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Abstract

This paper sets up a two-country model of offshoring with monopolistically competitive product and monopsonistically competitive labour markets. In our model, an incentive for offshoring exists even between symmetric countries, because shifting part of the production abroad reduces local labour demand and allows firms to more strongly execute their monopsonistic labour market power. However, offshoring between symmetric countries has negative welfare effects and therefore calls for policy intervention. In this context, we put forward the role of a common minimum wage and show that the introduction of a moderate minimum wage increases offshoring and reduces welfare. In contrast, a sizable minimum wage reduces offshoring and increases welfare. Beyond that, we also show that a sufficiently high common minimum wage cannot only eliminate offshoring but also inefficiencies in the resource allocation due to monopsonistic labour market distortions in closed economies.

JEL-Codes: F120, F160, F230, J420.

Keywords: offshoring, minimum wage, welfare effects.

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1 Introduction

"*When minimum wages are moderate and well designed, adverse employment effects can be avoided.*" OECD (2018, p.72)

Minimum wages have regained prominence in the context of labour market policy over recent years, with the introduction of a statutory minimum wage in Germany in 2015 and the recent decision of several US states to increase existing minimum wages being two prominent examples. From a theoretical point of view, it is clear that minimum wages can have positive employment and wage effects in the presence of monopsonistic market power: If firms face positively sloped labour supply curves, they have an incentive to constrain employment in order to keep labour costs from rising. As a consequence, firms are too small and too many of them enter the market from a social planner's point of view (see Robinson, 1933; Manning, 2003). A well-designed minimum wage can provide remedy for the monopsonistic distortion in the labour market, increase employment and wages, and therefore lead to higher welfare.

In this paper, we contribute to the literature on minimum wages in monopsonistic labour markets by focussing on the effect of minimum wages in open economies. In doing so, our aim is to shed light on potential effects of a recent directive of the European Parliament and European Council to introduce a common framework "*for setting adequate statutory minimum wages, [...] and enhancing the effective access of workers to minimum wage protection*" (European Commission, 2023, p. 7), which we interpret as a political attempt to establish coordinated minimum wage policies in open economies. For our analysis, we embed the monopsonistic labour market in a deliberately stylised trade model in the spirit of Krugman (1979, 1980) with two identical economies, in which a large number of firms uses labour as the only factor input to produce differentiated goods under monopolistic competition. Beyond assuming a non-standard labour market, we deviate from the textbook version of the Krugman model by considering offshoring instead of final goods trade as the form of international market integration. As we will show below, minimum wages have a particularly interesting – and previously unnoticed – role in this case.

To provide a microfoundation for the monopsonistic labour market distortion, we follow McFadden (1976), Thisse and Toulemonde (2010), and Card et al. (2018) and assume that beyond their pecuniary utility from the wage payment, workers also receive an idiosyncratic non-pecuniary job utility, which is firm-specific.[1] Workers choose employment in the firm that offers the highest utility. If a firm wants to hire more workers, it has to offer higher wages to all its workers in order to compensate marginal applicants for their lower non-pecuniary utility. This mechanism establishes

[1] Card et al. (2018) mention workplace location and workplace culture as two important non-pecuniary utility aspects of a job.

a positive link between labour supply and wages at the firm level. As we have shown in Egger et al. (2022), hiring workers from two segmented labour markets lowers local labour demand and therefore allows firms to more strongly execute their monopsony power. It follows that offshoring has a cost-reducing effect, even if firms are active in symmetric countries.

In the benchmark case without a minimum wage, we reproduce the important insight from previous research that monopsonistic competition in the labour market distorts the resource allocation in a closed economy, leading to excessive entry and to firms that are too small. Offshoring reinforces this distortion in resource allocation. As a consequence, it is wasteful and in our model unambiguously generates a welfare loss.[2] Due to the existence of iceberg trade costs for the intra-firm imports of intermediates, firms hire less than half of their workforce abroad, and with foreign plants smaller than home plants as a result, they pay lower wages to their workers in offshore production than to their workers onshore. Due to the existence of this wage gap, there is a range of values of the minimum wage for which it is binding for offshore production but not for onshore production.

We show that a sufficiently low minimum wage in this range, somewhat counterintuitively, leads to more offshoring although it increases the remuneration of offshore workers. The key to understanding this effect is the well-established result that a binding minimum wage takes away the cost penalty of higher employment that is typical for monopsonistically competitive markets. The positive effect of avoiding this cost penalty counteracts the direct negative effect of increasing wages at low levels of the minimum wage (see Manning, 2003). The logic is similar in our offshoring model. However, with the minimum wage only binding for offshore employment, the *relative* cost of expanding foreign employment is reduced, making wasteful offshoring more attractive for firms.

Introducing a minimum wage that is just binding for offshore labour has no consequences for offshoring or welfare since firms are constrained by the labour supply in their offshore location. The effect of the minimum wage is entirely absorbed by the shadow price measuring the marginal profit of increasing offshore employment. Increasing the minimum wage lowers the shadow price of foreign labour supply, increases offshore employment, and lowers welfare. This process continues until the shadow price of foreign labour supply falls to zero. While at this point a further increase of the minimum wage continues to lower labour demand and to increase labour supply, the additional labour supply has no value to the firm, so that the higher wage paid to foreign workers makes production shifting less attractive and therefore reduces offshoring.

Since offshoring is wasteful, less of it increases welfare. Manning (2003) introduces the terms

[2] The welfare implications of offshoring are more benign in the heterogeneous firm model studied by Egger et al. (2022), where the negative effect of a stronger labour market distortion is counteracted by a beneficial reallocation of labour from less productive to more productive firms, which, if strong enough, may induce positive welfare effects of offshoring.

supply-constrained and *demand-constrained* firms to distinguish outcomes with positive and zero shadow prices of labour supply. In our offshoring model, this distinction has the additional interpretation of separating the subintervals of minimum wages, in which a further increase of them is welfare-reducing or welfare-enhancing.

As a final result of our analysis we show that there is another threshold, at which the common minimum wage eliminates the incentive for offshoring and, at the same time, becomes binding for domestic employment. In this case, a further increase in the minimum wage raises domestic employment of firms, which are now supply-constrained in their home market. The increase in the minimum wage lowers the shadow price of domestic labour supply and increases welfare up to a point in which the minimum wage reaches the real wage in a Krugman-type model without monopsonistic labour market distortions.[3] This equilibrium is reached at a point at which the shadow price of domestic labour supply falls to zero, while firm-level labour demand equals firm-level labour supply.

Our analysis contributes to a growing literature studying the effects of international trade in models with monopsonistic labour market distortions (see MacKenzie, 2017; Holzner and Larch, 2021; Jha and Rodriguez-Lopez, 2021; Egger et al., 2022; Heiland and Kohler, 2022; Pham, 2023). Most closely related to our model, Jha and Rodriguez-Lopez (2021) and Egger et al. (2022) consider a static model, in which monopolistic competition prevails in the product market whereas monopsonistic competition prevails in the labour market and in which the microfoundation of the monopsonistic labour market distortion is based on Thisse and Toulemonde (2010) and Card et al. (2018). In contrast to them, we consider homogeneous firms and analyse the effects of minimum wages. The role of minimum wages in open economies has been addressed in the seminal contributions of Brecher (1974) and Davis (1998). Egger et al. (2012) introduce minimum wages in a new trade theory model with monopolistic competition and heterogeneous firms. These papers have been concerned with the question of how differences in the level of minimum wages affect international trade and welfare, while abstracting from monpsonistic distortions in the labour market.[4]

Our analysis also contributes to the theoretical research on offshoring. Thereby, most of the existing literature focuses on offshoring between asymmetric countries explaining the cost-saving

[3] It is well understood from Dixit and Stiglitz (1977) that when imposing a utility function with constant elasticity substitution, which we do, the resource allocation in the Krugman model is efficient. See Benassy (1996) and Dhingra and Morrow (2019) for further discussion of this result.

[4] Ahlfeldt et al. (2022) study the role of minimum wages in a quantitative spatial model along the lines of Redding and Rossi-Hansberg (2017), relying on a monopsonistically competitive labour market model similar to Egger et al. (2022). In an application for Germany, they show that the introduction of a nation-wide statutory minimum wage in 2015 has increased welfare by two percent. Similar to Ahlfeldt et al. (2022), our model not only speaks to welfare effects but also to the distributional consequences of minimum wages. Well in line with recent evidence reported by Dustmann et al. (2022), we thereby show that raising minimum wages reduces the wage gap, which arises in our model between offshore and onshore employment.

motive of firms by fundamental differences of countries in production technology or factor endowment (see Kohler, 2004; Grossman and Rossi-Hansberg, 2008; Rodríguez-Clare, 2010; Egger et al., 2015). However, empirically most of the offshoring activities are observed between similar countries (see Alfaro and Charlton, 2009, for evidence). There is only a small number of papers that provides an explanation for offshoring of this type, with prominent examples including Grossman and Rossi-Hansberg (2012) and Antràs et al. (2017). Egger et al. (2022) point to the important role of monopsonistic labour market distortions for explaining cost-saving offshoring between two fully symmetric countries. This is the mechanism that is also considered in our analysis. However, in contrast to Egger et al. (2022) we consider homogeneous instead of heterogeneous firms which makes costly offshoring always a wasteful activity.

