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Analyses of topical policy issues

Do minimum wages deliver what they promise? Effects of minimum wage on employment, output, and income inequality from occupational choice theory[☆,☆☆]

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ABSTRACT

This paper addresses the unresolved debate on the effects of minimum wages on output, employment, and income inequality by modeling an occupational choice economy calibrated for a representative OECD economy. The minimum wage sets a minimum skill requirement for employees, which reduces the effective labor supply and raises its price. Consequently, salaries increase, business profits fall, and some entrepreneurs transition to solo self-employment. With a minimum-to-average wage ratio of 0.43 (the OECD countries average in 2020), a 10% increase in the minimum wage reduces output, employment, and inequality among employees by 0.2%, 1.0%, and 2.1%, respectively, and increases total income inequality by 0.57%. If the minimum-to-average wage ratio were 0.55, output, employment, and inequality among employees would decrease by 0.87%, 3.55%, and 5.19%, respectively, and income inequality would rise by 2.09%. In summary, the effects are mainly negative, contrary to what is promised, and quantitatively large for *high* minimum-to-average wage ratios.

1. Introduction

Many countries around the world have long maintained a statutory minimum wage that employers must pay their employees for work in a given period.[1] Minimum wages are generally justified on efficiency (for example, to increase output and employment in monopsonistic labor markets) and distributional grounds (to reduce poverty) (Manning, 2021). The results of extensive research on the observed effects of minimum wages on employment and income inequality, collected in several survey papers (Brown et al., 1982; Card and Krueger, 1995; Neumark and Wascher, 2008; Belman and

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[1] Of the 38 OECD member countries, 30 (including the largest ones) have a comprehensive national minimum wage or minimum wage regulation, and the remaining eight countries set minimum wages as part of collective bargaining agreements at the industry level (OECD, 2022). For a more comprehensive description of the diversity of minimum wage policies around the world, see International Labor Organization (ILO, 2022).

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Wolfson, 2014, 2019; Congressional Budget Office, 2014; Neumark and Shirley, 2021), have not yet settled the debate on whether the minimum wage delivers what its proponents promise. The difficulty in reaching a consensus on the true effects of a minimum wage has been attributed not only to the heterogeneity of observation units, time frames, and identification strategies across the numerous empirical studies but also to the lack of a theoretical benchmark against which to compare the measured effects (Beaudry et al., 2018).

This paper models an occupational choice economy (Lucas, 1978; Rosen, 1982) and compares the equilibrium outcomes in terms of income inequality, output and occupational group sizes, with and without a minimum wage and/or changes in the existing minimum wage. The parameters of the model are calibrated using data representative of Organization for Economic Co-operation and Development (OECD) countries. The economy includes four possible occupational groups: employees, voluntary and involuntary solo self-employed, and entrepreneur–managers (employers). Each group contributes to production in a different way and receives an income according to this contribution. Individuals endowed with general skills choose the occupation that maximizes their income given their skills. In the market equilibrium, no individual wants to change occupation, and the entrepreneur–managers' demand for operational skills is equal to the total supply of those who choose to work as employees. We calculate the equilibrium outcomes, including the total output, the contribution of each occupational group and the distribution of labor income for all individuals and within each occupational group. Comparative static analysis allows us to evaluate the changes in equilibrium outcomes due to changes in the exogenous parameters, including the initial value of the ratio of the minimum wage to the median wage, the so-called Kaitz index (KI), and compare them with the effects of changes in the minimum wage evaluated in empirical studies.

The input of workers (employees) into production is their general skill (multiplied by the working time normalized to one for all occupied), which is transformed into operational skill in combination with the entrepreneur–managers who employ and supervise them. The entrepreneur–managers contribute through the quality of their strategic decisions (proportional to their skill) and the skill-weighted working time allocated to joint production with employees. The skill-weighted time of the solo self-employed is divided between entrepreneurial and operational work. In the absence of a minimum wage, there is an equilibrium market price per unit of operational skill that determines the size of each occupational group. Employees' wages equal their skill level times the market price, so the income of low-skilled workers will be comparatively low (but they could all find salaried jobs), and one of the purported policy goals of minimum wages is to reduce the number of low-wage workers.

A statutory minimum wage will set a floor for the remuneration that employers have to pay to employees for a standardized working time. For the market price of skills in the absence of a minimum wage, this floor will lead employers to hire only individuals with skills above a minimum threshold. Individuals with skills below the threshold will lose their jobs (Neumark, 2018) and join the occupational group of "involuntary" solo self-employed (our assumption; the alternatives would be unemployment or the informal economy). The minimum wage has spillover effects on the rest of the economy. The exclusion of low-skilled people from the pool of workers reduces the supply of operational skills, leading to an increase in the equilibrium price of the skill. This price rise, in turn, induces changes in occupational choices. Some individuals who "voluntarily" worked as solo self-employed will now prefer to work as employees. Moreover, with the higher price of entrepreneurial skill, the profits of entrepreneur–managers fall, and some of them, the least skilled, will earn higher incomes as solo self-employed and change their occupation, i.e., a number of firms will close down. Overall, a minimum wage increases self-employment and reduces the number of firms and employees.

Since the modeled economy is assumed to have no market frictions, the minimum wage will reduce the total output produced (Stiger, 1946). However, the way in which this reduction in output takes place is not entirely obvious. In the minimum wage equilibrium, some entrepreneur–managers, the least skilled, fire all their employees and become solo self-employed, and the rest reduce employment (fire some employees) as the price of operational skill rises. The average skill of the entrepreneur–managers who remain in business grows, as does the average productivity of their employees. The entrepreneur–managers who move to voluntary solo self-employment are the most skilled within their new occupational group, while some former voluntary solo self-employed individuals (the least skilled) move to work as employees; therefore, the average skill and the productivity of voluntary solo self-employed people also expand with the minimum wage. Finally, low-skilled workers who lose their jobs as employees are less productive as solo self-employed individuals than they were as employees. Apart from the involuntary solo self-employed, who did not exist before the minimum wage was introduced, the other occupational groups increase their average productivity with the minimum wage. The loss of total output caused by the minimum wage is explained by the lower contribution to this output of the former employees working as involuntary solo self-employed and by the fact that the entrepreneur–managers who become voluntary solo self-employed as well as the voluntary solo self-employed individuals who change their occupation to work as employees are less productive in their new occupation (with the minimum wage) than they were in their previous occupation (without the minimum wage).

Our results show that overall income inequality (Gini index) increases with the minimum wage but with differences between the occupational groups. Because employee compensation is proportional to the price of operational skill, which grows with the minimum wage, and because the skill gap between high-skilled and low-skilled employees decreases, the income inequality within the occupational group of employees drops with the minimum wage. The increase in overall income inequality is due to the growth in the number of involuntary solo self-employed individuals caused by the minimum wage (the low-skilled workers who lose their jobs). One explicit aim of a minimum wage policy is to raise the income of low-paid workers. If we consider the 20% of employees who had the lowest wages without a minimum wage, those who are not dismissed and continue as employees will earn a higher salary with the introduction of the minimum wage (because of the rise in the price of skill). However, those who lose their jobs and join the group of involuntary solo self-employed (or become unemployed) will experience a huge reduction in their income, sufficient to expand the Gini index of the whole working population.

To validate the proposed model, we compare the efficiency and distributional effects of introducing a minimum wage or increasing the existing wage, as predicted by the model and calibrated values of the parameters, with the effects estimated in previous empirical studies. These works separately assess the effects of the minimum wage on employment (excluding solo self-employment) and output (Meer and West, 2016; Beaudry et al., 2018; Caliendo et al., 2018; Cengiz et al., 2019; Harasztosi and Lindner, 2019; Bossler and Gerner, 2020; Holtemöler and Pohle, 2020; Drucker et al., 2021; Alexandre et al., 2022; Dustmann et al., 2022; Seok and You, 2022) and the impact on income inequality (Lee, 1999; Neumark et al., 2004; Autor et al., 2016; Dube, 2019). The results confirm that, overall, the effects predicted by the model are consistent with those reported in empirical research. Importantly, they show that a minimum wage begins to have economically relevant effects at a KI value of 0.4; the effects are significant but relatively small for KI indexes between 0.4 and 0.55 and become relatively large for KI values above 0.55. Manning (2021) explicitly mentions a KI of 60% as the upper bound for the maximum recommendable minimum wage; the lower bound of 40% found in this paper is new to the literature.

Among OECD countries, the average KI was below 0.40 until 2015. In the prepandemic year 2019, the KI was below 0.40 in 12 countries and between 0.40 and 0.55 in 18 countries; only Colombia had a KI above 0.55 (0.59).[2] According to the model, with an initial KI of 0.43, the average KI for OECD countries in 2020, a 10% increase in the minimum wage reduces aggregate output by 0.2%, employment by 1.0%, and the Gini index of employee wages by 2.1% and increases the Gini index (of total population income) by 0.57%. However, with an initial KI of 0.60, the same 10% increase in the minimum wage would eventually have much larger effects: output, employment, and the Gini index of employee wages would fall by 1.3%, 5.12%, and 6.47%, respectively, and the Gini index (of total population income) would increase by 2.82%.

The importance of the initial level of the KI for the estimated magnitude of the effects of the minimum wage, together with the distribution of actual KI values across countries and over time, may explain why some empirical analyses do not find economically significant effects of the introduction of a minimum wage (the minimum wage is lower than or equal to 40% of the median wage) and why others find that the effects of enlarging the existing wage are very small or even unappreciable (the initial and final KIs are relatively low).

Understanding the reasons why the effects of minimum wages can differ across economies and for an economy over time is important for policymakers who use these observed effects for comparative purposes. Other studies have attributed the differences in the estimated effects to differences in labor market institutions, which are generally complementary to each other and to the minimum wage (Obadić et al., 2023). This paper shows that differences in the effects of the minimum wage can also be observed in economies with similar labor market institutions due to differences in the KI and/or in the distribution of skills and/or in production and organizational technologies. Since the parameters of the model have been calibrated for a representative OECD country, the threshold of the KI at which the minimum wage has economically meaningful effects could be different for countries with model parameters that differ from the calibrated ones. Finally, since the model assesses the efficiency and distributional outcomes of the minimum wage in the equilibrium of a unique occupational choice model, it provides policymakers with a tool for assessing the trade-offs between the outcomes of their concern (Harper, 2007, p. 115).

