotiate their bargaining agreements more often, and with decreasing bargaining power (Haapanala, Marx and Parolin, 2023). For highly educated workers, who are less likely to unionize, automation has instead being beneficial as automation has been accompanied with higher demand for their skills given their ability to use (new) machines (Agrawal, Gans and Goldfarb, 2019; Belloc, Burdin and Landini, 2023).

Automation thus has had the dual quality of both replacing labor and reducing unions' bargaining power. However, whereas the prospect of being laid off has been under the purview of market forces shaping the supply and demand for labor, the decision to unionize belongs to the worker. Thus as the union premium has declined with the bargaining power of unions, so has workers' incentives to unionize, resulting in lower unionization rates (Rosenfeld, 2014). Hence solidaristic efforts to stand up for vulnerable workers are potentially obstructed by the increasing returns to skilled labor.

In general, the trends toward more automation and international competition have continued over the years, as manufacturing production has become more automatized in European countries and East Asian countries. However, the negative impact of automation on unions has not been exclusive to the US—the case study herein. Unions have continued to lose ground in the past decades across the world. In fact, we observe a negative correlation between the change in the adoption of manufacturing robots and unionization rates across the world (Figure 1). [12]

Figure 1: Changes in unionization rates and robot adoption in OECD countries



3 Automation and unions' political power

In the previous section I discussed evidence indicating that firms' decision to adopt labor saving technologies in response to increased competition affects unions through i) the positive effect of automation on unemployment and ii) the negative effect of automation on unions' bargaining power: When unions lose members and their union membership premiums decline, it is harder for them to generate successful grassroots movements. Smaller unions have less manpower and financial resources to carry out unions' political activities. With lower de facto power, it is increasingly dif-

[12]While unionization rates have continued to decline in the manufacturing sector, unionization rates have increased in other sectors of traditionally skilled labor, affected by artificial intelligence. Exploring this form of automation is outside of the scope of this paper and explored in work in progress: Balcazar, Becher and Stegmuller. (2024).

ficult for unions to influence politics and policy because legislators can ignore unions' preferences at a lower political cost. Thus automation should weaken unions, and consequently the political power of organized labor.

A problem with these mechanisms is that they compound each other to generate lower unionization. Hence, it is hard to distinguish between them and their relative relevance to better characterize the role of automation on unions' political power. However, recall that automation affects unemployment by replacing workers with machines. Higher unemployment in turn reduces the amount of manpower and the resources unions can tap into because the *number* of unionized workers falls in response. Thus an essential characteristic of this mechanism is that automation is more likely to replace unskilled labor vis-á-vis skilled labor, because the tasks performed by the latter type of labor are much harder to automate. In contrast, workers' incentives to unionize depend essentially on the benefit of participating in rent-seeking through the union vis-á-vis using that time and effort in productive activities (Appendix B). The relative benefit of unionization may fall when workers' bargaining power declines because unions' can extract less rents from the employer, reducing the union premium, or when the relative value of the outside option (working) is higher because rent-seeking is inherently unproductive. Thus this mechanism affects the *incentives* to unionize. To elaborate further:

- Automation reduces the bargaining power of unions because the threat of strike weakens as a result of automation. Employers can replace manual labor with machines, keeping production high and costs low despite the possibility of a work stoppage. As a result, the benefit from rent-seeking versus productive activities (such as wage premiums) declines, increasing the *opportunity cost* of unionization. Workers thus have less incentives to join the union in response to automation, reducing the *share* of workers that are unionized.

- Automation affects the incentives of skilled and unskilled labor differently: The tasks performed by unskilled labor are easier to automate because they have a high routine content, whereas those performed by skilled labor are not because they have a low routine content.

> Thus, while machines substitute the work of unskilled labor, they can complement the work of skilled labor. As a result, automation can increase the wage differences between unskilled labor and skilled labor, because skilled labor becomes relatively more productive per unit of labor vis-á-vis its unskilled counterpart. Therefore automation can increase the opportunity cost of unionization for skilled workers because their non-union wages are higher vis-á-vis their union wages.

To provide an example, I collect data on more than three hundred thousand union dues reports submitted by unions to the Office of Labor-Management Standards form the National Labor Relations Board, between 2000 and 2014. First, I harmonize union-dues values to dues per hour in constant prices of 2009. Second, I use wage data gleaned from the top job aggregators – Indeed and SimplyHired – and data form the Bureau of Labor Statistics to estimate the wage per hour at constant prices of 2009 of two types of worker: i) An assembly line worker, whose job is (for instance) manually assembling parts of a manufacturing product. This worker is unskilled because she can perform the job-tasks with a basic level of skill/education, and can be replaced by a assembly robot. ii) An industrial robot operator, whose job is to operate the assembly robot. This worker is skilled because he needs at least some technical degree to code in order to operate the robot.[13] Table 1 displays the market wages of the two types of workers: the assembly worker receives a 2% wage premium from unionization while the latter's receives a decrease of 5% in its market wage.[14]

Altogether, this implies that unskilled labor has incentives to unionize because the union membership premium increases in response to automation, but skilled labor does not since the benefit of unionization falls because their market wages are higher.[15] These divergent preferences for unionization hamstring worker organization, thereby reducing unions' bargaining power. As a result, workers' incentives to unionize should fall more sharply in response to automation as workers

[13] See `https://www.fanucamerica.com/education`

[14] These estimates are similar to previous estimates of wage compression from unionization by Lemieux, MacLeod and Parent (2009); Frandsen (2010); Card, Lemieux and Riddell (2017); Collins and Niemesh (2019).

[15] Automation could boost the bargaining power of skilled labor because they can generate more harm with a strike, but unions compress the wage differences between skilled and unskilled labor, countervailing this effect. My empirical results below suggest that the latter effect dominates.

Table 1: Market wages for two workers in the assembly line and their opportunity cost for union activities

	Assembly line worker	Industrial robot Operator
Hourly rate	19.65	33.74
Union premium	0.36	-1.67
Hourly union fee	2.03	
Unionizing net gain	2%	-5%

Note: Values come are obtained using data from job aggregators – Indeed and SimplyHired – and the Bureau of Labor Statistics for the period 2000-2014. Values are in constant USD (2009=100).

become more skilled; the same should hold true for legislators' responsiveness to the interests of unions. Hence we define the first hypotheses herein:

H1. *An increase in automation reduces unionization where the supply of skilled labor is high.*

H2. *An increase in automation reduces public policy responsiveness to unions where the supply of skilled labor is high.*

Note that the *opportunity cost* mechanism in hypotheses H1 and H2 is more demanding than the alternative unemployment mechanism. On the one hand, this mechanism requires that the number of unionized workers changes faster than the number of workers in response to automation. That is, automation must affect workers' incentives to unionize and not only the demand for labor. Secondly, the unemployment mechanism predicts that automation should reduce unionization wherein the supply of unskilled workers is higher because machines replace unskilled labor, whereas the opportunity cost mechanism predicts the opposite. Therefore we can potentially disentangle the effects of automation on the outcomes herein by looking at the moderating effect of workers' skill.

3.1 Political attitudes and policymaking

Hypothesis H2 indicates that automation affects the policymaking process. To understand the connection between the political participation from workers and policy responsiveness from legislators, it is essential to consider the role of labor unions in society: unions provide costly information to workers, which allow them to make informed political choices. As a result, workers are more likely to display support for redistributive policy, and other domestic and international policies that are important for labor (Section 2). For example, Minchin (2017) documents the efforts made by unions to coordinate the dissemination of politically and policy-making relevant information through union newspaper such as the AFL-CIO news. This means that we should observe an effect of automation on voters attitudes towards social issues away from redistribution and cosmopolitanism, as well as lower support from legislators for related bills. Regarding the latter, I remain agnostic on the distribution of these differential effects by skill level, except for predicting a negative differential effect on bills related to social welfare. I summarize these hypotheses below:

H3. *An increase in automation reduces workers' attitudes in support of redistribution and cosmopolitanism.*

H4. *An increase in automation reduces public policy responsiveness to unions for social-welfare policy and associated international policy where the supply of skilled labor is high.*

4 Data and variables

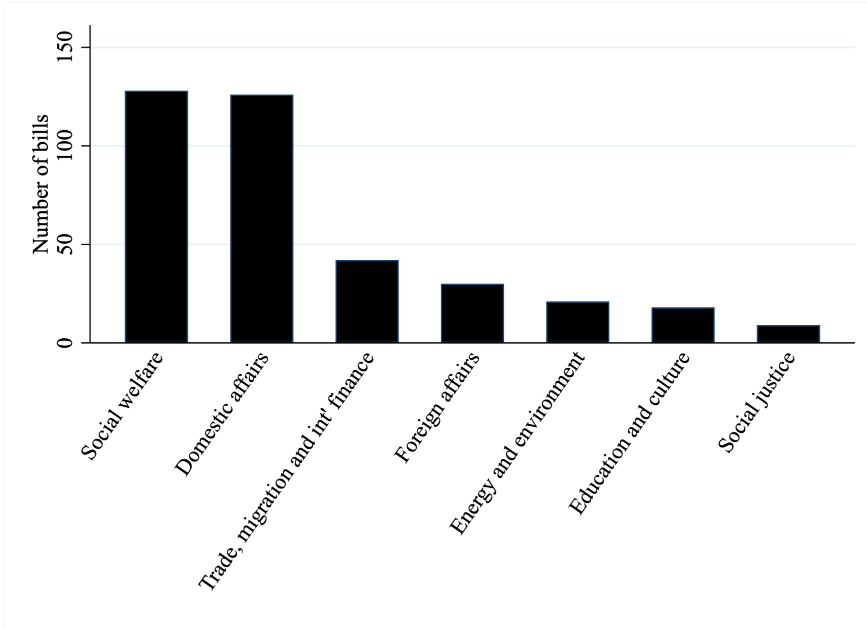
Policy responsiveness to unions

To measure policy responsiveness to unions' interests I use data from the AFL-CIO, which is the largest and most important federation of workers in the US. The AFL-CIO tracks the voting record of legislators on "issues important to working families, including strengthening Social Security and Medicare, freedom to join a union, improving workplace safety and more"—AFL-CIO. I use the federation's legislative scorecard to measure the percentage of votes by each congressman that are in line with unions' revealed preferences, in each session of congress. For example, in the first session of the 109th congress, the AFL-CIO's official position was to vote *Nay* on the "Job-Training Reauthorization–H.R. 27" bill, which cut overall funding for critical job-training programs. Thus if a congressperson voted in agreement with half of the AFL-CIO official positions in every bill during 2005, her score for that year would be 50%.

For the analysis herein, I use data from the 2005 onwards because in early 2005 some unions split from the AFL-CIO; however Minchin (2017) indicates that this event didn't affect the federation in the years thereafter. By restricting the data in this way, I make sure the AFL-CIO's power remains largely unaffected by changes in its composition. This decision is also empirically consistent with the fact that data on exposure to robots in the U.S. starts in 2004.

Bill types. I use data from the Library of Congress to identify the specific policy topics related to each bill. Unsurprisingly, the bills (or bill amendments) that unions support cover a wide range of topics (Table A1). About half of all bills are concerned with broad legislation regarding social welfare policy and trade, migration and international finance (Figure 2).

Figure 2: Number of bills with an official position from the AFL-CIO, by topic (2001-2014)



Note: Information about the bills' topics is available in Table A1.

Union membership and union activities

Data on union membership comes from the Labor Organization Annual Financial Reports and Constitutions and Bylaws. I use the harmonized data from Becher, Stegmueller and Käppner (2018). This data is highly accurate because failure to report, and to report truthful information, has steep fines and can be punishable with jail time.[16] Additionally to union membership, I also compute the ratio of union members to workers.

To measure union activities I collect data on collective bargaining processes and strikes. Employers and labor unions are required by law to collectively bargain a contract when there are disagreements; they must also agree on the duration of such contract. The data on work stoppages and collective bargaining notices comes from the Bureau of Labor Statistics and the U.S. Federal Mediation and Conciliation Service. I obtain congressional-district-level aggregates for the num-

[16]The legal basis for these reports is the Labor-Management Reporting and Disclosure Act (LMRDA) of 1959. This act introduced a comprehensive system of reporting: unions have to file an initial report with the Office of Labor-Management Standards (OLMS) followed by a yearly report using a so-called LM form. For the public sector, the Civil Service Reform Act (CSRA) of 1979 created a similar system.

ber of workers participating in these union activities. I measure these variables for the private sector and the public sector separately.

Political participation

To measure political participation I use rich data I collected from the OLMS-LS regarding unions' political expenditures: I collect data regarding total direct and indirect disbursements to all entities and individuals during associated with political disbursements or contributions in money. I aggregate these quantities at the congressional district level, in constant U.S. dollars of 2009.

I also obtain data on individual political donations to candidates, campaigns, or political organizations from the Cooperative Congressional Election Study (CCES). This variable is measured as a dummy: one indicates that the individual donated, zero if otherwise.

Political attitudes

I obtain data on individuals political attitudes regarding redistributive policy and cosmopolitanism from the CCES.[17] I collect data on opinions about taxation and austerity, approval of gay marriage, abortion, immigration and affirmative action. To analyze this data I create indexes for redistributive attitudes and cosmopolitanism.

Exposure to robots

Data on exposure to robots comes from the International Federation of Robotics (IFR). I use the Bartik measure of industrial exposure to robots from Acemoglu and Restrepo (2020), which combines industry-level variation in the usage of robots (the *shift*) and baseline employment shares (the

[17] Cosmopolitanism encompasses different dimensions of community, such as promoting moral standards, global political structures, cultural expression and tolerance, or developing a platform for equality of opportunity.

share). This *shift-share* measures the local industry level of robot adoption predicted by interacting local industry employment shares with national industry changes in robot adoption.

The shift is the measure of robot adoption adjusted by industry growth defined by

$$A^{US}_{i,(t_0,t_1)} = \frac{M^{US}_{i,t_1} - M^{US}_{i,t_0}}{L^{US}_{i,1990}} - g^{US}_{i,(t_0,t_1)} \frac{M_{i,t_0}}{L^{US}_{i,1990}},$$

where M^{US}_{i,t_0} is the number of robots in industry i at time t_0 in the U.S., similarly for M^{US}_{i,t_1}; $g^{US}_{i,(t_0,t_1)}$ is the growth rate of output of industry i between t_0 and t_1;[18] $L^{US}_{i,1990}$ is the baseline employment level in industry i in 1990. The share, $\mathscr{L}^{1990}_{ci}$, corresponds to the share of industry i in the total employment of commuting zone c in 1990,which is a time period that predates the onset of rapid advances in robotics technology and the acceleration of robot adoption in the world.[19]

Putting the shift and the share together, the measure of exposure to robots is given by

$$\mathrm{R}^{US}_{c,(t_0,t_1)} = \sum_i \mathscr{L}^{1990}_{ci} \cdot A^{US}_{i,(t_0,t_1)}.$$

I recompute this measure at the congressional district level by finding the correspondences between commuting zones and their counties in the 1990 census, and the congressional districts from 1992 to 2014, accounting for redistricting, using data from the Michigan Population Studies Center. I denote this district-level measure by $\mathrm{R}^{US}_{d,(t_0,t_1)}$, where d is the congressional district.