The remainder of this paper is organised as follows. In Section 2, we introduce the main ingredients of our model and analyse the effects of offshoring in a setting with two symmetric countries featuring monopolistic competition in the product market and monopsonistic competition in the labour market. In Section 3, we introduce a common minimum wage and analyse its effects on offshoring and welfare. Section 4 concludes with a summary of the most important results and a brief discussion of potential extensions of our model.

2 A model of offshoring with monopsonistic labour markets

We consider offshoring in a model with two symmetric countries, with each country being populated by $N > 0$ workers. Firms are identical, and they are active in monopolistically competitive goods markets and monopsonistically competitive labour markets. We start by analysing the optimisation problem of a single firm and then embed the solution into general equilibrium.

2.1 The firm's problem

Production requires a fixed input of $f > 0$ units of services. The firm procures this input from a perfectly competitive service sector at a given unit price $s > 0$, which is exogenous to the firm and determined in general equilibrium. The firm also hires labour for the production process, with one unit of labour producing one unit of a tradable intermediate, which in turn is the sole input into production of non-tradable output y, with an input coefficient that also equals one. The firm can split the production of intermediates between the home and the foreign economy, and because it faces upward-sloping labour supply functions in both markets it has an incentive to do so. For intermediates produced offshore, an iceberg-type trade cost has to be incurred to import them to the home economy for assembly of y, and therefore $\tau > 1$ units of the foreign-produced intermediate are required per unit of output y.

In the goods market, the firm faces an iso-elastic demand function, which is given by $q = A_q p^{-\sigma}$ with $\sigma > 1$ as the the absolute value of the constant price elasticity of demand, p as the price set by the firm, and A_q as a demand shifter that is exogenous to the firm but endogenous in general equilibrium. In the labour market, the firm faces an upward-sloping supply function, which is given by $l = A_l w^{\varepsilon}$, with $\varepsilon > 0$ as the wage elasticity of labour supply, w as the firm's wage rate, and A_l as a supply shifter comprising labour market conditions that are exogenous to the individual firm but endogenous in general equilibrium. Due to our assumption of symmetric countries, the firm faces the same labour supply curve in its home and in its foreign market. In the subsequent, we use an asterisk to indicate variables associated with foreign employment and to distinguish them from variables associated with home employment.

The firm maximises operating profits, π, by choosing labour input for onshore and offshore production, ℓ and ℓ^*, respectively, subject to its goods demand and labour supply functions, its technology $\ell + \ell^* = y$, and the market-clearing conditions, $y = q$, $\ell = l$, and $\tau\ell^* = l^*$. The profit-maximisation problem of the firm is therefore given by

$$\max_{\ell,\ell^*} \pi = A_q^{\frac{1}{\sigma}} \left(\ell + \ell^*\right)^{\frac{\sigma-1}{\sigma}} - A_l^{-\frac{1}{\varepsilon}} \left(\tau\ell^*\right)^{\frac{1+\varepsilon}{\varepsilon}} - A_l^{-\frac{1}{\varepsilon}} \ell^{\frac{1+\varepsilon}{\varepsilon}}. \tag{1}$$

In an interior equilibrium with positive firm-level employment in home and foreign, the first-order conditions establish (making use of the labour supply curves) the following pricing rule:

$$w = \tau w^* = \frac{\varepsilon}{1+\varepsilon}\frac{\sigma-1}{\sigma}\, p, \tag{2}$$

with $\sigma/(\sigma-1)$ as the constant markup of prices over marginal costs and $(1+\varepsilon)/\varepsilon$ as the constant markdown of average variable labour costs on marginal labour costs. An interior solution therefore requires equal labour costs in home and foreign, $w = \tau w^*$, with the relative employment for offshore and onshore production pinned down by the two labour supply curves according to $\ell^*/\ell = \tau^{-1-\varepsilon}$. Combining goods demand, domestic labour supply, and the price-setting rule in Eq. (2), we can express the employment in onshore production as follows

$$\ell = \left[\frac{\sigma-1}{\sigma}\frac{\varepsilon}{1+\varepsilon}\left(\frac{A_q}{A_l}\right)^{\frac{1}{\sigma}}\left(1+\tau^{-1-\varepsilon}\right)^{-\frac{1}{\sigma}}\right]^{\frac{\varepsilon\sigma}{\varepsilon+\sigma}} A_l. \tag{3}$$

Substituting Eqs. (2) and (3) into the operating profits in Eq. (1), we can finally solve for

$$\pi = \frac{\sigma+\varepsilon}{\varepsilon(\sigma-1)}\left(1+\tau^{-1-\varepsilon}\right) w\ell, \tag{4}$$

which completes our discussion of the firm's problem.

2.2 The market equilibrium

Free entry of firms establishes $\pi = sf$, which in view of Eq. (4) gives a relationship between firm level variables w and ℓ and the three general equilibrium variables A_q, A_l, and s. These general equilibrium variables are determined next. To solve for demand shifter A_q, we follow Dixit and Stiglitz (1977) and Krugman (1980) in assuming that consumers have preferences over differentiated goods that can be represented by a utility function of the following form: $U = \left[\sum_{i=1}^{M} q_i^{(\sigma-1)/\sigma}\right]^{\sigma/(\sigma-1)}$, where U is utility of the representative agent, q_i is consumption of variety i, and $\sigma > 1$ equals the constant elasticity of substitution between the differentiated varieties. We use utility as our numéraire, setting the price of one unit of utility equal to one. In this case, utility equals aggregate consumption expenditures, and utility maximisation gives the iso-elastic demand function introduced in Section 2.1, with the demand shifter equal to economy-wide utility (or income) $A_q = U$.

To determine supply shifter A_l, we follow McFadden (1976), Thisse and Toulemonde (2010), and Card et al. (2018) and assume that employment in firms results as a solution of a discrete choice problem of workers, who aim to maximise a logarithmic utility function of the following form: $v_i(\omega) = \ln w_i + b_i(\omega) - \bar{b}$, where w_i is the wage rate paid by firm i and $b_i(\omega)$ is an idiosyncratic, non-pecuniary workplace preference of worker ω, which is drawn from a Type-I extreme value (Gumbel) distribution with mean zero and scale parameter ε, given by $F(b) = \exp(-\exp[-\varepsilon b])$, and $\bar{b}$ is a common utility shifter that is explained in further detail below. The probability of worker ω to choose employment in firm i equals the probability that the firm offers the highest utility level. As formally shown in Appendix A.1, this probability can be expressed as

$$\text{Prob}[v_i(\omega) \geq \max\{v_i(\omega')\}] = \frac{w_i^{\varepsilon}}{\sum_{i=1}^{M_t} w_i^{\varepsilon}}, \tag{5}$$

where M_t is the total number of home plus foreign firms offering production jobs in the home market. The solution in Eq. (5) determines worker ω's labour supply to firm i in probabilistic form. Multiplying Eq. (5) by the mass of workers seeking employment in the production sector, L_m, then gives total firm-level labour supply in Section 2.1, with $A_l = L_m / \left(\sum_{i=1}^{M_t} w_i^{\varepsilon}\right)$.

Before continuing with our discussion of the general equilibrium, it is worth noting that the *ex ante* expected utility of workers seeking employment in production firms can be expressed as $\mathbb{E}[v_i(\omega)] = \ln w_i + \mathbb{E}[b_i(\omega)] - \bar{b}$, with $\mathbb{E}[b_i(\omega)] = (1/\varepsilon) \ln \sum_{i=1}^{M_t} w_i^{\varepsilon} - \ln w_i - (1/\varepsilon)\Gamma'(1)$ and $-\Gamma'(1)$ as the Euler-Mascheroni constant (see Appendix A.2 for derivation details). With symmetric firms, w_i can only have two possible realisations, namely $w_i = w$ if employment is in onshore production of a home firm or $w_i = w^*$ if employment is in offshore production of a foreign firm. Following Egger et al. (2022), we set $\bar{b} = (1/\varepsilon)\ln\{M[w^\varepsilon + (w^*)^\varepsilon]\} - \ln w - (1/\varepsilon)\Gamma'(1)$, implying that $\mathbb{E}[v_i(\omega)] = \ln w$.[5]

We next determine the allocation of workers between the production and the service sector. Thereby, we consider a two-step process. Workers first receive an imperfect signal upon their b_i-draws, which informs them for given wage offers by firms about their preferred employer in the production sector and thus reveals w_i and $\mathbb{E}[b_i(\omega)]$ to them. Once this is known, workers choose between employment in the production sector and employment in the service sector, where they receive a utility of $v_s = \ln s$, with s as the factor return in service production and with non-pecuniary utility from services normalised to zero. The sectoral choice of workers is irreversible and made under uncertainty about the *ex post* realisation of the idiosyncrative non-pecuniary utility $b_i(\omega)$. In equilibrium, workers must be indifferent between employment in the service sector and employment in the production sector, which can either be in onshore jobs of domestic firms or it can be in offshore jobs of foreign firms. This establishes $v_s = \mathbb{E}[v_i(\omega)]$ and thus $w = s$.[6]

