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Trade in Tasks: Revisiting the Wage and Employment Effects of Offshoring*

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July 2019

Abstract

We revisit Grossman and Rossi-Hansberg's (2008) famous result, that under certain conditions offshoring of low-skilled labor tasks raises the domestic wage for low-skilled workers. Our re-examination features a less benign environment where Rybczynski-type reallocation of factors to absorb offshoring-induced job displacement is ruled out. We allow for simultaneous offshoring of both skilled and unskilled labor, and we derive new results on the role of factor-bias in offshoring, identifying conditions under which offshoring has a "lifiting-all-boats" effect benefitting all workers. Extending our analysis to a frictional labor market with equilibrium unemployment due to costly matching, we demonstrate that under these same conditions offshoring is also associated with rising employment.

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1 Introduction

In this paper we re-examine Grossman and Rossi-Hansberg's (2008) famous result, that under certain conditions offshoring of low-skilled labor tasks raises the wage of low-skilled workers. This result emerges in a Heckscher-Ohlin-type setting where offshoring takes place in a small economy featuring diversified production, meaning that it produces as many goods as there are factors, or types of labor. Crucially, the underlying assumption of frictionless intersectoral-mobility ensures that the displacement effect of offshoring is conveniently absorbed by Rypczynski-type reallocation of all factors across sectors. Our re-examination features a less benign environment where any such reallocation is ruled out by assuming a single sector economy. We allow for simultaneous offshoring of both skilled and unskilled labor, and we derive results about the precise conditions, under which such offshoring "lifts all boats", i.e., benefits all workers. We also extend the analysis to a frictional labor market with equilibrium unemployment due to costly matching, in which offshoring may cause a simultaneous increase in wages and employment.

Policy makers often express concerns about the disruptive effects of enhancing the globalization of supply chains, even if they are generally in favor of freer trade. The Transpacific Partnership (TPP) is a case in point. After it had been signed in February 2016, the TPP met increasing criticism in the US, even though Americans generally supported freer trade, eventually leading both candidates in the presidential election of 2016 to promise they would withdraw US membership in the TPP once in office; which happened very soon after Trump took office. According to some observers, a possible explanation for this divergence is that the TPP was seen as standing, not so much for freer trade as such, but for a further globalization of supply chains (cf. The Economist, 2016b). The underlying argument is a difference in perception by workers: Freer trade means that their firms face fiercer competition from foreign firms on the domestic goods market, whereas globalization of supply chains effectively means US workers face direct competition, within their firms, from cheap foreign workers. Arguably, this perception also lies behind more targeted policies towards offshoring, like President Trump's cajoling of US firms to change their plans and keep jobs in the U.S. rather than move them to Mexico (cf. The Economist, 2016a). Perhaps more interestingly, and more importantly, while G20 countries have not increased their overall levels of tariffs during the period from 2010 to 2016, they did increasingly resort to contingent protection (anti-dumping, countervailing duties and safeguards), and these measures were targeted away from final goods imports to intermediate goods imports in globalized supply chains; see Bown (2018).

Offshoring thus seems put onto the defensive. However, in general terms, the worries seem at odds with economic orthodoxy which views offshoring as enhancing the gains from trade since it allows the principle of comparative advantage to rule on a much finer level of resolution (cf. Mankiw and Swagel, 2006). Indeed, theory even suggests that offshoring is particularly benign to workers. In their canonical model of offshoring, Grossman and Rossi-Hansberg (2008) show that under certain conditions trade in tasks of low-skilled workers yields gains for low-skilled workers without hurting high-skilled workers. This stands in stark contrast to the traditional paradigm for trade in final goods which holds that gains from trade typically entail winners and losers among different types of factor owners. They identify three channels through which offshoring of labor tasks may affect wages: (i) the productivity channel, (ii) the job displacement channel, and (iii) the terms of trade channel. A small economy will only observe channels (i) and (ii), and in their type of model, featuring complete intersectoral factor mobility, a well diversified economy will see the displacement effect absorbed by Rybczynski-type factor reallocation, leaving the productivity channel as a source of wage increases. But surely, against the backdrop of overwhelming evidence against complete factor mobility, brushing aside displacement effects by Rybczynski-type reallocation must be worrying. Might the concern about wages and unemployment be justified in a less benign setup departing from frictionless reallocation?

We address this question by going to the far extreme where any such reallocation is ruled out by assuming a single sector economy. For the sake of clearly isolating effects, we assume a small economy, thus squarely focusing on the productivity effect and the job displacement effect of offshoring. For a meaningful discussion of "lifting-all-boats" scenarios, we allow for two factors, high-skilled and low-skilled workers, and we assume offshoring to take place independently, and differentially, for both low- and high-skilled labor tasks. We make a distinction between two possible sources of job displacement through offshoring, one driven by increasing the range of tasks moved offshore if this becomes less costly (an extensive margin effect), the other driven by input substitution away from tasks performed domestically to tasks performed more cheaply offshore (an intensive margin effect). The impact of offshoring on wages for a certain type of worker depends on how these two job displacement effects, working towards a lower wage, compare with the productivity effect mandating a higher wage. Importantly, in general equilibrium any type of worker also benefits from an offshoring-induced higher productivity of the other type of worker – a standard complementarity effect.

We speak of a low-skill factor bias in offshoring, if the share of tasks moved offshore (extensive margin) is higher for low-skilled labor than for high-skilled labor. A key insight emerging from our analysis is that, whatever the factor bias of offshoring, there is a partially offsetting relationship between the displacement effect and the productivity effect of offshoring. The intuition for this is simple: Absent all offshoring, wage levels are determined by the relative scarcity of the two types of labor. Allowing for differential offshoring of both types of labor tasks, the factor offshored more extensively becomes less scarce, facing a downward pressure on the wage. At the same time, however, it benefits over-proportionately from a relatively larger productivity effect on domestic workers, precisely because a larger share of the labor tasks are obtained less expensively from offshore. As regards the wage effects, it turns out that for a large class of offshoring scenarios the productivity effect is the dominating force, simultaneously for low- and high-skilled workers, thus "lifting of all boats".

More specifically, we derive the following results. First, comparing wages in a cum-offshoring equilibrium with autarky wages, the intensive margin displacement effect as such is always strictly dominated by the productivity effect, contributing to higher (real) wages with offshoring for *both* types of workers. In percentage terms, this intensive margin effect on wages is indeed uniform for both types of workers. Moreover if the factor bias in offshoring is not too large, then it works to the benefit of both types of workers who will enjoy a higher wage than under autarky. Secondly, in relative terms, the wage effect works in favor of the factor with the lower extensive margin displacement effect. Third, for an exogenous separation of tasks that are amenable to offshoring from those that aren't, a piecemeal reduction in the cost of offshoring proportionally lifts up wages of both low and high-skilled workers. Fourth, for a plausible specification of task heterogeneity, endogenously determining the range of tasks that are moved offshore, we again observe a uniformly beneficial effect of a piecemeal reduction in the offshoring cost on both types of wages. Moreover, cum-offshoring wages are higher than autarky wages for both types of workers, provided that the difference between the offshoring potential, measured as the gap between domestic autarky wage and the foreign wage, is sufficiently small.