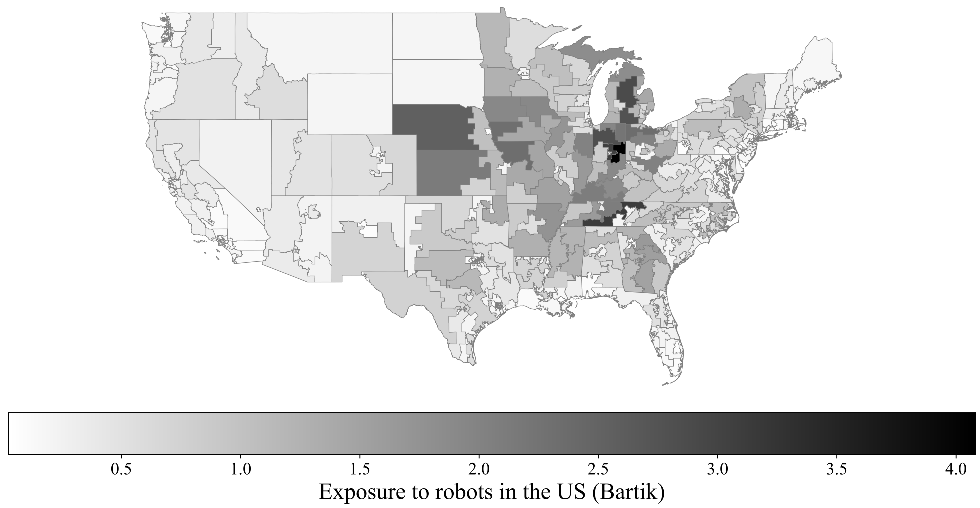
Since this *shift-share* is sourced in first differences, attrition from redistricting generates 24 missing congressional districts out of 435 (Figure 3).[20] Despite these data limitations, my results below are robust to numerous statistical tests. Further, since the scope conditions I defined in the theory laid out in the previous section are broad, they should limit additional concerns about the external validity of my findings.

[18]This term is relatively unimportant because 96% of the variation in the adjusted penetration of robots across industries between 1993 and 2007 is driven by the increase in robot density.

[19]Global robot adoption increased by 50% from the early 90s to the early 2000s, and doubled by the early 2010s.

[20]Brynjolfsson et al. (2023) shows that there is geographical concentration in robot adoption in the Rust Belt; my independent variable considers this fact and the potential for economic interdependence across regions in the U.S.

Figure 3: Geographical distribution of exposure to robots



Additional covariates

I also obtain data on a number of variables that could affect both the exposure to robots, union activities and my political outcomes: i) Data on population sizes, employment and demographics drawn from the American Community Survey and the 1970 and 1990 population censuses, ii) Data on industry-level changes obtained from County Business Patterns and NBER-CES Manufacturing Industry Database, iii) Data on pre-treatment exposure to Chinese imports, offshoring, task routinizatio and deindustrialization come from work by David Autor, and by Leonardo Baccini and Stephen Weymouth, iv) I measure skilled labor as the percentage of manufacturing workers pre-treatment, using census data from 2000, which should be commensurable with the theoretical discussion above (see Agrawal, Gans and Goldfarb 2019).

Table A2 in the Appendix shows the summary statistics. All variables are measured as annualized changes. Overall, in places with high robot exposure, we can observe negative changes on employment, unions' political expenditures and measures of union activity, and lower policy responsiveness to unions. We also observe lower support for cosmopolitanism.

5 Empirical strategy

My objective is to estimate the impact of the exposure to robots on union outcomes and political outcomes. However, workers, firms and lawmakers could anticipate automation and forestall or even promote robot adoption through a number of mechanisms (Section 2.1). Thus causality may run in the direction opposite to the one I hypothesize. Additionally, unobserved characteristics of the local socio-economic structure could shape the incentives of firms to adopt robots, and the incentives of workers to participate in union activities and politics. For instance, the existence of strong bonds in local communities can improve workers' ability to organize, to forestall (or promote) robot adoption, and (or) to participate in union activities and in politics. This could generate bias in OLS estimates.

I address reverse causality and omitted variable bias using an instrumental variable corresponding to the measure of exposure to robots attributable to industry-leaders in robotics. Thus define the Bartik instrument

$$\mathrm{R}_{c,(t_0,t_1)} = \sum_i \mathscr{L}_{ci}^{1970} \cdot \overline{APR}_{i,(t_0,t_1)}.$$

For this instrument, the shift is

$$\overline{A}_{i,(t_0,t_1)} = \frac{1}{5} \sum_{j \in EURO5} \left[\frac{M_{i,t_1}^j - M_{i,t_0}^j}{L_{i,1990}^j} - g_{i,(t_0,t_1)}^j \frac{M_{i,t_0}}{L_{i,1990}^j} \right],$$

with $EURO5 = \{\text{Denmark, Finland, France, Italy, Sweden}\}$.[21] In this expression, M_{i,t_0}^j is the number of robots in industry i in country j at time t_0, similarly for M_{i,t_1}^j; $g_{i,(t_0,t_1)}^j$ is the growth rate of output of industry i in country j between t_0 and t_1, and $L_{i,1990}^j$ is the baseline employment level in industry i and country j.

The share, $\mathscr{L}_{ci}^{1970}$, corresponds to the share of industry i in total commuting zone employment

[21] These countries account for a substantial percent of the world industrial robot market (Acemoglu and Restrepo, 2020). Further, although the IFR reports data for Japan, the IFR's recommendation is to exclude Japan from the analyses because the Japanese data underwent a major reclassification during the period of interest.

in 1970, in the US. Thus I focus on the historical, persistent differences in the industrial specialization of areas that predated the modern age of industrial robots, which starts in the 1980s.[22] This period of time also allows me to avoid mechanical correlations or mean reversion associated with temporary changes in industry employment in the 1980s.

This *shift-share* measures the local industry level of robot adoption predicted by interacting local industry employment shares with industry changes in robot adoption in leaders in automation. The share measures the level of treatment uptake of the shift, which is essentially the treatment. In this way the shift-share captures spatial interdependence through the concept of treatment uptake in a first-differences design, accounting for the geographical concentration in robot adoption to an extent. I aggregate this variable to the congressional district using spatial correspondences and denote the district-level measure by $\mathrm{R}^{EURO5}_{d,(t_0,t_1)}$.

In the first stage I estimate the following regression:

$$\mathrm{R}^{US}_{d,(t_0,t_1)} = \gamma + \delta \mathrm{R}^{EURO5}_{d,(t_0,t_1)} + \Delta \mathbf{X}'_d \theta + \Delta \mathbf{Z}'_{d,(t_0-1,t_1-1)} \psi + \varepsilon_{d,(t_0,t_1)}, \tag{1}$$

where $\Delta \mathbf{X}'_d$ is a rich vector of pre-treatment confounders in first-differences; $\mathbf{Z}'_{d,(t_0-1,t_1-1)}$ includes pre-treatment changes in union bargaining processes and strikes to account for pre-treatment union strength and the possibility that workers could anticipate task automation; $\varepsilon_{d,(t_0,t_1)}$ is the idiosyncratic error term. Since this regression is in first differences, the fixed effects are accounted for.

Importantly, a shift-share instrument needs an element of exogenous variation in order to provide statistically identification of the effect of exposure to robots on the outcomes analyzed herein (Jaeger, Ruist and Stuhler, 2018; Goldsmith-Pinkham, Sorkin and Swift, 2020; Borusyak, Hull and Jaravel, 2021). All in all, the identification assumption rests on the fact that areas adopting more industrial robots do so thanks to technological innovations occurring across industries, which trigger changes in the choices to automate by local industries, to remain competitive. Moreover, changes

[22] The first industrial robot was designed in 1954. However it was only until the 1980s that industrial robots began to be made in large numbers, with a new robot being introduced in the market at the rate of one a month.

in robot usage in other advanced economies must not correlated with other trends such as common shocks to import competition or rising wages, or respond to the decline of an industry in the US. Acemoglu and Restrepo (2020) verify that there is no substantive correlation between robot adoption and any of the other major trends affecting U.S. local labor markets, such as: import competition from China and Mexico; offshoring; the decline of routine tasks; investments in information technology (IT) capital; and overall capital deepening. Also, the exposure to robots is unrelated to past trends in labor market outcomes from 1970 to 1990, which is the period that predated the onset of rapid advances in robotics technology. Furthermore, I do not find evidence in support of potentially unobservable confounders (Section A.5). Additionally, I analyze the effective regression weights of my regression, which capture the contribution of every unit to the results I obtain, showing that my results are driven by districts where the treatment uptake should be strongest, such as the Rust Belt, furthermore I find that my results are also heterogeneity robust (Section A.5).[23]

In the second stage, I proceed to estimate the effect of exposure to robots on union membership:

$$\Delta(\mathrm{y}_d; t'_0, t'_1) = \alpha + \beta \widehat{\mathrm{R}}^{US}_{d,(t_0,t_1)} + \Delta \mathbf{X}'_d \delta + \mathbf{Z}'_{d,(t_0-1,t_1-1)} \phi + \varepsilon_{d,(t_0,t_1)}, \tag{2}$$

where $\Delta(\mathrm{y}_d; t'_0, t'_1)$ is the post-treatment change in the outcome of interest; $\widehat{\mathrm{R}}^{US}_{d,(t_0,t_1)}$ is the predicted exposure to robots from the first stage regression. We can interpret the main coefficient of interest, β, as the annualized change in the outcome when exposure to robots increases in one robot per one thousand workers in response to international pressures regarding automation.

Recall that my theory states that the negative impact of robot exposure is driven by a high opportunity cost of union participation (Section 3). Specifically, skilled workers face a higher opportunity cost of joining the union in response to automation because they become more productive. Hence the negative impact of robots must be bigger in those place with a bigger share of skilled labor pre-treatment.

[23] See the discussions in de Chaisemartin and Lei (2023) and Borusyak and Hull (2024).

To evaluate this hypothesis, I estimate the moderating effect of pre-treatment changes in the share of workers with college education or above. I consider the following regression:

$$\Delta(\mathrm{y}_d;t'_0,t'_1) = \alpha + \beta_1 \widehat{\mathrm{R}}^{US}_{d,(t_0,t_1)} + \beta_2 \widehat{\mathrm{R}}^{US}_{d,(t_0,t_1)} \times \Delta \mathrm{S}_d + \Delta \mathbf{X}'_d \delta + \mathbf{Z}'_{d,(t_0-1,t_1-1)} \phi + \varepsilon_{d,(t_0,t_1)}, \tag{3}$$

where S_d is the change in the share of skilled labor between 1970 and 1990; β_1 corresponds to the effect of exposure to robots when $\Delta \mathrm{S}_d = 0$, while $\beta_1 + \beta_2 \times S_d$ is the estimated effect of tariff revenues for different values of change in the share of skilled labor.

Since my theory states that the negative impact of robot exposure is driven by a high opportunity cost of union participation, which should be higher for skilled labor, I also estimate the moderating effect of the pre-treatment share of workers with college education or above; I consider the following regression:

$$\Delta(\mathrm{y}_d;t'_0,t'_1) = \alpha + \beta_1 \widehat{\mathrm{R}}^{US}_{d,(t_0,t_1)} + \beta_2 \widehat{\mathrm{R}}^{US}_{d,(t_0,t_1)} \times \mathrm{S}_d + \Delta \mathbf{X}'_d \delta + \mathbf{Z}'_{d,(t_0-1,t_1-1)} \phi + \varepsilon_{d,(t_0,t_1)}, \tag{4}$$

where S_d is the change in the pre-treatment share of skilled labor; β_1 corresponds to the effect of exposure to robots when $\mathrm{S}_d = 0$, while $\beta_1 + \beta_2 \times S_d$ is the estimated effect of robot exposure for different values of change in the share of skilled labor.

Union strength as a mechanism. I posit herein the union strength is an important mechanism connecting automation with various political outcomes; i.e., a mediator. However, causal mediation analysis is difficult insofar as the assumption of sequential ignorability are likely unsatisfied in most cases (Bullock, Green and Ha, 2010; Imai, Keele and Yamamoto, 2010; Imai et al., 2011; Bullock and Green, 2021).[24] While Becher and Stegmuller (2024) attempts to circumvent this type of problem by instrumenting (post-treatment) union strength using historical unionization in coal and metal mines and steel plants as a source of plausibly exogenous variation for union power, following the instrumental-variables mediation approach by Frölich and Huber (2017), this ap-

[24] Sequential ignorability states that, conditional on pretreatment covariates, the treatment is independent of all potential values of the outcome and mediating variables, and that the observed mediator is independent of all potential outcomes given the observed treatment and pretreatment covariates.

proach is problematic herein for two reasons: i) The instrument for unions should be orthogonal to automation to satisfy the exclusions restriction, but as discussed in Section 2.2, robotization may respond to unionization and viceversa (reverse causality).[25] Thus such an instrument would not be valid in the context of my analysis. ii) It is difficult to credibly assume that historical unionization in coal and metal mines and steel plants did not have an effect in any other outcome besides unions, that could potentially influence politics today through other channels. The literature on historical legacies has shown that relevant economic and social structures have persistent effects that determine outcomes in the present (Cirone and Pepinsky, 2022), and metal mines and steel plants have been one of such structures in the US (Warren, 2008; Rogers, 2009).Therefore such an instrument is generally invalid. For the purposes herein I follow a more conservative, and standard strategy of estimating a regression of the treatment (robot adoption) on the mediator (union strength), and then a reduced form regression of the robot adoption on the political outcomes to avoid statistical limitations in these type of analyses.