We can now use the indifference condition $w = s$ to determine the sectoral allocation of workers. Due to a unitary labour input coefficient the aggregate labour demand of the service sector, L_s, is given by the product of the fixed service requirement per firm and the number of firms: $L_s = fM$. Aggregate labour demand in the production sector, L_m, follows from the aggregation of firm-specific labour demands: $L_m = (\tau\ell^* + \ell)M$. Acknowledging $\tau\ell^* = \tau^{-\varepsilon}\ell$ and noting that Eqs. (3) and (4) combined with $w = s$ determine $\ell = [f\varepsilon(\sigma-1)/(\sigma+\varepsilon)]/(1+\tau^{-1-\varepsilon})$, we compute

$$\frac{L_m}{L_s} = \frac{\varepsilon(\sigma-1)}{\sigma+\varepsilon}\Lambda(\tau), \qquad \text{with} \qquad \Lambda(\tau) \equiv \frac{\tau+\tau^{1+\varepsilon}}{1+\tau^{1+\varepsilon}} > 1. \tag{6}$$

Combining Eq. (6) with the resource constraint $N = L_m + L_s$ allows us to solve for aggregate employment in the production and the service sector:

$$L_m = \frac{\varepsilon(\sigma-1)\Lambda(\tau)}{\sigma+\varepsilon+\varepsilon(\sigma-1)\Lambda(\tau)}N \qquad \text{and} \qquad L_s = \frac{\sigma+\varepsilon}{\sigma+\varepsilon+\varepsilon(\sigma-1)\Lambda(\tau)}N.$$

The mass of firms entering the production sectors then follows as

$$M = \frac{\sigma+\varepsilon}{\sigma+\varepsilon+\varepsilon(\sigma-1)\Lambda(\tau)}\frac{N}{f}. \tag{7}$$

[5] Additional firm entry lowers employment per firm, ceteris paribus, thereby increasing the average realisation of the non-pecuniary job utility due to a better fit between the worker and the firm (see Card et al., 2018). To neutralise this market thickness effect, which is common to all firms, we subtract from utility the term $\bar{b}$. Since this correction term is neither firm- nor worker-specific, it does not change the relative attractiveness of firms in the perception of workers. The correction term does, however, prevent in our model a labour market induced externality of firm entry that would give the number of firms an influence on the relative attractiveness of working inside or outside the production sector beyond its usual impact on labour demand.

[6] Since the *ex ante* expected level of $b_i(\omega)$ equals its *ex post* average realisation at the firm, the information at whom's labour supply curve the worker would be has no bearing in our model on the relative attractiveness for workers to be employed in the production or the service sector.

To complete the solution of the general equilibrium, we finally use Eq. (3) to solve for the wage paid in onshore production:

$$w = \frac{\sigma - 1}{\sigma} \frac{\varepsilon}{1+\varepsilon} \left[\frac{\sigma + \varepsilon}{\sigma + \varepsilon + \varepsilon(\sigma - 1)\Lambda(\tau)} \frac{N}{f} \right]^{\frac{1}{\sigma - 1}} \equiv \tilde{w}(\tau), \tag{8}$$

with derivation details deferred to Appendix A.3.

2.3 Welfare

With expected utility equalised between possible employment options within and across sectors, welfare in our model is equal to $\ln w$. Since the price of consumption bundle U is normalised to one, this corresponds to the logarithm of the real wage. Therefore, welfare effects in our model can be derived from Eq. (8), with wages responding to changes in the trade cost parameter τ through adjustments in $\Lambda(\tau)$. Thereby, auxiliary function $\Lambda(\tau)$ captures in our model the distortion in labour allocation due to offshoring and its implication for wages. The limiting case of prohibitive trade costs captures the autarky equilibrium with $\lim_{\tau \to \infty} \Lambda(\tau) = 1$, and in this case we compute a wage rate equal to

$$\lim_{\tau \to \infty} \tilde{w}(\tau) = \frac{\sigma - 1}{\sigma} \frac{\varepsilon}{1+\varepsilon} \left(\frac{\sigma + \varepsilon}{1+\varepsilon} \frac{N}{\sigma f} \right)^{\frac{1}{\sigma - 1}} \equiv w_a. \tag{9}$$

It is easily confirmed that $dw_a/d\varepsilon > 0$, implying that a stronger monopsony power of firms, i.e. a lower level of ε, decreases welfare. The intuition for this result is well understood from the seminal work by Robinson (1933) and Manning (2003). Firms with monopsonistic labour market power strategically reduce their output to lower the wage penalty of higher employment. This induces a fall in firm-level employment ℓ and leads to excessive firm entry, which is captured by $dM/d\varepsilon < 0$. Excessive firm entry leads to a distortion of the inter-sectoral labour allocation and as a result to an oversized service sector.

Auxiliary function $\Lambda(\tau)$ is non-monotonic in τ. It has a minimum function value equal to one in the two polar cases of $\tau \to \infty$ (no offshoring) and $\tau = 1$ (costless offshoring), while it is strictly larger than one for intermediate values of τ.[7] Costly offshoring therefore reduces welfare in our model. Regarding the effect of changes in the trade cost parameter on welfare, there are two counteracting effects. On the one hand, a higher trade cost implies that more labour is wasted per unit of intermediate shipped, which reduces welfare, ceteris paribus. On the other hand, it induces firms to produce a smaller share of their intermediates offshore, which reduces the labour used up in transportation, leading to an increase in welfare, ceteris paribus. The first effect dominates in

[7] Differentiation reveals that $\Lambda(\tau)$ has a unique interior maximum larger than one at $\bar{\tau} > 1$, with $\bar{\tau}$ implicitly given by $1 + (1+\varepsilon)\bar{\tau}^{\varepsilon} - \varepsilon\bar{\tau}^{1+\varepsilon} = 0$.

our model if trade costs are low, and hence a large share of intermediates is produced offshore. The second effect dominates at high levels of τ. Specific to our model, we find that firm-level output is given by $q = (1 + \tau^{-1-\varepsilon})\ell = f\varepsilon(\sigma - 1)/(\sigma + \varepsilon)$ and it is therefore independent of the trade cost parameter. Hence, the reallocation of labour in response to changing τ materialises in the movement of workers across sectors due to firm exit and firm entry.

The following proposition summarises the effects of offshoring and changes in the trade cost parameter τ on welfare.

Proposition 1 *If offshoring is costly, it reduces domestic welfare. Thereby, the impact of higher trade costs on welfare is non-monotonic. Welfare decreases in the trade cost parameter at low levels of τ, and it increases in the trade cost parameter at high levels of τ.*

Proof Analysis in the text.

The important insight from Proposition 1 that offshoring has negative welfare effects is akin to the finding in Egger et al. (2022). However, in the heterogeneous firms model put forward by Egger et al. (2022) the potentially negative effects of offshoring are mitigated by an *a priori* positive welfare effect of a reallocation of workers to more productive firms, who expand their output if offshoring becomes attractive for them but not for their competitors with low productivity. Hence, in contrast to our model, there is an additional welfare stimulus from an output expansion of the most productive producers, which decreases the likelihood of welfare loss. Lacking such intra-sectoral reallocation effects, negative welfare effects of offshoring are more pronounced in our setting. Moreover, since for symmetric countries an incentive to offshore only exists in the case of monopsonistic labour markets, the negative welfare effects considered here do not materialise in other models of offshoring, in which a cost-saving motive for production shifting arises from asymmetries of countries in their production technologies or factor endowments (see Kohler, 2004; Grossman and Rossi-Hansberg, 2008; Rodríguez-Clare, 2010; Egger et al., 2015).

3 A common minimum wage

In this section, we consider the effect of introducing a common minimum wage in the two economies and analyse the welfare effects of this policy. Since this is the interesting case, we focus on a minimum wage that is only binding for offshore but not for onshore employment. Higher levels of the minimum wage that are also binding for onshore employment are briefly addressed in Section 3.4. Similar to Section 2, we begin our analysis with a detailed discussion of the firm's problem.

