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# Offshoring Tasks, yet Creating Jobs?

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**Abstract**

We show that in a model of task trade with unemployment due to search and matching the productivity effect of offshoring, emphasized by Grossman & Rossi-Hansberg (2008), emerges as a mechanism of job creation. While improvements in the technology of offshoring cause job losses at the extensive margin where ever more tasks are performed abroad, it also causes job creation at the intensive margin, due to cost-savings associated with inframarginal tasks. We identify conditions under which job creation dominates job destruction. We also show that employment may follow a non-monotonic pattern of adjustment to successive improvements in the technology of offshoring.

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# 1 Introduction

Economic globalization has reached unprecedented "levels of resolution". Due to advances in the technology of communication and transport, international division of labor affects ever finer slices of the value added chain. Offshoring, i.e., the relocation of such slices in low wage countries has become a hallmark of modern day globalization. Grossman & Rossi-Hansberg (2008) speak of a new paradigm that they call trade in tasks. Arguably, staunch believers in gains from trade should welcome this development: If trade is good, then more of it – through trade in tasks – is better. If certain domestic jobs are lost, it is because their opportunity cost exceeds the cost of offshoring. Keeping such jobs would be tantamount to forgone efficiency gains.

This view stands in marked contrast to the widespread anxiety that such "high-resolution globalization" meets in the general public, and with many policy makers. Typically, offshoring comes with an unbundling of production processes, whereby certain workers face competition head on from foreign labor on the level of single tasks within their firms, as opposed to competition on the level of finished goods, which mainly takes place between firms, thus affecting different types of workers on a more equal footing. In this sense, offshoring reflects what might be called a new industrial revolution, based on technological as well as social change, that undermines the traditional firm as an "organic solidarity among its members".[1] As a result, many workers now perceive a much more precarious job environment than they did 20 years ago. It is widely taken for granted that in the near future task-level arbitrage across high- and low-wage countries will be responsible for job losses or wage cuts for certain parts of industrial countries' labor force. Indeed, in the aggregate it may even increase both, the degree of inequality and the level of unemployment, although the quantitative importance of this adjustment is subject to debate.

Empirically, however, the contribution of offshoring to wage inequality and unemployment is very difficult to establish. Some authors point out that wage cuts and job losses due to offshoring are minuscule, relative to the overall labor market turnover; see Bhagwati, Panagariya & Srinivasan (2004) and Bhagwati (2009). Others point out that the big wave of offshoring is yet to come. Thus, Blinder (2006, 2009) argues that offshoring in industrial countries like the US is likely to become a much "bigger deal" than many sanguine observers appear to expect, with fundamental consequences for domestic labor markets. He expects vast future improvements in technologies that are relevant for linking different types of tasks involved in manufacturing as well as services, and he calculates that 20 to 30 percent of US jobs will

[1] See Cohen (2009) for a description of this loss of solidarity which was at the heart of the 20th century industrial firm.

potentially become offshorable as a result.[2] He sees significant potentials for both, job creation and job destruction, but expects a sizable *net* job loss for the US.

There is solid micro-level evidence that offshoring has caused sizable job losses in some countries and periods in time.[3] However, the job creation effect of offshoring is far more difficult to establish empirically. It is also less well understood theoretically. It seems fairly obvious that, on a very general level, we should expect the net effect to be ambiguous. Perhaps less obviously, we should also expect it to vary as economies move from low to high levels of offshoring. If globalization is mainly driven by lower costs of cross-border transactions, as often argued particularly in the context of offshoring, then economies that already do much of it would seem in a better position to reap benefits from getting even more. Formally, at the margin of autarchy, the very first step of offshoring does not involve any first-order effect of cost-savings, while subsequent steps do. Therefore, the relationship between the increase in offshoring and the associated change in (un)employment may be non-monotonic in the costliness of trade in tasks.

Currently, we do not have any theoretical model that would imply such a non-monotonic relationship. General equilibrium theory of trade would lead us to expect that, if offshoring is driven by less costly trade in tasks, there should be cost-savings which are reflected in the form of higher factor earnings or enhanced employment *somewhere* in the economy.[4] In the model of task trade recently proposed by Grossman & Rossi-Hansberg (2008), these gains accrue to the workers whose tasks have been moved offshore. For instance, offshoring of tasks performed entirely by low-skilled labor entails a rise in the wage for domestic low-skilled workers. This may appear counter-intuitive at first sight, but it reflects a straightforward general equilibrium relationship. In a Heckscher-Ohlin setting with two types of workers and two industries, the cost of both low- and high-skilled labor is uniquely tied down by zero-profit conditions. If cheaper offshoring lowers the cost of tasks already performed abroad, this must be offset by a higher wage for domestic low-skilled workers, provided that final goods prices do not change. Grossman & Rossi-Hansberg (2008) call this the *productivity effect* of offshoring.[5]

With all cost-savings fully absorbed by a rise in the low-skilled wage rate, the wage for high-skilled labor remains unchanged and firms face no incentive to change their input mix. If a larger part of low-skilled labor tasks

[2]See OECD (2007) and Bottini, Ernst & Luebker (2007) for a survey of empirical studies.

[3]See NAPA (2006) for the U.S. and ERM (2007) for the European Union.

[4]The same need not hold true, if offshoring is an integral part of adjustment to some other exogenous shock, say a change in final goods prices.

[5]A completely analogous productivity effect obtains, if offshoring takes place in tasks performed by high-skilled, instead of low-skilled labor.

is performed offshore, this implies lower demand for domestic low-skilled labor per unit of output in both industries. With perfect labor mobility across industries, a full employment equilibrium is restored through a reallocation of both types of labor towards the less skill-intensive of the two industries. This is perfectly analogous to the Rybczynski-type reallocation that takes place when an economy absorbs increased endowment of low-skilled labor. For this reason, Grossman & Rossi-Hansberg (2008) speak of a *supply effect* of offshoring. A similar effect may arise for high-skilled labor, again with reallocation of both types of labor restoring a full employment equilibrium.

Arguably, assuming full employment in perfect labor markets and allowing for smooth Rybczynski-type reallocation is bound to make offshoring appear as a rather benign phenomenon. Allowing for labor market frictions, it seems very unlikely that job losses and job creation caused by offshoring should always even out. In this paper, we therefore place the Grossman & Rossi-Hansberg (2008) paradigm of offshoring in a framework where employment requires search and matching of workers, leading to equilibrium unemployment. Given our intention to move away from the benign environment of smooth reallocation, we go to the far extreme of assuming a single sector. Moreover, reflecting the empirical observation that offshoring affects both low- and high-skilled labor, we assume a single type of labor that combines with a non-labor input, say capital, to produce a final good. Blinder (2009) and many others argue that what matters for offshoring is whether a job involves personal of impersonal task characteristics. As in Grossman & Rossi-Hansberg (2008), we model this through a schedule of offshoring costs, defined over a continuum of tasks. Together with a given foreign labor cost, this determines the margin between tasks performed domestically and abroad.

Contrary to a-priori intuition and wide-spread belief, we find that an extension of the range of offshore tasks need not destroy jobs. Indeed, it may even generate additional domestic jobs. The reason is that with trade in tasks domestic employment involves a twin margin of adjustment. At the *extensive margin*, jobs are lost, if an improvement in the technology of offshoring prompts firms to increase the set of tasks performed abroad. This is the Grossman & Rossi-Hansberg (2008) supply (or endowment) effect. However, at the *intensive margin*, cheaper offshoring means lower labor cost as a whole, which prompts firms to expand employment for the entire set of tasks, including the ones for which domestic procurement is still cheaper. Thus, the productivity effect of offshoring emphasized by Grossman & Rossi-Hansberg (2008) emerges as a vehicle of *potential net job-creation.*

However, net job-creation is not a foregone conclusion, but emerges only if the expansionary intensive margin effect is sufficiently strong. We identify two types of conditions that determine whether this is the case. First, there is a *local condition* that describes the difference in the costliness of offshoring between two "neighboring" tasks. And secondly, there is what we call the

*interval condition* which relates to the variation across tasks, in terms of being more or less *im*personal, over the continuum up to the equilibrium margin of offshoring. We describe these conditions in detail and provide interpretations in terms of empirically observable magnitudes. In an economy that reaches a point of net job creation through offshoring, then changes of *labor market institutions*, such as employers' relative bargaining power or the cost of recruitment, have counterintuitive effects on domestic employment.

As a result of the twin-margin-adjustment, the outcome may be a *non-monotonic adjustment* of domestic employment as ever more personal tasks become subject to offshoring. Starting out with zero offshoring, initial improvements of the offshoring technology always harm labor in terms of both, a wage cut and lower employment. In other words, for low levels of offshoring the extensive margin of job losses dominates the adjustment. But once the economy has reached a critical level of offshoring, the intensive margin of job creation *may* dominate the extensive margin, so that offshoring becomes a vehicle of net job creation.

In addition to analytical results, we present numerical simulations that substantiate our theoretical analysis and highlight some important implications. In particular, we identify a principal distinction between two types of industries, separated by a fundamental difference in their offshoring technologies. The distinction can loosely be described as one between "deep" and "shallow" domestic cost advantage. Our numerical analysis shows that these two types of industries will exhibit distinct patterns of employment effects, as they engage ever deeper into offshoring in a scenario of the type foreseen by Blinder (2009).

The paper is structured as follows. In the next section we develop a stylized model of offshoring and unemployment. Offshoring is modeled as trade in a continuum of tasks. Unemployment is determined by labor market frictions modeled along the familiar paradigm of search and matching. The trading equilibrium involves imports of tasks in exchange of exports of the final good. Section 3 presents a complete comparative static analysis, with a clear focus on domestic net job creation, whereby the exogenous shock is an improvement in the offshoring technology, deriving two propositions on the employment effect of such a technology shock. Section 4 turns to a numerical treatment, intended to develop a deeper understanding of the detailed properties of the offshoring technology that are responsible for such non-monotonicity.