6 Effect of exposure to robots on unions

I start by investigating the effect of exposure to robots on union membership. I focus on private sector activity because automation is most likely to affect this sector in contrast to the public sector, where tasks are harder to automate.[26] Table 2 below reports the effect of exposure to robots on union membership (panel A) and on the unionization rate (panel B): Columns (1) to (3) report the naive (OLS) effect of exposure to robots on union membership, whereas columns (4) to (6) report the instrumental variables (2SLS) estimate. Columns (1) and (4) do not include controls while columns (2) and (5) include the full set of controls except pre-treatment collective bargaining and strikes; columns (3) and (6) control for pre-treatment bargaining and strikes. Standard errors are clustered at the state level.[27] Note that the first-stage F-test of excluded instruments is above

[25] See also the discussion in Collard-Wexler and De Loecker (2015).
[26] I also provide a basis for this choice via placebo tests (Section A.7).
[27] My results are also robust to spatial clustering using Conley standard errors (not shown).

standard reference values, indicating that the Bartik instrument is strong. Since columns (3) and (6) reduce the sample size, my preferred specifications do not control for collective bargaining and strikes. For ease of interpretation I standardized my variables by dividing them by their standard deviation—therefore we look at the annual effect of an increase in about 600 robots in the district in standard deviations of the outcome.

The point estimates for the 2SLS regression are bigger than those of the OLS, however they are statistically similar—which is a feature of shift-share designs. Notice also that once I control for confounders the effect of robots is much stronger. This occurs because controls capture any potential long-run responses to robotization shocks, allowing us to focus in the short-run response to automation (Jaeger, Ruist and Stuhler, 2018).[28] Moreover, when I control for union activities (column 6), my results remain fairly stable.

My results in panel A indicate that an increase in one standard deviation in robot adoption workers per year is related to a reduction in 0.14 standard deviations in the percentage of unionized workers. That is more than a 2% decline in the number of unionized workers. The results in panel B indicate that an increase in one standard deviation in robot adoption workers per year reduces the share of unionized workers by 0.11 standard deviations; that is about a 0.03 percentage points reduction. This effect is large and relevant considering that union density has decreased at about 0.3 percentage points per year between the 1950s and 2014 (Hirsch, Macpherson and Vroman, 2018), and at a 0.04 points per year during the period of analysis (Table A2). Therefore automation explains a substantial amount of deunionization.

6.1 Union activities

I find that exposure to robots has a negative effect and statistically significant effect on union collective bargaining, and no statistically significant effect on strikes (Table 3). Specifically, I find that

[28]Local shocks may trigger adjustments that gradually offset their local impact, with a period of positive employment and wage growth—a *reinstatement effect*—following the potentially negative effect on the demand of labor of a local technological shock—a *substitution effect*.

Table 2: Effect of exposure to robots on union membership

	OLS			*2SLS*		
	(1)	(2)	(3)	(4)	(5)	(6)
	Panel A. % change in no. of unionized workers					
US exposure to robots	-0.376* (0.208)	-1.383*** (0.371)	-1.187*** (0.366)	-0.343* (0.200)	-1.537** (0.601)	-1.294** (0.600)
Observations	412	412	400	412	412	400
	Panel B. Change in union density (%)					
US exposure to robots	-0.019** (0.007)	-0.032** (0.013)	-0.025 (0.015)	-0.020** (0.008)	-0.041** (0.018)	-0.033* (0.019)
Observations	412	412	400	412	412	400
Demographic controls	No	Yes	Yes	No	Yes	Yes
Industry controls	No	Yes	Yes	No	Yes	Yes
Other shocks	No	Yes	Yes	No	Yes	Yes
Col. bargain and stoppages	No	No	Yes	No	No	Yes

	Panel C. First stage regression		
Exposure to robots	0.954*** (0.055)	0.833*** (0.058)	0.823*** (0.053)
F for excluded instruments	304	203	242
Observations	412	412	400
Demographic controls	No	Yes	Yes
Industry controls	No	Yes	Yes
Other shocks	No	Yes	Yes
Col. bargain and stoppages	No	No	Yes

Note: Standard errors clustered at state level are in parentheses. Coefficients that are significantly different from zero are denoted by the following system: *10%, **5%, and ***1%. Controls include: changes in size of the population, in the share of female labor, Hispanic, white, black and Asian groups, changes in the share of people with high school, college and masters degrees, and in the share of people with 65 years of age and above; changes in the share of manufacturing and light manufacturing in industry; pre-treatment changes in unionization and Right-to-Work Laws; the China import shock, hanges in the share of routine task labor and other measures of deindustrialization.

an increase in one standard deviation in robot adoption workers reduces by 0.08 standard deviations in the number of workers in collective bargaining agreements (approximately 35 workers).

This effect of automation on union activity is relevant because if a collective bargaining process doesn't fail, there cannot be a strike. Therefore these results suggest that robot adoption isn't associated with bargaining failure. This is consistent with the observation that automation forces workers to negotiate with their employers with reduced bargaining power (Section 2.2).

These results are robust to sensitivity analysis on unobserved confounding, to dropping districts with replacement, to an effective weights analysis, and to a reduced form analysis. These results are available in Section A.5 in the Appendix.

6.2 Political participation

Automation may also affect political participation through its effect on unions. To evaluate this I first estimate the effect of exposure to robots on political expenditures and campaign contributions. First, I find that the effect of exposure to robots on unions' political expenditures, although negative, is not statistically significant (Table A4). Although these results suggest that political participation outcomes from unions remain unaffected statistically, these outcomes do exhibit heterogeneous effects consistent with my theoretical framework (Section 7).

Second, I estimate the effect of exposure to robots on individual campaign contribution for workers. I find that an increase in 600 robots at the district level reduces the likelihood of donating by 1%.[29] Since the likelihood of donation is about 10%, exposure to robots results in a drop in 1/10th in the likelihood of political participation through donations. These results indicate that workers are less likely to donate as a result of automation.[30]

[29] I also explore the effect of exposure to robots on vote shares for democrats, but I do not find evidence of a statistically significant effect of automation on this quantity (not shown).

[30] I show in Section 7 that this is unlikely to be driven by the effect of robots on job market outcomes.

Table 3: Effect of exposure to robots on collective bargaining and strikes

	OLS			*2SLS*		
	(1)	(2)	(3)	(4)	(5)	(6)
	Panel A. Change in no. of workers in collective bargaining (thou.)					
US exposure to robots	-0.021 (0.021)	-0.068** (0.032)	-0.064* (0.034)	-0.026 (0.022)	-0.084** (0.036)	-0.079** (0.038)
Observations	412	412	400	412	412	400
	Panel B. Change in no. of workers striking (thou.)					
US exposure to robots	-0.000 (0.000)	0.001 (0.001)	0.001 (0.001)	-0.000 (0.000)	0.003 (0.003)	0.003 (0.003)
Observations	412	412	400	412	412	400
Demographic controls	No	Yes	Yes	No	Yes	Yes
Industry controls	No	Yes	Yes	No	Yes	Yes
Other shocks	No	Yes	Yes	No	Yes	Yes
Col. bargain and stoppages	No	No	Yes	No	No	Yes

	Panel C. First stage regression		
Exposure to robots	0.954*** (0.055)	0.833*** (0.058)	0.823*** (0.053)
F for excluded instruments	304	203	242
Observations	412	412	401
Demographic controls	No	Yes	Yes
Industry controls	No	Yes	Yes
Other shocks	No	Yes	Yes
Col. bargain and stoppages	No	No	Yes

Note: Standard errors clustered at state level are in parentheses. Coefficients that are significantly different from zero are denoted by the following system: *10%, **5%, and ***1%. Controls include: changes in size of the population, in the share of female labor, Hispanic, white, black and Asian groups, changes in the share of people with high school, college and masters degrees, and in the share of people with 65 years of age and above; changes in the share of manufacturing and light manufacturing in industry; pre-treatment changes in unionization and Right-to-Work Laws; the China import shock, hanges in the share of routine task labor and other measures of deindustrialization; pre-treatment changes in unionization and Right-to-Work Laws.

Table 4: Effect of exposure to robots on individual donations, employed, 2SLS

	OLS			*2SLS*		
	(1)	(2)	(3)	(4)	(5)	(6)
US exposure to robots	-0.008*** (0.003)	-0.010** (0.005)	-0.008 (0.005)	-0.018*** (0.004)	-0.011* (0.007)	-0.010 (0.007)
Observations	35219	35219	24266	35219	35219	24266
Demographic controls	No	Yes	Yes	No	Yes	Yes
Industry controls	No	Yes	Yes	No	Yes	Yes
Other shocks	No	Yes	Yes	No	Yes	Yes
Col. bargain and stoppages	No	No	Yes	No	No	Yes

	Panel C. First stage regression		
Exposure to robots	0.964*** (0.057)	0.843*** (0.065)	0.845*** (0.067)
F for excluded instruments	289	175	169
Observations	35219	35219	24266
Demographic controls	No	Yes	Yes
Industry controls	No	Yes	Yes
Other shocks	No	Yes	Yes
Col. bargain and stoppages	No	No	Yes

Note: Standard errors clustered at state level are in parentheses. Coefficients that are significantly different from zero are denoted by the following system: *10%, **5%, and ***1%. Controls include: changes in size of the population, in the share of female labor, Hispanic, white, black and Asian groups, changes in the share of people with high school, college and masters degrees, and in the share of people with 65 years of age and above; changes in the share of manufacturing and light manufacturing in industry; pre-treatment changes in unionization and Right-to-Work Laws; the China import shock, hanges in the share of routine task labor and other measures of deindustrialization; pre-treatment changes in unionization and Right-to-Work Laws.

6.3 Political attitudes

As automation negatively affects unions, we may observe as well changes in voters' political attitudes; recall that unions promote other-regarding attitudes (Section 2). To evaluate this, I estimate the effect of exposure to robots on the indexes of support for redistribution and of cosmopolitanism. I find evidence that an increase in 600 robots reduces cosmopolitanism by 7 percentage points (Table 5). However, I find that increase in 600 robots at the district level reduces support for taxation by 1% (Table A3).

The evidence above establishes that automation affects unionization, union activities and political participation. Hence, in the next sections I test the main hypotheses in this manuscript.

7 The moderating effect of skilled labor

My theory states that the negative impact of robot exposure is driven by a high opportunity cost of union participation. Specifically, skilled workers face a higher opportunity cost of joining the union in response to automation because they become more productive. Hence the negative impact of robots must be bigger in those place with a bigger share of skilled labor.

Figure 4 below displays my results. We observe a negative and statistically significant effect of automation on unionization rates in places where the labor force became more skilled pre-treatment, lending credence to hypothesis H1. This negative effect exists for a substantive portion of the distribution of the moderator (dashed bars in the figure). The marginal effect of robots for union membership exhibits the same decreasing pattern, but it is statistically much weaker.

These results are in line with my theoretical expectations because the effect of robots on unionization is visible and more negative in places with increased shares of skilled labor. These results indicate that the mechanism linking automation with union decline is not unemployment because the slope in the estimated marginal effect should be positive instead (Section 3).

Table 5: Effect of exposure to robots on workers' political attitudes

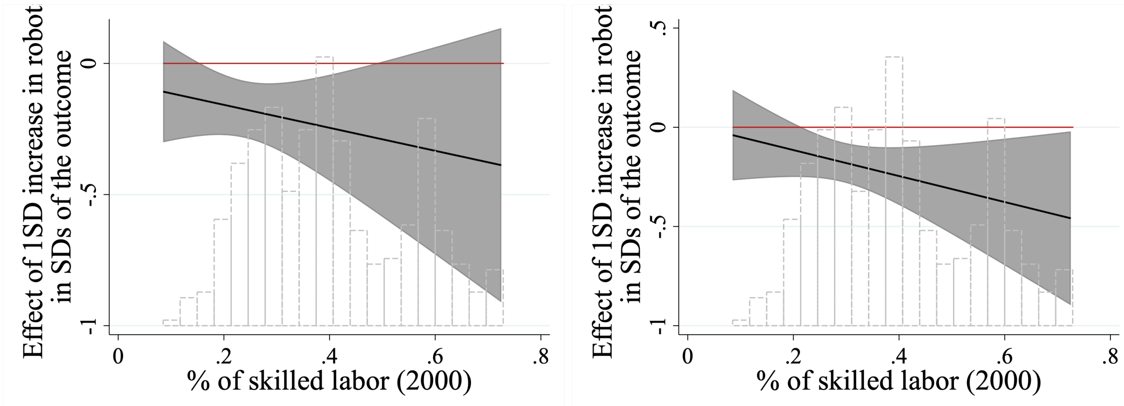
	OLS			*2SLS*		
	(1)	(2)	(3)	(4)	(5)	(6)
	Panel A. Index of redistribution					
US exposure to robots	0.004 (0.013)	-0.015 (0.017)	-0.020 (0.018)	0.005 (0.013)	-0.030 (0.018)	-0.037* (0.021)
Observations	25286	25286	17429	25286	25286	17429
	Panel B. Index of cosmopolitanism					
US exposure to robots	-0.094*** (0.021)	-0.074** (0.031)	-0.062* (0.031)	-0.100*** (0.021)	-0.090*** (0.029)	-0.074** (0.032)
Observations	31020	31020	21057	31020	31020	21057
Demographic controls	No	Yes	Yes	No	Yes	Yes
Industry controls	No	Yes	Yes	No	Yes	Yes
Other shocks	No	Yes	Yes	No	Yes	Yes
Col. bargain and stoppages	No	No	Yes	No	No	Yes

	Panel C. First stage regression		
Exposure to robots	0.964*** (0.057)	0.843*** (0.065)	0.845*** (0.067)
F for excluded instruments	289	175	169
Observations	35219	35219	24266
Demographic controls	No	Yes	Yes
Industry controls	No	Yes	Yes
Other shocks	No	Yes	Yes
Col. bargain and stoppages	No	No	Yes

Note: Standard errors clustered at state level are in parentheses. Coefficients that are significantly different from zero are denoted by the following system: *10%, **5%, and ***1%. Controls include: changes in size of the population, in the share of female labor, Hispanic, white, black and Asian groups, changes in the share of people with high school, college and masters degrees, and in the share of people with 65 years of age and above; changes in the share of manufacturing and light manufacturing in industry; pre-treatment changes in unionization and Right-to-Work Laws; the China import shock, hanges in the share of routine task labor and other measures of deindustrialization.

Figure 4: Heterogeneous effects of exposure to robots on union activity (conditional on the share of skilled labor)

(a) % change in no. of unionized workers **(b) Change in unionization rates**



Note: 95% confidence intervals, clustered at state level, in the shaded area. Controls include: changes in size of the population, in the share of female labor, Hispanic, white, black and Asian groups, changes in the share of people with high school, college and masters degrees, and in the share of people with 65 years of age and above; changes in the share of manufacturing and light manufacturing in industry; pre-treatment changes in unionization and Right-to-Work Laws; the China import shock, hanges in the share of routine task labor and other measures of deindustrialization.

