Offshoring, Unemployment, and Wages: The role of labor market institutions

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Abstract

This paper shows the importance of labor market institutions in determining the impact of offshoring on unemployment. Looking at wage setting institutions, it shows that when wage is determined through collective bargaining, there is a non-monotonic relationship between the cost of offshoring and unemployment. Starting from a high cost of offshoring, a decrease in the cost of offshoring reduces unemployment first and then increases it. The non-monotonicity of unemployment in the cost of offshoring does not obtain if the wage is determined by individual Nash bargaining instead of collective bargaining. In a two country framework of offshoring (source country and host country) it is shown how changes in the labor market institutions in one country affects labor markets in both countries. For example, an increase in the recruitment cost or unemployment benefit in the host country can increase unemployment in both the host and the source country. Increases in the recruitment cost or unemployment benefits in the source country are likely to increase unemployment in the source country, but reduce unemployment in the host country.

Key words: offshoring, unemployment, collective bargaining, unions, unemployment benefits, recruitment cost

JEL Classification Codes: F16, J64, J50

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1 Introduction

There has been a resurgence of interest in analyzing the impact of globalization on unemployment. Most papers use models of search unemployment where wages are set through individual Nash bargaining between the worker and the employer, and therefore, do not take into account the role of collective bargaining in the wage setting process. This is a serious omission because for many European countries collective bargaining plays an important role in the wage setting. Union density varied among OECD countries from a low of 8% in France to a high of 71% in Sweden in 2007 (OECD, 2010). However, union density grossly understates the extent of collective bargaining or the percentage of workers covered by collective bargaining. According to OECD (1992), in 1992 the percentage of workers covered by collective bargaining exceeded union membership by 30%. This is particularly so in some countries like France where despite a very low union density, approximately 80% of workers are covered by collective bargaining (Delacroix, 2006). In Germany, approximately 61% of workers were covered by collective bargaining in 2004 (Braun and Scheffel, 2007). In general, in countries like Norway, Sweden, and Finland a very high percentage of workers are covered by collective bargaining[2], while in countries like the U.S., Canada, and Japan only a small percentage of employees are covered by collective bargaining. This motivates us to study the implications of different wage setting institutions for unemployment in a globalized world.

The facet of globalization that we study in this paper is offshoring where by offshoring we mean the sourcing of inputs (goods and services) from foreign countries which enables the fragmentation of production process[3]. The key motivation for fragmenting the production process is the ability to procure these inputs at a lower cost from abroad than at home. When production of these inputs moves to foreign countries, the fear at home is that jobs will be lost and unemployment will rise making it a salient public policy issue[4].

[2] According to Venn (2009) the numbers are 72 % for Norway, 92% for Sweden, and 90% Finland.

[3] Our concept of offshoring includes the procurement of inputs both from a foreign affiliate and a non-affiliate. Sometimes the term foreign outsourcing is used for the latter and the two together are also referred to as "externalization abroad" (see OECD, 2007).

[4] Offshoring is quantitatively important as well. According to OECD (2007), the index of outsourcing abroad of goods and services (value of goods and services offshored as a share of domestic demand) in year 2000 was 81% in Belgium, 69% in Netherlands, 61% in both Denmark and Sweden, and 43% in Finland. UNCTAD in 2004 found that 39 percent of the

This paper constructs a Pissarides style search model of unemployment to study the impact of offshoring on unemployment and wage. While wage is set through individual Nash bargaining in the standard Pissarides framework, we postulate an institutional setting where wages are set through collective bargaining and contrast the results with those obtained using individual bargaining. We also extend the model to a two country setting where the price of the offshored input is determined endogenously and analyze the implications of offshoring and changes in the labor market institutions on labor market outcomes in both the source and the host country.

Collective bargaining is modeled using a monopoly union model where the union sets the wage in the first stage and then the firm chooses employment in the second stage. Looking at the small country case first, it is shown that the unemployment of domestic workers could be less in an offshoring equilibrium compared to autarky. The reason is that the mere possibility of offshoring changes the behavior of unions. Now, seeing the possibility of jobs moving abroad, unions reduce their wage demand in the first stage, which induces firms to hire more domestic workers. More generally, there is a non-monotonic relationship between the cost of offshoring and unemployment. Starting from a cost of offshoring close to the autarky cost of obtaining the input domestically, a decrease in the cost of offshoring decreases unemployment first, and when the cost of offshoring becomes small unemployment starts rising. In all cases, however, whether comparing autarky equilibrium to offshoring equilibrium, or for comparative statics with respect to the cost of offshoring, more offshoring is always associated with a decrease in the wage. The result on decreased wage due to a decrease in the cost of offshoring is consistent with the anecdotal evidence that one of the key motivations for offshoring is to reduce the bargaining power of workers/unions. In addition to providing analytical results, we also undertake a calibration exercise using parameters for a country with pervasive collective agreements, Sweden, and show that the relationship between offshoring cost and unemployment is non-monotonic. The calibration exercise predicts that a decrease in the cost of offshoring, starting from the present level, would reduce unemployment in Sweden.

In contrast to the above results, when wage is set through individual Nash bargaining, we do not obtain the non-monotonicity of unemployment in the cost of offshoring. A decrease in the cost of offshoring always leads to an increase in unemployment. Also, comparing autarky equilibrium with offshoring equilibrium, we get the result that unemployment is always higher in an offshoring

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top 500 European firms had engaged in offshoring of services (UNCTAD 2004, 153).

equilibrium.

Next, we extend the model to a two country case where the price of the offshored input is determined endogenously. To the best of our knowledge, this is the first attempt to study the implications of offshoring for unemployment in a two country framework. We introduce a country Foreign (host country for offshoring) that supplies the offshored input to Home (source country for offshoring). Now, the labor market policies in either country affect the world price of the offshored input and consequently the labor market outcomes in both countries. In this setting it is shown that a decrease in the exogenous element of the offshoring cost reduces the unemployment in Foreign, but the impact on Home unemployment is similar to that in the small open economy case. That is, the non-monotonicity of unemployment with respect to the exogenous element of offshoring cost obtains even when the price of the offshored input is determined endogenously.

Looking at the implications of labor market policies, it is shown that increases in recruitment costs or unemployment benefits in Foreign lead to an increase in the price of the offshored input. Consequently, the impact on Home is similar to that of an increase in the offshoring cost discussed for the small open economy case earlier. That is, Home wage increases and Home unemployment is likely to increase with collective bargaining but decrease with individual bargaining. As far as the Foreign labor market is concerned, in the case of an increase in the unemployment benefits Foreign wage increases unambiguously, but the impact on Foreign unemployment is theoretically ambiguous. The direct effect of an increase in unemployment benefit is to increase unemployment in Foreign but the feedback effect working through an induced increase in the price of the offshored input decreases unemployment. Numerical simulations suggest that the direct effect dominates and therefore, unemployment increases in Foreign. The impact of an increase in the recruitment cost on Foreign wage and unemployment is also theoretically ambiguous, but numerical simulations suggest that both Foreign wage and unemployment are likely to increase.

Finally, an increase in the recruitment cost or unemployment benefit in Home increases offshoring by Home. The consequent increase in the price of the offshored input increases Foreign wage and reduces Foreign unemployment. Home wage increases but the impact on Home unemployment is theoretically ambiguous. Numerical simulations suggest that Home unemployment increases in the case of collective bargaining. Therefore, we conclude from our two country analysis that while increases in Foreign unemployment benefits or recruitment costs are likely to increase unemployment in both

Home and Foreign, increases in Home unemployment benefits or recruitment costs are likely to increase unemployment in Home but reduce unemployment in Foreign.

To sum up, a key prediction of our model is that the impact of offshoring on unemployment in the source country is much more benign in the presence of collective bargaining than in the absence of it. An implication is that offshoring is more likely to increase unemployment in the U.S. where wages are mostly negotiated individually compared to Europe where wages are mostly set by collective bargaining. This is in contrast to some earlier work on globalization and unemployment (e.g. Davis (1998), Moore and Ranjan (2005)) where globalization in the form of trade with unskilled labor intensive countries is likely to lead to a larger increase in unemployment in Europe with an inflexible labor market than in the U.S. which has a more flexible labor market[5].

1.1 Related Literature

While the traditional approach of trade economists has been to work with full employment models, in a series of papers Carl Davidson and Steven Matusz studied the implications of introducing unemployment arising from labor market frictions in trade models. The main focus of their work, as discussed in Davidson and Matusz (2004), 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. Moore and Ranjan (2005) show how trade liberalization in a skill-abundant country can reduce the unemployment of skilled workers and increase the unemployment of unskilled workers. Skill-biased technological change on the other hand, can reduce the unemployment of unskilled workers. Helpman and Itskhoki (2010) use an imperfectly competitive set up with heterogeneous firms to look at how gains from trade and comparative advantage depend on labor market rigidities, and how labor-market policies in a country affect its trading partner. They also study the impact of trade liberalization on unemployment. Trade liberalization in their set up doesn't affect sectoral unemployment, however, the aggregate unemployment is affected due to workers moving from one sector to another. Depending on whether the country's comparative advantage is in the high unemployment or low unemployment sector, trade liberalization

[5] In Davis (1998) Europe has a binding minimum wage while the U.S. has no minimum wage, while in Moore and Ranjan (2005) Europe has greater unemployment benefit than the U.S.

could increase or decrease aggregate unemployment[6]. Another related paper, Felbermayr et al. (2011) incorporates search unemployment in a one sector model with firm heterogeneity to study the implications of a bilateral reduction in trade cost on unemployment. A decrease in trade cost in their setting improves the average productivity of firms which in turn reduces the effective cost of posting vacancy leading to lower unemployment and higher wages. The present paper differs from these studies in two respects. One, the facet of globalization studied in these papers is a reduction in the trading cost of final goods while we focus on offshoring. Second, none of these papers allows the wage to be determined by collective bargaining[7].

Mitra and Ranjan (2010) study the impact of offshoring in a two sector model where some jobs in one of the two sectors can be offshored while all the jobs in the other sector must remain onshore[8]. In this setting they show that offshoring could lead to a decrease in unemployment in both sectors if there is sufficient intersectoral mobility of labor. The key to the unemployment reducing effect of offshoring in that paper is the positive productivity effect of offshoring due to a complementarity between the offshored input and the domestically procured input. In contrast, in the present paper, offshored input and domestic labor are perfect substitutes. Therefore, in the absence of the wage setting mechanism induced by collective bargaining, offshoring is going to increase unemployment. To isolate the new insight arising from collective bargaining, we have removed the possible productivity effect of offshoring from the model. Bringing in any positive productivity effect of offshoring simply strengthens its unemployment reducing effect. Using a constant elasticity of substitution production function we verify that our results described above go through when the elasticity of substitution is high. However, for lower elasticity of substitution (complementarity between offshored input and domestic labor) increased offshoring is associated with reduced unemployment irrespective of the wage

[6] Also see Helpman, Itskhoki and Redding (2010) where trade increases wage inequality but the impact on unemployment is ambiguous.

[7] In the working paper version, Felbermayr et al. (2008) also looked at a case where the wage and employment are chosen through efficient bargaining between the union and the firm, however, their results for this case are qualitatively similar to those obtained using individual bargaining.

[8] Davidson, Matusz and Shevchenko (2008) also study the implications of offshoring in a job search model. However, their focus is on the offshoring of high-tech jobs on low and high-skilled workers' wages, and on overall welfare.

setting mechanism, that is for both collective bargaining and individual bargaining.