# 2 A Model of Offshoring and Unemployment

## 2.1 Production

We assume an economy that produces a single good $x$. This is motivated by simplicity and our intention to depart from the benign environment with smooth Rybczynski-type reallocation of factors, which has counterfactual implications.[6] Production of good $x$ involves labor $l$ according to

$$x = F(l) := Al^{\delta} \quad \text{where} \quad 0 < \delta < 1. \tag{1}$$

Concavity of $x$ in $l$, for $\delta < 1$, may be interpreted as the presence of a second factor, say capital, which is in fixed supply. It is straightforward to show that the profit-maximizing employment level $l$ must satisfy

$$l = \delta x / W, \tag{2}$$

where $W$ is the cost of employing a unit of $l$, expressed in units of the final good. This cost depends on the details of offshoring and on domestic labor market conditions, as will become clear below. Maximum profits are equal to

$$\pi = (1 - \delta)\, x, \tag{3}$$

where $x$ is as given in (1), with input levels satisfying (2). Profits may be interpreted as income to owners of the second factor capital. Given wage-costs per unit of $l$, equations (2) and (1) determine a unique output level $x$, and profits are then determined by (3).[7]

A unit of the labor input $l$ involves the performance of many tasks, according to a Leontief-type technology. Following Grossman & Rossi-Hansberg (2008) we assume a continuum of tasks, indexed by $i \in [0, 1]$. Without loss of generality, we assume that for a unit-level of $l$ the same amount of labor is required on each of these tasks. Units are scaled such that the entire measure of tasks required per unit of $l$ is equal to unity. Thus, in order to secure a level $l$ of the labor input, a firm has to employ an amount of labor equal to $l \int_0^1 \mathrm{d}i$. The labor required to perform a subset of tasks $i \in [0, j]$, $j < 1$, is equal to $l \int_0^j \mathrm{d}i$.

Firms decide on where to perform tasks, based on cost advantage. We make no distinction between intra-firm performance and outsourcing of tasks to independent suppliers. Tasks may be performed abroad where firms face perfectly elastic supply of labor at a wage rate $w^*$. Suppose a firm wants

[6] Feenstra (2010) shows that these implications *may* disappear also in a conventional $2 \times 2$ model, once we allow the economy to be large. Reallocation is then no longer of a Rybczynski-type, but subject to goods price changes.

[7] See Keuschnigg & Ribi (2009) for a similar production structure, but a somewhat cruder notion of offshoring.

to secure an input level $l$ and it wants to perform the tasks within the subrange $i \in [0, \bar{\imath}]$ abroad. Then the cost of these offshore activities are equal to $w^* l \int_0^{\bar{\imath}} \beta t\,(i) \mathrm{d}i$. The term $\beta t(i)$ denotes the extra cost caused by offshore performance of task $i$, over and above the amount of labor needed if the task is performed domestically. This is the familiar notion of "iceberg cost". The function $t(i)$ depicts the variation of this cost across tasks, while $\beta$ measures the overall costliness of offshoring. For obvious reasons, we assume $\beta \geq 1$ and $t(0) = 1$. Moreover, without loss of generality, we may rank tasks such that $t'(i) > 0$.[8] We follow Blinder (2009) in calling tasks with low (high) values of $t(i)$ impersonal (personal) tasks.[9]

We assume that the domestic labor market is characterized by search frictions along the lines of Pissarides (2000). Firms have to post vacancies in order to find suitable workers, and there is a constant cost per vacancy equal to $\kappa$, measured in terms of the final good. The rate at which a vacancy is turned into a successful match is denoted by $q\,(\theta)$, where $\theta$ denotes the ratio of vacancies to the number of unemployed, i.e., the labor market tightness. With a real rate of interest equal to $r$ and a job separation rate equal to $\lambda$, the recruiting cost per unit of steady state employment of domestic labor is equal to $(r + \lambda)\kappa/q(\theta)$. In the following, we simplify by assuming a static environment, whence $r = 0$ and the entire labor force is initially unemployed, which implies that $\lambda = 1$.[10]

Denoting the wage rate by $w$, the cost per unit-level of a task, if performed domestically, is then equal to $w + \kappa/q\,(\theta)$. We shall turn to the determination of $w$ as well as the matching rate $q\,(\theta)$ below. Moving any task offshore, the firm saves on both, domestic factor costs $w$ and hiring costs $\kappa/q\,(\theta)$. The cost-savings are the same across all tasks. Cost-minimization requires that these savings be offset, at the margin, by the cost of performing a task abroad, $\beta t(i)$, which increases in $i$. It is straightforward to determine a marginal task $I$ which separates tasks $i < I$ performed offshore from tasks $i > I$ that are performed domestically. The marginal task satisfies

$$w + \frac{\kappa}{q\,(\theta)} = \beta t\,(I)\, w^*. \tag{4}$$

We thus assume that there are no hiring costs for offshoring. Moreover, we assume that $w + \kappa/q\,(\theta) > \beta t\,(0)\, w^*$ in order to arrive at a non-trivial offshoring equilibrium with $I > 0$.[11] Notice that this does not require $w^* < w$.

[8] In Kohler (2004), the unit of offshoring is a task that involves both types of primary inputs, with a perfectly analogous definition of offshoring costs. Grossman & Rossi-Hansberg (2009) apply the same notion of offshoring costs, focusing on a different force behind offshoring, viz. external scale economies on the task level.

[9] See Leamer & Storper (2001) and Levy & Murnane (2004) for broader descriptions of the underlying characteristics that determine the magnitude of $t(i)$.

[10] A similar modeling of the labor market is found in Keuschnigg & Ribi (2009)

[11] The assumption of a low foreign labor cost is meant to reflect, albeit in a stylized way,

The foreign cost advantage derives from a lower wage, as well as the absence of hiring cost. The extensive margin of offshoring $I$ decreases with $\beta$, the overall costliness of offshoring.

If a firm posts $v$ vacancies, it will end up paying $wq(\theta)v$ in terms of wage costs, plus hiring costs $\kappa v$. Given $I$, the profit-maximizing domestic employment $l$ satisfies

$$\max_{l}\left\{F(l)-\left[w+\frac{\kappa}{q(\theta)}\right]l(1-I)-w^{*}l\beta\int_{0}^{I}t(i)\,\mathrm{d}i\right\}. \tag{5}$$

Observing condition (4) on $I$, maximum profits may be rewritten as

$$\pi = \max_{l}\left\{F(l)-\left[w+\frac{\kappa}{q(\theta)}\right]\Omega(I)\,l\right\}, \tag{6}$$

$$\text{whereby}\quad \Omega(I) := (1-I)+\frac{\int_{0}^{I}t(i)\,\mathrm{d}i}{t(I)}. \tag{7}$$

The term $\Omega(I)$ is well known from Grossman & Rossi-Hansberg (2008). It captures the entire factor cost savings from offshoring. Obviously, $\Omega(I)=1$ if $I=0$, and from $t'(i)>0$ it follows that $\Omega(I)<1$ if $I>0$. Moreover, it can be shown that $\Omega'(I)<0$ for all $I\in(0,1]$. Notice that the term $\Omega(I)$ makes the entire schedule of offshoring cost $t(i)$ an integral part of the technology.

The first order condition for employment is

$$F_l(l)=\Omega(I)\left[w+\frac{\kappa}{q(\theta)}\right], \tag{8}$$

where $F_l(l)$ denotes the marginal productivity of labor.[12] Solving this equation for $l$, the labor cost $W$ in equation (2) now emerges as

$$W=\Omega(I)\left[w+\kappa/q(\theta)\right]. \tag{9}$$

The first order condition on employment can be written as

$$\left[F_l(l)-\Omega(I)\,w\right]q(\theta)=\Omega(I)\,\kappa. \tag{10}$$

The left-hand side gives the expected job rent from posting a vacancy for an additional unit of $l$, taking into account that cost-minimizing offshoring

the doubling of the world labor force through the "entry" of China and India, as well as the ex-Soviet bloc countries; see Freeman (2009).

[12] In a dynamic formulation, the firm maximizes the present value of periodic profits, whereby posted vacancies of time $t$ determine the rate of change in employment through the matching rate $q(\theta)$ and the rate of job separation rate $\lambda$. The job separation rate $\lambda$ and the interest rate $r$ raise the steady state "effective" cost of posting vacancies, such that condition (8) is replaced by $F_l(l)=\Omega(I)\{w+(r+\lambda)[\kappa/q(\theta)]\}$. Since all results of this paper go through for this dynamic version, it is worth simplifying the analysis to the static version.

reduces the wage cost below the negotiated wage for domestic workers. This must be equal to the cost of posting such a vacancy, whereby this cost is similarly affected by cost-savings through offshoring. Put differently, the recruiting cost applies not to the entire unit of $l$, but only to the tasks that are performed domestically. Since recruiting cost $\kappa$ is expressed in terms of the final good (with a unitary price), it must be scaled down on an equal footing with the labor cost through the cost savings term $\Omega(I)$.

## 2.2 Wage Bargaining

For simplicity, we assume that each firm is matched with a single worker.[13] Given the hiring cost, the firm and the worker find themselves in a bargaining situation, once a match has occurred. We follow the standard approach in assuming a Nash bargaining solution for the wage rate $w$. At this stage, we want to simplify as much as possible, hence we assume a zero outside option for the worker.[14] Denoting the worker's bargaining power by $\gamma$, Nash bargaining implies a wage rate $w$ that satisfies

$$\max_{w} \left\{ (w)^{\gamma} \left[ F_l(l) - \Omega\left(I\right) w \right]^{1-\gamma} \right\}, \tag{11}$$

whereby $l$ satisfies (8). Notice that the overall surplus from filling a job is equal to $F_l(l)$, whereas $F_l(l) - \Omega\left(I\right) w$ is the firm's job rent, given cost-savings $\Omega(I)$ from offshoring tasks $i \in [0, I]$. The first order bargaining condition reads as $\gamma \left[ F_l(l) - \Omega\left(I\right) w \right] = (1-\gamma)\Omega(I)w$. Observing the first-order condition on $l$ in (8), we obtain

$$w = \frac{\gamma}{1-\gamma} \frac{\kappa}{q\left(\theta\right)}. \tag{12}$$

## 2.3 Domestic Employment

Given a labor force with mass 1, the rate at which workers find jobs, denoted by $e$, is determined by the amount of vacancies $v$ according to a matching function $M(1, v)$, which we assume to be homogeneous of degree 1. In this static model of matching, the entire labor force needs to be matched, hence the initial number of unemployed is equal to the entire labor force and the labor market tightness is $\theta \equiv v$. Domestic employment is then determined as $e = M(1, v)$. Defining $q\left(\theta\right) := M/\theta = M(1/\theta, 1)$, we may rewrite the employment equation as

$$e = e(\theta) := \theta q\left(\theta\right). \tag{13}$$

[13]This assumption is not entirely innocuous. Given the assumption of a unitary mass of labor, it implies a certain corresponding mass of firms.