Other outcomes. Looking at union activities, political attitudes and political participation, I find evidence as well for a heterogeneous effect of exposure to robots on cosmopolitanism, unions' political expenditures and individual contributions to politics by workers (figures A5 to A7). First, I find that an increase in 600 robots at the district level leads to a reduction 2% in the likelihood of donating to politics, for skilled workers that are not union members, providing evidence for hypothesis H2.

Second, I find that exposure to robots increase the political expenditures from unions (hypothesis H3). Although this may look puzzling at first glance, I use a model of distributive conflict with automation to show that this behavior indeed emerges from strategic interactions (Appendix B). In a nutshell: as the labor force becomes more skilled, the opportunity cost of rent-seeking for unskilled (skilled) labor diminishes as automation increases (decreases). This means that unskilled (skilled) workers are more (less) likely to invest more (less) resources into political participation. In other words, unskilled workers may allocate more money into union political activities, but with diminishing manpower.

Third, I find that an increase in 600 robots at the district level reduces support for taxation by about 1% among unskilled workers. Furthermore, I find that the same shock reduces the likelihood that unskilled workers are cosmopolitan. Altogether these results suggests that strong unions are particularly important for shaping the preferences of unskilled workers.

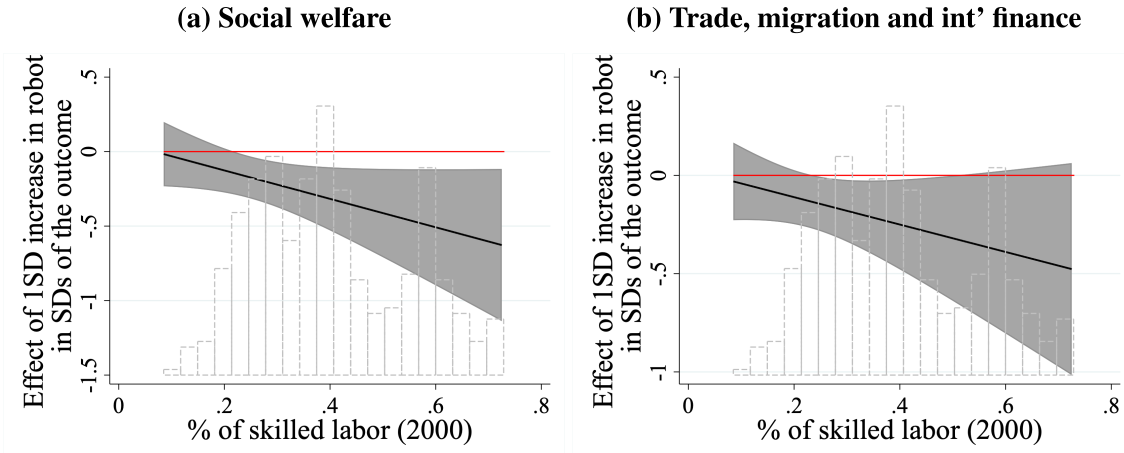
All in all, my results above are robust to placebo tests using public sector workers and import competition as a competing mechanisms. These results are available in Section A.7 in the Appendix.

8 Effect of automation on policy responsiveness

Next, I proceed to evaluate the impact of robot adoption on policymaking: hypothesis H4. In this case it is unwise to use two-stage least squares: Policy making is a complex process that involves a back and forth between groups with diverse interests and strategic considerations. Thus policy is not only subject to the direct consequences from production choices, but to a myriad of other phenomena that can take place directly (or indirectly) as a result of automation. Therefore the exclusion restriction for instrumental variables is likely violated for this outcome.

To address this issue, I focus on exploring the reduced form effect of exposure to robots on public policy responsiveness to union's interests. I focus on analyzing public policy responsiveness to unions' interests for those bills that are related to trade, migration and international finance and social welfare policy; i.e., approximately 45% percent of the total number of bills. On the one hand, I find evidence for a robust and negative reduced-form link between automation and legislators' responsiveness to unions' preferences when it comes to welfare policy (hypothesis H4). I find that on average an (exogenous) increase in one standard deviation in robot adoption workers is associated to a decline (on average) of about 0.4 standard deviations in the likelihood that legislators vote in line with workers' interest; that is about 1.5 bills per year. On the other hand, I find weak evidence for a negative and similar-sized reduced-form link between automation and legislators' responsiveness to unions' preferences when it comes to trade policy.[31]

Figure 5: Heterogeneous effects of exposure to robots on policy responsiveness, by bill type (conditional on the share of skilled labor)



Note: 95% confidence intervals, clustered at state level, in the shaded area. Controls include: changes in size of the population, in the share of female labor, Hispanic, white, black and Asian groups, changes in the share of people with high school, college and masters degrees, and in the share of people with 65 years of age and above; changes in the share of manufacturing and light manufacturing in industry; pre-treatment changes in unionization and Right-to-Work Laws; the China import shock, hanges in the share of routine task labor and other measures of deindustrialization;

These results are robust to a demediation analysis evaluating unemployment as an additional mechanism for the effect of robot adoption on politics (Acharya, Blackwell and Sen, 2016).[32] These results are available in Section A.8 in the Appendix.

9 Conclusions

One of the fundamental global economic shifts of the last 50 years has been the automation of work. I couple the insights from the literature on unions and the economics of automation, to uncover a novel mechanism linking automation with unions' strength, and the consequences of this phenomenon for domestic and international politics and policy. I find a connection between

[31]Regarding domestic bills, my results suggest that automation also reduce legislators' responsiveness to unions' preferences (not shown). The amount of variation for all other bills is too small for a meaningful analysis.

[32]Demediation analysis uses the Frisch-Waugh-Lovell theorem for "blipping-down" the variation explained by a mediator. Since this analysis is subject to the problems arising from sequential confounding discussed in Section 5, I consider the robustness test in this regard suggestive and not causal.

automation and public policy responsiveness to unions interests, through the negative effect of automation on unionization. I find evidence of a decline in political activities by workers, consistent with the idea that weaker unions may translate into lower political participation by workers. Relatedly, I also find that unions have less influence over workers' attitudes toward taxation and cosmopolitanism. Consequently, I show that higher exposure to robots reduces public policy responsiveness to unions' interests from congresspeople. Furthermore, I demonstrate that the effect of automation on these outcomes is larger in districts with higher shares of skilled workers, lending support to the hypothesized opportunity-cost mechanism that I propose herein.

As more automation becomes a reality of today's economic environment, the findings herein help us understanding the political consequences of the future of work for matters of international integration. Specifically, my findings indicate that while automation may lead to economic progress, it may also undermine social progress because it reduces the responsiveness of policy makers to the preferences of collectives that advocate for policies that protect workers in an era of economic change. As a result it becomes harder for societies to sustain the redistributive commitment that supports international integration.

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Appendices

A Empirical Appendix

A.1 Empirical Appendix

Table A. 1: Description of bills' topics

Area	Topic	Description
Domestic affairs	Agriculture and Food	Primary focus of measure is agricultural practices; agricultural prices and marketing; agricultural education; food assistance or nutrition programs; food industry, supply, and safety; aquaculture; horticulture and plants. Measures concerning international trade in agricultural products may fall under Foreign Trade and International Finance policy area.
	Economics and Public Finance	Primary focus of measure is budgetary matters such as appropriations, public debt, the budget process, government lending, government accounts and trust funds; monetary policy and inflation; economic development, performance, and economic theory.
	Finance and Financial Sector	Primary focus of measure is U.S. banking and financial institutions regulation; consumer credit; bankruptcy and debt collection; financial services and investments; insurance; securities; real estate transactions; currency. Measures concerning financial crimes may fall under Crime and Law Enforcement. Measures concerning business and corporate finance may fall under Commerce policy area. Measures concerning international banking may fall under Foreign Trade and International Finance policy area.
	Congress	Primary focus of measure is Members of Congress; general congressional oversight; congressional agencies, committees, operations; legislative procedures; U.S. Capitol. Measures concerning oversight and investigation of specific matters may fall under the issue-specific relevant policy area.
	Government Operations and Politics	Primary focus of measure is government administration, including agency organization, contracting, facilities and property, information management and services; rulemaking and administrative law; elections and political activities; government employees and officials; Presidents; ethics and public participation; postal service. Measures concerning agency appropriations and the budget process may fall under Economics and Public Finance policy area.
	Law	Primary focus of measure is matters affecting civil actions and administrative remedies, courts and judicial administration, general constitutional issues, dispute resolution, including mediation and arbitration. Measures concerning specific constitutional amendments may fall under the policy area relevant to the subject matter of the amendment (e.g., Education). Measures concerning criminal procedure and law enforcement may fall under Crime and Law Enforcement policy area.
	Crime and Law Enforcement	Primary focus of measure is criminal offenses, investigation and prosecution, procedure and sentencing; corrections and imprisonment; juvenile crime; law enforcement administration. Measures concerning terrorism may fall under Emergency Management or International Affairs policy areas.
	Emergency Management	Primary focus of measure is emergency planning; response to civil disturbances, natural and other disasters, including fires; emergency communications; security preparedness.
Education and culture	Arts, Culture, Religion	Primary focus of measure is art, literature, performing arts in all formats; arts and humanities funding; libraries, exhibitions, cultural centers; sound recording, motion pictures, television and film; cultural property and resources; cultural relations; and religion. Measures concerning intellectual property aspects of the arts may fall under Commerce policy area. Measures concerning religious freedom may fall under Civil Rights and Liberties, Minority Issues policy area.
	Education	Primary focus of measure is elementary, secondary, or higher education including special education and matters of academic performance, school administration, teaching, educational costs, and student aid.
	Science, Technology, Communications	Primary focus of measure is natural sciences, space exploration, research policy and funding, research and development, STEM education, scientific cooperation and communication; technology policies, telecommunication, information technology; digital media, journalism. Measures concerning scientific education may fall under Education policy area.
	Social Sciences and History	Primary focus of measure is policy sciences, history, matters related to the study of society. Measures concerning particular aspects of government functions may fall under Government Operations and Politics policy area.
	Sports and Recreation	Primary focus of measure is youth, amateur, and professional athletics; outdoor recreation; sports and recreation facilities. Measures concerning recreation areas may fall under Public Lands and Natural Resources policy area.

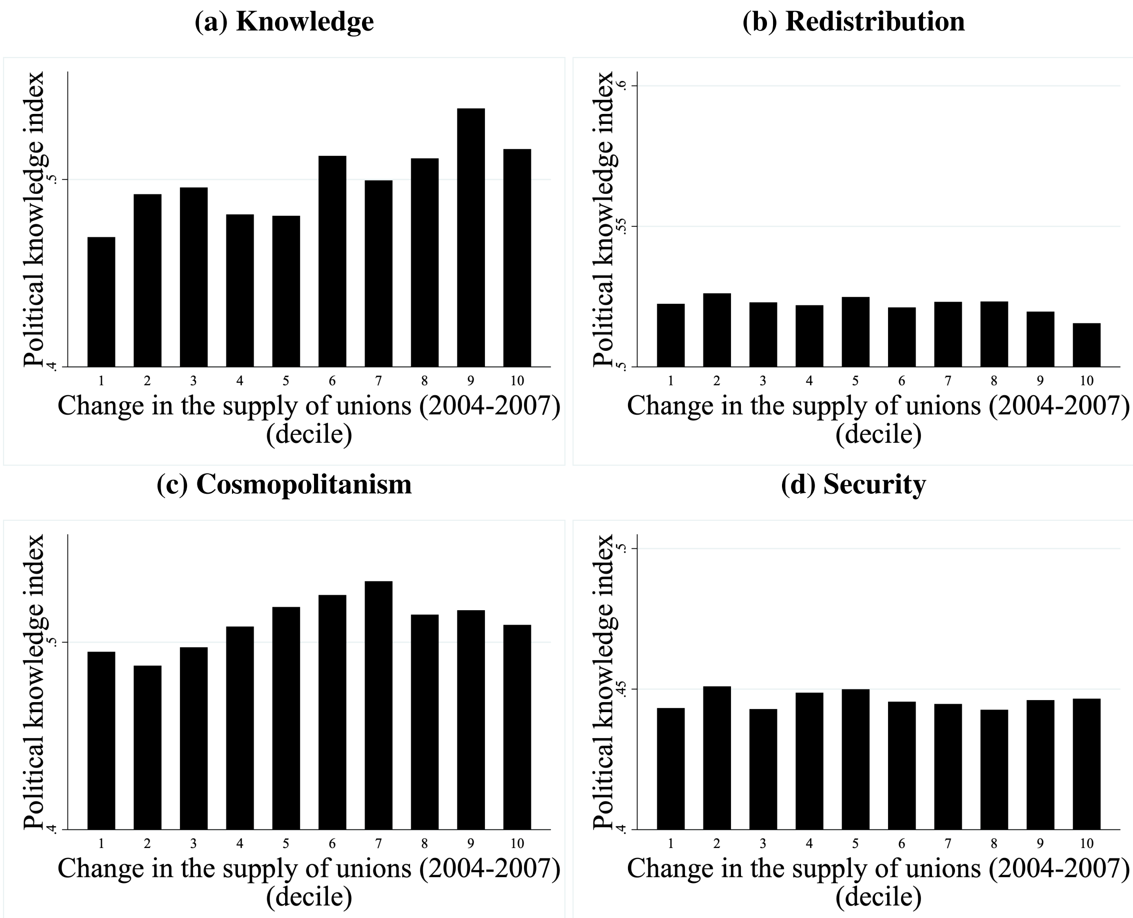
Area	Topic	Description
Energy and environment	Animals	Primary focus of measure is animal protection; human-animal relationships; wildlife conservation and habitat protection; veterinary medicine. Measures concerning endangered or threatened species may fall under Environmental Protection policy area. Measures concerning wildlife refuge matters may fall under Public Lands and Natural Resources policy area.
	Energy	Primary focus of measure is all sources and supplies of energy, including alternative energy sources, oil and gas, coal, nuclear power; efficiency and conservation; costs, prices, and revenues; electric power transmission; public utility matters.
	Environmental Protection	Primary focus of measure is regulation of pollution including from hazardous substances and radioactive releases; climate change and greenhouse gases; environmental assessment and research; solid waste and recycling; ecology. Measures concerning energy exploration, efficiency, and conservation may fall under Energy policy area.
	Public Lands and Natural Resources	Primary focus of measure is natural areas (including wilderness); lands under government jurisdiction; land use practices and policies; parks, monuments, and historic sites; fisheries and marine resources; mining and minerals. Measures concerning energy supplies and production may fall under Energy policy area.
	Water Resources Development	Primary focus of measure is the supply and use of water and control of water flows; watersheds; floods and storm protection; wetlands. Measures concerning water quality may fall under Environmental Protection policy area.
Foreign affairs	International Affairs	Primary focus of measure is matters affecting foreign aid, human rights, international law and organizations; national governance; arms control; diplomacy and foreign officials; alliances and collective security. Measures concerning trade agreements, tariffs, foreign investments, and foreign loans may fall under Foreign Trade and International Finance policy area.
	Armed Forces and National Security	Primary focus of measure is military operations and spending, facilities, procurement and weapons, personnel, intelligence; strategic materials; war and emergency powers; veterans' issues. Measures concerning alliances and collective security, arms sales and military assistance, or arms control may fall under International Affairs policy area.
Social justice	Civil Rights and Liberties, Minority Issues	Primary focus of measure is discrimination on basis of race, ethnicity, age, sex, gender, health or disability; First Amendment rights; due process and equal protection; abortion rights; privacy. Measures concerning abortion rights and procedures may fall under Health policy area.
	Native Americans	Primary focus of measure is matters affecting Native Americans, including Alaska Natives and Hawaiians, in a variety of domestic policy settings. This includes claims, intergovernmental relations, and Indian lands and resources.