Among the studies on the spillover effect of labor market institutions in a country on its trading partners, Felbermayr et al.(2009) construct a North-North type model with a single composite good where countries export varieties of differentiated intermediate goods to each other. In that setting, a decrease in unemployment benefit in one country reduces unemployment everywhere. In our North-South type model in contrast, the impact depends on two things: the wage setting institutions; and whether the change in labor market policy originates in Home (the source country for offshoring) or Foreign (the host country for offshoring).

Even though Helpman and Itskhoki (2010) is mainly a North-North model focusing on trade between symmetric countries, the paper does analyze the impact of changes in labor market policies in an asymmetric country setting where the asymmetry arises due to differences in unemployment benefits in the two countries. In this setting, an increase in unemployment benefit in the differentiated goods sector in a country has a non-monotonic effect on the aggregate unemployment in this country but raises the unemployment in the trading partner. The mechanism through which these results obtain are completely different from our paper. In the country experiencing the increase in unemployment benefits, the direct effect is to raise unemployment in the differentiated goods sector which happens to be the high unemployment sector. However, the loss of competitive edge in the differentiated goods sector also means that this sector shrinks and the labor moves out of this sector. The result is that the first effect dominates initially but is outweighed by the second effect for further increases in unemployment benefits. Since the trading partner gets an edge in the differentiated sector, the expansion of the differentiated sector there means an increase in aggregate unemployment. In our framework, the transmission of labor market policies in one country to its trading partner works through changes in the world price of the offshored input.

It is worth mentioning that while the theoretical literature on the relationship between offshoring and unemployment is nascent, there is now a vast literature on other aspects of offshoring.[9] Following the tradition in standard trade theory, these studies assume full employment.

While there is not much theoretical work on the impact of globalization on labor markets characterized by collective bargaining, there is a sizeable empirical literature on the subject, but it mainly focus on the union wage premium and not on the employment effects of offshoring. Dumont et al. (2006)

[9] See Helpman (2006) for a review of this literature and Grossman and Rossi-Hansberg (2008) for a recent contribution.

estimate the impact of globalization on the bargaining power of workers using data from 5 European countries and find that all the measures of globalization reduce the bargaining power of workers. Using data from Belgium, Brock and Dobbelaere (2006) do not find evidence of trade or inward FDI having an impact on the bargaining power of workers. They find some evidence of technological change having a positive effect on the bargaining power of workers. Finally, using data from Germany, Braun and Scheffer (2007) find that greater international outsourcing reduces the union wage premium of low skilled workers.

The rest of the paper proceeds as follows. In section 2 we provide the basic ingredients of the model. Sections 3 and 4 solve for the autarky and offshoring equilibriums, respectively, for the small open economy case with collective bargaining. Section 5 discusses the small open economy case with individual bargaining. Section 6 provides the calibration exercise. The two country model is developed in section 7 and section 8 concludes.

2 The Model

We are first going to describe the autarky equilibrium in a country called "Home". Then we look at the impact of offshoring in Home under the assumption that Home is a small country, that is, it takes the price of the offshored input as given. Then we look at a two country world where a country "Foreign" is the source for offshored inputs. In this case the price of the offshored input is determined endogenously. In the notation below the subscript h under a variable is going to denote its value for Home and the subscript f is going to denote its value for Foreign.

2.1 The goods market

There is a single final good Z which can be produced using 3 different technologies. In Home there is a traditional technology that allows one unit of labor to produce b_h amount of the final good. In Foreign the traditional technology allows one unit of labor to produce b_f amount of the final good. In addition, Home can produce this good using a more sophisticated technology, which requires some entrepreneurial input, which is in fixed supply, and hence this technology exhibits diminishing returns to scale. The more sophisticated technology requires producing the final good using intermediate inputs which can be produced using domestic labor or foreign labor. The production function using the sophisticated technology is given by

$$Z = AX^{\gamma};\ 0 < \gamma < 1 \tag{1}$$

where X is the amount of intermediate inputs used. γ captures the diminishing returns and is useful in making the firm size determinate for the purposes of union wage setting. We further assume that one unit of Home labor can produce one unit of the intermediate input. Foreign does not have access to the sophisticated technology, however, it can produce the intermediate inputs that go into the production of the final good using sophisticated technology[10].

2.2 The labor market

The labor market in both countries is characterized by a standard Pissarides (2000) type search friction. Since the labor market in the two countries has a lot of similar characteristics, we are going to use the subscript $i = h, f$, to denote the value of the variable for Home and Foreign, respectively. To produce the intermediate input X, a firm needs to open job vacancies and hire workers. The cost of vacancy is c_i in terms of the final good. Denote the total size of work force by $\overline{L}_i$, rate of vacancy by v_i, and the rate of unemployment by u_i. Define $\theta_i = \frac{v_i}{u_i}$ as the measure of market tightness where $v_i\overline{L}_i$ is the total number of vacancies and $u_i\overline{L}_i$ is the number of unemployed workers searching for jobs. Define $m_i(v_i, u_i)$ as a constant returns to scale matching function given below.

$$m_i(v_i, u_i) = \mu_i v_i^{\delta_i} u_i^{1-\delta_i} \tag{2}$$

Define $q_i(\theta_i) = \frac{m_i(v_i,u_i)}{v_i}$, where $q_i(\theta_i)\epsilon t$ is the probability of a vacancy being filled during a small interval of time ϵt. Since $m_i(v_i, u_i)$ is constant returns to scale, $q_i'(\theta_i) = (\delta_i - 1)\mu_i\theta_i^{\delta_i - 2} < 0$. Note that $\frac{m_i(v_i,u_i)}{u_i} = \theta_i q_i(\theta_i)$ where $\theta_i q_i(\theta_i)\epsilon t$ is the probability of an unemployed worker finding a job during a small interval of time ϵt. It follows that $\frac{1}{q_i(\theta_i)}$ is the average duration of a vacancy and $\frac{1}{\theta_i q_i(\theta_i)}$ is the average spell of unemployment. Also, any job can be hit with an idiosyncratic shock with probability λ_i and be destroyed.

In steady-state the flow into unemployment must equal the flow out of unemployment:

$$\lambda_i(1 - u_i) = \mu_i\theta_i^{\delta_i}u_i$$

[10] This is similar in spirit to the modeling of South in the Antras and Helpman (2004) model of offshoring where the South cannot produce the varieties of final good but can produce the inputs that go into it.

The above implies

$$u_i = \frac{\lambda_i}{\lambda_i + \mu_i \theta_i^{\delta_i}} \tag{3}$$

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, λ_i, and negatively related to the degree of market tightness θ_i.

Having introduced the common elements of the labor market, we switch to a discussion of autarky equilibrium in Home followed by a discussion of the offshoring equilibrium when Home is a small country. We will return to the two country case later.

3 Autarky Equilibrium in Home

We assume a monopoly union approach towards wage setting where the union sets the wage first and then the firm chooses employment. This is the approach taken by Pissarides (1986) which is one of the first attempts to bring collective bargaining in a search unemployment framework. As argued by Pissarides (1986), in the context of a search model where firms have to search for workers and any job can be destroyed due to an idiosyncratic shock, letting firms choose the level of employment seems to be a more realistic description of reality. This is also the approach taken by Delacroix (2006) who studies the implications of unions for the labor market and its interaction with policies in a multisector matching model[11].

We solve the model backwards where we first solve the firm's problem in the second stage for a given wage, and then we solve for the wage in the first stage.

Firm's Problem

To save notation assume that there is a unit mass of firms in the economy. Therefore, we do not have to use separate notations for the firm specific variables and the economy specific variables. Denote

[11] Qualitatively similar results obtain using the "right to manage" approach where the wage is set in the first stage through bargaining between the union and the firm and employment is determined by the firm in the second stage. In this setting, wage depends on the bargaining power of the union relative to the bargaining power of the firm, and when the union has all the bargaining power in wage setting, the model converges to that of monopoly union. The results using the right to manage approach were presented in an earlier version of the paper and are available upon request. The possibility of offshoring reducing unemployment exists even in the efficient bargaining approach where the firm and the union simultaneously choose the efficient levels of employment and wage.

the number of vacancies posted by a firm by V_h. 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

$$\dot{L_h}(t) = \mu_h \theta_h(t)^{\delta_h - 1} V_h(t) - \lambda_h L_h(t) \tag{4}$$

Note that since one unit of Home labor produces one unit of the intermediate good, in autarky $X = L_h$, and hence $Z = AX^\gamma = AL_h^\gamma$. Denoting the wage by w_h and the rate of discount by ρ, the profit maximization problem for an individual firm can be written as

$$\underset{V_h(s), L_h(s)}{Max} \int_t^\infty e^{-\rho(s-t)} \left\{ A\left(L_h(s)\right)^\gamma - w_h(s) L_h(s) - c_h V_h(s) \right\} ds \tag{5}$$

The firm maximizes (5) subject to (4), taking $w_h(s)$ and $\theta_h(s)$ as given. Denoting the Lagrangian multiplier associated with (4) by ψ and dropping the time notation s to reduce clatter, the current value Hamiltonian for the firm can be written as

$$H = AL_h^\gamma - w_h L_h - c_h V_h + \psi[\mu_h \theta_h^{\delta_h - 1} V_h - \lambda_h L_h]$$

The first order conditions for the above maximization are follows.

$$V_h \;:\; c_h = \psi \mu_h \theta_h^{\delta_h - 1} \tag{6}$$

$$L_h \;:\; w_h + \psi \lambda_h = \gamma A L_h^{\gamma - 1} + \dot{\psi} - \rho \psi \tag{7}$$

In steady-state $\dot{\psi} = 0$, therefore, (6) and (7) imply

$$\gamma A L_h^{\gamma - 1} = w_h + \frac{(\rho + \lambda) c_h}{\mu_h \theta_h^{\delta_h - 1}} \tag{8}$$

The above equation determines employment L_h as a function of w_h and θ_h. Note that a higher w_h demanded by the union results in a lower employment, L_h.

Wage Determination by Union

As mentioned earlier, the wage is proposed by the union in the first stage. We assume the case of a small union that takes the economywide market tightness θ_h as given while proposing a wage w_h. Just as it was assumed earlier that there is a unit mass of firms, assume that there is a unit mass of unions each with $\overline{L}_h$ members and each union deals with a single firm and vice-versa. Following the common practice in the literature, we assume that the union maximizes the surplus (or the rent) of its members. While employed workers get a wage of w_h, unemployed workers get b_h. Recall from the earlier discussion that workers have access to a traditional technology that allows them to produce b_h amount of final good. Implicitly we are assuming that unemployed workers are able to engage in production using this technology. Alternatively, b_h can be viewed as the sum of unemployment benefits and the monetary equivalent of the value of leisure of unemployed workers. Later we will use change in b_h to capture the change in unemployment benefit.

