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Can Offshoring Reduce Unemployment?

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Abstract: In this paper, in order to study the impact of offshoring on sectoral and economywide rates of unemployment, we construct a two-sector, general-equilibrium model in which labor is mobile across the two sectors, and unemployment is caused by search frictions. We find that, contrary to general perception, wage increases and sectoral unemployment decreases due to offshoring. This result can be understood to arise from the productivity enhancing (cost reducing) effect of offshoring. If the search cost is identical in the two sectors, or is higher in the sector which experiences offshoring, the economywide rate of unemployment decreases. When we modify the model to disallow intersectoral labor mobility, the negative relative price effect on the offshoring sector may offset the positive productivity effect, and result in a rise in unemployment in that sector. In the other sector, offshoring has a much stronger unemployment reducing effect in this case.

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1 Introduction

"Offshoring" is the sourcing of inputs (goods and services) from foreign countries. When production of these inputs moves to foreign countries, the fear at home is that jobs will be lost and unemployment will rise. In the recent past, this has become an important political issue. The remarks by Greg Mankiw, when he was Head of the President's Council of Economic Advisers, that "outsourcing is just a new way of doing international trade" and is "a good thing" came under sharp attack from prominent politicians from both sides of the aisle. Recent estimates by Forrester Research of job losses due to offshoring equaling a total of 3.3 million white collar jobs by 2015 and the prediction by Deloitte Research of the outsourcing of 2 million financial sector jobs by the year 2009 have drawn a lot of attention from politicians and journalists (Drezner, 2004), even though these job losses are only a small fraction of the total number unemployed, especially when we take into account the fact that these losses will be spread over many years.[2] Furthermore, statements by IT executives have added fuel to this fire. One such statement was made by an IBM executive who said "[Globalization] means shifting a lot of jobs, opening a lot of locations in places we had never dreamt of before, going where there is low-cost labor, low-cost competition, shifting jobs offshore", while another statement was made by Hewlett-Packard CEO Carly Fiorna in her testimony before Congress that "there is no job that is America's God-given right anymore" (Drezner, 2004). The alarming estimates by Bardhan and Kroll (2003) and McKinsey (2005) that 11 percent of our jobs are potentially at risk of being offshored have provided anti-offshoring politicians with more ammunition for their position on this issue.

While the relation between offshoring and unemployment has been an important issue for politicians, the media and the public, there has hardly been any careful theoretical analysis of this relationship by economists. In this paper, in order to study the impact of offshoring on sectoral

[2] The average number of gross job losses per week in the US is about 500,000 (Blinder, 2006). Also see Bhagwati, Panagariya and Srinivasan (2004) on the plausibility and magnitudes of available estimates of the unemployment effects of offshoring.

and economywide rates of unemployment, we construct a two-sector, general-equilibrium model in which unemployment is caused by search frictions a la Pissarides (2000).[3] There is a single factor of production, labor. Firms in one sector, called sector Z, use labor to produce two inputs which are then assembled into output. The production of one of these inputs (production input) can be offshored, but the other input (headquarter services) must be produced using domestic labor only. There is another sector, X, that uses only domestic labor to produce its output. Goods Z and X are combined to produce the consumption good C.

The main result of this paper is that in the presence of intersectoral labor mobility, offshoring leads to wage increases and unemployment reductions in both sectors. Intuitively, offshoring reduces the cost of production and hence the relative price of good Z because one of the inputs is offshored. The resulting increase in the relative price of the non-offshoring sector X leads to greater job creation and hence reduced unemployment there. The impact on unemployment in the Z sector depends on two mutually opposing forces. A decrease in the relative price of Z would reduce job creation there. However, the marginal product of workers engaged in headquarter activities in the Z sector increases because each such worker works with more production input, given that this input is now being obtained from abroad (the South) and is cheaper. The latter effect would increase job creation in headquarter activities in the Z sector. In the presence of labor mobility, the no arbitrage condition ensures that the net effect is a reduction in unemployment in the Z sector. Since wage increases and unemployment decreases in the X sector, the same must happen in the Z sector as well, otherwise, workers will have an incentive to move from the Z sector to the X sector, which cannot be an equilibrium. Even though offshoring of the production input destroys the jobs of workers engaged in the production of this input in the Z sector, labor mobility ensures that the positive productivity effect dominates the negative relative price effect in the Z sector, resulting in lower unemployment. Additional headquarter jobs in the Z sector and additional X-sector jobs are created, and the number of these jobs created exceeds the number of production jobs offshored.

[3] For a comprehensive survey of the search-theoretic literature on unemployment, see Rogerson, Shimer and Wright (2005).

The impact of offshoring on overall economywide unemployment depends on how the structure or the composition of the economy changes. Even though both sectors have lower unemployment post-offshoring with intersectoral labor mobility, whether the sector with the lower unemployment or higher unemployment expands will also be a determinant of the overall unemployment rate. If the search cost is identical in the two sectors, implying identical rates of sectoral unemployment, then the economywide rate of unemployment declines unambiguously after offshoring. Alternatively, if the search cost is higher in the sector which experiences offshoring (implying a higher wage as well as a higher rate of unemployment in that sector), then the economywide rate of unemployment also decreases because some workers move to the other sector which has a lower unemployment rate.

In the absence of intersectoral labor mobility (this can be considered to be the shorter-run version of the model with labor mobility), it is possible for unemployment to increase in the Z sector which offshores its input, however, unemployment in the X sector must decrease. That is, it is possible for the negative relative price effect to dominate the positive productivity effect in the Z sector. Whether this will be the case or not will depend on the importance of good Z in final consumption and on the headquarter intensity in the production of good Z. However, since the relative price of good X increases, there is an increase in wage and a decrease in unemployment in the X sector. As well, since workers cannot move from Z sector to X sector, the favorable relative price effect of offshoring on X sector (in which production is always fully domestic) is stronger under no labor mobility than under mobile labor. Therefore, the reduction in the unemployment rate in the X sector (due to offshoring) is greater in this shorter run version of the model than in the model with intersectoral labor mobility.

Our theoretical results are consistent with the empirical results of Amiti and Wei (2005a, b) for the US and the UK. They find no support for the "anxiety" of "massive job losses" associated with offshore outsourcing from developed to developing countries.[4] Using data on 78 sectors in the UK for the period 1992-2001, they find no evidence in support of a negative relationship

[4] The offshoring variable they use, which they call offshoring intensity, is defined as the share of imported inputs (material or service) as a proportion of total nonenergy inputs used by the industry.

between employment and outsourcing. In fact, in many of their specifications the relationship is positive. In the US case, they find a very small, negative effect of offshoring on employment if the economy is decomposed into 450 narrowly defined sectors which disappears when one looks at more broadly defined 96 sectors. Alongside this result, they also find a positive relationship between offshoring and productivity. These results are consistent with opposing effects on employment (and unemployment) created by offshoring. In this context , Amiti and Wei (2005a) write: "On the one hand, every job lost is a job lost. On the other hand, firms that have outsourced may become more efficient and expand employment in other lines of work. If firms relocate their relatively inefficient parts of the production process to another country, where they can be produced more cheaply, they can expand their output in production for which they have comparative advantage. These productivity benefits can translate into lower prices generating further demand and hence create more jobs. This job creation effect could in principle offset job losses due to outsourcing." This intuition is consistent with the channels in our model and the reason for obtaining a result that shows a reduction in sectoral and overall unemployment as a result of offshoring.

A discussion of the related theoretical literature is useful here, as it puts in perspective the need for our analysis. While the relationship between offshoring and unemployment has not been analytically studied before by economists, there is now a vast literature on offshoring and outsourcing.[5] All the models in that literature, following the tradition in standard trade theory, assume full employment. In spite of this assumption in the existing literature, it is important to note that our results are similar in spirit to those in an important recent contribution by Grossman and Rossi-Hansberg (2006) where they model offshoring as "trading in tasks" and show that even factors of production whose tasks are offshored can benefit from offshoring due to its productivity enhancing effect. Our paper is also closely related to the fragmentation literature which analyzes the economic effects of breaking down the production process into different components, some of which can be moved abroad.[6] In this literature, the possibility of fragmentation leading to the

[5] See Helpman (2006) for a review of this literature.

[6] See for instance Arndt (1997), Jones and Kierzkowski (1990 and 2001) and Deardorff (2001a and b).

equivalent of technological improvement in an industry has been shown.[7]

Also closely related to our work is a very recent working paper by Davidson, Matusz and Shevchenko (2006) that uses a model of job search to study the impact of offshoring of high-tech jobs on low and high-skilled workers' wages, and on overall welfare. Another paper looking at the impact of offshoring on the labor market is Karabay and McLaren (2006) who study the effects of free trade and offshore outsourcing on wage volatility and worker welfare in a model where risk sharing takes place through employment relationships. Bhagwati, Panagariya and Srinivasan (2004) also analyze in detail the welfare and wage effects of offshoring.

It is also important to note that there does exist a literature on the relationship between trade and search induced unemployment (e.g. Davidson and Matusz (2004), Moore and Ranjan (2005), Helpman and Itskhoki (2007)). The main focus of this literature, as discussed in Davidson and Matusz, has been the role of efficiency in job search, the rate of job destruction and the rate of job turnover in the determination of comparative advantage.[8] Using an imperfectly competitive set up, Helpman and Itskhoki look at how gains from trade and comparative advantage depend on labor market rigidities as captured by search and firing costs and unemployment benefits, and how labor-market policies in a country affect its trading partner. Moore and Ranjan, whose focus is quite different from the rest of the literature on trade and search unemployment, show that the impact of skill-biased technological change on unemployment can be quite different from that of globalization. None of these models deals with offshoring.

[7] See for instance Jones and Kierzkowski (2001).

[8] See also the influential and well cited paper by Davidson, Martin and Matusz (1999) for a careful analysis of these relationships under very general conditions.

2 A Model of Offshoring and Unemployment

2.1 Preferences

All agents share the identical lifetime utility function

$$\int_t^\infty \exp^{-r(s-t)} C(s) ds, \tag{1}$$

where C is consumption, r is the discount rate, and s is a time index. Asset markets are complete. The form of the utility function implies that the risk-free interest rate, in terms of consumption, equals r.