Area	Topic	Description
Social welfare	Labor and Employment	Primary focus of measure is matters affecting hiring and composition of the workforce, wages and benefits, labor-management relations; occupational safety, personnel management, unemployment compensation. Measures concerning public-sector employment may fall under Government Operations and Politics policy area.
	Families	Primary focus of measure is child and family welfare, services, and relationships; marriage and family status; domestic violence and child abuse. Measures concerning public assistance programs or aging may fall under Social Welfare policy area.
	Health	Primary focus of measure is science or practice of the diagnosis, treatment, and prevention of disease; health services administration and funding, including such programs as Medicare and Medicaid; health personnel and medical education; drug use and safety; health care coverage and insurance; health facilities. Measures concerning controlled substances and drug trafficking may fall under Crime and Law Enforcement policy area.
	Housing and Community Development	Primary focus of measure is home ownership; housing programs administration and funding; residential rehabilitation; regional planning, rural and urban development; affordable housing; homelessness; housing industry and construction; fair housing. Measures concerning mortgages and mortgage finance may fall under Finance and Financial Sector policy area.
	Social Welfare	Primary focus of measure is public assistance and Social Security programs; social services matters, including community service, volunteer, and charitable activities. Measures concerning such health programs as Medicare and Medicaid may fall under Health policy area.
	Taxation	Primary focus of measure is all aspects of income, excise, property, inheritance, and employment taxes; tax administration and collection. Measures concerning state and local finance may fall under Economics and Public Finance policy area.
	Transportation and Public Works	Primary focus of measure is all aspects of transportation modes and conveyances, including funding and safety matters; Coast Guard; infrastructure development; travel and tourism. Measures concerning water resources and navigation projects may fall under Water Resources Development policy area.
Trade, migration and international finance	Immigration	Primary focus of measure is administration of immigration and naturalization matters; immigration enforcement procedures; refugees and asylum policies; travel and residence documentation; foreign labor; benefits for immigrants. Measures concerning smuggling and trafficking of persons may fall under Crime and Law Enforcement policy area. Measures concerning refugees may fall under International Affairs policy area.
	Commerce	Primary focus of measure is business investment, development, regulation; small business; consumer affairs; competition and restrictive trade practices; manufacturing, distribution, retail; marketing; intellectual property. Measures concerning international competitiveness and restrictions on imports and exports may fall under Foreign Trade and International Finance policy area.
	Foreign Trade and International Finance	Primary focus of measure is competitiveness, trade barriers and adjustment assistance; foreign loans and international monetary system; international banking; trade agreements and negotiations; customs enforcement, tariffs, and trade restrictions; foreign investment. Measures concerning border enforcement may fall under Immigration policy area.

Notes: The topics and their descriptions come from https://www.congress.gov/browse/policyarea. I built groupings of these areas to facilitate analysis (first column).

A.2 Attitudes and automation

Figure A. 1: Political attitudes by decile of change in the number of unions



Source: Author's compilations. The knowledge index is an average of several questions that survey respondents answer correctly regarding: knowing the respondent's senators vote on immigration, minimum wage, capital gains, abortion, stem cell research, the war on Iraq and the CAFTA trade agreement. The redistribution index is built from questions regarding preferences for using taxes instead of fiscal austerity to balance the federal budget; the index of cosmopolitanism is built from questions regarding preferences for immigration, abortion, gay marriage and affirmative action; the security index is built from questions regarding preferences on U.S. military activities overseas: oil extraction; attacking terrorists; promoting democracy; addressing human rights violations; supporting military allies; not using international law to promote U.S. interests.

A.3 Descriptive statistics

Table A. 2: Summary statistics

	All districts				Average by quartiles of exposure to US robots				
	Average	Sd.	Min	Max	Q1	Q2	Q3	Q4	Q5
Outcomes (as changes between 2004 and 2014):									
Exposure to robots in the US (robots/1000 workers)	0.53	0.59	0.03	4.08	0.08	0.15	0.31	0.63	1.50
Exposure to robots (robots/1000 workers)	0.46	0.48	0.02	2.92	0.07	0.15	0.28	0.59	1.20
Union size (%)	-2.09	10.95	-52.03	38.73	-1.08	-2.06	-2.97	-1.79	-2.56
Union density (%)	-0.04	0.36	-2.97	3.17	0.01	-0.04	-0.05	-0.07	-0.05
Workers in collective bargains (thou.)	-0.07	0.44	-3.81	3.29	-0.02	-0.09	-0.04	-0.07	-0.13
Workers in strikes (thou.)	0.00	0.03	-0.40	0.00	0.00	0.00	0.00	0.00	-0.01
Union contributions (mill. USD, 2009=100)	-0.07	0.13	-0.73	0.48	-0.08	-0.09	-0.07	-0.06	-0.07
Union lobbying (mill. USD, 2009=100)	0.75	0.46	-1.07	1.55	0.86	0.72	0.79	0.72	0.66
Union pol. representation (mill. USD, 2009=100)	0.52	0.42	-0.80	1.32	0.69	0.52	0.52	0.45	0.42
Number of TAA petitions	1.76	2.40	0.00	17.00	2.10	1.38	1.78	2.13	1.50
Number of workers in TAA petitions	183.74	390.01	0.00	3480	169.39	119.38	200.24	222.88	191.23
Days of delay in TAA petitions	131.73	201.08	0.00	791	108.99	139.37	138.95	124.49	140.76
Ratio of workers to investigators in TAA petitions	78.99	170.20	0.00	2170	67.20	57.84	62.56	90.62	104.31
AFL-CIO score	-0.13	3.83	-8.93	9.66	1.33	0.54	-0.25	-1.10	-1.17
% change in wages (2000-2014)	-6.92	4.43	-21.23	5.71	-7.03	-6.73	-5.70	-6.99	-8.16
Employment rate (2000-2014)	0.57	1.82	-5.24	5.25	2.06	0.96	0.31	0.13	-0.63
Covariates (as changes between 1970 and 1990):									
Population (thou.)	45.01	67.70	-27.98	343.48	68.00	51.83	68.09	17.59	18.45
Share of female workers (%)	0.00	0.04	-0.10	0.17	-0.02	0.00	-0.01	0.01	0.00
Share of Hispanic workers (%)	0.19	0.26	-0.83	1.45	0.40	0.21	0.17	0.08	0.06
Share of white workers (%)	-0.15	0.19	-1.09	0.40	-0.29	-0.18	-0.12	-0.08	-0.06
Share of black workers (%)	0.03	0.13	-0.46	0.66	0.10	0.04	-0.01	0.03	0.01
Share of Asian workers (%)	0.09	0.11	-0.03	0.55	0.18	0.13	0.10	0.03	0.03

	All districts				Average by quartiles of exposure to US robots				
	Average	**Sd.**	**Min**	**Max**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**
Share with high school degree or less (%)	0.02	0.07	-0.29	1.10	0.01	0.01	0.03	0.02	0.02
Share with some college (%)	-0.92	0.18	-1.38	-0.43	-0.97	-1.03	-0.94	-0.87	-0.78
Share with college degree (%)	0.52	0.10	0.27	0.83	0.47	0.54	0.53	0.54	0.51
Share with graduate studies (%)	0.36	0.13	0.08	0.66	0.46	0.45	0.37	0.29	0.25
Share that is foreign born (%)	0.04	0.04	-0.06	0.16	0.04	0.04	0.03	0.04	0.03
Share 65 yo. Or more (%)	0.13	0.08	-0.04	0.54	0.11	0.13	0.14	0.15	0.14
Share employed in manufactures (%)	-0.46	0.30	-1.20	0.29	-0.50	-0.49	-0.40	-0.48	-0.43
Share employed in light manufacturing (%)	-0.13	0.16	-0.98	0.23	-0.10	-0.09	-0.16	-0.16	-0.14
Share in routine task activities (%)	0.10	0.12	-0.36	0.47	0.04	0.08	0.12	0.12	0.13
Import competition index	15.44	16.04	0.75	110.02	3.29	5.32	11.26	19.95	37.52
Pre-treatment col. bargain and strikes (as changes between 2003 and 2013):									
Workers in collective bargains (thou.)	-0.04	0.31	-1.63	4.63	0.00	-0.03	-0.04	-0.07	-0.07
Days on collective bargain	45.07	315.33	-100.12	3793.60	28.66	10.65	36.34	69.01	75.90
Workers in strikes (thou.)	-0.02	0.17	-2.33	0.46	0.00	-0.07	-0.01	-0.02	-0.02
Days on strike	-0.79	9.90	-89.30	105.14	-0.49	-2.92	0.57	0.47	-1.74
CCES:									
Donated to campaingn	0.23	0.42	0.00	1.00	0.25	0.25	0.24	0.21	0.20
Budget deficit - raise taxes	0.60	0.27	0.00	1.00	0.58	0.59	0.60	0.60	0.61
Budget deficit - raise income taxes	0.10	0.22	0.00	1.00	0.10	0.10	0.09	0.10	0.09
Budget balance - raise taxes (1st)	0.81	0.39	0.00	1.00	0.81	0.81	0.81	0.81	0.81
Budget balance - raise taxes (2nd)	0.45	0.50	0.00	1.00	0.45	0.44	0.44	0.46	0.45
Redistribution index	0.52	0.28	0.00	1.00	0.52	0.52	0.52	0.53	0.52

	All districts				Average by quartiles of exposure to US robots				
	Average	**Sd.**	**Min**	**Max**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**
Supports immigration	0.53	0.50	0.00	1.00	0.56	0.53	0.53	0.52	0.50
Support gay marriage	0.56	0.50	0.00	1.00	0.61	0.58	0.56	0.54	0.52
Support abortion	0.53	0.50	0.00	1.00	0.63	0.58	0.54	0.48	0.43
Support affirmative action	0.44	0.50	0.00	1.00	0.51	0.46	0.44	0.41	0.38
Cosmopolitanism index	0.51	0.33	0.00	1.00	0.58	0.54	0.51	0.48	0.45
Education	0.42	0.49	0.00	1.00	0.49	0.45	0.43	0.38	0.34
Employment Status	0.62	0.49	0.00	1.00	0.65	0.63	0.62	0.61	0.59
Union Membership	0.30	0.46	0.00	1.00	0.31	0.31	0.29	0.29	0.29

A.4 Mechanisms

Table A. 3: Effect of exposure to robots on voters' political attitudes

	2SLS					
	(1)	(2)	(3)	(4)	(5)	(6)
	Panel A. Redistribution					
	Budget deficit				**Budget balance**	
	raise taxes	**raise income tax**			**raise tax (1st)**	**raise tax (2nd)**
US exposure to robots	-0.970**	2.058			0.004	-0.003
	(0.453)	(2.520)			(0.004)	(0.006)
Observations	21759	21059			25763	22700
	Panel B. Cosmopolitanism					
	Supports					
		immigration	**gay marriage**	**abortion**	**aff. action**	
US exposure to robots		-0.012	-0.024**	-0.018**	-0.007	
		(0.010)	(0.011)	(0.009)	(0.008)	
Observations		21518	21466	28350	28451	
Demographic controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry controls	Yes	Yes	Yes	Yes	Yes	Yes
Other shocks	Yes	Yes	Yes	Yes	Yes	Yes
Col. bargain and stoppages	Yes	Yes	Yes	Yes	Yes	Yes

Note: Standard errors clustered at state level are in parentheses. Coefficients that are significantly different from zero are denoted by the following system: *10%, **5%, and ***1%.

Table A. 4: **Effect of exposure to robots on unions' political expenditures**

	OLS			*2SLS*		
	(1)	(2)	(3)	(4)	(5)	(6)
	Panel A. Changes in unions' contributions (USD. Mill, 2009=100)					
US exposure to robots	0.009	-0.000	-0.003	0.016	0.020	0.018
	(0.011)	(0.012)	(0.013)	(0.011)	(0.019)	(0.019)
Observations	401	401	401	401	401	401
	Panel B. Changes in unions' lobbying contributions (USD. Mill, 2009=100)					
US exposure to robots	-0.056	0.033	0.026	-0.087	0.042	0.029
	(0.033)	(0.034)	(0.035)	(0.058)	(0.060)	(0.060)
Observations	401	401	401	401	401	401
	Panel C. Changes in unions' pol. Representation (USD. Mill, 2009=100)					
US exposure to robots	-0.081	0.046	0.038	0.014	0.048	0.042
	(0.054)	(0.050)	(0.049)	(0.055)	(0.056)	(0.058)
Observations	401	401	401	401	401	401
Demographic controls	No	Yes	Yes	No	Yes	Yes
Industry controls	No	Yes	Yes	No	Yes	Yes
Other shocks	No	Yes	Yes	No	Yes	Yes
Col. bargain and stoppages	No	No	Yes	No	No	Yes

	Panel C. First stage regression		
Exposure to robots	0.954***	0.833***	0.823***
	(0.055)	(0.058)	(0.053)
F for excluded instruments	304	203	242
Observations	412	412	400
Demographic controls	No	Yes	Yes
Industry controls	No	Yes	Yes
Other shocks	No	Yes	Yes
Col. bargain and stoppages	No	No	Yes

Note: Standard errors clustered at state level are in parentheses. Coefficients that are significantly different from zero are denoted by the following system: *10%, **5%, and ***1%.