Statutory minimum wages are most often justified as policy choices that reduce income inequality and poverty rates and improve economic efficiency when employers have market power and/or when there are job search frictions.[3] If employer market power and job search frictions were generalized across economies, then the commonly observed effect of the introduction of a minimum wage would be an increase in output and employment. However, the number of research papers finding a negative effect of the minimum wage on employment is at least as large as the number identifying a neutral or positive effect (Neumark and Shirley, 2021). Moreover, the evidence for nonnegative effects of minimum wages on employment comes from research on local or regional markets, where employer market power and/or search frictions are more likely to be present. This study models a stylized economy as a single product and a single labor market, where the size and composition of the occupational groups are determined as market equilibrium outcomes. All firms compete

2 The OECD (2022) publishes updates on the regulation of minimum wages in member countries. Although most of the countries have statutory minimum wages, they differ in whether the statutory minimum wage is the same for the whole country and for all workers and Jobs; https://stats.oecd.org/Index.aspx?DataSetCode=MIN2AVE.

3 Most of the literature on the efficiency and distributional effects of minimum wages considers settings in which markets are imperfect (Cahuc et al., 2014). For example, Manning (2003, 2021) studied the effects of minimum wages in monopsony labor markets, and Flinn (2006) considered labor markets in which imperfect and asymmetric information leads to a costly search before employers and workers are matched. Berger et al. (2022) examined the efficiency and welfare effects of minimum wages in a general equilibrium setting in which firms produce and sell a homogeneous output that is sold in competitive markets, but production takes place in fragmented local oligopsony labor markets with heterogeneous firms and labor. The economy is composed of many local labor markets, but in each market the number of firms is exogenously determined. In the occupational choice model proposed in this paper, there is only one product and one economy-wide market, but the number of firms is endogenously determined and changes according to the minimum wage. Hurst et al. (2022) also model the effects of minimum wages in a general equilibrium setting, but the firms are homogeneous, and the results are only informative with regard to distributional effects.

to hire from the same pool of potential employees, so the assumption of monopsony in the labor market is not realistic in the setting of this investigation.[4]

The rest of this paper is organized as follows. Section 2 outlines the occupational choice model used in the analysis, including the value of the parameters calibrated using OECD data. Section 3 shows the comparative static results of changes in the minimum wage considering different initial values of the KI index, while Section 4 repeats the comparative static analysis but with income inequality variables; in both sections, the predictions of the model are compared with those obtained in empirical studies. The conclusions summarize the main findings of this investigation.

2. The occupational choice model

Working population and the distribution of general skills

The total labor force is normalized to 1. Individuals differ in the amount of "general skill" represented by the variable q. General skill is a measure of "human capital" nourished by inputs of innate abilities, formal education, and work experience. It includes each person's endowment of literacy, numeracy and interpersonal abilities. The term "general" means that a person can transfer his or her skills from one occupation to another (not job specific), i.e., general skills can be an input of employees, solo self-employed and entrepreneurs-managers.

We assume that the variable quantity of skill (for the sake of simplicity, *skill* from now on), q, is distributed among the population according to a lognormal distribution (the log of q will be normally distributed with mean λ and standard deviation σ), with $E[q] = e^{\lambda+\frac{\sigma^2}{2}}$; $\mathrm{var}[q] = e^{2\lambda+\sigma^2}\left(e^{\sigma^2}-1\right)$; $Median[q] = e^{\lambda}$; and coefficient of variation $CV = \sqrt{\left(e^{\sigma^2}-1\right)}$.

In the original model of occupational choices used to study the size distribution of firms, Lucas (1978) assumes that all individuals have the same operational skill (one unit) and that entrepreneurial skills follow a Pareto distribution on the population. To model the distribution of labor income across the population and within each occupational group, this paper, like Rosen (1982), assumes that individuals have different levels of a general skill that can be used as a productive input to perform operational and/or entrepreneurial-managerial tasks, including those of the new group of the solo self-employed.

The assumption of a log-normal distribution of skill in this paper is justified by the fact that the skill is general, not specific, and by the evidence from the PIAAC-OECD study (https://www.oecd.org/skills/piaac/) of a single-picked and bell-shaped distribution of cognitive skills in OECD countries (OECD, 2019; Broecke et al., 2018; Backhaus, 2020). However, the qualitative results of the paper are robust to other choices of the general skill distribution, such as the normal or the t-student.

Supervision hierarchies

In occupational choice models, entrepreneurs compete for the control of the resources of the economy, offering salaries to attract employees whose labor services will be combined with capital ones to produce goods and services sold in the market. As in Rosen (1982), entrepreneur–managers supervise the work of employees so that entrepreneur and employee together produce labor services, representing the effective labor input.

In particular, an entrepreneur of skill q that dedicates a fraction of working time t_i to the supervision of an employee of skill q_i will produce a quantity of labor service $l_i = (t_i q)^{\beta} q_i^{1-\beta}$. The parameter β, between zero and 1, is a proxy for the supervision technology, with a higher beta meaning a relatively greater intensity of supervision. The entrepreneur decides how much of their total supervision time (normalized working time set equal to 1 for all occupied) is allocated to each employee so that , $\sum_i l_i$, is maximized, with , $\sum_i t_i = 1$. The total labor services resulting from the joint interaction of the entrepreneur and all the supervised employees, at the optimal allocation of supervision time, is given by $L = q^{\beta} Q^{1-\beta}$, where $Q = \sum_i q_i$. The supervision hierarchy in Rosen's model converts the general skills of employees into a homogeneous commodity of operational skill that is perfectly interchangeable across firms.

The production and profit functions

The production of final output involves three inputs and a production function (technology). The inputs are the labor services, $L = q^{\beta} Q^{1-\beta}$, the capital services, K, and the "quality" of the entrepreneurial decisions, captured directly by the indivisible and nonreplicable level of skill. With a Cobb–Douglas production function with constant returns to scale in labor and capital services, the total output produced will be equal to:

$$Y = \theta q L^{1-\mu} K^{\mu} = \theta q \left(q^{\beta} Q^{1-\beta}\right)^{1-\mu} K^{\mu} = \theta q^{1+\beta(1-\mu)} Q^{(1-\beta)(1-\mu)} K^{\mu} \tag{1}$$

where Y is the total output produced; q is the skill of the entrepreneur that enters into the production function in two ways: in the joint production with employees of labor services, and as a term of the total factor productivity

[4] Empirical research on minimum wages has sometimes focused on specific groups of employees, such as teenagers (Card, 1992; Neumark and Wascher, 1992; Dolado et al., 1996; Neumark et al., 2014; Allegretto et al., 2017) and low-wage workers (Clemens and Wither, 2019; Abowd et al., 2000), while others have focused on specific industries (Katz and Krueger, 1992; Card and Krueger, 1994; Aaronson and French, 2007; Aaronson et al., 2008, 2018; Dube et al., 2010).

component of the production function, together with θ, the positive parameter of the general technological level; μ is the elasticity of output to the capital service input. The decreasing returns on Q in the production of labor services imply that $(1-\beta)(1-\mu)+\mu = 1-\beta(1-\mu)$, is lower than 1, i.e., decreasing returns to scale in the production of final output. A higher β implies lower-scale economies in production; since β depends on the internal organization of firms, it will be interpreted as a measure of organizational size diseconomies.

The output produced is sold in a competitive market at the price of 1, and there is a perfectly elastic supply of capital services at a unit price of c. For a market price per unit of operational skill w, the profit-maximizing input quantities of capital services and operational skills will be determined by solving the problem:

$$\Pi\left(q\right) = Max_{Q,K}\theta q^{1+\beta(1-\mu)}Q^{(1-\beta)(1-\mu)}K^{\mu} - cK - wQ \tag{2}$$

The solution to the problem gives the maximum profit[5] as a function of the entrepreneur's general skill q:

$$\Pi^{*}\left(q\right) = \beta\left(1-\mu\right)\left(\theta\left(\frac{\mu}{c}\right)^{\mu}\right)^{\frac{1}{\beta(1-\mu)}}\left(\frac{\left(1-\mu\right)\left(1-\beta\right)}{w}\right)^{\frac{1-\beta}{\beta}} q^{\frac{1+\beta(1-\mu)}{\beta(1-\mu)}} \tag{3}$$

A solo self-employed individual will have access to the same production technology, but the only labor input will be their level of skill (operational skill and quality of entrepreneurial decisions at the same time). The production function of the solo self-employed individual is given by:

$$Y = k\theta qq^{1-\mu}K^{\mu} = k\theta q^{2-\mu}K^{\mu} \tag{4}$$

The parameter $k \leq 1$ accounts for the possibility that the lack of specialization penalizes the productivity of the solo self-employed relative to that of firms with employees.

The maximum revenue, net of the cost of capital services, of a solo self-employed with skill q is given by:

$$R^{*}\left(q\right) = \left(1-\mu\right)\left(k\theta\left(\frac{\mu}{c}\right)^{\mu}\right)^{\frac{1}{1-\mu}} q^{\frac{2-\mu}{1-\mu}} \tag{5}$$

A person with skill q working as an employee will earn a salary equal to

$$S = wq \tag{6}$$

Minimum wage

Let S_{min} denote the legally established minimum wage that an employer must pay to a hired employee. For a market price per unit of skill w^{*}, employers will only hire individuals with skills above the value of q_0, given by q_0=max$\left(\frac{S_{min}}{w^{*}}, 0\right)$

Throughout this paper, individuals with skills lower than q_0 will be assumed to work as solo self-employed (SSE). They will be called "involuntary" solo self-employed individuals (ISSE) to differentiate them from other (voluntary) solo self-employed individuals (VSSE) who have enough skills to work as employees but earn more income as self-employed individuals.