Each worker has one unit of labor to devote to market activities at every instant of time. The total size of the workforce is L. The final consumption good C is produced under CRS using two goods Z and X as inputs (or equivalently can be considered to be a composite basket of these two goods) as follows:

$$C = F(Z, X) \tag{2}$$

We choose the final consumption good C as numeraire. Let P_z and P_x be the prices of Z and X, respectively. Since the price of $C = 1$, we get

$$1 = g(P_z, P_x) \tag{3}$$

where g is increasing in both P_z and P_x. Therefore, an increase in P_z implies a decrease in P_x. Also, (2) implies that the relative demand for Z is given by

$$\left(\frac{Z}{X}\right)^d = f(\frac{P_z}{P_x}); f' < 0 \tag{4}$$

2.2 Goods and labor markets

Production of good X is undertaken by perfectly competitive firms. To produce one unit of X a firm needs to hire one unit of labor.

Z is also produced by competitive firms, but using a slightly more sophisticated technology involving two separate stages which are combined into the final good. The production function for Z is given as follows.

$$Z = \frac{1}{\tau^{\tau}(1-\tau)^{1-\tau}} m_h^{\tau} m_p^{1-\tau} \tag{5}$$

where m_h is the labor input into certain core activities (say headquarter services) which have to remain within the home country and m_p is the labor input for production activities which can potentially be offshored.[9]

If we denote the total amount of labor employed by a firm by N, then we have

$$N = m_h + m_p \tag{6}$$

To produce either X or Z, a firm needs to open job vacancies and hire workers. The cost of vacancy in terms of the numeraire good is c_i in sector $i = X, Z$.[10] Let L_i be the total number of workers who look for a job in sector i. Any job in either sector can be hit with an idiosyncratic shock with probability δ and be destroyed. Define $\theta_i = \frac{v_i}{u_i}$ as the measure of market tightness in sector i, where $v_i L_i$ is the total number of vacancies in sector i and $u_i L_i$ is the number of unemployed workers searching for a job in sector i. The probability of a vacancy filled is $q(\theta_i) = \frac{m(v_i,u_i)}{v_i}$ where $m(v_i, u_i)$ is a constant returns to scale matching function. Since $m(v_i, u_i)$ is constant returns to scale, $q'(\theta_i) < 0$. The probability of an unemployed worker finding a job is $\frac{m(v_i,u_i)}{u_i} = \theta_i q(\theta_i)$ which is increasing in θ_i.

[9] Even though we have assumed a Cobb-Douglas production function for analytical tractability, the qualitative results will go through with a more general production function.

[10] The robustness of our results to alternatively defining and fixing vacancy costs in terms of good Z or in terms of labor is discussed in the penultimate section of this paper.

2.3 Profit maximization by firms in the Z sector

Denote the number of vacancies posted by a firm in the Z sector by V. Assuming that each firm is large enough to employ and hire enough workers to resolve the uncertainty of job inflows and outflows, the dynamics of employment for a firm is

$$\dot{N}(t) = q(\theta_z(t))V(t) - \delta N(t) \tag{7}$$

The wage for each worker is determined by a process of Nash bargaining with the firm separately which (along with alternative modes of bargaining, including multilateral bargaining) is discussed later. While deciding on how many vacancies to open up the firm correctly anticipates this wage. Effectively, the firm solves a two stage problem where in stage 1 it chooses vacancies and in stage 2 it enters into bargaining with workers to determine wages.[11] Therefore, the profit maximization problem for an individual firm can be written as

$$\underset{V(s),m_h(s),m_p(s)}{Max} \int_t^{\infty} e^{-r(s-t)} \left\{ P_z(s)Z(s) - w_z(s)N(s) - c_z V(s) \right\} ds \tag{8}$$

The firm maximizes (8) subject to (5), (6), and (7). We provide details of the firm's maximization exercise in the appendix. Since we are going to study only the steady state in this paper, we suppress the time index hereafter. The steady-state is characterized by $\dot{N}(t) = 0$. From the first-order conditions of the firm's maximization problem, the optimal mix of headquarter and production labor is given by

$$\frac{m_h}{m_p} = \frac{\tau}{1-\tau} \tag{9}$$

[11] As shown by Stole and Zwiebel (1996), the subgame perfect equilibrium of this type of set up can possibly involve a choice of employment greater than what a wage taking firm would do. This is because by choosing higher employment in stage 1 a firm can lower the marginal product of a worker and thus reduce the wage it has to pay in the second stage. As we will see shortly for the autarky case (and later for the offshoring case), the value of marginal product of labor in our set up will be constant for a given P_z, and therefore, a firm has no such strategic motive. Hence, the second stage wage is effectively independent of the first stage employment choice (see Cahuc and Wasmer (2001) for a formal proof).

which in turn makes the output effectively linear in the total employment of the firm as follows:

$$Z = N \tag{10}$$

The key equation from the firm's optimal choice of vacancy, derived in the appendix, is given by

$$\frac{P_z - w_z}{(r+\delta)} = \frac{c_z}{q(\theta_z)} \tag{11}$$

The expression on the left-hand side is the marginal benefit from a job which equals the present value of the stream of the marginal revenue product net of wage of an extra worker after factoring in the probability of job separation each period. The right-hand side expression is the marginal cost of a job which equals the cost of posting a vacancy, c_z, multiplied by the average duration of a vacancy, $\frac{1}{q(\theta_z)}$. Alternatively, $\frac{1}{q(\theta_z)}$ is the average number of vacancies required to be posted to create a job per unit of time. (11) yields the asset value of an extra job for a firm which will be useful in the wage determination below. An alternative way to write (11) is

$$P_z = w_z + \frac{(r+\delta)c_z}{q(\theta_z)} \tag{12}$$

This is the modified pricing equation in the presence of search frictions where in addition to the standard wage cost, expected search cost is added to the marginal cost of producing a unit of output.

Denoting the rate of unemployment in the Z sector by u_z, in steady-state the flow into unemployment must equal the flow out of unemployment:

$$\delta(1 - u_z) = \theta_z q(\theta_z) u_z$$

The above implies

$$u_z = \frac{\delta}{\delta + \theta_z q(\theta_z)} \tag{13}$$

The above is the standard Beveridge curve in Pissarides type search models where the rate of unemployment is positively related to the probability of job destruction, δ, and negatively related to the degree market tightness θ_z.

As mentioned earlier, firms in X sector use one unit of labor to produce one unit of output, and therefore, following an exercise similar to that in Z sector, we obtain the analogues of equations (12) and (13) for the X sector.

2.4 Wage Determination

Wage is determined for each worker through a process of Nash bargaining with his/her employer. Workers bargain individually and simultaneously with the firm.[12] Rotemberg (2006) justifies this assumption by viewing it as a situation where each worker bargains with a separate representative of the firm. Thus each worker and the representative that he bargains with assume at the time of bargaining that the firm will reach a set of agreements with the other workers that leads these to remain employed.

Denoting the unemployment benefit in terms of the final good by b, it is shown in the appendix that the expression for wage is the same as in a standard Pissarides model and is given by

$$w_i = b + \frac{\beta c_i}{1-\beta}[\theta_i + \frac{r+\delta}{q(\theta_i)}]; i = x, z \tag{14}$$

The above wage equation along with the (12) and (13) derived earlier, which we gather below, are the three key equations determining w_i, θ_i, and u_i for a given P_i.

$$P_i = w_i + \frac{(r+\delta)c_i}{q(\theta_i)}; i = x, z \tag{15}$$

$$u_i = \frac{\delta}{\delta + \theta_i q(\theta_i)}; i = x, z \tag{16}$$

For each of the two sectors, for a given price we can determine the wage, w_i and the market tightness, θ_i as follows. Equation (14) represents the wage curve, WC which is clearly upward

[12] As shown by Stole and Zweibel (1996), the outcome of this wage bargaining is similar to the Shapley value of a worker obtained under multilateral bargaining. It is shown in the appendix that the Shapley value of a worker is exactly the same as the wage rate obtained from Nash bargaining when $\beta = 1/2$. See Helpman and Itskhoki (2007) and Acemoglu, Antras and Helpman (2007) for recent uses of multilateral Shapley bargaining. Also, a model of collective bargaining would leave everything unchanged in our paper.

sloping in the (w, θ) space in Figure 1. The greater is the labor market tightness, the higher is the wage that emerges out of the bargaining process (as the greater is going to be the value of each occupied job). Note that the position of this curve is independent of the price, P_i. Equation (15) is the pricing equation. As explained in Pissarides (2000), it also represents the job creation curve, as it equates the value of the marginal product of labor, P_i, to the wage, w_i plus the expected capitalized value of the firm's hiring cost, $\frac{(r+\delta)c_i}{q(\theta_i)}$. This is the marginal condition in the creation of the last job. For a given price, as shown in Figure 1, the job creation curve, represented by JC is downward sloping in the (w, θ) space. The capitalized value of the hiring cost is increasing in market tightness, θ_i. Therefore, for a given value of the marginal product of labor, there is a tradeoff between the wage and the market tightness. The intersection of WC and JC gives the partial equilibrium levels of w_i and θ_i for a given P_i. As the price, P_i, increases, JC shifts up, leading to an increase in w_i and θ_i, and thus from the Beveridge curve a reduction in unemployment.

2.5 No arbitrage condition

Since unemployed workers can search in either sector, the income of the unemployed must be the same from searching in either sector. As shown in equation (32) in appendix, the income of the unemployed searching in sector-i is given by $rU_i = b + \frac{\beta}{1-\beta} c_i \theta_i$. Perfect labor mobility implies the no arbitrage condition of $U_z = U_x$, which in turn, implies

$$c_z \theta_z = c_x \theta_x \tag{17}$$

That is, the labor market tightness for each sector is inversely proportional to its vacancy cost. Next, it can be verified from the wage equation in (14) that when $c_z \theta_z = c_x \theta_x$ wage is higher in the sector having a lower market tightness. Thus the unemployment rate as well as the wage rate will be higher in the sector with the higher search cost.