A.5 Robustness

Sensitivity to unobserved confounding. I check the sensitivity of the estimated results with respect to deviations from the conditional exogeneity assumption; i.e., if there are unobserved variables that affect assignment into treatment and the outcome variable simultaneously that estimated coefficients may not be robust to. I explicitly relax the exogeneity assumption by allowing for

Table A. 5: Effect of exposure to robots on private sector employment

	(1)	(2)	(3)	(4)	(5)	(6)
	Panel A. Changes in private sector employment (thou. individuals)					
US exposure to robots	-0.746*** (0.166)	-0.492*** (0.157)	-0.457*** (0.166)	-1.263*** (0.294)	-0.804*** (0.260)	-0.737*** (0.274)
Observations	413	413	401	412	412	400
Demographic controls	No	Yes	Yes	No	Yes	Yes
Industry controls	No	Yes	Yes	No	Yes	Yes
Other shocks	No	Yes	Yes	No	Yes	Yes
Col. bargain and stoppages	No	No	Yes	No	No	Yes

	Panel B. First stage regression		
Exposure to robots	0.954*** (0.055)	0.833*** (0.058)	0.823*** (0.053)
F for excluded instruments	304	203	242
Observations	412	412	400
Demographic controls	No	Yes	Yes
Industry controls	No	Yes	Yes
Other shocks	No	Yes	Yes
Col. bargain and stoppages	No	No	Yes

Note: Standard errors clustered at state level are in parentheses. Coefficients that are significantly different from zero are denoted by the following system: *10%, **5%, and ***1%.

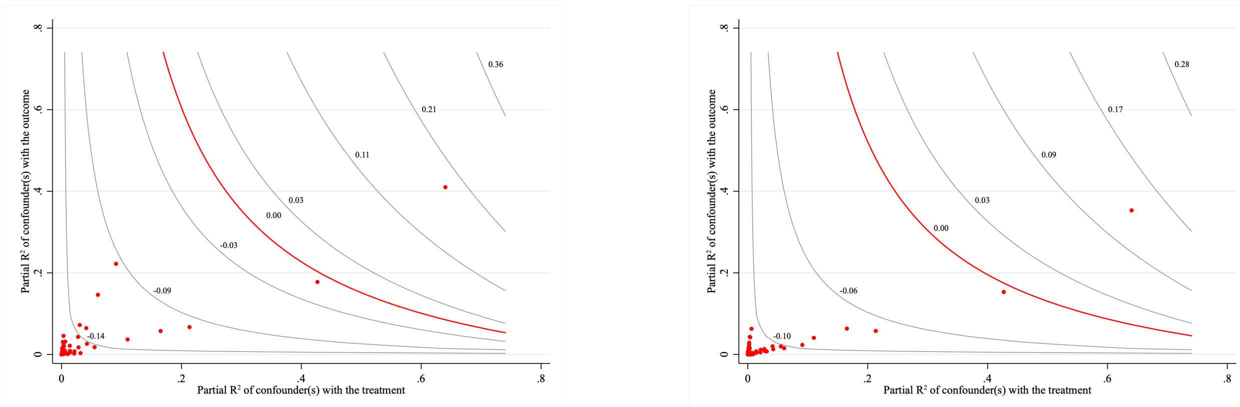
a limited amount of correlation between treatment and unobserved components of the outcomes (Imbens, 2003). I find that an unobservable confounder that could potentially overturn my main results needs to exhibit a higher partial R^2 vis-á-vis the confounders I already included (Figure A2), which is unlikely to exist since it would need to have a much stronger effect than import competition— the confounder with the highest partial R^2.

Parameter stability to observations. To further corroborate that there's no one observation driving the results, I carry out a robustness tests wherein I drop on congressional district at a time with replacement (*á la* Jackknife). I find that my treatment indicator is quite stable and statistically significant for each permutation (Figure A3).

Geographical concentration of robot adoption. My theory indicates that we should focus our attention in the presence of heterogeneous effects. The results of my analyses, displayed in Figure

Figure A. 2: Sensitivity analysis to unobserved confounding

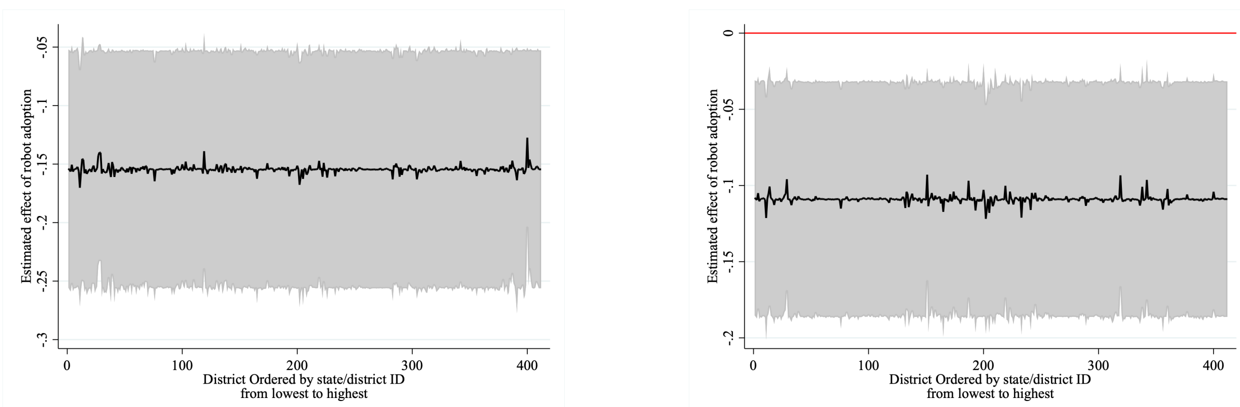
(a) % change in no. of unionized workers **(b) % change in no. of unionized workers**



Note: 95% confidence intervals, clustered at state level, in the shaded area.

Figure A. 3: Parameter stability to excluding one district with replacement

(a) % change in no. of unionized workers **(b) % change in no. of unionized workers**



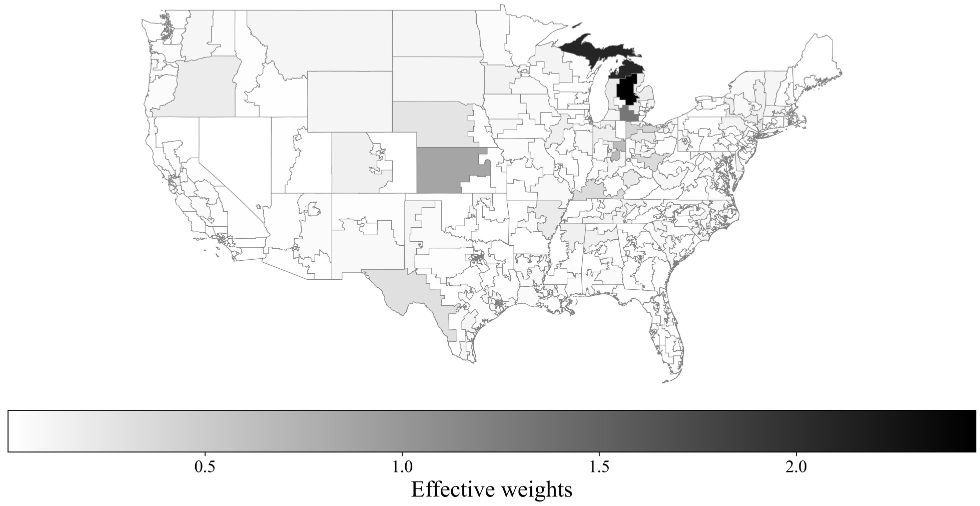
Note: 95% confidence intervals, clustered at state level, in the shaded area.

A4, show that the effect of automation on unionization is driven especially by those districts in the Rust Belt. This stands to reason insofar the Rust Belt should be area of largest treatment uptake given its reliance on the manufacturing sector for providing employment.

Reduced form effect

I also study the reduced form effect of robot exposure, to focus only the exogenous component of robot exposure. Since my theory establishes that international pressures owing to robot adoption are what drives local robot adoption, and thus its local effects on unions and politics, I expect

Figure A. 4: Geographical analysis of effective weights



Note: Effective weights are obtained following Aronow and Samii (2016).

similar results to those I previously obtained. Table A6 shows that the reduced-form findings are in line with previous results, in magnitude and direction.

Table A. 6: Effect of exposure to robots on union membership, reduced form

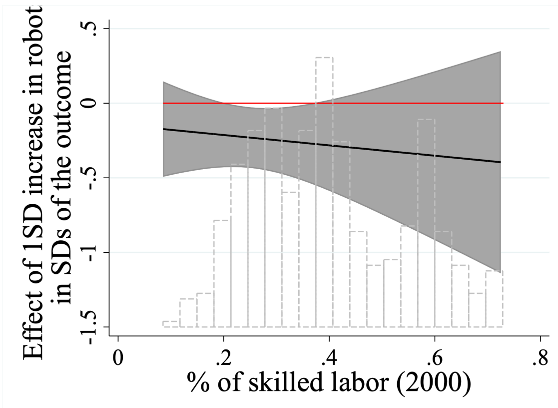
	(1)	(2)	(3)	(4)
	Panel A. % change in no. of unionized workers			
Exposure to robots	-0.328*	-0.647	-0.715*	-1.280**
	(0.193)	(0.389)	(0.376)	(0.529)
Districts	412	412	412	412
	Panel B. Change in union density (%)			
Exposure to robots	-0.019**	-0.015	-0.018	-0.034**
	(0.008)	(0.011)	(0.012)	(0.016)
Observations	412	412	412	412
Demographic controls	No	Yes	Yes	Yes
Industry controls	No	No	Yes	Yes
Other shocks	No	No	No	Yes

Note: Standard errors clustered at state level are in parentheses. Coefficients that are significantly different from zero are denoted by the following system: *10%, **5%, and ***1%.

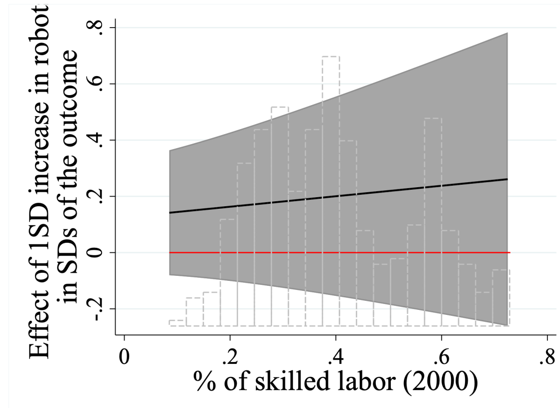
A.6 Heterogeneous effects

Figure A. 5: Heterogenous effects of exposure to robots on union and worker activities (conditional on the share of skilled labor)

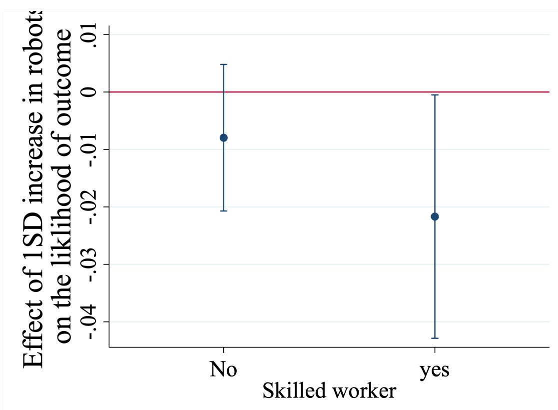
(a) Change in no. of workers in collective bargaining (thou.)



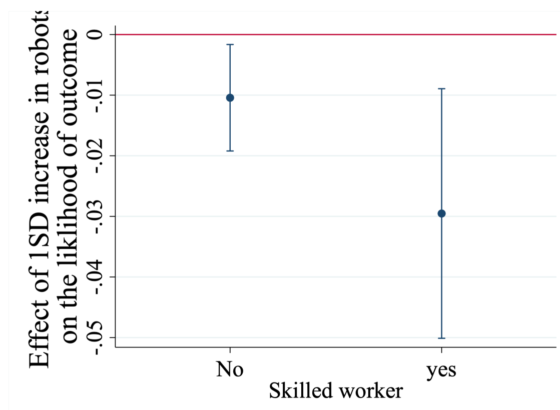
(b) Change in no. of workers striking (thou.)



(c) Likelihood of donating to a political campaign



(d) Likelihood of donating to a political campaign, non-union members



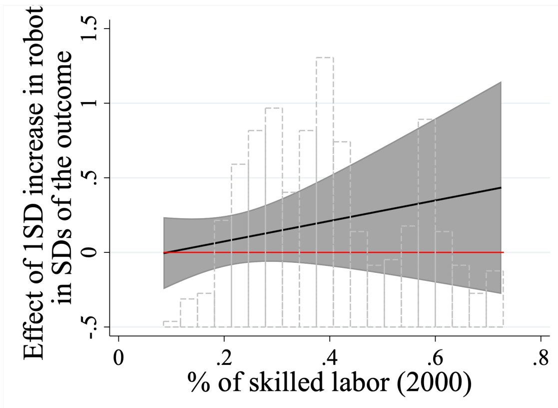
Note: 95% confidence intervals, clustered at state level, in the shaded area.

A.6.1 Deskilling

One important consequence of automation is deskilling, which is the process by which *skilled labor* becomes obsolete by the introduction of new technologies. Deskilling shifts downward the relative marginal productivity of skilled labor vis-á-vis capital, substituting skilled labor. Thus the process of deskilling should have the opposite implications on workers' incentives to unionize because deskilling threatens substituting the skilled labor force. As theorized, exposure to robots has stronger negative effects on unionization rates in places where the level of task routinization

Figure A. 6: Heterogenous effects of exposure to robots on union expenditures (conditional on the share of skilled labor)

(a) Changes in union contributions (USD. Mill, 2009=100)



(b) Changes in union lobbying (USD. Mill, 2009=100)

(c) Changes in union representation (USD. Mill, 2009=100)

Note: 95% confidence intervals, clustered at state level, in the shaded area.

has increased, precisely due to the deskilling process (Figure A8).[A.1]

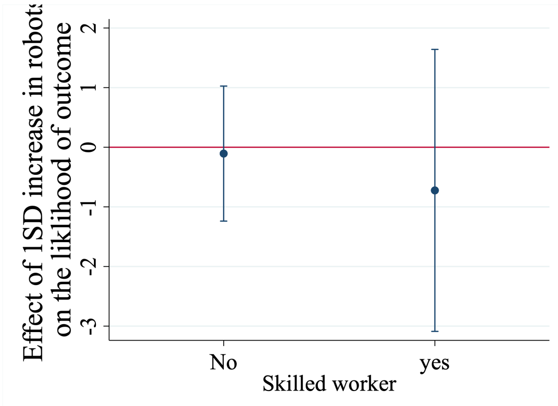
A.7 Placebos

Public sector workers. The public sector has, in general, a very different production structure than the private sector and thus workers' tasks are less susceptible to automation. Therefore public sector unions should have a lower level of treatment uptake vis-á-vis public sector unions, if not null. My results in Figure A9 shows the absence of an statistically significant effect for exposure

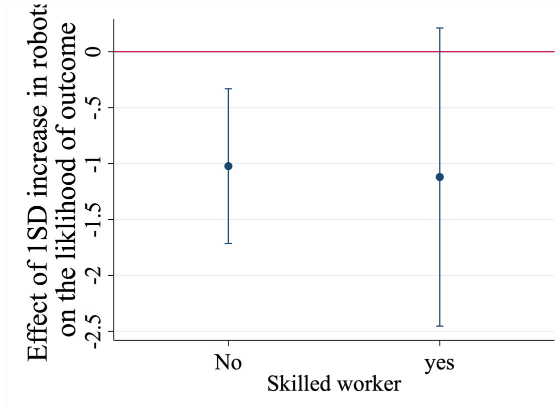
[A.1] The correlation between task routinization and the share of skilled labor is -0.60.