[14]It would be easy to introduce an unemployment benefit. However, as we do not want to model government policy in this paper, we simplify by setting the benefit equal to zero.

Note that $q'(\theta) = -M'_U/\theta^2 < 0$, where $M'_U$ is the partial derivative of the matching function with respect to the number of unemployed searching for a match. Any increase in the number of vacancies raises labor market tightness, thus reducing the rate at which vacancies are filled. At the same time, it raises employment, $e'(\theta) > 0$. Note that this setup implies less than full employment, unless the wage falls all the way down to zero, which is equivalent to a dynamic case where, due to full employment, the outside option in wage bargaining is equal to the ongoing wage.

The number of domestic vacancies posted depends on the desired level of overall labor input $l$, as determined above. Remembering $\theta \equiv v$, the model is closed through

$$\theta q(\theta) = (1 - I)l. \tag{14}$$

## 2.4 General Equilibrium

Our model determines five endogenous variables: The overall labor input $l$, the extensive margin of offshoring $I$, as well as the labor market tightness $\theta$, the domestic wage rate $w$ and domestic employment $e$ (with a rate of unemployment equal to $1-e$). The corresponding equilibrium conditions are the cost-minimization condition for offshoring (4), the labor demand equation (8), the bargaining condition (12), and the two conditions relating production to labor market tightness (14) and employment (13).[15]

Total household income is equal to

$$Y = w(1 - I)l + (1 - \delta)x, \tag{15}$$

whereby the final term is profit income; see (3). Income is spent on the final good. The domestic economy imports tasks, and exports the final good $x$. Exports of the final good are equal to the level of output $x$, net of the resource use involved in hiring of domestic labor, minus demand: $\{x - [\kappa/q(\theta)](1 - I)l\} - Y$. In turn, imports of tasks are equal to

$$w^* l\beta \int_0^I t(i)\mathrm{d}i = \left[w + \frac{\kappa}{q(\theta)}\right][\Omega(I) - (1 - I)]\, l \tag{16}$$

This follows from (5) and (4). The aggregate value of net imports is thus equal to

$$\begin{aligned} B &= Y - x + [\kappa/q(\theta)](1 - I)l \\ &\quad + \left[w + \frac{\kappa}{q(\theta)}\right][\Omega(I) - (1 - I)]\, l \end{aligned} \tag{17}$$

[15] This equilibrium involves an externality. The firm's hiring decision ignores the impact of a higher labor market tightness on the filling rate $q(\theta)$, or the average duration of a vacancy. However, there is an offsetting externality through dissipation of the job surplus into a job rent accruing to the worker, rather than the firm. The equilibrium is efficient if these two externalities offset each other, which is known as the Hosios condition.

Recognizing that profits $(1-\delta)x$ are equal to $x - Wl$, we may write

$$\begin{aligned} Y &= w(1-I)l + x - Wl, \\ &= w(1-I)l + x - \Omega(I)\left[w + \kappa/q(\theta)\right]l \end{aligned} \tag{18}$$

This implies that $B = 0$. If all equilibrium conditions are satisfied, then trade is balanced.

While an equilibrium with $I = 0$ is obviously relevant, an equilibrium at the other extreme with $I = 1$ does not exist.[16] In this one sector economy, it would also have no meaning economically. In a multi-sector model, an equilibrium with $I = 1$ simply means that a sector is no longer viable domestically, which makes perfect sense if factors are mobile across sectors. However, for reasons emphasized in the introduction, we want to focus on the case of intersectoral immobility.

# 3 Offshoring and Job Creation

We now explore the comparative static properties of this equilibrium with respect to the general costliness of offshoring, focusing primarily on domestic employment. Unless indicated otherwise, we use the hat notation to denote relative changes. Suppose, then, that we have $\hat{\beta} < 0$, meaning that trade becomes less costly across the board for all tasks. Intuitively, we expect more offshoring, and perhaps a loss of domestic jobs, as well as a fall in the domestic wage rate. From equation (4), which determines the margin of offshoring, equilibrium adjustment may take place along three dimensions: $I$, $w$ and $\theta$. There will always be an increase in the offshoring margin $I$, but the effect on the wage rate $w$ and labor market tightness $\theta$, and thus on domestic employment $e$, is ambiguous. An extension of the range of imported tasks *may* come with higher domestic employment. If it does, it will also be associated with a higher wage $w$ and will, thus, be a Pareto improvement. We shall explore the precise conditions under which this is the case. Moreover, tracing out domestic employment (or the change thereof) as a function of $I$ (or $\beta$), we find a potential for non-monotonicity: While the first steps of offshoring will always spell job losses, subsequent steps of offshoring may entail net job creation.

Suppose that the economy already performs some of the less personal tasks offshore, meaning that $0 < I < 1$. As offshoring becomes less costly across all tasks, $\hat{\beta} < 0$, more tasks will be moved offshore, $\hat{I} > 0$. Other

[16] $I = 1$ implies $e = 0$. At the same time it implies $v = 0$ and thus zero labor market tightness $\theta = 0$, which means $q(\theta) \to \infty$. In turn, from the wage bargaining condition (12), this implies $w \to \infty$, which is the full employment level of $w$, thus contradicting $v = 0$. Looking at (4), we also recognize that in such a situation the term $\beta t(1)w^*$ would exceed $\kappa/q(\theta)$, with $q(\theta) \to \infty$, thus leaving room for a positive domestic wage rate with positive employment.

things equal, domestic jobs would be lost. However, other things are not equal. While a higher $I$ restores indifference *at the margin* between domestic and offshore task performance, a lower $\beta$ implies a lower cost of importing *inframarginal* tasks. Remember that the entire cost-savings from offshoring, relative to domestic task performance, are measured through $\Omega(I) < 1$ as defined in (7), whereby $\Omega'(I) < 0$, provided that $I > 0$ to start with. In other words, as $\hat{\beta} < 0$ causes $\hat{I} > 0$, firms will benefit from a lower $\Omega(I)$. This implies a lower wage cost $W$ as given in (9), which in turn implies an expansion of production and, thus, *total* labor demand $l$. Since *domestic* labor demand is equal to $(1-I)l$, we thus have two opposing forces, and the net effect is ambiguous.

To identify the conditions under which one or the other of these forces dominates, we make use of four types of elasticity concepts. The first is the familiar elasticity of overall labor demand $l$ with respect to the wage cost $W$, $\Delta := 1/(1-\delta) > 0$; see equations (2) and (1). The second is the elasticity of the matching function $\eta := -\theta q'(\theta)/q(\theta)$, which satisfies $0 < \eta < 1$.[17] In the sequel, we shall use $\tau := \eta/(1-\eta) > 0$. A large value of $\tau$ (or $\eta$) indicates a low elasticity of labor-market matching with respect to the number of vacancies, i.e., weak labor market institutions. Two more elasticity concepts relate to the technology of offshoring. We use $\zeta(I) := It'(I)/t(I)$ to denote the elasticity of the cost-schedule for offshoring, evaluated at the equilibrium offshoring margin $I$. Given our ranking assumption, we have $\zeta(I) > 0$ for $0 < I < 1$. Loosely speaking, a large value of $\zeta(I)$ indicates that the next candidate task for offshoring is significantly more personal, or less algorithmic, in nature, so that the firm must expect a correspondingly large cost of offshore performance, compared to the marginal task $I$. And finally, we introduce an elasticity $\xi(I) := I\Omega'(I)/\Omega(I)$ to measure the cost reduction that comes about if, for whatever reason, the cost-minimizing margin of offshoring as determined in (4) increases. We assume the driving force to be $\hat{\beta} < 0$, but it is obvious that the entire analysis goes through also for an exogenous reduction in the foreign wage rate $w^*$. Given the definition of $\Omega(I)$ in (7), we have $\xi(I) < 0$ if $0 < I \leq 1$.[18]

Paving the ground for our subsequent comparative static analysis, we must first explain the exact meaning of the elasticity $\xi(I)$. This measures the degree to which an expansion of the extensive margin of offshoring lowers the cost of labor, which in turn drives adjustment at the intensive margin of employment. Figure 1 illustrates the driving forces. The dark-shaded triangle measures the incremental cost-savings $t_0(I^0)I^0 - \int_0^{I^0} t_0(i)\mathrm{d}i \equiv t_0(I^0)[1 - \Omega_0(I^0)]$, whereby a subscript 0 indicates a certain technology of offshoring.

[17] With $e(\theta) = M(1,v) = M(1,\theta)$, it follows from linear homogeneity of $M$ that $e'(\theta) > 0$, with $\hat{e}/\hat{\theta} = 1-\eta > 0$. This implies that $0 < \eta < 1$.

[18] See the appendix for a detailed discussion of the properties of $\Omega(I)$ and the elasticities related to the costliness of offhsoring.

In figure 1, $t_0(i)$ is assumed to take a linear shape. To grasp the key channels of influence, we compare this with a convex shape $t_1(i)$. These two schedules represent two alternative technologies of offshoring, with a distinct difference in how the costliness of trade varies across the continuum of tasks. For instance, they may be associated with two different industries, as in our numerical exercise below.

