Minimum Wages and Optimal Redistribution
in the Presence of Taxes and Transfers[*]

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Abstract

This paper characterizes optimal redistribution for a social planner with three instruments: labor income taxes and transfers, corporate income taxes, and a minimum wage. The modeled economy features search-and-matching frictions, generates positive firm profits in equilibrium, and can accommodate limited employment effects and spillovers to non-minimum wage jobs after minimum wage increases. The analysis formalizes the effects of the minimum wage on the relative welfare of low-skill workers, high-skill workers, and capitalists as a function of sufficient statistics for welfare, social preferences for redistribution, and fiscal externalities. Minimum wages are more likely to be desirable when corporate taxes are low because minimum wages can generate corporate revenue losses. Minimum wages can improve welfare even under optimal income taxes by shifting the incidence of the tax system when there is bunching in the wage distribution at the minimum wage. I estimate the sufficient statistics that guide the welfare analysis using US state-level variation in minimum wages. Minimum wages have increased low-skill workers' welfare –especially for teens– with null effects on high-skill workers. Aggregate welfare effects on capitalists are negligible but they are negative and sizable in certain industries, especially in non-professional services. Income maintenance benefits have also decreased after minimum wage hikes, suggesting that the effects of minimum wage increases on labor market outcomes generate fiscal externalities. A simple calibration based on the empirical estimates suggests that small minimum wage increases today would increase welfare, especially when incorporating distributional concerns between workers and capitalists.

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"The simplest expedient which can be imagined for keeping the wages of labor up to the desirable point would be to fix them by law; the ground of decision being, not the state of the labor market, but natural equity; to provide that the workmen shall have reasonable wages, and the capitalist reasonable profits."

John Stuart Mill, *Principles of Political Economy*, 1884.

1   Introduction

A large literature finds that minimum wage increases have sizable effects on the wage distribution (Lee, 1999; Autor et al., 2016; Dube, 2019; Haanwinckel, 2020; Fortin et al., 2021; Engbom and Moser, 2022) while yielding limited employment consequences (Manning, 2021). Do these findings imply that governments should use the minimum wage to redistribute toward low-wage workers? While this question was raised by Stigler (1946) more than seventy years ago, a consensus on the desirability of the minimum wage for redistributive purposes, especially when other policy tools are available for the policymaker, remains elusive among economists.

It is hard to study the redistributive role of the minimum wage in the presence of taxes and transfers because it is not clear whether it should be viewed as a substitute or a complement to tax-based redistribution. For example, Neumark (2016) and Hurst et al. (2022) suggest that the EITC can replicate the redistributive effects of the minimum wage with fewer distortions. However, the interactions between the minimum wage and the tax system, such as the ones discussed in OECD (2009), Reich and West (2015), or Dube (2019), suggest a rationale for simultaneously using both instruments when thinking about optimal redistribution. One way to address this question is to formally model the decision of the social planner assuming that multiple instruments are available for affecting the income distribution. Earlier work based on this approach has provided mixed answers to this question using insightful but restrictive theoretical environments that shut down empirically relevant avenues by which minimum wages may affect welfare. For example, Hungerbühler and Lehmann (2009), Lee and Saez (2012), Cahuc and Laroque (2014), and Lavecchia (2020) each abstract from firm profits, corporate taxation, and empirically relevant general equilibrium effects of the minimum wage that can dampen employment impacts. Therefore, the role of the minimum wage in the optimal redistributive policy mix remains unsettled in the literature.

In this context, this paper characterizes optimal redistribution for a social planner with three instruments –labor income taxes and transfers, corporate income taxes, and a minimum wage– using a novel theoretical framework that makes progress in dealing with the limitations of the related literature. The paper is structured in three parts. The first part proposes a model of the labor market that can accommodate limited employment effects and spillovers to non-minimum wage jobs after minimum wage increases, with positive profits in equilibrium. The second part uses the model to analyze the welfare implications of the minimum wage following an optimal policy approach where a social planner chooses the policy parameters to maximize aggregate welfare. This analysis formalizes the effects of the minimum wage on the relative welfare of low-skill workers, high-skill workers, and capitalists as a function of sufficient

statistics for welfare, social preferences for redistribution, and fiscal externalities. The third part provides estimates of the sufficient statistics exploiting US state-level variation in minimum wages and uses the results to develop a simple calibration to assess the welfare consequences of minimum wage changes.

The model of the labor market features directed search and two-sided heterogeneity. On one side, there is a population of workers with heterogeneous skills and costs of participating in the labor market that decide whether to enter the labor market. Conditional on participating in the labor market, workers decide on jobs to which they will apply. On the other side, there is a population of capitalists with heterogeneous productivities that decide whether to create firms. Conditional on creating a firm, capitalists decide the number of vacancies they post and their corresponding wages. In the model, minimum wage increases affect the workers' job application strategies which, in turn, induce reactions in the posting behavior of firms. I show that these behavioral responses can lead to limited employment effects and spillovers to non-minimum wage jobs. In addition, firms earn positive profits in equilibrium.

In addition to the generation of more realistic predictions of changes in the minimum wage, the model reproduces empirically relevant features of low-wage labor markets. The model admits wage dispersion for similar workers (Card et al., 2018), wage posting rather than bargaining (Hall and Krueger, 2012; Caldwell and Harmon, 2019; Lachowska et al., 2022), endogenous finite firm-specific labor supply elasticities (Staiger et al., 2010; Azar et al., 2019; Dube et al., 2020; Bassier et al., 2021; Sokolova and Sorensen, 2021), and bunching in the wage distribution at the minimum wage (Cengiz et al., 2019). Moreover, the competitive nature of directed search models (Wright et al., 2021) generates efficient outcomes in terms of search and posting behavior that imply that the model avoids arguments in favor of the minimum wage motivated by the correction of search and matching inefficiencies (e.g., Burdett and Mortensen, 1998; Acemoglu, 2001; Hungerbühler and Lehmann, 2009). This allows the analysis to focus on redistribution –rather than efficiency– rationales for analyzing minimum wage policy.

With the model in hand, I proceed to analyze the the role of the minimum wage in the redistributive policy mix following an optimal policy approach where a social planner chooses the minimum wage, the income tax schedule, and the corporate tax rate to maximize social welfare.

The first result characterizes the tradeoff induced by the minimum wage in the absence of taxes. The minimum wage affects the welfare of active low- and high-skill workers through its effects on the labor market equilibrium, and the welfare of capitalists through its effects on profits. This implies that the minimum wage can affect both the relative welfare between low- and high-skill workers and between workers and capitalists. The change in workers' welfare is summarized by the change in the expected utility of participating in the labor market which, under some assumptions, is equal to the change in the average post-tax wage of labor market participants including the unemployed. This sufficient statistic aggregates all wage, employment, and participation responses that can affect workers' utility in a single elasticity. While the signs of the workers' sufficient statistics are theoretically ambiguous, welfare

improvements for workers are not tied to positive employment effects. In fact, the sufficient statistics can be used to compute, given wage effects, the disemployment effects that can be tolerated for the minimum wage to have positive effects on workers' welfare.

The second result solves for the optimal minimum wage under fixed income and corporate taxes, that is, under a tax system that is taken as given by the social planner. This result characterizes the mechanic interactions between the minimum wage and the tax system that play a role in the policy design problem. The welfare tradeoff discussed above is augmented with fiscal externalities from both sides of the market. On the workers' side, changes in wages and employment may induce a change in tax collection and transfer spending. On the firms' side, the change in profits affects the corporate tax revenue. When the corporate tax rate is low –which could happen, for example, under international tax competition– the optimal minimum wage increases, both because the corporate revenue loss is smaller and the welfare gains from redistributing from capitalists to workers increase.

The third result considers a situation where the social planner can simultaneously choose both the tax system and the minimum wage. Having an optimal tax system limits the ability of the minimum wage to directly increase workers' welfare because the desired after-tax allocations can be achieved more efficiently by a targeted non-linear income tax schedule. However, binding minimum wages may be desirable for redistributive purposes even if taxes are optimal because the minimum wage can shift the incidence of the tax system, making tax-based redistribution more efficient (OECD, 2009). To understand why, suppose that the optimal tax schedule considers an EITC at the bottom of the distribution. Firms internalize that the EITC increases job applications for a given posted wage, so they react by lowering posted pre-tax wages (Rothstein, 2010). Then, the EITC becomes both a transfer to workers and capitalits. The minimum wage limits the ability of firms to decrease wages, thereby increasing the efficacy of the EITC to redistribute toward low-skill workers. The importance of this mechanism depends on the mass of workers earning the minimum wage. When bunching at the minimum wage is large, this analysis suggests that the minimum wage could be a complement to tax-based redistribution.

The final part of the paper estimates the sufficient statistics that play a role in the theoretical analysis. I follow Cengiz et al. (2019, 2022) and estimate stacked event studies exploiting state-level variation in minimum wages using Vaghul and Zipperer (2016) data on local minimum wages for the period 1979-2019. Events are defined as state-level hourly minimum wage increases of at least \$0.25 (in 2016 dollars) in states where at least 2% of the pre-event year working population earned less than the new minimum wage. The preferred specification uses a sample of 72 balanced events that exclude relevant minimum wage increases where pre-trends can be confounded by multiple treatments.

The data consists of yearly state-level aggregates of different outcomes of interest. On the workers' side, I follow Cengiz et al. (2019, 2022) and use the individual-level NBER Merged Outgoing Rotation Group of the CPS to compute average pre-tax hourly wages and employment and participation rates to

compute a pre-tax version of the sufficient statistic. Low- and high-skill workers are broadly defined by having or not a college degree. To estimate workers' side fiscal externalities and transform pre-tax values to post-tax values, I use data on income maintenance benefits (total and per-working age individual) taken from the BEA regional accounts. On the capitalists' side, given the lack of firm-level microdata, I proxy state-level average profits using the gross operating surplus estimates from the BEA regional accounts normalized by the average number of private establishments reported in the QCEW data files.

Results show that minimum wage increases have increased low-skill workers' welfare, with a corresponding null effect on high-skill workers. The estimated elasticity of average pre-tax wages of active low-skill workers (including the unemployed) with respect to changes in the state-level minimum wage ranges between 0.09 and 0.16 in the preferred specification. Conversely, all specifications estimate a precise zero elasticity for the high-skill workers' analog. When decomposing the elasticity of low-skill workers across different margins, I find that the entire effect is driven by an increase in the wage conditional on employment: no effect is found on hours, employment, or participation. The analysis also suggests that the most benefited group within low-skill workers are teens (workers aged 16-19) whose elasticity ranges between 0.27 and 0.34. This finding implies stronger redistributive benefits from the minimum wage because teens are much more likely to be located in the lower part of the income distribution within low-skill workers (Manning, 2021; Cengiz et al., 2022).

The estimated elasticity of income maintenance benefits (both total and normalized by working-age population) ranges between -0.31 and -0.37, suggesting relevant fiscal externalities derived from minimum wage increases. This result is consistent with Reich and West (2015), who find elasticities of around -0.2 for SNAP expenditures after minimum wage increases, and Dube (2019), who finds that after-tax income elasticities are one third smaller than pre-tax income elasticities. These fiscal externalities partially attenuate the welfare gains for workers derived from pre-tax wage increases.

The estimated elasticity of average profits per establishment is zero when pooling all industries to compute the state-level aggregates. However, some industries display negative profit effects. Non-professional services stands out with elasticities that range from -0.12 and -0.21. Construction, wholesale trade, and finance also show negative profit effects, although the point estimates are noisy and unstable across specifications. The lack of effects on manufacturing and other capital intensive industries suggests that the interaction between the minimum wage and the corporate tax rate is particularly relevant because international tax competition puts bounds on corporate tax rates given the effects it has on capital-intensive industries. In a sense, the minimum wage can be thought of as a sector-specific tax of profits that is not subject to the typical distortions of the corporate tax rate driven by international capital mobility.

To better understand the welfare consequences of these results, I use the empirical estimates to develop a simple calibration of the theoretical solution to the social planner's problem. The analysis consistently finds that past minimum wage increases have been welfare-improving, and that small minimum wage

increases today would also be socially beneficial. While the calibration predicts welfare gains even in the absence of distributional concerns, these gains are an order of magnitude larger after incorporating distributional concerns between workers and capitalists. The analysis confirms the importance of the corporate tax rate since it appears as the most relevant parameter for assessing the welfare implications of the minimum wage when distributional concerns are incorporated. The welfare gains are much larger when calibrated corporate tax rates are small since the efficiency cost of the policy change –the loss in corporate tax revenue due to smaller profits– is attenuated. Similar conclusions are reached when computing the marginal value of public funds (Finkelstein and Hendren, 2020; Hendren and Sprung-Keyser, 2020) as an alternative indicator of the welfare consequences of increasing the minimum wage.

Related literature The main contribution of this paper is to the normative analysis of the minimum wage in frameworks with taxes and transfers. Lee and Saez (2012) use a competitive supply-demand framework and show that the case for binding minimum wages under optimal taxes depends on labor rationing assumptions. Cahuc and Laroque (2014) contest Lee and Saez (2012)'s result by arguing that the minimum wage cannot improve welfare on top of an optimal non-linear tax schedule even if the labor demand is modeled as a standard monopsonist. Both analyses abstract from search frictions, firm-level heterogeneity, and do not give a role to firm profits. Hungerbühler and Lehmann (2009) and Lavecchia (2020) consider random search models but also abstract from firm profits, restricting the role of the minimum wage under optimal taxes to solving search and matching inefficiencies. This paper adds to this literature by considering a theoretical framework that gives a role to profits and explicitly generates more realistic predictions of minimum wage changes, thus increasing the policy-relevance of the analysis. The framework is built to emphasize the distributional dimension of the problem and derives results based on estimable sufficient statistics, which facilitates the empirical assessment of the theoretical analysis.

A complementary growing literature studies the welfare consequences of the minimum wage using structural models that abstract from the tax-design question. Some papers within this literature also abstract from the distributional dimension and focus on efficiency rationales motivated by labor market imperfections (Flinn, 2006; Wu, 2021; Ahlfeldt et al., 2022; Drechsel-Grau, 2022). Two recent papers give a more important role to redistribution within the analysis. Berger et al. (2022b) propose a general equilibrium model of oligopsonistic labor markets and find that welfare improvements from minimum wage increases stem mainly from redistribution, because reductions in labor market power can simultaneously generate misallocation as large-productive firms may increase their market share. Consistent with my analysis, they find that the main distributional benefits of the minimum wage come from redistributing from capitalists to low-skill workers. Hurst et al. (2022) develop a general equilibrium model to compare the short- and long-run distributional impacts of the minimum wage and tax-based redistribution, finding that tax-based redistribution dominates the minimum wage because the latter encourages capital-labor substitution in the long-run, which generates unintended distributional consequences within low-skill

workers. My analysis differs from theirs since I focus on the optimal policy design and its short- and medium-run –rather than long-run– distributional consequences. Interestingly, they also find that the minimum wage can improve the efficacy of the EITC by setting a wage floor to firms.[1]

This paper also contributes to other strands of the literature. First, it adds to the analysis of redistributive policies in labor markets with frictions (Hungerbühler et al., 2006; Stantcheva, 2014; Sleet and Yazici, 2017; Kroft et al., 2020; Bagger et al., 2021; Hummel, 2021b; Mousavi, 2021; Craig, 2022; Doligalski et al., 2022). Second, it contributes to the analysis of redistribution between capital and labor (Atesagaoglu and Yazici, 2021; Eeckhout et al., 2021; Hummel, 2021a) by formalizing a role for the minimum wage in this problem. Third, it adds to a literature that studies the interaction of different policies in second-best contexts (Diamond and Mirrlees, 1971; Atkinson and Stiglitz, 1976; Gaubert et al., 2020; Ferey, 2020). Fourth, the model presented adds to the literature that studies the theoretical foundations of monopsony power and firm wage premiums (Card et al., 2018; Haanwinckel, 2020; Huneeus et al., 2021; Jarosch et al., 2021; Kroft et al., 2021; Berger et al., 2022a,b; Engbom and Moser, 2022; Lamadon et al., 2022). Finally, the empirical results add to a large empirical literature, referenced throughout the paper, that studies the effects of minimum wages on different labor market and firms outcomes.

2 Model of the Labor Market

This section proposes a tractable model of the labor market that can accommodate limited employment effects and spillovers to non-minimum wage jobs after minimum wage increases, features positive firm profits in equilibrium, and reproduces additional stylized facts of low-wage labor markets.

2.1 Setup

Overview The model is static and features two-sided heterogeneity. On one side, there is a population of workers that is heterogeneous in two dimensions. First, workers have different skills. For simplicity, I assume workers are either low-skill or high-skill. Second, workers have heterogeneous costs of participating in the labor market. On the other side, there is a population of capitalists with heterogeneous productivities. I assume individuals are either workers or capitalists.

Labor market interactions are modeled following a directed search approach inspired by Moen (1997).[2] Capitalists decide whether to create firms based on expected profits. Conditional on creating a firm, they post wages and vacancies, with all vacancies posted at a given wage forming a *sub-market*.[3] Labor

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[1]Dworczak et al. (2021) indirectly analyzes the redistributive consequences of the minimum wage using an alternative framework. They analyze redistribution through markets and price controls using mechanism design techniques.

[2]The interaction between minimum wages and directed search frameworks has received little attention in the literature. For applications, see Shi (2009), Gautier and Moraga-González (2018), Wu (2021), and Hurst et al. (2022).

[3]The notion of sub-market should not be confounded with the notion of local labor market. Sub-markets only vary with

markets are segmented, meaning that wages and vacancies are skill-specific. Workers observe wages and vacancies and make their labor market participation and application decisions. In equilibrium, there is a continuum of sub-markets indexed by m, characterized by skill-specific wages, w_m^s, vacancies, V_m^s, and applicants, L_m^s, with $s \in \{l, h\}$ indexing skill.

Matching technology There are standard matching frictions within each sub-market. The number of matches within a sub-market is given by the matching function $\mathcal{M}^s(L_m^s, V_m^s)$, with $\mathcal{M}^s$ continuously differentiable, increasing and concave, and with constant returns to scale. The matching technology is allowed to be different for low- and high-skill workers (Berman, 1997; Hall and Schulhofer-Wohl, 2018).