Figure A. 7: Heterogenous effects of exposure to robots on political attitudes (conditional on the share of skilled labor)

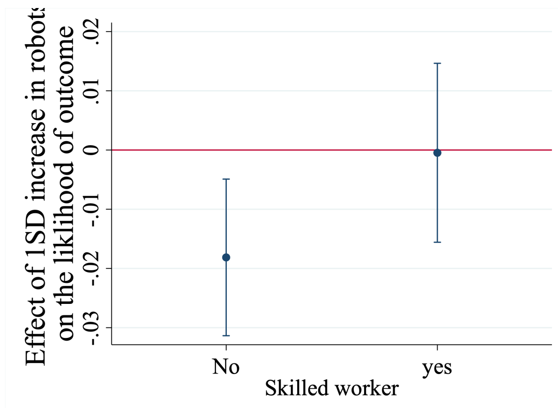
(a) Redistribution



(b) Budget balance - increase taxes



(c) Cosmopolitanism



Note: 95% confidence intervals, clustered at state level, in the shaded area.

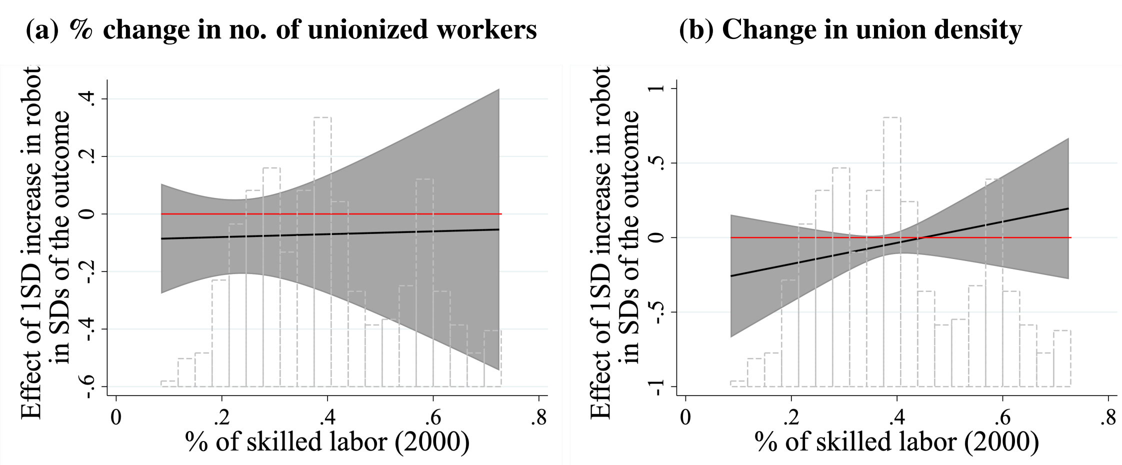
to robots on public workers.

Import competition. Automation is–among other things–a consequence of international competition. However we should not expect clear evidence for the opportunity-cost mechanism proposed herein when we use international competition as a treatment, while removing robot adoption as a covariate. Figure A10 shows that indeed there is little evidence for the alternative treatment, conditional on the share of skilled labor.

Figure A. 8: Heterogenous effects of exposure to robots on union activity (conditional on changes in the task routinization)

Note: 95% confidence intervals, clustered at state level, in the shaded area.

Figure A. 9: Effects of exposure to robots on public unions' activity (conditional on share of high-skilled labor)



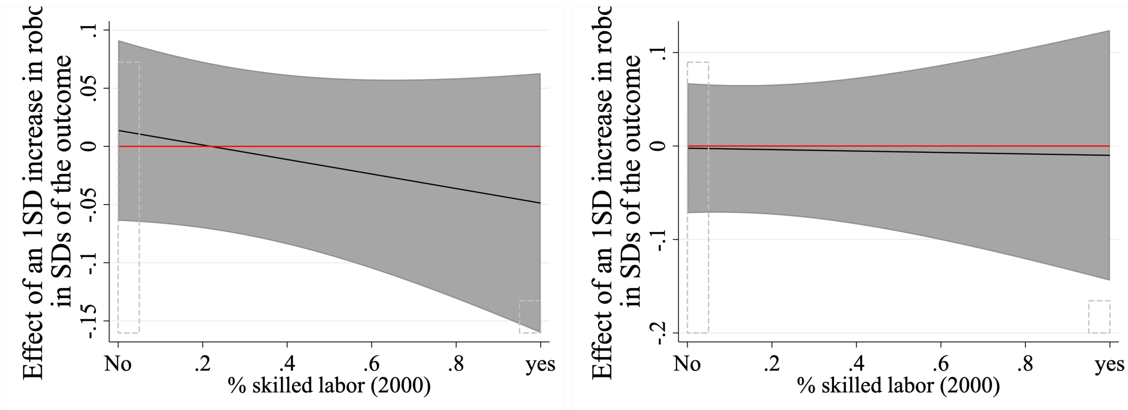
Note: 95% confidence intervals, clustered at state level, are added.

A.7.1 Right-to-work laws (RWL)

In general, I do not observe a differential effect of automation on unions, in RWL districts (Figure A11). Therefore there is not enough evidence to support the idea that the Right-to-Work legislation confounds the moderating effect of workers' skill on my main outcomes. This is not unexpected because places with Right-to-Work laws gained less educated labor force over time: I find that the correlation between Right-to-Work laws and changes in the share of skilled labor between 1970

Figure A. 10: Heterogenous effects of import competition on unions and worker activities (conditional on share of high-skilled labor)

(a) % change in no. of unionized workers **(b) Change in unionization rates**

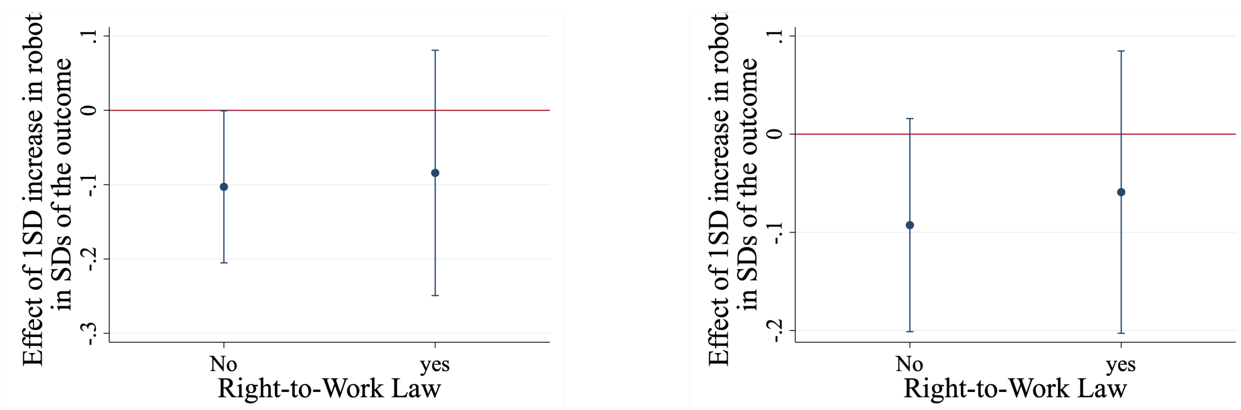


Note: 95% confidence intervals, clustered at state level, in the shaded area.

and 1990 is -0.18.

Figure A. 11: Heterogenous effects of exposure to robots on union and workers activities (conditional on Right-to-Work laws)

(a) % change in no. of unionized workers **(b) Change in unionization rates**

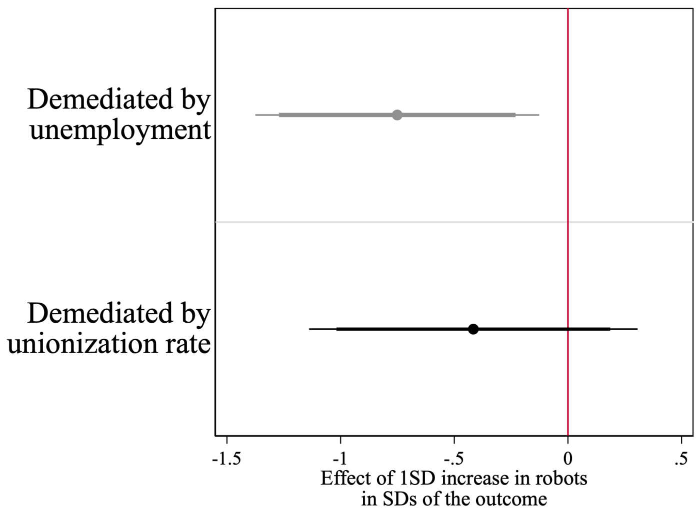


Note: 95% confidence intervals, clustered at state level, in the shaded area.

A.8 Demediation analysis

Firstly, I demediate the effect of employment on the reduced form impact of exposure to robots on both union membership and public policy responsiveness to unions' interests. Secondly, I demediate the effect of union membership on the reduced form impact of exposure to robots on public policy responsiveness to unions interests.[A.2] I find that after demediating for unionization, the point estimate for exposure to robots on policy responsiveness falls and becomes statistically insignificant; this does not happen when demediating for unemployment (Figure A12). This provides suggestive evidence that while employment is an important mechanism mapping automation to societal outcomes, unionization is a relevant mechanism in the causal chain from automation to public policy responsiveness to unions' interests.

Figure A. 12: Demediation analysis of the effect of exposure to robots



Note: 95% confidence intervals, clustered at state level, in the shaded area.

[A.2]Demediating entails to residualize the outcome on a regression wherein every covariate and the treatment are interacted with the mediator, to then regress the treatment including all covariates on the demediated outcome.

B Mathematical Appendix

B.1 Distributive conflict between labor and capital

Consider an entrepreneur labeled by k, and n workers that are hired by the entrepreneur to produce a good or a service. For simplicity we assume that the entrepreneur only provides capital K to the production process (e.g., it buys robots), and the workers only provide labor L.

The entrepreneur is endowed with an amount $A > L > 0$ of assets that he can choose to allocate between purchasing capital $K \geq 0$ or political influence $r_k \geq 0$:

$$A \geq r_k + K.$$

For example, the owners of capital can use part of their initial resources to influence public policy.[B.1] In contrast, each worker $i = 1, \ldots, n$ decides whether to comply (or join) their union: $r_i \in \{0, 1\}$, where $r_i = 1$ means that worker i joins the union activities and $r_i = 0$ that she allocates her effort to working. Given the decision of each worker $r = (r_1, \ldots, r_n)$, the total amount of labor that becomes productive is given by

$$L = n - f \sum_i r_i,$$

where $f \in [0, 1]$ is a factor that determines the magnitude of the effect of union related activities on the effective labor provided by the workforce. $\sum_i r_i$ can also be thought as the resources that workers have to participate in politics.

The political mechanism is characterized by a symmetric contest success function $\phi(\cdot, \cdot)$. The way that the resources in the economy, after production, are divided among the entrepreneur k and the workers $\{1, \ldots, n\}$ is determined by the political influence r_k and the number of unionized

[B.1] Although the owners of capital are outside of the scope of this paper, the existence of this group is necessary and warranted for the purposes of the model on the basis of the *institutional thesis* (Section 2.1).

workers $\sum_i r_i$. The share of the resources that each gets is determined by a *Contest Success Function* (CSF) $\phi : \mathbb{R}_+^2 \mapsto [0,1]$. With is assumed to be differentiable at $\mathbb{R}_+^2 \setminus \{(0,0)\}$ and symmetric:

$$\phi(x,y) + \phi(y,x) = 1.$$

Assume also that rent-seeking effort is used to determine the distribution of resources in the economy. The value of these is parameterized using a *constant elasticity of substitution* function,

$$F(L,K) = \left(L^{1-\alpha} + K^{1-\alpha}\right)^{\frac{1}{1-\alpha}},\ \alpha \in (0,1);\ L,K \geq 0,$$

where α is the substitution parameter, which captures the degree of complementarity (or substitutability) between capital and labor.[B.2]

The payoffs for the entrepreneur and each worker are given by:

$$U_k = \phi(r_k, r_w) \cdot F(K,L);$$
$$U_w = \phi(r_w, r_k) \cdot F(K,L).$$

The equilibrium concept is Nash equilibrium in pure strategies. Qualitatively, there are three distinct kind of equilibria: (i) no worker unionizes ($r_i = 0$ for all i); (ii) all workers unionize ($r_i = 1$ for all i); and (iii) an interior equilibrium where some workers unionize but not all.

Now consider the following conditions on contest success functions: We say that ϕ satisfies the Skaperdas (1992) properties if the following holds:

- $\phi_1 \in (0,\infty)$;
- $\phi_{11}(r_1,r_2) < 0$ if and only if $r_1 > r_2$;

[B.2] It is straightforward to prove that Hicks-Neutral technological change has no effect on the decision to unionize, and that factor-biased technological change has ambiguous effects on workers' decision to join the union.

- $\phi_{12}(r_1, r_2) > 0$ if and only if $r_1 > r_2$;
- $\phi \in (0,1)$;
- $\phi_{11}\phi < \phi_1^2$;
- $\phi \cdot (1-\phi)\phi_{12} + (2\phi - 1)\phi_1\phi_2 = 0$.