2.6 Autarky Equilibrium

We solve for the equilibrium value of the relative price, $\frac{P_z}{P_x}$, which in turn will give us the equilibrium values of wages and unemployments in the two sectors in autarky.

Note from (3) that an increase in P_z requires a decrease in P_x to keep the price of numeraire at 1. This represents the zero profit condition (ZPC) for the numeraire sector, C, and is represented by a downward sloping line denoted by ZPC in Figure 2a.

Next, using the no arbitrage condition (17) we obtain a positive relationship between P_x and P_z as follows. Starting from any P_x, we can determine w_x and θ_x from the intersection of WC and JC for sector X. Next, θ_z is determined from the no arbitrage condition (17). Then w_z is determined from (14). Since we know θ_z and w_z, we can determine P_z from (15), which means the position of the curve JC for this sector should be such that it passes through the (w_z, θ_z) we just determined. The price, P_z, being a determinant of the position of JC will adjust to make this happen.

As P_x goes up, JC in the X sector shifts up, leading to an increase in w_x and θ_x and, through the mechanism outlined above, an increase in w_z, θ_z and P_z. A higher price of a sector's output implies higher value of marginal product of a worker in that sector and therefore a higher present value of the income stream of an unemployed worker searching in that sector. Since these incomes of the unemployed need to be equalized across the two sectors, a higher price in one sector implies a higher price in the other. This positive relationship between P_x and P_z due to the no arbitrage condition is called $NAC(A)$ in Figure 2a, where A denotes autarky.

The two relationships between P_x and P_z, NAC and ZPC in Figure 2a, uniquely determine the general equilibrium values of P_x and P_z. Once we know P_x and P_z we obtain the general equilibrium values of w_i, θ_i, and u_i, using (14)-(16), through the WC-JC apparatus described above (Figure 1).

Notice the Ricardian element in the model in that the relative supply of Z is a horizontal line at the $\frac{P_z}{P_x}$ determined by the intersection of NAC and ZPC curves described above. The relative demand for Z given in (4) is downward sloping and is represented by the RD curve in Figure 2b.

The horizontal RS curve (at the price determined by NAC and ZPC curves in Figure 2a) is the relative supply curve. The intersection of the two curves determines the general equilibrium $\frac{Z}{X}$.

2.7 Equilibrium with the possibility of offshoring

Now, suppose firms in the Z sector have the option of procuring input m_p from abroad instead of producing them domestically.[13] The per unit cost of imported input is w_s in terms of the numeraire good C, and this country takes this per unit cost as given.[14] This includes transportation cost, tariffs, foreign wage costs and possible search costs, all of which, for analytical tractability, we assume to be proportional to the amount of the input imported. If and when offshoring takes place, the final good C will be exported to pay for the imports of m_p. For a firm offshoring its production input, the production function specified in (5) can be written as $Z = \frac{1}{\tau^{\tau}(1-\tau)^{1-\tau}} N^{\tau} m_p^{1-\tau}$, where N is the domestic labor used for headquarter services. This firm maximizes $\int_t^{\infty} e^{-r(s-t)}\{P_z(s)Z(s) - w_z(s)N(s) - w_s m_p(s) - c_z V(s)\}ds$. The equation of motion for employment given in (7) remains valid.[15]

With each firm taking the equilibrium θ_z as given, in steady state, we get

$$\frac{N}{m_p} = \frac{\tau w_s}{(1-\tau)\left(w_z + \frac{(r+\delta)c_z}{q(\theta_z)}\right)} \tag{18}$$

[13] The assumption here is that one unit of home (domestic) labor can produce one unit of the production input. Therefore, we use m_p to denote both the number of units of the imported input in the offshoring case as well as the number of units of production labor in the autarky case.

[14] The assumption that w_s is fixed is effectively a small country assumption. However, as argued in the section on possible extensions, there is no loss of generality resulting from it. One can also easily work out the implications for the country from which the input is being imported.

[15] As in the autarky case, there is no role for strategic overemployment here as well. The marginal product of headquarter labor in Z gets fixed for a given P_z as follows: w_s is equated to the value of marginal product of production input. Under CRS, this fixes the ratio of headquarter to production input for a given P_z, which in turn fixes the marginal product of headquarter labor.

The price equals marginal cost condition is given by

$$P_z = w_s^{1-\tau}\left(w_z + \frac{(r+\delta)c_z}{q(\theta_z)}\right)^{\tau} \tag{19}$$

Since the value of a domestic job still equals $\frac{c_z}{q(\theta_z)}$ in steady-state, the wage is still given by

$$w_z = b + \frac{\beta c_z}{1-\beta}[\theta_z + \frac{r+\delta}{q(\theta_z)}] \tag{20}$$

In the rest of this section we use the following notational simplification.

Definition 1: $\omega \equiv \frac{w_z + \frac{(r+\delta)c_z}{q(\theta_z)}}{w_s}$

In the above definition ω is the cost of domestic labor relative to foreign labor. It is clear that in order for firms to offshore we require $\omega > 1$.[16]

We can determine the offshoring equilibrium in sector Z using the WC-JC apparatus in Figure 1 as follows. Notice that (19) represents the new job creation curve in the Z sector as it can be written as $P_z\omega^{1-\tau} = \left(w_z + \frac{(r+\delta)c_z}{q(\theta_z)}\right)$. After offshoring, the new value of the marginal product is $P_z\omega^{1-\tau}$ which, for a given P_z, is greater than the value of the marginal product, P_z under autarky (as $\omega > 1$).[17] Thus, for a given P_z, we can represent sector Z's new job creation curve in Figure 1 by JC' which is to the right of the autarky job creation curve which we represent by JC. The wage bargaining curve remains at WC. The intersection between JC' and WC shows us that the partial

[16] It is possible that the value of ω is less than 1 under autarky and greater than 1 when all firms offshore, resulting in the possibility of multiple equilibria - autarky and offshoring. However, starting from autarky, in such a case firms will be faced with a coordination problem that will prevent them from moving into an offshoring equilibrium. Therefore, for our analysis, for offshoring to take place it will be required that $\omega > 1$ under autarky, which will imply that $\omega > 1$ also once offshoring has taken place. As shown in the subsection on comparative static exercises, the value of ω depends on parameters of the model such as δ, b, c_i and the efficiency of matching. It also depends on w_s which is taken as given. In other words, there are several degrees of freedom to make sure that the restriction $\omega > 1$ holds.

[17] Since w_s is equated to the value of the marginal product of production input, the ratio of headquarter to production input gets completely pinned down by w_s and P_z. This ratio of headquarter to production input in turn completely pins down ω (see equation 18). Thus, ω gets fixed by w_s and P_z.

equilibrium effect (under constant P_z) of offshoring is an unambiguous increase in both w_z and θ_z (which leads to a reduction in u_z).

We next derive the general equilibrium effects of offshoring. Start with a given P_x. The partial equilibrium for the X sector remain unaltered relative to the partial equilibrium under autarky. Thus, w_x and θ_x remain the same, and also w_z and θ_z remain unaltered from the no arbitrage condition (17) and the unaltered wage curve of the Z sector. The corresponding P_z is obtained from the new pricing equation (19). As well, as in the case of autarky, an increase in P_x implies an increase in P_z. What is different is that (19) implies that P_z must be lower than under autarky for each level of P_x. Thus, the upward sloping no arbitrage condition under offshoring lies below the the one under autarky and is denoted by $NAC(O)$ in Figure 2a. The zero profit condition for the final good P_x given in (3), which for obvious reasons is unaltered and is denoted by ZPC in Figure 2a. The equilibrium levels of P_x and P_z are obtained by the intersection of $NAC(O)$ and ZPC. It is clear that P_x is higher and P_z is lower in the offshoring equilibrium compared to the no offshoring case.

In an offshoring equilibrium P_x is higher, which means, from the WC-JC diagram for the X sector, that w_x and θ_x are higher, which in turn from the no arbitrage condition and the unaltered wage curve for the Z sector, implies that w_z and θ_z are also higher. Since θ_x and θ_z are higher, both u_x and u_z are lower than in the no-offshoring equilibrium, i.e., the rates of unemployment in both sectors decrease. An increase in the price of good X is able to support higher labor costs in that sector. Since the wage curve implies that wage and market tightness increase together, we have an increase in both these variables in the X sector. Unemployment goes down as a result. Market tightness in the X and Z sectors go together, and so we get a reduction in Z sector unemployment rate as well. In terms of the WC-JC apparatus illustrated in Figure 1, in sector Z we have the new JC curve, denoted by JC", which is below JC' but above JC since the reduction in P_z has been less than the vertical distance between $NAC(A)$ and $NAC(O)$. The move from JC to JC' represents a pure, partial equilibrium productivity effect on w_z and θ_z and this effect on these two variables is positive. The move from JC' to JC" is a general equilibrium, relative price effect and is negative. This negative general-equilibrium effect cannot dominate the positive partial equilibrium effect due to the no-arbitrage condition.

Another way to understand the above result is as follows. An increase in P_x implies an increase in the value of a job in the X sector relative to the cost of vacancy. Therefore, there is greater job creation there and hence a decrease in unemployment. In the Z sector there are two opposing forces on the value of a job. While offshoring increases the productivity of the sector, thereby raising the value of a domestic job (for headquarter services) at unchanged prices, the price of good Z goes down rendering the net impact ambiguous. In fact, this is what happens when workers cannot move from Z sector to the X sector as we discuss in detail later. When workers can move, however, the productivity effect must dominate the relative price effect, leading to an increase the value of a domestic job in the Z sector as well. Here is why. Suppose the value of a job in the Z sector decreased. This would mean a rise in unemployment and a fall in the wage in Z sector. We know that the value of a job in sector X has increased. Since workers are mobile, more unemployed workers will look for a job in the X sector. That is, the number of workers affiliated with sector Z, L_z, will decrease and the number of workers affiliated with sector X, L_x, will increase. This will go on until the value of looking for a job in either sector is equalized. This can happen only if $\theta_z = \dfrac{c_x \theta_x}{c_z}$. Therefore, if θ_x rises θ_z must rise as well.