Arguably, these results do not justify the special concern that policy makers apparently have regarding the globalization of supply chains. However, wages are but one side of this concern. Speaking to the near conviction of policy makers and the general public that offshoring not only depresses domestic wages, but may also come with employment losses leading to higher unemployment, we extend our baseline model to allow for endogenous employment responses. Embedding our offshoring model in a static version of Pissarides's (2000) of search and matching framework, we show that a piecemeal reduction in the cost of offshoring is not only associated with a proportional rise in wages for both types of labor, but also with a proportional increase in the aggregate employment of all workers. The dominant productivity effect of offshoring makes it more profitable for task producers to increase their employment by expanding their (costly) hiring activities. As more vacancies are posted, it becomes more difficult to find suitable workers in order to form successful job matches. The increased value of a successful job match then is shared with workers, who benefit from higher wages as a result from firm-level bargaining between workers and their employers.

Our paper contributes to a voluminous literature on the labor market effects of offshoring, surveyed by Feenstra (2010), Harrison et al. (2011) and, more recently, by Hummels et al. (2018). Earlier literature (cf. Feenstra and Hanson, 1996, 1997; Kohler, 2004) has modelled offshoring as the import of value-added components that combine skilled and unskilled labor in order to explain rising skill premiums around the globe and explore the role of offshoring for factor price adjustment to goods price changes. Grossman and Rossi-Hansberg (2008) zoom in on labor, introducing the concept of (skill-specific) tasks as the unit of analysis in order to explore the wage effects of offshoring. All of these papers use a two-sector Heckscher-Ohlin framework, hence the results are based on the assumption of Rybczynski-type intersectoral reallocation of factors. Arguably, this is a benign environment, as this reallocation absorbs all job displacement occurring with an increase in offshoring. Our point of departure is Grossman and Rossi-Hansberg (2008), but by focussing on a single-sector economy we assume a somewhat less "benign" environment. We explore how the labor supply effect (already present in Feenstra and Hanson, 1996, 1997) interacts with the productivity effect from Grossman and Rossi-Hansberg (2008) in shaping the wage and employment effects of offshoring. Our paper thereby addresses the important question of how exactly to model the offshoring process, allowing for both an exogenously fixed extensive task margin (as for example in Antràs and Helpman (2004), Mitra and Ranjan (2010), or Egger et al. (2015)) and for an endogenously adjusting extensive task margin (as for example in Grossman and Rossi-Hansberg (2008) and Egger et al. (2016)).[1]

Finally, our paper also contributes to the theoretical literature on the unemployment effects of offshoring. Keuschnigg and Ribi (2009) explore the effects of welfare state policies in an economy where high domestic wages prompt firms with a sufficiently high success probability to offshore their entire production process of a low-tech input using low-skilled labor. This is different from the Grossman and Rossi-Hansberg (2008) environment in that it rules out any productivity effect of offshoring. Assuming that employment of low-skilled workers is subject to costly search, the displacement effect then leads to an unambiguous increase in unemployment whenever the offshoring becomes less costly. Keuschnigg and Ribi (2009) explore the implications of welfare state policies in the form of an unemployment insurance and a redistributive income tax. They then explore the implications of welfare state policies. Focussing on a two-sector general-equilibrium model with labour-market search frictions, Mitra and Ranjan (2010) show that offshoring is associated with increasing wages and decreasing sectoral unemployment provided that workers are perfectly mobile across sectors. With imperfect inter-sectoral labour mobility unemployment in the offshoring sector may rise. Introducing collective bargaining into a search model, Ranjan (2013) shows that there is a non-monotonic relationship between offshoring and unemployment: unemployment falls for declining offshoring costs, that are sufficiently high in the initial equilibrium, and increases when the costs of offshoring become sufficiently low.[2] Analysing offshoring in a model with heterogeneous firms and rent sharing at the firm-level, Egger et al. (2016) find that the level of equilibrium unemployment is tied to the distribution of wages across firms, and that by altering the composition of firms offshoring can have a non-monotonic effect on equilibrium unemployment.[3]

We structure our paper as follows: In Section 2.1 we develop our model of offshoring, describing the two margins of job displacement as well as the productivity effect, and de-

[1] Building on the work of Grossman and Rossi-Hansberg (2008), who assume task to be perfect complements, we follow Groizard et al. (2014) and generalise the task assembly to allow for an arbitrary degree of substitutability between tasks.

[2] In an early contribution Skaksen (2004) shows that in a unionised labor market the mere possibility of offshoring results in declining wages and more employment. However, if the costs of offshoring fall below a critical level, the trade union suddenly gives up its strategy of wage moderation and accepts an employment cut in exchange for higher domestic wages.

[3] Sethupathy (2013) and Groizard et al. (2014) also explore the reallocation of workers between heterogeneous firms in response to an offshoring shock.

riving equilibrium relationships for wages conditional on extensive margin job replacement through offshoring. In Section 3 we derive our key wage results for alternative specifications of task heterogenity. Section 4 then extends our results to a framework with search and matching frictions, in which aggregate employment endogenously responds to a decline in the offshoring costs. Section 5 concludes.

2 Production, Offshoring, and Wages

We consider an economy in which two types of intermediate inputs are used to produce a homogeneous *numéraire* good. One of the intermediate inputs is produced relying on low-skilled labor, the other is produced using high-skilled labor, each given in inelastic domestic supply. For each input, production means that workers perform a continuum of tasks. Each task is essential, but tasks may be substituted for each other. Domestic intermediate input producers may draw on foreign labor to perform production tasks, thus importing tasks for intermediate input production. In doing so, they face a perfectly elastic foreign supply of each type of labor at given (low) foreign wage rates while using their domestic technology.[4] However, imports of tasks are subject to an "iceberg-type" real trade cost, varying along the continuum of tasks, but also including a common cost shifter which serves to analyze an increase in globalization. The economy pays for imported tasks by means of exporting the final good.

We use a subscript $i \in \{L, H\}$ to indicate whether the production of an intermediate input relies on low- or high-skilled labour. Production of the aggregate *numéraire* good is governed by a Cobb-Douglas production technology $F(Q_L, Q_H) = Q_L^{\mu_L} Q_H^{\mu_H}$ featuring constant returns to scale, i.e. $\mu_L + \mu_H = 1$. Producers are price takers on all markets and maximize their profits. Relative demand for low- and high-skill intermediate inputs Q_i and Q_j therefore emerge as:

$$p_i = \mu_i \left(\frac{Q_j}{Q_i} \right)^{\mu_j} \quad i, j \in \{L, H\} \text{ with } i \neq j, \tag{1}$$

in which p_i denotes the price of intermediate input i.

[4] Baldwin calls this type of globalization the "third unbundling"and portrays it as an unbeatable combination of "G7 know-how with developing nation labor"; see (Baldwin, 2016)

2.1 Displacement Effects in Partial Equilibrium

Production of i-specific intermediates requires a continuum of tasks $\hat{\eta}_i \in [0,1]$ to be performed by low- or high-skilled workers, respectively. Relaxing the assumption of perfect task complementarity (cf. Grossman and Rossi-Hansberg, 2008), we stipulate that tasks are assembled according to a Cobb-Douglas technology, such that the output of intermediate i is given by $Y_i = \exp[\int_0^1 \ln l_i(\hat{\eta}_i) d\hat{\eta}_i]$, in which $l_i(\hat{\eta}_i) \geq 0$ denotes the quantity of labour employed in the performance of task $\hat{\eta}_i$. As in Grossman and Rossi-Hansberg (2008), tasks differ in terms of their offshoring cost, modelled as "iceberg-cost", with a multiplicative general cost shifter $\tau \geq 1$ and a schedule $T(\hat{\eta}_i) \geq 1$, which is increasing in $\hat{\eta}_i$. Without loss of generality, we assume $T(0) = 1$. Thus, $\tau T(\hat{\eta}_i)$ units of foreign labour of type i have to be employed in order to have the task $\hat{\eta}_i$ performed in the same amount and quality as obtained from using one unit of domestic labour.