Denote the asset value of an employed worker by E_h and the asset value of an unemployed worker by U_h. These asset values are given in flow terms as follows.

$$\rho E_h = w_h + \lambda_h(U_h - E_h) \tag{9}$$

$$\rho U_h = b_h + \mu_h \theta_h^{\delta_h}(E_h - U_h) \tag{10}$$

The above two imply that

$$\rho E_h = \frac{(\rho + \mu_h \theta_h^{\delta_h})w_h + \lambda_h b_h}{\rho + \lambda_h + \mu_h \theta_h^{\delta_h}} \tag{11}$$

$$\rho U_h = \frac{\mu_h \theta_h^{\delta_h} w_h + (\rho + \lambda_h) b_h}{\rho + \lambda_h + \mu_h \theta_h^{\delta_h \delta}} \tag{12}$$

If the total number of union members is $\overline{L}_h$ and L_h of them become employed, then the expected welfare of a union member is given by

$$\left(\frac{\overline{L}_h - L_h}{\overline{L}_h}\right)\rho U_h + \left(\frac{L_h}{\overline{L}_h}\right)\rho E_h$$

If the firm rejects the union's wage offer then all members get their unemployment income ρU_h. Therefore, the union's objective is to maximize the aggregate surplus or rent of its members given by

$$\left(\left(\frac{\overline{L}_h - L_h}{\overline{L}_h}\right)\rho U_h + \left(\frac{L_h}{\overline{L}_h}\right)\rho E_h - \rho U_h\right)\overline{L}_h = \rho(E_h - U_h)L_h = \frac{\rho(w_h - b_h)L_h}{\rho + \lambda_h + \mu_h \theta_h^{\delta_h}} \tag{13}$$

where the last equality follows from (11) and (12)[12].

The subgame perfect equilibrium where the union chooses wage and the firms decide on employment can be obtained by maximizing (13) subject to (8). It is shown in the appendix that the solution to the above problem yields the following expression for wage.

$$w_h = b_h + \gamma(1-\gamma)AL_h^{\gamma-1} \tag{14}$$

[12] Effectively the union is maximizing the surplus (or rent) of employed members (as in Felbermayr et al.(2008)) since the unemployed members don't earn a rent.

Next, if the total amount of labor available in Home is $\overline{L}_h$, then it must be the case that in equilibrium $\overline{L}_h (1 - u_h) = L_h$. Using the expression for u_h in (3) we get

$$\overline{L}_h \left(\frac{\mu_h \theta_h^{\delta_h}}{\lambda_h + \mu_h \theta_h^{\delta_h}} \right) = L_h \tag{15}$$

Therefore, the key endogenous variables in autarky equilibrium, θ_h, w_h, and L_h are determined by (8), (14), and (15). The existence and uniqueness of autarky equilibrium is established in the appendix.

4 Offshoring Equilibrium for a Small Country

Now assume that the input that goes into producing the final good using sophisticated technology can be imported from abroad at a price of p_f. There are costs associated with making the imported input work in the domestic production process. We can think of it as the cost of adapting the foreign produced input to domestic production process. We assume that to use M units of the foreign produced input in the domestic production process, an amount $\phi h(M) M$ must be imported, where $\phi h(M) > 1$ and $h'(M) > 0$. Therefore, the effective per unit cost of the imported input is $p_f \phi h(M)$. The restriction $h'(M) > 0$ captures in a reduced form sense the fact that some inputs may be harder/costlier to offshore than others as in Grossman and Rossi-Hansberg (2008). In our setting it ensures that the firm faces an upward sloping supply curve for the imported input, and yields an interior solution even though domestic and foreign produced inputs are perfect substitutes in efficiency units. The parameter ϕ captures the general cost of offshoring arising from costs related to communications barriers, legal restrictions, cultural differences, trade barriers etc. and will be useful in comparative statics below. In ensuing discussions we will call ϕ the "*offshoring cost*" and $h(M)$ the "*adaptation cost*". In the small country case p_f is exogenous, but in the two country case discussed later p_f is going to be endogenously determined.

We solve the offshoring equilibrium as follows. The representative firm takes w_h, θ_h, and p_f as given and chooses its employment and extent of offshoring optimally in the second stage. The union chooses the wage in the first stage.

For a given $w_h(s)$, $\theta_h(s)$, and p_f, the firm maximizes the following objective function in the second stage.

$$\underset{V_h(s), L_h(s), M(s)}{Max} \int_t^\infty e^{-\rho(s-t)} \left\{ A(L_h(s) + M(s))^\gamma - w_h(s) L_h(s) - p_f \phi h(M) M(s) - c_h V_h(s) \right\} ds$$

subject to the labor adjustment equation (4). Dropping the time notation s, the current value Hamiltonian in this case is given by

$$H = A(L_h + M)^{\gamma} - w_h L_h - p_f \phi h(M) M - c_h V_h + \psi[\mu_h \theta_h^{\delta_h - 1} V_h - \lambda_h L_h]$$

The first order conditions are

$$M \quad : \quad \gamma A(L_h + M)^{\gamma-1} = p_f \phi(h(M) + h'(M)M) \tag{16}$$

$$V_h \quad : \quad c_h = \psi \mu_h \theta_h^{\delta_h - 1} \tag{17}$$

$$L_h \quad : \quad w_h + \psi \lambda_h = \gamma A(L_h + M)^{\gamma-1} + \dot{\psi} - \rho\psi \tag{18}$$

Again, in steady-state $\dot{\psi} = 0$, and therefore, (17) and (18) imply

$$\gamma A(L_h + M)^{\gamma-1} = w_h + \frac{(\rho + \lambda_h)c_h}{\mu_h \theta_h^{\delta_h - 1}} \tag{19}$$

Next, (16) and (19) imply

$$\begin{aligned} L_h &= 0 \text{ and } M > 0 \text{ if } \gamma A(M)^{\gamma-1} = p_f \phi(h(M) + Mh'(M)) < w_h + \frac{(\rho + \lambda_h)c_h}{\mu_h \theta_h^{\delta_h - 1}} \\ M &= 0 \text{ and } L_h > 0 \text{ if } \gamma A(L_h)^{\gamma-1} = w_h + \frac{(\rho + \lambda_h)c_h}{\mu_h \theta_h^{\delta_h - 1}} < p_f \phi \ h(0) \end{aligned}$$

We assume that parameters are such that we always get an interior solution. In that case, equations (16) and (19) determine L_h and M for given values of w_h, θ_h, and p_f.

4.1 Determination of wage in offshoring equilibrium

As in autarky, the offshoring wage is determined by the union in the first stage. The offshoring wage is obtained by maximizing (13) subject to (16) and (19). It is shown in the appendix that the wage is given by

$$w_h = b_h + \frac{L_h \left((1-\gamma)\gamma A(L_h + M)^{\gamma-2} p_f \phi(2h'(M) + Mh''(M))\right)}{(1-\gamma)\gamma A(L_h + M)^{\gamma-2} + p_f \phi(2h'(M) + Mh''(M))} \tag{20}$$

The 4 equations (16), (19), (20) along with (15) determine the 4 endogenous variables- w_h, θ_h, L_h and $M-$in an offshoring equilibrium. Comparing autarky with the offshoring equilibrium, we derive the following analytical result (proved in the appendix).

Proposition 1 *In the vicinity of autarky equilibrium ($M \approx 0$), the wage and the unemployment rate both are lower in an offshoring equilibrium than in autarky.*

As mentioned in the introduction, the mere possibility of offshoring leads to a reduction in the wage demand by the union which increases the hiring of domestic workers by the firm.

4.2 Comparative Statics with respect to cost of offshoring

A change in ϕ in our model captures the exogenous change in the cost of offshoring. For a linear adaptation cost, $h(M) = d + gM$, we prove the following result in the appendix.[13]

Proposition 2 *In an offshoring equilibrium the wage is monotonically increasing and the extent of offshoring is monotonically decreasing in the cost of offshoring, ϕ. The rate of unemployment is non-monotonic in ϕ. Starting in the vicinity of autarky equilibrium ($M \approx 0$), a decrease in ϕ leads to a decrease in unemployment first but beyond a point unemployment starts increasing as ϕ decreases further.*

The intuition behind the non-monotonicity of unemployment with respect to the offshoring cost can be understood as follows. Upon a decrease in the offshoring cost, unions foresee jobs moving abroad, and therefore, moderate their wage demands. This moderation of wage demand leads to more hiring of domestic workers as long as the offshoring cost is relatively high. That is, firms can do more of both: offshoring and hiring of domestic workers. However, beyond a point the offshoring cost becomes so low that it makes sense to substitute offshored input for domestic workers, leading to an increase in domestic unemployment.

Even though the result above is proved analytically for the linear adaptation cost case, numerical calibrations discussed below using convex and concave functions provide similar results.

4.3 Comparative Statics with respect to labor market policies

As mentioned earlier, a change in b_h is used to capture the impact of changes in unemployment benefits. A change c_h captures the change in recruitment cost. The following results are proved in the appendix.

Proposition 3 *Increases in unemployment benefits or recruitment costs increase the extent of offshoring. They also increase unemployment and wage.*

[13] The analytical proof of non-monotonicity of unemployment is given for $d = 0$ case.

Intuitively, a higher b_h increases the reservation wage of the union which results in higher wage demand and consequently, firms find it profitable to hire less domestic workers and increase offshoring. An increase in the recruitment cost induces firms to post less vacancies and hire less domestic workers which increases unemployment in addition to increasing offshoring. Higher recruitment cost also results in a higher wage. The reason is that the higher the recruitment cost the lower the sensitivity of hiring to wage, and therefore, the union is willing to trade-off higher wage for lower employment.

The results described in the proposition above are also useful in deriving the implications of changes in labor market institutions in Home in the 2 country extension discussed below.

Next, we contrast the impact of offshoring when the wages are determined through collective bargaining with the case when wages are determined by individual bargaining.

5 Offshoring with Individual Wage Bargaining

Assume that instead of the wage being determined by a union, firms enter into individual bargaining with matched workers. It is assumed that the domestic employment as well as the amount of inputs offshored is chosen in the first stage correctly anticipating the wage that will be determined through individual bargaining in the second stage.

The firm maximizes

$$\underset{V(s),L_h(s),M(s)}{Max} \int_t^{\infty} e^{-\rho(s-t)} \left\{ A(L_h(s)+M(s))^{\gamma} - w_h(s)L_h(s) - p_f \phi h(M)M(s) - c_h V(s) \right\} ds$$

subject to (4).

In doing the firm maximization, an issue to consider is whether the wage that is determined in the second stage is taken as given by the firm or whether the firm recognizes the impact its employment choice will have on the wage negotiated later. In particular, a relevant issue is whether if the bargaining breaks down with a worker, is the wage renegotiated with all workers or not. If it is, then the firm takes this into account while choosing employment in the first stage. In this case there is a feedback effect from the marginal product to the wage setting, first pointed out by Stole and Zwiebel (1996), which results in overhiring by the firm because it recognizes that hiring an extra worker will reduce the marginal product of each worker and therefore, reduce the wage the firm will pay to each worker. Dropping the time notation s, the first order condition for employment choice in this case can be written as

$$\gamma A(L_h + M)^{\gamma-1} - L_h \frac{dw_h}{dL_h} = w_h + \frac{(\rho + \lambda_h)c_h}{\mu_h \theta_h^{\delta_h - 1}} \tag{21}$$

The term $\frac{dw_h}{dL_h}$ captures the effect identified by Stole and Zwiebel (1996).