For illustrative purposes, we assume that the two equilibria corresponding to these technologies feature a common extensive margin of offshoring $I^0$, where a superscript index indicates the initial equilibrium depicted in figure 1. We further simplify our illustration by assuming $t_0(I^0) = t_1(I^0)$. Notice that this implies different underlying values of either $\beta$ or $w^*$. More specifically, from equation (7) it follows that

$$\left[w_0^0 + k\,/q\left(\theta_0^0\right)\right]/\,w_0^{*0}\beta_0^0 = \left[w_1^0 + k\,/q\left(\theta_1^0\right)\right]/\,w_1^{*0}\beta_1^0, \tag{19}$$

where $w_0^{*0}\beta_0^0$ and $w_1^{*0}\beta_1^0$ are the two levels of foreign labor cost that are implied by our assumption $t_0(I^0) = t_1(I^0)$. Given that the initial level of cost-savings in this equilibrium is larger for technology 1 than for technology 0, $\Omega_1(I^0) < \Omega_1(I^0)$, we expect $w_1^0 > w_0^0$ and $\theta_1^0 > \theta_0^0$, and hence $w_1^{*0}\beta_1^0 > w_0^{*0}\beta_0^0$.

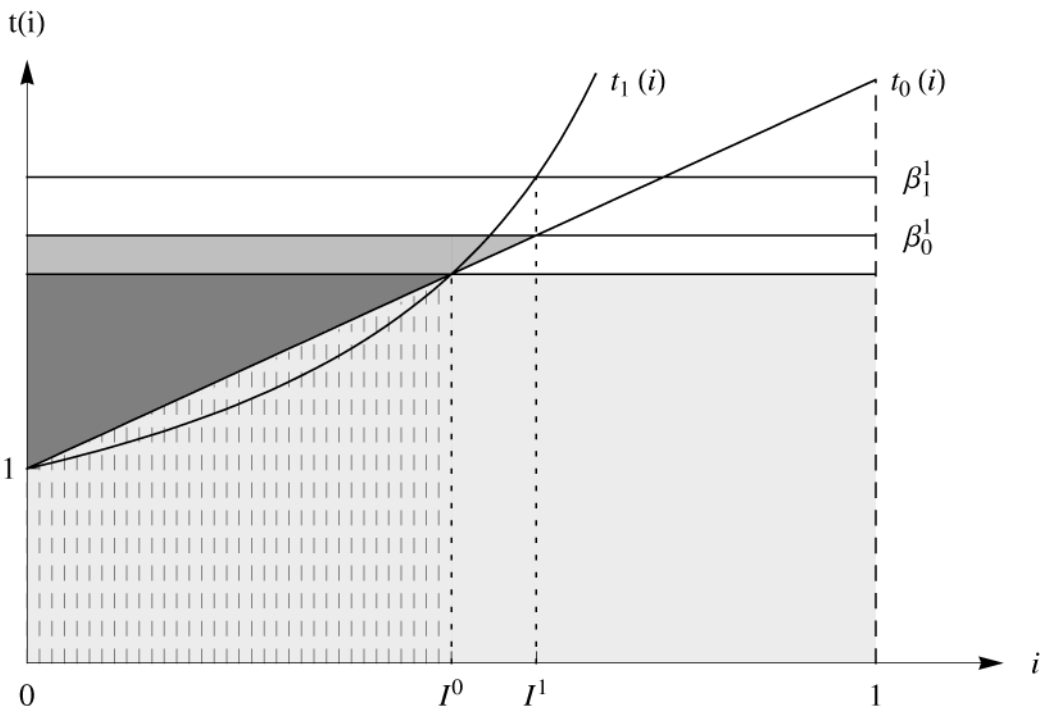


Figure 1: *Inframarginal cost savings from offshoring*

Now consider an increase in $I$, say brought about by a lower value of $\beta$. Figure 1 looks at a case where for each of the two technologies a lower $\beta$ leads to an increase of the offshoring margin to a new common level $I^1$.

What are the associated degrees of cost savings in terms of lower values of $\Omega(I)$? The lighter shaded area measure the *incremental* cost-savings for the linear schedule $t_0(i)$. We recognize two different aspects of the offshoring technology that determine this change. The first is obvious: A higher slope of the $t(i)$-schedule, as measured through the elasticity $\zeta(I^0)$, implies higher cost-savings. In what follows, we call this the *local condition* of offshoring. In Figure 1, this would imply larger *incremental* cost savings (not drawn to avoid clutter) for the convex schedule $t_1(i)$.[19]

However, there is a second aspect which we shall henceforth refer to as the *interval condition* for cost savings. By this we mean the shape of the entire cost schedule $t(i)$ over the interval of tasks $i \in [0, I]$. We show in appendix A2 that the elasticity $\xi(I)$ may be decomposed into $\xi(I) = -\zeta(I)\Sigma(I)$, where $\Sigma(I)$ is a measure of the degree of concavity of $t(i)$ up to $i = I$:

$$\Sigma\left(I\right) \equiv \int_0^I t\left(i\right) \mathrm{d}i \Big/ \left[\left(1-I\right) t\left(I\right) + \int_0^I t\left(i\right) \mathrm{d}\right] \tag{20}$$

In figure 1, for technololgy 0 the term $\Sigma_0(I^0)$ is measured by the dashed area, relative to that same area plus the neighboring rectangle to the right. It isobvious that $\Sigma_1(I^0) < \Sigma_0(I^0)$. In other words, while the local condition for cost savings from further offshoring seems more favorable for the convex schedule $t_1(i)$, the interval condition is more favorable for $t_0(i)$. More generally, other things equal, the less convex (more concave) the cost schedule $t(i)$ over the interval $i \in [0, I]$, the higher the leverage for further cost savings on account of the interval condition. It becomes obvious that for a concave schedule (not depicted to avoid clutter) the value of $\Sigma(I)$ rises very steeply already for low levels of offshoring, while for a convex schedule it remains rather low throughout much of the adjustment path generated by ever lower values of $\beta$. At the same time, however, the local condition becomes ever more favorable for a convex schedule, while the opposite is true for a concave schedule. In section 4, we provide a numerical treatment that sheds further light on alternative possible technologies of offshoring.

As a first step towards comparative static analysis, we identify the condition under which adjustment to cheaper offshoring requires no change in either $\theta$ or $w$. The arbitrage condition of offshoring (4) then requires $\hat{I} = -\hat{\beta}/\zeta(I) > 0$, whereby the inequality follows from our scenario $\hat{\beta} < 0$. From (9), the labor cost $W$ changes according to $\hat{W} = -\hat{\beta}\xi\left(I\right)/\zeta\left(I\right) < 0$, and total labor demand follows as $\hat{l} = \Delta\hat{\beta}\xi(I)/\zeta(I) > 0$. For this to be an equilibrium, domestic employment $(1-I)\,l$ must remain unaltered, i.e., $-\left[I/(1-I)\right]\hat{I} + \hat{l} = 0$. The term $-\left[I/(1-I)\right]\hat{I} < 0$ captures job destruction at the extensive margin, while $\hat{l} > 0$ captures job creation at the intensive margin. Inserting for $\hat{I}$ and $\hat{l}$, the condition for job destruction and creation

[19]Notice that this is conditional upon a given increase in the offshoring margin. Of course, for a given cut in $\beta$, a less steep schedule $t(i)$ implies a larger increase in $I$.

to cancel out emerges as $I/(1-I) = \Delta\xi(I)$. If $-\Delta\xi(I) > I/(1-I)$, an increase in domestic labor demand requires an increase in $w$ and $\theta$, and vice versa. We thus arrive at the following proposition.

**Proposition I: i)** *Equilibrium adjustment to less costly offshoring holds a rise in both, the wage rate and employment, provided that* $-\Delta\xi(I) > I/(1-I)$. *The opposite holds true, if* $-\Delta\xi(I) < I/(1-I)$. **ii)** *The wage bargaining power of firms and the elasticity of matching with respect to the number of vacancies play no role for the direction of employment and wage adjustment.*

It is instructive to trace out possible adjustment paths of employment as $I$ increases from low to high values, caused by ever less costly offshoring. By and large, this is the process envisaged by Blinder (2009). For zero offshoring to start with, we have $\xi(0) = 0$. There can be no job creation at the intensive margin: $\hat{l} = \Delta\hat{\beta}\xi(0)/\zeta(0) = 0$, and the adjustment at the extensive margin implies a job loss. At the other extreme, as $I \to 1$, we have $I/(1-I) \to \infty$, and the job loss at the extensive margin again dominates. Will there be a range of values for $I$ where the intensive margin of job creation dominates the adjustment, so that offshoring literally creates jobs? The answer depends on how the values of $\xi(I)$ and $\zeta(I)$ change with successive increases in $I$.

The dashed line in figure 2 depicts a possible non-monotonic adjustment of $\theta$ (and thus domestic employment), as $I$ moves from zero to ever larger values. Taking into account the wage bargaining condition (12), we may depict equation (4) as an upward sloping *extensive margin locus (EM)* in $\theta$-$I$ space, with a slope equal to $\hat{\theta}/\hat{I} = \zeta(I)/\eta > 0$. The interpretation is straightforward. According to the wage bargaining condition, an increase in labor market tightness $\theta$ implies a higher domestic wage rate $w$, which in turn implies a higher level of offshoring $I$, according to the extensive margin condition on $I$. The locus shifts down with cheaper offshoring, $\hat{\beta} < 0$. It shifts down also for an increase in $\gamma$, which means a lower wage bargaining power of firms, and for a higher $\kappa$, i.e., for more costly hiring.