We denote the skill-specific wages at home and abroad by $w_i \geq 0$ and $w_i^* \geq 0$, respectively. Accounting for the task-specific offshoring costs $\tau T(\hat{\eta}_i)$, there is a critical task $\eta_i \in [0,1]$ such that $\tau T(\hat{\eta}_i) w_i^* < w_i$ for all tasks $\hat{\eta}_i \in [0, \eta_i)$ and $\tau T(\hat{\eta}_i) w_i^* > w_i$ for all tasks $\hat{\eta}_i \in (\eta_i, 1]$. Cost minimization then requires that all tasks in $\hat{\eta}_i \in [0, \eta_i)$ are performed abroad (offshore) while tasks in $\hat{\eta}_i \in (\eta_i, 1]$ are performed domestically (onshore). In the following we therefore refer to η_i as the *extensive* margin of offshoring for input i. Intermediate input producers choose their task levels so as to minimize cost. The minimum unit cost for input i emerges as:

$$c_i = \exp\left(\int_0^{\eta_i} \ln[\tau T(\hat{\eta}_i) w_i^*] \, \mathrm{d}\hat{\eta}_i + \int_{\eta_i}^1 \ln w_i \, \mathrm{d}\hat{\eta}_i\right).$$

Noting that $\int_{\eta_i}^1 \ln w_i \, \mathrm{d}\hat{\eta}_i = \ln w_i - \int_0^{\eta_i} \ln w_i \, \mathrm{d}\hat{\eta}_i$, we may write $c_i = w_i/\Omega_i$, with

$$\Omega_i = \exp\left(\int_0^{\eta_i} \ln\left[\frac{1}{\tau T(\hat{\eta}_i)} \frac{w_i}{w_i^*}\right] \mathrm{d}\hat{\eta}_i\right) \geq 1 \tag{2}$$

denoting the *productivity effect* of offshoring familiar from Grossman and Rossi-Hansberg (2008). By offshoring the tasks $\hat{\eta}_i \in [0, \eta_i)$ for which foreign labor costs are relatively lower, producers of the input i reduce their cost by a factor $1/\Omega_i < 1$ (relative to a scenario without offshoring), which is equivalent to a productivity increase of $\Omega_i - 1$ percent.

Applying Shephard's Lemma to $c_i = w_i/\Omega_i$, we can derive intermediate input producers' domestic labour demand per unit of output Y_i as:

$$L_i/Y_i = (1-\eta_i)/\Omega_i < 1. \tag{3}$$

Since under autarky we have $L_i/Y_i = 1$, offshoring is associated with a reduction in the domestic per-unit labour demand. The term $(1-\eta_i)/\Omega_i < 1$ measures the total *worker displacement effect* of offshoring that is at the core of the public discussion. It has two parts. The first is the direct job displacement due to the fact that only a fraction $1-\eta_i < 1$ of tasks performed falls on domestic labor demand; we speak of the extensive margin displacement effect. The second part derives from the fact that the tasks in $\hat{\eta}_i \in [0, \eta_i)$ are produced at a lower cost than the domestic tasks $\hat{\eta}_i \in (\eta_i, 1]$, so that offshoring firms find it optimal to substitute away from tasks performed domestically to tasks performed more cheaply abroad. We call this the intensive margin displacement effect, and its magnitude is measured by $1/\Omega_i < 1$. The excess supply of labour generated by job displacement is isomorphic to an increase in the economy's labor supply, which is the reason why Grossman and Rossi-Hansberg (2008) refer to a *labour supply effect* of offshoring. It should be noted, however, that Grossman and Rossi-Hansberg (2008) rule out substitution between tasks, hence their labour supply effect simply equals $1-\eta_i$.

2.2 Wage Effects in General Equilibrium

General equilibrium requires market clearing for both types of labour and both types of intermediate inputs. Denoting fixed labor supply by N_i, we have $L_i = N_i$ and $Q_i = Y_i$, which implies $Q_i = [\Omega_i/(1-\eta_i)]\, N_i$. Inserting this into Eq. (1) and invoking zero profits, $p_i = w_i/\Omega_i$, allows us to solve for the two wage rates:

$$w_i = \Omega_i^{\mu_i}\Omega_j^{\mu_j}\left[(1-\eta_i)/(1-\eta_j)\right]^{\mu_j} w_i^A, \quad i,j \in \{L,H\} \text{ with } i \neq j, \tag{4}$$

in which $w_i^A > 0$ denotes the autarky wage rate $w_i^A = \mu_i(N_j/N_i)^{\mu_j}$. Note that Eq. (4) does not represent a closed form solution, as Ω_L and Ω_H as well as η_L and η_H are jointly endogenous to τ. Nevertheless, it delivers interesting insights into the wage effect of offshoring, which we summarise in form of Proposition 1:

Proposition 1 (wage effects of offshoring)

(a) *For either type of labour, the labor supply effect of offshoring at the intensive margin is dominated by the productivity effect. If both labour types experience the same labor supply effect at the extensive margin, offshoring is associated with a uniform wage gain from offshoring (compared to autarky) for all workers.*

(b) *Relative wages are determined by the relative labor supply effect of offshoring at the extensive margin* $(1-\eta_i)/(1-\eta_j)$*. This effect works in favour of the factor with the lower extensive margin.*

(c) *If offshoring has a low-skill bias, then high-skilled workers unambiguously gain from offshoring. But there is a distinct possibility of both types of labor gaining from offshoring, even if the factor bias in offshoring is not too large.*

Proof The proof of (a) and (b) follows immediately from Eq. (4), in which $\Omega_i^{\mu_i}\Omega_j^{\mu_j} \geq 1$ and $w_i = \Omega_i^{\mu_i}\Omega_j^{\mu_j}$, if $\eta_i = \eta_j$ for $i \neq j$. As to part (c), the necessary condition for labor of type i to benefit from offshoring is

$$\frac{1-\eta_i}{1-\eta_j} > \Omega^{-\mu_j} < 1, \tag{5}$$

in which $\Omega = \Omega_i^{\mu_i}\Omega_j^{\mu_j}$. If offshoring has a low-skill bias, $\eta_L > \eta_H$, then $(1-\eta_H)/(1-\eta_L) > 1$, hence this condition is trivially satisfied for high-skilled workers. But there is a distinct possibility for $(1-\eta_L)/(1-\eta_H) > \Omega^{-\mu_H}$ even if $\eta_L > \eta_H$, because $\Omega^{-\mu_H} < 1$. ■

To understand Proposition 1, it is instructive to focus on the knife-edge case $\eta_i = \eta$, implying a uniform extensive margin labour supply effect from offshoring for both types of labour. We refer to this as offshoring having no factor bias. We can then decompose the wage effect for any type of labor into two effects. First, offshoring affects the skill intensity of final goods production according to $Q_H/Q_L = (\Omega_H/\Omega_L)(N_H/N_L)$. Under autarky the skill intensity of production is equal to the skill-intensity of the endowment, i.e. $Q_H/Q_L = N_H/N_L$. With offshoring, there is substitution towards the type of labour with the larger productivity effect, reducing that labour's marginal productivity while increasing the marginal productivity of the other type of labour. This is the *intensive margin displacement effect* introduced above. But secondly, there is the direct effect from a higher productivity on account of cheaper imported tasks. Part (a) of Proposition 1 is now easily understood. Whichever type of labor is hurt from the intensive margin displacement effect enjoys a higher productivity increase. And conversely, whichever type of labor benefits from the intensive margin displacement effect enjoys a lower productivity effect. With decreasing marginal returns to either factor ($\mu_i < 1$), the productivity effect dominates the intensive margin displacement effect for either type of labour so that offshoring proportionally scales up both wages w_i.