The impact on the economywide unemployment depends on the relative search costs in the two sectors.

Case I: In the special case of $c_x = c_z$, we have $\theta_x = \theta_z$ and hence $u_x = u_z$. Therefore, aggregate unemployment falls along with the fall in sectoral unemployment due to offshoring.

When $c_x \neq c_z$, we have $\theta_x \neq \theta_z$, and therefore, the two sectors have different unemployment rates. Now, the impact of offshoring on economywide unemployment depends on the direction of labor movement, that is whether labor moves to the high unemployment sector or low unemployment sector. When $c_x = c_z$, and the production function for the final good, C, is Cobb-Douglas, it is easy to show that the size of the labor force in the Z sector post-offshoring is less than in the pre-offshoring equilibrium (See proof in appendix). Even though the result above obtains for

$c_x = c_z$, using a continuity argument we can say that it will hold if c_x and c_z are not too different. Numerical simulations confirm that the result on L_z decreasing upon offshoring is valid even when $c_x \neq c_z$ (c_x and c_z are fairly far apart). In this case we get the following additional results.

Case II: $c_x < c_z$. In this case, it is easy to verify that $\theta_x > \theta_z$, and hence $u_x < u_z$. That is, Z sector has a higher wage as well as unemployment. Now, since offshoring shifts labor from sector Z to sector X, there is going to be an unambiguous decrease in aggregate unemployment. Although the wages of workers in both sectors increase, the number of workers earning the higher wage declines.

Case III: $c_x > c_z$. In this case, even though the rate of unemployment decreases in both sectors, since labor moves into the sector with higher unemployment the impact on aggregate unemployment is ambiguous.

The comparison of the offshoring and autarky equilibria can be summarized as follows:

Proposition 1 *In an offshoring equilibrium, sectoral wages are higher and sectoral unemployment rates lower than in the autarky equilibrium. When $c_x \leq c_z$, there is an unambiguous decrease in aggregate unemployment as a result of moving from autarky to an offshoring equilibrium. When $c_x > c_z$, the impact on aggregate unemployment is ambiguous.*

2.8 Intrasectoral versus intersectoral labor reallocation

In this model, there is labor mobility across the two sectors, X and Z and across the two types of jobs, production and headquarter activity in sector Z. This leads to the possibility of intrasectoral labor reallocation between the two types of jobs and intersectoral labor reallocation once the economy moves from autarky to offshoring. As shown in the appendix, when $c_x = c_z$ and the production function for C is Cobb-Douglas with the share of intermediate good Z being γ, the labor force in the Z sector under autarky is $L_z^A = \gamma L$. Once offshoring has taken place, this falls to $L_z^O = \frac{\gamma\tau}{1-\gamma+\gamma\tau}L$. In other words, the contraction in the labor force of the Z sector (or the expansion in the labor force of the X sector) equals $L_z^A - L_z^O = \frac{\gamma(1-\tau)(1-\gamma)}{(1-\gamma+\gamma\tau)}L$, which is decreasing in the headquarter intensity, τ. This is intuitive since a high headquarter intensity means that most of the labor force is employed in headquarter activity to begin with and production activities form a small fraction of jobs in the Z sector, thus allowing the scope for very little intersectoral labor reallocation upon offshoring.

We next look at intrasectoral reallocation. The number of jobs in headquarter activity under autarky equals $m_h^A = (1-u^A)\gamma\tau L$, while the number of headquarter jobs increases to $m_h^O = (1-u^O)\frac{\gamma\tau}{1-\gamma+\gamma\tau}L$. It is easy to verify that $m_h^O > m_h^A$. Thus, some of the production jobs lost in the Z sector can be made up by expansion in the number of headquarter jobs. Together with the expansion in the number of jobs in the X sector, this more than makes up for the number of jobs offshored, and leads to a fall in the unemployment rate.

3 The Case of No Intersectoral Labor Mobility

Since the transitional dynamics of the model are very complicated, to study the shorter run implications of offshoring on unemployment, we discuss a case where there is no intersectoral labor mobility, that is L_x and L_z are held fixed. The only connection between the two sectors is through goods prices.

Let us start with the determination of autarky equilibrium without labor mobility. Note that the ZPC curve in Figure 2a is still valid but the NAC curve representing the no arbitrage condition doesn't hold. Therefore, the relative price $\frac{P_z}{P_x}$ is now determined by the relative supply and relative demand. To derive the relative supply curve, note that an in increase $\frac{P_z}{P_x}$ implies an increase in P_z and a decrease in P_x from ZPC. An increase in P_i implies increases in w_i and θ_i from Figure 1a and a fall in u_i. Therefore, an increase in $\frac{P_z}{P_x}$ implies an increase in $\frac{Z}{X}(=\frac{(1-u_z)L_z}{(1-u_x)L_x})$. Let us call this relationship, the short-run relative supply curve, and the horizontal relative supply curve we derived earlier, shown in Figure 2b, the long-run relative supply curve. At $L_x = L_x^A$ and $L_z = L_z^A$ (where L_i^A represents labor force in sector $i = x, z$, in an autarky equilibrium when labor is mobile across sectors) it is easy to see that both the long-run and the short-run curves cut the relative demand curve at exactly the same point A (See Figure 3 where $SRS^A(L_z^A)$ stands for short-run relative supply in the autarky case at the long-run autarkic intersectoral allocation of labor, $L_z = L_z^A$ and $L_x = L - L_z^A$).

Let us now derive the offshoring equilibrium under no labor mobility. The derivation of the short run supply curve in the case of offshoring is similar to that in the autarky case discussed above, the only difference is that equation (15) is replaced by (19). Therefore, the short-run supply curve under offshoring is again upward sloping. Next, we show in the appendix that the short run supply curve under offshoring represented by $SRS^O(L_z^A)$ in Figure 3 lies to the right of the short run supply curve under autarky, $SRS^A(L_z^A)$. The short run offshoring equilibrium is at point C in Figure 3 where the equilibrium relative price, p_{sr}^O, is lower compared to the autarky equilibrium at A.

Since the P_x increases upon offshoring, the wage increases and the unemployment decreases in the X sector. What happens to unemployment in the Z sector in the short run equilibrium is ambiguous, however, because the no arbitrage condition does not hold anymore. The impact on Z sector depends on the relative strengths of the productivity and relative price effects. Due to the inability of workers to move, the negative relative price effect is much stronger compared to the labor mobility case making it possible for the unemployment to rise. When the production function for C is Cobb-Douglas with the exponent of intermediate good Z being γ, the result depends on parameters γ and τ. The higher the γ the weaker the negative price effect while the higher the τ the stronger the productivity effect. Alternatively, a high γ can be viewed as implying a high demand for Z sector output and consequently a high derived demand for labor in the Z sector, while a high τ implies a high demand for headquarter services which uses domestic labor. Therefore, with a high γ or τ, a larger amount of labor can be absorbed in the Z sector without a rise in unemployment.

Next, we compare the offshoring equilibria with and without labor mobility as follows. It was shown in the appendix that when $c_x = c_z$, we have $L_z^O < L_z^A$, that is labor moves out of the Z

sector as a consequence of offshoring in the presence of labor mobility.[18] In the no labor mobility case, note from (37) in the appendix giving the relative supply of Z that, holding the economy's aggregate labor force constant, decreasing L_z shifts the short-run relative supply curve in the case of offshoring to the left. Therefore, the short run offshoring relative supply curve with $L_z = L_z^O$ lies to the left of the short-run offshoring supply curve with $L_z = L_z^A$. The curve representing the short run offshoring supply with $L_z = L_z^O$ is denoted by $SRS^O(L_z^O)$ in Figure 3. The intersection of $SRS^O(L_z^O)$ with the relative demand curve at point B captures the offshoring equilibrium with labor mobility. Thus, the offshoring equilibrium relative price in the case of no labor mobility corresponding to point C in Figure 3 is lower than the relative price that obtains in the case of labor mobility corresponding to point B. Therefore, in the absence of labor mobility, offshoring leads to a lower wage and a higher unemployment in the Z sector compared to the case with full labor mobility. Also the favorable relative price effect of offshoring for the X sector is stronger under no labor mobility than under mobile labor. Therefore, the reduction in the unemployment rate in the X sector (due to offshoring) is greater in the short-run than in the long run. This means that unemployment in sector X falls by a considerable amount in the short run and then rises in the long run, with the new long run unemployment rate being lower than the initial long-run unemployment rate. Thus, we have the following proposition:

Proposition 2 *In the shorter run case where intersectoral labor mobility is not allowed, in an offshoring equilibrium, the reduction in the relative price of Z is greater than what obtains under intersectoral labor mobility. Thus, the increase in wage and the reduction in sectoral unemployment in sector Z under offshoring are smaller under no labor mobility than under intersectoral labor mobility, with the possibility being there that sectoral unemployment goes up as a result. In the X sector, the increase in wage and the reduction in sectoral unemployment as a result of offshoring are greater.*

The model without intersectoral mobility of labor can also be used to analyze the impact of

[18] As discussed earlier, numerical simulations confirm that $L_z^O < L_z^{NO}$, even when $c_x \neq c_z$.

offshoring on different skill types. For example, if skilled jobs are being offshored, we can label workers employed in the Z sector as skilled and workers employed in the X sector as unskilled. The model would predict that offshoring would reduce the unemployment of unskilled workers and have an ambiguous impact on the unemployment of skilled workers.

4 Some Comparative Static Exercises

While the focus of this paper is to understand the implications of offshoring for unemployment, we can also use the model to understand how labor market institutions affect offshoring and consequently unemployment. To this end, we first study the impact of an increase in the unemployment benefit, b, on offshoring and unemployment. We will also look at the impact of a change in the bargaining power β and the change in search costs.