3.1 The firm's problem with low minimum wages

With a common minimum wage that is binding for offshore but not for onshore employment, firm-level operating profits change to $\pi = A_q^{\frac{1}{\sigma}} (\ell + \ell^*)^{\frac{\sigma-1}{\sigma}} - \tau \underline{w} \ell^* - A_l^{-\frac{1}{\varepsilon}} \ell^{\frac{1+\varepsilon}{\varepsilon}}$, and the firm chooses ℓ, ℓ^* to maximise these profits under the constraint that its labour demand for offshore production is no larger than its foreign labour supply at the given minimum wage: $\tau\ell^* \leq A_l^* \underline{w}^\varepsilon$. The corresponding Lagrangian is therefore given by

$$\max_{\ell,\ell^*,\lambda} \mathscr{L}(\ell,\ell^*,\lambda) = A_q^{\frac{1}{\sigma}} (\ell + \ell^*)^{\frac{\sigma-1}{\sigma}} - \tau \underline{w} \ell^* - A_l^{-\frac{1}{\varepsilon}} \ell^{\frac{1+\varepsilon}{\varepsilon}} - \lambda \left(\tau\ell^* - A_l^* \underline{w}^\varepsilon\right). \tag{10}$$

Combining the first-order conditions for the profit-maximising employment choices ℓ, ℓ^* establishes a modified pricing rule

$$w = \frac{\varepsilon}{1+\varepsilon}(\tau\underline{w} + \lambda) = \frac{\varepsilon}{1+\varepsilon}\frac{\sigma-1}{\sigma}\, p, \tag{11}$$

where an interior solution with $\ell, \ell^* > 0$ and a parameter domain with $\tau > (1+\varepsilon)/\varepsilon$ have been assumed. This pricing rule differs from Eq. (2), because wages in the foreign market are no longer set as a constant markdown on marginal labour costs if the minimum wage is binding.[8] In addition, the complementary slackness condition corresponding to problem (10) is given by $\lambda \left(\tau\ell^* - A_l^* \underline{w}^\varepsilon\right)$, where the Lagrangian parameter λ measures the shadow price (and thus the marginal profit) of increasing foreign labour supply. We can distinguish two possible cases regarding the complementary slackness condition. The first one is $\lambda > 0$ and it implies $\tau\ell^* - A_l^* \underline{w}^\varepsilon = 0$. The second one is $\tau\ell^* - A_l^* \underline{w}^\varepsilon > 0$ and it implies $\lambda = 0$. In the first case, firm-level labour demand exceeds firm-level labour supply, while, in the second case, firm-level labour supply exceeds firm-level labour demand at given binding minimum wages in the foreign country. Following Manning (2003) we associate the former case with a *supply-constrained* firm and the latter case with a *demand-constrained* firm. Whether firms are supply-constrained or demand-constrained depends on the level of the minimum wage. In the remainder of this section, we shed further light on these two cases from the perspective of a single firm, beginning with the analysis of a supply-constrained producer.

If $\lambda > 0$ and $\tau\ell^* - A_l \underline{w}^\varepsilon = 0$, relative offshore to onshore employment is given by $\tau\ell^*/\ell = (\underline{w}/w)^\varepsilon$. Moreover, domestic employment can be expressed as

$$\ell = \left\{\frac{\sigma-1}{\sigma}\frac{\varepsilon}{1+\varepsilon}\left(\frac{A_q}{A_l}\right)^{\frac{1}{\sigma}}\left[1 + \left(\frac{\underline{w}}{w}\right)^\varepsilon \frac{1}{\tau}\right]^{-\frac{1}{\sigma}}\right\}^{\frac{\sigma\varepsilon}{\sigma+\varepsilon}} A_l, \tag{12}$$

and thus as a function of the endogenous domestic wage rate w. Making use of the pricing rule in

[8] A sufficiently high trade cost parameter $\tau > (1+\varepsilon)/\varepsilon$ is needed to ensure that for any $\lambda > 0$ the minimum wage is non-binding for onshore employment in the home country.

Eq. (11) and $\tau\ell^*/\ell = (\underline{w}/w)^\varepsilon$, operating profits $\pi = p(\ell+\ell^*) - \underline{w}\tau\ell^* - w\ell$ can be rewritten in the following form:

$$\pi = \left\{ \frac{\sigma}{\sigma-1} \frac{1+\varepsilon}{\varepsilon} \left[1 + \left(\frac{\underline{w}}{w} \right)^{\varepsilon} \frac{1}{\tau} \right] - \left[1 + \left(\frac{\underline{w}}{w} \right)^{1+\varepsilon} \right] \right\} w\ell. \tag{13}$$

In the limiting case of $\tau\underline{w} = w$, the minimum wage is is just binding for offshore employment, and in this case Eqs. (12) and (13) coincide with Eqs. (3) and (4). Then, the shadow price of foreign labour supply λ fully absorbs the effect of the minimum wage, i.e. $\lambda = [(1+\varepsilon)/\varepsilon]w - \tau\underline{w} = \tau\underline{w}/\varepsilon$ according to Eq. (11). Increasing the minimum wage would induce firms to adjust their home market wages as well as their employment in onshore and offshore production, which in turn will lead to changes in the economy-wide variables A_q, A_l, and s. The consequences of these adjustment effects are studied in Section 3.2, where the market equilibrium for the case of supply-constrained firms is analysed.

Turning to the case of a demand-constrained firm with $\lambda = 0$ and $\tau\ell^* - A_l\underline{w}^\varepsilon > 0$, we can conclude from Eq. (11) that the domestic wage paid for onshore employment is proportional to the minimum wage paid for offshore employment and given by $w = [\varepsilon/(1+\varepsilon)]\tau\underline{w}$. Onshore employment is then pinned down by substituting the domestic wage into the domestic labour supply curve, whereas offshore employment is obtained by adding the goods demand function. We compute

$$\ell = A_l \left(\frac{\varepsilon}{1+\varepsilon} \tau\underline{w} \right)^{\varepsilon} \quad \text{and} \quad \ell^* = A_q \left(\frac{\sigma-1}{\sigma} \frac{1}{\tau\underline{w}} \right)^{\sigma} - A_l \left(\frac{\varepsilon}{1+\varepsilon} \tau\underline{w} \right)^{\varepsilon}. \tag{14}$$

Substituting Eqs. (11) and (14) into the operating profits $\pi = p(\ell+\ell^*) - \underline{w}\tau\ell^* - w\ell$, we obtain

$$\pi = \left\{ \frac{\sigma}{\sigma-1} \frac{1+\varepsilon}{\varepsilon} \rho - \left[1 + (\rho-1) \frac{\tau\underline{w}}{w} \right] \right\} w\ell, \quad \text{with} \quad \rho \equiv \frac{A_q}{A_l} \left(\frac{\sigma-1}{\sigma} \frac{\varepsilon}{1+\varepsilon} \right)^{\sigma} \left(\frac{1+\varepsilon}{\varepsilon} \frac{1}{\tau\underline{w}} \right)^{\sigma+\varepsilon} \tag{15}$$

as a measure of offshore relative to onshore employment: $\tau\ell^*/\ell = \tau(\rho-1)$. Setting $\tau\underline{w} = [(1+\varepsilon)/\varepsilon]w$ (and thus $\lambda = 0$) as well as $\tau\ell^* = A_l(\underline{w}/w)^\varepsilon$, we observe that Eqs. (12) and (13) coincide with Eqs. (14) and (15), respectively. Moreover, setting $\rho = 1$ and $\ell^* = 0$ establishes an upper bound for $\underline{w}$ at which offshoring becomes unattractive for firms. Again, this insight is only preliminary, because it is inferred for a given level of economy-wide variables A_q, A_l, and s, which clearly change with adjustments in the minimum wage. For the case of demand-constrained firms, we study the adjustments of aggregate variables in the market equilibrium in Section 3.3.

3.2 Market equilibrium for supply-constrained firms

Making use of $w = s$ and Eq. (13), the zero-profit condition $\pi = sf$ can be solved for

$$\ell \left\{ \frac{\sigma}{\sigma - 1} \frac{1+\varepsilon}{\varepsilon} \left[1 + \left(\frac{\underline{w}}{w} \right)^{\varepsilon} \frac{1}{\tau} \right] - \left[1 + \left(\frac{\underline{w}}{w} \right)^{1+\varepsilon} \right] \right\} = f, \tag{16}$$

which gives domestic employment ℓ as a function of $\underline{w}/w$. Differentiating domestic employment with respect to $\underline{w}/w$, we compute

$$\frac{d\ell}{d(\underline{w}/w)} = - \frac{\ell}{\underline{w}/w} \frac{1+\varepsilon}{f\tau} \left(\frac{\underline{w}}{w} \right)^{\varepsilon} \left[\frac{\sigma}{\sigma - 1} - \frac{\tau \underline{w}}{w} \right]. \tag{17}$$

There are two possible outcomes. If $\sigma/(\sigma - 1) \geq (1 + \varepsilon)/\varepsilon$, $d\ell/d(\underline{w}/w) < 0$ holds for all possible $\underline{w}/w$. In contrast, if $\sigma/(\sigma - 1) < (1+\varepsilon)/\varepsilon$, ℓ has a minimum at some $(\underline{w}/w)_0 \in \Big(1/\tau, (1+\varepsilon)/(\varepsilon\tau)\Big)$. In general it is not clear, which of the two outcomes materialises and we will therefore postpone further discussion on firm-level employment effects in onshore production to latter stages of our analysis.