In the general case with $\eta_i \neq \eta_j$ the *extensive displacement effect*, i.e., the factor bias of offshoring, comes into play as well. Rewriting Eq. (4), we may decompose the wage effect of offshoring in comparison with autarky into the *productivity effect* (which proportionally scales up wages of labour type i by the factor $\Omega_i > 1$) and the two types of labour displacement effects as follows:

$$\ln w_i = \ln w_i^A \underbrace{+ \ln \Omega_i}_{\substack{\text{productivity}\\ \text{effect}}} \underbrace{- \mu_j \left(\ln \Omega_i - \ln \Omega_j\right)}_{\substack{\text{intensive margin}\\ \text{job displacement}}} \underbrace{- \mu_j \left[\ln\left(1-\eta_j\right) - \ln\left(1-\eta_i\right)\right]}_{\substack{\text{extensive margin}\\ \text{job displacement}}}.$$

In models with many sectors and complete factor mobility (cf. Grossman and Rossi-Hansberg, 2008), Rybczynski-type reallocation absorbs all labour displacement effects. Offshoring then appears as a lifting all boats scenario, in which all wages rise through the productivity effects of offshoring, i.e., $w_i = \Omega_i w_i^A$. However, from a theoretical perspective such a benign environment may seem questionable. Eq. (4) reveals that in the present case featuring a less benign environment negating Rybczynski-type reallocation, a "lifting of all boats" scenario of offshoring emerges, if $\eta_i = \eta_j$, i.e., if the factor bias in offshoring not too large, as stated in part (c) of Proposition 1.

3 Specifying Task Heterogeneity

In this section, we explore conditions for a "lifting all boats"-scenario in more detail by examining how Ω_i and η_i are jointly determined by the details of task heterogeneity. We do so in two ways. First by comparing the autarky equilibrium with an offshoring equilibrium under a non-prohibitive level of τ, and secondly by focusing on the marginal effects of a reduction in τ on w_H and w_L. Obviously, what matters for the joint determination of Ω_i and η_i is the schedule $T(\hat{\eta}_i)$, which describes the heterogeneity of tasks in terms of the costs that must be incurred when they are performed in offshore locations. A key purpose of the analysis is to identify types of task heterogeneity that guarantee a "lifting all boats"-effect of offshoring?

It turns out that for the two most commonly used specifications of $T(\hat{\eta}_i)$ the relative extensive labour supply effect $(1-\eta_i)/(1-\eta_j)$ is a constant. Any decline in the offshoring cost shifter τ then results in an increase of $\Omega_i^{\mu_i}\Omega_j^{\mu_j}$, which proportionately scales up wages w_i for both $i \in \{L, H\}$, even if the (relative) labour supply effect of offshoring cannot conveniently be absorbed through a Rybczynski-type reallocation effect.

3.1 Exogenous Extensive Task Margin

The trade literature often assumes that offshorability is a discrete task characteristic, with some tasks being offshorable and others not (cf. Antràs and Helpman, 2004; Skaksen, 2004; Mitra and Ranjan, 2010; Hogrefe and Wrona, 2015; Egger et al., 2015).[5] In the present context, the dichotomy of offshorable and non-offshorable tasks translates into an offshoring cost schedules with parametrically fixed levels of $\eta_i \in (0,1)$, such that:

$$T(\hat{\eta}_i) = \begin{cases} 1 & \text{for } \hat{\eta}_i \in [0, \eta_i), \\ \infty & \text{for } \hat{\eta}_i \in [\eta_i, 1], \end{cases} \tag{6}$$

for all $i \in \{L, H\}$. This specification may seem like a trivial case, but it is worth exploring the consequences of an exogenously fixed extensive task margin within in the present model. For offshoring to occur in the first place we must have $w_i^*\tau < w_i^A$ for $i = L$, or $i = H$, or both. The productivity effect of offshoring Ω_i in Eq. (2) then straightforwardly simplifies to

$$\Omega_i = \left(\frac{1}{\tau}\frac{w_i}{w_i^*}\right)^{\eta_i}. \tag{7}$$

It is obvious from Eq. (4) that with a symmetric offshoring technology for both types of tasks, i.e. $\eta_L = \eta_H$, offshoring "lifts all boats," provided that $w_i > \tau w_i^*$ for $i \in \{H, L\}$. This condition is trivially satisfied, since otherwise firms would abstain from offshoring. We show in Appendix A.1 that inserting Eq. (7) into Eq. (4) leads to the following closed form solution for wages:

$$\begin{aligned} \ln w_i = \ln w_i^A - \frac{\tilde{\eta}}{1-\tilde{\eta}}\ln\tau + \frac{1}{1-\tilde{\eta}}[\eta_L\mu_L\ln\omega_L + \eta_H\mu_H\ln\omega_H] \\ + \frac{1}{1-\tilde{\eta}}\left[(1-\eta_j)\mu_j\ln(1-\eta_i) - (1-\eta_j)\mu_j\ln(1-\eta_j)\right], \end{aligned} \tag{8}$$

[5] Keuschnigg and Ribi (2009) look at the extreme case in which firms face a choice between zero offshoring and relocating *all* of their production activities abroad.

in which $\tilde{\eta} \equiv \eta_L \mu_L + \eta_H \mu_H \in (0,1)$ and $\omega_i \equiv w_i^A / w_i^* > 1$. In the sequel, we shall refer to ω_i as the offshoring potential. Eq. (8) holds for $i, j \in \{L, H\}$ with $i \neq j$, and allows us to state the following proposition:

Proposition 2 (exogenous extensive margins)

(a) In an equilibrium featuring offshoring of both low- and high-skilled tasks, any decline in the offshoring cost τ proportionally lifts up both wages.

(b) With symmetric offshoring technologies, i.e. $\eta_L = \eta_H$, wages for both factors are higher in an offshoring equilibrium than under autarky.

(c) For $\eta_i > \eta_j$ factor j always prefers offshoring relative to autarky; and factor i prefers offshoring relative to autarky, if the offshoring bias $\eta_i - \eta_j$ is not too large.