Under these assumptions, the sub-market skill-specific job-finding rate (that is, the workers' probability of finding a job conditional on applying) can be written as

$$p_m^s = \frac{\mathcal{M}^s(L_m^s, V_m^s)}{L_m^s} = \mathcal{M}^s(1, \theta_m^s) = p^s(\theta_m^s), \tag{1}$$

with $\partial p^s(\theta_m^s)/\partial\theta_m^s \equiv p_\theta^s > 0$, where $\theta_m^s = V_m^s/L_m^s$ is the sub-market skill-specific vacancies to applicants ratio, usually referred to as *sub-market tightness*. Intuitively, the higher the ratio of vacancies to applicants, the more likely that an applicant will randomly be matched with one of those vacancies.

Likewise, the sub-market skill-specific job-filling rate (that is, the firms' probability of filling a vacancy conditional on posting it) can be written as

$$q_m^s = \frac{\mathcal{M}^s(L_m^s, V_m^s)}{V_m^s} = \mathcal{M}^s\left(\frac{1}{\theta_m^s}, 1\right) = q^s(\theta_m^s), \tag{2}$$

with $\partial q^s(\theta_m^s)/\partial\theta_m^s \equiv q_\theta^s < 0$. Intuitively, the lower the ratio of vacancies to applicants, the more likely that the firm will be able to randomly fill the vacancy with a worker.

I assume that neither workers nor firms internalize that their application and posting behavior affects equilibrium tightness, so they take p_m^s and q_m^s as given when making their individual decisions.

Workers The population of workers is normalized to 1. The exogenous shares of low- and high-skill workers are given by α_l and α_h, respectively. Conditional on skill, each worker draws a parameter $c \in \mathcal{C} = [0, C] \subset \mathbb{R}$ that represents the cost of participating in the labor market, which admits different interpretations such as search costs, disutility of (extensive margin) labor supply, or other opportunity costs of working such as home production. Let f_s and F_s be the skill-specific density and cumulative distributions of c, respectively, assumed to be smooth.

Workers derive utility from the after-tax wage net of labor market participation costs.[4] The utility

wages and, in principle, all workers are equally able to apply to them. Both concepts could be closer in a more general model with multidimensional firm heterogeneity and heterogeneous application costs.

[4]Since the model abstracts from intensive margin responses, I refer to wages and incomes indistinctly. In the empirical

of not entering the labor market is $u_0 = y_0$, where y_0 is a lump-sum transfer paid by the government to non-employed individuals. u_0 is the same for all workers, regardless of their (s, c) type. When entering the labor market, workers apply to jobs. Following Moen (1997), I assume that workers can apply to jobs in only one sub-market.[5] Conditional on employment, after-tax wages are given by $y_m^s = w_m^s - T(w_m^s)$, where T is the (possibly non-linear) income tax-schedule, with $T(0) = -y_0$. Then, the expected utility of entering the labor market for a worker of type (s, c) is given by

$$u_1(s, c) = \max_m \{p_m^s y_m^s + (1 - p_m^s) y_0\} - c, \tag{3}$$

since workers apply to the sub-market that gives them the highest expected after-tax wage internalizing that the application ends in employment with probability p_m^s and unemployment with probability $1 - p_m^s$.

Recall that p_m^s depends on the mass of workers of skill s that apply to jobs in sub-market m: given a stock of vacancies, the more workers apply, the smaller the likelihood of being employed. Then, individuals take p_m^s as given but it is endogenously determined by the aggregate application behavior. This implies that, in equilibrium, all markets have the same expected after-tax wage, i.e., $p_i^s y_i^s + (1 - p_i^s) y_0 = p_j^s y_j^s + (1 - p_j^s) y_0 = \max_m \{p_m^s y_m^s + (1 - p_m^s) y_0\}$, for all i, j; if not, workers have incentives to change their applications toward markets with higher expected values, pushing downward the job-filling probabilities and restoring the equilibrium. Then, workers face a trade-off between wages and employment probabilities because it is more difficult to get a job in sub-markets that pay higher wages.

In what follows, I define $U^s \equiv \max_m \{p_m^s y_m^s + (1 - p_m^s) y_0\}$ so $u_1(s, c) = U^s - c$. The labor market participation decision is given by $l(s, c) = 1\{u_1(s, c) \geq u_0\}$. Let $L_A^s = \alpha_s \cdot \int l(s, c) dF_s(c)$ denote the mass of active workers of skill s, that is, the mass of workers of skill s that enter the labor market. Inactive workers are then given by $L_I = L_I^l + L_I^h = 1 - L_A^l - L_A^h$. If after-tax wages are higher than y_0, then $u_1(s, 0) > 0$. Since $u_1(s, c)$ is decreasing in c this implies that $l(s, c) = 1$ if $c \leq U^s - y_0$, $l(s, c) = 0$ otherwise. Then, $L_A^s = \alpha_s \cdot F_s(U^s - y_0)$. Denote by L_m^s the mass of individuals of skill s applying to jobs in sub-market m, so $L_A^s = \int L_m^s dm$. For simplicity, I assume away sorting patterns in the labor market, that is, application decisions conditional on participating in the labor market are independent from c.

Note that the expression $U^s = p_m^s y_m^s + (1 - p_m^s) y_0$ implies that θ_m^s can be written as a function of w_m^s and U^s, for all m. Formally, $\theta_m^s = \theta_m^s(w_m^s, U^s)$, with $\partial \theta_m^s / \partial w_m^s < 0$ and $\partial \theta_m^s / \partial U^s > 0$.[6] This result facilitates the analysis below since implies that, conditional on wages, equilibrium behavior can be summarized by the scalars U^s without needing to characterize the continuous sequence of θ_m^s.

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section I validate the assumption by showing no responses in weekly hours to minimum wage changes.

[5] As explained below, this assumption makes the equilibrium tractable and induces an efficiency property that is helpful for the normative analysis. Kircher (2009) and Wolthoff (2018) develop models when workers can simultaneously apply to several sub-markets.

[6] Since $U^s = p^s(\theta_m^s)(w_m^s - T(w_m^s)) + (1 - p^s(\theta_m^s)) y_0$, then $dU^s = p_\theta^s \cdot d\theta_m^s \cdot y_m^s + p_m^s \cdot (1 - T'(w_m^s)) \cdot dw_m^s$. Recalling that $p_\theta^s > 0$ and asssuming $T'(w_m^s) < 1$ yields the result.

Capitalists The population of capitalists is normalized to K. Each capitalist draws a parameter $\psi \in \Psi = \left[\underline{\psi}, \overline{\psi}\right] \subset \mathbb{R}^+$ that represents firm productivity. Let o and O be the density and cumulative distributions of ψ, respectively, assumed to be smooth.

Capitalists observe ψ and choose whether to create a firm. Firms are price-takers in the output market (with the price normalized to 1). Technology only uses workers for production, so a firm of productivity ψ that hires (n^l, n^h) workers generates a revenue equal to $\psi \cdot \phi(n^l, n^h)$, with ϕ twice differentiable, $\phi_s > 0$ and $\phi_{ss} \leq 0$. Firms choose skill-specific wages, w^s, and vacancies, v^s, knowing that n^s is the result of the matching process. While firms take the job-filling probabilities as given, they internalize that paying higher wages increases the job-filling probabilities. In other words, the wage choice is equivalent to the sub-market choice. Following the discussion above, I rewrite the job-filling probabilities as $\tilde{q}^s(w^s, U^s) = q(\theta^s(w^s, U^s))$, with $\tilde{q}_w^s = q_\theta \cdot (\partial \theta^s / \partial w^s) > 0$, so $n^s = \tilde{q}^s(w^s) \cdot v^s$. Posting v^s vacancies has a cost $\eta^s(v^s)$, with $\eta_v^s > 0$ and $\eta_{vv}^s > 0$. Then, pre-tax profits are given by revenues net of labor costs:

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\begin{aligned}
\pi\left(\psi; w^l, w^h, v^l, v^h\right) &= \psi \cdot \phi\left(\tilde{q}^l(w^l, U^l) \cdot v^l, \tilde{q}^h(w^h, U^h) \cdot v^h\right) \\
&\quad - \left(w^l \cdot \tilde{q}^l(w^l, U^l) \cdot v^l + \eta^l(v^l)\right) - \left(w^h \cdot \tilde{q}^h(w^h, U^h) \cdot v^h + \eta^h(v^h)\right).
\end{aligned} \tag{4}
$$

Firms pay a flat corporate tax rate on profits, t, so after-tax profits are given by $(1-t)\pi\left(\psi; w^l, w^h, v^l, v^h\right)$.

Conditional on ψ, firms are homogeneous. Then, the solution to the profit maximizing problem can be characterized by functions $w^s(\psi)$ and $v^s(\psi)$. Appendix A derives the first-order conditions and shows that dispersion in productivities leads to dispersion in wages, with wages *marked down* relative to the marginal productivities, and possibly with more productive firms paying higher wages.[7] Within firms and skill type, wages and vacancies are positively correlated, implying that more productive firms hire more workers. Finally, the within firm correlation between low- and high-skill workers depends on the sign of ϕ_{lh}. That is, if low- and high-skill workers are complements ($\phi_{lh} > 0$), more productive firms hire both more low- and high-skill workers.

Without loss of generality, m indexes sub-markets as well as the productivity levels of capitalists that create firms, so $w_m^s = w^s(\psi_m)$, $v_m^s = v^s(\psi_m)$, and $V_m^s = K \cdot v^s(\psi) \cdot o(\psi)$. Let $\Pi(\psi) = \max_{w^l, w^h, v^l, v^h} \pi\left(\psi; w^l, w^h, v^l, v^h\right)$ be the value function of firms of type ψ. Capitalists have to pay a fixed cost, ξ, to create firms, and receive the lump-sum transfer when remaining inactive, so they become active when $(1 - t) \cdot \Pi(\psi) \geq \xi + y_0$. Since profits are strictly increasing in productivity, the entry rule defines a productivity threshold implicitly determined by $(1 - t) \cdot \Pi(\psi^*) = \xi + y_0$ such that capitalists create firms only if $\psi \geq \psi^*$. Then, the mass of active capitalists is given by $K_A = K \cdot (1 - O(\psi^*))$. The mass of inactive capitalists, K_I, is given by $K_I = K \cdot O(\psi^*)$, with $K_A + K_I = K$.

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[7]I say *possibly* since large second-order cross effects across skill types can induce non-linearities in the wage-productivity relationship. For more details, see Appendix A.

2.2 Discussion

Before introducing a minimum wage to the model, I briefly discuss some features and limitations of the proposed framework and its equilibrium.

Directed search   The choice of directed search is motivated by two different reasons. First, directed search models are framed as *competitive* since they usually lead to efficient (or constrained-efficient) outcomes in terms of search and posting behavior (Wright et al., 2021). That is, in these models there is no inefficient excess or lack of applicants or vacancies, as can happen, for example, in random search models (Hosios, 1990; Mangin and Julien, 2021). In the model developed in this paper, the arbitrage of applicants that equalizes expected utility across sub-markets ensures this property (Moen, 1997). While this simplification may seem restrictive, it fosters a focus on the redistributive properties of the minimum wage rather that its efficiency-enhancing potential in contexts with search and matching inefficiencies, which has been explored previously in the literature (e.g., Burdett and Mortensen, 1998; Acemoglu, 2001; Hungerbühler and Lehmann, 2009; Lavecchia, 2020).

Second, directed search offers a mechanism for inducing sorting of workers to firms that leads to wage dispersion for similar workers in equilibrium. This can rationalize *firm fixed-effects* which have shown to be empirically relevant (Card et al., 2018). The mechanism for inducing sorting –the positive relationship between posted wages and applications per vacancy– is supported by empirical evidence (Dal Bó et al., 2013; Banfi and Villena-Roldan, 2019; He et al., 2021).[8,9]

Monopsony power   While search and posting behavior is efficient, the model admits monopsony power through endogenous wage-dependent job-filling probabilities that have a similar flavor to the standard monopsony intuition of upward-slopping firm-specific labor supply curves (Robinson, 1933; Card et al., 2018) supported by recent empirical evidence (Staiger et al., 2010; Azar et al., 2019; Dube et al., 2020; Bassier et al., 2021; Sokolova and Sorensen, 2021). Because of monopsony power, wages are *marked down* relative to the marginal productivities.[10] This implies that minimum wages could induce positive employment effects through the standard monopsony argument, however, this employment effect would not be efficiency-improving as usually understood since total output would be reduced through a reduction in profits. Potential employment effects acquire a redistributive flavor in this framework.

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[8]Marinescu and Wolthoff (2020) show that the relationship between wages and applications is more complex when more general patterns of heterogeneity are considered. The positive relationship only holds after controlling for job-titles, which can be accommodated by the model's assumption of segmented labor markets.

[9]An alternative sorting mechanism is to assume idiosyncratic preferences for firms (Card et al., 2018). I avoid including preference heterogeneity since it may complicate the optimal policy analysis developed in next section (Eden, 2021).

[10]Variable vacancy creation costs prevent firms for posting infinite vacancies to push down wages to a unique market value, thus mediating the elasticity. See Appendix A for details.

Wage posting and bunching The equilibrium of the model is consistent with other stylized facts of low-wage labor markets. In addition to wage dispersion of similar workers and monopsony power, the model features wage posting rather than bargaining, which has been found to be more relevant for low-wage jobs (Hall and Krueger, 2012; Caldwell and Harmon, 2019; Lachowska et al., 2022). Also, the model can rationalize bunching in the wage distribution at the minimum wage (Cengiz et al., 2019).

Limitations The theoretical setup imposes several simplifying assumptions to preserve the required tractability for the optimal policy analysis. Some of these assumptions may seem restrictive to analyze the effects of minimum wages on labor market outcomes.

One important limitation is that the dimensions of worker and firm heterogeneity are limited and insufficient for rationalizing observed labor market outcomes. On the workers' side, the model assumes that all workers within skill get the same expected utility. This requires no predictable sorting pattern of workers to firms within skill type, which is at odds with the empirical evidence. For example, Cengiz et al. (2022) show that teens are more likely to work at minimum wage firms than older workers with the same education level. As suggested by Hurst et al. (2022), this could be masking important distributional effects if there are winners and losers within skill-type of minimum wage changes. Extending the model in this direction would imply that U^s –which plays an important role in the optimal policy analysis of the next section– could be different, for example, for low- and high-skill workers of different ages if younger workers sort more frequently to firms that pay lower wages. I come back to this discussion in Section 4 where I empirically test for heterogeneities in the estimated welfare changes within skill groups.

On the firms' side, one-dimensional heterogeneity is clearly an over-simplification. Firms could differ, for example, in their production functions (as in Haanwinckel, 2020) or in the provision of non-wage amenities.[11] On a more general note, assuming that heterogeneity is only driven by productivity predicts a stark relationship between productivity, wages, and size which contradicts the fact that large and productive firms may pay low-wages. In that regard, this assumption should be interpreted as an instrument for inducing wage dispersion in equilibrium rather than a realistic prediction of the labor market. Importantly, as shown in the next section, the optimal policy analysis is based on reduced-form profit elasticities, so the empirical analysis will be robust to richer forms of firm-level heterogeneity.

Another important assumption of the model is that workers are risk-neutral: expected utility is money-metric and abstracts from a differential valuation of changes in employment probabilities and after-tax

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[11]It is well documented that non-wage job-amenities are relevant for workers' decisions (Bonhomme and Jolivet, 2009; Mas and Pallais, 2017; Lavetti and Schmutte, 2018; Maestas et al., 2018; Sorkin, 2018; Taber and Vejlin, 2020; Jäger et al., 2021; Le Barbanchon et al., 2021; Lindenlaub and Postel-Vinay, 2021; Marinescu et al., 2021; Sockin, 2021; Lamadon et al., 2022; Roussille and Scuderi, 2022). Beyond helping to rationalize more realistic firm-size and wage distributions, amenities may matter for the minimum wage analysis because of two reasons. First, if workers rank firms using a composite index of expected wages and amenities, the tax system would distort workers' choices by inducing a wedge between the value of earnings and amenities, a point raised in Lamadon et al. (2022). Second, if amenities are endogenous, minimum wage increases may induce firms to worsen the non-wage attributes of the job, a point raised in Clemens et al. (2018) and Clemens (2021). This could attenuate potential welfare gains to workers after minimum wage hikes.

wages through, for example, a concave transformation of after-tax wages as in the general expected utility theory (Savage, 1954). In essence, the model implicitly assumes that there is a perfect compensating differential between after-tax wages and employment probabilities which limits the interpretation of the firm fixed effects. Incorporating concavity in the flow utility function does not affect the high-level analysis, but induces a complication for defining the empirical approximations of the relevant sufficient statistics derived in the optimal policy analysis. I come back to this discussion in the next section.

This is a non-exhaustive discussion of the limitations of the model. In Appendix A I briefly discuss the implications of abstracting from dynamics, intensive margin responses, capital in the production function, and informal labor markets.

2.3 Introducing a minimum wage

I introduce a minimum wage, $\overline{w}$, to explore how the predictions of the model speak to the related empirical literature. I separately explore the effects on workers and capitalists decisions.

Low-skill workers   Recall that, in equilibrium, $U^l = p^l(\theta^l_m) \cdot y^l_m + (1 - p^l(\theta^l_m)) \cdot y_0$, for all sub-markets m. Let i be the sub-market constrained by the minimum wage, so $w^l_i = \overline{w}$, and $U^l = p^l(\theta^l_m) \cdot (\overline{w} - T(\overline{w})) + (1 - p^l(\theta^l_m)) \cdot y_0$. Differentiating yields

$$\frac{dU^l}{d\overline{w}} = p^l_\theta \cdot \frac{d\theta^l_i}{d\overline{w}} \cdot (\overline{w} - T(\overline{w}) - y_0) + p^l(\theta^l_i) \cdot (1 - T'(\overline{w})). \tag{5}$$

Since $p^s(\theta^l_i) > 0$, and assuming $T'(\overline{w}) < 1$, $dU^l/d\overline{w} = d\theta^l_i/d\overline{w} = 0$ is not a feasible solution of (5). This implies that changes in $\overline{w}$ necessarily affect the equilibrium values of U^l, θ^l_i, or both.