With firm-level employment in onshore production given by Eq. (16) and with the ratio of offshore to onshore employment corresponding to $\tau\ell^*/\ell = (\underline{w}/w)^{\varepsilon}$, we can next determine economy-wide employment in production by aggregating onshore and offshore employment over all firms. This gives $L_m = M\ell + M\tau\ell^* = M\ell\,[1 + (\underline{w}/w)^{\varepsilon}]$. At the same time, total employment in the service sector is given by $L_s = Mf$, and we can therefore compute

$$\frac{L_m}{L_s} = \frac{\varepsilon(\sigma - 1)}{\sigma + \varepsilon} \Lambda_0 \left(\frac{\underline{w}}{w} \right), \qquad \Lambda_0 \left(\frac{\underline{w}}{w} \right) \equiv \frac{1 + \left(\frac{\underline{w}}{w}\right)^{\varepsilon}}{1 + \frac{\sigma(1+\varepsilon)}{\sigma+\varepsilon} \left(\frac{\underline{w}}{w}\right)^{\varepsilon} \frac{1}{\tau} - \frac{\varepsilon(\sigma-1)}{\sigma+\varepsilon} \left(\frac{\underline{w}}{w}\right)^{1+\varepsilon}}. \tag{18}$$

Auxiliary function $\Lambda_0(\underline{w}/w) > 1$ has a similar interpretation as in the model variant without minimum wages. It measures the distortion of resource allocation due to offshoring. Making use of the labour market clearing condition $N = L_m + L_s$, we get explicit solutions for economy-wide employment in production and services:

$$L_m = \frac{\varepsilon(\sigma - 1)\Lambda_0 \left(\frac{\underline{w}}{w}\right)}{\sigma + \varepsilon + \varepsilon(\sigma - 1)\Lambda_0 \left(\frac{\underline{w}}{w}\right)} N, \qquad L_s = \frac{\sigma + \varepsilon}{\sigma + \varepsilon + \varepsilon(\sigma - 1)\Lambda_0 \left(\frac{\underline{w}}{w}\right)} N.$$

The number of firms active in either country can then be expressed as follows

$$M = \frac{\sigma + \varepsilon}{\sigma + \varepsilon + \varepsilon(\sigma - 1)\Lambda_0 \left(\frac{\underline{w}}{w}\right)} \frac{N}{f}. \tag{19}$$

In a next step, we determine the consumer demand shifter by aggregating income over all workers. This gives $A_q = Mw\ell + M\underline{\ell}^*\tau + Msf = Mw\ell\{1 + (\underline{w}/w)^{1+\varepsilon} + f/\ell\}$. Combining the solution for A_q with domestic labour supply and Eq. (16) establishes $A_q = MA_l w^{1+\varepsilon}[1 + (\underline{w}/w)^\varepsilon/\tau]\sigma(1 + \varepsilon)/[\varepsilon(\sigma - 1)]$, which can be solved for a ratio of the goods demand and the labour supply shifter

$$\frac{A_q/A_l}{1 + (\underline{w}/w)^\varepsilon/\tau} = \frac{\sigma}{\sigma - 1}\frac{1 + \varepsilon}{\varepsilon}\frac{(\sigma + \varepsilon)w^{1+\varepsilon}}{\sigma + \varepsilon + \varepsilon(\sigma - 1)\Lambda_0\left(\frac{\underline{w}}{w}\right)}\frac{N}{f}. \tag{20}$$

Substituting Eq. (20) into Eq. (12) and acknowledging that setting equal labour demand and labour supply for onshore employment at the firm level establishes $A_l = \ell w^{-\varepsilon}$, we can derive an implicit general equilibrium relationship between the exogenous minimum wage $\underline{w}$ and the endogenous domestic wage w according to

$$\Gamma(w, \bar{w}) \equiv \left(\frac{\sigma - 1}{\sigma}\frac{\varepsilon}{1 + \varepsilon}\right)^{\sigma-1}\frac{1}{1 + \frac{\varepsilon(\sigma-1)}{\sigma+\varepsilon}\Lambda_0\left(\frac{\underline{w}}{w}\right)}\frac{N}{f} - w^{\sigma-1} = 0. \tag{21}$$

Thereby $\Gamma(w, \bar{w})$ is the labour market clearing condition evaluated at the firm level for equilibrium realisations of A_l and A_q. In Appendix A.4, we show that under the sufficient condition $\sigma - 1 \geq \varepsilon$, Eq. (21) establishes a negative relationship between domestic wage w and the minimum wage $\underline{w}$, implying that $\underline{w}/w$ increases monotonically from a low level of $1/\tau$ to a high level of $[(1 + \varepsilon)/\varepsilon]/\tau$, when the minimum wage increases from the lower threshold $\underline{w}_0$ to the upper threshold $\underline{w}_1$. Thereby, the lower threshold of the minimum wage can be derived from Eq. (21) as $\underline{w}_0 \equiv \tilde{w}(\tau)/\tau$, whereas the upper threshold can be solved for

$$\underline{w}_1 \equiv \frac{\sigma - 1}{\sigma}\frac{1}{\tau}\left[\frac{\sigma + \varepsilon}{\sigma + \varepsilon + \varepsilon(\sigma - 1)\tilde{\Lambda}(\tau)}\right]^{\frac{1}{\sigma-1}}, \qquad \tilde{\Lambda}(\tau) \equiv \frac{\tau\left(\frac{1+\varepsilon}{\varepsilon}\right)^\varepsilon + \tau^{1+\varepsilon}}{\frac{1+\varepsilon}{\sigma+\varepsilon}\left(\frac{1+\varepsilon}{\varepsilon}\right)^\varepsilon + \tau^{1+\varepsilon}} < \Lambda(\tau). \tag{22}$$

Imposing a parameter constraint with $\sigma - 1 \geq \varepsilon$, we have $\sigma/(\sigma - 1) < (1 + \varepsilon)/\varepsilon$, and hence at the firm level onshore employment decreases in the minimum wage at small levels of $\underline{w}$, whereas it increases in the minimum wage at high levels of $\underline{w}$. With offshore employment in supply-constrained firms always increasing in the minimum wage, we therefore have counteracting effects of an increase in the minimum wage on total onshore plus offshore firm-level employment if $\underline{w}$ is small. However, with $\underline{w}/w$ monotonically increasing in $\underline{w}$, it follows from $q = \ell[1 + (\underline{w}/w)^\varepsilon/\tau]$ and Eq. (16) that $dq/d\underline{w} > 0$, and hence firm size unambiguously increases in the minimum wage. The larger firm size raises domestic labour demand ceteris paribus and therefore induces domestic wages to increase. However, a higher minimum wage also leads to more offshoring – $\tau\ell^*$ increases in $\underline{w}$ – which counteracts the former effect, due to a decrease in domestic labour demand for given firm size. Our finding of $dw/d\underline{w} < 0$ shows that the second effect dominates if firms are supply-constrained.

3.3 Market equilibrium for demand-constrained firms

If firms are demand-constrained, we have $\ell + \tau\ell^* < A_l(w)^\varepsilon + A_l(\underline{w})^\varepsilon$. Moreover, for a full employment equilibrium to be consistent with indifference of workers between the three possible occupations, it must as well be true that total variable and fixed labour demand per firm exceeds firm-level variable labour supply. If firms are demand-constrained in the foreign market, workers seeking employment in offshore production have a lower probability ceteris paribus to find employment than workers seeking employment in onshore production. This probability gap is immaterial for wages and thus consistent with factor returns $w = [\varepsilon/(1+\varepsilon)]\tau\underline{w} = s$ only if the excessive labour supply finds employment in the outside service sector. Assumption $\ell + \tau\ell^* + f \geq A_l(w)^\varepsilon + A_l(\underline{w})^\varepsilon$ ensures that this is the case. For the moment, we simply assume that this additional condition is fulfilled, while we will derive a formal requirement for it to hold at the end of this section. Making use of $w = s$, $\tau\underline{w}/w = (1+\varepsilon)/\varepsilon$, and Eq. (15), the zero-profit condition $\pi = sf$ then solves for

$$\ell\left\{\frac{\sigma}{\sigma-1}\frac{1+\varepsilon}{\varepsilon}\rho - \left[1 + (\rho-1)\frac{1+\varepsilon}{\varepsilon}\right]\right\} = \ell\ \frac{\rho(1+\varepsilon)+\sigma-1}{\varepsilon(\sigma-1)} = f, \tag{23}$$

establishing firm-level onshore employment ℓ as a negative function of ρ.