Under autarky, when b goes up, we show in the appendix, using a Cobb-Douglas matching function and imposing the intersectoral labor mobility condition, that $P_z - P_x$ goes up or down or remains constant as the intersectoral differential in the search cost per worker (which is proportional to $\frac{c_z}{q(\theta_z)} - \frac{c_x}{q(\theta_x)}$) goes up or down or remains constant. For a given price, an increase in b shifts the wage curve up in each sector and its point of intersection with JC shifts to the left, leading to a higher wage but a lower labor market tightness (that leads to a higher rate of unemployment). The lower market tightness increases $q(\theta)$ and thus reduces the search cost per worker. The search cost per worker is higher in the sector that has the higher cost of posting a vacancy and as shown in the appendix, that is also the sector that has a bigger decline in the search cost per worker as a result of an increase in the unemployment benefit, b.[19] Therefore, when b goes up, the NAC curve shifts up

[19] The intuition is that with the labor mobility condition $c_z\theta_z = c_x\theta_x$, the percentage change in the labor-market tightness is the same in both sectors. With the Cobb-Douglas matching function implying a constant elasticity of the probability of filling a vacancy (and of the expected number of vacancies to be posted to be able to hire a worker) with respect to labor market tightness, we get the same percentage change in both sectors in the number of job postings per worker employed and therefore, the same percentage change in the search expenditure per worker. As a result, we get a bigger absolute change in search expenditure per worker in the sector with a higher initial search

(and equilibrium P_z goes up) when $c_z < c_x$, the NAC curve shifts down (and P_z goes down) when $c_z > c_x$, and everything remains unchanged when $c_z = c_x$. Offshoring takes place when autarky P_z $=w_z + \frac{(r+\delta)c_z}{q(\theta_z)}$ is greater than w_s. Thus parameter changes that lead to an increase (decrease) in this P_z make offshoring likely (unlikely).

Of the three cases, the ranking of vacancy costs that seems most realistic is $c_z > c_x$, as Z is the more sophisticated sector, with labor performing two different kinds of tasks. In this case, an increase in the unemployment benefit makes offshoring less likely because the cost of domestic labor in sector Z decreases with b. The intuition here is as follows. As we have seen, an increase in b has two effects on the wage and the cost of production. One is the direct effect of increasing the wage, since the term b appears in the wage equation. The other is the indirect effect that takes place by reducing market tightness which also reduces the search cost per worker, $\frac{c_i}{q(\theta_i)}$, thereby putting downward pressure on the wage and the cost of production. When $c_z > c_x$, the search cost per worker (in the overall cost per worker employed) is relatively more important in sector Z as compared to sector X. Thus, we have a reduction in the equilibrium relative price of Z and therefore in its domestic average labor cost of production (inclusive of search), which reduces the likelihood of offshoring.[20]

We obtain similar results with an increase in the bargaining power of workers, β. Furthermore, an increase in search cost in sector Z, c_z, clearly shifts the NAC curve up and increases the likelihood of offshoring. If an increase in c_z leads to offshoring, it will cause a downward jump in sectoral unemployment.

Another parameter of interest is the job destruction rate, δ. It is straightforward to see from the equation, $P_z = P_x + \frac{(r+\delta)}{1-\beta}\left(\frac{c_z}{q(\theta_z)} - \frac{c_x}{q(\theta_x)}\right)$ that NAC shifts up as a result of an increase in δ when

expenditure per worker.

[20] Here, if we take the effect of b on offshoring into account we can get a discontinuous effect of b on the sectoral unemployment rate. For example, with lower and lower values of b, unemployment keeps falling in autarky until we cross a lower threshold b and we get offshoring, at which point unemployment jumps further down discontinuosly. In the opposite case of $c_z < c_x$, we get both non-monotonocity and discontinuity in this relationship.

$c_z > c_x$, making offshoring more likely. This is so since an increase in δ raises the importance of the search component relative to the direct production component in activities of the firm, and this effect is greater in the sector that has larger vacancy costs to start with.[21] We can also look at the effects of exogenous increases in $q(\theta)$ (brought about by an improvement in matching technology). As a result of this change, $\frac{(r+\delta)}{q(\theta)}$ goes down in the same proportion in both sectors, making offshoring less likely when $c_z > c_x$, and more likely when $c_z < c_x$. The reason here is that a more efficient matching technology reduces the importance of search in the overall functioning of the firm and this effect is greater in the sector that has larger vacancy costs to start with. It is now very easy to find a worker.

Thus we find that the effect of an increase in labor market frictions or rigidities on offshoring depends on the nature of the friction or rigidity being considered as well as the relative size of the vacancy costs in the two sectors. Under the more likely case that $c_z > c_x$, offshoring becomes more likely with a reduction in the unemployment benefits, the bargaining power of workers and efficiency in matching and an increase in the vacancy cost in sector Z and the common job destruction rate across the two sectors.

5 Possible Extensions and Discussion

We have presented two models in this paper with different assumptions on intersectoral labor mobility. However, these two possibilities do not exhaust all possible combinations of assumptions on inter and intrasectoral labor mobility. One can imagine a situation where there is no mobility across the two types of jobs in the Z sector and but there is mobility of production labor between the two sectors, i.e., headquarter jobs require skilled workers, while production jobs require unskilled

[21] This is important in the context of the findings of Davis (2008) who provides evidence that the risk of job destruction has gone down over the last 30 years. Thus, while other factors such as lower production costs in the South (relative to those in the North), lower trade costs (transport costs and tariffs) etc may have led to greater offshoring in recent times, the reduction in the job destruction rate might have moderated their effects.

or relatively less skilled workers. In other words, there are two types of labor in the economy. After offshoring, the production input cost in sector Z equals w_s, and all the domestic production labor moves to sector X. At a constant P_z, the marginal product of headquarter labor rises since the cost of production input (now all imported) in sector Z falls to w_s, which when equated to its value of marginal product at a constant product price implies a higher ratio of production input to headquarter labor, in turn implying a higher marginal product of headquarter labor. This is the partial equilibrium effect by which the JC curve for headquarter labor shifts up (and that for labor in sector X remains fixed). Thus, upon offshoring, at a constant P_x (and therefore at constant P_z), unemployment falls for skilled workers who work in the headquarter activities in the Z sector, while it remains constant in sector X. Therefore, more headquarter labor is employed in sector Z. In addition, since the ratio of production input to headquarter labor has gone up, employment of production input (now all imported) has also gone up. Hence, we get an increase in the output of Z at any given price. The output of X at a given price and for given X-sector labor force will remain constant. However, the X-sector labor force actually increases upon offshoring since all the domestic production labor from Z actually flows into X. Thus, both the outputs of X and Z go up for a given P_x and whether the relative supply Z/X goes up or down as a result of offshoring will depend on parameters of the model. Assuming that the vacancy cost of production labor is the same in both sectors, if the final good C is highly intensive in Z, a large part of the domestic production labor force will be employed in sector Z under autarky, and for given relative prices of Z and X, we will get a very large increase in the X-sector labor force upon offshoring. Conversely, with a low Z-intensity of C, we will get only a small increase in the X-sector labor force upon offshoring (again for given relative prices). The Z-intensity of C does not affect the post-offshoring output of Z as long as P_z is constant. On the other hand, if w_s is very low, we get a large increase in the output of Z upon offshoring. Thus, with low Z-intensity of C and a low w_s, the relative supply of Z shifts to the right upon offshoring, and as in the previous two models, equilibrium P_z

falls and P_x rises upon offshoring.[22] While this results in a positive effect on the JC curve for X-sector labor, it results in a negative general equilibrium effect on the JC curve for headquarter labor. If the direct productivity effect dominates this negative effect, unemployment of headquarter labor can still go down. In any event, production labor (all in sector X now) unemployment goes down. On the other hand, with high Z-intensity of C and a relatively high w_s (but low enough to result in offshoring), the relative supply of Z shifts to the left and equilibrium P_z rises and P_x falls upon offshoring. In this case, the general equilibrium effect for headquarter labor in sector Z is positive, and it is negative in sector X. Thus, in this case unemployment of headquarter labor falls unambiguously and that of production labor rises unambiguously.[23] The general result from the two cases is that upon offshoring, unemployment cannot rise at the same time for both types of labor, but can fall for both. At least, one type of labor will experience a fall in its unemployment rate.

We next focus on the modeling of vacancy cost in this paper. We have modeled vacancy cost, c, in terms of the numeraire good which seemed natural given the two sector structure of the model. One could alternatively model the vacancy cost either in terms of labor or foregone output. In the former case, the vacancy cost would be $c_i w_i$ for sector $i = X, Z$, where w_i is the sectoral wage. In the latter case, it would be $c_i p_i$. We find that, under fairly plausible and reasonable conditions, the qualitative results would be unchanged. The key to obtaining our result on unemployment is that productivity changes should not be fully absorbed by wage changes, which will obtain with alternative specifications of search costs as well.

The third possible line along which we can extend our theory is to explicitly bring in the country

[22] The derivation of these results can be obtained from the authors upon request.

[23] In this case of high Z-intensity of C and a relatively high w_s, there is the possibility of an interior (mixed) equilibrium, where simultaneously some amount of domestic production labor is used in the Z sector and some amount of offshoring takes place. In this case, the domestic labor cost (including the cost of search) gets equated to w_s. The impact on the unemployment of the two different types of labor is qualitatively the same as what we have seen in the complete offshoring equilibrium of this case (high Z-intensity of C and a relatively high w_s).

to which we offshore the manufacturing of the production input in sector Z. Let us here stick to the assumption of intersectoral and intrasectoral mobility. We call here the country whose production jobs are being offshored the North and the country to which these jobs are being offshored the South. Let us assume that the consumption good C is the only good produced in the South but using a small scale, Ricardian (CRS) production technology, in which every firm uses one worker at a very low level of productivity. Unlike the North, the production of C does not take place in multiple stages but in a single stage using only labor.[24] Due to the low productivity there, the JC curve (for C in the South) in the JC-WC diagram will be at a very low level (closer to the origin) resulting in a low wage and low labor-market tightness (high unemployment). Upon offshoring, the South starts producing the production input for the North.[25] As long as both this production input and C are produced in the South, the price of the input remains fixed by the following argument. The price of C is fixed at one (numeraire good in both countries) which fixes θ in the C sector in the South and, in turn by the labor mobility condition, fixes θ in the production input sector. This in turn fixes the wage and the price in the input sector in the South. So the production input supply curve of the South is horizontal as long as production is diversified. If a higher price is offered for it, there is going to be complete specialization in the production of the production input, from which point the supply curve will be upward sloping. Beyond this point, unemployment will keep decreasing as price of the input increases. Realistically speaking, we should not expect complete specialization in the production of input in the South, and so we can expect the North to face a constant price of the input. All our earlier results then remain intact for the North. Southern unemployment rate will actually go up as a result of offshoring when the vacancy cost there is higher in the input sector than in C production (which would be a reasonable assumption to make if the input sector is more sophisticated). Qualitatively, this becomes quite similar to a Lewis and a Harris-Todaro type scenario in the South in that the labor costs are being fixed by the huge relative

[24] The cost of not being able to (or not having access to) the roundabout method of producing C is low productivity.