Intuitively, an increase in the minimum wage mechanically makes minimum wage jobs more attractive for low-skill workers. This effect on expected utility is captured by $p^l(\theta^l_i) \cdot (1 - T'(\overline{w}))$ since the increase in the attractiveness of this sub-market is the net-of-tax gain conditional on working, $1 - T'(\overline{w})$, times the employment probability, $p^l(\theta^l_i)$. This mechanic effect attracts new applicants toward minimum-wage sub-markets (from other sub-markets and/or workers from outside the labor force), thus pushing θ^l_i downwards until the across sub-market equilibrium is restored. This decreases the employment probability in sub-market i, whose effect on expected utility is captured by the change in the employment probability, $p^l_\theta \cdot (d\theta^l_i/d\overline{w})$, times the change in after-tax income, $\overline{w} - T(\overline{w}) - y_0$. How these two effects balance will determine the extent to which the overall effect on expected utility is positive or negative.

This mechanic is the essence of the general equilibrium effects of the model: the initial change in applications toward minimum-wage jobs triggers a sequence of reactions that reconfigure labor market outcomes. For example, changes in $\overline{w}$ also affect the equilibrium of unconstrained low-skill sub-markets. To see this, let j be a sub-market that is not constrained by the minimum wage, so $w^l_j > \overline{w}$ and

$U^l = p^l(\theta^l_j) \cdot y^l_j + (1 - p^l(\theta^l_j)) \cdot y_0$. Differentiating yields

$$\frac{dU^l}{d\overline{w}} = p^l_\theta \cdot \frac{d\theta^l_j}{d\overline{w}} \cdot (w^l_j - T(w^l_j) - y_0) + p^l(\theta^l_j) \cdot (1 - T'(w^l_j)) \cdot \frac{dw^l_j}{d\overline{w}}. \tag{6}$$

Equation (5) suggests that the left-hand-side is unlikely to be zero, implying that θ^l_j or w^l_j or both are possibly affected by changes in the minimum wage in (6). There are two mechanics that mediate this spillover. First, the change in applicant flows between sub-markets and from in and out of the labor force affect the employment probabilities of all sub-markets until the equilibrium condition of equal expected utilities is restored. This is captured by the first term of equation (6). If workers change their applications toward the minimum wage sub-market, employment probabilities mechanically increase in the remaining sub-markets, thus attenuating the application responses. Second, as discussed below, firms can also respond to changes in applicants, potentially modifying vacancies and wages. The potential wage response is captured in the second term of equation (6) and changes in vacancy posting will implicitly enter in the terms $d\theta^l_m/d\overline{w}$ of equations (5) and (6).

Changes in U^l also induce changes in labor market participation, since $L^l_A = \alpha_l \cdot F_l(U^l - y_0)$ and, therefore $dL^l_A/d\overline{w} = \alpha_l \cdot f_l(U^l - y_0) \cdot (dU^l/d\overline{w})$. Then, whenever $dU^l/d\overline{w} > 0$, minimum wage hikes increase labor market participation. Note, however, that the behavioral response is scaled by $f_l(U^l)$, which may be negligible. This may result in an equilibrium effect with positive effects of expected utilities with negligible participation effects at the aggregate level.

High-skill workers If $\min_m\{w^h_m\} > \overline{w}$, equilibrium effects for high-skill workers take the form of equation (6). Then, the question is whether there are equilibrium forces that rule out solutions of the form $dU^h/d\overline{w} = d\theta^h_i/d\overline{w} = dw^h_i/d\overline{w} = 0$. In this model, effects in high-skill sub-markets are mediated by the production function, since demand for high-skill workers depends on low-skill workers through ϕ. Then, this model may induce within-firm spillovers explained by a technological force. Changes in low-skill markets affect high-skill posting, thus affecting high-skill workers application decisions.

Firms Low-skill workers react to changes in the minimum wage by potentially changing their application strategies and extensive margin decisions, thus affecting sub-markets' tightness. This, in turn, has an impact on the profit maximization problem of the firms since sub-market tightness affect job-filling probabilities. The effects of minimum wage changes on firms' decisions are more involved given the potential non-linearities and second-order effects implicit in the production and vacancy cost functions. Appendix A formally addresses the problem and provides analytical results. In what follows, I describe the main conclusions of the analysis.

It is illustrative to separate the analysis between constrained and unconstrained firms. Constrained firms operate in sub-markets where the minimum wage binds for low-skill workers so they optimize low-

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skill vacancies and high-skill wages and vacancies taken low-skill wages as given. The effect of minimum wage changes on low-skill vacancy posting by constrained firms is ambiguous. There are two first-order effects that work in opposite directions. On one hand, an increase in the minimum wage induces a mechanical increase in labor costs, decreasing the expected value of posting a low-skill vacancy. On the other hand, if sub-market tightness decreases given the increase in applicants, job-filling probabilities increase. This mechanism increases the expected value of posting a low-skill vacancy.

Importantly, it is possible to have productivity dispersion across constrained firms: all firms whose unconstrained optimal low-skill wage is lower than $\overline{w}$ bunch at $\overline{w}$. Within the minimum wage sub-markets, the net effect on vacancies is more likely to be negative the lower the productivity. This implies that the least productive firms among the constrained group reduce their size after increases in the minimum wage, while the most productive firms within this group could have null or positive firm-specific employment effects. Standard envelope arguments imply that profits for all constrained firms decrease after minimum wage increases, regardless of the firm-specific employment effect. This in turn leads marginal firms to exit the market after increases in the minimum wage.

In the model, unconstrained firms also react by adapting their posted wages and vacancies to changes in their relevant sub-market tightness. While the analytical expression for the wage spillover is difficult to sign and interpret given the several effects that play a role in this reaction (see equation (A.IX)), it directly depends on the change in sub-market tightness and, therefore, it is non-zero provided the sub-market tightness of unconstrained firms change, something that is likely to happen given the analysis of equations (5) and (6). Moreover, since wages and vacancies are positively correlated at the firm and skill level, if wage spillovers are positive, then unconstrained firms also post more vacancies and, therefore, increase their size. Therefore, the model has potential to generate reallocation effects.

Relation to empirical literature One motivation for building a model of the labor market is to develop an optimal policy analysis that incorporates more realistic predictions after changes in the minimum wage. The purposely imposed tractability needed for the analysis of the next section puts limits on the ability of the model to fully rationalize labor market dynamics.[12] However, in what follows, I argue that the proposed framework is more suitable for analyzing minimum wage impacts relative to the frameworks used by the related literature.

One systematic finding of the empirical literature is that minimum wage hikes generate positive wage effects with limited –or elusive– disemployment effects (see Manning, 2021 for a recent review). This empirical fact is inconsistent with a perfectly competitive model of the labor market, and is difficult to rationalize with a random search framework since it requires an implausibly large labor force participation

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[12]For estimated structural models with richer levels of heterogeneity and flexibility that accurately match a comprehensive set of empirical effects of the minimum wage together with other labor market moments, see Haanwinckel (2020), Ahlfeldt et al. (2022), Berger et al. (2022b), Drechsel-Grau (2022), and Engbom and Moser (2022).

response that is at odds with the empirical literature (Cengiz et al., 2022).

The proposed framework can rationalize positive wage effects with limited employment and participation effects through the applications margin that follows from the directed search assumption. When the minimum wage increases, constrained firms face a mechanic increase in their labor costs. However, job applicants reallocate applications toward these jobs, increasing the expected value of posting vacancies for constrained firms. This *applications effect* attenuates the negative shock in labor costs, eventually preventing the firm from decreasing employment. The reorganization of applications within the mass of active workers can mediate this result when the size of the density at the margin of indifference is low enough to prevent important participation responses.

Two additional findings of the recent empirical literature is that minimum wage hikes (i) generate spillovers to non-minimum wage jobs in terms of wages and employment both within and between firms (Giupponi and Machin, 2018; Cengiz et al., 2019; Derenoncourt et al., 2021; Dustmann et al., 2022), and (ii) have negative effects on firm profits (Draca et al., 2011; Harasztosi and Lindner, 2019; Drucker et al., 2021). The model incorporates both sets of predictions. The same responses in applications that dampen the employment effects in low-skill labor markets generate spillovers in the model to both (i) firms that pay higher wages through changes in their sub-markets' tightness, and (ii) high-skill workers through technological restrictions dictated by the production function. In addition, the model features positive profits in equilibrium that decrease for constrained firms after minimum wage increases.

While these attributes represent an improvement relative to standard tractable frameworks like supply-demand and random search models, the model misses other relevant effects of the minimum wage, namely (i) the passthrough of minimum wage increases to output prices (MaCurdy, 2015; Allegretto and Reich, 2018; Harasztosi and Lindner, 2019; Renkin et al., 2020; Leung, 2021; Ashenfelter and Jurajda, 2022), and (ii) the effects of worker- and firm-level productivity (Riley and Bondibene, 2017; Mayneris et al., 2018; Coviello et al., 2021; Ruffini, 2021; Ku, 2022). Appendix A discusses these effects in more detail and argues that it is unlikely for them to play a central role in the optimal policy analysis developed in the next section.

3 Optimal Policy Analysis

This section characterizes optimal redistribution for a social planner with labor income taxes and transfers, corporate income taxes, and a minimum wage. The analysis is based on the labor market model presented in the previous section. I start abstracting from taxes to characterize the effects of the minimum wage on the relative welfare of low-skill workers, high-skill workers, and capitalists as a function of sufficient statistics for welfare and social prefereces for redistribution. I then include taxes to analyze the fiscal externalities of the minimum wage and explore other complementarities between the policies.

3.1 Social planner's problem

The notion of *optimal policy* refers to policy parameters that maximize a social welfare function subject to a government budget constraint. Following related literature (Kroft et al., 2020; Lavecchia, 2020; Hummel, 2021b), the social planner is assumed to be utilitarian and maximize the sum of expected utilities. I assume the social planner does not observe workers nor capitalists primitives (i.e., c nor ψ) and, therefore, constrains the policy choice to second-best incentive-compatible policy schemes.

The social welfare function is given by

$$
\begin{aligned}
SW(\overline{w}, T, t) \;=\; & \left(L_I^l + L_I^h + K_I \right) \cdot G(y_0) + \alpha_l \cdot \int_0^{U^l - y_0} G(U^l - c) dF_l(c) \\
& + \alpha_h \cdot \int_0^{U^h - y_0} G(U^h - c) dF_h(c) + K \cdot \int_{\psi^*}^{\overline{\psi}} G\left((1-t)\Pi(\psi) - \xi\right) dO(\psi),
\end{aligned}
\tag{7}
$$

where $(\overline{w}, T, t)$ are the policy paramters –the minimum wage, the (possibly non-linear) income tax schedule, and the flat corporate tax rate, respectively–, and G is an increasing and concave function that accounts for social preferences for redistribution. G plays the role of inducing curvature to the individual money-metric utilities thus allowing social gains from redistributing from high- to low-expected income individuals. The degree of concavity of G defines the social preferences for redistribution (see discussion below). The incentive compatibility constraints are implicit in the limits of integration since the planner internalizes that the policy parameters affect the equilibrium objects U^l, U^h, and ψ^*.

The first term in (7) accounts for the utility of inactive workers and inactive capitalists. Both get income equal to y_0. The second and third terms account for the expected utility of low- and high-skill workers that enter the labor market, also referred to as active workers. The average expected utility of active workers of skill s is $\int_0^{U^s - y_0} G(U^s - c) d\tilde{F}_s(c)$, where $\tilde{F}_s(c) = F_s(c)/F_s(U^s - y_0)$. Then, total expected utility is given by $L_A^s \cdot \int_0^{U^s - y_0} G(U^s - c) d\tilde{F}_s(c)$ which yields the expressions above noting that $L_A^s = \alpha_s \cdot F(U^s - y_0)$. Finally, the last term accounts for the utility of active capitalists. Their average utility is $\int_{\psi^*}^{\overline{\psi}} G((1-t)\Pi(\psi) - \xi) d\tilde{O}(\psi)$, with $\tilde{O}(\psi) = O(\psi)/(1 - O(\psi^*))$. Their total utility is therefore $K_A \cdot \int_{\psi^*}^{\overline{\psi}} G((1-t)\Pi(\psi) - \xi) d\tilde{O}(\psi)$, which yields the expression above noting that $K_A = K \cdot (1 - O(\psi^*))$.

Assuming no exogenous spending requirement, the planner's budget constraint is given by

$$
\begin{aligned}
\left(L_I^l + L_I^h + K_I + \rho^l \cdot L_A^l + \rho^h \cdot L_A^h \right) \cdot y_0 \;\leq\; & \int \left(E_m^l \cdot T(w_m^l) + E_m^h \cdot T(w_m^h) \right) dm \\
& + t \cdot K \cdot \int_{\psi^*}^{\overline{\psi}} \Pi(\psi) dO(\psi),
\end{aligned}
\tag{8}
$$

where $E_m^s = p_m^s \cdot L_m^s$ is the mass of employed workers of skill s in sub-market m and ρ^s is the skill-specific unemployment rate given by L_ρ^s / L_A^s, with $L_\rho^s = L_A^s - \int E_m^s dm$ the mass of workers that enter the labor force and are not matched with vacancies. The budget constraint establishes that the transfer paid to

inactive workers, unemployed workers, and inactive capitalists (left-hand-side), must be funded by the tax collection on employed workers and active capitalists (right-hand-side).

Understanding G To better understand the role of G, define the average social marginal welfare weights (SMWWs) of inactive workers, active workers of skill type s, and active capitalists of type ψ as

$$g_0 = \frac{G'(y_0)}{\gamma}, \qquad g_1^s = \frac{\alpha_s \cdot \int_0^{U^s - y_0} G'(U^s - c) dF_s(c)}{\gamma \cdot L_A^s}, \qquad g_\psi = \frac{G'((1 - t)\Pi(\psi) - \xi)}{\gamma}, \tag{9}$$

where $\gamma > 0$ is the social planner's budget constraint multiplier. Average SMWWs represent the social value of the marginal utility of consumption normalized by the social cost of raising funds, thus measuring the social marginal value of redistributing one dollar uniformly across a group of individuals. When SMWWs are above one, the planner benefits from redistributing toward that group since the gains in the social value of utility outweigh the distortions induced by the increase in revenues. That is, a given value of g_X indicates that the government is indifferent between g_X more dollars of public funds and 1 dollar of additional consumption of individuals of group X (Saez, 2001).

The utilitarian assumption used in equation (7) implies that the SMWWs are endogenous to final allocations (and, therefore, to the policy parameters) since social welfare only depends on concave transformations of individual money-metric utilities. Alternative formulations of the problem can generate different microfoundations for the SMWWs, for example, through exogenous Pareto weights or generalized SMWWs (Saez and Stantcheva, 2016). More generally, SMWWs are sufficient statistics for preferences for redistribution since their values inform the willingness to transfer incomes between different groups of individuals. I return to this when discussing the results of the optimal policy analysis.

Rationing assumptions Since the social planner is assumed to care about expected utilities, rationing assumptions conditional on entering the labor market do not affect the welfare analysis. That is, since all workers have equal ex-ante expected utilities, the allocation to jobs and unemployment does not condition the planner's problem. By contrast, rationing assumptions are central in optimal policy analyses based on competitive labor markets, a characteristic that can be considered restrictive.[13] As discussed in Section 2, this would not be the case if additional layers of worker-level heterogeneity induce particular sorting patterns that imply that some groups –for example teens– are more likely to work at low-wage firms or to be unemployed. This can affect the analysis since the presence of winners and losers within skill-group may distort the assessment of the distributional effects of the minimum wage increases (Hurst et al., 2022). I return to this question in Section 4 when testing for heterogeneities in the empirical estimation of the worker-level sufficient statistics.

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[13] For example, G. Mankiw's reading of Lee and Saez (2012) results is: "Rather than providing a justification for minimum wages, the paper seems to do just the opposite. It shows that you need implausibly strong assumptions, such as efficient rationing, to make the case." See http://gregmankiw.blogspot.com/2013/09/some-observations-on-minimum-wages.html.

3.2 Case with no taxes

I now analyze the redistributive properties of the minimum wage using the welfare-based framework described above. I start abstracting from the tax system to isolate the effects on the relative tradeoff between low-skill workers, high-skill workers, and capitalists. Taxes and transfers are introduced to the analysis in the next subsection.

PROPOSITION I: *In the absence of taxes, increasing the minimum wage is welfare improving if*

$$\frac{dU^l}{d\overline{w}} \cdot L_A^l \cdot g_1^l + \frac{dU^h}{d\overline{w}} \cdot L_A^h \cdot g_1^h + K \cdot \int_{\psi^*}^{\overline{\psi}} g_\psi \frac{d\Pi(\psi)}{d\overline{w}} dO(\psi) \quad > \quad 0. \tag{10}$$

Proof: See Appendix B.

Proposition I shows that a small increase of the minimum wage affects the relative welfare of active low-skill workers (first term), active high-skill workers (second term), and active capitalists (third term). While changes in U^s and ψ^* after minimum wage hikes also affect extensive margin decisions, those margins do not induce first-order welfare effects because marginal workers and capitalists are initially indifferent between states. Depending on the change in utility for the different groups ($dU^s/d\overline{w}$ and $d\Pi(\psi)/d\overline{w}$), the social value of those changes (g_1^s and g_ψ), and the size of the groups (L_A^s and $K \cdot o(\psi)$), increasing the minimum wage may be desirable or not for the social planner.

The proposition explicitly incorporates profits to the distributional discussion. Previous optimal policy analyses with minimum wages, taxes, and transfers abstract from profits, thus only considering welfare tradeoffs between workers (Hungerbühler and Lehmann, 2009; Lee and Saez, 2012; Cahuc and Laroque, 2014; Lavecchia, 2020). Giving a role to profits allows the minimum wage to redistribute from capitalists to workers on top of its effects on the labor income distribution.