Alternatively, one can think of the wage being bargained by each worker simultaneously with the firm (say a separate representative of the firm) without the possibility of renegotiation. Or, the firm could simply be myopic and ignore the consequences of its first stage employment choice on wage bargaining in the second stage. In this case, the first order condition for employment choice is given by

$$\gamma A(L_h + M)^{\gamma-1} = w_h + \frac{(\rho + \lambda_h)c_h}{\mu_h \theta_h^{\delta_h - 1}} \tag{22}$$

The first order condition for the optimal choice of M is the same as in the union wage case and is given by

$$\gamma A(L_h + M)^{\gamma-1} = p_f \phi(h(M) + Mh'(M)) \tag{23}$$

Denote the bargaining power of workers in Nash bargaining by β_h. It is shown in the appendix that the wage equation when the firm recognizes the effect of employment choice on wage bargaining is given by

$$w_h = (1 - \beta_h)b_h + \beta_h c_h \theta_h + L_h^{-\frac{1}{\beta_h}} \gamma A \int_0^{L_h} (x + M)^{\gamma-1} x^{\frac{1}{\beta_h} - 1} dx \tag{24}$$

To obtain the wage in autarky, simply set $M = 0$.

Note from (24) that

$$L_h \frac{dw_h}{dL_h} = -\frac{1}{\beta_h} L_h^{-\frac{1}{\beta_h}} \gamma A \int_0^{L_h} (x + M)^{\gamma-1} x^{\frac{1}{\beta_h} - 1} dx + \gamma A(L_h + M)^{\gamma-1} \tag{25}$$

Using (25), the first order condition (21) can be written as

$$\frac{1}{\beta_h} L_h^{-\frac{1}{\beta_h}} \gamma A \int_0^{L_h} (x + M)^{\gamma-1} x^{\frac{1}{\beta_h} - 1} dx = w_h + \frac{(\rho + \lambda_h)c_h}{\mu_h \theta_h^{\delta_h - 1}} \tag{26}$$

Equations (23), (24), (26), along with (15) are the 4 key equations determining L_h, M, w_h, and θ_h in the case of individual wage bargaining when the firm recognizes the effect of employment choice on wage bargaining. The value of unemployment is obtained from equation (3).

It is difficult to obtain analytical results on the impact of offshoring in the case above, therefore, we will rely on numerical calibrations. However, in the other case mentioned earlier which obtains when either the firm is myopic or there is no possibility of renegotiation, we can obtain analytical results. It is shown in the appendix that the wage equation in this case is given by

$$w_h = (1-\beta)b_h + \beta_h c_h \theta_h + \beta_h \gamma A (L_h + M)^{\gamma - 1} \tag{27}$$

Therefore, equations (22), (23), (27), along with (15) determine L_h, M, w_h, and θ_h.

The following results on the impact of offshoring under the restriction that the adaptation cost function $h(M)$ is not too concave $(2h'(M) + h''(M) > 0)$ are proved in the appendix.

Proposition 4 *When the wage is determined through individual bargaining, compared to an autarky equilibrium, the wage is always lower and the unemployment is always higher in an offshoring equilibrium. Moreover, in an offshoring equilibrium the wage is monotonically increasing and the rate of unemployment is monotonically decreasing in the cost of offshoring, ϕ.*

In terms of intuition, the key difference in the individual bargaining case comes from the fact that when an individual worker bargains with the firm, all that the worker cares about is his own wage. A decrease in the cost of offshoring does reduce his wage but the worker is not going to accept a deeper wage cut to increase domestic employment. In the case of union wage setting on the other hand, seeing a decrease in the cost of offshoring, the union reduces wage demand to moderate the impact on employment.

6 Numerical Calibrations for the small country case

The country chosen for calibration exercise is Sweden because most of the workers there are covered by collective bargaining agreements. According to Venn (2009), 92% of workers in Sweden were covered by collective bargaining agreement. Most of the parameters chosen for our calibration exercise for Sweden are taken from Albrecht et al. (2006) who conduct a calibration exercise to assess the labor market effects of the Swedish knowledge lift program. Since they work with two different types of workers, low and medium skilled, while we have only one type of worker in the model, we construct an aggregate rate of job destruction and exit rate from unemployment based on their disaggregated numbers. We provide the details of this exercise in the appendix as well as the choice of several parameters. Below we discuss the choice of some crucial parameters.

We obtain an estimate of the exit rate from unemployment, $\mu_h \theta_h^{\delta_h}$, of 1.948 based on the numbers in Albrecht et al. (2006). No independent estimate of θ_h are available so, rather than picking θ_h arbitrarily, we use $\theta_h = .5$ from Hall (2005). The most commonly used estimate of the elasticity of matching function, δ_h, in the literature including that in Albrecht et al. (2006) is 0.5, which is what we use as well. These values of θ_h and δ_h pin down the scale parameter in the matching function, μ_h, at 2.755. Alternative values of θ_h provide different values of the scale parameter but results are qualitatively similar. Ekholm and Hakkala (2008) provide several estimates of the extent of offshoring for Sweden. We use one of their measures called the share of imported input in total intermediate consumption (narrow) the value of which for all industries in 1995 is .072. The word narrow refers to the fact that the input is imported within the industry rather than from other industries and may be a more relevant measure for the kind of offshoring we have in mind where the imported inputs are close substitutes for domestically produced inputs. However, using their alternative measures of offshoring in numerical exercise provides qualitatively similar results. Note that the amount of inputs produced domestically in our model is given simply by L_h. Therefore, the ratio of imported inputs to total intermediate consumption in our model is $\frac{M}{L_h+M}$. Our baseline calibration sets $\frac{M}{L_h+M} = .07$.

We have three remaining parameters: c_h, ϕ, and p_f to determine. Recall that ϕ in our model captures the general cost of offshoring arising from costs related to communications barriers, legal restrictions, cultural differences, trade barriers etc. A commonly used value of the transportation cost alone in calibration exercises is 1.3 (e.g. Felbermayr et al, 2011). Since ϕ includes more than just transportation cost, we choose a slightly higher initial value of ϕ at 1.5. The remaining two parameters c_h and p_f are chosen to match the unemployment rate of .077 for 1995 and $\frac{M}{L_h+M} = .07$. We are going to try 3 alternative specifications of the adaptation cost function $h(M)$: Linear case : $h(M) = 1 + M$; Convex Case: $h(M) = (1 + M)^2$; Concave Case: $h(M) = \sqrt{(1 + M)}$. Depending on the specification of $h(M)$, we obtain different values of c_h and p_f. In our comparative static exercises, for each specification of the adaptation cost function, we hold the values of c_h and p_f constant at their respective baseline values.

Figure 1 shows the results of comparative statics with respect to the offshoring cost parameter ϕ when $h(M) = 1 + M$. The horizontal line in each figure shows the hypothetical autarky value of the variable of interest. Figure 1a shows the non-monotonicity of unemployment with respect to ϕ. The horizontal line drawn from the right axis at .099 shows the hypothetical autarky unemployment for the baseline parameter values (to show the non-monotonicity of unemployment clearly, we have drawn the horizontal line from right axis in Figure 1a). That is, Figure 1a says that if Sweden were a closed economy, then with these parameter values its unemployment rate would be 9.9% instead of it being 7.7%. The highest value of ϕ in this figure is at 1.75. At this value of ϕ, M becomes zero. That is, even though Sweden is notionally open, but the offshoring cost is so high that offshoring becomes zero. The unemployment at this value of ϕ is 7.85%. The difference between the hypothetical autarky unemployment of 9.9% and the unemployment of 7.85% when $\phi = 1.75$ and consequently, $M = 0$, numerically verifies the result described in proposition 1 with respect to unemployment. Figure 1b shows that the wage in Sweden decreases as the offshoring cost decreases. The difference between the horizontal line and the downward sloping line at $\phi = 1.75$ verifies proposition 1 with respect to wage.

Figures 1c and 1d show the impact of offshoring on unemployment and wage in the case of individual bargaining. These figures are drawn using the value of workers bargaining power, β_h, of 0.5. Again the free parameters c_h and p_f are chosen to yield $u_h = .077$ and $\frac{M}{L_h+M} = .07$ when $\phi = 1.5$. The horizontal lines capture the hypothetical autarky values. In both figures 1a and 1c, the value of unemployment in an offshoring equilibrium corresponding to $\phi = 1.5$ is 0.077 by construction. It is easily seen from figures 1c and 1d that a decrease in the offshoring cost leads to an increase in unemployment and a decrease in wage. As well, offshoring unemployment is always higher and the wage is lower than in the case of autarky which verifies proposition 4.

One way to look at the quantitative significance of collective bargaining in determining labor market outcomes is to note from figures 1a and 1c that an increase in the offshoring cost from $\phi = 1.5$ to $\phi = 1.75$ increases unemployment by 0.185 percentage points with collective bargaining, but the same increase in offshoring cost reduces unemployment by 0.5 percentage points in the case of individual bargaining, a difference of 0.7 percentage points.

Figures 2 and 3 repeat the same exercise for convex and concave $h(M)$ functions, respectively. To highlight the non-monotonicity of unemployment with respect to offshoring cost, depending on the specification of $h(M)$, we choose different minimum values of ϕ : 0.5 in figure 2 and 1 in figure 3. As well, in figures 2a and 3a, again the right axis is used to depict the hypothetical autarky value of unemployment. The qualitative results in figures 2 and 3 are similar to those in figure 1. It is worth pointing out that as ϕ decreases, unemployment starts increasing sooner in the concave cost case (figure 3a) than in the convex cost case (figure 2a) with the linear case in figure 1a lying in between. Even though offshoring increases in response to a decrease in ϕ, the reduction in the offshoring cost is partially offset by an increase in the adaptation cost due to $h'(M) > 0$. This latter effect is the strongest in the case of a convex $h(M)$ function and the weakest in the case of a concave $h(M)$ function. Because of this, the range over which firms find it profitable to hire more domestic workers and do more offshoring is larger the more convex the $h(M)$ function.

6.1 Numerical results with CES production function

In the baseline model it was assumed that the input produced by domestic labor and offshored input were perfect substitutes once the latter were adapted. However, our results hold more generally when the substitutability between domestic labor and offshored input is high. We confirm this numerically using the constant elasticity of substitution (CES) production function of the following form.

$$Z = A(L_h^{\frac{\sigma-1}{\sigma}} + M^{\frac{\sigma-1}{\sigma}})^{\frac{\sigma\gamma}{\sigma-1}}; \sigma > 0$$

where σ is the elasticity of substitution between domestic labor and offshored input. To conserve space, the equations for the CES production function case are not reported in the paper but available in an online appendix. The results of the numerical calibrations using the CES production function are shown in figure 4 which assumes a linear adaptation cost: $h(M) = 1 + M$. Figure 4a shows the relationship between unemployment and offshoring cost, ϕ, for $\sigma = 10$, when the wage is determined through collective bargaining. We again obtain a non-monotonic relationship between unemployment and ϕ similar to the one obtained for the perfect substitute case in figure 1a. We have verified that as $\sigma \to \infty$ the results converge to those in figure 1a. One difference between figure 1a and figure 4a is that for $\phi \geq 1.75$, offshoring becomes zero ($M = 0$) in figure 1a and therefore, unemployment becomes delinked from the offshoring cost for $\phi \geq 1.75$. In the imperfect substitute case drawn in figure 4a, offshoring goes to zero only in the limit as $\phi \to \infty$ and therefore, the offshoring unemployment rate keeps increasing and asymptotes a horizontal line as $\phi \to \infty$. Figure 4b is drawn for the case of $\sigma = 4$ where again a non-monotonic relationship obtains between the cost of offshoring and unemployment. Figures 4d and 4e are the analogues of figures 4a and 4b for the individual bargaining case. As was the case in figures 1-3, with individual bargaining, a decrease in the cost of offshoring leads to an increase in unemployment.