Proof Part (a) of Proposition 2 is obvious from the fact that $\tilde{\eta} = \eta_L \mu_L + \eta_H \mu_H$ is a weighted average over $\eta_L \in [0,1)$ and $\eta_H \in [0,1)$ and therefore smaller than one. In the symmetric case $\eta_L = \eta_L$ the last term in Eq. (8) vanishes, which proves Part (b) of Proposition 2. Finally, Part (c) of Proposition 2 directly follows from $(1 - \eta_j)\mu_j / (1 - \tilde{\eta}) > 0$. ■

The intuition for Part (a), looking at marginal liberalization, is straightforward. If the extensive margins η_L and η_H are exogenously fixed, then a reduction in τ does not generate any labor displacement at the extensive margin, provided the equilibrium features offshoring of both factors to start with. Part (b) compares an offshoring equilibrium with autarky. As we know from Proposition 1, the displacement effect at the intensive margin is strictly dominated by the productivity effect, and the net effect is the same, proportionally, for both types of labour. The exact same logic now applies for a regime shift from autarky to offshoring, provided that the extensive margin labour supply effects are the same for high- and low-skilled labour.

If the extensive margin displacement effects are heterogeneous, as in Part (c) of Proposition 1), then having a lower extensive margin displacement effect reinforces the productivity effect in the wage comparison. However, suffering from a stronger extensive margin displacement effect will not imply a wage loss, provided that the difference is not too large.

In Appendix A.2 we show that the above results for a symmetric offshoring technology readily extends to a more general modelling environment, in which the elasticity of substitution between tasks is allowed to take arbitrary (non-negative) values $\varepsilon \in [0, \infty)$. The wage effect of falling offshoring costs τ can then be expressed as $\mathrm{d}\ln w_i/\mathrm{d}\ln\tau = -\psi/(1-\psi) \leq 0$, in which $\psi \in [0,1]$ collects several terms that converge to the constant η for $\varepsilon = 1$.

3.2 Endogenous Extensive Task Margin

If tasks are differ in terms of the cost that have to be incurred when moving them to an offshore location, then the extensive task margin η_i becomes endogenous. The literature assumes that tasks may be ordered in line with their offshorability, leading to a monotonic offshoring cost schedule (cf. Kohler, 2004; Grossman and Rossi-Hansberg, 2008; Sethupathy, 2013; Wright, 2014; Groizard et al., 2014). Following Grossman and Rossi-Hansberg (2008, p. 1986), we adopt the parameterization:

$$T(\hat{\eta}_i) = (1-\hat{\eta}_i)^{-t}, \tag{9}$$

with $t > 0$ serving as a shape parameter determining the degree of task heterogeneity at any point $\hat{\eta}_i$ of the task interval. For simplicity, we assume this parameter to be the same for both types of labor. Task heterogeneity increases as we move up to higher values in the interval $\hat{\eta}_i \in [0,1]$. The elasticity of $T(\hat{\eta}_i)$, given by $t\hat{\eta}_i/(1-\hat{\eta}_i)$, is a local measure of how strongly task differ in terms of their offshorability. The extensive task margin η_i is implicitly determined by the condition $T(\eta_i)\tau w_i^* = w_i$. Using Eq. (9) we obtain:

$$\eta_i = 1 - \tau^{\frac{1}{t}} (w_i^*/w_i)^{\frac{1}{t}} \in (0,1) \;\; \forall \;\; \tau w_i^* < w_i. \tag{10}$$

Substituting $\tau w_i^*/w_i = (1-\eta_i)^t$ together with $T(\hat{\eta}_i)$ from Eq. (9) into Eq. (2) allows us to express the productivity effect of offshoring as follows:

$$\Omega_i = \Omega(\eta_i) = [(1-\eta_i)\exp(\eta_i)]^{-t} \geq 1. \tag{11}$$

We have $\partial\Omega(\eta_i)/\partial\eta_i > 0$ according to Eq. (11), and $\partial\eta_i/\partial\tau < 0$ according to Eq. (10). Other things equal, lower offshoring costs τ raise both extensive margins of offshoring, thus lowering the demand for both types of labour. At the same time, the increase in η_i is associated with increased cost saving from the offshoring of infra-marginal tasks, captured by the productivity effects $\Omega_i > 1$.

As before, Eq. (4), together with Eq. (10), implies that $w_i/w_j = [(1-\eta_i)/(1-\eta_j)]^{-t} w_i^A/w_j^A$, leading to the following solution for the relative displacement effect at the extensive margin:

$$\frac{1-\eta_i}{1-\eta_j} = \left(\frac{w_j^A}{w_j^*} \Big/ \frac{w_i^A}{w_i^*} \right)^{\frac{1}{1+t}}. \tag{12}$$

Thus, Eq. (4) allows us to rewrite the wage rate as:

$$\ln w_i = \ln w_i^A + \mu_i \ln \Omega(\eta_i) + \mu_j \Omega(\eta_j) + [\mu_j/(1+t)](\ln \omega_j - \ln \omega_i), \quad i, j \in \{L, H\}, \quad i \neq j. \tag{13}$$

This allows us to formulate the following proposition on wage effects with an endogenous extensive offshoring margin.

Proposition 3 (endogenous extensive margins)

(a) In an equilibrium that features low- and high-skilled offshoring any decline in the offshoring cost τ proportionally lifts up both wages.

(b) With symmetric offshoring potentials, i.e. $\omega_L = \omega_H$, wages for both factors are higher in an offshoring equilibrium than under autarky.

(c) For $\omega_j > \omega_i$ factor j always prefers offshoring relative to autarky, and factor i prefers offshoring relative to autarky, provided that $\omega_j - \omega_i$ is not too large.

Proof See Appendix A.3. ■

Proposition 3 closely resembles Proposition 2, with the major difference that the extensive task margins η_L and η_H now are endogenous, which allows us to express the relative labour supply effect at the extensive margin as a function of the exogenous offshoring potentials $\omega_i \equiv w_i^A/w_i^* > 1 \ \forall \ i \in \{L, H\}$. As a consequence, any decline in the offshoring costs τ is associated with a proportional increase in both wages w_i, provided that both factors are offshored in equilibrium (cf. Part (a) of Proposition 3). In the Appendix we also demonstrate that the quantitative wage effect of a decline in the offshoring costs $\partial \ln w_i/\partial \ln \tau = -\tilde{\eta}/(1-\tilde{\eta}) > 0$ is the same in Eq. (8) and Eq. (13), which directly follows from the envelope theorem, according to which all indirect effects (which would work through an adjustment in the endogenous extensive task margins η_L and η_H) can be ignored. If both factors have the same offshoring potential, i.e. $\omega_L = \omega_H$, offshoring wages are unambiguously larger than under autarky (by the factor $\Omega(\eta) \geq 1$). For heterogeneous offshoring potentials, i.e. $\omega_i \neq \omega_j$, (cf. Part (c) of Proposition 3) the factor with the higher offshoring potential $\omega_i > \omega_j$ will be offshored more intensively $\eta_i > \eta_j$. The relative labour supply effect at the extensive margin then works to the (dis)advantage of the factor with the lower (higher) offshoring potential.

In Appendix A.4 we demonstrate that our result also holds in a more general modelling environment, which allows the elasticity of substitution between tasks to take arbitrary (non-negative) values $\varepsilon \in [0, \infty)$. The wage effect of falling offshoring costs τ can then be computed as $\mathrm{d} \ln w_i / \mathrm{d} \ln \tau = -(1-\varphi)/\varphi \leq 0$, in which $\varphi \in (0,1)$ collects several terms that converge to $1 - \tilde{\eta}$ for $\varepsilon = 1$.