Welfare weights To better understand why the framework emphasizes the distributional consequences of the minimum wage, consider a situation where $g_1^l = g_1^h = g_\psi = 1$, for all ψ. In that case, equation (10) reduces the welfare question to assessing changes in total output. The efficiency properties of the labor market model proposed in Section 2 imply that equation (10) should never hold when SMWWs are set to 1 for everyone. The analysis is different when SMWWs are not 1 for everyone. Total output could decrease after minimum wage increases, but if the gains for winners are more socially valuable than the losses for losers, then increasing the minimum wage can be welfare-improving. For example, if the social planner does not care about the utility of capitalists and high-skill workers, there could be scope to increase the minimum wage if the utility of low-skill workers increases after the policy change.

How to define the value of the SMWWs? The utilitarian assumption implies that SMWWs are endogenous to final allocations, so they are inversely proportional to after-tax incomes.[14] How steep

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[14]Equation (7) builds on the assumption that the only income capitalists receive are their unique firm's profits. However,

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is the relationship will depend on the concavity of G. Alternatively, equation (10) could be derived using a local perturbation approach to avoid the utilitarian microfoundation and impose exogenous social valuation criteria (Saez and Stantcheva, 2016).

While developing a general normative theory of SMWWs in the context of the minimum wage policy is beyond the scope of this paper, what is important to internalize is that SMWWs are sufficient statistics for preferences for redistribution. When empirically assessing equation (10), imputing numbers to g_1^l, g_1^h, and g_ψ according to a desired normative criteria will help to assess whether increasing the minimum wage can have positive effects on aggregate welfare given its redistributive consequences.

Sufficient statistics Given values for the SMWWs, if the sizes of the groups are observed, the missing piece for taking equation (10) to the data is to have empirical estimates of $dU^s/d\overline{w}$ and $d\Pi(\psi)/d\overline{w}$. Reduced-form estimates of these elasticities would allow the quantitative assessment of Proposition I without needing to impose structural restrictions on the primitives of the model of the labor market. That is, empirical counterparts of $dU^s/d\overline{w}$ and $d\Pi(\psi)/d\overline{w}$ work as sufficient statistics (Chetty, 2009; Kleven, 2021) for assessing the welfare implications of minimum wage changes.

Profits are in principle observable so it is feasible to have reduced-form estimates of $d\Pi(\psi)/d\overline{w}$. Regarding U^s, recall that, in the absence of taxes, $U^s = p_m w_m$. Multiplying both sides by the sub-market mass of applicants, L_m^s, and integrating over m, gives

$$U^s = \frac{\int E_m^s w_m^s dm}{L_A^s} = (1 - \rho^s) \int \nu_m^s w_m^s dm + \rho^s \cdot 0, \tag{11}$$

where ρ^s is the skill-specific unemployment rate and $\nu_m^s = E_m^s / \int E_m^s dm$ are employment-based weights. This implies that U^s is equal to the average wage of active workers including the unemployed. In the case with taxes, U^s is equal to the average post-tax wage of active workers including the unemployed, which means that $dU^s/d\overline{w}$ is equal to the change in the average pre-tax wage of active workers including the unemployed net of the change in their average tax liabilities.[15] In both cases, U^s can be computed using

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in the real world capitalists may receive income from several firms and income sources. This implies that the social welfare function is likely to overestimate capitalists' SMWWs given the concavity of G. Since results are based on reduced-form profit elasticities, average SMWWs can be adjusted to incorporate information about the owners of the affected firms.

[15]Recall that, in the case with taxes, $U^s = p_m^s y_m^s + (1 - p_m^s)y_0$. Multiplying both sides by the sub-market mass of applicants, L_m^s, and integrating over m, gives

$$U^s = \frac{\int E_m^s (w_m^s - T(w_m^s) - y_0)dm}{L_A^s} + y_0 = \frac{\int E_m^s w_m^s dm}{L_A^s} - \frac{\int E_m^s (T(w_m^s) + y_0)dm}{L_A^s} + y_0, \tag{12}$$

where $E_m^s = p_m^s \cdot L_m^s$. If the tax schedule is constant, then

$$\frac{dU^s}{d\overline{w}} = \frac{d}{d\overline{w}} \left(\frac{\int E_m^s w_m^s dm}{L_A^s} \right) - \frac{d}{d\overline{w}} \left(\frac{\int E_m^s (T(w_m^s) + y_0)dm}{L_A^s} \right). \tag{13}$$

The first term represents the change in the average pre-tax wage among active workers (see equation (11)). The second term represents the change in average tax liabilities net of transfers among active workers.

data on wages, tax liabilities, employment and participation rates. Then, these reduced-form elasticities can be estimated to quantitatively assess equation (10). Section 4 makes progress in this regard.

Two things are worth discussing about the sufficient statistic for workers, $dU^s/d\overline{w}$. First, it captures all the general equilibrium effects of the minimum wage that affect workers' utility, including effects on wages, employment, and participation. There is an unsettled discussion in the public debate about the appropriate way of weighting these different effects. The framework proposed by this paper offers a model-based avenue for aggregating them in a single elasticity. Interestingly, while the sign of $dU^s/d\overline{w}$ is in principle ambiguous, it is not completely determined by the sign of the employment effects. Appendix A shows that this framework allows to compute the disemployment effects that can be tolerated for the minimum wage to increase average workers' welfare given positive wage effects. If employment and wage effects are positive, welfare effects on workers are, not surprisingly, unambiguously positive.

Second, the result in equation (11) relies on the risk-neutrality assumption made in Section 2. If workers have concave flow utilities of after-tax wages, then Proposition I remains true but the empirical counterpart of U^s is not longer the average wage among active workers including the unemployed and, moreover, cannot be estimated without further assumptions on the workers' flow utility function. This is a conceptually important limitation, since job-losses could outweight, in a utility sense, actuarially fair wage increases. One way to assess the concerns of using the risk-neutral sufficient statistic is to decompose the empirical estimate across the different margins. If changes in employment are negligible relative to changes in wages, then the risk-neutrality assumption should not have first-order effects on the interpretation of the estimated elasticities. I come back to this discussion in Section 4.

Heterogeneous minimum wages Sometimes, national minimum wages coexists with industry- or region-specific minimum wages (e.g., Cengiz et al., 2019; Derenoncourt et al., 2021; Card and Cardoso, 2022). Proposition I provides a first-order approximation to understand the rationale of such heterogeneous minimum wage schemes: if, for example, the tradeoff depicted in equation (10) varies across regions because they have different fundamentals, then the optimal minimum wage across regions is likely to be heterogeneous. The understanding of this question, however, is incomplete in the proposed framework because heterogeneous minimum wages may induce additional behavioral responses, such as migration responses (e.g., Ahlfeldt et al., 2018, 2022; Monras, 2019; Pérez, 2022) that are not incorporated in the model. For a formal normative analysis that integrates migration responses, see Simon and Wilson (2021).

3.3 Case with taxes

The case without taxes is useful for understanding the direct welfare effects of the minimum wage. However, the absence of taxes makes the analysis so far incomplete. Changes in labor market outcomes and profits affect tax collection and transfer spending. These fiscal externalities (and other potential

interactions between the policies) matter for assessing whether increasing the minimum wage is desirable.

Fixed taxes   I first consider a case with fixed taxes, that is, a case where the social planner takes $T(\cdot)$ and t as given, sets y_0 to mechanically balance the budget constraint, and chooses $\overline{w}$ to maximize social welfare. This case is useful to understand the mechanic interactions between the minimum wage and the tax system and, in cases where political and other unmodeled constraints restrict the scope for tax reforms, this case may be the policy-relevant scenario for assessing the total welfare effects of marginal minimum wage increases.

PROPOSITION II: *If taxes are fixed, increasing the minimum wage is welfare improving if*

$$
\begin{aligned}
\frac{dU^l}{d\overline{w}} \cdot L_A^l \cdot g_1^l &+ \frac{dU^h}{d\overline{w}} \cdot L_A^h \cdot g_1^h + K \cdot (1-t) \cdot \int_{\psi^*}^{\overline{\psi}} g_\psi \frac{d\Pi(\psi)}{d\overline{w}} dO(\psi) \\
&+ \int \left(\frac{dE_m^l}{d\overline{w}} \left(T(w_m^l) + y_0 \right) + E_m^l T'(w_m^l) \frac{dw_m^l}{d\overline{w}} \right) dm \\
&+ \int \left(\frac{dE_m^h}{d\overline{w}} \left(T(w_m^h) + y_0 \right) + E_m^h T'(w_m^h) \frac{dw_m^h}{d\overline{w}} \right) dm \\
&+ t \cdot K \cdot \int_{\psi^*}^{\overline{\psi}} \frac{d\Pi(\psi)}{d\overline{w}} dO(\psi) - \frac{dK_I}{d\overline{w}} \cdot (t \cdot \Pi(\psi^*) + y_0) \quad > \quad 0.
\end{aligned}
\tag{14}
$$

Proof: See Appendix B.

The first line of Proposition II reproduces the same welfare tradeoff described in Proposition I, with the subtlety that taxes and transfers affect the levels of after-tax income and, therefore, the SMWWs. The second to fourth lines summarize the fiscal externalities on both sides of the market. The sign and magnitude of these fiscal externalities matter for the overall assessment of the minimum wage desirability since they either relax or restrict the budget constraint of the social planner, consequently relaxing or restricting the redistribution already done by the existing tax system.

The second line describes the fiscal externalities on low-skill labor markets. The first term shows that, if low-skill employment increases, the government increases tax collection, $T(w_m^l)$, and saves in transfers paid to unemployed individuals, y_0. The opposite happens when employment decreases: the government forgoes tax collection and pays additional transfers to non-employed workers. The second term shows that if the wages of employed workers change, income tax collection changes according to the shape of the income tax schedule, $T'(w_m^l)$. The third line represents the same effects but for high-skill labor markets.

While fiscal externalities at the worker-level have been discussed in the minimum wage literature (e.g., Reich and West, 2015; Dube, 2019), fiscal externalities on the capitalists' side have been absent from the discussion. The fourth line characterizes these fiscal externalities. The first term shows that changes in profits affect the corporate tax revenue. If profits decrease, the social planner collects less revenue. The second term shows that firms that exit the market also generate a negative fiscal externality since they

switch from paying taxes to receiving a transfer. Note that both effects are increasing in the corporate tax rate: the larger t, the larger the revenue loss produced by smaller profits and extensive margin responses.

Firm-level fiscal externalities seem particularly relevant in the current state of international tax competition. International tax competition posits substantial challenges to the establishment and enforcement of high effective corporate tax rates, especially in developed countries (Keen and Konrad, 2013; Clausing et al., 2021; Devereux et al., 2021; Bachas et al., 2022; Johannesen, 2022). If corporate taxes are low, then the rationale for using the minimum wage to redistribute from capital to labor becomes stronger. International tax competition is not explicitly modeled in the proposed framework, so it is fair to question whether higher minimum wages could generate a similar impact on international capital flows. Minimum wage workers are usually concentrated in labor-intensive immobile industries such as non-professional services (Cengiz et al., 2019; Harasztosi and Lindner, 2019). The empirical evidence provided in Section 4 is consistent with this observation. By contrast, international tax competition is usually thought to be triggered by the behavior of tradable capital-intensive industries such as manufacturing. The scope for an international minimum wage competition, then, seems limited.

Optimal taxes The previous analysis illustrates the mechanical interaction between the minimum wage and the tax schedule but does not answer if both policies are desirable at the joint optimum. It is not ex-ante clear whether the redistributive consequences of the minimum wage can be reproduced more efficiently by non-linear income tax schedules or if both policies can complement each other to make redistribution more efficient. The following proposition explores the desirability of the minimum wage when the social planner jointly optimizes the tax system and the minimum wage.

PROPOSITION III: *If taxes are optimal, increasing the minimum wage is welfare improving if*

$$
\begin{aligned}
\frac{\partial U^l}{\partial \overline{w}} \cdot L_A^l \cdot g_1^l + \frac{\partial U^h}{\partial \overline{w}} \cdot L_A^h \cdot g_1^h + K \cdot (1-t) \cdot \int_{\psi^*}^{\overline{\psi}} g_\psi \frac{\partial \Pi(\psi)}{\partial \overline{w}} dO(\psi) \\
+ \int \left(\frac{\partial E_m^l}{\partial \overline{w}} \left(T(w_m^l) + y_0 \right) + E_m^l \frac{\partial w_m^l}{\partial \overline{w}} \right) dm \\
+ \int \left(\frac{\partial E_m^h}{\partial \overline{w}} \left(T(w_m^h) + y_0 \right) + E_m^h \frac{\partial w_m^h}{\partial \overline{w}} \right) dm \\
+ t \cdot K \cdot \int_{\psi^*}^{\overline{\psi}} \frac{\partial \Pi(\psi)}{\partial \overline{w}} dO(\psi) - \frac{\partial K_I}{\partial \overline{w}} \cdot (t \cdot \Pi(\psi^*) + y_0) \quad > 0 \quad .
\end{aligned}
\tag{15}
$$

Proof: See Appendix B.

At a high-level, Proposition III reproduces the same intuition than Proposition II: the desirability of the minimum wage for redistributive purposes depends on both the effects on the relative welfare of low-skill workers, high-skill workers, and capitalists, and on the fiscal externalities generated on labor markets and profits. However, when taxes are optimized together with the minimum wage, the way in

which the minimum wage affects welfare and generate fiscal effects changes.

This is reflected in two important differences between Proposition II and Proposition III. First, all relevant elasticities are *micro* rather than *macro* elasticities (Landais et al., 2018b,a; Kroft et al., 2020; Lavecchia, 2020). I use partial rather than total derivatives to represent this difference. Macro elasticities (present in Propositions I and II) internalize all general equilibrium effects of the minimum wage, while micro elasticities (present in Proposition III) mute some of these effects by keeping after-tax allocations constant. To see why, recall that $U^s = p_m^s y_m^s + (1 - p_m^s) y_0 \equiv p_m^s \cdot \Delta y_m^s + y_0$. Taxes being optimal imply that Δy_m^s and y_0 are fixed when choosing the optimal minimum wage, so the minimum wage directly affects workers' welfare only through changes in p_m^s. Then, under optimal taxes, changes in pre-tax wages do not trigger mechanic changes in application strategies and, therefore, the labor market equilibrium effects of the minimum wage are only driven by changes in vacancy posting as a response to the increase in labor costs, which ultimately make the welfare effects proportional to potential employment effects.[16] This implies that the direct welfare effects of the minimum wage on workers are both more likely to be negative, but also potentially smaller in absolute terms, formalizing the intuition that tax-based redistribution is more efficient when flexible non-linear schedules are available to the policymaker. This force reduces the attractiveness of the minimum wage as a redistributive policy echoing the arguments developed in Cahuc and Laroque (2014), Neumark (2016), and Hurst et al. (2022).

Second, the fiscal externalities are also affected by optimal taxes. Concretely, since after-tax allocations are fixed by the optimal tax schedule, changes in wages due to the minimum wage affect within-firm redistribution. This is captured by the term $E_m^s \cdot (\partial w_m^s / \partial \overline{w})$: there are fiscal gains from wage increases because they switch the burden of redistribution from the government to firms and, therefore, relax the social planner's budget constraint.[17] While wage spillovers are less likely to be quantitatively relevant given the argument developed above, for minimum wage sub-markets we have that $\partial w_m^l / \partial \overline{w} = 1$, so the fiscal gain is equivalent to the mass of low-skill workers earning the minimum wage. To develop intuition, consider the case of the EITC. Firms internalize that the EITC increases job applications for a given posted wage, so they optimally react by lowering pre-tax wages (Rothstein, 2010). In this setting, the EITC becomes both a transfer to workers and firms. The minimum wage puts a floor to this response and, therefore, increases the efficacy of the EITC to redistribute toward low-skill workers. This argument

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[16]To see why, if $U^s = p_m^s \cdot \Delta y_m^s + y_0$, multiplying L_m^s on both sides and integrating over m yields $(U^s - y_0) \cdot L_A^s = \int E_m^s \cdot \Delta y_m^s dm$. Then

$$\frac{\partial U^s}{\partial \overline{w}} \cdot (L_A^s + (U^s - y_0) f^s (U^s - y_0)) \quad = \quad \int \frac{\partial E_m^s}{\partial \overline{w}} \Delta y_m^s dm. \tag{16}$$

[17]Firm-level heterogeneity and entry distortions impede t to fully redistribute from capitalists to workers. The average welfare weight for capitalists is below 1 at the optimal corporate tax rate (see Appendix A). Part of this result relies on the corporate tax rate being flat. Extending to non-linear frameworks may induce additional welfare gains from using the tax system relative the minimum wage. For example, Saez and Zucman (2021) propose non-linear payroll taxes to mimic minimum wages. Non-linear corporate taxes, however, are not common practice and may induce additional behavioral responses that affect the efficiency of the tax system (e.g., Bachas and Soto, 2020).

formalizes the complementarity intuition developed in OECD (2009).

The bottom line of Proposition III is that binding minimum wages may be desirable even when taxes are optimal, although it is ultimately a quantitative question. On one hand, potential employment losses driven by increases in minimum wages when some of the equilibrium effects are muted by the tax schedule support the first argument against binding minimum wages. The value of these micro elasticities is an empirical question that, unfortunately, is difficult to assess given the required exogenous variation (changes in minimum wages keeping fixed the after-tax allocations). On the other hand, the mass of workers earning exactly the minimum wage, which has been shown to be non-negligible (Cengiz et al., 2019), supports the second argument in favor of the minimum wage. The relative importance of these two competing forces determines whether minimum wages can be desirable on top of optimal taxes.

Missing pieces Before concluding the theoretical analysis, I briefly discuss two missing pieces that may affect the optimal policy analysis whose formal treatment is beyond the scope of this paper.