Aggregating firm-level employment over all firms gives total employment in production as $L_m = M\ell[1+\tau(\rho-1)]$. Noting further that total employment in services corresponds to $L_s = Mf$, economy-wide employment in production relative to services can be written as follows:

$$\frac{L_m}{L_s} = \frac{\varepsilon(\sigma-1)}{\sigma+\varepsilon}\Lambda_1(\rho), \qquad \Lambda_1(\rho) \equiv \frac{1+\tau(\rho-1)}{1+\frac{\sigma(1+\varepsilon)}{\sigma+\varepsilon}(\rho-1) - \frac{\varepsilon(\sigma-1)}{\sigma+\varepsilon}\frac{1+\varepsilon}{\varepsilon}(\rho-1)}. \tag{24}$$

Auxiliary function $\Lambda_1(\rho) > 1$ has a similar interpretation as $\Lambda(\tau)$ and $\Lambda_0(\underline{w}/w)$. It is a measure for the distortion of resource allocation due to offshoring if firms are demand-constrained. The auxiliary function can be simplified to $\Lambda_1(\rho) = [1+\tau(\rho-1)]/\{1+[(1+\varepsilon)/(\sigma+\varepsilon)](\rho-1)\}$, with the distortion of resource allocation from offshoring increasing in ρ and reaching a minimum value equal to one if $\rho = 1$. This is the case, in which ℓ^*/ℓ falls to zero, so that offshoring vanishes. Combining Eq. (18) with the economy-wide resource constraint $N = L_m + L_s$ we can solve for total employment in production and services,

$$L_m = \frac{\varepsilon(\sigma-1)\Lambda_1(\rho)}{\sigma+\varepsilon+\varepsilon(\sigma-1)\Lambda_1(\rho)}N, \qquad L_s = \frac{\sigma+\varepsilon}{\sigma+\varepsilon+\varepsilon(\sigma-1)\Lambda_1(\rho)}N,$$

respectively, as well as for the equilibrium number of firms entering in either economy:

$$M = \frac{\sigma+\varepsilon}{\sigma+\varepsilon+\varepsilon(\sigma-1)\Lambda_1(\rho)}\frac{N}{f}. \tag{25}$$

In a next step, we sum up income over all workers in production and services to $A_q = Mw\ell + M\underline{w}\tau\ell^* + Msf$. Making use of Eqs. (15) and (23), we can then solve for the ratio of the consumer demand and the labour supply shifter as

$$\frac{A_q}{A_l}\frac{1}{\rho} = \frac{\sigma}{\sigma-1}\frac{1+\varepsilon}{\varepsilon}\frac{(\sigma+\varepsilon)w^{1+\varepsilon}}{\sigma+\varepsilon+\varepsilon(\sigma-1)\Lambda_1(\rho)}\frac{N}{f}. \tag{26}$$

Solving Eq. (26) for ρ, setting it equal to the solution for ρ from Eq. (15), and substituting $w = [\varepsilon/(1+\varepsilon)]\tau\underline{w}$, we obtain an implicit relationship between $\underline{w}$ and ρ, which is given by

$$\Psi(\rho,\underline{w}) \equiv \left(\frac{\sigma-1}{\sigma}\frac{\varepsilon}{1+\varepsilon}\right)^{\sigma-1}\frac{\sigma+\varepsilon}{\sigma+\varepsilon+\varepsilon(\sigma-1)\Lambda_1(\rho)}\frac{N}{f} - \left(\frac{\varepsilon}{1+\varepsilon}\tau\underline{w}\right)^{\sigma-1} = 0. \tag{27}$$

Thereby, Eq. (27) is a labour-market clearing condition, which determines the relative offshore employment $\tau\ell^*/\ell = \tau(\rho-1)$ of firms that is for a given minimum wage consistent with the full employment of onshore workers supplied to the firm. Acknowledging that $\Lambda_1'(\rho) > 0$ implies $\partial\Psi/\partial\rho < 0$, whereas $\partial\Psi/\partial\underline{w} < 0$ is immediate, Eq. (27) establishes a negative relationship between ρ and $\underline{w}$: $d\rho/d\underline{w} < 0$.

In the liming case of $\rho = 1$, Eq. (27) establishes an upper bound for minimum wages allowing for offshoring:

$$\underline{w}_2 = \frac{\sigma-1}{\sigma}\frac{1}{\tau}\left[\frac{\varepsilon+\sigma}{\sigma(1+\varepsilon)}\frac{N}{f}\right]^{\frac{1}{\sigma-1}}. \tag{28}$$

The corresponding domestic wage is given by $w = [\varepsilon/(1+\varepsilon)]\tau\underline{w}_2$ and it is equal to the autarky wage in Eq. (9). Moreover, setting $\rho = 1+(\underline{w}/w)^\varepsilon/\tau$ and $\underline{w}/w = [(1+\varepsilon)/\varepsilon\tau]$, we obtain a lower threshold for minimum wages that support an outcome with offshoring of demand-constrained firms. The respective minimum wage threshold equals $\underline{w}_1$ in Eq. (22). An increase in the minimum wage from $\underline{w}_1$ to $\underline{w}_2$ induces a monotonic decrease of the relative firm-level employment in offshore production, $\tau\ell^*/\ell = \tau(\rho-1)$. At the same time, it follows from Eq. (23) that $d\ell/d\rho < 0$, implying that firms expand their onshore employment if the minimum wage increases. Both of these effects tend to increase domestic labour demand and therefore contribute to a positive wage effect in home, as confirmed by $dw/d\underline{w} > 0$.

The above solution has been derived under the assumption that $\ell + \tau\ell^* + f \geq A_l(w)^\varepsilon + A_l(\underline{w})^\varepsilon$. Making use of $w = [\varepsilon/(1+\varepsilon)]\tau\underline{w}$, $\tau\ell^*/\ell = \tau(\rho-1)$, and Eq. (23), we can reformulate this constraint as $\rho(1+\varepsilon)+\sigma-1+\varepsilon(\sigma-1)\tau(\rho-1) \geq \varepsilon(\sigma-1)[(1+\varepsilon)/(\varepsilon\tau)]^\varepsilon$. This constraint is more likely fulfilled for high levels of ρ, and setting $\rho = 1$, it reduces to $(\sigma+\varepsilon)/[\varepsilon(\sigma-1)] \geq (1+\varepsilon)/(\varepsilon\tau)]^\varepsilon$. Noting that the right-hand must be smaller than one for the minimum wage to be unbinding for onshore employment, we find $\varepsilon < 1$ to be sufficient for a full employment equilibrium to materialise at factor returns $w = [(1+\varepsilon)/\varepsilon]\tau\underline{w} = s$ and arbitrary levels of σ, τ, and ρ. Thereby, expressing the condition as an upper bound on ε is intuitive, as lower levels of ε are associated with less elastic responses of firm-level labour supply to increases in the minimum wage. If $\varepsilon < 1$ the increase in firm-level labour supply is sufficiently weak for $\ell + \tau\ell^* + f \geq A_l(w)^\varepsilon + A_l(\underline{w})^\varepsilon$ to hold for arbitrary levels of σ, with σ capturing the negative response of variable labour demand to increasing goods prices.

3.4 Welfare effects of a common minimum wage

In the analysis from Sections 3.2 and 3.3, we have determined the adjustments in the domestic wage in response to a higher common minimum wage. Thereby, we have seen important differences in this response for environments in which firms are supply-constrained and environments in which firms are demand-constrained in their hiring of offshore employment. From Section 2, we know that in our model the domestic wage is decisive for welfare. This is, because *ex ante* welfare is equalised between the three possible occupations as worker in onshore or offshore production or as worker in the service sector with differences in the expected non-pecuniary job utility compensating workers for prevailing wage differences. The following proposition summarises the welfare effects of introducing a common minimum wage and of marginally increasing this minimum wage.

Proposition 2 *We impose $\tau > (1+\varepsilon)/\varepsilon$. Then, under the sufficient condition $\sigma - 1 \geq \varepsilon$, the introduction of a moderate common minimum wage in interval $(\underline{w}_0, \underline{w}_1]$ leads to additional offshoring and thereby lowers welfare. Under the additional condition of $\varepsilon < 1$, the introduction of a sizable common minimum wage from interval $(\underline{w}_1, \underline{w}_2]$ reduces offshoring with positive welfare effects. A small increase of an initially moderate minimum wage has negative welfare effects, whereas a small increase of an initially sizable minimum wage has positive welfare consequences.*

Proof Analysis in the text.

Whereas a common minimum wage of $\underline{w} = \underline{w}_2$ eradicates offshoring in our model, thereby implementing an autarky equilibrium, it does not eliminate all distortions in the monopsonistic labour market. As outlined in Section 2.3 firms with monopsonistic labour market power are too small and hence too many of these firms enter in the autarky equilibrium. Therefore, increasing the common mininmium wage above $\underline{w}_2$ can further increase welfare.[9] More specifically, we show in Appendix A.5 that setting a minimum wage of

$$\underline{w} = \frac{\sigma - 1}{\sigma}\left(\frac{N}{\sigma f}\right)^{\frac{1}{\sigma-1}} \equiv \underline{w}_3. \tag{29}$$

[9]A minimum wage to be binding in a closed economy it must be at least as high as autarky wage w_a in Eq. (9). Comparing Eqs. (9) and (28) we conclude that under the parameter constraint $\tau > (1+\varepsilon)/\varepsilon$ a minimum wage to be binding in the closed economy must exceed $\underline{w}_2$.

gives a market solution that equals the limiting case of $\varepsilon \to \infty$, which corresponds to a setting without monopsonistic labour market distortions. In this case, we have $\ell = (\sigma - 1)f$ and $M = N/\sigma f$ and thus a firm size and a firm number that are equal to the textbook version of the Kurgman model. This is a notable benchmark in our setting, because it has been shown by previous research that the resource allocation is efficient in a Krugman-type model if utility features constant elasticity of substitution between the differentiated varieties of consumer goods (see Dixit and Stiglitz, 1977).