4 Offshoring and Employment

The policy debate about offshoring focuses at least as much on employment effects as it does on wages. Employment effects can arise in two forms: reallocation of labor across sectors, as in Grossman and Rossi-Hansberg (2008) and Wright (2014), or changes from employment into unemployment, as in Egger and Kreickemeier (2008), Keuschnigg and Ribi (2009), Mitra and Ranjan (2010), or Egger et al. (2015). Arguably, unemployment effects are more of a concern to policy makers than reallocation effects, which is nicely reflected in our single sector model where any employment effect must be a movement into or out of unemployment. Up to this point, however, we have ruled out unemployment effects by assuming full employment of both types of labor. In order to analyse the employment effects of offshoring, we now extend our model to allow for unemployment.

4.1 Search, Employment and Wages

We adopt a static version of the search and matching model by Pissarides (2000), which explains unemplomyment as an equilibrium phenomenon. This model stipulates that employment relationships are generated through the interaction between the number of people out of work and the number of vacancies firms are willing to post, given that posting vacancies is costly to them. In our case, an employment relationship relates to the performance of a certain task. Thus, the firm in our case is a task producer. Search and matching takes place separately for the two types of workers, with the number of workers of type i available for matching equal to the endowment N_i. Potential task producers face a matching technology represented by $M_i = A_i V_i^{1-\alpha} U_i^{\alpha}$, where M_i is the number of matches, V_i is the number of vacancies posted, and U_i is the number unemployed workers of type i. Note that there is no employment without search, hence in this static model we have $U_i = N_i$. The parameter $\alpha \in (0, 1)$, assumed to be the same for both types of workers, represents the matching elasticity which measures how the number of matches changes with the number of unemployed. The overall efficiency of the skill-specific matching technology is captured by $A_i > 0$.[6]

Using $\theta_i \equiv V_i/U_i$ to denote the skill-specific labour market tightness, the probability of a vacancy to be matched is $m_i(\theta_i) \equiv M_i/V_i = A_i\theta_i^{-\alpha}$ and the corresponding probability for a worker is $\theta_i m_i(\theta_i) \equiv M_i/U_i = A_i\theta_i^{1-\alpha}$. Note that there is no employment without search, hence $U_i = N_i$. Posting vacancies and hiring is costly, at a rate equal to $\kappa_i > 0$ per vacancy. The search cost per match is then equal to $\kappa_i m_i(\theta_i) = \kappa_i/(A_i\theta_i^{-\alpha})$. In the full employment version of our model, the price of a domestic task was equal to the wage rate w_i. Costly search now implies a wedge between the wage rate and the task price which we denote by w_i. Taking task prices q_i and wages w_i as well as the labor market tightness θ_i as given, task producers open up new positions as long as their profit margin $q_i - w_i$ is large enough to cover the expected cost per match. Under free entry, the *job creation* condition then reads as

$$q_i - w_i = \frac{\kappa_i}{A_i}\theta_i^{\alpha}. \tag{14}$$

Once a match occurs, the task producer and the worker bargain over sharing the job surplus. Note that on the task level there is a unitary productivity of labor, hence there is no scope for intra-firm bargaining as in Stole and Zwiebel (1996). We assume that wages w_i are determined by generalized Nash bargaining, in which workers have a zero outside option and a bargaining power equal to $\gamma_i \in (0, 1)$. This implies that the wage rate w_i is determined according to

$$w_i = \arg\max \left\{ w_i^{\gamma_i} \left(q_i - w_i\right)^{1-\gamma_i} \right\}. \tag{15}$$

[6]We assume that A_i is sufficiently low for the model to feature equilibrium unemployment for both skill types.

From the corresponding first order condition it follows that $w_i = \gamma_i q_i$. Using Eq. (14) we can solve for the task price and the wage rate as functions of the labour market tightness θ_i:

$$q_i = \frac{1}{1-\gamma_i}\frac{\kappa_i}{A_i}\theta_i^{\alpha} \qquad \text{and} \qquad w_i = \frac{\gamma_i}{1-\gamma_i}\frac{\kappa_i}{A_i}\theta_i^{\alpha}. \tag{16}$$

The first of these equations implies an inverse task supply curve. If successful matches are more valuable to task producers because of a higher task price q_i, then – other things equal – more vacancies V_i are posted, which directly translates into a higher labor market tightness θ_i and, therefore, into a larger task supply. The second expression in Eq. (16) reflects the fact that a tighter labour market makes it harder to fill open vacancies, which – other things equal – increases the "supply price" of tasks and, thus, the surplus of the employment relationship. Nash bargaining then implies a higher wage rate.

The number of matches follows directly from the matching technology, $M_i = \theta_i m_i(\theta_i) N_i$. In view of the unitary labor productivity in task production, M_i must be seen as employment for task supply:

$$E_i^S = A_i N_i \theta_i^{1-\alpha}. \tag{17}$$

As to final producers, given the task price q_i and a cost-minimizing extensive margin of offshoring, they face a per unit cost of intermediate input i equal to q_i/Ω_i. The offshoring cost savings factor Ω_i is determined by complete analogy to Eq. (2) above, with w_i being replaced by q_i. If the foreign labor market is similarly characterized by search and matching, w_i^* in Eq. (2) must be interpreted as the foreign task price. As before, we can apply Shephard's Lemma to obtain the conditional *domestic* task demand for production of intermediate i:

$$E_i^D = Y_i(1-\eta_i)/\Omega_i. \tag{18}$$

In this equation η_i as well as Ω_i depend on the task price q_i as well as on the exogenous magnitudes of τ and w_i^*. Eq. (18) adds up the symmetric demands for specific tasks in the interval $1-\eta_i$ to a total demand for domestic employment E_i^D, taking into account that all tasks are produced with unitary labour productivity.

Labor market equilibrium requires $E_i^D = E_i^S = E_i$ for $i = H, L$, and the equilibrium rates of unemployment are equal to $u_i = 1 - A_i\theta_i^{1-\alpha}$. Note that wages w_i and employment E_i are both positively related to the labor market tightness θ_i through Eqs. (16) and (17). We now proceed with a symmetric specification of the two labor markets: $A_i = A$, $\kappa_i = \kappa$, and $\gamma_i = \gamma$, which allows us to link the relative labour market tightness to the ratio of wages and employment levels:

$$\frac{\theta_i}{\theta_j} = \left(\frac{w_i}{w_j}\right)^{\frac{1}{\alpha}} = \left(\frac{N_j}{N_i}\frac{E_i}{E_j}\right)^{\frac{1}{1-\alpha}}. \tag{19}$$

4.2 Employment Effects in General Equilibrium

General equilibrium requires market clearing for the two intermediate inputs $Y_i = Q_i$, with Q_i determined as in Eq. (1) above. In addition, it requires zero profits in the production of the two intermediate inputs, which now reads as $q_i/\Omega_i = p_i$ or, equivalently, $w_i = \gamma\Omega_i p_i$. Equating demand and supply in Eqs. (17) and (18) while imposing market clearing for intermediates, $Y_i = Q_i$, we obtain the following relationship between intermediate input use and labor market tightness:

$$Q_i = AN_i\theta_i^{1-\alpha}\Omega_i \Big/ (1-\eta_i). \tag{20}$$

Inserting the above expression into Eq. (1) and invoking zero profits, we finally obtain

$$w_i = \Omega_i^{\mu_i}\Omega_j^{\mu_j}\left(\frac{1-\eta_i}{1-\eta_j}\right)^{\mu_j}\left(\frac{\theta_i}{\theta_j}\right)^{\mu_j(\alpha-1)}\gamma\mu_i\left(\frac{N_j}{N_i}\right)^{\mu_j} \quad i,j\in\{L,H\} \text{ with } i\neq j. \tag{21}$$