Market equilibrium conditions and calibrated values of the parameters

The market equilibrium from occupational choices will satisfy two conditions: no individual will have an incentive to change occupation, and the supply of operational skills for individuals who choose to work as employees is equal to the entrepreneur–managers' demand for operational skills. The system of equations for the equilibrium is as follows:

$$q_0 = S_{\min}/w^{*} \tag{7}$$

$$w^{*}q_1 = \left(1-\mu\right)\left(k\theta\left(\frac{\mu}{c}\right)^{\mu}\right)^{\frac{1}{1-\mu}} q_1^{\frac{(2-\mu)}{(1-\mu)}} \tag{8}$$

$$\left(k\theta\left(\frac{\mu}{c}\right)^{\mu}\right)^{\frac{1}{1-\mu}} q_2^{\frac{(2-\mu)}{(1-\mu)}} = \beta\left(\theta\left(\frac{\mu}{c}\right)^{\mu}\right)^{\frac{1}{\beta(1-\mu)}}\left(\frac{\left(1-\mu\right)\left(1-\beta\right)}{w^{*}}\right)^{\frac{(1-\beta)}{\beta}} q_2^{\frac{1+\beta(1-\mu)}{\beta(1-\mu)}} \tag{9}$$

$$\begin{aligned}\frac{1}{2}\left(\frac{k^{\frac{1}{1-\mu}}}{\beta}\right)^{\frac{1}{1-\beta}} q_2^{\frac{-1}{\beta(1-\mu)}} e^{\lambda\left(1+\frac{1}{\beta(1-\mu)}\right)+\frac{\sigma^2}{2}\left(1+\frac{1}{\beta(1-\mu)}\right)^2}\left(1+Erf\left[\frac{\lambda+\sigma^2\left(1+\frac{1}{\beta(1-\mu)}\right)-\ln[q_2]}{\sigma\sqrt{2}}\right]\right) = \\ = \frac{1}{2}q_2^{\frac{-1}{\beta(1-\mu)}} e^{\lambda+\frac{\sigma^2}{2}}\left(Erf\left[\frac{\lambda+\sigma^2-\ln\left[S_{\min}/w^{*}\right]}{\sigma\sqrt{2}}\right] - Erf\left[\frac{\lambda+\sigma^2-\ln[q_1]}{\sigma\sqrt{2}}\right]\right)\end{aligned} \tag{10}$$

Eqs. (7), (8) and (9) give, respectively, the minimum level of skills to be hired as an employee, q_0, the skill that makes an individual indifferent between working as an employee and as a voluntary solo self-employed individual, and the level of skill that makes an individual indifferent between working as voluntary solo self-employed and as an entrepreneur–manager. Eq. (10) sets the condition of supply $\int_{q_0}^{q_1} q\,dG\left(q\right)$ equal to the demand $\int_{q_2}^{\infty} Q\left(q;w^{*}\right)dG\left(q\right)$ of operational skills

[5] The supplementary material shows more details about the production function, the solution to the profit-maximizing problem, and the characterization of the equilibrium.

of employees, substituting $Q(q;w^*)$ with the demand for the operational skill of an entrepreneur–manager with skill q and the market price of skill w^* from the profit-maximizing conditions (problem (2), see supplementary material for more details).

This system has no closed-form solution, so to analyze the properties of the equilibrium, we need to solve it numerically to ascertain the calibrated values of the exogenous parameters (λ, σ, β, θ, μ, k, c and S_{min}).

The values of four parameters (λ, θ, μ, c) are set exogenously. The parameter in the production function θ and the location parameter of the distribution of skills λ are normalized to 1 and 2, respectively. The user cost of capital is set to a value of $c = 0.12$, (depreciation rate of 8% and real financial cost of capital of 4%, realistic for a representative OECD country). The elasticity of output to capital services μ is set equal to the estimate of the share of the cost of operating capital assets over gross value added (from profit maximization conditions), $\mu = \frac{cK}{Y} = 0.25$, also realistic for OECD economies. The scale economies of production $(1-\beta)(1-\mu)+\mu$ have been set equal to 0.7, lower than the 0.8 for the US economy (Guner et al., 2008), considering that the relative importance of large firms in the US will be higher than in the representative OECD country. Solving for β in $(1-\beta)(1-0.25)+0.25 = 0.7$, we have $\beta = 0.4$. The remaining parameters (σ, k and S_{min}) are obtained from the market equilibrium conditions using data for sizes of different occupational groups from over 31 OECD countries in 2019 (the last year before the COVID-19 pandemic).[6] The entrepreneur–managers of the model are matched with employers and managers in the empirical data.[7] Salaried employees in nonmanagerial jobs are those who occupy operational jobs, accounting for approximately 80% of the working population; employers and managers represent approximately 8%. The remaining 12% include solo self-employed and unemployed individuals. The calibrated values of the rest of the parameters that (approximately) replicate these average sizes of occupational groups are $\sigma = 0.39$, $k = 0.67$, and $S_{min} = 50$ (see Medrano-Adán et al., 2019 for more details about the calibration process). Solving the model for the calibrated values of the parameters yields the following cutoff levels of skill that determine the indifferent points of occupational choice in Eqs. (7) to (10), $q_0 = 3.72$, $q_1 = 10.89$, $q_2 = 12.79$, and the equilibrium price per unit of skills, $w^* = 13.42$.

The profits of entrepreneur–managers, the income of the solo self-employed and the salaries of employees in operational jobs, from Eqs. (3), (5) and (6), are given by:

$$\Pi^*(q) = 0.00339q^{13/3}, \quad q \geq q_2 = 12.79 \tag{11}$$

$$R^*(q) = 0.56\,q^{7/3}, \quad q \leq q_0 = 3.31 \quad \text{or} \quad q_1 = 10.89 \leq q \leq q_2 = 12.79 \tag{12}$$

$$S^*(q) = 13.42q, \quad q_0 = 3.31 \leq q \leq q_1 = 10.89 \tag{13}$$

Fig. 1 shows the graphical representation of the market equilibrium from the representation of the compensation of individuals in each occupational group as a function of their respective level of skill—from Eqs. (11) to (13), as well as the distribution of skills in the population.

3. Comparative static analysis: The effect of a minimum wage on employment and output

This section examines how the market equilibrium output and employment from occupational choices adjust to changes in the minimum wage for the values of the parameters calibrated above with data from the (average) representative OECD country. For clarification purposes, the exposition starts with an explanation of how the market equilibrium unit price of operational skill is determined with and without a minimum wage, represented graphically in Fig. 2.

The aggregate demand function depends on the price (w) per unit of operational skill. If this price increases, the demand for skills will decrease for two reasons: there is a reduction in the demand for skills by the firms that continue to operate in the market, and there are fewer entrepreneurs in the market (as w goes up, some of the less-skilled entrepreneurs will change occupation). Mathematically, the aggregate demand function of operational skills may be written as:

$$D(w) = \frac{1}{2}\left(\theta\left(\frac{\mu}{c}\right)^{\mu}\right)^{\frac{1}{\beta(1-\mu)}}\left(\frac{(1-\mu)(1-\beta)}{w}\right)^{\frac{1}{\beta}} e^{\left(1+\frac{1}{\beta(1-\mu)}\right)\left[\lambda+\left(1+\frac{1}{\beta(1-\mu)}\right)\frac{\sigma^2}{2}\right]} \times\left(1+Erf\left[\frac{\sigma^2+\beta(1-\mu)(\lambda-\log[q_2])}{\beta(1-\mu)\sigma\sqrt{2}}\right]\right)$$

where q_2 depends on w and determines the number of entrepreneurs in equilibrium (if w goes up, q_2 increases and the number of entrepreneurs decreases).

[6] List of countries: Austria, Belgium, Brazil, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Korea, Republic of, Latvia, Lithuania, Luxembourg, Mexico, the Netherlands, Norway, Poland, Portugal, the Russian Federation, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States.

[7] We have combined data from Eurostat on self-employment (https://ec.europa.eu/eurostat/databrowser/view/LFSA_ESGAED/default/table?lang=en), the OECD on the distribution of labor force (https://stats.oecd.org/Index.aspx?DataSetCode=ALFS_POP_LABOUR), the ILO on "employment by sex, status in employment and occupation" (https://www.ilo.org/shinyapps/bulkexplorer57/?lang=en&segment=indicator&id=EMP_TEMP_SEX_STE_OCU_NB_A), and the World Bank on wage and salaried workers (https://data.worldbank.org/indicator/SL.EMP.WORK.ZS), Self-employed (https://data.worldbank.org/indicator/SL.EMP.SELF.ZS), and Employers (https://data.worldbank.org/indicator/SL.EMP.MPYR.ZS).

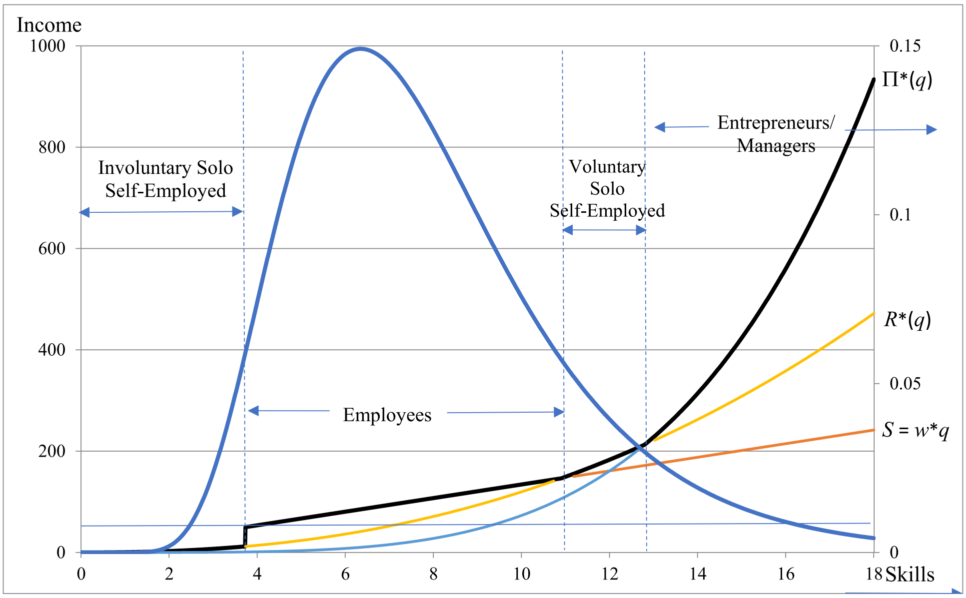

Fig. 1. Graphical representation of the occupational choice equilibrium for the calibrated values of the model parameters.
Note: The bell-shaped curve represents the probability density function of the distribution of skills, $g(q)$. The curves $\Pi^*(q)$, $R^*(q)$, and w^*q represent the profits of entrepreneur–managers, the income of the solo self-employed, and the salaries of employees in operational jobs, respectively. The black curve is the income in equilibrium (upper envelope of $\Pi^*(q)$, $R^*(q)$, and w^*q, given the minimum wage $S_{\min}$).