Increasing the minimum wage from $\underline{w}_2$ to $\underline{w}_3$ has a monotonic positive effect on welfare. This explains the widespread view among economists that moderate minimum wages can increase welfare, while avoiding negative employment effects (see OECD, 2018; Manning, 2021; Dustmann et al., 2022). However, our analysis makes clear that this view needs to be qualified, since in an open economy introducing a low minimum wage can in fact lower both production employment and welfare, even if a common minimum wage is introduced everywhere. Hence, our results, while supporting the joint directive of the European Parliament and the European Council to introduce a common minimum wage policy, also show that choosing a minimum wage that is too low has potentially problematic side-effects if offshore production is empirically important.

4 Conclusions

This paper analyses the distortions from monpsonistically competitive labour markets in a Krugman-type model of offshoring. We show that in this setting firms choose to offshore even in the case of symmetric countries, because dividing labour demand between two segmented labour markets allows them to more strongly execute their monopsonistic power, which reduces wages and increases profits. Since offshoring reduces firm size and stimulates firm entry, it reinforces the distortions in the resource allocation materialising in monopsonistic labour markets and is therefore wasteful.

We show that introducing a common minimum wage can reduce the incentives to offshore and thereby provide a remedy for the welfare loss from offshoring. However, the effect of minimum wages in open economies is non-monotonic. It leads to more offshoring and reduces welfare if introduced at a low level, while it reduces offshoring with positive welfare effects if introduced at a high level. A sufficiently high level of the minimum can eliminate offshoring as well as other distortions in the resource allocation, and it may therefore establish the social optimum.

Providing first insights upon the consequences of international coordination in minimum wage policy, as recently initiated by a directive of the European Parliament and the European Council, our analysis leaves aside other topics that may also be relevant in this context. For instance, we do not consider the optimal design of common minimum wages in the case of country asymmetries, since this would clearly complicate the analysis and thus divert attention of the reader from the important insight of our analysis that the impact of higher minimum wages is non-monotonic in open economies. Moreover, focussing on cooperation in minimum wage policy, we do not shed light on the consequences of an uncoordinated introduction of minimum wages by just one economy. Finally, we neither contrast minimum wages with other policy instruments nor do we analyse their interaction with such instruments in open economies. All of these aspects while important for the practical implementation of common minimum wage policy in the European Union are beyond the analysis of this paper and therefore left for future research.

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A Appendix

A.1 Derivation details for Eq. (5)

Making use of indirect utility function $v_i(\omega) = \ln w_i + b_i(\omega) - \bar{b}$, worker ω prefers a job in firm i to all other jobs if $v_i(\omega) \geq \max_{i' \neq i}\{v_{i'}(\omega)\}$.[10] This condition is formally equivalent to $\max_{i' \neq i}\{b_{i'}(\omega) + \ln w_{i'} - \ln w_i\} \leq b_i(\omega)$. Making use of the Gumbel distribution of b, $F(b) = \exp(-\exp[-\varepsilon b])$, the conditional probability of worker i choosing employment in firm i when observing $b_i(\omega) = b$ can then be derived as

$$\begin{aligned}
\text{Prob}\Big[v_i(\omega) \geq \max_{i' \neq i}\{v_{i'}(\omega)\}\Big| b_i(\omega) = b\Big] &= \prod_{i' \neq i} \exp\left(-\exp\left[-\varepsilon\Big(b + \ln w_i - \ln w_{i'}\Big)\right]\right) \\
&= \exp\left(-\exp[-\varepsilon b]\left[\sum_{i' \neq i}\left(\frac{w_{i'}}{w_i}\right)^{\varepsilon}\right]\right)
\end{aligned}$$

Integrating over b, we compute the ex ante, unconditional probability that worker ω chooses employment in firm i as follows:

$$\text{Prob}[v_i(\omega) \geq \max_{i' \neq i}\{v_{i'}(\omega)\}] = \int_{-\infty}^{\infty} \exp\left(-\exp[-\varepsilon b]\left[\sum_{i' \neq i}\left(\frac{w_{i'}}{w_i}\right)^{\varepsilon}\right]\right) dF(b), \tag{A.1}$$

which, substituting $dF(b) = \varepsilon \exp[-\varepsilon b]F(b)$ can be solved for Eq. (5). This completes the proof.

A.2 Derivation details for $\mathbb{E}[b_i(,\omega)]$

The *ex ante* expected level of idiosyncratic utility of worker ω from employment in firm i is given by $\mathbb{E}[b_i(\omega)] = \mathbb{E}[b_i(\omega)|v_i(\omega) \geq \max_{i' \neq i}\{v_{i'}(\omega)\}]$. This implies

$$\mathbb{E}[b(\omega)] = \frac{1}{\text{Prob}[v_i(\omega) \geq \max_{i' \neq i}\{v_{i'}(\omega)\}]} \int_{-\infty}^{\infty} b \exp\left(-\exp[-\varepsilon b]\left[\sum_{i' \neq i}\left(\frac{w_{i'}}{w_i}\right)^{\varepsilon}\right]\right) dF(b). \tag{A.2}$$

Substituting $F(b) = \exp(-\exp[-\varepsilon b])$, $dF(b) = \varepsilon \exp[-\varepsilon b]F(b)$, and the auxiliary variables $a = \exp(-\varepsilon b) / \text{Prob}[v_i(\omega) \geq \max_{i' \neq i}\{v_{i'}(\omega)\}]$, we can rewrite Eq. (A.2) as follows:

$$\mathbb{E}[b_i(\omega)] = -\frac{1}{\varepsilon}\int_0^{\infty} \ln(a)\exp(-a)da + \frac{1}{\varepsilon}\ln\sum_{i=1}^{M_t} w_i^{\varepsilon} - \ln w_i.$$

Acknowledging that $\int_0^{\infty} \ln(a)\exp(-a)da = \Gamma'(1)$, we obtain the solution for $\mathbb{E}[b_i(,\omega)]$ reported in the main text. This completes the proof.

[10]This proof follows the formal details in the Online Appendix of Egger et al. (2022).

A.3 Derivation details for Eq. (8)

We first note that $\sum_{i=1}^{M_t} w_i^\varepsilon = M w^\varepsilon (1+\tau^{-1-\varepsilon})$. Making use of Eqs. (6) to (7), we then compute $A_l = L_m / \sum_{i=1}^{M_t} w_i^\varepsilon = (L_m/M) w^{-\varepsilon} (1+\tau^{-\varepsilon})^{-1} = [\varepsilon(\sigma-1)/(\sigma+\varepsilon)] f w^{-\varepsilon} (1+\tau^{-1-\varepsilon})^{-1}$. Moreover, noting that total consumption expenditures equal total factor income, we have $A_q = Mw\ell + M\tau w^* \ell^* + Msf$, which – making use of $w = \tau w^*$, $\tau \ell^* = \tau^{-\varepsilon}\ell$, and $(1+\tau^{-1-\varepsilon})\ell = f\varepsilon(\sigma-1)/(\sigma+\varepsilon)$ – can be solved for $A_q = wMf\sigma(\varepsilon+1)/(\sigma+\varepsilon)$. This allows us to us to rewrite Eq. (3) as follows:

$$\ell = \left(\frac{\sigma-1}{\sigma} \frac{\varepsilon}{1+\varepsilon} \right)^{\frac{\varepsilon(\sigma-1)}{\sigma+\varepsilon}} M^{\frac{\varepsilon}{\sigma+\varepsilon}} w^{\frac{\varepsilon(1+\varepsilon)}{\sigma+\varepsilon}} A_l. \tag{A.3}$$

Noting further that $A_l = \ell w^{-\varepsilon}$ and substituting for M, we can solve for the wage rate in Eq. (8). This completes the proof.

A.4 The relationship between w and $\underline{w}$ established by Eq. (21)