The key difference to the perfectly competitive wage rate in Eq. (4) derives from the new equilibrium condition for labor market equilibrium, viz. Eq. (19) instead of $E_i/E_j = N_i/N_j$. The closed form solution thus requires a further loop. Using Eq. (19), we can replace θ_i/θ_j in Eq. (21) by $(w_i/w_j)^{1/\alpha}$. From Eq. (21) we can then compute relative wages as $w_i/w_j = [(1-\eta_i)/(1-\eta_j)]^{\alpha}(\mu_i/\mu_j)^{\alpha}(N_j/N_i)^{\alpha}$, which may be substituted back into Eq. (21) to obtain

$$w_i = \Omega_i^{\mu_i}\Omega_j^{\mu_j}\left[(1-\eta_i)/(1-\eta_j)\right]^{\alpha\mu_j} w_i^A \quad i,j\in\{L,H\} \text{ with } i\neq j, \tag{22}$$

in which $w_i^A = \gamma\mu_i^{\mu_i}\mu_j^{\mu_j}\left(\mu_i/\mu_j\right)^{\alpha\mu_j}\left(N_j/N_i\right)^{\alpha\mu_j}$ again denotes the autarky wage. Combining the expression for w_i in Eq. (16) and Eq. (17) we obtain the following solution for employment levels:

$$E_i = N_i A^{\frac{1}{\alpha}}\left(w_i\frac{1-\gamma}{\gamma\kappa}\right)^{\frac{1-\alpha}{\alpha}} \quad i = L, H. \tag{23}$$

Proposition 4 (wage and employment effects of offshoring)

(a) *For either type of labour, the labor supply effect of offshoring at the intensive margin is dominated by the productivity effect. If both labour types experience the same labor supply effect at the extensive margin, offshoring is associated with a uniform wage gain from offshoring (compared to autarky) for all workers. This effect is the same with equilibrium unemployment as in a full employment equilibrium.*

(b) *Relative wages are determined by the relative supply effect of offshoring at the extensive margin $(1-\eta_i)/(1-\eta_j)$. This effect works in favour of the factor with a the lower extensive margin, but compared to a full employment equilibrium, the effect is mitigated through equilibrium unemployment.*

(c) *If offshoring has a low-skill bias, then high-skilled workers unambiguously gain from offshoring. But there is a distinct possibility of both types of labor gaining from offshoring, even if the factor bias in offshoring is not too large. The same applies for employment of both types of workers.*

Proof The proof of (a) and (b) follows immediately from comparison of Eqs. (4) and (21), and noting that $0 < \alpha < 1$, and observing Eq. (23), assuming - trivially - that w_i is larger than w_i^A. The proof of (c) works by complete analogy to Proposition 1. ■

Going through the same steps as in the Subsections 3.1 and 3.2 it is easily verified that for the two most commonly used specifications of the offshoring cost schedule $T(\hat{\eta}_i)$ the relative labour supply effect at the extensive margin, $(1-\eta_i)/(1-\eta_j)$, does not depend on endogenous variables of the model, nor on the offshoring cost shifter τ. Hence, Propositions 2 and 3 continue to hold with equilibrium unemployment. Moreover, from the above it follows that any positive (negative) wage effect will be associated with a positive (negative) employment effect. The intuition for wages w_i and employment E_i moving in the same direction is straightforward: The productivity effects of offshoring increase the task price q_i through an increase of $\Omega_i^{\mu_i}\Omega_j^{\mu_j} \geq 1$, which increases task producers' profit margin $q_i - w_i$ in the job creation condition in Eq. (14). Task producers respond by posting more vacancies, thereby creating more jobs. In turn, workers benefit from higher job surpluses, which are shared – according to Eq. (15) – among workers and task producers.

5 Conclusion

Policy makers and workers in developed countries are more sceptical about globalization of supply chains than they are about freer trade in general. They are fearful of strong downward pressure on domestic wages and employment as firms engage in cost-minimization through offshoring certain labor tasks to low wage foreign countries. Economists are much more sanguine. They see globalization of value added chains as a special form of trade, somewhat habitually emphasizing gains from trade. Indeed, the canonical model of trade in tasks developed by Grossman and Rossi-Hansberg (2008) even portrays offshoring as a form of trade which is distinctly more benign in that it allows for Pareto improvements while trade in final goods typically features winners and losers. The explanation lies in the productivity effect of offshoring, coupled with the assumption that the job displacement effects of offshoring may conveniently be absorbed by smooth, Rybcynski-type intersectoral reallocation of factors.

Smooth factor reallocation across sectors is no doubt an extremely optimistic assumption. We argue that this calls for a re-examination of the beneficial effects of offshoring under a somewhat less benign economic environment that lacks such reallocation. We do so by developing an offshoring model featuring a single sector economy, thus going to the other extreme of *no* factor reallocation, and by examining offshoring scenarios involving both high- and low-skilled tasks. Moreover, we extend the model to include unemployment effects, based on the well-known search-and-matching paradigm of unemployment. The key question is whether this type of reexamination prompts us to significantly revise the sanguine position on offshoring suggested by Grossman and Rossi-Hansberg (2008).

Our conclusion from the above analysis is: not really, or only to a limited extent. The main simple point is that, barring reallocation of factors, those most severely hit by job displacement are also those enjoying the largest productivity effect. It is only if offshoring is characterized by a strong factor-bias that we must expect a winners-and-losers scenario. For a moderate factor-bias there a distinct possibility of offshoring to benefit both types of workers, low- and high-skilled, both in terms of wages and employment.

A Appendix

A.1 Proof of Equation 8

We begin with the derivation of Eq. (8): Inserting Eq. (7) into Eq. (4) yields:

$$w_i^{1-\eta_i\mu_i-\eta_j\mu_j} = \tau^{-\eta_i\mu_i-\eta_j\mu_j} w_i^{*-\eta_i\mu_i} w_j^{*-\eta_j\mu_j} \left(\frac{w_j}{w_i}\right)^{\eta_j\mu_j} \left(\frac{1-\eta_i}{1-\eta_j}\right)^{\mu_j} w_i^A. \tag{A.1}$$

Eq. (4) also implies that:

$$\frac{w_j}{w_i} = \frac{1-\eta_j}{1-\eta_i}\frac{w_j^A}{w_i^A}. \tag{A.2}$$

Inserting the above relationship into Eq. (A.1) allows us to solve for:

$$w_i^{1-\tilde{\eta}} = (w_i^A)^{1-\tilde{\eta}}\tau^{-\tilde{\eta}} \left(\frac{1-\eta_i}{1-\eta_j}\right)^{-\mu_j\eta_j+\mu_j} \left(\frac{w_j^A}{w_j^*}\right)^{\eta_j\mu_j} \left(\frac{w_i^A}{w_i^*}\right)^{\eta_i\mu_i}, \tag{A.3}$$

in which we have made use of definition of $\tilde{\eta} \equiv \eta_L\mu_L + \eta_H\mu_H$. Eq. (8) now follows directly from the above expression. ■