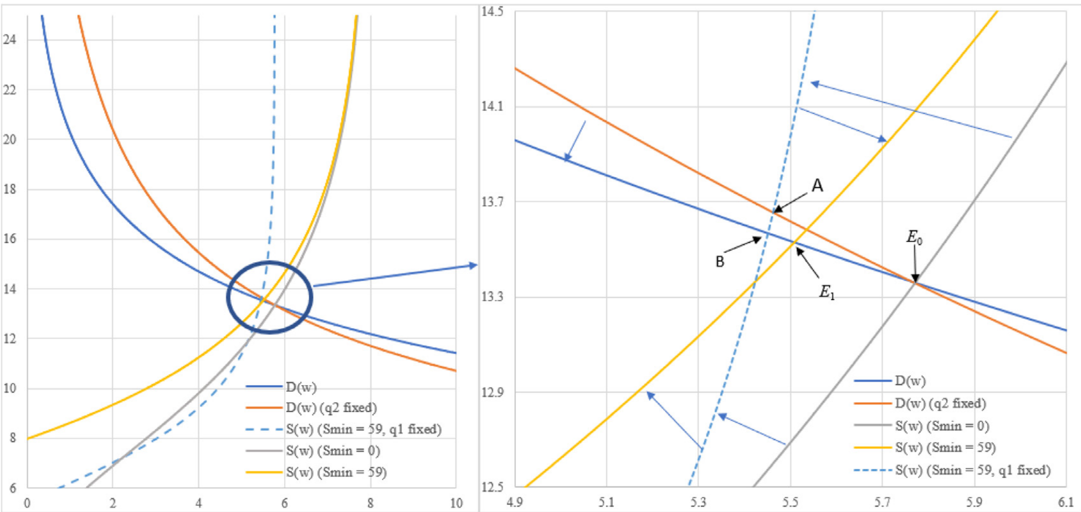

Fig. 2. Effect of minimum wage on aggregate labor demand and supply (horizontal axis) as functions of the unit price of skill w (vertical axis) for the calibrated values of the parameters of the model.
Note: The left picture shows a panoramic view of labor demand and supply, and the right picture presents a closer image of the area around the equilibrium.

The aggregate supply function depends directly on the skill price (w) through its impact on the minimum level of skill required to be hired as an employee and indirectly through the effect of w on the number of self-employed (if w goes up, some of the less-skilled voluntary self-employed will prefer to become salaried employees). Mathematically, the aggregate supply function may be written as:

$$S(w)=\frac{1}{2}e^{\lambda+\frac{\sigma^2}{2}}\left(Erf\left[\frac{\lambda+\sigma^2-\ln[S_{\min}/w]}{\sigma\sqrt{2}}\right]-Erf\left[\frac{\lambda+\sigma^2-\ln[q_1]}{\sigma\sqrt{2}}\right]\right)$$

where q_1 depends on w and its value determines the number of voluntary self-employed in equilibrium (if w increases, q_1 increases, too, i.e., some of the former less-skilled voluntary self-employed individuals become salaried employees).

When the minimum wage is first introduced or it is increased, the demand and supply functions move toward the left (decrease), and as a result, the equilibrium value of the skill price and the number of skills demanded by the entrepreneurs in the equilibrium decrease (Fig. 2). Without a minimum wage, the market equilibrium is represented by point E_0, where the aggregate supply for operational skills (gray line) equals the aggregate demand (orange line). When a minimum wage is introduced ($S_{min} = 59$), the following developments occur:

1. The aggregate supply of operational skill shifts to the left, from the gray line to the flashing blue line. With a minimum wage, individuals with skill less than q_0 lose their jobs as operational employees. If the other cutoff skill values q_1 and $q_2$did not change, the aggregate demand curve $L(w)$ would not change either, and the reduction in supply would cause a "large" increase in the price of skill w, with the equilibrium moving from E_0 to point A.
2. The increase in w causes shifts in both aggregate demand and supply (indirect effects) due to changes in the occupational choices of (some) entrepreneurs, voluntary solo self-employed individuals, and employees in response to the increase in the price of skill.

    a. First, as the price of skill w rises, q_2 increases; that is, some firms close, and their respective entrepreneurs join the group of voluntary solo self-employed. The reduction in the number of firms reduces the aggregate demand from the orange curve to the continuous blue one, with a new equilibrium B.
    b. Second, the higher price of skill in the new equilibrium than in the equilibrium without a minimum wage induces some voluntary self-employed (the least skilled) individuals to become salaried workers (q_1 increases). At the same time, the lower demand for operational skill from a reduction in the number of entrepreneurs reduces the equilibrium price of skill compared with that if the demand had not adjusted downward, which reduces the number of individuals who lose their jobs as employees. These effects in combination shift the aggregate supply to the right, from the flashing blue curve to the yellow one.

3. Overall, the initial direct effect (point 1 above) together with the indirect effects (point 2) imply that the introduction of a minimum wage changes the equilibrium from E_0 to E_1 in Fig. 2. In the new equilibrium, the number of salaried employees in operational jobs is lower than in the equilibrium without minimum wage because those who shift from employees to involuntary solo self-employed are more numerous than those who change their occupation from voluntary self-employed to salaried workers (attracted by the increase in the price per unit of skill, w).
4. In summary, the introduction of or an increase in a minimum wage reduces the aggregate demand and the aggregate supply of operational skill and increases the equilibrium price of skill. The higher price of skill reduces the number of entrepreneurs/firms, the number of voluntary solo self-employed (there are more initial voluntary solo self-employed that shift to salaried employees than entrepreneurs that shift to voluntary solo self-employed), and the number of employees (those that shift to involuntary solo self-employed are more than the number of initial voluntary solo self-employed that shift to employees). An increase in the minimum wage increases the size of the group of involuntary solo self-employed. An economy-wide minimum wage has effects that go beyond those of wages on the employment of low-wage employees and extend throughout the economy.

Effects on selected endogenous variables

This section examines the effects of the minimum wage on the equilibrium values of the price of operational skill, output, and sizes of occupational groups from the values shown in Table 1.[8] The first five columns in the table show the equilibrium values of the selected endogenous variables for different values of the minimum wage variable. The remaining columns in Table 1 (on the right) show the calculated elasticities of the equilibrium variables to a 1% increase in the minimum wage in the respective column, keeping the rest of the parameters at their base case value. Table 1 is complemented with Fig. 3, which shows the percentage change in the equilibrium value of the respective endogenous variable when changing from no minimum wage to the respective minimum wage expressed in terms of KI value (percentage of the equilibrium average salary). For instance, from the gray curve corresponding to the number of persons occupied as employees in the equilibrium, the point (60%, −10%) indicates that with a minimum wage equal to 60% of the average salary of employees, the number of employees in the equilibrium will be 10% lower than the number of employees without a minimum wage.

The first result worth highlighting from Table 1 and Fig. 3 is that up to approximately 40% of the mean salary of employees, the introduction of a minimum wage hardly modifies the equilibrium values of the endogenous variables (column two). For values above 40% of the average salary, the effects of a minimum wage on the equilibrium values of the endogenous variables can be substantial, increasing more than proportionately with the starting level of this salary. Manning (2021) refers to research in the United States that found that minimum wages had higher and nonlinear effects on employment for a KI above 0.6, consistent with what could be expected from Fig. 3.

Increases in the minimum wage, involving a higher KI, increase the equilibrium price per unit of skill: 0.036 (0.27%) increase in the price of skill if the KI increases from 0.4 to 0.5, and a 0.125 (0.94%) increase if KI changes from 0.5 to 0.6.

[8] More details of the calculations, including the mathematical expressions used in the calculation of the endogenous variables in Sections 3 and 4 can be found in the supplementary material.

Table 1
Equilibrium values and elasticities of occupational and output variables to changes in the minimum wage, keeping the rest of the parameters at their base case value, for different ranges of the Kaitz index (minimum-to-average wage ratio).

	Equilibrium without minimum wage	Equilibrium values of selected endogenous variables (for various levels of the minimum wage)				Arc elasticity values of selected endogenous variables with respect to the minimum wage[a]		
Kaitz ratio	0.0	0.40	0.50	0.60	0.70	0.4 to 0.5	0.5 to 0.6	0.6 to 0.7
Minimum wage	0.0	37.0	47.0	59.0	77.0	37 to 47	47 to 59	59 to 77
Involuntary SSE (ISSE)	0.00%	0.60%	2.83%	8.87%	22.94%	13.73	8.37	5.20
Voluntary SSE (VSSE)	8.11%	8.10%	8.05%	7.88%	7.37%	−0.023	−0.082	−0.213
(All) SSE	8.11%	8.70%	10.9%	16.7%	30.3%	0.926	2.115	2.654
Employees	83.8%	83.2%	81.1%	75.5%	62.7%	−0.093	−0.271	−0.555
Employers	8.14%	8.12%	8.05%	7.78%	7.01%	−0.036	−0.128	−0.324
Employees per employer	10.29	10.24	10.08	9.70	8.94	−0.058	−0.147	−0.257
Unit price operational skill. w	13.36	13.37	13.40	13.53	13.92	0.010	0.037	0.095
(Total) output	190.0	189.8	188.8	185.6	177.2	−0.020	−0.066	−0.148
Productivity without ISSE	186.4	187.4	190.5	198.9	219.7	0.063	0.172	0.342
Mean salary	92.0	92.5	94.2	98.7	109.9	**0.068**	0.186	0.371
Mean profit	631.4	631.7	633.2	638.3	654.8	0.009	0.032	0.085
Mean income involuntary SSE	0.00	4.60	7.64	12.00	19.21	2.436	2.240	1.967
Mean income voluntary SSE	173.3	173.5	174.3	177.1	186.1	0.017	0.063	0.166

[a]Arc elasticities are calculated assuming a discrete change in the minimum wage given by the initial and final values shown in row 2. For instance, if the minimum wage changes from 37 to 47 (equivalently, the KI changes from 0.4 to 0.5), the arc elasticity of the mean salary of employees to the minimum wage (0.068, shown in bold in the table) is the percentage change in the mean salary divided by the percentage change in the minimum wage. If the initial value of the minimum wage is 37 and increases to 47, the mean salary increases from 92.5427 to 92.5782; thus, the arc elasticity reported in the table is $\left(\frac{94.247-92.543}{92.543}\right) / \left(\frac{47-37}{37}\right) = 0.068$. This number means that, on average, for each percentage point of increase in the minimum wage (in the interval from 37 to 47), the mean salary has increased 0.068%.
SSE, ISSE and VSSE stand for solo self-employed, involuntary solo self-employed, and voluntary solo self-employed, respectively.