It was mentioned earlier that if there is complementarity between the offshored input and domestic labor (as in the model of Grossman and Rossi-Hansberg (2008)), then greater offshoring can lead to lower unemployment even with individual bargaining. In our model the complementarity effect becomes stronger as σ declines. Figure 4c plots the relationship between offshoring and unemployment for $\sigma = 2.5$ for the collective bargaining case[14]. Due to the complementarity, an increase in offshoring (lower ϕ) leads to a decrease in unemployment. And finally, as mentioned in the introduction, figure 4f shows that greater offshoring is associated with reduced unemployment even in the case of individual bargaining when $\sigma = 2.5$.

Therefore, we claim that the result that we derived on the non-monotonic relationship between offshoring and unemployment in the collective bargaining case when domestic labor and offshored input are perfect substitutes holds more generally for high elasticity of substitution between the two inputs.

7 Offshoring in a two country world

Now, we discuss the two country case where the price of the offshored input, p_f, is determined endogenously. Assume that one unit of Foreign labor can produce one unit of the intermediate input. The alternative for Foreign labor is to produce b_f units of the final good using a traditional technology. We also assume that the wage in the production of the intermediate good in Foreign is determined through individual Nash bargaining and not collective bargaining.[15] Since Foreign does not have the sophisticated technology to produce the final good, and there is constant returns to scale in the production of the intermediate good, there is no loss of generality in assuming that Foreign has one worker firms.

With one worker firms, if the price of the intermediate input is p_f, the value of output produced by one unit of labor is p_f. Since firms have to post vacancies and pay workers a wage of w_f, free entry in vacancy creation implies the following.

$$p_f = w_f + \frac{(\rho + \lambda_f)c_f}{\mu_f \theta_f^{\delta_f - 1}} \tag{28}$$

[14] All the parameters used to draw figures 4c and 4f are the same as in figures 1-3, and 4a,4b,4d,4e, except for one: b_h. In the baseline case we used a value of b_h that gave a replacement rate of 67%. It turns out that for this value of b_h, the implied c_h when $\sigma = 2.5$ becomes negative in the collective bargaining case. Therefore, we used a value of b_h such that the replacement rate is 50%.

[15] It is possible for the wages in Foreign also to be determined by collective bargaining. However, to avoid discussing too many cases, we restrict the wage determination in Foreign to individual bargaining.

Assume the bargaining power of workers to be β_f. Following the same steps as in the case of Home, it is shown in the appendix that the wage determined through Nash bargaining in Foreign is

$$w_f = (1-\beta_f)b_f + \beta_f(p_f + c_f\theta_f) \tag{29}$$

The above two equations determine w_f and θ_f for each p_f. It can be verified that (28), which is commonly referred to as the Job Creation (JC) condition in the search literature, implies a downward sloping relationship between w_f and θ_f. (29), referred to as the Wage Bargaining (WB) condition, implies an upward sloping relationship between w_f and θ_f. The intersection of these two relationships determines w_f and θ_f for a given p_f as is shown in Figure 5a. Once we know θ_f we can find out the amount of labor employed in this sector, which also equals the output of the intermediate good produced by Foreign, from the equation below.

$$\overline{L}_f\,(1-u_f) = \overline{L}_f\left(\frac{\mu_f\theta_f^{\delta_f}}{\lambda_f + \mu_f\theta_f^{\delta_f}}\right) = L_f \tag{30}$$

where u_f is the rate of unemployment in Foreign. Therefore, for each p_f we obtain the supply of intermediate input produced in Foreign from the 3 equations (28), (29), and (30) above. An increase in p_f shifts both the JC and the WB curves up in Figure 5a. It can be verified from (28) and (29) that the vertical shift in the JC curve is more than the vertical shift in the WB curve. Therefore, both w_f and θ_f increase. An increase in θ_f, in turn, implies from (30) that the supply of intermediate input from Foreign increases. Therefore, the supply curve for the intermediate input produced in Foreign is upward sloping.

The demand for the intermediate input produced in Foreign comes from Home. The demand curve can be derived from the 4 equations, (15), (16), (19), (20), which give L_h, θ_h, w_h, and M for a given p_f for Home. Recall that in the small open economy case we had shown that $\frac{dM}{d\phi} < 0$. Since ϕ and p_f are isomorphic in the small open economy case, it follows that $\frac{dM}{dp_f} < 0$. When firms in Home use M the amount purchased from Foreign is $\phi h(M)M$ given that some of the Foreign produced input is lost in the adaptation process. Since $h'(M) > 0$, it is easily verified that

$$\frac{d\left(\phi h(M)M\right)}{dp_f} = \phi\left(h(M) + h'(M)M\right)\frac{dM}{dp_f} < 0 \tag{31}$$

The price p_f is determined by the market clearing condition for the input produced in Foreign:

$$L_f = \phi h(M)M \tag{32}$$

Since the demand is downward sloping and the supply is upward sloping, there exists a price p_f that clears the market for the intermediate input produced in Foreign as shown in Figure 5b.

The offshoring equilibrium in a two country world is characterized by the 8 equations (15), (16), (19), (20), (28), (29), (30) and (32), which solve for the 8 endogenous variables of interest: $L_h, M, w_h, \theta_h, L_f, w_f, p_f$, and θ_f.

7.1 Comparative Statics

7.1.1 Decrease in the cost of offshoring

Starting from an offshoring equilibrium, at a given price of the intermediate input, p_f, a decrease in the cost of offshoring increases the amount of offshored input used in Home: $\frac{\partial M}{\partial \phi} < 0$. What happens to the price, p_f, depends on what happens to the amount of input purchased from Foreign, $\phi h(M)M$:

$$\frac{\partial \left(\phi h(M)M\right)}{\partial \phi} = h(M)M + \phi \left(h(M) + h'(M)M\right) \frac{\partial M}{\partial \phi}$$

There are two effects of a decrease in the cost of offshoring. Since offshoring becomes more attractive firms want to use more offshored inputs. However, it also reduces the amount that needs to be purchased for any given amount used in the production process. A sufficient condition for $\frac{\partial(\phi h(M)M)}{\partial \phi} < 0$ is

$$\left| \frac{\phi}{M} \frac{\partial M}{\partial \phi} \right| > \frac{h(M)}{(h(M) + h'(M)M)} \tag{33}$$

We will assume that this condition is satisfied that is the first effect mentioned above dominates. Numerical simulations using the parameters used in Figures 1-3 confirm that $\frac{\partial(\phi h(M)M)}{\partial \phi} < 0$ for the three cases of the adaptation cost. The results are shown in figure 6. When (33) is satisfied, we get the reasonable result that a decrease in the offshoring cost increases the demand for inputs produced in Foreign. That is, the demand curve in Figure 5b shifts to the right. Since nothing happens to the supply curve, there is an increase in the price, p_f. An implication is that Foreign is going to export more intermediate inputs.

An increase in p_f implies from Figure 5a that the wage in Foreign increases and unemployment decreases. The impact on Home labor market depends on two effects: a direct effect of a decrease in ϕ which is same as in the small country case and a feedback effect arising from an increase in p_f. Whether the feedback effect completely offsets or partially offsets the direct effect depends on the parameters and can be answered only in specific cases[16]. Figure 7 provides numerical examples of the relationship between offshoring and unemployment when p_f is endogenous. To construct figure 7 we need to specify parameters for Foreign. To avoid using too many new parameters in the two country case, we continue to use the parameters for Sweden for Home. For Foreign we arbitrarily choose the parameters, some of them same as in Sweden, so that the baseline two country case reproduces the baseline result for Sweden. The parameters for Foreign are listed in the appendix. For all 3 cases of adaptation cost, the results with endogenous p_f in figure 7 are similar to those with exogenous p_f in figures 1a, 2a, and 3a. That is, as is reasonable, the feedback effect from p_f is not strong enough to offset the direct effect of a change in ϕ. We summarize the results in a proposition below.

Proposition 5 *A decrease in the cost of offshoring in a two county world increases offshoring and increases wage and reduces unemployment in Foreign, the source country. The impact on Home, the host country, labor market is qualitatively similar to that in the small country case.*

It is worth re-iterating that the non-monotonicity of Home unemployment in offshoring cost obtains even in a two country setting when the price of the offshored input is endogenously determined.

7.1.2 Changes in Foreign Labor Market Institutions

We study the impact of changes in unemployment benefits or recruitment costs in Foreign on the labor markets in both Home and Foreign. Note that we have described b_f as the amount of final good that a worker can produce using traditional technology. As with b_h discussed earlier, we interpret b_f broadly to include unemployment benefits as well. In that case, an increase in b_f can be thought of as an increase in the unemployment benefit. In all these cases, the impact on Home labor market works through changes in p_f. Therefore, we need to figure out how the supply of intermediate input by Foreign changes in response to changes in its labor market policies.

Let us first discuss the impact of an increase in b_f. An increase in unemployment benefit, b_f, shifts the upward sloping WB curve to the left leaving the downward sloping curve JC curve unaffected in Figure 5a. This leads to a decrease in θ_f and an increase in w_f. A decrease in θ_f implies a decrease in the supply of the intermediate input produced by Foreign. Since the demand from Home is unchanged, there is an increase in the price, p_f. Therefore, the impact of an increase in b_f on Home is similar to

[16] The increase in p_f in Home is similar to the terms of trade loss arising from a tariff reduction in a large country.

that of an increase in ϕ described in proposition 2. That is, unemployment may increase in Home in the presence of collective bargaining.[17] The impact on Foreign consists of a direct effect and a feedback effect arising from an increase in p_f. Since the feedback effect on wage is in the same direction as the direct effect, wage increases unambiguously. For unemployment, the direct effect of an increase in b_f is to increase unemployment, but the feedback arising from an increase in p_f is to reduce unemployment, rendering the net effect theoretically ambiguous. The impact of an increase in β_f, the bargaining power of Foreign workers, is qualitatively similar to the impact of an increase in b_f.

An increase in the recruitment cost, c_f, leads to a leftward shift in both JC and WB curves in Figure 5a. Therefore, θ_f decreases unambiguously. It is verified in the appendix that w_f decreases as well. A decrease in θ_f implies a decrease in the supply of the intermediate input produced by Foreign leading to an increase in p_f. Since p_f increases, the impact on Home is similar to that of an increase in b_f. As far as the impact on Foreign is concerned, the direct effect of an increase in c_f is a decrease in wage and an increase in unemployment, however, the feedback effect arising from an increase in p_f goes in the opposite direction. Therefore, the impact on both wage and unemployment in Foreign is theoretically ambiguous.

We summarize the results below.

Proposition 6 *Increases in unemployment benefits or recruitment costs in Foreign lead to less offshoring by Home. Home wage increases, and Home unemployment is likely to increase in the presence of collective bargaining. Foreign wage increases when the unemployment benefit in Foreign increases, but the impact on Foreign unemployment is ambiguous. The impact of an increase in recruitment cost on Foreign wage and unemployment is theoretically ambiguous.*

Figures 8 and 9 provide numerical examples of the comparative statics with respect to b_f and c_f, respectively. Figure 8 shows that Home unemployment, Home wage, Foreign Unemployment and Foreign wage are all increasing in b_f. That is, an increase in the Foreign unemployment benefit increases Home unemployment by increasing the world price of the offshored input. Figures 8a and 8b are consistent with the results obtained in the small open economy case for a change in offshoring cost. Since Foreign unemployment in figure 8c increases as b_f increases, it means that the direct effect discussed earlier dominates the feedback effect. Figure 9 shows that all 4 variables are increasing in the

[17] In the presence of individual bargaining in Home, however, unemployment decreases unambiguously.