From the intensive margin condition on employment, we may write $l = l(\theta, I)$. This is the solution to the first order condition (8), if we insert the wage bargaining condition for $w$. For obvious reasons, we have $l_\theta < 0$ and $l_I > 0$. Demand for domestic labor is equal to $(1-I)l$. To meet this demand, recruiting must be such that

$$\theta q(\theta) = (1-I)l(\theta, I) \tag{21}$$

This defines a *labor market equilibrium locus (LME)* in $\theta$-$I$ space. The slope of this locus satisfies

$$\frac{\hat{\theta}}{\hat{I}} = -\frac{I/(1-I) + \Delta\xi(I)}{1-\eta+\Delta\eta} \tag{22}$$

Since $0 < \eta < 1$, this is positive if and only if $-\Delta\xi(I) > I/(1-I)$, which is the condition for a positive employment and wage effect in proposition 1

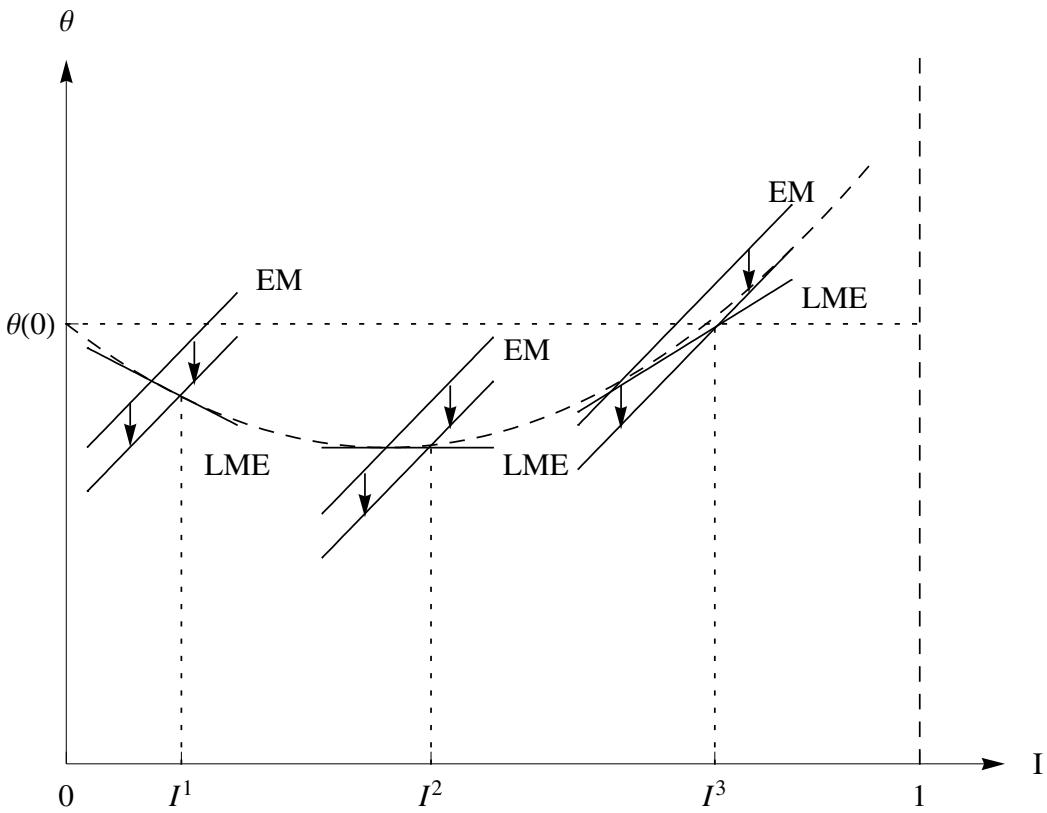


Figure 2: *Non-monotonic adjustment at the labor market*

above. It is clearly negative at the initial margin of $I = 0$, as well as for $I \to 1$. However, for interior values of $I$, the slope may well be positive.

The line $\theta(I)$ in figure 2 depicts a possible adjustment path of domestic labor market tightness driven by ever less costly offshoring. From the preceding arguments it follows that for low values of $I$ this line falls below the initial level $\theta(0)$.[20] The figure singles out three values of $I$, where the extensive margin of job losses still dominates for $I = I^1$, while the two margins just offset each other at $I^2$, and the intensive margin job creation dominates at $I^3$. Note that the slope of the labor market equilibrium (LME) locus, if positive, must be smaller than the extensive margin (EM) locus. The intuition is that less costly offshoring must always increase $I$; the formal proof follows in appendix A2. To make the case very strongly, the figure even assumes that for values larger than $I^3$, domestic employment is larger than it was without any offshoring at all. This is, of course, a mere theoretical possibility which would seem somewhat questionable empirically.

It is interesting to look at the comparative statics of labor market insti-

[20]Given the normalization $t(0) = 1$, the value of $\theta(0)$ is determined as $\theta(0) = q^{-1}\left[\frac{\kappa}{1-\gamma}\Big/\beta w^*\right]$, where $q^{-1}(\cdot)$ is the inverse function of $q(\cdot)$.

tutions. An increase in recruiting cost $\kappa$ has an effect which is completely analogous to a reduction in the cost of offshoring. The same applies for a reduction in the firm's wage bargaining power. The intuition is that these changes disrupt the extensive margin condition on $I$ in exactly the same way as does a lower $\beta$, meaning that they increase the cost of domestic task performance, relative to task performance offshore. We thus arrive at the following corollary.

**Corollary:** *With trade in tasks, a reduction in the wage bargaining power of firms or an increase in the hiring cost both have a positive effect on domestic employment, provided that* $-\Delta\xi(I) > I/(1-I)$.

It is now relatively straightforward to solve the model for $\hat{e}/\hat{\beta}$. We simply use the relationship between changes at the offshoring margin $I$ and the cost of offshoring, i.e., $\hat{I} = (\eta\hat{\theta} - \hat{\beta})/\zeta(I)$, as well as the relationship $\hat{e} = (1-\eta)\hat{\theta}$ from the matching technology, and insert into (22) to obtain

$$\frac{\hat{e}}{\hat{\beta}} = \frac{\psi(I)}{1+\lambda(I)\tau}. \tag{23}$$

In this equation we have defined $\lambda(I)$ and $\psi(I)$, respectively, as follows

$$\lambda(I) := \frac{I}{(1-I)\zeta(I)} + \Delta\frac{\xi(I)+\zeta(I)}{\zeta(I)} > 0, \tag{24}$$

$$\psi(I) := \frac{I}{(1-I)\zeta(I)} + \Delta\frac{\xi(I)}{\zeta(I)}. \tag{25}$$

In the appendix we show that $[\xi(I)+\zeta(I)]/\zeta(I) \equiv (1-I)/\Omega(I) > 0$, hence $\xi(I)/\zeta(I) \equiv (1-I)/\Omega(I) - 1 < 0$. The term $1+\lambda(I)\tau > 0$ reflects a mitigation effect reflecting wage adjustment on the domestic labor market.

All other endogenous variables follow in a straightforward way from the relevant equations above. Moreover, since less costly offshoring, $\hat{\beta} < 0$, enhances employment at the intensive margin $l$, we observe a rise in output $x$ and an increase in profits $\pi = (1-\delta)x$. If one assumes that such profits accrue to capital owners, then capitalists are always on the winning side of offshoring. In contrast, the effect on domestic labor is ambiguous. If the conditions of propositions I and II are satisfied, then the increase in offshoring caused by less costly trade in tasks constitutes a Pareto improvement.

It might be argued that the elasticity $\xi(I)$, which plays a key role in the above propositions, is a somewhat arcane concept which seems quite remote from empirical quantification. However, the following proposition shows that it may be related in a relatively straightforward way to observable magnitudes.

**Proposition II:** *If we denote the domestic wage cost per unit of labor input* $l$ *as* $d := [w + \kappa/q(\theta)](1-I)$*, and the cost of imported tasks per unit of output as* $m := w^*\beta\int_0^I t(i)\mathrm{d}i$*, then, at any interior equilibrium level of offshoring*

*$I \in (0,1)$, the elasticity of employment of domestic labor with respect to the costliness of offshoring is negative, $\hat{e}/\hat{\beta} < 0$, if and only if $\Delta\zeta(I)$ is larger than $(d/m+1)\, I/(1-I)$.*

We relegate the proof of this proposition to appendix A3. A positive net job creation from enhanced offshoring requires a large enough labor demand elasticity, reinforced by a large elasticity of the cost of offshoring further tasks. In addition, it requires a relatively low ratio of initial domestic labor cost to cost of imported tasks. The term $\Delta\zeta(I)$ captures a *"local property"* at the equilibrium extensive margin of offshoring $I$. By way of contrast, the term $(d/m+1)\, I/(1-I)$ depicts the *"interval property"* of this margin, meaning the position of $I$ in the interval, as well as the inframarginal curvature of the $t(i)$-schedule which is reflected in $m$. Proposition II is, of course, closely related to proposition I. But it formulates a crucial additional insight in that it establishes a relationship between the interval condition of net job creation and observable magnitudes $m$ and $d$. It thus also establishes a potential for significant improvements of empirical approaches towards estimating the impact of trade in task in structural labor demand or reduced form employment equations.

# 4 A Numerical Treatment

An important insight from the preceding analysis is that the relationship between domestic employment and the extensive margin of offshoring *may be* non-monotonic. Offshoring further tasks may eventually lead to net job creation, as industries move from incipient trade in tasks to "high-volume-offshorers". However, this is not a forgone conclusion, but depends on details of the offshoring technology. In this section we shed further light on this potential non-monotonicity through a numerical analysis.

Toward this end, we must calibrate the schedule $t(i)$, which captures the offshoring technology, i.e., the variation in the degree to which tasks are of a *personal*, or *impersonal* nature. Blinder (2009) argues that the offshoring that many countries and industries have been witnessing in the recent past is the beginning of a long-run process where technological advances move ever more tasks into the realm of "offshorability", which have hitherto been considered too personal to move offshore. He stresses that this is a gradual process of a secular nature. In the present context, this scenario may be seen as both, changing the shape of $t(i)$ as well as successive shifts in $\beta$, leading to increases in $I$ on a given schedule $t(i)$. In the preceding section, we have mostly looked at single steps of such reductions in a comparative static fashion. In this section, we take a numerical perspective on the entire adjustment path, highlighting the specific features of the offshoring technology $t(i)$ that are responsible for whether there is a certain range of tasks where offshoring leads to job creation. To sharpen our focus, we concentrate on the term

$\psi(I)$, which governs the direction of employment adjustment; see equation (23).