[25] One can here think of offshoring as also leading to a transfer (to the South) of the know-how of manufacturing the production input.

size of the rest of the economy. We can also look at the unrealistic, theoretical case of complete specialization in the input. In this case, the price would be higher than the flat part of the supply curve but for offshoring to take place, has to be lower than the cost of production of the input in the North. In this case, it is possible for the Southern unemployment rate to go down.[26]The results for the North remain as before.

The model in the paper can be extended along several other dimensions. In our current paper we do not explicitly model outsourcing, as is currently understood to be subject to contracting problems.[27] If firms have the choice to outsource their production activities to a foreign supplier in an incomplete contract framework, whether a firm outsources or produces inputs domestically will depend on the tradeoff between the domestic labor market frictions and contracting costs. One can also extend the model to include the search cost of hiring workers offshore.

Another possible extension would be to endogenize the bargaining power of workers in the wage bargaining process. In our current model, wages increase with offshoring, however, there is some evidence to suggest that wages of workers have stagnated despite productivity gains coming from globalization and technological progress. If we make workers' bargaining power a decreasing function of the number of firms offshoring, it would be possible to show a decrease in wages resulting from offshoring. This would be similar in spirit to the Mitchell (1985) description of "norm shift" in wage determination. Since our focus in the present paper is on unemployment effects of offshoring, we do not pursue this extension in the present paper. We plan to pursue these extensions in a separate paper, as they seem to be beyond the scope of the current one.

[26]It is possible for the Southern supply curve of the production input to start sloping up much before complete specialization if only a fraction (less than one) of the labor force is competent in input production in the South, while everyone there is equally competent in the low-productivity, small-scale production of the consumption good. Offshoring then can possibly result in a reduction in the unemployment rate for the workers who are competent in input production, while the unemployment rate of the remaining workers remains unchanged. Overall unemployment rate can decline as a result.

[27]See the survey by Helpman (2006). Also, see Mitra and Ranjan (2008) for an explcit modeling of incomplete contracts, in the context of external economies of offshoring (but not in the context of unemployment).

6 Conclusions

In this paper, in order to study the impact of offshoring on sectoral and economywide rates of unemployment, we construct a two sector general equilibrium model in which unemployment is caused by search frictions. We find that, contrary to general perception, wage increases and sectoral unemployment decreases due to offshoring. This result can be understood to arise from the productivity enhancing (cost reducing) effect of offshoring. This result is consistent with the recent empirical results of Amiti and Wei (2005a, b) for the US and UK, where, when sectors are defined broadly enough, they find no evidence of a negative effect of offshoring on sectoral employment.

Even though both sectors have lower unemployment post-offshoring, whether the sector with the lower unemployment or higher unemployment expands will also be a determinant of the overall unemployment rate. If the search cost is identical in the two sectors, implying identical rates of unemployment, then the economywide rate of unemployment declines unambiguously after offshoring. Alternatively, even if the search cost is higher in the sector which experiences offshoring (implying a higher wage as well as higher rate of unemployment in that sector), the economywide rate of unemployment decreases because workers move from the higher unemployment sector to the lower unemployment sector.

When we modify the model to disallow intersectoral labor mobility, the negative relative price effect on the sector in which firms offshore some of their production activity becomes stronger. In such a case, it is possible for this effect to offset the positive productivity effect, and result in a rise in unemployment in that sector. In the other sector, offshoring has a much stronger unemployment reducing effect in the absence of intersectoral labor mobility than in the presence of it.

We can also point out the welfare implications of offshoring in our model. Since wages are expressed in terms of the numeraire consumption good, the welfare implications of offshoring are straightforward. As we have shown that wage increases and the economywide unemployment decreases (when $c_x \leq c_z$) due to offshoring, the impact on welfare is positive.

We also work out the comparative static results of changing some of the parameters representing labor market institutions. We find that the effect of an increase in labor market frictions or rigidities on offshoring depends on the nature of the friction or rigidity being considered as well as the relative size of the vacancy costs in the two sectors. Under the more likely case that vacancy costs are higher in the Z sector than in the X sector, offshoring becomes more likely with a reduction in the unemployment benefits, the bargaining power of workers and efficiency in matching and an increase in the vacancy cost in sector Z and the common job destruction rate across the two sectors.

There are two main messages from the paper. Firstly, how offshoring will affect unemployment will depend on the alternative opportunities available for the type of labor whose jobs have been offshored. If these workers can freely start searching for alternative jobs, we see a reduction in the unemployment rates for all types of workers. These alternative jobs can be in the same sector (such as more headquarter jobs in our model) or in another sector (such as X-sector jobs in our model). Secondly, with impediments to movements across sectors and across jobs, the likelihood of unemployment for some workers goes up as a result of offshoring. However, the unemployment rates for all types of workers will never go up at the same time as a result of offshoring.

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7 Appendix

7.1 Maximization problem of the firm in the autarky case

The firm maximizes (8) subject to (7), and (6). Denoting the Lagrangian multiplier associated with (7) by λ, and with (6) by ϕ, the current value Hamiltonian for each firm can be written as

$$\begin{aligned} H &= P_z \frac{1}{\tau^\tau (1-\tau)^{1-\tau}} m_h^\tau m_p^{1-\tau} - w_z N - c_z V + \lambda[q(\theta_z)V - \delta N] \\ &\quad + \phi[N - m_h - m_p] \end{aligned}$$

The first order conditions for the above maximization are follows.

$$m_h \quad : \quad \frac{P_z \tau m_h^{\tau-1} m_p^{1-\tau}}{\tau^\tau (1-\tau)^{1-\tau}} = \phi \tag{21}$$

$$m_p \quad : \quad \frac{P_z (1-\tau) m_h^\tau m_p^{-\tau}}{\tau^\tau (1-\tau)^{1-\tau}} = \phi \tag{22}$$

$$V \quad : \quad c_z = \lambda q(\theta_z) \tag{23}$$

$$N \quad : \quad w_z + \lambda\delta - \phi = \dot{\lambda} - r\lambda \tag{24}$$

Now, (21) and (22) imply

$$\frac{m_h}{m_p} = \frac{\tau}{1-\tau} \tag{25}$$

using the above in (21) gives

$$P_z = \phi \tag{26}$$

Next, note from (23) that for a given θ_z, λ is constant. Using $\dot{\lambda} = 0$, (23), and (26) in (24) we get

$$P_Z - w_z = (r+\delta)\lambda = \frac{(r+\delta)c_z}{q(\theta_z)} \tag{27}$$

λ is the shadow value of an extra job.

7.2 Wage Determination

Let U_z denote the income of the unemployed in the Z sector, the asset value equation for the unemployed in this sector is given by

$$rU_z = b + \theta_z q(\theta_z)[E_z - U_z] \tag{28}$$

where E_z is the expected income from becoming employed in the Z sector. As explained in Pissarides (2000), the asset that is valued is an unemployed worker's human capital. The return on this asset is the unemployment benefit b plus the expected capital gain from the possible change in state from unemployed to employed given by $\theta_z q(\theta_z)[E_z - U_z]$.

The asset value equation for an employed worker in sector Z is given by

$$rE_z = w_z + \delta(U_z - E_z) \Rightarrow E_z = \frac{w_z}{r+\delta} + \frac{\delta U_z}{r+\delta} \tag{29}$$

Again the return on being employed equals the wage plus the expected change in the asset value from a change in state from employed to unemployed. Assume the rent from a vacant job to be zero which is ensured by no barriers to the posting of vacancy. Now, denote the surplus for a firm from an occupied job by J_z. Since the wage is determined using Nash bargaining where the bargaining weights are β and $1-\beta$, we get the following wage bargaining equation:

$$E_z - U_z = \beta(J_z + E_z - U_z) \tag{30}$$

The above implies that

$$E_z - U_z = \frac{\beta}{1-\beta} J_z = \frac{\beta}{1-\beta} \frac{c_z}{q(\theta_z)} \tag{31}$$

where the last equality follows from the fact that the value of an occupied job, J_z, equals $\frac{c_z}{q(\theta_z)}$ as shown in (11). Plugging the value of $E_z - U_z$ from above into the asset value equation for the unemployed in (28) we have a simplified version of this asset value equation

$$rU_z = b + \frac{\beta}{1-\beta} c_z \theta_z \tag{32}$$

Next, (29) implies that

$$E_z - U_z = \frac{w_z}{r+\delta} - \frac{rU_z}{r+\delta} \tag{33}$$

Use (31) to substitute out $E_z - U_z$ and (32) to substitute out rU_z in the above expression to get the following simplified wage equation:

$$w_z = b + \frac{\beta c_z}{1-\beta}[\theta_z + \frac{r+\delta}{q(\theta_z)}]$$

Similarly, in the case of the X sector, we obtain $w_x = b + \frac{\beta c_x}{1-\beta}[\theta_x + \frac{r+\delta}{q(\theta_x)}]$.

7.3 Sectoral reallocation of labor after offshoring

Claim**:** When $C = \frac{1}{\gamma^\gamma(1-\gamma)^{1-\gamma}} Z^\gamma X^{1-\gamma}$ and $c_x = c_z$, the labor force in the Z sector is smaller in an offshoring equilibrium than in autarky.