We first differentiate $F(\underline{w}/w) \equiv \left[1 + \frac{\varepsilon(\sigma-1)}{\sigma+\varepsilon} \Lambda_0 \left(\underline{w}/w\right)\right]^{-1}$. This gives

$$\begin{aligned} F'\left(\frac{\underline{w}}{w}\right) &= -F\left(\frac{\underline{w}}{w}\right) \frac{\frac{\varepsilon(\sigma-1)}{\sigma+\varepsilon} \Lambda_0' \left(\frac{\underline{w}}{w}\right)}{1 + \frac{\varepsilon(\sigma-1)}{\sigma+\varepsilon} \Lambda_0 \left(\frac{\underline{w}}{w}\right)} \\ &= -F\left(\frac{\underline{w}}{w}\right) \frac{\frac{\varepsilon(\sigma-1)}{\sigma+\varepsilon} \Lambda_0 \left(\frac{\underline{w}}{w}\right)}{1 + \frac{\varepsilon(\sigma-1)}{\sigma+\varepsilon} \Lambda_0 \left(\frac{\underline{w}}{w}\right)} \frac{(\sigma-1)\hat{F}(\underline{w}/w)}{\underline{w}/w}, \end{aligned}$$

with

$$\hat{F}\left(\frac{\underline{w}}{w}\right) \equiv \frac{\varepsilon}{\sigma-1} \frac{(\underline{w}/w)^\varepsilon}{1+(\underline{w}/w)^\varepsilon} f\left(\frac{\underline{w}}{w}\right), \qquad f\left(\frac{\underline{w}}{w}\right) \equiv \frac{1 - \frac{\sigma(1+\varepsilon)}{\sigma+\varepsilon}\frac{1}{\tau} + \frac{\sigma-1}{\sigma+\varepsilon}\left(\frac{\underline{w}}{w}\right)^{1+\varepsilon} + \frac{(1+\varepsilon)(\sigma-1)}{\sigma+\varepsilon}\frac{\underline{w}}{w}}{1 + \frac{\sigma(1+\varepsilon)}{\sigma+\varepsilon}\frac{1}{\tau}\left(\frac{\underline{w}}{w}\right)^\varepsilon - \frac{\varepsilon(\sigma-1)}{\sigma+\varepsilon}\left(\frac{\underline{w}}{w}\right)^{1+\varepsilon}}$$

and

$$f'\left(\frac{\underline{w}}{w}\right) = \frac{\frac{(1+\varepsilon)(\sigma-1)}{\sigma+\varepsilon}\left[1 + \left(\frac{\underline{w}}{w}\right)^\varepsilon\right]\left[1 - \hat{F}(\underline{w}/w) + \sigma\left(1 - \frac{w}{\tau\underline{w}}\right)\hat{F}\left(\underline{w}/w\right)\right]}{1 + \frac{\sigma(1+\varepsilon)}{\sigma+\varepsilon}\frac{1}{\tau}\left(\frac{\underline{w}}{w}\right)^\varepsilon - \frac{\varepsilon(\sigma-1)}{\sigma+\varepsilon}\left(\frac{\underline{w}}{w}\right)^{1+\varepsilon}}.$$

Noting that the minimum wage to be binding requires $\underline{w}/w > 1/\tau$, it follows that (i) $f(\underline{w}/w) > 0$ and in extension $\hat{F}(\underline{w}/w) > 0$ and that (ii) $f'(\underline{w}/w) > 0$ and in extension $\hat{F}'(\underline{w}/w) > 0$ if $\hat{F}(\underline{w}/w) \leq 1$. We next evaluate $\hat{F}(\underline{w}/w)$ at the maximum possible level of $\underline{w}/w = [(1+\varepsilon)/\varepsilon]/\tau \equiv \omega$. This gives

$$\hat{F}(\omega) = \frac{\varepsilon}{\sigma-1} \frac{\omega^\varepsilon + \frac{\sigma-1-\varepsilon}{\sigma+\varepsilon}\omega^{1+\varepsilon} + \frac{\sigma-1}{\sigma+\varepsilon}\omega^{1+2\varepsilon}}{1 + \frac{\varepsilon}{\sigma+\varepsilon}\omega^{1+\varepsilon} + \omega^\varepsilon + \frac{\varepsilon}{\sigma+\varepsilon}\omega^{1+2\varepsilon}}$$

and thus $\hat{F}(\omega) < 1$ if $(\sigma - 1 - \varepsilon)(\sigma + \varepsilon)\omega^{\varepsilon} + \varepsilon^2\omega^{1+\varepsilon} + (\sigma + \varepsilon)(\sigma - 1) > 0$. Therefore, $\sigma - 1 \geq \varepsilon$ is a sufficient condition for $\hat{F}(\omega) < 1$. Finally $\hat{F}(\omega) < 1$ implies that $\hat{F}(\underline{w}/w) < 1$ must hold for all $\underline{w}/w \in (1/\tau, \omega)$. If there were a $\hat{\omega} \in (1/\tau, \omega)$, with $\hat{F}(\hat{\omega}) > 1$, then $\hat{F}(\underline{w}, w) > 1$ would hold for all $\underline{w}/w \in (\hat{\omega}, \omega)$, since crossing $\hat{F}(\underline{w}/w) = 1$ from above is not possible. However, this would contradict $\hat{F}(\omega) < 1$.

Partially differentiating $\tilde{\Gamma}(w, \underline{w})$ with respect to $\underline{w}, w$, we compute

$$\begin{aligned}
\left.\frac{\partial \tilde{\Gamma}}{\partial \underline{w}}\right|_{\tilde{\Gamma}=0} &= -w^{\sigma-1}\frac{\sigma-1}{\underline{w}} \frac{\frac{\varepsilon(\sigma-1)}{\sigma+\varepsilon}\Lambda_0\left(\frac{\underline{w}}{w}\right)}{1+\frac{\varepsilon(\sigma-1)}{\sigma+\varepsilon}\Lambda_0\left(\underline{w}/w\right)}\hat{F}(\underline{w}/w) < 0, \\
\left.\frac{\partial \tilde{\Gamma}}{\partial w}\right|_{\tilde{\Gamma}=0} &= w^{\sigma-1}\frac{\sigma-1}{w}\left[\frac{\frac{\varepsilon(\sigma-1)}{\sigma+\varepsilon}\Lambda_0\left(\frac{\underline{w}}{w}\right)}{1+\frac{\varepsilon(\sigma-1)}{\sigma+\varepsilon}\Lambda_0\left(\underline{w}/w\right)}\hat{F}(\underline{w}/w) - 1\right].
\end{aligned}$$

Under the sufficient condition $\sigma - 1 \geq \varepsilon$, we have $\hat{F}(\underline{w}/w) < 1$ and thus $\partial\tilde{\Gamma}/\partial w\big|_{\tilde{\Gamma}=0} < 0$. In this case, Eq. (21) establishes $dw/d\underline{w} < 0$. This completes the proof.

A.5 Raising the minimum wage in a closed economy

Under autarky, the firm's constrained optimisation problem for a minimum wage $\underline{w} \geq w_a$ is given by

$$\max_{\ell,\lambda} \mathscr{L}(\ell,\lambda) = A_q^{\frac{1}{\sigma}}\ell^{\frac{\sigma-1}{\sigma}} - \underline{w}\ell - \lambda\left(\ell - A_l\underline{w}^{\varepsilon}\right). \tag{A.4}$$

Provided that a full employment equilibrium exists, the first-order condition for the profit-maximising level of ℓ establishes the markup rule $p = [\sigma/(\sigma-1)](\underline{w} + \lambda)$, with $p = A_q^{1/\sigma}\ell^{-1/\sigma}$. Moreover, the complementary slackness condition for the constrained optimisation problem is given by $\lambda\left(\ell - A_l\underline{w}^{\varepsilon}\right)$.

We consider the case the case of a supply-constrained firm with $\lambda > 0$ and $\ell = A_l\underline{w}^{\varepsilon}$. Then, the zero-profit condition establishes

$$\ell\left(\zeta^{\frac{1}{\sigma}} - 1\right) = f, \qquad \zeta \equiv \frac{A_q}{A_l}\left(\frac{1}{\underline{w}}\right)^{\varepsilon+\sigma}. \tag{A.5}$$

Labour-market clearing implies $N = M(\ell + f)$ and thus $M = \left(1 - \zeta^{-1/\sigma}\right)N/f$, while the aggregation of labour income gives $A_q = N\underline{w}$. Making use of $\ell = A_l\underline{w}^{\varepsilon}$ and Eq. (A.5), we determine the implicit relationship between ζ and $\underline{w}$ by

$$\Omega(\zeta, \underline{w}) \equiv \left(\zeta^{\frac{1-\sigma}{\sigma}} - \zeta^{-1}\right)\frac{N}{f} - \underline{w}^{\sigma-1} = 0. \tag{A.6}$$

Partially differentiating Ω, we compute

$$\frac{\partial\Omega}{\partial\underline{w}} = -(\sigma-1)\underline{w}^{\sigma-2} < 0, \qquad \frac{\partial\Omega}{\partial\zeta} = -\left(\frac{\sigma-1}{\sigma}\zeta^{\frac{1}{\sigma}}-1\right)\left(\frac{1}{\zeta}\right)^2.$$

Acknowledging from pricing rule $p = [\sigma/(\sigma-1)](\underline{w}+\lambda)$ and Eq. (A.5) that $\zeta^{1/\sigma} = [\sigma/(\sigma-1)](1+\lambda/\underline{w})$, it follows that $\partial\Omega/\partial\underline{w} = -(\lambda/\underline{w})\zeta^{-2} < 0$. Hence, we can conclude that Eq. (A.6) establishes a negative link between ζ and $\underline{w}$ and thus also a negative link between $\underline{w}$ and λ: $d\zeta/d\underline{w} < 0$, $d\lambda/d\underline{w} < 0$. This implies $d\ell/d\underline{w} > 0$ and $dM/d\underline{w} < 0$, thereby confirming that increasing the minimum wage above $\underline{w}_2$ provides remedy for the excess entry of too small firms in the presence of a mnopsonistic labour market distortion. Finally, evaluating ℓ and M in the limiting case of $\lambda = 0$ and thus $\zeta^{1/\sigma} = \sigma/(\sigma-1)$ gives $\ell = f/(\sigma-1)$ and $M = N/(\sigma f)$. This completes the proof.