What is of interest here is not the level of $t(i)$ as such, but its slope and its shape in the sense of the above mentioned local and interval condition, respectively. In economic terms, what we call an offshoring technology $t(i)$ is a summary measure of the way in which different tasks performed by labor in a certain industry vary in terms of being more or less personal in nature. The shift parameter $\beta$ measures what any given degree of "personal-ness" $t(i)$ means in terms of additional cost that arises from offshore (as opposed to domestic) performance. In turn, the shape of $t(i)$ is a full description of how "personal-ness" varies across the entire range of tasks. Thus, the derivative $\beta t'(i)$ is a cost-equivalent measure of the extent to which increasing the margin of offshoring leads into more personal types of tasks that are inherently less easy to offshore.

The assumption that $t'(i) > 0$ throughout the entire interval is crucial and subject to criticism. This assumption is sometimes taken to mean that the technology of production must not require a specific sequencing of tasks, which seems somewhat extreme. In fact, however, it does not imply any assumption, whatsoever, on task sequencing. Suppose each task $i$ in the interval $i \in [0, 1]$ has its unique position in a rigid technological sequencing which is different from the ordering in terms of $t(i)$. Wherever this position, $\beta t(i)$ measures the cost of relocating this task abroad, by the time the task is due. Of course, if the task is a "downstream activity" and if offshoring it requires shipment of a bulky semi-finished good, then the offshoring cost will be accordingly high. More generally, if technological sequencing is important, then $t(i)$ reflects both, the variation of "personal-ness" as well as the sequencing of tasks. If highly personal tasks appear high up in the technological sequencing, and conversely for the least personal tasks, then the schedule $t(i)$ is likely to be very flat, and $\beta$ is likely to be high. The reason is that tasks that appear inherently easy to offshore, because they are impersonal in nature, partly loose this advantage as they appear late in the sequencing where offshoring requires much transport of embodied prior tasks. However, the value added chain will often be such that, even if sequencing does play a role, a specific task $i$ does not require the physical presence of a semi-finished good that embodies all tasks $j \in [0, i)$. If production involves tasks which are are "disembodied", then the sequence in which they need to be performed is plainly irrelevant for the schedule $t(i)$.

The critical assumption is not absence of technological sequencing, but absence of economies of scope in the sense that offshoring several consecutive tasks is less costly than the total cost of offshoring each of these tasks individually. Formally, if instead of the costliness of offshoring we order tasks according to their technological sequencing (using an index $j$), and if $\mathcal{S}$ is any range in the interval $j \in [0, 1]$, then the critical assumption is that the cost of offshoring the entire range of tasks $\mathcal{S}$ is *additive*, i.e., equal to $\int_{j \in \mathcal{S}} t(j) \mathrm{d}j$.

The interesting alternative is *subadditivity*, which arises, for instance, if tasks are embodied (and offshoring thus requires transport of semi-finished goods), and if offshoring a range of tasks $\mathcal{S}$ involves a fixed cost which is independent of the size of $\mathcal{S}$. It is this complication which is ruled out in our analysis, but not technological sequencing as such.[21]

It is relatively obvious that the shape of the entire schedule $t(i)$ should vary significantly across industries. Our numerical analysis in this section reveals that this variation may imply vastly different patterns of employment reactions as industries travel along the interval $I \in [0, 1)$.[22] Accepting the notion of a continuum of tasks and the assumption $t'(i) > 0$, assuming monotonicity also of the second derivative $t''(i)$ should be a relatively innocuous further assumption. The numerical section makes this assumption. Differences across industries are then conveniently described by focusing on the limiting behavior of $t(i)$ as $i \to 1$. Our analysis suggests a fundamental distinction between industries where this limit is a finite number, and industries where it is equal to infinity.

This distinction is of clear economic significance. The former type of industry bears a close resemblance to what Bhagwati (2006) calls "shallow" or "thin" cost advantage.[23] In such industries, a relatively moderate improvement in the technology of linking tasks performed in different locations may eventually lead to a complete dislocation of all tasks, i.e., to a disappearance of the industry from the domestic landscape. As we have argued above, in our stylized single-sector-model an equilibrium with $I = 1$ does not exist, but in a more general context, particularly one with labor mobility between several sectors, it certainly commands some relevance. By way of contrast, a case where $t(i)$ approaches infinity might be dubbed "deep" cost advantage. At least for a subrange of tasks, domestic viability of this industry is more deeply entrenched, so that less costly offshoring as such will never wipe out the industry as a whole.

Armed with this intuition, we can now turn to a numerical view on these two types offshoring technology. In the following, we trace out values of $\psi(I)$ throughout the entire interval $I \in [0, 1)$ for alternative functional forms representing "deep" or "shallow" advantage industries.

[21] Harms, Lorz & Urban (2009) present a model that features this subadditivity, where the outcome is offshoring in discrete steps involving whole chinks of the continuum.

[22] We acknowledge that a well-behaved equilibrium with $I = 1$ does not exist by specifying the relevant interval as an open interval $[0, 1)$.

[23] We deliberately abstain from using the term *comparative* advantage which does not fit a singe-sector general equilibrium model.

## 4.1 "Deep" Cost Advantage

Given the assumptions made above, the case of "deep" cost advantage is described by a strictly convex function of the form[24]

$$t(i) = (1-i)^{-\mu}, \tag{26}$$

where $\mu > 0$. Notice that a larger value of $\mu$ implies a higher slope at any given $I$, as well as a higher degree of convexity for the entire schedule. Given this functional form, the crucial term that determines whether further offshoring comes with net job creation or destruction emerges as[25]

$$\psi(I) = \begin{cases} 1 + \Delta \ln(1-I) / [1 - \ln(1-I)] & \text{if } \mu = 1 \\ \mu^{-1} - \Delta \left[1 - (1-I)^{1-\mu}\right] / \left[1 - \mu (1-I)^{1-\mu}\right] & \text{if } \mu \neq 1. \end{cases} \tag{27}$$

Taking limits, we find that $\lim_{I \to 0} \psi(I) = 1/\mu > 0$, while $\lim_{I \to 1} \psi(I) = (1-\mu)/\mu - \delta/(1-\delta)$ for $\mu \leq 1$, and $\lim_{I \to 1} \psi(I) = -\delta/(1-\delta)\mu$ for $\mu > 1$. Figure 3 looks at how the term $\psi(I)$ behaves as the extensive margin of

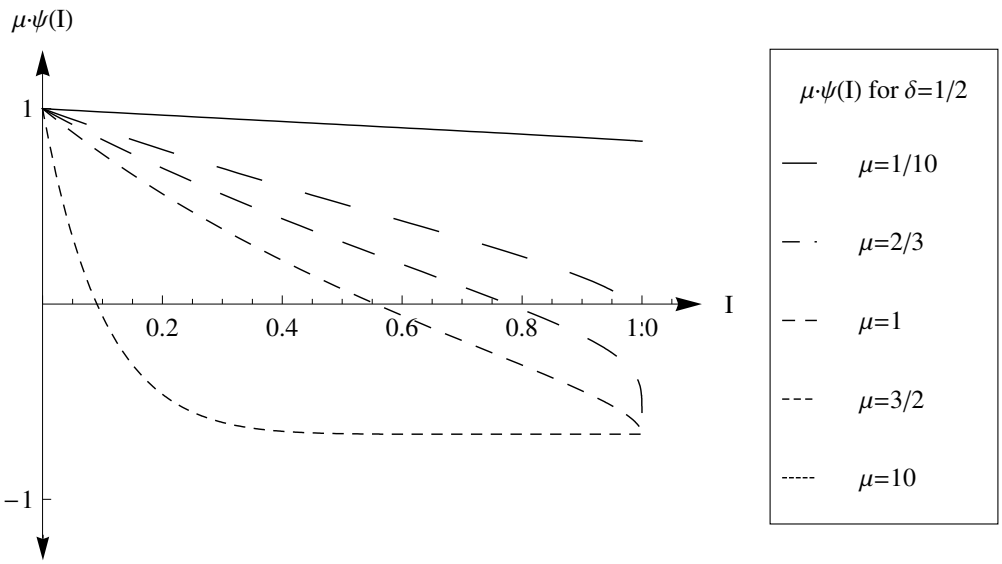


Figure 3: *Offshoring with "deep" cost advantage*

offshoring increases from low to high values of $I$. The driving force of this movement should be seen as a successive reductions in $\beta$. To anchor all lines at a common unitary value for $I = 0$, we scale the plot to $\mu\psi(I)$. Obviously, this does not affect the horizontal intersection points which mark the turning

[24]This case is also briefly considered in Grossman & Rossi-Hansberg (2008).

[25]See appendix A4 where we derive equation (27) and some useful properties of the function $\psi(I)$.

points where the Grossman & Rossi-Hansberg (2008) productivity effect of offshoring turns into a vehicle of net job creation.

The principal message of figure is 3 simple, clear and important. If the offshoring technology features a large enough value of $\mu$, then an industry with "deep" cost advantage features a non-monotonic relationship between domestic employment and the extensive margin of offshoring. Initial imports of tasks will always be at the expense of domestic jobs, but if further technological improvements take the industry beyond a critical level of offshoring, this will be accompanied by rising levels of the wage rate and domestic employment. To put it somewhat bluntly, the relationship between domestic jobs and offshoring may be subject to a "curse of small steps": A little bit of offshoring may hurt employment, while a large dose might be a boon. Alas, economies cannot arbitrarily decide about the dose: It is endogenous to $\beta$. In view of the subsequent discussion of the "shallow" cost advantage case, we note that a high value of $\mu$ represents much overall "task diversity" in terms of offshoring costs.