On the positive side, the theoretical attractiveness of the income tax system for redistributive purposes relies on its flexibility (given its unrestricted non-linearity) and its perfect enforcement. In the real world, income tax schedules are usually not fully non-linear (e.g., they follow a bracket structure) and, more importantly, are not perfectly enforced and costly to administrate. Taxes can be avoided or evaded (e.g., Andreoni et al., 1998; Slemrod and Yitzhaki, 2002; Kleven et al., 2011; Pomeranz, 2015; Guyton et al., 2021) and the take up of benefits at the bottom of the distribution can be far from perfect (e.g., Currie, 2006; Kopczuk and Pop-Eleches, 2007; Chetty et al., 2013; Bhargava and Manoli, 2015; Guyton et al., 2017; Goldin, 2018; Cranor et al., 2019; Finkelstein and Notowidigdo, 2019; Linos et al., 2021). These frictions put limits to the redistributive ability of the tax system. In addition, abstracting from tax evasion rules out additional complementarities between the minimum wage and the tax system. For example, if workers under report their incomes, then the minimum wage can increase tax collection by setting a floor on reported labor income (Bíró et al., 2021; Feinmann et al., 2022).

On the normative side, note that the minimum wage affects the distribution before taxes and transfers while the tax system corrects pre-tax values to generate the after-tax distribution.[18] The model assumes that the social value of after-tax wages does not depend on its decomposition between pre-tax wages and taxes and transfers. However, recent literature finds that changes in the distribution before taxes and transfers seem to be the relevant force behind long-run decreases in inequality, supporting redistributive policies that affect the *pre-distribution* (Bozio et al., 2020; Blanchet et al., 2021). This seems consistent with people's preferences. For example, McCall (2013) provides survey evidence that suggest that the US public care about inequality and redistribution, but prefer policies that address inequality within the firm rather than with taxes and transfers. This is consistent with the results of state-level ballot initiatives

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[18]This claim is true only to a first-approximation since changes in taxes can also affect the pre-tax income distribution (Alvaredo et al., 2013; Roine et al., 2009; Piketty et al., 2014; Vergara, 2022).

which have systematically approved to increase the minimum wage and rejected to increase top marginal income tax rates, in both Democratic and Republican states (Saez, 2021). Such social preferences could be incorporated by generalizing the SMWWs (Saez and Stantcheva, 2016).

4   Sufficient Statistics Estimation

Section 3 derives conditions under which the minimum wage is desirable for redistribution. These conditions depend on the welfare impacts of minimum wage changes on low-skill workers, high-skill workers, and capitalists, which are summarized by sufficient statistics. This section exploits US state-level variation in minimum wages to estimate these sufficient statistics using publicly available data. I estimate the macro-version of the sufficient statistics, that is, the version that considers all general equilibrium effects of minimum wage changes, so results can be used to quantitatively assess Proposition II.[19]

4.1   Empirical strategy

The empirical strategy exploits state-level variation in minimum wages to estimate stacked event studies.

Events   I follow Cengiz et al. (2019, 2022) strategy to define state-level events. Using data from Vaghul and Zipperer (2016) for the 1979-2019 period, the state-by-year minimum wage is defined as the maximum between the statutory values of the federal and state minimum wages throughout the calendar year. Nominal values are transformed to 2016 dollars using the R-CPI-U-RS index including all items. An event is defined as a state-level hourly minimum wage increase above the federal minimum wage of at least \$0.25 (in 2016 dollars) in a state with at least 2% of the employed population affected, where the affected population is computed using the NBER Merged Outgoing Rotation Group of the CPS (henceforth, CPS-MORG).[20] These restrictions are imposed to focus on minimum wage increases that are likely to have effects on the labor market. Binding federal minimum wage increases are not recorded as state-level events, however, regressions control for small state-level and federal minimum wage increases.

Figure 1 shows the distribution of events across time. Panel (a) plots the distribution of the 172 annual state-level minimum wage increases that can be identified as events in the Vaghul and Zipperer (2016) data using Cengiz et al. (2019, 2022) strategy. As I discuss below, for ensuring balance and avoid confounding pre-trends with multiple treatments, the preferred specification uses a selected sample of 72 events, whose distribution is plotted in Panel (b). These are events where treated states do not experience other events in the three years previous to the event and whose timing allow to observe the outcomes from

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[19]Estimating micro elasticities requires a cleanly identified natural experiment where minimum wages vary and after-tax allocations are fixed constant, an exercise that cannot be implemented with the data and variation used in this paper.

[20]This is done by computing employment counts by wage bins and checking whether, on average, the previous year share of workers with wages below the new minimum wage is above 2%.

Figure 1: State-level events by year

(a) All events   (b) Selected events
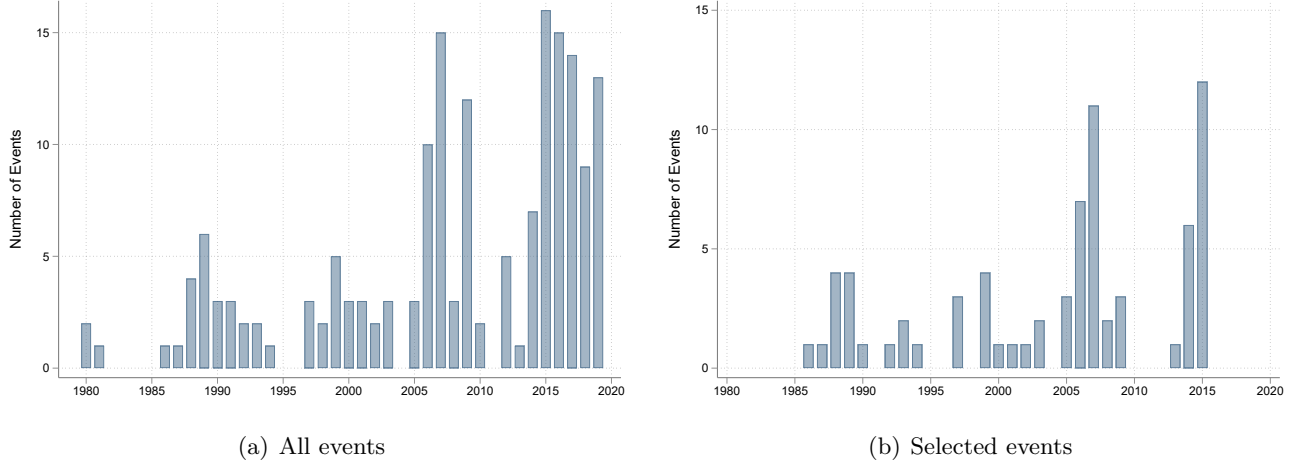
Notes: This figure plots the annual frequency of state-level minimum wage increases classified as events following Cengiz et al. (2019, 2022). Data on minimum wages is taken from Vaghul and Zipperer (2016). A state-level hourly minimum wage increase above the federal level is classified as an event if the increase is of at least $0.25 (in 2016 dollars) in a state with at least 2% of the working population affected, where the affected population is computed using the NBER Merged Outgoing Rotation Group of the CPS. Panel (a) considers all 172 events. Panel (b) considers a selected sample of 72 events where treated states do not experience other events in the three years previous to the event and whose timing allow to observe the outcomes from three years before to four years after.

three years before to four years after. Both figures show that state-level minimum wage increases have become more frequent in recent years. Table C.I of Appendix C display the list of the considered events with their corresponding treated states and years. Figure C.I of Appendix C shows that, on average, events represent state-level real hourly minimum wage increases of between 10% and 15%.

Estimating equation Estimating event studies in this setting is challenging because of two reasons. First, events do not induce an absorbing status. That is, states may increase their minimum wages several times throughout the period considered. Second, treatment effect heterogeneity may induce bias when treatment adoption is staggered (de Chaisemartin and D'Haultfœuille, 2022; Roth et al., 2022).

To deal with both issues, I implement a stacked event study (Cengiz et al., 2019, 2022; Gardner, 2021; Baker et al., 2022) as follows. For each event, I define a time window that goes from 3 years before the event to 4 years after. Then, all states that do not experience events in the event-specific time-window define an event-specific control group. This, in turn, defines an event-specific dataset. Finally, all event-specific datasets are appended and used to estimate a standard event study with event-specific fixed effects. This leads to the following estimating equation:

$$\log Y_{ite} = \sum_{\tau=-3}^{4} \beta_\tau D_{ite}^\tau + \alpha_{ie} + \gamma_{te} + \rho_{ite} + \epsilon_{ite}, \tag{17}$$

where i, t, and e index state, year, and event, respectively, Y_{ite} is an outcome of interest (see next subsection), D_{ite}^τ are event indicators with τ the distance from the event (in years), α_{ie} are state-by-event

fixed effects, γ_{te} are year-by-event fixed effects, and ρ_{iqe} are state-by-year-by-event varying controls that include small state-level minimum wage increases and binding federal minimum wage increases.[21] I also consider specifications where the year-by-event fixed effects are allowed to vary across census regions or census divisions. β_{-1} is normalized to 0. To allow for correlation within states across events, standard errors are clustered at the state level. Regressions are weighted by state-by-year average total population, computed using the monthly CPS files.

I also consider non-saturated differences-in-differences regressions:

$$\log Y_{ite}^s = \beta T_{ie} \text{Post}_{te} + \alpha_{ie} + \gamma_{te} + \rho_{ite} + \epsilon_{ite}, \tag{18}$$

where T_{ie} is an indicator variable that takes value 1 if state i is treated in event e, Post_{te} is an indicator variable that takes value 1 if year t is larger or equal than the treatment year in event e, and all other variables are defined as in equation (17). The coefficient of interest is β, which captures the average treatment effect in the post-event years (from $\tau = 0$ to $\tau = 4$).

I estimate the stacked event studies using both the full sample of events –which maximizes sample size and statistical power– and the selected sample of events –which ensures that events are balanced and do not confound pre-trends with multiple treatments (the preferred specification).

4.2 Data

Outcomes of interest consist on state-level aggregates computed using publicly available data.

Workers The sufficient statistic that summarizes changes in active workers' welfare driven by minimum wage changes is $dU^s/d\overline{w}$, for $s \in \{l, h\}$. Equations (11) and (13) show that, under the assumptions of the model, $dU^s/d\overline{w}$ equals the change in the average post-tax wage of active workers of skill s including the unemployed, which can be decomposed into changes in the average pre-tax wage of active workers including the unemployed and changes in the average net tax liability of active workers.

I use the CPS-MORG data for the period 1979-2019 to compute average pre-tax hourly wages and employment and participation rates at the state-by-year-by-skill level. Low-skill (high-skill) workers are defined as not having (having) a college degree. Cengiz et al. (2019) show that in the CPS-MORG data minimum wages are correlated with negative employment changes at the very top of the wage distribution. Then, to avoid distorting low-skill workers' statistics with this abnormal behavior at the top of the wage distribution, I restrict the low-skill workers sample to workers that are either out of the labor force,

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[21]Following Cengiz et al. (2019, 2022), controls for small state-level and binding federal minimum wage increases are included as follows. Let $\hat{t}$ be the year in which the small state-level or binding federal minimum wage increase takes place. Then, define $Early_t = 1\{t \in \{\hat{t}-3, \hat{t}-2\}\}$, $Pre_t = 1\{t = \hat{t}-1\}$ and $Post_t = 1\{t \in \{\hat{t}, \hat{t}+1, \hat{t}+2, \hat{t}+3, \hat{t}+4\}\}$, and let $Small_i$ and Fed_i be indicators of states that face small state-level and binding federal minimum wage increases, respectively. Then ρ_{ite} includes all the interactions between $\{Early_t, Pre_t, Post_t\} \times \{Small_i, Fed_i\}$ for each event separately.

unemployed, or in the bottom half of the wage distribution when employed.

In the CPS-MORG data, hourly wages are either directly reported or can be indirectly computed by dividing reported weekly earnings by weekly hours worked. I drop self-employed individuals and compute average wages (including zeros for the unemployed) across individuals that are in the labor force by state and year. Nominal wages are transformed to 2016 dollars using the R-CPI-U-RS index including all items. Observations whose hourly wage is computed using imputed data (on wages, earnings, and/or hours) are excluded to minimize the scope for measurement error. Since imputation flags are unreliable for years 1994 and 1995, those years are excluded from the analysis on worker-level outcomes.

One limitation of the CPS-MORG data is the lack of information on taxes and transfers. To deal with this, I consider data on income maintenance benefits taken from the BEA regional accounts to proxy the net tax liabilities at the bottom of the distribution. BEA data is available from 1979 to 2019. Regressions using income maintenance benefits as dependent variable allow to both adjust worker-level regressions from pre- to post-tax values and to directly estimate fiscal externalities on labor market outcomes.[22]

Capitalists The sufficient statistic that summarizes changes in active capitalists' welfare driven by minimum wage changes is the change in firm profits, $d\Pi(\psi)/d\overline{w}$, for $\psi \in [\psi^*, \overline{\psi}]$.

Absent firm-level microdata, I compute a measure of average profits per firm by state and year. I use the Gross Operating Surplus (GOS) estimates from the BEA regional accounts as a proxy of state-level aggregate profits and divide them by the average number of private establishments reported in the QCEW data files.[23] Nominal profits are transformed to 2016 dollars using the R-CPI-U-RS index including all items. Aggregate data is available for the period 1979-2019. I also use industry-level data available for the period 1990-2019.[24]

Descriptive statistics Table 1 shows descriptive statistics for the non-stacked panel. The total number of observations is 2,091 (51 states times 41 years). Worker-level aggregates exclude years 1994 and 1995 because of the imputation step. All monetary values are annual and in 2016 dollars.[25] Average pre-tax

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[22]The BEA definition of income maintenance benefits is as follows: "Income maintenance benefits consists largely of Supplemental Security Income (SSI) benefits, Earned Income Tax Credit (EITC), Additional Child Tax Credit, Supplemental Nutrition Assistance Program (SNAP) benefits, family assistance, and other income maintenance benefits, including general assistance." This fiscal externality does not include changes in tax collection from high-skill workers. However, as shown below, minimum wage changes have zero effects on high-skill workers pre-tax outcomes, so the consequent fiscal externalities are expected to be negligible as well.

[23]The BEA definition of gross operating surplus is as follows: "Value derived as a residual for most industries after subtracting total intermediate inputs, compensation of employees, and taxes on production and imports less subsidies from total industry output. Gross operating surplus includes consumption of fixed capital (CFC), proprietors' income, corporate profits, and business current transfer payments (net)."

[24]QCEW data at the industry level is only available since 1990. Before 1997, BEA regional accounts classified industries using SIC. In 1997, the classification switched to NAIC. QCEW files use NAIC codes for the whole period. Below, I focus on broad industry categories for making both periods comparable.

[25]While the theoretical and empirical analysis on workers' outcomes is based on average hourly wages, I annualize these values by multiplying them by 52 weeks and the average number of hours worked by skill-group. I below show that weekly

Table 1: Descriptive statistics

|	Obs.	Mean	Std. Dev.	Min	Max
Low-skill workers:					
U^l (annualized)	1,989	15,970.13	1,618.12	10,779.71	21,370.79
Hourly wage	1,989	10.93	0.82	8.90	13.82
Weekly hours worked	1,989	33.34	1.79	27.20	37.97
Employment rate	1,989	0.84	0.06	0.53	0.96
Participation rate	1,989	0.43	0.06	0.25	0.58
High-skill workers:					
U^h (annualized)	1,989	56,222.77	8,425.01	36,323.96	87,326.46
Hourly wage	1,989	27.82	4.31	18.17	43.09
Weekly hours worked	1,989	40.46	0.98	36.97	43.49
Employment rate	1,989	0.96	0.02	0.88	0.99
Participation rate	1,989	0.71	0.07	0.46	0.87
Income maintenance benefits (per working-age individual)	2,091	875.63	356.68	179.21	2194.19
Profit per establishment (all industries - 1979-2019)	2,091	608,633.96	187,452.85	268,542.94	2,353,092.25
Profit per establishment (all industries - 1990-2019)	1,530	630,079.43	167,494.19	276,057.06	1,596,039.00
Profit per establishment (non-professional services - 1990-2019)	1,524	154,271.48	66,641.84	62,175.63	575,952.75
Profit per establishment (finance - 1990-2019)	1,530	2,035,570.80	1,185060.30	430,362.66	9,804,113.00

Notes: This table shows descriptive statistics for the non-stacked panel. The unit of observation is a state-year pair. Nominal values are transformed to 2016 dollars using the R-CPI-U-RS index including all items. U^l and U^h are the average pre-tax wage including the unemployed annualized by computing Hourly Wage × Weekly Hours × Employment Rate × 52. Worker-level aggregates are computed using the CPS-MORG data. Income maintenance benefits are taken from the BEA regional accounts. Profit per establishment corresponds to the gross operating surplus taken from the BEA regional accounts normalized by the number of private establishments reported in the QCEW data. Non-professional services include educational services, health care, arts, entertainment, recreation, accomodation, and food services. Finance includes finance, insurance, real estate, rental, and leasing.

incomes (accounting for the unemployed) are more than 3 times larger for high-skill workers relative to low-skill workers. This is explained by higher hourly wages and weekly hours conditional on employment, and higher employment rates. The average sum of income maintenance benefits per working-age individual is 875 dollars, which represents around 5% of low-skill workers pre-tax income. The average pre-tax profit per establishment is around 12 times larger than the average pre-tax high-skill worker income including the unemployed. However, there is wide heterogeneity by industry. For example, the average pre-tax profit per establishment in non-professional services is around 3 times larger than the average pre-tax high-skill worker income including the unemployed. For finance, the factor increases to more than 35.

4.3 Results

Workers Figure 2 plots the estimated coefficients $\{\beta_\tau\}_{\tau=-3}^{4}$ of equation (17) with their corresponding 90% confidence intervals using the average pre-tax hourly wage of active low-skill workers including the unemployed, the average pre-tax hourly wage of active high-skill workers including the unemployed, and income maintenance benefits (both per working-age population and total) as dependent variables. These figures plot results using the preferred selected sample of 72 events. Results with the complete sample of

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hours worked conditional on employment are not affected by minimum wage changes.