Proof: Note that the relative demand (4) when (2) is Cobb-Douglas is given by

$$\left(\frac{Z}{X}\right)^d = \frac{\gamma P_x}{(1-\gamma)P_z} \tag{34}$$

The relative demand for Z equal to relative supply in autarky equilibrium can be written as

$$\frac{L_z}{L - L_z} = \frac{\gamma(1-u_x)P_x}{(1-\gamma)(1-u_z)P_z} \tag{35}$$

Next, $c_x = c_z$ implies $\theta_x = \theta_z$, which in turn implies $w_x = w_z$, and hence $P_x = P_z$. Now, the choice of numeraire implies $P_x = P_z = 1$. Also, $\theta_x = \theta_z$ implies $u_x = u_z$. Therefore, from (35)

$$\frac{L_z}{L - L_z} = \frac{\gamma}{1-\gamma}$$

Let L_z^A denote the size of the labor force in the Z sector in the no-offshoring equilibrium. The above expression implies that $L_z^A = \gamma L$.

Similarly, the relative demand equals relative supply in the offshoring equilibrium can be written as

$$\frac{L_z}{L - L_z} = \frac{\gamma(1-u_x)\tau\omega^{\tau-1}P_x}{(1-\gamma)(1-u_z)P_z}$$

Again, $c_x = c_z$ implies $\theta_x = \theta_z$ and hence $u_x = u_z$. Also, $\frac{P_z}{P_x} = \omega^{\tau-1}$. Therefore, the above becomes

$$\frac{L_z}{L - L_z} = \frac{\gamma\tau}{1-\gamma}$$

Denoting the equilibrium L_z in the case of offshoring by L_z^O, from above we get

$$L_z^O = \frac{\gamma\tau}{1-\gamma+\gamma\tau}L$$

Therefore, $L_z^O < L_z^A$ for any $\tau < 1$. QED

The number of workers displaced from Z sector as a result of offshoring is $L_z^A - L_z^O = \frac{\gamma(1-\tau)(1-\gamma)}{(1-\gamma+\gamma\tau)}L$

7.4 Multilateral Wage Bargaining

Following Acemoglu, Antras and Helpman (2007), we study multilateral Shapley bargaining betweeen the firm and the various workers that are being employed by the firm. "In a bargaining game with a finite number of players, each player's Shapley value is the average of her contributions to all coalitions that consist of players ordered below her in all feasible permutations." (Acemoglu, Antras and Helpman, 2007). The set of players here are the firm and the workers. In any of these coalitions, if the firm itself is ordered below a worker, then the marginal contribution of this worker is her value of marginal product, while if the firm is ordered after her, the marginal contribution of this worker to the coalition of workers preceding her in the ordering is just the unemployment benefit that she receives. We are going to assume that in autarky if the firm precedes a worker in the ordering, the value of a worker's marginal product is going to be calculated assuming that the firm is able to optimally divide the existing labor in the coalition into headquarter workers and production workers. Since all these workers are being drawn from the same labor force, the labor costs and the wage rate associated with each of them will be identical. We apply directly the Acemoglu-Antras-Helpman approach to the calculation of Shapley values for a continuum of players, the total measure of which in our model equals N.[28] A worker that has a measure n of

[28] Acemoglu, Antras and Helpman (2007) derive their approach to computing the Shapley value for a continuum of players from the original approach for a discrete number of players.

players before her in the sequence will with probability n/N have the firm before her and will have the firm after her with probability $1 - n/N$. Therefore her expected marginal contribution with position n in the sequence is $(n/N)P_z + (1-n/N)rU_z$, where U_z is the asset value of an unemployed worker. Integrating over all n and taking the average we have the Shapley value of a worker under autarky as the following:

$$S = \frac{1}{N}\int_0^N [(n/N)P_z + (1 - n/N)b]\, dn = \frac{1}{2}P_z + \frac{1}{2}rU_z$$

In other words, under this type of bargaining the revenue R is distributed between workers and the firm, with workers getting $R/2 + NrU_z/2$ and the firm getting $R/2 - NrU_z/2$. Foreseeing this outcome of the wage bargaining problem, the firm now maximizes

$$\int_t^\infty e^{-r(s-t)}\left\{\frac{1}{2}P_z Z - NrU_z/2 - c_z V\right\} ds$$

in the first stage subject to exactly the constraints we mention in the text. This maximization problem gives us in the steady state $P_z = \left(b + \frac{2(r+\delta)c_z}{q(\theta_z)}\right)$, which when plugged into the Shapley value gives us

$$S = w_z = rU_z + \frac{(r+\delta)c_z}{q(\theta_z)} \tag{36}$$

This in turn, along with $P_z = \left(rU_z + \frac{2(r+\delta)c_z}{q(\theta_z)}\right)$, implies that we still have

$$P_z = \left(w_z + \frac{(r+\delta)c_z}{q(\theta_z)}\right)$$

Note from (33) and (31) in the text that the expression for bargained wage is

$$w_z = rU_z + \frac{\beta}{1-\beta}\frac{(r+\delta)c_z}{q(\theta_z)}$$

Therefore, for $\beta = 1/2$, the Shapley value of a worker is exactly the same as the wage obtained using Nash bargaining in the text.

Under offshoring, let us assume that the firm comes in with the entire amount of input (i.e., it has already bought or placed an order for the entire quantity of the imported input it needs). In this case, the Shapley value becomes

$$\begin{aligned} S &= \frac{1}{N}\int_0^N \left[(n/N)P_z\frac{1}{\tau^\tau(1-\tau)^{1-\tau}}\tau n^{\tau-1}m_p^{1-\tau}+(1-n/N)rU_z\right]dn \\ &= \frac{\tau}{1+\tau}P_z\frac{1}{\tau^\tau(1-\tau)^{1-\tau}}N^{\tau-1}m_p^{1-\tau}+\frac{1}{2}rU_z=\frac{\tau R/N}{1+\tau}+\frac{1}{2}rU_z \end{aligned}$$

In this case, the firm gets $\frac{R}{\tau+1}-\frac{1}{2}NrU_z$. The firm then maximizes

$$\int_t^\infty e^{-r(s-t)}\left\{\frac{1}{1+\tau}P_zZ-NrU_z/2-w_sm_p-c_zV\right\}ds$$

in the first stage subject to the constraints mentioned in the main text. Therefore, we have

$$P_z=(1+\tau)\left(\frac{rU_z}{2}+\frac{(r+\delta)c_z}{q(\theta_z)}\right)^\tau w_s^{1-\tau}\text{and } m_p=N\frac{\left(\frac{rU_z}{2}+\frac{(r+\delta)c_z}{q(\theta_z)}\right)}{w_s}\frac{1-\tau}{\tau}$$

Plugging these equations into the expression for our Shapley value we have

$$S=w_z=rU_z+\frac{(r+\delta)c_z}{q(\theta_z)}$$

which is exactly the same as the Shapley value obtained under autarky. Therefore, the qualitative results are unchanged.

7.5 Comparing autarky and Offshoring supply curves without intersectoral labor mobility

Start with any relative price $\frac{P_z}{P_x}$. At the corresponding P_x, the unemployment and wage in sector X are the same under offshoring as in the case of autarky at the same price. In sector Z, at the corresponding P_z the corresponding $\left(w_z+\frac{(r+\delta)c_z}{q(\theta_z)}\right)$, determined by (19) now, is higher in the offshoring case because w_s is lower than the cost of domestic labor. Note from (20) that w_z and θ_z

are positively related. Therefore, for every P_z, θ_z must be higher in the offshoring case implying a lower unemployment in the Z sector. The relative supply of Z is given by

$$\frac{Z}{X} = \frac{1}{\tau^{\tau}(1-\tau)^{1-\tau}} \frac{N^{\tau} m_p^{1-\tau}}{(1-u_x)L_x}$$

Next, note that $m_p = \frac{N(1-\tau)\left(w_z + \frac{(r+\delta)c_z}{q(\theta_z)}\right)}{\tau w_s}$, and therefore,

$$\frac{Z}{X} = \frac{N\omega^{1-\tau}}{\tau(1-u_x)L_x} \tag{37}$$

Now, compared to the autarky case, at each P_z, $N(= (1-u_z)L_z)$ is higher because u_z is lower. Also, $\omega > 1$ and $\tau < 1$, therefore, the offshoring $\frac{Z}{X}$ is higher. Hence, the short run relative supply, $SRS^O(L_z^A)$, in the offshoring case lies to the right of the one in the autarky case shown by $SRS^A(L_z^A)$ in Figure 3.

7.6 Comparative statics with respect to b, β and c_i

When b goes up, the average cost of employing domestic labor in sector X, given by $\left(w_x + \frac{(r+\delta)c_x}{q(\theta_x)}\right)$, remains unchanged for a given P_x. In the (w, θ) space, the downward sloping curve representing the autarky job creation (JC) equation, $P_x = \left(w_x + \frac{(r+\delta)c_x}{q(\theta_x)}\right)$ remains unchanged. The upward sloping wage curve (WC) representing $w_x = b + \frac{\beta c_x}{1-\beta}[\theta_x + \frac{r+\delta}{q(\theta_x)}]$ shifts towards a higher w_x for any given θ_x.Given the downward sloping nature of the JC curve, the intersection of the JC and WC curves now implies a higher wage and lower labor-market tightness in sector X. We are now interested in seeing what happens under autarky to the NAC curve, i.e., what happens to P_z for a given P_x as b increases. Plugging in the WC equation into the JC equation in each of the sectors and imposing the labor mobility condition, $c_x\theta_x = c_z\theta_z$, we can write $P_z - P_x = \frac{r+\delta}{1-\beta}\left[\frac{c_z}{q(\theta_z)} - \frac{c_x}{q(\theta_x)}\right]$. Using a Cobb-Douglas matching function, $m(v_i, u_i) = \mu v_i^{\eta} u_i^{1-\eta}$, we have $q(\theta_i) = \mu\theta_i^{\eta-1}$, imposing which we now have $P_z - P_x = \frac{r+\delta}{(1-\beta)\mu}\left[\left(\frac{c_z}{c_x}\right)^{\eta} - 1\right] c_x\theta_x^{1-\eta}$, which is increasing in θ_x if $c_z > c_x$, decreasing in θ_x if $c_z < c_x$ and invariant to θ_x if $c_z = c_x$. Since θ_x goes down as a result of an increase in b for a given P_x, the NAC curve shifts up (and P_z goes up) when $c_z < c_x$, NAC curve shifts down (and

P_z goes down) when $c_z > c_x$ and NAC remains unmoved (and P_z is unchanged) as a 45 degree line if $c_z = c_x$.