From the analysis in the previous section, one might expect that the extensive margin will eventually dominate again, once the industry approaches very high values of $I$. However, for offshoring technologies represented by (26), the prevalence of "infinitely personal" tasks shields domestic labor from such a scenario. Indeed, it is interesting to note that the employment effect, once turning positive — or, equivalently, $\mu\psi(I)$ turning negative – will remain so even for very large values of $I$.[26]

## 4.2 "Shallow" Cost Advantage

The same does not hold true for cases with a "shallow" cost advantage. For the present purpose these cases may be characterized by

$$t(i) = 1 + \phi i^{\epsilon}, \tag{28}$$

with $\phi, \epsilon > 0$. This representation of the offshoring technology has a somewhat richer structure. Although the slope of this line is jointly determined by both $\phi$ and $\epsilon$, we may still view $\phi$ as the slope parameter, as it uniquely pins down $t(1) = 1 + \phi$. In turn, $\epsilon < 1$ ($\epsilon > 1$) makes the schedule a concave (convex) function, while $\epsilon = 1$ implies the knife edge case of linearity. In economic terms a steep slope of the schedule $t(i)$ may be interpreted as a case with a high overall degree of *"task diversity"*: Tasks differ a lot in terms of being more or less personal. Any given degree of task diversity may be associated with varying degrees of *"task concavity"*. By this we mean that task diversity does not come with a uniform distribution of the associated cost of offshoring across all tasks, which would be represented by $\epsilon = 1$. Instead,

[26] Again, we should like to point out that in our model an equilibrium where $I = 1$ does not exist; see section 2 above.

with "'task concavity" the diversity is concentrated more on less personal tasks that are relatively easy to offshore. Conversely for "task concavity".

This structure allows us to shed further light on the *local* and *interval conditions*, respectively, of offshoring that we have introduced in section 3 above. Figures 4 and 5 give two separate illustrations of $\psi(I)$, in order to highlight the role of task diversity and task concavity for job creation and job destruction with offshoring of tasks. The crucial term $\psi(I)$ now emerges as

$$\psi(I) = \left[\frac{1}{1-I} - \Delta \frac{\left(1+\frac{\phi}{1+\epsilon}I^{\epsilon}\right)\phi\epsilon I^{\epsilon}}{\left(1+\phi I^{\epsilon}\right)^{2} - \left(1+\phi I^{\epsilon}\right)\left(\frac{\phi\epsilon}{1+\epsilon}I^{\epsilon+1}\right)}\right]\left(\frac{I^{1-\epsilon}}{\epsilon\phi} + \frac{I}{\epsilon\phi^{2}}\right). \quad (29)$$

As before, we want to anchor our illustration at $\psi(0) = 1$. It is straightforward to see that for any functional form of $t(i)$ the term $[t'(I)/t(I)]\psi(I)$ approaches a value of 1, as $I$ approaches 0. Hence we scale our plots accordingly.[27] Figure 4 highlights variations in the steepness of $t(i)$, while figure 5 highlights different degrees of convexity (concavity). Both figures use $\delta = 1/2$, as in figure 3.

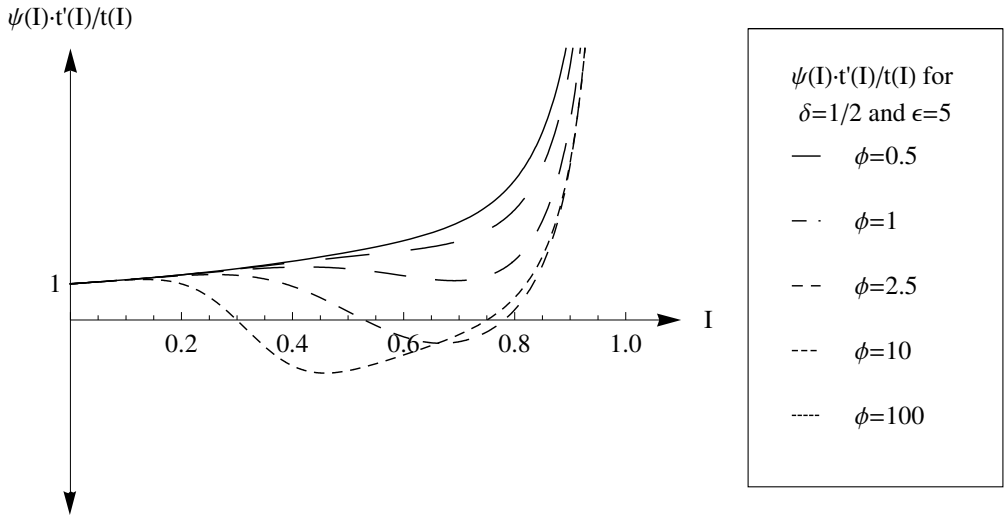


Figure 4: *"Shallow" cost advantage and degree of "task diversity"*

The principal message of figure 4 is again obvious, whereby it should be noticed that it assumes a value of $\epsilon = 5$, which means task convexity. For such an offshoring technology, non-monotonicity of the relationship between employment and the offshoring margin arises only for a very high degree of task diversity. In other words, industries with little variation in the cost of

[27] This implies that we ignore $I/\zeta(I) = I^{1-\epsilon}/\epsilon\phi + I/\epsilon\phi^{2} > 0$ for $I > 0$ on the right hand side of equation (29). But this is inconsequential for our qualitative analysis.

offshoring across different tasks do not enjoy any subrange of tasks where further offshoring creates domestic jobs. In other words, in an environment where the tasks affected by offshoring are almost equally impersonal (or personal), as for instance with $\phi = 0.5$, offshoring is unlikely to cause net job creation. However, note that the overall degree of task diversity measures what we have called the local condition of offshoring only for the linear case ($\epsilon = 1$). Moreover, given the finite upper limit of $t(1)$, positive domestic employment reaction to further offshoring will eventually be lost, as the secular process of ever lower $\beta$ continues.

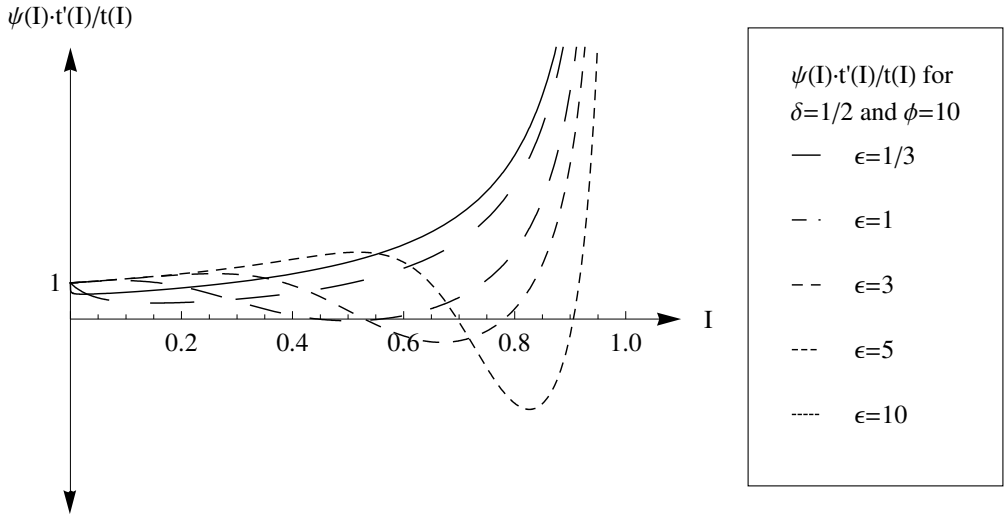


Figure 5: *"Shallow" cost advantage and degree of "task concavity"*

Figure 5 depicts alternative degrees of task concavity (measured through $\epsilon$), assuming a large degree of overall task diversity ($\phi = 10$). We observe a notable pattern of variation. For a concave offshoring technology ($\epsilon < 1$), domestic employment falls monotonically with an increase in offshoring margin. In terms of our discussion in the previous section, although for each conceivable level of offshoring the interval condition is more favorable for a more concave technology, any increase in the term $\Sigma(I)$ that comes with a higher $I$ is coupled with a worsening of the local condition, i.e., a lowering of $\zeta(I)$.[28] The opposite is true for a convex technology, where the changes in the local as well as the interval condition reinforce each other. In this sense, task convexity is inherently conducive to net job creation over a certain subrange of offshoring. However, it requires a minimum amount of convexity. In figure 5, such subranges are emerge for $\epsilon = 3$, $\epsilon = 5$ and $\epsilon = 10$. These cases suggest a further noteworthy conclusion: While higher task convexity makes

[28]Notice the difference between the *local* measure $t`(I)$ and the *overall* degree of task diversity.

a non-monotonic relationship between domestic employment and the level of offshoring more likely, it also postpones the range of tasks where this relationship turns positive to ever later stages, thus aggravating the above mentioned "curse of small steps".

In a nutshell, the insights from our numerical exercise may be summarized as follows: Task diversity and task convexity both contribute to the likelihood that over a certain range of tasks an increase in the level of offshoring gives rise to higher domestic employment. But this range of tasks is likely to follow late in the secular process of offshoring.

# 5 Conclusion

In the general public, offshoring is associated, first and foremost, with job losses. This is mirrored by a corresponding rhetoric and attitude of policy makers. Empirical studies have produced mixed results, but it is probably fair to say that overall the evidence does not suggest a strong macroeconomic impact of offshoring on the level of unemployment. Yet, micro-level evidence clearly shows that industrial restructuring often involves a fair dose of offshoring which is associated with domestic job losses.

Existing theoretical models of offshoring shed little light on this issue. With very view exceptions, they rely on general equilibrium trade models that assume full employment. In this paper we have presented a theoretical model that allows us to juxtapose job destruction and job creation as a result of offshoring. Our model envisages a process of "high-resolution globalization", whereby profit maximizing decisions about sourcing of tasks lead to a steady increase in the share of tasks performed offshore, due to an improved technology of linking tasks across distance and country borders. We call this the extensive margin of job destruction. At the same time, however, there is an intensive margin of job creation where cost-savings that derive from such technological improvements induce firms to expand their entire production and thus their labor demand.