Figure 2: Changes in workers' welfare after minimum wage increases (selected events)
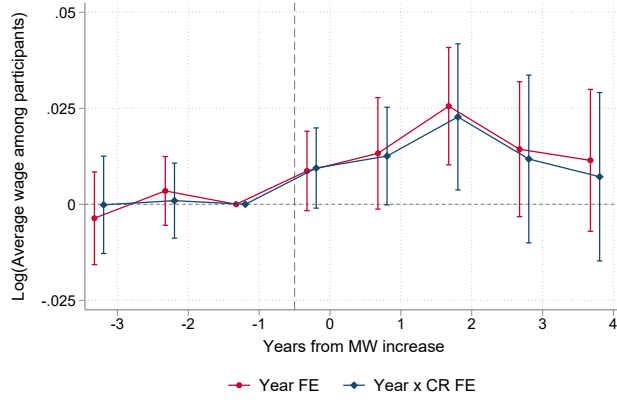
(a) Low-skill workers
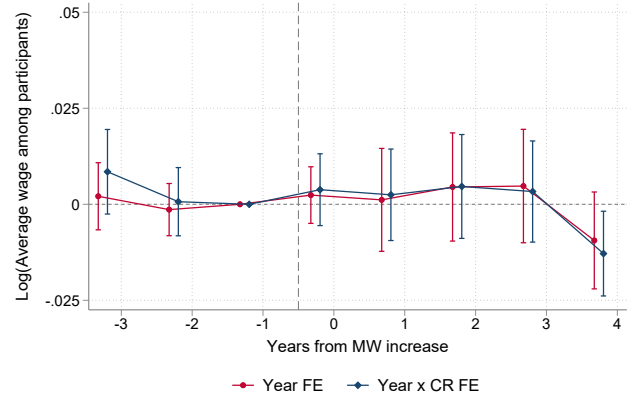
(b) High-skill workers

(c) Income maintenance benefits (per working-age pop.)

(d) Income maintenance benefits (total)

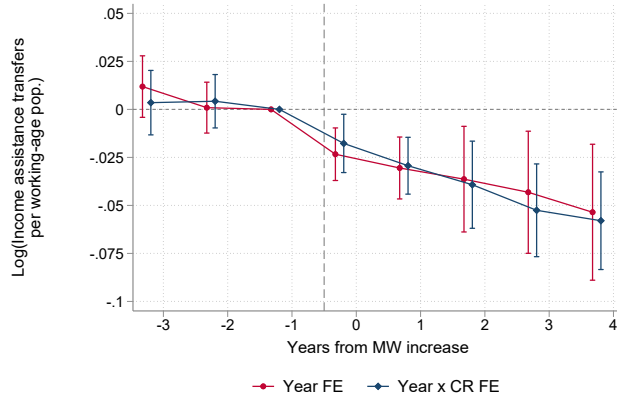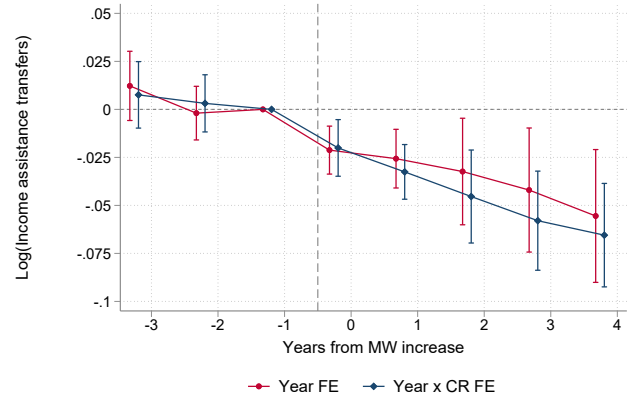Notes: These figures plot the estimated β_τ coefficients with their corresponding 90% confidence intervals from equation (17). Estimations consider a selected sample of events where treated states do not experience other events in the three years previous to the event and whose timing allow to observe the outcomes from three years before to four years after. Panel (a) uses the average pre-tax wage of low-skill workers including the unemployed as dependent variable. Panel (b) uses the average pre-tax wage of high-skill workers including the unemployed as dependent variable. Panels (c) and (d) use per working-age population and total income maintenance benefits as dependent variable, respectively. Red lines represent specifications that control by year-by-event fixed effects. Blue lines represent specifications that control by census-region-by-year-by-event fixed effects. Standard errors are clustered at the state level, and regressions are weighted by state-by-year average population computed using the CPS monthly files.

events are presented in Figure C.II of Appendix C.[26] Each figure plots regressions with two different types of time fixed-effects: year-by-event fixed effects and census-region-by-year-by-event fixed effects. Table 2 presents the estimated coefficients β of equation (18) that summarize the average treatment effect in the post period, considering results using both all and the selected sample of events, and also including specifications that control for census-division-by-year-by-event fixed effects.

Panel (a) of Figure 2 shows that state-level minimum wage increases have increased the average pre-

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[26]The comparison between Figures 2 and C.II illustrates the tradeoff of using the full set of events versus the restricted sample. Using all events generate more precise estimates at the cost of inducing small pre-trends, potentially due to the presence of events in the pre-period. Reassuringly, both strategies yield similar conclusions for all the outcomes considered.

Table 2: Worker-level results

(a) Low-skill Workers

	All events			Selected events		
$\hat{\beta}$	0.025	0.021	0.025	0.014	0.012	0.020
	(0.008)	(0.008)	(0.012)	(0.008)	(0.010)	(0.010)
Year FE	Y	N	N	Y	N	N
Year x CR FE	N	Y	N	N	Y	N
Year x CD FE	N	N	Y	N	N	Y
Obs.	36613	36613	34797	14860	14860	14099
Events	172	172	172	64	64	64
$\Delta \log$ MW	0.101	0.101	0.101	0.128	0.128	0.126
Elast.	0.251	0.204	0.242	0.107	0.093	0.160

(b) High-skill Workers

	All events			Selected events		
$\hat{\beta}$	0.002	0.001	0.003	0.000	-0.003	0.001
	(0.004)	(0.003)	(0.005)	(0.006)	(0.005)	(0.007)
Year FE	Y	N	N	Y	N	N
Year x CR FE	N	Y	N	N	Y	N
Year x CD FE	N	N	Y	N	N	Y
Obs.	36613	36613	34797	14860	14860	14099
Events	172	172	172	64	64	64
$\Delta \log$ MW	0.101	0.101	0.101	0.128	0.128	0.126
Elast.	0.024	0.010	0.034	0.002	-0.022	0.009

(c) Income Maintenance Benefits (Per Working-Age Individual)

	All events			Selected events		
$\hat{\beta}$	-0.032	-0.038	-0.038	-0.041	-0.041	-0.046
	(0.009)	(0.006)	(0.008)	(0.012)	(0.009)	(0.012)
Year FE	Y	N	N	Y	N	N
Year x CR FE	N	Y	N	N	Y	N
Year x CD FE	N	N	Y	N	N	Y
Obs.	37749	37749	35914	17604	17604	16818
Events	172	172	172	72	72	72
$\Delta \log$ MW	0.101	0.101	0.102	0.127	0.127	0.125
Elast.	-0.314	-0.374	-0.376	-0.322	-0.322	-0.368

(d) Income Maintenance Benefits (Total)

	All events			Selected events		
$\hat{\beta}$	-0.032	-0.045	-0.038	-0.038	-0.047	-0.045
	(0.008)	(0.008)	(0.007)	(0.012)	(0.011)	(0.012)
Year FE	Y	N	N	Y	N	N
Year x CR FE	N	Y	N	N	Y	N
Year x CD FE	N	N	Y	N	N	Y
Obs.	37749	37749	35914	17604	17604	16818
Events	172	172	172	72	72	72
$\Delta \log$ MW	0.101	0.101	0.102	0.127	0.127	0.125
Elast.	-0.321	-0.449	-0.376	-0.301	-0.367	-0.363

Notes: This table shows the estimated β coefficient from equation (18). All columns represent different regressions using different dependent variables (all in logarithms), fixed effects, and samples of events. Panel (a) uses the average pre-tax wage of low-skill workers including the unemployed as dependent variable. Panel (b) uses the average pre-tax wage of high-skill workers including the unemployed as dependent variable. Panel (c) uses income maintenance benefits per working age individual as dependent variable. Panel (d) uses total income maintenance benefits as dependent variable. $\Delta \log$ MW is the average change in the log of the real state-level minimum wage across events in the year of the event. Elast. is the implied elasticity, that comes from dividing the point estimate by $\Delta \log$ MW. Standard errors (in parentheses) are clustered at the state level and regressions are weighted by state-by-year population.

tax hourly wage of active low-skill workers including the unemployed. Table 2 shows that the implied elasticity ranges between 0.09 and 0.16 in the preferred specification, and becomes almost two times larger when using the full sample of events. Panel (b) of Figure 2 shows that these minimum wage increases have had null effects on the average pre-tax hourly wage of active high-skill workers including the unemployed. These results suggest that state-level minimum wages have reduced welfare gaps between low- and high-skill active workers. Panels (c) and (d) of Figure 2 show that part of the increase in the average pre-tax hourly wage of active low-skill workers including the unemployed has been offset by a reduction in income maintenance benefits. Table 2 shows that the implied elasticity of income maintenance benefits per working age population ranges between -0.31 and -0.37, depending on the specification. Results are consistent when using total income maintenance benefits, suggesting that these results are not driven by changes in the underlying working-age population.

To better understand how minimum wages have affected low-skill workers, Table 3 shows two sets of complementary results. To simplify exposition, Table 3 only presents results using the selected sample of events. Results using the full sample of events can be found in Table C.II of Appendix C. The different panels consider different sets of time fixed effects. Within each panel, columns (1)-(4) decompose the overall effect on different margins: hourly wage, weekly hours (both conditional on employment),

Table 3: Additional results for low-skill workers (selected events)

(a) Year-by-event fixed effects

| | Margins | | | | Het.: Age | | | Het.: Educ | | |
	Wage	Hours	Emp.	Part.	[16,19]	[20,30]	>30	HS drop.	HS comp.	Coll. inc.
$\hat{\beta}$	0.014	-0.001	-0.000	-0.003	0.036	0.012	0.010	0.017	0.011	0.015
	(0.003)	(0.004)	(0.007)	(0.007)	(0.012)	(0.009)	(0.009)	(0.012)	(0.009)	(0.007)
Obs.	14860	14860	14860	14860	14860	14860	14860	14860	14860	14860
Events	64	64	64	64	64	64	64	64	64	64
$\Delta \log$ MW	0.128	0.128	0.128	0.128	0.128	0.128	0.128	0.128	0.128	0.128
Elast.	0.109	-0.010	-0.002	-0.020	0.283	0.096	0.080	0.135	0.089	0.119

(b) Census-region-by-year-by-event fixed effects

| | Margins | | | | Het.: Age | | | Het.: Educ | | |
	Wage	Hours	Emp.	Part.	[16,19]	[20,30]	>30	HS drop.	HS comp.	Coll. inc.
$\hat{\beta}$	0.012	-0.004	-0.000	-0.005	0.034	0.011	0.009	0.010	0.010	0.015
	(0.003)	(0.004)	(0.008)	(0.008)	(0.012)	(0.010)	(0.010)	(0.013)	(0.010)	(0.010)
Obs.	14860	14860	14860	14860	14860	14860	14860	14860	14860	14860
Events	64	64	64	64	64	64	64	64	64	64
$\Delta \log$ MW	0.128	0.128	0.128	0.128	0.128	0.128	0.128	0.128	0.128	0.128
Elast.	0.097	-0.031	-0.004	-0.037	0.267	0.086	0.072	0.075	0.078	0.119

(c) Census-division-by-year-by-event fixed effects

| | Margins | | | | Het.: Age | | | Het.: Educ | | |
	Wage	Hours	Emp.	Part.	[16,19]	[20,30]	>30	HS drop.	HS comp.	Coll. inc.
$\hat{\beta}$	0.011	-0.000	0.009	-0.002	0.042	0.016	0.020	0.025	0.019	0.020
	(0.003)	(0.005)	(0.009)	(0.011)	(0.016)	(0.012)	(0.011)	(0.017)	(0.011)	(0.011)
Obs.	14099	14099	14099	14099	14099	14099	14099	14099	14099	14099
Events	64	64	64	64	64	64	64	64	64	64
$\Delta \log$ MW	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126
Elast.	0.086	-0.002	0.075	-0.017	0.338	0.127	0.156	0.198	0.149	0.159

Notes: This table shows the estimated β coefficient from equation (18) using different dependent variables for low-skill workers (all in logarithms). Regressions only consider the sample of selected events. Panel (a) uses year-by-event fixed effects. Panel (b) uses census-region-by-year-by-event fixed effects. Panel (c) uses census-division-by-year-by-event fixed effects. Within each panel, columns (1)-(4) decompose the overall effect in four margins: wage (conditional on employment), hours (conditional on employment), employment rate, and participation rate. Columns (5)-(7) use the average pre-tax hourly wage of active low-skill workers including the unemployed that are between 16 and 19 years old, between 20 and 30 years old, and older than 30, respectively. Columns (8)-(10) use the average pre-tax hourly wage of active low-skill workers including the unemployed that are high school dropouts, have complete high-school education, and have incomplete college education, respectively. $\Delta \log$ MW is the average change in the log of the real state-level minimum wage across events in the year of the event. Elast. is the implied elasticity, that comes from dividing the point estimate by $\Delta \log$ MW. Standard errors (in parentheses) are clustered at the state level and regressions are weighted by state-by-year population.

employment rate, and participation rate. Results indicate that all the effect of minimum wage increases on the average pre-tax hourly wage of active low-skill workers including the unemployed is driven by an increase in the wage conditional on employment, with no effect on hours, employment, or participation.[27] Columns (5)-(7) estimate the main effect on the average pre-tax hourly wage of active workers including the unemployed for different samples of low-skill workers split by age. The effect is positive for all groups, but it is between 2 and 3 times larger for teens. This suggests that the coarse aggregation at the skill-level is possibly underestimating the distributional benefits of the minimum wage since teens are more likely to work on minimum wage jobs (Manning, 2021; Cengiz et al., 2022). Columns (8)-(10) show that there is no heterogeneous effect by educational status among the individuals with no college education.

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[27]The lack of employment responses suggests that the result is robust to including curvature in the flow utility of workers.

Figure 3: Changes in capitalists' welfare after minimum wage increases (selected events)
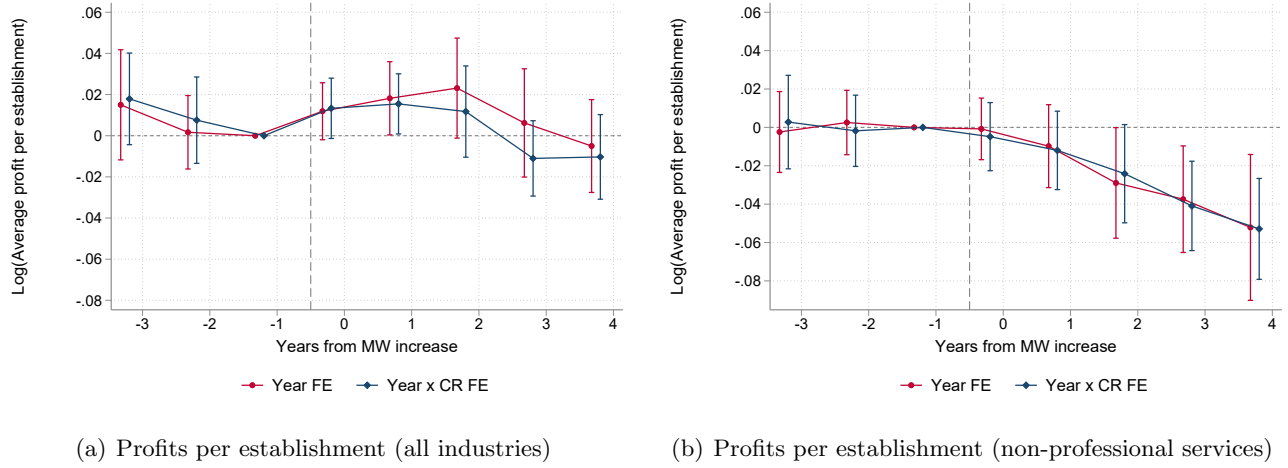
(a) Profits per establishment (all industries)   (b) Profits per establishment (non-professional services)

Notes: These figures plot the estimated β_τ coefficients with their corresponding 90% confidence intervals from equation (17). Estimations consider a selected sample of events where treated states do not experience other events in the three years previous to the event and whose timing allow to observe the outcomes from three years before to four years after. Panel (a) uses the gross operating surplus per private establishment in all industries as dependent variable. Panel (b) only considers the non-professional services industry, that is, educational services, health care, arts, entertainment, recreation, accomodation, and food services. Red lines represent specifications that control by year-by-event fixed effects. Blue lines represent specifications that control by census-region-by-year-by-event fixed effects. Standard errors are clustered at the state level, and regressions are weighted by state-by-year average population computed using the CPS monthly files.

Capitalists   Figure 3 plots the estimated coefficients $\{\beta_\tau\}_{\tau=-3}^{4}$ of equation (17) with their corresponding 90% confidence intervals using the gross operating surplus per private establishment as dependent variable. These figures plot results using the preferred selected sample of 72 events. Results with the complete sample of events are presented in Figure C.III of Appendix C. Each figure plots regressions with two different types of time fixed-effects: year-by-event fixed effects and census-region-by-year-by-event fixed effects. Panel (a) shows results aggregating all industries. Panel (b) focuses on non-professional services –educational services, health care, arts, entertainment, recreation, accomodation, and food services–, a sector that is usually flagged as having larger shares of minimum wage workers (Card and Krueger, 1994; Dube et al., 2010; Cengiz et al., 2019; Ruffini, 2021). Regressions are restricted to the 1990-2019 period to use the industry classification. Table 4 presents the estimated coefficients β of equation (18) that summarize the average treatment effect in the post period, considering results using both all and the selected sample of events, and also including specifications that control for census-division-by-year-by-event fixed effects. Table 5 provides a slightly more granular industry-level decomposition of the main result.

Panel (a) shows that there is no effect on profits per establishment when pooling all industries. This is possibly explained by the fact that minimum wage workers represent a small share of the overall economy. However, Panel (b) shows that when looking at the non-professional services industry, where the share of minimum wage workers is larger, there is a negative effect on profits per establishment. Table 4 shows that the implied elasticity is between -0.12 and -0.21 in the preferred specification.