The next proposition provides sufficient conditions for the existence of an equilibrium where each worker chooses $r_i \in [0,1]$, relaxing the assumption that each worker's decision is binary:

Proposition 1. *If either $\phi_{11} < 0$ or the Skaperdas (1992) assumptions hold, then we can characterize the solution to the relaxed game (i.e. where $r_i \in [0,1]$), (r_k^*, r_w^*) with the FOCs:*

$$\phi_1(r_k^*, r_w^*)F(K^*, L^*) \leq (K^*)^{-\alpha} F_1(K^*, L^*)$$
$$\phi_1(r_w^*, r_k^*)F(K^*, L^*) \leq f \cdot (L^*)^{-\alpha} F_2(K^*, L^*)$$

Proof. Proof strategy:

- Case 1: If ϕ_{11} holds, then it means that the SOC is met whenever the FOC is met.

$$\frac{\partial^2}{\partial r_k}[\phi(r_k, r_w)F(K - r_k, L - fr_w] = \underbrace{\phi_{11} \cdot F}_{<0} - 2\overbrace{\phi_1 \cdot F_1}^{>0} + \underbrace{\phi \cdot F_{11}}_{<0} < 0,$$
$$\frac{\partial^2}{\partial r_w}[\phi(r_w, r_k)F(K - r_k, L - fr_w] = \underbrace{\phi_{11} \cdot F}_{<0} - 2\overbrace{\phi_1 \cdot F_2}^{>0} + \underbrace{\phi \cdot F_{22}}_{<0} < 0$$

  Since the CES function is concave on L and K. This means that–omitting the constraints–the best response can be computed by the value that minimizes the distance between the FOC and 0. Depending on ϕ it might be the case that the best response is a corner solution, and thus we can only establish the inequality condition of the FOCs.

- Case 2: If the Skaperdas (1992) conditions are met, then by theorems 1 and 2 there is a unique interior Nash equilibrium in pure strategies, and can be characterized by the FOCs.

□

The next proposition provides an existence result for the Nash equilibrium:

Proposition 2. *Under the conditions above, and if $r_w^* \in (0,n)$, there exist an equilibrium of the game where r_w workers unionize and $r_w \in (r_w^* - 1, r_w^* + 1)$.*

Proof. Because $r_w^* \in (0,n)$, then the FOCs are met with equality. As Skaperdas (1992) shows the concatenation of the best responses (of the relaxed game) has a unique fixed point, then $BR_k' < 0$ and $BR_w' < 0$ around (r_k^*, r_w^*). Noting also that because the payoff functions have an inverted U on the respective rent seeking effort of each agent, then it must be the case that

$$BR_w(BR_k(\lceil r_w^* \rceil)), BR_w(BR_k(\lfloor r_w^* \rfloor)) \subseteq \{\lceil r_w^* \rceil, \lfloor r_w^* \rfloor\},$$

otherwise the stability of the equilibrium would be violated. The proof is completed by noting that (because of the inverted U shape) either $\lceil r_w^* \rceil$ or $\lfloor r_w^* \rfloor$ must be a fixed point of the concatenation of the best responses. Thus an equilibrium exist when workers have the binary decision. □

Next, we focus on the comparative statics regarding the number of unionized workers. The following proposition illustrates and interprets the equations that characterize the comparative statics of this model:

The ratio CSF—which is the other commonly used CSF in applications—has the property of $\phi_{11} < 0$. Thus we can restrict to the class of CSF includes the ratio CSF.

Proposition 3. *Assume (r_k^*, r_w^*) is an interior solution, then the following comparative statics hold:*

$$\frac{\partial r_k^*}{\partial \alpha} = \overbrace{\frac{\frac{K^{1-\alpha}\ln(K)+L^{1-\alpha}\ln(L)}{K^{1-\alpha}+L^{1-\alpha}} - \ln(K)}{\frac{\phi_{11}(r_k,r_w)}{\phi_1(r_k,r_w)} - \frac{(1-\alpha)K^{-\alpha}}{K^{1-\alpha}+L^{1-\alpha}} - \frac{\alpha}{K}}}^{\textit{direct effect}} - \overbrace{\frac{\partial r_w}{\partial \alpha} \cdot \frac{\frac{\phi_{12}(r_k,r_w)}{\phi_1(r_k,r_w)} - f\frac{(1-\alpha)L^{-\alpha}}{K^{1-\alpha}+L^{1-\alpha}}}{\frac{\phi_{11}(r_k,r_w)}{\phi_1(r_k,r_w)} - \frac{(1-\alpha)K^{-\alpha}}{K^{1-\alpha}+L^{1-\alpha}} - \frac{\alpha}{K}}}^{\textit{strategic effect}}$$

$$\frac{\partial r_w^*}{\partial \alpha} = \underbrace{\frac{\frac{K^{1-\alpha}\ln(K)+L^{1-\alpha}\ln(L)}{K^{1-\alpha}+L^{1-\alpha}} - \ln(L)}{\frac{\phi_{11}(r_w,r_k)}{\phi_1(r_w,r_k)} - f\frac{(1-\alpha)L^{-\alpha}}{K^{1-\alpha}+L^{1-\alpha}} - \frac{f\alpha}{L}}}_{\textit{direct effect}} - \underbrace{\frac{\partial r_k}{\partial \alpha} \frac{\frac{\phi_{12}(r_w,r_k)}{\phi_1(r_w,r_k)} - \frac{(1-\alpha)K^{-\alpha}}{K^{1-\alpha}+L^{1-\alpha}}}{\frac{\phi_{11}(r_w,r_k)}{\phi_1(r_w,r_k)} - f\frac{(1-\alpha)L^{-\alpha}}{K^{1-\alpha}+L^{1-\alpha}} - \frac{f\alpha}{L}}}_{\textit{strategic effect}}$$

Proof. The FOC:

$$\phi_1(r_k,r_w)(K^{1-\alpha}+L^{1-\alpha}) = K^{-\alpha}$$
$$\phi_1(r_w,r_k)(K^{1-\alpha}+L^{1-\alpha}) = fL^{-\alpha}$$

then taking the ln()

$$\ln(\phi_1(r_k,r_w)) + \ln(K^{1-\alpha}+L^{1-\alpha}) = \ln() - \alpha\ln(K)$$
$$\ln(\phi_1(r_w,r_k)) + \ln(K^{1-\alpha}+L^{1-\alpha}) = \ln(f) + \ln() - \alpha\ln(L)$$

Then differentiating the FOC by α:

$$\frac{\partial r_k}{\partial \alpha}\left(\frac{\phi_{11}(r_k,r_w)}{\phi_1(r_k,r_w)} - \frac{(1-\alpha)K^{-\alpha}}{K^{1-\alpha}+L^{1-\alpha}} - \frac{\alpha}{K}\right) + \frac{\partial r_w}{\partial \alpha}\left(\frac{\phi_{12}(r_k,r_w)}{\phi_1(r_k,r_w)} - f\frac{(1-\alpha)L^{-\alpha}}{K^{1-\alpha}+L^{1-\alpha}}\right)$$
$$= \frac{K^{1-\alpha}\ln(K)+L^{1-\alpha}\ln(L)}{K^{1-\alpha}+L^{1-\alpha}} - \ln(K)$$
$$\frac{\partial r_k}{\partial \alpha}\left(\frac{\phi_{12}(r_w,r_k)}{\phi_1(r_w,r_k)} - \frac{(1-\alpha)K^{-\alpha}}{K^{1-\alpha}+L^{1-\alpha}}\right) + \frac{\partial r_w}{\partial \alpha}\left(\frac{\phi_{11}(r_w,r_k)}{\phi_1(r_w,r_k)} - f\frac{(1-\alpha)L^{-\alpha}}{K^{1-\alpha}+L^{1-\alpha}} - \frac{f\alpha}{L}\right)$$
$$= \frac{K^{1-\alpha}\ln(K)+L^{1-\alpha}\ln(L)}{K^{1-\alpha}+L^{1-\alpha}} - \ln(L)$$

After some derivations we find a closed form expression for the partial derivatives:

$$\frac{\partial r_k}{\partial \alpha} = \frac{\begin{vmatrix} \frac{K^{1-\alpha}\ln(K)+L^{1-\alpha}\ln(L)}{K^{1-\alpha}+L^{1-\alpha}} - \ln(K) & \frac{\phi_{12}(r_k,r_w)}{\phi_1(r_k,r_w)} - f\frac{(1-\alpha)L^{-\alpha}}{K^{1-\alpha}+L^{1-\alpha}} \\ \frac{K^{1-\alpha}\ln(K)+L^{1-\alpha}\ln(L)}{K^{1-\alpha}+L^{1-\alpha}} - \ln(L) & \frac{\phi_{11}(r_w,r_k)}{\phi_1(r_w,r_k)} - f\frac{(1-\alpha)L^{-\alpha}}{K^{1-\alpha}+L^{1-\alpha}} - \frac{f\alpha}{L} \end{vmatrix}}{\begin{vmatrix} \frac{\phi_{11}(r_k,r_w)}{\phi_1(r_k,r_w)} - \frac{(1-\alpha)K^{-\alpha}}{K^{1-\alpha}+L^{1-\alpha}} - \frac{\alpha}{K} & \frac{\phi_{12}(r_k,r_w)}{\phi_1(r_k,r_w)} - f\frac{(1-\alpha)L^{-\alpha}}{K^{1-\alpha}+L^{1-\alpha}} \\ \frac{\phi_{12}(r_w,r_k)}{\phi_1(r_w,r_k)} - \frac{(1-\alpha)K^{-\alpha}}{K^{1-\alpha}+L^{1-\alpha}} & \frac{\phi_{11}(r_w,r_k)}{\phi_1(r_w,r_k)} - f\frac{(1-\alpha)L^{-\alpha}}{K^{1-\alpha}+L^{1-\alpha}} - \frac{f\alpha}{L} \end{vmatrix}}$$

$$\frac{\partial r_w}{\partial \alpha} = \frac{\begin{vmatrix} \frac{\phi_{11}(r_k,r_w)}{\phi_1(r_k,r_w)} - \frac{(1-\alpha)K^{-\alpha}}{K^{1-\alpha}+L^{1-\alpha}} - \frac{\alpha}{K} & \frac{K^{1-\alpha}\ln(K)+L^{1-\alpha}\ln(L)}{K^{1-\alpha}+L^{1-\alpha}} - \ln(K) \\ \frac{\phi_{12}(r_w,r_k)}{\phi_1(r_w,r_k)} - \frac{(1-\alpha)K^{-\alpha}}{K^{1-\alpha}+L^{1-\alpha}} & \frac{K^{1-\alpha}\ln(K)+L^{1-\alpha}\ln(L)}{K^{1-\alpha}+L^{1-\alpha}} - \ln(L) \end{vmatrix}}{\begin{vmatrix} \frac{\phi_{11}(r_k,r_w)}{\phi_1(r_k,r_w)} - \frac{(1-\alpha)K^{-\alpha}}{K^{1-\alpha}+L^{1-\alpha}} - \frac{\alpha}{K} & \frac{\phi_{12}(r_k,r_w)}{\phi_1(r_k,r_w)} - f\frac{(1-\alpha)L^{-\alpha}}{K^{1-\alpha}+L^{1-\alpha}} \\ \frac{\phi_{12}(r_w,r_k)}{\phi_1(r_w,r_k)} - \frac{(1-\alpha)K^{-\alpha}}{K^{1-\alpha}+L^{1-\alpha}} & \frac{\phi_{11}(r_w,r_k)}{\phi_1(r_w,r_k)} - f\frac{(1-\alpha)L^{-\alpha}}{K^{1-\alpha}+L^{1-\alpha}} - \frac{f\alpha}{L} \end{vmatrix}}$$

To assess the overall effect of changes in α while taking into account strategic it is sufficient to assume $\phi(r_w, r_k) = r_w/(r_w + r_k)$. Indeed, the ratio CSF—which is the other commonly used CSF in applications—has the property of $\phi_{11} < 0$ and the propositions above hold. □

Thus the relevant problem that labor faces is that when machines complement labor, the higher level of complementarity provides incentives to invest less resources in rent-seeking, but the owners of capital are undoubtedly stronger in the political arena. This occurs because thanks to the initial unequal distribution of assets, automation increases the marginal productivity for workers more rapidly than that for capital, and as a consequence, the force that pushes downwards the rent-seeking action is stronger than the force that pushes upwards rent-seeking for capital; the opposite occurs when automation reduces the relative marginal productivity of workers (e.g., deskilling).

Heterogeneous workers. Each worker is characterized by a different opportunity cost of participating in union related activities $c_i > 0$. For simplicity, we assume that for any two workers i and j, $i < j$ implies $c_i < c_j$. Given the vector of decisions workers $r = (r_1, \ldots, r_n)$, total labor is given by the following expression:

$$L = n - \sum_{i=1}^{n} c_i r_i.$$

Hence high skilled workers (i.e., high c_i) face a higher cost of joining the union vis-á-vis less skilled workers because for the former the net marginal return to labor is comparatively higher than that of rent-seeking:

Proposition 4. *Let (r,k) be an equilibrium of the heterogeneous worker's extension. Then*

- *There is at most one worker such that $r_i \in (0,1)$.*
- *There is a threshold c^* such that $r_i = 0$ $(= 1)$ if and only if $c_i < c^*$ $(> c^*)$.*

Proof. To show the first bulletpoint of the proposition let's assume there are two workers i and j such that $r_i, r_j \in (0,1)$, this implies that their FOC is met with equality:

$$\left[(A_w - r_w)^{1-\alpha} + (-r_k)^{1-\alpha}\right](A_w - r_w)^{\alpha} = nc_i r_w (r_w + r_k),$$
$$\left[(A_w - r_w)^{1-\alpha} + (-r_k)^{1-\alpha}\right](A_w - r_w)^{\alpha} = nc_j r_w (r_w + r_k),$$

which implies that $c_i = c_j$, which is a contradiction.

To prove the second bulletpoint of the proposition, it is enough to note that if i^* is such that $U_i'(r_i^*; c_i) = 0$, and if j is such that $c_j < c_{i*}$, then this implies that $U_{i*}' < U_j'$, and it cannot be the case that $r_j < 1$ otherwise since $0 = U_{i*}' < U_j'$, thus j has incentives to deviate. □

Thus the more skilled the worker is (i.e., larger c_i) the less likely it will have incentives to join the union. This occurs because those with higher opportunity costs are less likely to join a union because the marginal return to labor is comparatively lower than that of rent-seeking. Therefore a higher share of workers inevitably weaken unions because it is tantamount to increasing the density of high (opportunity) costs in the distribution of marginal costs of joining the union.[B.3]

[B.3] Including employment in the model adds few additional insights and it makes the model much less tractable.