Modeling offshoring in a framework of job search and matching, we are able to identify the forces that govern the relative strengths of the two job margins in the adjustment to less costly offshoring. The forces depend on details of the offshoring technology which is represented by a rising schedule of offshoring cost that describes the relative ease with which different tasks – lined up in a continuum – may be moved to an offshore low-cost location. This reflects varying degrees to which tasks are personal or impersonal in nature. A no-arbitrage condition familiar from Grossman & Rossi-Hansberg (2008) ties down the line between tasks permormed offshore and tasks performed domestically. This line moves as offshoring becomes less costly, as envisaged by Blinder (2009).

Our comparative static analysis has established the possibility that offshoring more tasks generates domestic jobs, at least over a certain range of tasks. In other words, the relationship between the level of offshoring and domestic employment may be non-monotonic. It will always be negative for low levels of offshoring, but may turn positive once the level of offshoring surpasses a certain threshold level. The conditions conducive to this result come in two forms, a local condition pertaining to the slope of the offshoring cost schedule at the relevant extensive margin of offshoring, and an interval conditions relating to the entire shape of that schedule for all inframarginal tasks. In turn, the interval condition is closely related to the degree of convexity of the offshoring cost schedule. We have also shown that these conditions, although seemingly remote from available data, can readily be framed in terms of observable variables.

Our numerical exercise has focused on certain parameterizations of the offshoring cost schedule, thus sheding further light on the properties of the offshoring technology that give rise to the aforementioned non-monotonicity.

A process of steady increase in offshoring, as envisaged by Blinder (2009) and others, involves a systematic variation in the relative importance of job destruction and job creation. We have traced out this variation theoretically, as well as through a numerical analysis. The conclusion is that for certain types of industries, identified by particular characteristics of their offshoring technology, the conditions for net job creation will be met. However, they will typically be met only at relatively late stages of offshoring, where technological improvements dictate offshoring also of tasks that are relatively personal in nature, with less personal tasks already having fallen victim to offshoring due to earlier improvements. We identify something like the "curse of small steps", meaning that a small dose of incipient offshoring is likely to hurt in terms of job losses and wage cuts, whereas further doses may lead to job and wage gains.

However, such non-monotonicity is not a foregone conclusion, but it is a distinct possibility. Whether or not it arises depends on both, the slope and the degree of convexity of the offshoring cost schedule. Loosely speaking, the larger the variation across tasks in the degree to which they are personal or impersonal, the stronger the job creation effect in later stages of offshoring. In a similar vein, the more equally dispersed the differences in the degree of personality across tasks, the more likely a net job gain at later stages of offshoring.

# Appendix

## A1 Properties of $\xi(I)$

The term $\Omega(I) < 1$ measures the degree to which the cost of a unit of labor is below the domestic wage rate, because some of the tasks are performed by cheaper labor offshore. The elasticity $\xi(I) := \Omega'(I)I/\Omega(I)$ measures the response of this savings factor to a change in $I$, assuming some underlying change in the cost of offshoring, from either $\beta$ or the foreign wage rate $w^*$, and assuming a constant domestic wage cost $w + \kappa/q(\theta)$. We have

$$\xi(I) = -\frac{\int_0^I t(i)\,\mathrm{d}i\, t'(I)}{[t(I)]^2}\frac{I}{\Omega(I)}, \tag{A.1}$$

$$= -\frac{\int_0^I t(i)\,\mathrm{d}i}{t(I)\,\Omega(I)}\zeta(I), \tag{A.2}$$

where $\zeta(I) := t'(I)\,I/t(I) > 0$ is the elasticity of the offshoring cost schedule $t(i)$. Note that $\xi(I) < 0$ for all $I \in (0,1]$ while $\xi(I) = 0$ for $I = 0$. these properties are inherited by $\xi(I)/\zeta(I)$. Substituting (7) into (A.2) yields

$$\xi(I) = -\Sigma(I)\,\zeta(I) \quad \text{with} \quad \Sigma(I) \equiv \left[\frac{\int_0^I t(i)\,\mathrm{d}i}{(1-I)\,t(I) + \int_0^I t(i)\,\mathrm{d}i}\right]. \tag{A.3}$$

Now it is easy to see, that the *interval condition* depends on the slope of $t(I)$ at $I$, represented by $\zeta(I)$, as well as the shape of $t(I)$ over the whole interval $I \in [0,1]$, captured by $\Sigma(I)$. Note that $\Sigma(I) \in [0,1)\ \ \forall\ I \in [0,1)$ and $\Sigma(I) = 1$ for $I = 1$. Furthermore note that $t(I)$ being strictly concave implies that $\int_0^I t(i)\,\mathrm{d}i$ comes close to its maximum (at $I = 1$) also for low values of $I$, while for $t(I)$ being strictly convex $\int_0^I t(i)\,\mathrm{d}i$ comes close to its maximum only at late stages of offshoring. Taking stock, for a convex (concave) cost schedule $\Sigma(I)$ is almost one at late (early) stages of offshoring. Moreover, we have

$$\begin{aligned}\xi(I) + \zeta(I) &= -\frac{\int_0^I t(i)\,\mathrm{d}i\, t'(I)}{[t(I)]^2}\frac{I}{\Omega(I)} + \frac{t'(I)I}{t(I)}, \\ &= \left[-\frac{\int_0^I t(i)\,\mathrm{d}i}{t(I)\,\Omega(I)} + 1\right]\frac{t'(I)I}{t(I)} > 0,\end{aligned} \tag{A.4}$$

and

$$\frac{\xi(I) + \zeta(I)}{\zeta(I)} = \left[\frac{-[\Omega(I) - (1-I)]}{\Omega(I)} + 1\right] = \frac{1-I}{\Omega(I)} > 0. \tag{A.5}$$

## A2 Labor market equilibrium locus

We prove that the slope of the labor market equilibrium locus (LME), if positive, is lower than the slope of the extensive margin (EM) locus

$$\left.\frac{\mathrm{d}\theta}{\mathrm{d}I}\right|_{\mathrm{LME}} = -\frac{I/(1-I)+\Delta\xi(I)}{1-\eta+\Delta\eta}\frac{\theta}{I} < \left.\frac{\mathrm{d}\theta}{\mathrm{d}I}\right|_{\mathrm{EM}} = \frac{\zeta(I)}{\eta}\frac{\theta}{I}. \tag{A.6}$$

Rearranging terms and multiplying out, we may write

$$-\frac{I/(1-I)}{(1-\eta)/\eta+\Delta} < \frac{[(1-\eta)/\eta+\Delta]\,\zeta(I)+\Delta\xi(I)}{(1-\eta)/\eta+\Delta}, \tag{A.7}$$

$$-\frac{I}{1-I} < \frac{1-\eta}{\eta}\zeta(I)+\Delta\left[\zeta(I)+\Delta\xi(I)\right], \tag{A.8}$$

and this holds true, since $\zeta(I)+\Delta\xi(I)>0$, as shown above.

## A3 Proof of Proposition II

Taking equation (23), and observing that $[1+\lambda(I)\tau] > 0$, it follows that $\hat{e}/\hat{\beta} < 0$, if and only if

$$\psi\left(I\right) = \frac{I}{1-I}\frac{1}{\zeta(I)} + \Delta\frac{\xi(I)}{\zeta(I)} < 0, \tag{A.9}$$

which may be rewritten as

$$\frac{\Omega(I)}{1-I} + \Delta\Omega'(I) < 0. \tag{A.10}$$

Inserting $\Omega'(I)$ we obtain

$$\int_0^I t(i)\mathrm{d}i\left[\frac{1}{1-I} - \Delta\frac{t'(I)}{t(I)}\right] < -t(I). \tag{A.11}$$

Multiplying both sides by $\beta w^*$, and using (4), we may write

$$m\left[1-\Delta\frac{t'(I)}{t(I)}(1-I)\right] < -\beta w^* t(I)(1-I) = -d. \tag{A.12}$$

Rearranging terms and multiplying out by $-1$, we finally obtain

$$\Delta\zeta(I) > \left(\frac{d}{m}+1\right)\frac{I}{1-I}, \tag{A.13}$$

which completes the proof.

## A4 Derivation of $\psi(I)$ for $t(i) = (1-i)^{-\mu}$

Given the offshoring cost schedule $t(i) = (1-i)^{-\mu}$ the aggregated offshoring costs for the range of tasks $I$ can be calculated as

$$\int_0^I t(i)\,\mathrm{d}i = \begin{cases} -\ln(1-I) & \text{if } \mu = 1 \\ \frac{1-(1-I)^{1-\mu}}{1-\mu} & \text{if } \mu \neq 1. \end{cases} \tag{A.14}$$

Inserting these expressions into equation (7) and (A.A.2) yields

$$\frac{\Omega'(I)}{\Omega(I)} = \begin{cases} \frac{\ln(1-I)}{[1-\ln(1-I)](1-I)} & \text{if } \mu = 1 \\ -\frac{\mu-\mu(1-I)^{1-\mu}}{\left[1-\mu(1-I)^{1-\mu}\right](1-I)} & \text{if } \mu \neq 1. \end{cases} \tag{A.15}$$

Finally the equations above can be combined with $I/\zeta(I) = (1-I)/\mu$ in order to obtain equation (27). The first order derivative of equation (27) with respect to $I$ can be written as

$$\frac{\partial\psi(I)}{\partial I} = \begin{cases} -\left(1+\frac{\alpha\delta}{1-\delta}\right)\frac{(1-I)^{-1}}{[1-\ln(1-I)]^2} & \text{if } \mu = 1 \\ -\left(1+\frac{\alpha\delta}{1-\delta}\right)\frac{(1-\mu)^2(1-I)^{-\mu}}{\left[1-\mu(1-I)^{1-\mu}\right]^2} & \text{if } \mu \neq 1, \end{cases} \tag{A.16}$$

which is strictly negative for $I \in (0, 1]$.

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