Consequently, the average salary of employees increases by 1.84% and 4.76%, respectively. Therefore, the (discrete) arc elasticity of the average salary of employees to the increase in the minimum wage is 0.068 and 0.186, respectively.[9] The arc elasticity increases more than proportionately if the increase in the minimum wage has a starting KI = 0.4 than if it has a starting KI = 0.5. Assessing the likely impact of minimum wage increases on economic outcomes will very much depend on the KI of the economy at the time of the increase.

The change in the minimum wage and the induced shifts in the equilibrium price of skill and the salaries of employees have an impact on the relative *sizes of occupational groups*. An increase in the KI from 0.40 to 0.50 reduces the proportion of employees by 2.1 percentage points, while the proportion of individuals working as involuntary solo self-employed (and/or unemployed) multiplies almost by five from 0.60% to 2.83% of the labor force. When KI rises from 0.50 to 0.60, the number of employees in the equilibrium decreases by 5.6 percentage points. This fall is the net result of the employees who shift to involuntary solo self-employed (6% of the labor force) and those voluntary solo self-employed who become employees (0.4% of the labor force) after the increase in the minimum wage. Finally, the group of voluntary solo self-employed increases due to low-skilled entrepreneurs (0.2% of the labor force) who change their occupation to become solo self-employed, as the higher price of skill after the minimum wage increase reduces profits below the income earned as solo self-employed.

From these results, the arc elasticities of the number of employees to changes in the minimum wage are −0.093 and −0.27 for a starting KI of 0.4 and of 0.5, respectively. The elasticity of employees to changes in the average salary induced by the change in the minimum wage would be −0.093/0.068 = −1.37 and −0.27/0.186 = −1.45. In the case of voluntary solo self-employed individuals, the arc elasticities to changes in the minimum wage are −0.023 with an initial KI of 0.40 and −0.082 with an initial KI of 0.50. For the involuntary self-employed, the elasticities are 13.7 and 8.37.

The change in the number of employees due to the rise in the minimum wage is the combined effect of (i) the reduction in the number of entrepreneur–managers that hire employees (extensive margin); (ii) the reduction in the number of employees hired by the entrepreneurs that continue as such after the rise in the minimum wage, (intensive margin); and (iii) the voluntary solo self-employed that become employees. For example, if the minimum wage is increased from a KI of 0.4 to 0.5, the number of entrepreneur–managers decreases by 0.96%, while the number of employees per entrepreneur drops by 1.58% for a total decrease of −2.52% in the number of employees. The intensive margin effect appears to be slightly more important than the extensive one in explaining the decrease in employees due to increases in the minimum wage.

The minimum wage reduces the total *output* produced, and the reduction increases with the starting level of the minimum wage relative to the mean salary: −0.54% if the KI increases from 0.4 to 0.5, and −1.69% when the KI goes from

[9] The discrete (arc) elasticities are calculated as the percentage change in the endogenous variable under consideration divided by the percentage change in the minimum wage, assuming that the KI changes from 0.4 to 0.5 (i.e., the minimum wage changes from 37.0 to 47.0, a change of 27.03%) or from 0.5 to 0.6 (i.e., the minimum wage changes from 47.0 to 59.0, a change of 25.53%). For example, the (discrete) arc elasticity of the average salary of employees to the increase in the minimum wage is given by $\left(\frac{94.25-92.55}{92.55}\right) / \left(\frac{47.00-37.00}{37.00}\right) = 0.068$.

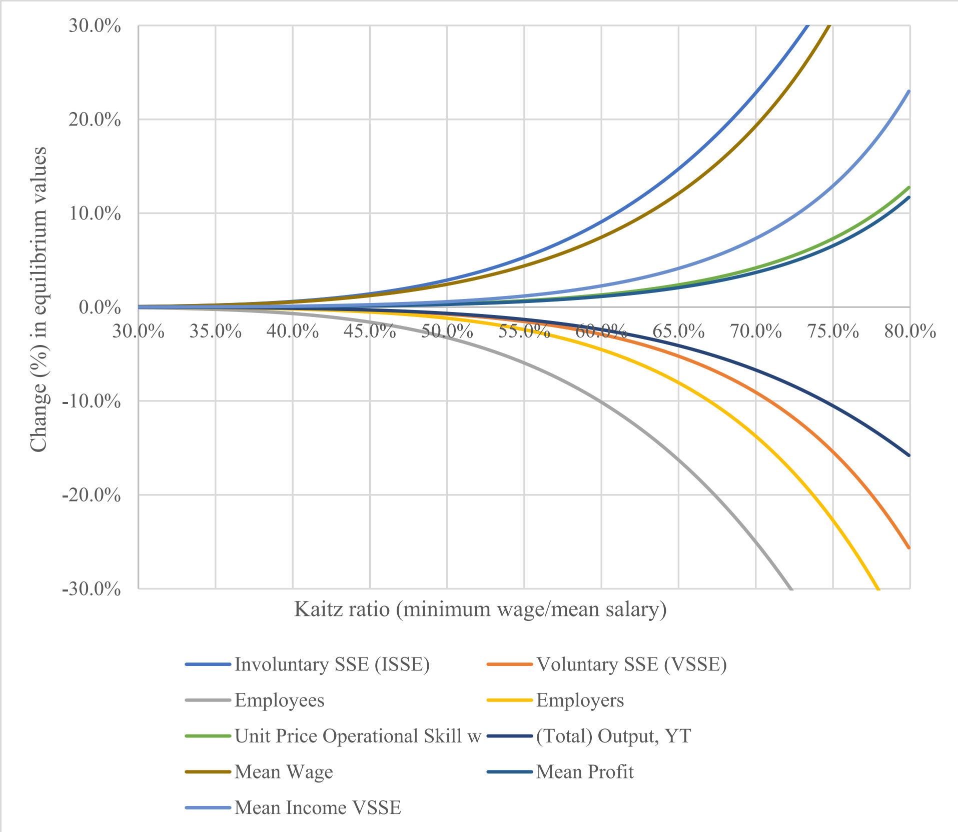

Fig. 3. Effects of a minimum wage on selected occupational and output variables.
Notes: The horizontal axis represents the Kaitz index (minimum-to-average wage ratio), and the vertical axis shows the percentage change in the equilibrium value of each selected endogenous variable when moving from the equilibrium without a minimum wage to the equilibrium with a minimum wage for the level of the Kaitz index in the horizontal axis.

0.5 to 0.6. Since, by assumption, all individuals in the economy are active (with or without a minimum wage), the change in output is equal to the change in average labor productivity. If the employees who lost their jobs were left unemployed instead of becoming involuntarily self-employed, the average productivity per occupied person would increase with the minimum wage (Table 1). The increase in average labor productivity is explained by the fact that the average skill of the employed in the economy with a sufficiently high minimum wage will be higher than the average skill of the employed in the economy without a minimum wage (the employees who lose their jobs after the minimum wage increase are the less skilled).

The occupational group with the highest *average per capita income* in the market equilibrium is that of entrepreneur–managers, followed by the voluntary solo self-employed, the employees, and the involuntary solo self-employed (the last one at a great distance). The order of occupied groups by average per capita income is the same as the ranking by average skill per capita, with the difference that in the group of employees, the per capita income increases proportionately with the skill, while in groups of entrepreneur–managers and solo self-employed, the income is an increasing and convex function of skill. The increase in the minimum wage causes an increase in the average salary of employees, in the average income of the solo self-employed, and in the average profit of entrepreneur–managers. In relative terms, the highest increase occurs in the per capita income of the involuntary solo self-employed, followed at a long distance by the mean salary of employees. The increase in the minimum wage raises the average income in all occupational groups because it changes the size and composition of the groups in such a way that the average skill within each occupational group is higher in the new equilibrium than in the old one.

Note also that with the increase in the minimum wage, the average salary, profit, and income of the voluntary solo self-employed each increase relatively less than the relative decrease in the number of occupied persons in these groups (in the case of employees, for example, 1.8% and 4.8% increases in per capita income, compared with decreases by 2.5% and 6.9% in the number of employees, for initial values of the KI of 0.4 and of 0.5, respectively). The minimum wage will then result in a decrease in the total income of all occupational groups, except for the involuntary solo self-employed group, in which it will increase.

Comparing the theoretical predictions with the evidence

Table 1 and Fig. 3 make clear that the same relative change in the minimum wage will have different effects on employment and output, depending on the initial KI value. The numbers in Table 1 are arc elasticity values from changes in the minimum wage for different values of the initial KI. In some cases, the impact of minimum wages is expressed in terms of point elasticities (the slope of the lines in Fig. 3 at each KI value), and it is important to have a sense of their magnitude. For instance, the point elasticity of output to minimum wage when KI = 0.6 is 11 times higher than when KI = 0.4.[10] The empirical studies on the effects of a minimum wage rarely report the KI of reference, which complicates the comparison between the empirical results and the theoretical predictions. There are, however, cross countries and over time data of KIs published by the OECD, which can be used as a general reference.[11] In 2020, for example, the KIs ranged from 0.21 in the United States (federal) to 0.61 in Colombia. The KIs of the large European economies of Germany, France, and Spain were 0.45, 0.49, and 0.46, respectively, values for which the theory predicts a moderate sensitivity of economic variables to changes in the minimum wage (Fig. 3).

A second consideration in comparing the results predicted based on the theory with the empirically observed ones is that for small relative changes in the minimum wage, the economic effects may be difficult to detect with standard econometric analysis (differences of differences, for example) because they will be small, there will be noise in the data, and the effects may by blurred by simultaneous changes in other exogenous variables. For example, the model predicts that if the minimum wage increases from 50% to 51% of the mean salary, the equilibrium price per unit of skill will increase by 0.022% and the number of employees will decrease by 0.19%. Note also that what matters for the effect of changes in the minimum wage is the KI, not the absolute value of the minimum wage. The KI ratio can change even though the minimum wage remains unchanged if an exogenous shock modifies the average wage in the economy.