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Table 4: Capitalists-level results

	(a) GOS per Establishment (All industries)						(b) GOS per Establishment (Non-professional services)					
	All events			Selected events			All events			Selected events		
$\hat{\beta}$	0.007	0.004	0.006	0.005	-0.004	-0.005	-0.024	-0.030	-0.012	-0.025	-0.027	-0.015
	(0.008)	(0.008)	(0.010)	(0.011)	(0.010)	(0.011)	(0.022)	(0.010)	(0.010)	(0.017)	(0.016)	(0.017)
Year FE	Y	N	N	Y	N	N	Y	N	N	Y	N	N
Year x CR FE	N	Y	N	N	Y	N	N	Y	N	N	Y	N
Year x CD FE	N	N	Y	N	N	Y	N	N	Y	N	N	Y
Obs.	32943	32943	31246	13732	13732	13069	32167	32167	30490	13679	13679	13016
Events	157	157	157	60	60	60	157	157	157	60	60	60
$\Delta \log$ MW	0.099	0.099	0.099	0.126	0.126	0.123	0.099	0.099	0.099	0.126	0.126	0.123
Elast.	0.072	0.043	0.065	0.037	-0.033	-0.040	-0.239	-0.303	-0.119	-0.200	-0.213	-0.122

Notes: This table shows the estimated β coefficient from equation (18). Regressions only consider the period 1990-2019 to make all columns comparable. All columns represent different regressions using different dependent variables (all in logarithms), fixed effects, and samples of events. Panel (a) uses the gross operating surplus per private establishment pooling all industries. Panel (b) only considers non-professional services, that is, educational services, health care, arts, entertainment, recreation, accomodation, and food services. $\Delta \log$ MW is the average change in the log of the real state-level minimum wage across events in the year of the event. Elast. is the implied elasticity, that comes from dividing the point estimate by $\Delta \log$ MW. Standard errors (in parentheses) are clustered at the state level and regressions are weighted by state-by-year population.

To further understand the industry-level heterogeneity, Table 5 shows results for a wide range of industries. To simplify exposition, Table 5 only presents results using the selected sample of events. Results using the full sample of events can be found in Table C.III of Appendix C. The different panels consider different sets of time fixed effects. The first two columns replicate the aggregate null effect for the periods 1979-2019 and 1990-2019 to check that the period selection does not affect the results. The rest of the columns estimate profit effects for different industries. The non-professional services industry stands out by displaying consistent negative effect across all specifications. For the other sectors, point estimates are sensitive to the way in which time fixed effects are specified and estimations are noisier. Negative effects seem to also characterize construction, wholesale trade, and finance, however, the dynamic specification that groups these three sectors together with non-professional services displays some pre-trends (see Figure C.IV of Appendix C). Surprisingly, the profits of the retail industry seems to be unaffected despite having a large share of minimum wage workers (Cengiz et al., 2019; Renkin et al., 2020). While these results should be interpreted with caution since they are noisy, unstable, and based on non-ideal aggregate data of profits, they suggest that industry heterogeneity matters for the effects on the capitalists' side and call for a more thorough analysis based on firm-level microdata.

Related literature The results on workers' outcomes are consistent with Cengiz et al. (2019, 2022) who find positive wage effects, limited employment effects, and limited participation effects in the part of the distribution close to the minimum wage using similar data and empirical strategy. Those findings are common in the related literature (Manning, 2021). While consistent, my results differ from theirs along two dimensions. First, I focus on wider skill groups that are not exactly composed by minimum wage workers. Second, the main focus of my analysis is the estimation of the composite sufficient statistic rather than the effect on different margins. The effects on income maintenance benefits are consistent with Reich

Table 5: Industry heterogeneity (selected events)

(a) Year-by-event fixed effects

	All	All	NNRR	Constr.	Manuf.	Transp.	Wholesale	Retail	Finance	Prof. serv	Non-prof. serv.
$\hat{\beta}$	0.002	0.005	0.032	-0.013	0.058	0.016	-0.027	0.011	-0.013	0.029	-0.025
	(0.008)	(0.011)	(0.036)	(0.041)	(0.040)	(0.032)	(0.024)	(0.014)	(0.015)	(0.013)	(0.017)
Obs.	17604	13732	13328	13677	13666	13682	13732	13732	13732	13732	13679
Events	72	60	60	60	60	60	60	60	60	60	60
$\Delta \log$ MW	0.127	0.126	0.127	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126
Elast.	0.015	0.037	0.251	-0.100	0.457	0.125	-0.211	0.090	-0.101	0.234	-0.200

(b) Census-region-by-year-by-event fixed effects

	All	All	NNRR	Constr.	Manuf.	Transp.	Wholesale	Retail	Finance	Prof. serv	Non-prof. serv.
$\hat{\beta}$	-0.003	-0.004	0.007	-0.057	0.050	-0.005	-0.041	-0.006	-0.017	0.019	-0.027
	(0.009)	(0.010)	(0.033)	(0.043)	(0.041)	(0.030)	(0.024)	(0.014)	(0.013)	(0.012)	(0.016)
Obs.	17604	13732	13285	13677	13666	13682	13732	13732	13732	13732	13679
Events	72	60	60	60	60	60	60	60	60	60	60
$\Delta \log$ MW	0.127	0.126	0.127	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126
Elast.	-0.023	-0.033	0.056	-0.456	0.395	-0.042	-0.323	-0.045	-0.135	0.150	-0.213

(c) Census-division-by-year-by-event fixed effects

	All	All	NNRR	Constr.	Manuf.	Transp.	Wholesale	Retail	Finance	Prof. serv	Non-prof. serv.
$\hat{\beta}$	-0.003	-0.005	-0.042	-0.047	0.023	-0.045	0.008	0.005	-0.020	0.006	-0.015
	(0.011)	(0.011)	(0.038)	(0.045)	(0.039)	(0.025)	(0.027)	(0.013)	(0.014)	(0.017)	(0.017)
Obs.	16818	13069	12605	13012	13003	13019	13069	13069	13069	13069	13016
Events	72	60	60	60	60	60	60	60	60	60	60
$\Delta \log$ MW	0.125	0.123	0.124	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123
Elast.	-0.020	-0.040	-0.338	-0.382	0.186	-0.362	0.069	0.040	-0.163	0.049	-0.122

Notes: This table shows the estimated β coefficient from equation (18) using the gross operating surplus per private establishment for different industries (all in logarithms) using census-division-by-year-by-event fixed effects. Regressions only consider the sample of selected events. Panel (a) uses year-by-event fixed effects. Panel (b) uses census-region-by-year-by-event fixed effects. Panel (c) uses census-division-by-year-by-event fixed effects. NNRR includes agriculture, forestry, fishing, hunting, and mining. Constr. includes construction. Manuf. includes durable and nondurable goods manufacturing. Transp. includes transportation. Wholesale includes wholesale trade. Retail includes retail trade. Finance includes finance, insurance, real estate, rental, and leasing. Prof. serv. includes professional and business services. Non-prof. serv. includes educational services, health care, arts, entertainment, recreation, accomodation, and food services. $\Delta \log$ MW is the average change in the log of the real state-level minimum wage across events in the year of the event. Elast. is the implied elasticity, that comes from dividing the point estimate by $\Delta \log$ MW. Standard errors (in parentheses) are clustered at the state level and regressions are weighted by state-by-year population.

and West (2015) and Dube (2019) who also find reductions in transfer spending after minimum wage increases. The effects on capitalists are, to my knowledge, the first profit elasticities estimated for the US and, while noisy and only suggestive, are qualitatively consistent with estimations for other countries based on granural firm-level data. Draca et al. (2011) study the introduction of the national minimum wage in the United Kingdom and find that profit margins fell by almost 30%. Harasztosi and Lindner (2019) find that profits fell around 1% after a large minimum wage increase in Hungary. This decrease represented around 30% of the average profitability in the pre-reform year. Drucker et al. (2021) study the Israeli case and finds a reduction of 7.5% in profits of highly exposed firms.

With respect to the recent structural literature that focus on the distributional impacts of the minimum wage, my results are consistent with the quantitative exercise in Berger et al. (2022b) that suggests that welfare gains are concentrated in workers and decreasing in skill, while welfare losses are concentrated in capital owners. My results also relate to Hurst et al. (2022) simulations. They find positive

aggregate effects on low-skill workers, but argue that within low-skill workers the ones at the bottom of the distribution are made worse off by the policy. My results differ from theirs since I find larger welfare increases for teens, which are more likely to be at the bottom of the distribution conditional on being low-skill. It should be kept in mind that both set of results are not fully comparable since Hurst et al. (2022) analysis focuses on the long-run consequences of the minimum wage increase (i.e., 15-20 years after the policy change). The long-run analysis is beyond the scope of this paper.

4.4 Back to the optimal policy analysis

The empirical results inform about the effects of minimum wages on low-skill workers, high-skill workers, and capitalits' welfare. However, the estimated elasticities are not sufficient to draw conclusions on the overall desirability of the minimum wage. Recall from Section 3 that to assess if increasing the minimum wage is welfare-improving, the social planner needs information on the social value of the welfare changes on active low-skill workers, the social value of the welfare changes on active high-skill workers, the social value of the welfare changes on active capitalists, and the fiscal externalities on both workers' and capitalists' sides. Results so far only depict an incomplete picture of this analysis. The remainder of the section uses the estimated elasticities to develop a simple calibration of Proposition II to get additional insights about the welfare properties of the minimum wage policy.

Revisiting Proposition II Consider the following modified version of equation (14). When taxes are fixed, increasing the minimum wage increases aggregate welfare if

$$\frac{d \log U^l}{d \overline{w}} \cdot U^l \cdot L_A^l \cdot g_1^l + K_A \cdot (1-t) \cdot \int_{\psi^*}^{\overline{\psi}} g_\psi \frac{d \log \Pi(\psi)}{d \overline{w}} \Pi(\psi) d\tilde{O}(\psi) + \text{ Fiscal effects } > 0, \quad (19)$$

where $K_A = K \cdot (1 - O(\psi^*))$, $\tilde{O}(\psi) = O(\psi)/(1 - O(\psi^*))$, and the fiscal effects consider both workers' and capitalists' sides fiscal externalities. The high-skill workers component is omitted since the estimations of Table 2 suggest that $dU^h/d\overline{w} = 0$.

On the workers' side, note from equation (13) that

$$U^l \cdot L_A^l = \int E_m^l w_m^l dm - \int E_m^l T(w_m^l) dm + y_0 \cdot L_A^l \cdot \rho^l, \quad (20)$$

that is, $U^l \cdot L_A^l$ is equal to total pre-tax income (first term) plus the net tax liabilities, which are composed by the taxes paid by employed workers (second term) and the transfers received by the unemployed workers. Total pre-tax annual income of employed low-skill workers can be computed using the CPS-MORG data. Since taxes paid at the bottom of the distribution are possibly negative, I use the total income maintenance benefits from the BEA regional accounts as a proxy for total net tax liabilities of

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low-skill workers. Then, the low-skill workers' side component of (19) can be written as

$$\frac{d \log U^l}{d\overline{w}} \cdot U^l \cdot L_A^l \cdot g_1^l \quad = \quad \epsilon_{U^l} \cdot (\text{TPTW} + \text{TIMB}) \cdot g_1^l, \tag{21}$$

where $\epsilon_{U^l} \equiv d \log U^l / d\overline{w}$, TPTW accounts for total annual pre-tax wages, and TIMB accounts for total income maintenance benefits.

On the capitalists' side, I impose that $\epsilon_\Pi \equiv d \log \Pi(\psi)/d\overline{w}$ is constant given the lack of firm-level microdata needed to estimate heterogeneous effects. Denoting as $\overline{\Pi}$ the (unweighted) average pre-tax profit of active firms, the capitalists' side component of (19) can be written as

$$K_A \cdot (1-t) \cdot \int_{\psi^*}^{\overline{\psi}} g_\psi \frac{d \log \Pi(\psi)}{d\overline{w}} \Pi(\psi) d\tilde{O}(\psi) \quad = \quad \epsilon_\Pi \cdot \text{TPTP} \cdot (1-t) \cdot g^K, \tag{22}$$

where $\text{TPTP} = K_A \cdot \overline{\Pi}$ accounts for total pre-tax profits and $g^K = \int_{\psi^*}^{\overline{\psi}} g_\psi \frac{\Pi(\psi)}{\overline{\Pi}} d\tilde{O}(\psi)$ is the average SMWW across active capitalists. TPTP can be computed using the data of the empirical analysis.

Finally, fiscal effects can be decomposed into workers' side and capitalists' side fiscal externalities. I proxy workers' side effects by the change in TIMB, with a corresponding semi-elasticity of $\epsilon_B \equiv d \log \text{TIMB}/d\overline{w}$. On the capitalists' side, I assume that fiscal externalities are well approximated by the loss in the corporate tax revenue due to the effects on profits.[28] Then

$$\text{Fiscal effects} \quad = \quad -\epsilon_B \cdot \text{TIMB} + \epsilon_\Pi \cdot t \cdot \text{TPTP}. \tag{23}$$

Then, (19) can be written as

$$\epsilon_{U^l} \cdot (\text{TPTW} + \text{TIMB}) \cdot g_1^l + \epsilon_\Pi \cdot \text{TPTP} \cdot (1-t) \cdot g^K - \epsilon_B \cdot \text{TIMB} + \epsilon_\Pi \cdot t \cdot \text{TPTP} \quad > \quad 0. \tag{24}$$

Recall that Proposition II characterizes conditions under which small increases of the minimum wage are welfare-improving. This can be quantitatively assessed by imputing values to the components of the left-hand-side of (24). From equation (24), it can also be computed the minimum SMWW on active low-skill workers that make the condition true, that is

$$g_1^{l*} \quad = \quad \frac{-\epsilon_\Pi \cdot \text{TPTP} \cdot (1-t) \cdot g^K + \epsilon_B \cdot \text{TIMB} - \epsilon_\Pi \cdot t \cdot \text{TPTP}}{\epsilon_{U^l} \cdot (\text{TPTW} + \text{TIMB})}, \tag{25}$$

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[28]This claim has two caveats. First, changes in the number of establishments can also generate a fiscal externality. Second, changes in corporate profits may affect personal income tax collection either through reported business income, dividends, or S-corps income. In Table C.IV of Appendix C I show that minimum wages do not predict changes in these margins, so the fiscal externalities of capitalists are well approximated by changes in pre-tax profits. The number of establishments, if anything, shows a small but non-significant increase after minimum wage changes. Business income, dividend income, and S-Corp income reported in SOI state-level public tables do not change after minimum wage increases, neither at the intensive (per return or per working age population) or extensive (number of returns with positive income) margins.

where g_1^{l*} is the critical SMWW on active low-skill workers. Holding fix the rest of the components, any $g_1^l \geq g_1^{l*}$ makes the minimum wage increase desirable for redistribution. Then, g_1^{l*} is a measure of the restrictions on social preferences for redistribution that make the policy change desirable. The smaller g_1^{l*}, the weaker the required preferences for redistribution toward low-skill workers.

Calibration   Calibration of equation (24) requires estimating four sets of components: (i) the monetary aggregates, {TPTW, TIMB, TPTP}, (ii) the semi-elasticities, $\{\epsilon_{U^l}, \epsilon_\Pi, \epsilon_B\}$, (iii) the corporate tax rate, t, and (iv) the SMWWs, $\{g_1^l, g^K\}$. Below I describe the steps followed to compute each of these components. Appendix D provides additional details about the calculations.

Values for {TPTW, TIMB, TPTP} can be directly computed from the data used in the empirical analysis. I use two assumptions for their computation: (i) the population weighted average values of pre-event years across treated states, and (ii) the population weighted average values for 2019. The former calculation is used to assess past minimum wage increases. The latter is used to speculate about small minimum wage increases today. For TPTP, I only consider the industries that were found to have negative profit effects, namely non-professional services, construction, wholesale trade.

Values for $\{\epsilon_{U^l}, \epsilon_\Pi, \epsilon_B\}$ can be recovered from Tables 2 and 5. ϵ_Π corresponds to the semi-elasticity of profits per establishment of each of the considered industries. ϵ_B corresponds to the semi-elasticity of total income maintenance benefits. Since ϵ_{U^l} accounts for changes in post-tax values, it cannot be directly recovered from Table 2. I proceed as follows. First, I add the values for TPTW and TIMB to estimate total post-tax incomes of active low-skill workers including the unemployed. Then, I apply the estimated semi-elasticities of Table 2 separately for the TPTW and TIMB components to estimate the total post-tax incomes of active low-skill workers including the unemployed after the minimum wage increase. Finally, I compute the percent change of the estimated post-tax incomes to recover ϵ_{U^l}. Since some of the semi-elasticities are sensitive to the inclusion of different time fixed effects, I calibrate equation (24) using different values for $\{\epsilon_{U^l}, \epsilon_\Pi, \epsilon_B\}$ that come from the different empirical models.

The value for the corporate tax rate, t, is computed based on observed US corporate tax rates. I consider two cases. First, I consider the statutory corporate tax rate. I set $t = 35\%$ when using the population weighted average value of pre-event years across treated states to compute {TPTW, TIMB, TPTP}, which is the tax rate that applied between 1993 and 2017, and $t = 21\%$ when using the population weighted average values for 2019 to compute {TPTW, TIMB, TPTP}, which is the current statutory corporate tax rate. Second, I consider measures of effective corporate tax rates following Zucman (2014).[29] For the first case I set $t = 23\%$, which is the average value for the period 1979-2017. In the second case I consider $t = 13\%$, which is the most recent value of the series.

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[29]Effective corporate tax rates are computed by dividing all the corporate taxes paid by US firms (to US and foreign governments) by total US corporate profits using national accounts data taken from the BEA NIPA tables.