Foreign recruitment cost. Figure 9c suggests that the direct effect dominates for Foreign unemployment, but Figure 9d suggests that the feedback effect dominates for Foreign wage.

7.1.3 Changes in Home Labor Market Institutions

As mentioned in proposition 3 for the small country case, increases in b_h or c_h increase offshoring for a given p_f. That is, increases in b_h or c_h increase the demand for offshored input and therefore, the demand curve in figure 5b shifts to the right. Since the supply curve for Foreign input is unchanged, the price of Foreign input, p_f, increases. The implication for Foreign labor market is an increase in wage and a decrease in unemployment. The impact on Home labor market consists of a direct effect discussed in proposition 3 and a feedback effect coming from an increase in p_f. The impact of an increase in p_f is the same as that of an increase in ϕ discussed in proposition 2. That is, Home wage increases, but Home unemployment changes non-montonically with respect to p_f. The net results is that the wage in Home is definitely going to increase, and Home unemployment is likely to increase as well in the presence of collective bargaining. The results are summarized below.

Proposition 7 *Increases in recruitment costs or unemployment benefits in Home increase offshoring by Home. Foreign wage increases and unemployment decreases. Home wage increases but the impact on Home unemployment is ambiguous.*

Figures 10 and 11 provide numerical examples of the impact of changes in Home unemployment benefits and recruitment costs. Figures 10b, 10c, 10d, 11b, 11c, and 11d simply confirm the unambiguous theoretical results described in proposition 6. The only ambiguous result in proposition 7 is with regard to the Home unemployment. Figures 10a and 11a show that Home unemployment increases as the unemployment benefit or recruitment cost in Home increases. Since with our baseline parameters, an increase in p_f (or ϕ) increases unemployment in the small country case shown in figure 1a, the feedback effect of an increase in b_f or c_f on Home unemployment is in the same direction as the direct effect, and therefore, Home unemployment increases unambiguously.

The results summarized in propositions 6 and 7 show the importance of labor market institutions in a globalized world. Lower unemployment benefits or recruitment costs in host countries give them an advantage in producing offshored inputs and therefore lead to greater offshoring with attendant consequences for the labor markets in source countries. Similarly, higher unemployment benefits or recruitment costs in source countries lead to greater offshoring which improve the labor market outcomes in host countries, but have ambiguous effects on unemployment in source countries.

8 Concluding Remarks

This paper shows the crucial role of labor market institutions in determining the impact of globalization on unemployment and wage. In particular, it shows how the results differ across alternative wage setting institutions such as individual bargaining and collective bargaining. While a model with individual bargaining predicts that offshoring would increase unemployment, we show that it can go down if wages are determined through collective bargaining. The calibration exercise using parameters for Sweden shows that for a large range of parameters a decrease in the cost of offshoring is associated with reduced unemployment. Extending the model to a two country set up allows us to study how labor market institutions in one country have spillover effects on the trading partner. In particular, an increase in the recruitment cost or unemployment benefit in the host country can increase unemployment in both the host and the source country. Increases in the recruitment cost or unemployment benefits in the source country are likely to increase unemployment in the source country, but reduce unemployment in the host country. An implication is that when thinking about labor market policies in open economies, the policymakers have to be mindful of the feedback effects of policies working through forces of globalization. For example, a more generous unemployment benefit in Home not only increases unemployment in Home directly as would be the case in a closed economy, but also leads to increased offshoring. Increased offshoring leads to an increase in the price of imported input, which can lead to further increases in unemployment if wages are determined by collective bargaining. Therefore, the impact of changes in labor market policies may be magnified in a globalized world.

Finally, while we have focused on the competitive threats from offshoring in this paper, similar considerations may be present within a country from its internal geography. For example, the possibility of jobs moving from a high wage region to a low wage region can have similar consequences for unemployment in the two regions as in our two country setting. We focus on offshoring for a couple of reasons: One, the wage differences within a country are usually smaller than across countries; Two, the impact of offshoring on aggregate unemployment for a country is likely to be much larger than from the movement of jobs from one region within a country to another, although in the latter case it could give rise to severe inter-regional differences in unemployment rates.

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9 Appendix

9.1 Calibration Parameters for Sweden

Calculation of job destruction rate and exit rate from unemployment based on Albrecht et al (2006).

Using the data on elapsed unemployment duration (AKU table 49) Albrecht et al fit an exponential distribution and estimate the exit rate out of unemployment for low skilled to be 1.867 and for medium skilled to be 2.163. Total unemployment of these two groups is .077. The fraction γ_1 of the unemployed is low skilled and the fraction γ_2 is medium skilled. p_1 is the fraction of low skilled in the labor force. p_2 is the fraction of medium skilled. δ_1 is the job destruction rate for low skilled job and δ_2 for medium skilled job. ϕ_1 is the fraction of vacancies requiring low skill and ϕ_2 is the fraction requiring medium skill. e_{11} : unskilled employed in unskilled jobs. e_{21} : medium skilled employed in low skilled jobs; e_{22} : medium skilled employed in medium skilled jobs. $m(\theta)$ exit rate for medium skilled. The data are the following.

$$u = .077; p_1 = .648; p_2 = .352; \gamma_1 = .724; \gamma_2 = .276; u_1 = .086; u_2 = .060$$

Exponential distribution for unemployment duration

$$m(\theta)\phi_1 = 1.867; m(\theta)(\phi_1 + \phi_2) = 2.163 = m(\theta)$$

The above implies

$$m(\theta) = 2.163; \phi_1 = .863; \phi_2 = .137$$

Steady state implies the following three conditions for job creation to equal job destruction.

$$\phi_1 m(\theta)\gamma_1 u = \delta_1 e_{11}; \phi_1 m(\theta)\gamma_2 u = \delta_1 e_{21}; \phi_2 m(\theta)\gamma_2 u = \delta_2 e_{22}$$

Now, $e_{11} = p_1 - \gamma_1 u = .592$, therefore, $\delta_1 = .176$. This implies $e_{21} = .225$. Since $e_{11} + e_{21} + e_{22} = 1 - u = .923$, $e_{22} = .106$. This in turn implies $\delta_2 = .059$. That is

$$\delta_1 = .176; \delta_2 = .059; e_{11} = .592; e_{21} = .225; e_{22} = .106$$

We are interested in calculating the average job destruction rate δ and the exit rate $\overline{m}(\theta)$. Summing up the three s-s conditions obtain

$$\begin{aligned}(\phi_1\gamma_1 + \phi_1\gamma_2 + \phi_2\gamma_2)m(\theta)u &= \delta_1 e_{11} + \delta_1 e_{21} + \delta_2 e_{22} \\ (\phi_1 + \phi_2\gamma_2)m(\theta)u &= \delta_1 e_{11} + \delta_1 e_{21} + \delta_2 e_{22}\end{aligned}$$

Therefore, $\overline{m}(\theta) = (\phi_1 + \phi_2\gamma_2)m(\theta)$ is the exit rate from unemployment for the two skill types as a whole, and $\delta = \frac{\delta_1 e_{11} + \delta_1 e_{21} + \delta_2 e_{22}}{1-u=e_{11}+e_{21}+e_{22}}$ is the job destruction rate for the groups combined.

$$\overline{m}(\theta) = (\phi_1 + \phi_2\gamma_2)m(\theta) = (.863 + .137 * .276)\, 2.163 = 1.948; \delta = .1625$$

These are the two key numbers that we are going to use in our calibration. In our notation δ corresponds to λ_h and $\overline{m}(\theta)$ corresponds to $\mu_h \theta_h^{\delta_h}$.

Table 1: Calibration Parameter Values for Sweden

Parameter	Description	Value	Source
ρ	Annual rate of discount	.05	Albrecht et al.(2006)
δ_h	Elasticity of matching function	.5	Albrecht et al.(2006)
λ_h	Annual job destruction rate .	.165	based on Albrecht et al (2006)
b_h	Unemployment benefit (replacement rate)	$.67w_h$	OECD (1999)[a]
γ	Production Function parameter	.66	OECD (1999)[b]
$\mu_h \theta_h^{\delta_h}$	Exit Rate from Unemployment	1.948	based on Albrecht et al (2006)
θ_h	Market tightness	0.5	Hall (2005)
μ_h	Scale parameter in the matching function	2.755	Obtained from $\mu_h \theta_h^{\delta_h}$ and θ_h
ϕ	Offshoring cost	1.5	Arbitrary
A	Aggregate productivity parameter	1	Normalization
$\overline{L}_h$	Size of Labor Force	1	Normalization
c_h	Recruitment cost	free	to match $u_h = .077$ and $\frac{M}{L_h+M} = .07$
p_f	Price of offshored input	free	to match $u_h = .077$ and $\frac{M}{L_h+M} = .07$
β_h	Bargaining power of workers	0.5	Felbermayr et al. (2011)

a : corresponds to a 67% replacement rate in Sweden in 1994-95.

b : estimates for Sweden range from .6 (OECD (1999) to .72 (Bentolila and St. Paul (2003). We chose the average of these two which also corresponds to the commonly used share of labor for many OECD countries.

9.1.1 Parameters for Foreign in the two country case

Parameter values for Foreign in the two country case: $\overline{L}_f = 1$, $\beta_f = .5, b_f = .2; \delta_f = \delta_h = .5; \rho = .05; \lambda_f = \lambda_h = .165, \theta_f = .18..$ μ_f and c_f are the free parameters that are chosen to be consistent with the baseline values of p_f and F obtained for Sweden with $\phi = 1.5$ and $h(M) = 1 + M$. That is, we use the baseline value of parameters underlying figure 1 for Sweden and choose μ_f and c_f for Foreign consistent with the implied values of p_f and F, the two variables that are relevant for Foreign. One downside of this approach is that since $F = .07$ in the baseline case for Sweden, Foreign employment in the input production is very small given the normalization $\overline{L}_f = 1$. The rest produce the final good using home production technology and show up as unemployed in our figures. Therefore, the absolute value of the unemployment rate for Foreign is not going to be realistic. Only the direction of change in the unemployment for Foreign is informative.