The empirical evidence mostly reports a nonpositive estimated elasticity of employment to increases in the minimum wage (wage) in the range of −0.3 to 0 (Brown et al., 1982; Belman and Wolfson, 2014; Neumark and Shirley, 2021). The range is sufficiently wide to include the estimated employment elasticity from KI = 0 to KI = 0.60 in Table 1 and in Fig. 3. Therefore, even though the occupational choice model is a highly stylized representation of the real world, it can reasonably accommodate the results of empirical studies.[12]

Table 2 of Beaudry et al. (2018) decomposes the demand for employment as a function of wages in extensive (changes of entrepreneurs in response to shifts in wages) and intensive (change of employees per entrepreneur) margins.[13] The estimated elasticity of the number of entrepreneurs to wages of employees is −0.86, while the elasticity of the demand of employees to wages controlling for the number of entrepreneurs is not statistically significant. Therefore, in that research, only the extensive margin effect was significant. The estimated elasticity of employment to wages in that study is −1.05 (Table 1 of their paper). The arc elasticities of employees to the average salary from increases in the minimum wage are −1.37 (if KI increases from 0.4 to 0.5) and −1.45 (if KI increases from 0.4 to 0.5). These elasticities would be approximately equal to the sum of the arc elasticity of employees per entrepreneur to average salary, −0.85 and −0.79, and the arc elasticity of entrepreneurs to the average salary, −0.52 and −0.68. The predictions from the model are reasonably consistent with the empirical results, even though the model assumes an economy without frictions.

In the calculation of the estimated effects of planned increases in the minimum wage in the city of Seattle, Beaudry et al. (2018) assumed a gradual transition in the increase in the minimum wage between 9.32 dollars per hour to 15 dollars per hour (14 at constant prices), a real increase of 43%, from 2014 until 2019. After the adjustment process was completed, their paper estimated a reduction in employment rate of −4.55 percentage points (from an initial value of 71.2%) when considering only the wage effect and of −2.1 points when including the congestion (frictions) effect (Table 8 of their paper). The occupational choice model assumes no frictions, so the only relevant effect for comparisons is the first one. The relative decrease in employment when the adjustment is completed is −0.064 (−4.55/71.2); since the increase in minimum wage is 43%, the elasticity of employment to the rise in the minimum wage is −0.148 (−0.064/0.43). Their study also estimated a change in the average wage after the adjustment in the increase of minimum wage was completed of 9.8%, that is, an elasticity of average to minimum wage of 0.23. According to the model, the point elasticity of employees to minimum wage (not reported in Table 1) ranges from −0.051 (KI = 0.4) to −0.192 (KI = 0.5), and the point estimate elasticity of average salary to minimum wage ranges from 0.038 (KI = 0.4) to 0.295 (KI = 0.6), or to 0.132 for KI= 0.5. The elasticities estimated by Beaudry et al. (2018) fall in the range of values predicted by the theory.[14]

10 The point elasticities of output to minimum wage are −0.117 if KI = 0.6 and −0.010 if KI = 0.4; the former is 11 times higher than the latter. However, the arc elasticities of output to minimum wage (reported in Table 1) are −0.148 if KI increases from 0.6 to 0.7 and −0.020 if KI increases from 0.4 to 0.5; the former is 7.4 times higher than the latter.

11 Source:https://stats.oecd.org/Index.aspx?DataSetCode=MIN2AVE.

12 Differences in results across individual studies are manifest; for example, Meer and West (2016) found that a minimum wage had statistically and economically significant negative effects on employment, while Cengiz et al. (2019) and Harasztosi and Lindner (2019) identified low net aggregate positive effects on employment. In 2018, the Spanish government increased the minimum wage for the whole economy by 22%. Barceló et al. (2021, 37) estimated an elasticity of employment to the rise in the minimum wage of between −0.03 and −0.05. The OECD published a KI = 0.34 for Spain in 2017 before the increase in the minimum wage, while according to Table 1 when the KI = 0.4 the elasticity of employees to the minimum wage is −0.051. The prediction based on the model is then broadly consistent with the data.

13 Beaudry et al. (2018) estimated labor demand functions using industry- and city-level US data. They found that "the number of entrepreneurs involved in creating jobs in a city moves proportional to the size of the city" (2177). In our occupational choice model, the size of the labor market is normalized to 1 and the sizes of occupational groups in the equilibrium increase proportionately with the size of the market, which means an elasticity of entrepreneur–managers to the size of the market equal to 1.

14 In comparing the empirical estimates with the theoretically predicted from the model, we should be cautious because the model has been calibrated for a representative OECD country, not for the labor market in Seattle.

Table 2
Equilibrium values and elasticities of inequality variables to changes in the minimum wage, keeping the rest of the parameters at their base case value, for different ranges of the Kaitz index (minimum-to-average wage ratio).

	Equilibrium without minimum wage	Equilibrium values of selected endogenous variables (for various levels of the minimum wage)				Arc elasticity values of selected endogenous variables with respect to the minimum wage[a]		
Kaitz ratio	0.0	0.40	0.50	0.60	0.70	0.4 to 0.5	0.5 to 0.6	0.6 to 0.7
Minimum wage	0.0	37.0	47.0	59.0	77.0	37 to 47	47 to 59	59 to 77
Gini index. GI (global)	0.406	0.407	0.413	0.431	0.470	**0.054**	0.166	0.298
GI employees	0.164	0.161	0.153	0.137	0.111	−0.189	−0.413	−0.619
GI employers	0.446	0.446	0.445	0.443	0.436	−0.006	−0.020	−0.052
GI self employed	0.06	0.12	0.29	0.49	0.56	4.920	2.717	0.468
P90/P10 wage employees	2.24	2.22	2.13	1.95	1.71	−0.149	−0.323	−0.412
P90/P50 wage employees	1.42	1.41	1.40	1.38	1.32	−0.028	−0.075	−0.133
P50/P10 wage employees	1.58	1.57	1.52	1.42	1.29	−0.122	−0.253	−0.291
P90/P10 income	3.18	3.18	3.17	3.14	10.35	−0.010	−0.036	7.532
P90/P50 income	1.93	1.93	1.92	1.90	1.85	−0.010	−0.036	−0.092
P50/P10 income	1.65	1.65	1.65	1.65	5.60	0.000	0.000	7.846
%Income low 10%	3.53%	3.42%	2.90%	1.25%	0.95%	−0.557	−2.228	−0.783
%Income top 1%	15.4%	15.4%	15.4%	15.5%	15.5%	0.005	0.012	0.011

[a]Arc elasticities are calculated assuming a discrete change in the minimum wage given by the initial and final values shown in row 2. For instance, if the minimum wage changes from 37 to 47 (equivalently, the KI changes from 0.4 to 0.5), the arc elasticity of the Gini index to the minimum wage (0.054, shown in bold in the table) is the percentage change in the Gini index divided by the percentage change in the minimum wage. If the initial value of the minimum wage is 37.0 and increases to 47, the Gini index increases from 0.0407 to 0.413; thus, the arc elasticity reported in the table is $\left(\frac{0.413-0.407}{0.407}\right) / \left(\frac{47-37}{37}\right) = 0.054$. This number means that, on average, for each percentage point of increase in the minimum wage (in the interval from 37 to 47), the Gini index has increased 0.054%.

Drucker et al. (2021), using data from Israel, found that small firms with lower profitability and lower income for entrepreneurs, and probably lower-skilled entrepreneurs as well, exited the market following increases in the minimum wage. Waltman et al. (1998) also identified a positive association between business failure rates and increases in the minimum wage. Alexandre et al. (2022), utilizing Portuguese data, confirmed that the rise of the minimum wage had a positive effect on firms' exit, especially among financially distressed firms, and reduced employment growth. This evidence would be consistent with the predictions from the occupational choice model. Draca et al. (2011), employing UK data, studied the impact of minimum wages on firm profitability, employment, and productivity as well as on the entry and exit rates of firms in different markets. They noted that following an increase in the minimum wage, wages increased across the board and firms' profitability decreased, which is consistent with the predictions from the model. They also discovered higher exit rates and lower entry rates for new firms across industries after the introduction of the minimum wage compared with previous trends. However, they did not find evidence that firms reduce employment following a rise in the minimum wage. Bossler and Gerner (2020) estimated an elasticity in labor demand from increases in average wages induced by the introduction of a minimum salary in Germany between −0.2 and −0.4, which is in line with the results of Caliendo et al. (2018).

Bassanini and Venn (2008) estimated the effect of a minimum wage (together with that of other labor market regulations) on productivity levels and growth with data from 11 OECD countries and found that the minimum wage increased productivity but not productivity growth. Sabia (2014a) did not find robust evidence of the effects of minimum wage on aggregate gross domestic product in the US, although there was evidence that an increase in the minimum wage changed the composition of output: it reduced the relative output in industries with relatively more low-skilled employees and increased it in those with fewer low-skilled employees. Alexandre et al. (2022) claim that the increase in the minimum wage in Portugal may have had a "cleansing" effect, with lower productivity firms exiting the market and the average productivity of the remaining ones increasing afterwards. The occupational choice model can accommodate these pieces of evidence: An increase in the minimum wage will result in a new market equilibrium involving fewer firms with employees. The firms that exit the market will be those with less-skilled entrepreneurs, and therefore, overall, the firms that continue operating will have more-skilled entrepreneurs and will be more productive than those before the increase in the minimum wage.

4. Comparative static analysis: Minimum wage and income inequality

The effect of the minimum wage on income inequality will be the result of the effect on the price per unit of skill and the effect on the composition and size of the occupational groups, which will affect the within-group distribution of skills. Table 2 and Fig. 4, equivalent to Table 1 and Fig. 3 above, report equilibrium values of endogenous variables on income inequality measures and arc elasticity estimates of changes in the equilibrium values of the endogenous inequality measures due to an increase in the minimum wage. Again, the economically relevant sensitivity of income inequality to minimum wage starts for KI values of 0.4.