Finally, values $\{g_1^l, g^K\}$ are computed using two approaches. First, I consider $g_1^l = g^K = 1$. This represents a case with no redistributive considerations so the welfare calculation is reduced to computing changes in total output. This benchmark can be thought of as a test for the efficiency of the labor market. Second, I follow the optimal taxation literature with endogenous SMWWs (e.g., Mirrlees, 1971; Saez, 2001; Piketty and Saez, 2013) and add structure to the framework presented in Section 3 by assuming that the G function of the social welfare criterion is CRRA, that is, that $G(V) = V^{1-\zeta}/(1-\zeta)$, with $\zeta > 0$ and preferences for redistribution increasing in ζ. This functional form allows to calculate g_1^l/g^K using (powers of) the ratio of average post-tax incomes. Denote by $\omega(\zeta) = g^l(\zeta)/g^K(\zeta)$ the ratio of average SMWWs given ζ, where $\omega(\zeta)$ is proportional to the ratio of average post-tax incomes (see Appendix D).[30] I set $g_1^l = 1$ and $g^K = 1/\omega(\zeta)$, which converges to $g^K = 0$ when average profits are order of magnitudes larger than the average incomes of workers. This latter limit case matches the normative assumption that is implicit in most of the related literature where the desirability of the policy is assessed by only looking at worker-level outcomes.

For a given calibration choice, I perform two complementary exercises. First, I check whether equation (24) holds. This informs about the desirability of the minimum wage for redistributive purposes holding $g_1^l = 1$ fixed. Second, I use (25) to compute g_1^{l*} and inform about the required preference for redistribution that would make the minimum wage increase welfare-improving.[31] This also informs by how far equation (24) holds or not.

Results   Table 6 summarizes the results. Each cell considers a different permutation of the calibration choices discussed above to answer (i) whether equation (24) holds when g_1^l is normalized to 1, and (ii) the value of g_1^{l*}. The three panels use different values for the semi-elasticities, $\{\epsilon_{U^l}, \epsilon_\Pi, \epsilon_B\}$, taken from the different estimated models using the selected sample of events of Tables 2 and 5 that vary in the time fixed effects considered. Within each panel, the left sub-panel uses the population weighted average values of pre-event years across all treated states considered in the empirical analysis to estimate $\{\text{TPTW}, \text{TIMB}, \text{TPTP}\}$, so the analysis assess the welfare implications of past-minimum wage increases, while the right sub-panel uses the population weighted averages of 2019, so it speculates about the welfare implications of hypothetical minimum wage increases today. Within each sub-panel, columns consider the different approaches for computing g^K, where the first column sets $g^K = 1$ (so distributional considerations are muted) and the other three compute $g^K = 1/\omega(\zeta)$ for $\zeta \in \{1, 1.5, 2\}$. Also, within each sub-panel, the rows consider either the statutory corporate tax rate or the effective corporate tax rate.

Table 6 shows that equation (24) is true in almost all cases. That is, past minimum wage increases

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[30]For simplicity, I do not consider the participation and entry costs that ultimately matter for the computation of the SMWWs. Given Jensen's inequality, to the extent that entry costs for firms do not represent a much more larger share of profits than search costs represent for low-skill workers average incomes (including the unemployed), abstracting for them implies that the calibration of $\omega(\zeta)$ is possibly a lower bound.

[31]Equation (25) is slightly different in the case of endogenous SMWWs because g^K is a function of g_1^l. See Appendix D.

Table 6: Quantitative calibration of Proposition II

(a) Semi-elasticities of models with year-by-event fixed effects

		Past minimum wage increases				Minimum wage increases today			
				g^K:				g^K:	
		1	$1/\omega(1)$	$1/\omega(1.5)$	$1/\omega(2)$	1	$1/\omega(1)$	$1/\omega(1.5)$	$1/\omega(2)$
Statutory t	Is (24) true?	✓	✓	✓	✓	✓	✓	✓	✓
	g_1^{l*}	0.533	0.118	0.116	0.115	0.642	0.061	0.060	0.060
Effective t	Is (24) true?	✓	✓	✓	✓	✓	✓	✓	✓
	g_1^{l*}	0.533	0.039	0.038	0.038	0.642	0.001	0.001	0.001

(b) Semi-elasticities of models with census-region-by-year-by-event fixed effects

		Past minimum wage increases				Minimum wage increases today			
				g^K:				g^K:	
		1	$1/\omega(1)$	$1/\omega(1.5)$	$1/\omega(2)$	1	$1/\omega(1)$	$1/\omega(1.5)$	$1/\omega(2)$
Statutory t	Is (24) true?	✓	✓	✓	✓	✗	✓	✓	✓
	g_1^{l*}	0.961	0.237	0.231	0.229	1.167	0.137	0.133	0.132
Effective t	Is (24) true?	✓	✓	✓	✓	✗	✓	✓	✓
	g_1^{l*}	0.961	0.097	0.094	0.093	1.167	0.028	0.027	0.027

(c) Semi-elasticities of models with census-division-by-year-by-event fixed effects

		Past minimum wage increases				Minimum wage increases today			
				g^K:				g^K:	
		1	$1/\omega(1)$	$1/\omega(1.5)$	$1/\omega(2)$	1	$1/\omega(1)$	$1/\omega(1.5)$	$1/\omega(2)$
Statutory t	Is (24) true?	✓	✓	✓	✓	✓	✓	✓	✓
	g_1^{l*}	0.456	0.103	0.102	0.102	0.531	0.051	0.051	0.051
Effective t	Is (24) true?	✓	✓	✓	✓	✓	✓	✓	✓
	g_1^{l*}	0.456	0.037	0.036	0.036	0.531	0.002	0.002	0.002

Notes: This table shows whether equation (24) holds and the corresponding estimate of g_1^{l*} for different calibration choices. The different panels use different values for the semi-elasticities, $\{\epsilon_{Ul}, \epsilon_\Pi, \epsilon_B\}$, taken from different estimated models in Tables 2 and 5 that vary in the time fixed effects considered. Within each panel, the left sub-panel uses the population weighted average values of pre-event years across all treated states considered in the empirical analysis to estimate $\{\mathrm{TPTW, TIMB, TPTP}\}$, while the right sub-panel uses the population weighted averages of 2019. Within each sub-panel, columns consider the different approaches for computing g^K, where the first column sets $g^K = 1$ and the other three compute $g^K = 1/\omega(\zeta)$ for $\zeta \in \{1, 1.5, 2\}$. Also, within each sub-panel, the rows consider either the statutory corporate tax rate or the effective corporate tax rate. The statutory and effective corporate tax rates are $(35\%, 23\%)$ in the left sub-panel and $(21\%, 13\%)$ in the right sub-panel, respectively. Additional details of the calibration can be found in Appendix D.

have been welfare improving, and small minimum wage increases today are likely to be as well. This is also true for 10 out of the 12 cases in which $g^K = 1$, implying that the efficient benchmark is rejected in most cases: the increase in post-tax incomes for low-skill workers including the unemployed more than compensates the fall in profits. Total output seems to have increased after minimum wage increases.

One important aspect of Table 6 is that g_1^{l*} decreases considerably when distributional concerns are incorporated through g^K. That is, the minimum SMWW for low-skill workers that makes a case for the minimum wage is an order of magnitude smaller when the increases in after-tax incomes for low-skill workers have a larger social value than the profit losses. Even when total output falls, the incorporation of distributional concerns makes the case for the minimum wage unambiguously favorable. Interestingly, the degree of concavity of the social welfare function, ζ, which measures the strength of the social preferences for redistribution, does not affect the analysis. This is mainly driven by the fact that average

post-tax profits are several times larger than average post-tax incomes of active low-skill workers, so the redistributive forces in (24) manifest even when the concavity of the social welfare function is moderate.

The corporate tax rate plays an important role in the analysis. Within each sub-panel, g_1^{l*} is larger when considering the statutory tax rate, which is larger than the effective tax rate.[32] The reason is that the larger the corporate tax rate, the larger the corporate tax revenue loss, which matters for welfare regardless of the social value put on capitalists' incomes. This reinforces the narrative developed in Section 3: if international tax competition is pushing tax rates down, the minimum wage can mimic sector-specific tax rates to redistribute profits from labor-intensive industries to workers.

Comparing the analysis of past minimum wage increases to hypothetical future ones provide two additional insights. First, when $g^K = 1$, the estimated g_1^{l*} is larger for assessing minimum wage increases today. That is, absent distributional concerns based on relative incomes, conditions on social preferences are stricter today than they were for past minimum wage increases. This suggests that the potential efficiency gains today are smaller than the ones that were expected in the past, which is consistent with past minimum wage increases actually being efficiency enhancing. Second, when distributional concerns between labor and capital are incorporated through endogenous SMWWs, the case for minimum wage increases is stronger today than in the past. This is mainly explained by two reasons. First, the disparity in average incomes between workers and capitalists is larger today than in the past. Second, the corporate tax rates –both statutory and effective– are smaller today than in the past. Both elements favor the use of the minimum wage for redistributive purposes.

MVPF The calibrated components of equation (24) can also be used to compute an alternative measure of the welfare impacts of the minimum wage: the Marginal Value of Public Funds (MVPF) (Finkelstein and Hendren, 2020; Hendren and Sprung-Keyser, 2020). The MVPF of a policy is an indicator of its efficacy that compares its benefits to its costs, where the former is measured as the willingness to pay of the beneficiaries and the latter includes both the direct costs and the fiscal externalities. I can compute the MVPF of the minimum wage since (i) all utility changes are money-metric and, therefore, can be interpreted as willingness-to-pay, and (ii) the estimated macro elasticities include all general equilibrium effects of the policy, including the fiscal externalities.

While minimum wage increases do not have direct costs for the government in terms of spending, they induce changes on the government's budget through the fiscal externalities. The costs of the policy are given by Costs $= -\epsilon_\Pi \cdot t \cdot \text{TPTP} + \epsilon_B \cdot \text{TIMB}$, that is, by the loss in the corporate tax revenue net of the savings due to the reduction in income maintenance benefits.

On the benefits side, workers' willingness to pay for the increase in the minimum wage is given by

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[32]This is true for all cases except when $g^K = 1$. In that case the corporate tax rate plays no role because the fiscal externality is exactly offset by the welfare effects of the corporate tax payment.

Table 7: Marginal Value of Public Funds

| | (a) Year FE | | | | (b) Year x CR FE | | | | (c) Year x CD FE | | | |
| | Past minimum wage increases | | Minimum wage increases today | | Past minimum wage increases | | Minimum wage increases today | | Past minimum wage increases | | Minimum wage increases today | |
	Stat. t	Eff. t	Stat. t	Eff. t	Stat. t	Eff. t	Stat. t	Eff. t	Stat. t	Eff. t	Stat. t	Eff. t
MVPF_L	7.43	22.58	14.06	1,002.32	3.50	8.62	6.49	32.13	8.63	24.32	17.98	473.63
MVPF_K	-3.63	-13.07	-9.73	-717.88	-3.22	-9.38	-7.88	-42.94	-3.50	-11.67	-9.50	-275.66
MVPF	3.80	9.51	5.23	284.44	0.29	-0.76	-1.39	-10.81	5.13	12.65	8.48	197.7

Notes: This table presents estimations of MVPF_L, MVPF_K, and MVPF for different calibration choices, defined as $\mathrm{MVPF}_L = \mathrm{WTP}_L/\mathrm{Costs}$, $\mathrm{MVPF}_K = \mathrm{WTP}_K/\mathrm{Costs}$, and $\mathrm{MVPF} = (\mathrm{WTP}_L + \mathrm{WTP}_K)/\mathrm{Costs}$, where $\mathrm{Costs} = -\epsilon_\Pi \cdot t \cdot \mathrm{TPTP} + \epsilon_B \cdot \mathrm{TIMB}$, $\mathrm{WTP}_L = \epsilon_{U^l} \cdot \mathrm{TPTW} + \epsilon_B \cdot \mathrm{TIMB}$, and $\mathrm{WTP}_K = \epsilon_\Pi \cdot (1-t) \cdot \mathrm{TPTP}$. The different panels use different values for the semi-elasticities, $\{\epsilon_{U^l}, \epsilon_\Pi, \epsilon_B\}$, taken from different estimated models in Tables 2 and 5 that vary in the time fixed effects considered. Within each panel, the left sub-panel uses the population weighted average values of pre-event years across all treated states considered in the empirical analysis to estimate $\{\mathrm{TPTW}, \mathrm{TIMB}, \mathrm{TPTP}\}$, while the right sub-panel uses the population weighted averages of 2019. Within each sub-panel, the rows consider either the statutory corporate tax rate or the effective corporate tax rate. The statutory and effective corporate tax rates are $(35\%, 23\%)$ in the left sub-panel and $(21\%, 13\%)$ in the right sub-panel, respectively. Additional details of the calibration can be found in Appendix D.

$\mathrm{WTP}_L = \epsilon_{U^l} \cdot \mathrm{TPTW} + \epsilon_B \cdot \mathrm{TIMB}$, that is, by the net-increase in after-tax incomes, which corresponds to the annualized increase in pre-tax wages net of the decrease in income maintenance benefits. Since profits decrease after minimum wage increases, capitalists are willing to pay to avoid the policy. This is equivalent to say that their willingness to pay is negative and equal to $\mathrm{WTP}_K = \epsilon_\Pi \cdot (1-t) \cdot \mathrm{TPTP}$. The standard formulation of the MVPF abstracts from SMWWs and restricts the attention to comparing total net benefits to total net costs, so is given by $\mathrm{MVPF} = (\mathrm{WTP}_L + \mathrm{WTP}_K)/\mathrm{Costs}$. Alternatively, one could compute versions that either focus on workers, $\mathrm{MVPF}_L = \mathrm{WTP}_L/\mathrm{Costs}$, or capitalits, $\mathrm{MVPF}_K = \mathrm{WTP}_K/\mathrm{Costs}$, when assessing the benefits of the policy.

Table 7 presents estimations of MVPF_L, MVPF_K, and MVPF for each of the cases considered in Table 6. As a benchmark, Hendren and Sprung-Keyser (2020) estimates a MVPF of 0.75 for the SSI, between 0.9 and 1.05 for the SNAP, and between 1.1 and 1.2 for the EITC. The MVPF is larger than 1 in 8 out of 12 cases, meaning that even when abstracting from distributional considerations, the benefits of the policy seem to outweigh the fiscal costs. The only cases in which the MVPF is below 1 or negative is when using the semi-elasticities from models with census-region-by-year-by-event fixed effects, since those models predict larger decreases in profits, so the negative willingness to pay of capitalists increase. The MVPF_L is always far larger than one, suggesting that when only workers' welfare is considered for computing the benefits the policy is very cost effective, especially when considering the alternatives such as the SSI, SNAP, or the EITC. The converse is true for the MVPF_K. This, again, calls for the importance of considering distributional concerns where there are clear winners and losers after a policy implementation. When the MVPF and the MVPF_L are above 1, their value is negatively correlated with the corporate tax rate considered because the cost of the policy is proportional to the corporate tax rate. This reinforces the narrative of minimum wage increases being more appealing for redistribution when corporate tax rates are small.

Caveats The calibration analysis is only suggestive. On a conceptual level, recall that Proposition II studies the desirability of the minimum wage when taxes are fixed. Then, the analysis does not inform whether the minimum wage is desirable if taxes are optimal and how the tax system can be reformed to approach its optimal design. That analysis requires information on the micro version of the semi elasticities which cannot be estimated with the empirical setting of this paper. Also, even if assuming fixed taxes is the policy-relevant scenario for assessing policy changes, the analysis is local in the sense that informs about small minimum wage increases. That is, Tables 6 and 7 do not provide information about how large is the optimal minimum wage.

On a technical level, the analysis assumes that the estimated semi-elasticities are valid today, which is not necessarily the case if some of the fundamentals have changed over time. Also, given the lack of firm-level micro data, the analysis abstracts from within-capitalist variation in profits that could play a role in the distributional consequences of the policy if profit elasticities are not constant (e.g., Drucker et al., 2021). Finally, elasticities are estimated using non-ideal aggregate data, yielding some results that are noisy and sensitive to the inclusion of different sets of time fixed effects.

With this in mind, this calibration analysis constitutes a first-step toward a more comprehensive understanding of the redistributive consequences of the minimum wage, especially when the relationship between labor and capital is considered. Better data and policy experiments can provide more precise assessments on the distributional consequences of hypothetical future minimum wage increases, a pressing issue in the current policy debate.

5 Conclusion

A large literature studies the labor market effects of the minimum wage, usually finding important wage effects with limited employment consequences. A smaller literature builds on these empirical findings to understand the role of the minimum wage in the optimal redistributive policy mix, especially when taxes and transfers are available for policymakers. This paper aims to contribute to this latter discussion.

The paper proposes a tractable model of the labor market to develop an optimal policy analysis. The model features two-sided heterogeneity, has positive firm profits in equilibrium, reproduces several facts of low-wage labor markets, and predicts realistic effects of minimum wage increases. Additional modelling choices make the framework especially appealing for understanding the distributional impacts of the minimum wage, on top of the widely studied potential efficiency-enhancing effects.

With the model of the labor market, the paper then develops an optimal policy analysis to characterize the effects of the minimum wage on the relative welfare of low-skill workers, high-skill workers, and capitalists as a function of sufficient statistics for welfare, social preferences for redistribution, and fiscal externalities. One important insight of the analysis is that the minimum wage can be a useful tool

for redistributing from capital to labor when exogenous forces –such as international tax competition– prevent social planners to enforce large corporate tax rates. This argument is reinforced after noting that the profit effects are concentrated on labor-intensive service industries. I also show that the ability of the minimum wage to shift the incidence of the tax system implies that there may be a role for binding minimum wages even when the tax system is optimal.

The sufficient statistics that guide the welfare analysis are estimated using state-level variation in minimum wages. I find that minimum wages have increased low-skill workers' welfare –especially for teens– with no effects on high-skill workers. Part of this effect is offset by a decrease in income maintenance benefits. Profits of labor-intensive industries also seem to decrease after minimum wage hikes. The estimated coefficients are used to calibrate a simple welfare analysis that shows that incorporating distributional concerns to the analysis, especially between labor and capital, is first-order for assessing the desirability of the minimum wage. While only suggestive, the analysis finds that past minimum wage increases have increased aggregate US welfare and that small future increases are likely to do that as well.

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