9.2 Wage Determination in Autarky

The optimal choice of wage by the union can be found as follows. The union maximizes $\frac{\rho(w_h-b_h)L_h}{\rho+\lambda_h+\mu_h\theta_h^{\delta_h}}$ in the first stage, anticipating firms to choose employment given by the condition (8) in the text. The problem is equivalent to maximizing the the following Lagrangian by choosing w_h and L_h.

$$\Upsilon = \left(\frac{\rho(w_h - b_h)L_h}{\rho + \lambda_h + \mu_h\theta_h^{\delta_h}}\right) + \xi[\gamma A L_h^{\gamma-1} - w_h - \frac{(\rho+\lambda)c_h}{\mu_h\theta_h^{\delta_h-1}}] \tag{34}$$

The first order conditions are

$$w_h \quad : \quad \left(\frac{\rho L_h}{\rho + \lambda_h + \mu_h\theta_h^{\delta_h}}\right) = \xi \tag{35}$$

$$L_h \quad : \quad \left(\frac{\rho(w_h - b_h)}{\rho + \lambda_h + \mu_h\theta_h^{\delta_h}}\right) = \xi(1-\gamma)\gamma A L_h^{\gamma-2} \tag{36}$$

Solve the above two to get

$$w_h = b_h + (1-\gamma)\gamma A L_h^{\gamma-1} \tag{37}$$

9.3 Existence and Uniqueness of Autarky Equilibrium

Using (15) to substitute out L_h in (8) and (14) obtain

$$\gamma A\left(\overline{L}_h\left(\frac{\mu_h\theta_h^{\delta_h}}{\lambda_h + \mu_h\theta_h^{\delta_h}}\right)\right)^{\gamma-1} = w_h + \frac{(\rho+\lambda_h)c_h}{\mu_h\theta_h^{\delta_h-1}} \tag{38}$$

$$w_h = b_h + \gamma(1-\gamma)A\left(\overline{L}_h\left(\frac{\mu_h\theta_h^{\delta_h}}{\lambda_h + \mu_h\theta_h^{\delta_h}}\right)\right)^{\gamma-1} \tag{39}$$

From (38) and (39) obtain the following equation determining the autarky equilibrium value of θ_h.

$$\gamma^2 A\left(\overline{L}_h\left(\frac{\mu_h\theta_h^{\delta_h}}{\lambda_h+\mu_h\theta_h^{\delta_h}}\right)\right)^{\gamma-1}=b_h+\frac{(\rho+\lambda_h)c_h}{\mu_h\theta_h^{\delta_h-1}} \tag{40}$$

It is easy to verify that the r.h.s of (40) is increasing in θ_h and has a vertical intercept at b_h. The l.h.s of (40) is decreasing in θ_h, asymptotes the vertical axis as $\theta_h\to 0$ while asymptotes $\frac{\gamma^2 A}{\overline{L}_h^{1-\gamma}}$ as $\theta\to\infty$. Therefore, there exists a unique θ_h that solves equation (40). It follows from (38) that there is a unique value of w_h in autarky.

9.4 Derivation of wage in the offshoring case

The Lagrangian is given by

$$\Upsilon=\left(\frac{\rho(w_h-b_h)L_h}{\rho+\lambda_h+\mu_h\theta_h^{\delta_h}}\right)+\psi[\gamma A(L_h+M)^{\gamma-1}-w_h-\frac{(\rho+\lambda_h)c_h}{\mu_h\theta_h^{\delta_h-1}}]+\varphi\left[p_f\phi(h(M)+Mh'(M))-w_h-\frac{(\rho+\lambda_h)c_h}{\mu_h\theta_h^{\delta_h-1}}\right] \tag{41}$$

The first order conditions with respect to w_h, L_h, and M are given by

$$w_h \;:\; \left(\frac{\rho L_h}{\rho+\lambda_h+\mu_h\theta_h^{\delta_h}}\right)=\psi+\varphi \tag{42}$$

$$L_h \;:\; \frac{\rho(w_h-b_h)}{\rho+\lambda_h+\mu_h\theta_h^{\delta_h}}=\psi(1-\gamma)\gamma A(L_h+M)^{\gamma-2} \tag{43}$$

$$M \;:\; \psi(1-\gamma)\gamma A(L_h+M)^{\gamma-2}=\varphi p_f\phi(2h'(M)+Mh''(M)) \tag{44}$$

Next, eliminate ψ and φ from the above 3 equations to get

$$w_h=b_h+\frac{L_h\left((1-\gamma)\gamma A(L_h+M)^{\gamma-2}p_f\phi(2h'(M)+Mh''(M))\right)}{(1-\gamma)\gamma A(L_h+M)^{\gamma-2}+p_f\phi(2h'(M)+Mh''(M))} \tag{45}$$

9.5 Proof of Proposition 1

The proof below uses the result that there exists a high level of offshoring cost, ϕ, at which the optimal amount of offshoring becomes zero ($M=0$). The value of this ϕ can be easily obtained using the three equations (16), (19) and (45) determining θ_h, M, and w_h in an offshoring equilibrium and setting $M=0$.

Note from the expression for wage in an offshoring equilibrium given in (45) that at $M=0$, the offshoring equilibrium wage is given by

$$w_h=b_h+\gamma(1-\gamma)AL_h^{\gamma-1}\frac{2p_f\phi h'(0)}{(1-\gamma)\gamma AL_h^{\gamma-2}+2p_f\phi h'(0)} \tag{46}$$

The equation (19) becomes

$$\gamma A L_h^{\gamma-1} = w_h + \frac{(\rho+\lambda)c_h}{\mu_h \theta_h^{\delta_h - 1}} \tag{47}$$

at $M = 0$. Next, using $L_h = \overline{L}_h \left(\frac{\mu_h \theta_h^{\delta_h}}{\lambda_h + \mu_h \theta_h^{\delta_h}}\right)$ and eliminating w_h from (46) and (47) obtain

$$\gamma A \left(\overline{L}_h \frac{\mu_h \theta_h^{\delta_h}}{\lambda_h + \mu_h \theta_h^{\delta_h}}\right)^{\gamma-1} \left[1 - \frac{(1-\gamma)2p_f \phi h'(0)}{(1-\gamma)\gamma A \left(\overline{L}_h \frac{\mu_h \theta_h^{\delta_h}}{\lambda_h + \mu_h \theta_h^{\delta_h}}\right)^{\gamma-2} + 2p_f \phi h'(0)}\right] = b_h + \frac{(\rho+\lambda)c_h}{\mu_h \theta_h^{\delta_h - 1}} \tag{48}$$

Re-write the above as

$$\gamma^2 A \left(\overline{L}_h \frac{\mu_h \theta_h^{\delta_h}}{\lambda_h + \mu_h \theta_h^{\delta_h}}\right)^{\gamma-1} + \frac{(\gamma(1-\gamma)A)^2 \left(\overline{L}_h \frac{\mu_h \theta_h^{\delta_h}}{\lambda_h + \mu_h \theta_h^{\delta_h}}\right)^{\gamma-3}}{(1-\gamma)\gamma A \left(\overline{L}_h \frac{\mu_h \theta_h^{\delta_h}}{\lambda_h + \mu_h \theta_h^{\delta_h}}\right)^{\gamma-2} + 2p_f \phi h'(0))}) = b_h + \frac{(\rho+\lambda)c_h}{\mu_h \theta_h^{\delta_h - 1}} \tag{49}$$

The expression above is the equation giving the offshoring equilibrium value of θ_h for $M = 0$. Compare the above to the equation giving the autarky equilibrium value of θ_h given in (40). Note that the r.h.s of of (49) is same as the r.h.s of (40). However, the l.h.s of (49) has an extra term compared to the l.h.s of (40). It is easy to verify that for each θ, the l.h.s of (49) is greater than the l.h.s of (40). Therefore, the θ_h that solves (49) is larger than the θ_h that solves (40). It can be verified from (47) which is valid both in autarky and in an offshoring equilibrium with $M = 0$, that a higher θ_h must imply a lower w_h as well. *Q.E.D.*

9.6 Proof of Proposition 2

9.6.1 Proof of $\frac{dw_h}{d\phi} > 0$

For $h(M) = d+gM$, the three equations, (16), (19) and (45), determining the 3 endogenous variables:θ_h, M, w_h can be written as follows.

$$\gamma A(L_h + M)^{\gamma-1} = w_h + \frac{(\rho+\lambda_h)c_h}{\mu_h \theta_h^{\delta_h - 1}} \tag{50}$$

$$p_f \phi(d + 2gM) = w_h + \frac{(\rho+\lambda_h)c_h}{\mu_h \theta_h^{\delta_h - 1}} \tag{51}$$

$$w_h = b_h + \frac{2p_f \phi g \gamma(1-\gamma) A L_h (L_h + M)^{\gamma-2}}{(1-\gamma)\gamma A(L_h + M)^{\gamma-2} + 2p_f \phi g} \tag{52}$$

Note that $L_h = \overline{L}_h \frac{\mu_h \theta_h^{\delta_h}}{\lambda_h + \mu_h \theta_h^{\delta_h}}$ in the above expressions. Note that setting $M = 0$ in the above three equations gives the value of ϕ that makes offshoring zero.

To reduce notational clutter define

Definition 1 $w_h' \equiv w_h + \frac{(\rho+\lambda_h)c_h}{\mu_h \theta_h^{\delta_h - 1}}$.

Note from (51) that

$$M = \frac{1}{2g}\left(\frac{w_h'}{p_f \phi} - d\right) \tag{53}$$

Recall that we are discussing the case of interior equilibrium where $L_h > 0, M > 0$, that is $\phi < \frac{w_h'}{p_f d}$ in the expression above.

Taking the total derivative of (53) with respect to ϕ obtain

$$\frac{dM}{d\phi} = -\frac{w_h'}{2p_f\phi^2 g} + \frac{1}{2p_f\phi g}\left(\frac{dw_h}{d\phi} + \frac{(1-\delta_h)(\rho+\lambda_h)c_h}{\mu_h\theta_h^{\delta_h}}\frac{d\theta_h}{d\phi}\right) \tag{54}$$

Next, from (50) and (53) obtain

$$L_h = \left(\frac{w_h'}{\gamma A}\right)^{\frac{1}{\gamma-1}} - \frac{1}{2g}\left(\frac{w_h'}{p_f\phi} - d\right) \tag{55}$$

Taking the total derivative of (55) with respect to ϕ obtain

$$\frac{dL_h}{d\phi} = -\left(\frac{1}{(1-\gamma)\gamma A}\left(\frac{w_h'}{\gamma A}\right)^{\frac{1}{\gamma-1}-1} + \frac{1}{2p_f\phi g}\right)\left(\frac{dw_h}{d\phi} + \frac{(1-\delta_h)(\rho+\lambda_h)c_h}{\mu_h\theta_h^{\delta_h}}\frac{d\theta_h}{d\phi}\right) + \frac{1}{2g}\left(\frac{w_h'}{p_f\phi^2}\right) \tag{56}$$

Since $L_h = \overline{L}_h \frac{\mu_h \theta_h^{\delta_h}}{\lambda_h + \mu_h \theta_h^{\delta_h}}$ in equilibrium, the above can be re-written as

$$(C3 + C1C4)\frac{d\theta_h}{d\phi} = -C1\frac{dw_h}{d\phi} + C2 \tag{57}$$

where we use the following new notations for reducing clutter.