Using very similar logic and in addition noting that $P_z - P_x = \frac{r+\delta}{(1-\beta)\mu}\left[\left(\frac{c_z}{c_x}\right)^{\eta} - 1\right] c_x \theta_x^{1-\eta}$ is directly increasing in β for given search costs and labor-market tightness, it is clear that for $c_z < c_x$, offshoring becomes more likely with an increase in β. And because of the direct effect of β, there is ambiguity here when $c_z > c_x$.

Finally an increase in c_z clearly shifts the NAC curve up and leads to offshoring, at which point there is a downward jump in sectoral unemployment.

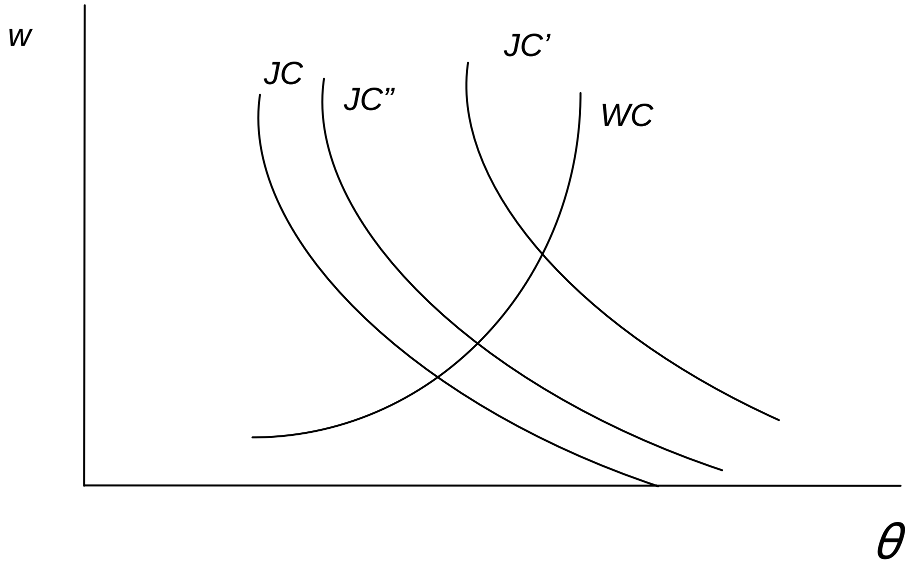

Figure 1: Partial Equilibrium

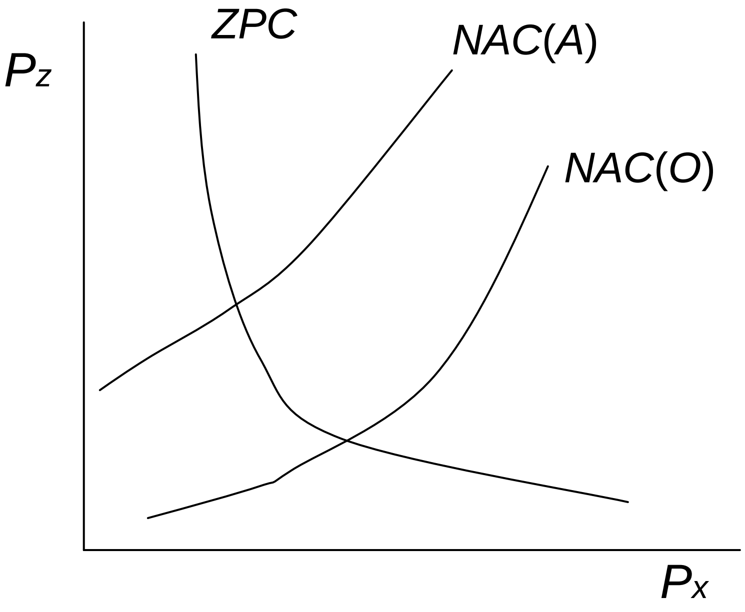

Figure 2a: Equilibrium Prices

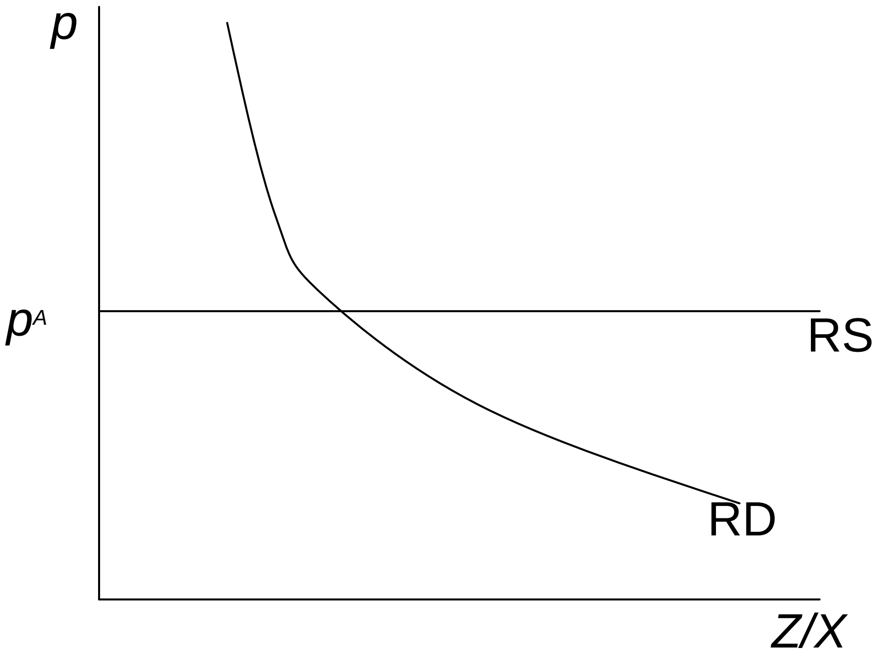

Figure 2b: Autarky Equilibrium

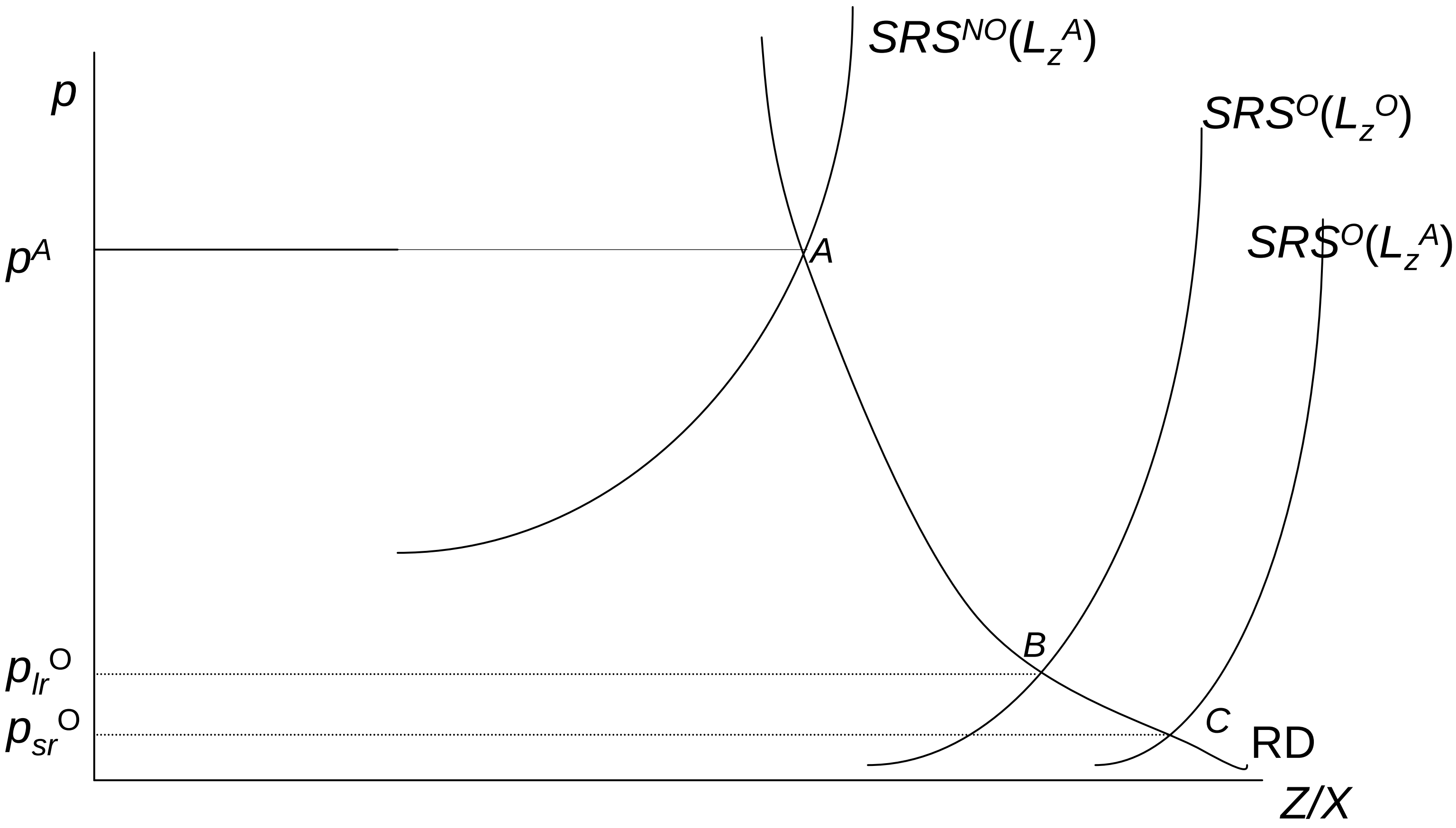

Figure 3: Offshoring Equilibrium With No Intersectoral Labor Mobility