The minimum wage slightly increases the overall Gini index due to the distribution of labor income. For example, according to the blue curve in Fig. 4, the point (60.5%, 6.1%) indicates that going from an economy with no minimum

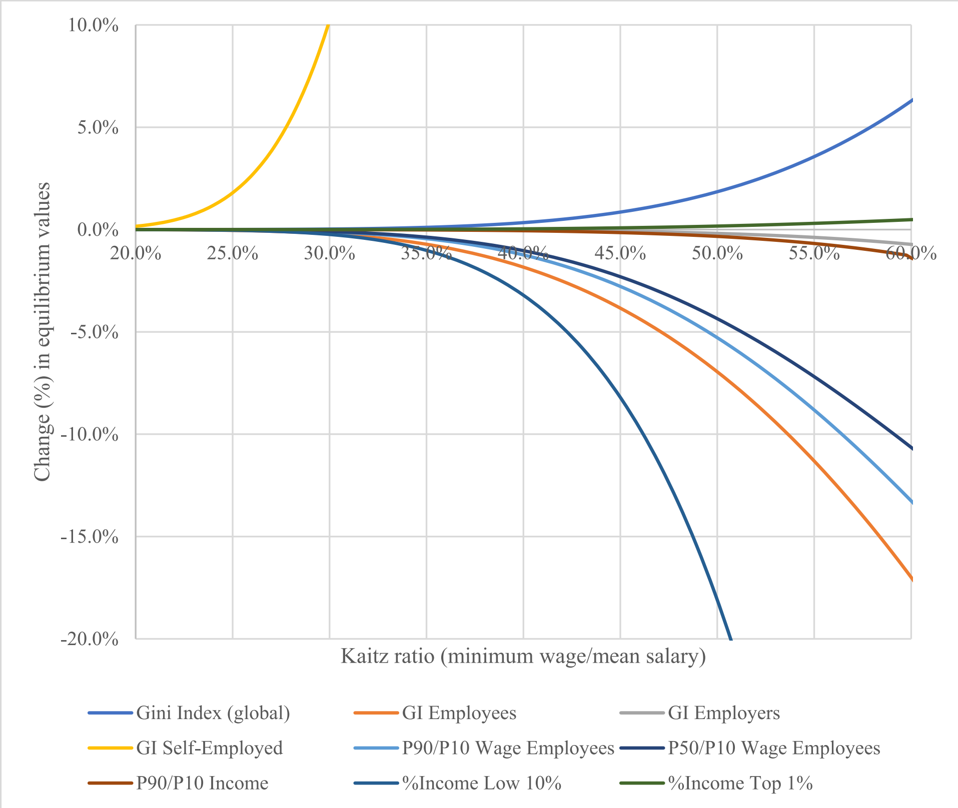

Fig. 4. Effects of a minimum wage on selected inequality variables.
Notes: The horizontal axis represents the Kaitz index (minimum-to-average wage ratio), and the vertical axis shows the percentage change in the equilibrium value of each selected endogenous variable when moving from the equilibrium without a minimum wage to the equilibrium with a minimum wage for the level of the Kaitz index in the horizontal axis.

wage to an economy with a minimum wage equal to 60% of the mean salary, the Gini index for the entire population will increase by 6.1%. Point elasticities (not reported in Table 2) but also arc elasticities (Table 2) confirm that, beyond a relative minimum wage, their absolute values increase more than proportionately as the minimum wage increases. For instance, an increase of 1% when the minimum wage is 37 (KI = 0.4) implies an increase in the Gini index of 0.027% (point elasticity of 0.027), but the same 1% increase with KI = 0.6 results in an increase in the Gini index of 0.263%, almost 10 times larger (point elasticity of 0.263).

There are, however, important composition effects: the Gini index increases in the income distribution within the group of solo self-employed individuals, especially in the group of involuntary ones; it is practically constant (for the range of minimum wages considered) in the group of entrepreneur–managers, and it decreases in the group of employees. For example, the Gini index of the salary of employees decreases by 5.1% when KI increases from 0.4 to 0.5 and by 10.6% when KI increases from 0.5 to 0.6. In the solo self-employed group, the respective relative changes in the Gini indexes are +133% and +69.4%. The explanation for these results is that the rise in the minimum wage implies a reduction in the dispersion of skills within each occupational group – except in the group of involuntary solo self-employed individuals in which dispersion increases – and an increase in the average skill level within the occupational group for all groups.

The elasticity of the ratio of percentile incomes PX/PY to increases in the minimum wage is negative in the distribution of income within the group of employees and negative or zero in the distribution of income in the whole occupied population. Consider, for example, the P50/P10 ratio within the group of employees. Since the income of an employee is equal to the price per unit of skill times its level of skill, the ratio of incomes will be equal to the ratio of skills, q50/q10 (the price of skill in numerator and denominator cancels out). The negative elasticity of the ratio P50/P10 to the increase in the minimum wage is explained by the negative effect of the increase in the minimum wage on the ratio q50/q10 within the group of employees, resulting from the compression in the within-group distribution of skills after the increase in the minimum wage. The same can be said about the response of the ratio P90/P50 of the income distribution of employees.

The results in Table 2 allow for a comparison of the sensitivity of the upper and lower parts of the distribution of skills and incomes of the employees in response to changes in the minimum wage. The rise from KI = 0.4 (0.5) to KI = 0.5 (0.6) implies a reduction in the P90/P50 ratio of 0.75% (1.92%) and a reduction of 3.30% (6.45%) in the P50/P10 ratio. Therefore, the compression in the bounds of skills within the employees after the rise in the minimum wage mainly affects the lower tail of the distribution: the low-skilled employees that lose their jobs and become involuntarily solo self-employed after the rise in minimum wage.

When the ratio of percentile incomes is calculated for the whole occupied population, the effect of the increase in the minimum wage on the value of the ratio will also depend on whether or not the minimum wage changes the occupational group of the person in the respective percentile. As said before, if P90 and P10 correspond to the incomes of persons who are both occupied as employees, then the ratio of incomes will be equal to the ratio of skills. However, if the P90 is a voluntary solo self-employed individual or an entrepreneur–manager, the price per skill for this person increases with the level of skill, and therefore, the ratio of incomes also depends on the level of skill. According to Table 2, the P50/P10 of the distribution of income of the entire population does not change with changes in the minimum wage, indicating that the individuals in the P50 and the P10 income percentiles are employees. On the other hand, the P90/P50 ratio of the income distribution slightly decreases with the rise in the minimum wage, indicating that the income of the P50 increases more than the income of the P90. The increment in P50 is the immediate result of the growth in the price per unit of skill after the increase in the minimum wage. The person in the P90 is a voluntary solo self-employed individual, and the income will depend on the level of skill, which does not change with the minimum wage.

Since the person in the P10 of the income distribution for the entire population is an employee in the range of minimum wages in which the comparative static analysis is performed, all involuntary solo self-employed individuals will belong to the group of people who earn an income lower than the P10. An increase in the minimum wage will increase the average income of individuals in the low 10th percentile of the distribution, but the total income of the group as a percentage of the total income will decrease (Table 2). The reason for this is that the loss of income of the total number of employees that shift to solo self-employed after the increase in the minimum wage is greater than the increase in the income of all the employees that continue in the low decile of the income distribution after the increase in the minimum wage (and consequently increase the price of skill). At the other end of the income distribution, the percentage of income in the top 1% does not change in practical terms with the minimum wage.

These results have implications for the effect of minimum wages on poverty. It is established that a person is in *poverty* if their income with regard to any concept is less than or equal to 60% of the median income of the reference group. In our analysis, the reference group is the entire population, and the only income that people receive is from working as an employee, as solo self-employed, or as entrepreneur–manager. In economies with sizes of occupational groups such as those of the core OECD countries, in the absence of a minimum wage, both the person with an income equal to the median of the distribution and the person with an income equal to 60% of the median income will be employees. Since their respective incomes will be the market price per unit of operational skill times their respective skill levels, the ratio of incomes will be the ratio of skills.

When there is a minimum wage, the price per unit of operational skill will increase, but the proportion of people in poverty will be the same as it was without a minimum wage, as long as the minimum wage does not change the occupation of the person with the median income and/or the occupation of the person with an income of 60% of the median. That is, as long as the two individuals continue to be employees. For the calibrated values of the parameters of the occupational choice model, the proportion of people in the situation of poverty is 10% and will continue at this proportion for all minimum wages equal to 0% to 60% of the median salary. What the minimum wage will change is the composition of the group of persons in poverty, their average incomes, and the proportion of income from poor people in the total income. As explained above, the increase in the minimum wage will increase the proportion of involuntary solo self-employed in the group of people in a situation of poverty, and although their average income will increase, the proportion of the income of people in poverty over total income will decrease. The reason is that for those who continue as employees, the increase in compensation from the rise in the price of operational skill does not compensate for the fall in the income of the employees who lost their jobs.

The political economy of the minimum wage

Fig. 5 shows the income of the individuals in each occupation as a function of the skill level in three economies, one with no minimum wage and the others with minimum wages of 60% and 70% of the mean salary. The comparison of the income functions allows us to identify the winners and losers when a minimum wage is introduced, which can be relevant to explaining why the minimum wage tends to receive wide political support as an economic policy. The results from the comparisons are summarized as follows. When KI = 0.6 compared to when there is no minimum wage at all, the following holds:

- The less-skilled individuals (those with $q < 4.36$) lose their jobs and become involuntarily self-employed. These individuals are less than 10% of the population, and in relative terms, their income decreases by more than 87%.
- All the individuals who were employees and who keep their jobs (those with $4.36 \leq q < 10.96$) obtain the same increase in salary of 1.3%; they represent more than 75% of the entire population.
- All the individuals who were voluntary self-employed and did not change occupation (those with $10.96 \leq q < 12.75$, 8% of the population) are not affected by the introduction of the minimum wage (they earn the same income as before).
- All the entrepreneurs who do not change occupation (those with $q > 12.87$, 7.8% of the entire population) experience a reduction in their profit/income of 1.9%.