A.2 CES Generalisation for Exogenous Extensive Margins

Allowing for arbitrary values of the elasticity of substitution between tasks $\varepsilon \in [0, \infty)$, we can derive the conditional task demands at home and abroad from the CES production technology $Y_i = [\int_0^1 l_i(\hat{\eta}_i)^{(\varepsilon-1)/\varepsilon} \mathrm{d}\hat{\eta}_i]^{\varepsilon/(\varepsilon-1)}$ as $l_i(\hat{\eta}_i) = Y_i/\Omega_i^\varepsilon$ and $l_i^*(\hat{\eta}_i) = (Y_i/\Omega_i^\varepsilon)[w_i/T(\hat{\eta}_i)\tau w_i^*]^\varepsilon$, whereas:

$$\Omega_i \equiv \left[\int_0^{\eta_i} T(\hat{\eta}_i)^{1-\varepsilon}\left(\frac{\tau w_i^*}{w_i}\right)^{1-\varepsilon} \mathrm{d}\hat{\eta}_i + 1 - \eta_i\right]^{\frac{1}{\varepsilon-1}} \geq 1. \tag{A.4}$$

is defined as the productivity effect of offshoring. Substituting the domestic and foreign labour demands $l_i(\hat{\eta}_i)$ and $l_i^*(\hat{\eta}_i)$ into the cost equation $\int_0^{\eta_i} w_i^* T(\hat{\eta}_i)\tau l_i^*(\hat{\eta}_i)\mathrm{d}\hat{\eta}_i + \int_{\eta_i}^1 w_i l_i(\hat{\eta}_i)\mathrm{d}\hat{\eta}_i$ of the representative offshoring firm allows us to solve for the perfectly competitive price of the intermediate input i as $p_i = w_i/\Omega_i$. Substituting $T(\hat{\eta}_i)$ from Eq. (6) then yields:

$$\Omega_i \equiv \left\{1 + \eta\left[\left(\frac{\tau w_i^*}{w_i}\right)^{1-\varepsilon} - 1\right]\right\}^{\frac{1}{\varepsilon-1}} > 1 \quad \text{if} \quad w_i > \tau w_i^*. \tag{A.5}$$

Substituting Ω_i from Eq. (A.5) together with $\eta_i = \eta$ from Eq. (6) into w_i from Eq. (4) not only implies that $d\ln w_i = d\ln w_j \ \forall \ i,j \in \{L, H\}$, but also allows us to derive the total differential:

$$\mathrm{d}\ln w_i = \psi \cdot \mathrm{d}\ln w_i - \psi \cdot \mathrm{d}\ln\tau, \tag{A.6}$$

in which $\psi \in [0,1]$ is defined as:

$$\psi \equiv \frac{\mu_i \eta (\tau w_i^*/w_i)^{1-\varepsilon}}{1-\eta+\eta(\tau w_i^*/w_i)^{1-\varepsilon}} + \frac{\mu_j \eta (\tau w_j^*/w_j)^{1-\varepsilon}}{1-\eta+\eta(\tau w_j^*/w_j)^{1-\varepsilon}} \in [0,1]. \tag{A.7}$$

For $\varepsilon = 1$ we have $\psi = \eta$. ■

A.3 Proof of Proposition 3

Substituting Eq. (9) into Eq. (2)yields:

$$\Omega_i = \left\{ \frac{\tau w_i^*}{w_i} \exp\left[1 - \left(\frac{\tau w_i^*}{w_i}\right)^{1/t}\right]\right\}^{-t}. \tag{A.8}$$

The log-differential is given by:

$$\mathrm{d}\ln\Omega_i = \frac{\partial \ln\Omega_i}{\partial\tau}\tau \mathrm{d}\ln\tau + \frac{\partial\ln\Omega_i}{\partial w_i} w_i \mathrm{d}\ln w_i, \tag{A.9}$$

with

$$\frac{\partial\ln\Omega_i}{\partial\tau} = -\frac{1}{\tau}\left[1 - \left(\frac{\tau w_i^*}{w_i}\right)^{1/t}\right] \quad \text{and} \quad \frac{\partial\ln\Omega_i}{\partial w_i} = \frac{1}{w_i}\left[1 - \left(\frac{\tau w_i^*}{w_i}\right)^{1/t}\right]. \tag{A.10}$$

With $1-\eta_i = (\tau w_i^* w_i)^{1/t}$ Eq. (A.9) becomes $\mathrm{d}\ln\Omega_i = -\eta_i \mathrm{d}\ln\tau + \eta_i \mathrm{d}\ln w_i$, and the log-change of wages obeys:

$$\mathrm{d}\ln w_i = -\mu_i\eta_i \mathrm{d}\ln\tau + \mu_i\eta_i \mathrm{d}\ln w_i - \mu_j\eta_j \mathrm{d}\ln\tau + \mu_j\eta_j \mathrm{d}\ln w_j, \quad i,j \in \{L,H\}, \quad i \neq j \tag{A.11}$$

which constitutes a system of two equations with two unknowns that can be solved for:

$$\mathrm{d}\ln w_i = \frac{\mu_i\eta_i + \mu_j\eta_j}{1-\mu_i\eta_i-\mu_j\eta_j}\mathrm{d}\ln\tau, \quad i,j \in \{L,H\} \text{ with } i \neq j \quad . \tag{A.12}$$

Part (a) of Proposition 3 directly follows from the above result. In the symmetric case $\eta_L = \eta_L$ the last term in Eq. (13) vanishes, which proves Part (b) of Proposition 3. Finally, Part (c) of Proposition 3 directly follows from $\mu_j/(1+t) > 0$. ■

A.4 CES Generalisation for Endogenous Extensive Margins

Substituting $T(\hat{\eta}_i)$ from Eq. (9) into Ω_i from Eq. (A.4) allows us to solve for:

$$\Omega_i(\eta_i) = (1-\eta_i)^{-t}\left[\frac{1}{t(\varepsilon-1)+1} + \frac{t(\varepsilon-1)}{t(\varepsilon-1)+1}(1-\eta_i)^{1+t(\varepsilon-1)}\right]^{\frac{1}{\varepsilon-1}} \geq 1, \tag{A.13}$$

which is an increasing function of η_i. Substituting $\Omega_i(\eta_i)$ from Eq. (A.13) together with $(1-\eta_i)^{-t} = (w_i/\tau w_i^*)$ from Eq. (10) into w_i from Eq. (4) not only implies that $d\ln w_i = d\ln w_j \ \forall \ i,j \in \{L,H\}$, but also allows us to derive the total differential:

$$0 = \mathrm{d}\ln\tau - \varphi\cdot\mathrm{d}\ln\tau + \varphi\cdot\mathrm{d}\ln w_i, \tag{A.14}$$

in which $\varphi \in (0,1)$ is defined as:

$$\varphi \equiv \frac{\mu_i(\tau w_i^*/w_i)^{\frac{1+t(\varepsilon-1)}{t}}}{\Omega_i(\eta_i)^{\varepsilon-1}} + \frac{\mu_j(\tau w_j^*/w_j)^{\frac{1+t(\varepsilon-1)}{t}}}{\Omega_j(\eta_j)^{\varepsilon-1}} \in (0,1). \tag{A.15}$$

For $\varepsilon = 1$ we have $\varphi = 1-\tilde{\eta}$. ■

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