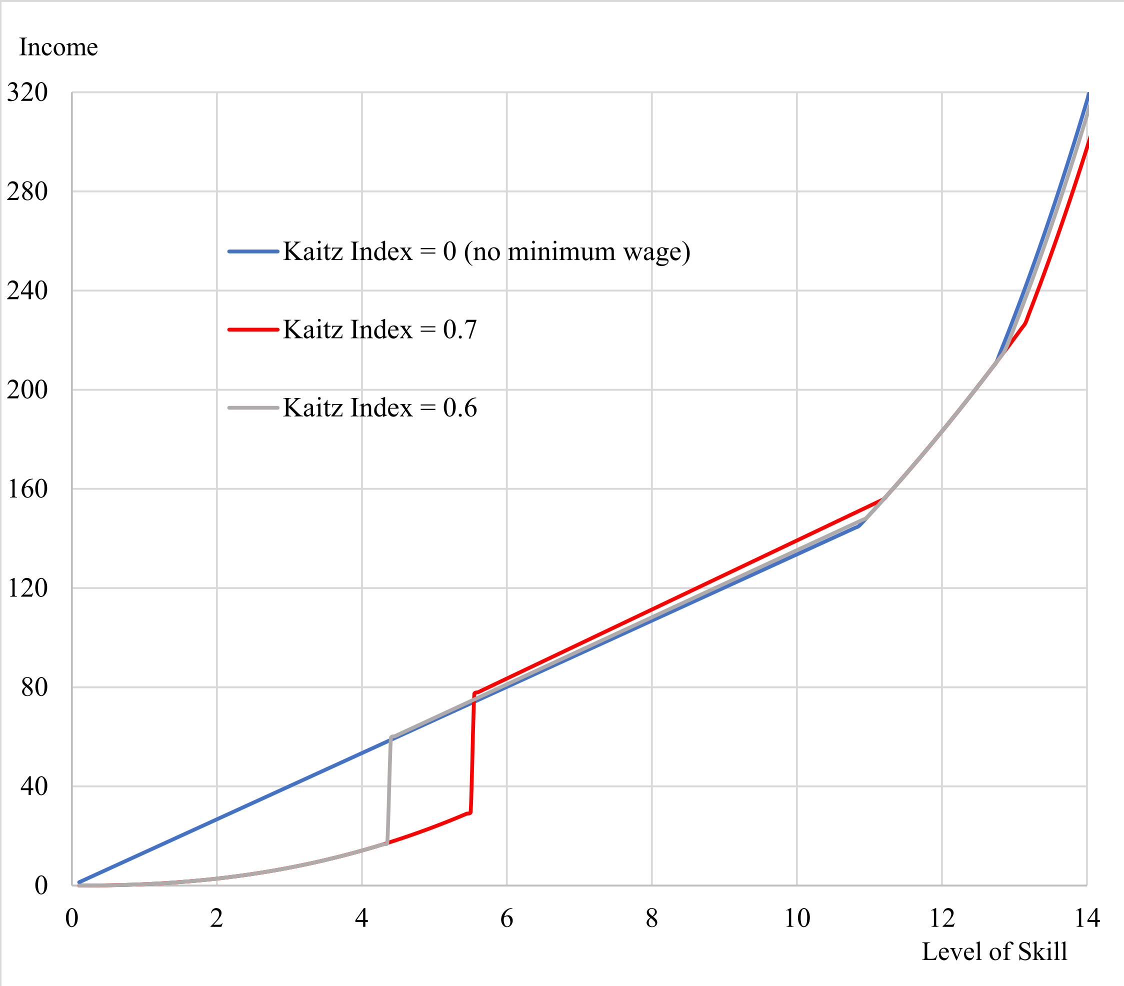

Fig. 5. Income as a function of skill without (blue line) and with a minimum wage (gray and red lines). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

- Finally, there are a small proportion of individuals who change occupations from voluntary self-employed to employees (earning, on average, approximately 0.7% more) and from entrepreneurs to voluntary self-employed (earning, on average, 1% less).

In summary, with the introduction of a minimum wage, income increases for a large majority of the population who continue to work as employees and decreases in a larger amount for individuals in both tails of the income distribution. The net effect on overall income inequality is positive; that is, the Gini index increases with the minimum wage because the main loss of income is concentrated in low-skilled individuals who lose their jobs as employees.

Evidence from empirical research

Several papers have investigated the effect of minimum wage regulations on the evolution of earnings inequality in the US (DiNardo et al., 1996; Lee, 1999; Autor et al., 2016), particularly in the evolution of the P90/P50 and P50/P10 ratios of the distribution of wages of employees. Lee (1999) concluded that the reduction of the minimum wage in real terms in the United States has historically contributed to the increase in wage inequality in the country, particularly through an increase in the P50/P10 ratio. Autor et al. (2016) used a different empirical methodology and estimated a lower impact from the reduction in the real minimum wage in the ratio P50/P10 and argued that the polarization of wages in the United States is mainly due to the increase in the P90/P50 ratio. They argued that technological factors, such as skill-based technological changes, have been more important than institutional factors as determinants of the documented wage polarization in the US (Autor et al., 2008; Acemoglu and Autor, 2011; Autor, 2014).

The occupational choice model predicts that, for example, the ratio of wages P50/P10 of employees will be a ratio of skills, q_{50}/q_{10}, because the unit price of skill is canceled out.[15] This means that the minimum wage will affect the ratio of wages in the lower and upper tails of the distribution only if changes in the minimum wage affect the distribution of skills of the individuals who choose to work as employees in operational jobs. In the short term, when the distribution of general skills in the population is given, this can only occur if the minimum wage affects the lower and/or upper bound of operational skills that determine the indifference between working as an employee or as voluntary or involuntary solo self-employed individuals. Over time, the distribution of general skills and the lower and upper bounds of skills in the distribution of skills among operational employees can change for reasons other than changes in the minimum wage, for example, for technological reasons.

According to Table 2 and with a given distribution of skills, the occupational choice model predicts an increase in the P50/P10 ratio when the real minimum wage decreases as well as a less-pronounced increase in the ratio P90/P50. Therefore, the occupational choice model does not explain the observed persistent increase in the P90/P50 ratio of the distribution of wages over time in the US. The wage polarization observed in the US according to the occupational choice model could be explained by the changes in the distribution of skills, as well as the evolution of an occupational group not considered thus far. The model assumes that the group of entrepreneur–managers includes only entrepreneurs with salaried employees and managers in top management positions, when in reality there are also managers in intermediate hierarchical positions. The income of these intermediate managers will be increasing and convex with their skill (Rosen, 1982). The intermediate managers will appear in the official statistics as salaried employees, and it could be that the percentile P90 of the distribution of wages corresponds to a person in a management position. The ratio P90/P50 could now increase over time as the "price" per unit of general skill in management positions also rises. This could happen, for example, because organizational size diseconomies decrease over time.

Card and Krueger (1995) did not find a relationship between minimum wage increases and the reduction of poverty rates in the US and justified this result with the argument that most people who live in poverty do not work. Sabia (2014b, 1031) noted "that past minimum wage increases have been largely ineffective at reducing poverty rates …" and argued that there are more efficient alternatives for reducing poverty. Neumark and Wascher (2008, Chapter 5), after reviewing the evidence, concluded that some low-income families gain as a result of higher minimum wages, but others lose because of diminishing employment opportunities; overall, low-income families are made worse off. After a review of the literature, Sabia (2015, 9) concluded that "There is little evidence that minimum wage increases reduce poverty among low-skilled workers during economic recessions", an observation that is similar to the findings of MaCurdy (2015) and consistent with the predictions from the theoretical model (in recessions the average salary will decrease and the KI ratio will increase if the minimum wage is not adjusted downward).

5. Conclusion

Occupational choice models provide new and relevant insights into the expected effects of minimum wage changes on output, employment and income inequality. In addition to quantifying these effects for the economy as a whole, the model can identify the effects for individuals with different skills and assess them separately for each occupational group (employees, solo self-employed and entrepreneur–managers). Although the occupational choice model presented in this paper is highly stylized, the predictions of how market equilibrium outcomes change in response to changes in the minimum wage can reasonably accommodate the efficiency and distributional effects of minimum wages measured in empirical research. Moreover, the analysis identifies the lower bound of the KI, 0.4, for the effects of the minimum wage to start being economically meaningful, while they grow rapidly as the KI approaches 0.6. For example, with an initial KI of 0.4, a 10% increase in the minimum wage reduces total output by 0.13%, employment by 0.64%, and the Gini index of employees' wages by 1.45% and increases the Gini index (of total population income) by 0.35%; with a KI of 0.55, output falls by 0.87%, employment by 3.55%, and the Gini index of employees' wages by 5.19% and increases the Gini index (of total population income) by 2.09%.

These findings are important because the KIs vary widely across economies and over time; therefore, the same percentage change in the minimum wage may have no effect at all if the initial KI is low and a significant effect if the initial KI is high. This may also explain why some empirical studies fail to find statistically significant effects of minimum wage changes (when the KI value in the observation period is low, our research predicts small effects; not statistically significant for available econometric techniques). The recommendation then is that empirical studies on the efficiency and distributional effects of minimum wages report the levels of KI around which the minimum wage changes are evaluated.

The prediction from the occupational choice model that minimum wages will reduce output and employment and will increase the average labor productivity of those that continue in the same occupational group has been confirmed by several empirical studies, including Seok and You (2022), for the group of employees with Korean data. The model shows that this happens because the relative increase in average productivity of those who remain in their initial occupational

[15] A higher minimum wage implies a higher price per unit of operational skills in the equilibrium, and for this reason, all employees in operational jobs, whether with low or high skills, will experience the same proportional increase in salaries. Beaudry et al. (2018) found that the wage effect in the demand for employment is similar in people with different educational (skill) levels, which would be consistent with the predictions from the model.

group after the introduction of the minimum wage is lower than the relative number of individuals who move to an occupational group with a lower average productivity (including the low-skilled employees who lose their job). The model also clarifies why low-skilled individuals are more productive as employees than as involuntary solo self-employed individuals: as employees, their productivity is enhanced by the complementary input of the entrepreneur–managers in joint production at the job level; as solo self-employed individuals, the labor input is limited to their respective level of skill.

The results of this paper can also explain the evidence questioning the effectiveness of the minimum wage in fighting poverty (Neumark and Wascher, 2008). Without a minimum wage, all people in poverty (with an income below 60% of the median) will be occupied as employees. When there is a minimum wage, those in poverty who keep their jobs will see their incomes increase, but those who lose their jobs and become involuntary solo self-employed (or unemployed) will see their incomes decrease. Overall, the model predicts that the introduction of a minimum wage will reduce the share of total income generated in the economy that goes to people in poverty, exactly the opposite of what is intended. This prediction coincides with the finding of Holtemöler and Pohle (2020) using German data: "low-wage employees who are still employed are better off (with the minimum wage) at the expense of those who lose their jobs". Moreover, the relatively large reduction in the market labor income of the low-skilled individuals who lose their jobs as employees explains why the overall Gini index of the distribution of the market labor income rises with the minimum wage. The real winners of the minimum wage policy are those individuals who remain employees (wage earners), by far the largest occupational group in middle- and high-income countries, which may explain why the minimum wage policy attracts much political attention and support despite its failure to deliver its purported results.

The complementarity of different labor institutions recommends that the effects of introducing a minimum wage be evaluated within the cluster of all the labor market institutions of the economy (Obadić et al., 2023). This paper adds new recommendations on the proper way to assess the impact of policy decisions on minimum wages, including the choice of the "adequate" relative minimum wage for a given country. In an official document, the Council of the European Union refers to indicators used at the international level of minimum wages of 60% of the median wage and 50% of the mean wage (https://data.consilium.europa.eu/doc/document/ST-9142-2021-INIT/en/pdf). The results of the paper show that for these reference values, the efficient and distributional effects of minimum wages can be important and that the importance can vary across economies depending on the respective values of the parameters of the model, such as the distribution of skill and the production and organization technologies. Future research will examine in more detail how variations in the parameters of the occupational choice model determine different equilibrium outcomes in economies with similar KI ratios.

Supplementary material: Calculation of the market equilibrium

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.eap.2023.08.009.

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