Definition 2

$$\begin{aligned} C1 &\equiv \left(\frac{1}{(1-\gamma)\gamma A}\left(\frac{w_h'}{\gamma A}\right)^{\frac{1}{\gamma-1}-1} + \frac{1}{2p_f\phi g}\right); C2 \equiv \frac{1}{2g}\left(\frac{w_h'}{p_f\phi^2}\right) \\ C3 &\equiv \overline{L}_h\frac{\lambda_h\mu_h\delta\theta_h^{\delta_h-1}}{\left(\lambda_h+\mu_h\theta_h^{\delta_h}\right)^2}; C4 \equiv \frac{(1-\delta_h)(\rho+\lambda_h)c_h}{\mu_h\theta_h^{\delta_h}} \end{aligned}$$

Next, using (50) and (55), re-write (52) as

$$w_h = b_h + \gamma(1-\gamma)A \frac{2p_f\phi g\left(\frac{w_h'}{\gamma A}\right) + p_f\phi d\left(\frac{w_h'}{\gamma A}\right)^{\frac{\gamma-2}{\gamma-1}} - \gamma A\left(\frac{w_h'}{\gamma A}\right)^{\frac{\gamma-2}{\gamma-1}+1}}{(1-\gamma)\gamma A\left(\frac{w_h'}{\gamma A}\right)^{\frac{\gamma-2}{\gamma-1}} + 2p_f\phi g} \tag{58}$$

Taking the total derivative of (58) we get

$$\frac{dw_h}{d\phi} = \gamma(1-\gamma)A(B1+B2) + \gamma(1-\gamma)A\left(\frac{dw_h}{d\phi} + C4\frac{d\theta_h}{d\phi}\right)(A1+A2+A3+A4) \tag{59}$$

where we use the following compact notation

Definition 3

$$B1 \equiv \frac{(2p_f g)\left(\frac{w_h'}{\gamma A}\right) + p_f d\left(\frac{w_h'}{\gamma A}\right)^{\frac{\gamma-2}{\gamma-1}}}{(1-\gamma)\gamma A\left(\frac{w_h'}{\gamma A}\right)^{\frac{\gamma-2}{\gamma-1}} + 2p_f\phi g}; B2 \equiv -2p_f g\frac{2p_f\phi g\left(\frac{w_h'}{\gamma A}\right) + p_f\phi d\left(\frac{w_h'}{\gamma A}\right)^{\frac{\gamma-2}{\gamma-1}} - \gamma A\left(\frac{w_h'}{\gamma A}\right)^{\frac{\gamma-2}{\gamma-1}+1}}{\left((1-\gamma)\gamma A\left(\frac{w_h'}{\gamma A}\right)^{\frac{\gamma-2}{\gamma-1}} + 2p_f\phi g\right)^2};$$

$$A1 \equiv \frac{\frac{(2p_f\phi g)}{\gamma A}}{(1-\gamma)\gamma A\left(\frac{w_h'}{\gamma A}\right)^{\frac{\gamma-2}{\gamma-1}} + 2p_f\phi g}; A2 \equiv \frac{\frac{\gamma-2}{(\gamma-1)\gamma A}p_f\phi d\left(\frac{w_h'}{\gamma A}\right)^{\frac{\gamma-2}{\gamma-1}-1}}{(1-\gamma)\gamma A\left(\frac{w_h'}{\gamma A}\right)^{\frac{\gamma-2}{\gamma-1}} + 2p_f\phi g};$$

$$A3 \equiv \frac{-\left(\frac{\gamma-2}{\gamma-1}+1\right)\left(\frac{w_h'}{\gamma A}\right)^{\frac{\gamma-2}{\gamma-1}}}{(1-\gamma)\gamma A\left(\frac{w_h'}{\gamma A}\right)^{\frac{\gamma-2}{\gamma-1}} + 2p_f\phi g}$$

$$A4 \equiv -\frac{\left[2p_f\phi g\left(\frac{w_h'}{\gamma A}\right) + p_f\phi d\left(\frac{w_h'}{\gamma A}\right)^{\frac{\gamma-2}{\gamma-1}} - \gamma A\left(\frac{w_h'}{\gamma A}\right)^{\frac{\gamma-2}{\gamma-1}+1}\right](2-\gamma)\left(\frac{w_h'}{\gamma A}\right)^{\frac{\gamma-2}{\gamma-1}-1}}{\left((1-\gamma)\gamma A\left(\frac{w_h'}{\gamma A}\right)^{\frac{\gamma-2}{\gamma-1}} + 2p_f\phi g\right)^2}$$

After substituting out $\frac{d\theta_h}{d\phi}$ using (57) in (59) and re-arranging we get

$$\frac{dw_h}{d\phi} = \frac{\gamma(1-\gamma)A(B1+B2) + \gamma(1-\gamma)A(A1+A2+A3+A4)\frac{C2C4}{(C3+C1C4)}}{\left(1-\gamma(1-\gamma)A(A1+A2+A3+A4)\frac{C3}{(C3+C1C4)}\right)} \tag{60}$$

To prove that $\frac{dw_h}{d\phi} > 0$, we need to verify that the denominator of the r.h.s above is positive. From the definitions of Ai above obtain

$$A1{+}A2{+}A3{+}A4 = \frac{2p_f\phi g\frac{2-\gamma}{(1-\gamma)}\left(\frac{w_h'}{\gamma A}\right)^{\frac{\gamma-2}{\gamma-1}-1}\left[\frac{p_f\phi d}{\gamma A} - \frac{w_h'}{\gamma A}\right] + \frac{(2p_f\phi g)^2}{\gamma A} - (1-\gamma)\gamma A\left(\frac{w_h'}{\gamma A}\right)^{\frac{2(\gamma-2)}{\gamma-1}} - 4p_f\phi g\left(\frac{w_h'}{\gamma A}\right)^{\frac{\gamma-2}{\gamma-1}}}{\left((1-\gamma)\gamma A\left(\frac{w_h'}{\gamma A}\right)^{\frac{\gamma-2}{\gamma-1}} + 2p_f\phi g\right)^2} \tag{61}$$

Therefore,

$$1-\gamma(1-\gamma)A\left(A1+A2+A3+A4\right)=\frac{\left[\begin{array}{c}2p_f\phi g(2-\gamma)\left(\frac{w_h'}{\gamma A}\right)^{\frac{\gamma-2}{\gamma-1}-1}\left[w_h'-p_f\phi d\right]+4\gamma(p_f\phi g)^2+\\ 2\left(\gamma(1-\gamma)A\right)^2\left(\frac{w_h'}{\gamma A}\right)^{\frac{2(\gamma-2)}{\gamma-1}}+8(1-\gamma)\gamma Ap_f\phi g\left(\frac{w_h'}{\gamma A}\right)^{\frac{\gamma-2}{\gamma-1}}\end{array}\right]}{\left((1-\gamma)\gamma A\left(\frac{w_h'}{\gamma A}\right)^{\frac{\gamma-2}{\gamma-1}}+2p_f\phi g\right)^2}>0 \tag{62}$$

Note from (53) that $M\geq 0$ implies $w_h'-p_f\phi d\geq 0$, and hence the expression above is positive. Since $\frac{C3}{(C3+C1C4)}<1$, $1-\gamma(1-\gamma)A\left(A1+A2+A3+A4\right)>0$ implies $1-\gamma(1-\gamma)A(A1+A2+A3+A4)\frac{C3}{(C3+C1C4)}>0$. Therefore, $\frac{dw_h}{d\phi}>0$. $Q.E.D.$

9.6.2 Proof of $\frac{dM}{d\phi}<0$

Using the compact notation re-write (54) as

$$\frac{dM}{d\phi}=-C2+\frac{1}{2p_f\phi g}\left(\frac{dw_h}{d\phi}+C4\frac{d\theta_h}{d\phi}\right) \tag{63}$$

Now, substitute out $\frac{d\theta_h}{d\phi}$ using (57) and simplify to obtain

$$\frac{dM}{d\phi}=\frac{1}{2p_f\phi g}\frac{C3}{C3+C1C4}\frac{dw_h}{d\phi}+\frac{1}{2p_f\phi g}\left(\frac{C4C2}{C3+C1C4}\right)-C2 \tag{64}$$

Next, substitute out $\frac{dw_h}{d\phi}$ in the above expression using (60) to obtain

$$\frac{dM}{d\phi}=\frac{\left[\begin{array}{c}\gamma(1-\gamma)A(B1+B2)C3+C4C2-\\ 2p_f\phi gC2\left(C3+C1C4\right)\left(1-\gamma(1-\gamma)A(A1+A2+A3+A4)\frac{C3}{(C3+C1C4)}\right)\end{array}\right]}{2p_f\phi g\left(C3+C1C4\right)\left(1-\gamma(1-\gamma)A(A1+A2+A3+A4)\frac{C3}{(C3+C1C4)}\right)} \tag{65}$$

It was shown earlier that $1-\gamma(1-\gamma)A(A1+A2+A3+A4)\frac{C3}{(C3+C1C4)}>0$. Therefore, the sign of $\frac{dM}{d\phi}$ depends on the sign of the numerator of (65) which we next verify is negative. The numerator of (65) is negative if the following inequality holds.

$$\left[C3(1-\gamma(1-\gamma)A(A1+A2+A3+A4))+C1C4\right]>\frac{\gamma(1-\gamma)A(B1+B2)\frac{C3}{C2}+C4}{2p_f\phi g} \tag{66}$$

Note from the definition of $C1$ that since $C1>\frac{1}{2p_f\phi g}$, therefore, $C1C4>\frac{C4}{2p_f\phi g}$. Therefore, for the inequality (66) to be true it is sufficient to show that

$$(1-\gamma(1-\gamma)A(A1+A2+A3+A4))>\frac{\gamma(1-\gamma)A(B1+B2)}{2p_f\phi gC2} \tag{67}$$

Note from the definition of $B1$, $B2$, and $C2$ that

$$\frac{\gamma(1-\gamma)A(B1+B2)}{2p_f\phi g C2} = \left(\frac{(2-\gamma)\gamma A(1-\gamma)2p_f\phi g\left(\frac{w_h'}{\gamma A}\right)^{\frac{\gamma-2}{\gamma-1}} + \gamma A(1-\gamma)^2 p_f\phi d\left(\frac{w_h'}{\gamma A}\right)^{\frac{2(\gamma-2)}{\gamma-1}-1}}{\left((1-\gamma)\gamma A\left(\frac{w_h'}{\gamma A}\right)^{\frac{\gamma-2}{\gamma-1}} + 2p_f\phi g\right)^2} \right) \tag{68}$$

The expression for $(1-\gamma(1-\gamma)A(A1+A2+A3+A4))$ is given in (62). Verify that the expression in (62) is greater than the expression in (68) because

$$((1-\gamma)\gamma A)^2\left(\frac{w_h'}{\gamma A}\right)^{\frac{2(\gamma-2)}{\gamma-1}} > \gamma A(1-\gamma)^2 p_f\phi d\left(\frac{w_h'}{\gamma A}\right)^{\frac{2(\gamma-2)}{\gamma-1}-1} \tag{69}$$

$$8(1-\gamma)\gamma A p_f\phi g\left(\frac{w_h'}{\gamma A}\right)^{\frac{\gamma-2}{\gamma-1}} > (2-\gamma)\gamma A(1-\gamma)2p_f\phi g\left(\frac{w_h'}{\gamma A}\right)^{\frac{\gamma-2}{\gamma-1}} \tag{70}$$

where the first inequality above follows from $w_h' > p_f\phi d$. Therefore, we have proved that $\frac{dM}{d\phi} < 0$. *Q.E.D.*

9.6.3 Proof of non-monotonicity of unemployment in ϕ

Note from (57) that

$$(C3 + C1C4)\frac{d\theta_h}{d\phi} = -C1\frac{dw_h}{d\phi} + C2$$

Since we have already established $\frac{dw_h}{d\phi} > 0$, we get the result that $\frac{d\theta_h}{d\phi} < 0$ if $\frac{dw_h}{d\phi} > \frac{C2}{C1}$ and $\frac{d\theta_h}{d\phi} > 0$ if $\frac{dw_h}{d\phi} < \frac{C2}{C1}$. Therefore, the sign of $\frac{d\theta_h}{d\phi}$ is same as the sign of $-C1\frac{dw_h}{d\phi} + C2$. Using (60) obtain

$$-C1\frac{dw_h}{d\phi} + C2 = -\frac{\gamma(1-\gamma)A(B1+B2)C1 + \gamma(1-\gamma)A(A1+A2+A3+A4)\frac{C1C2C4}{(C3+C1C4)}}{\left(1-\gamma(1-\gamma)A(A1+A2+A3+A4)\frac{C3}{(C3+C1C4)}\right)} + C2$$

Since $C2 > 0$, the above implies the following

$$\frac{d\theta_h}{d\phi} > 0 \text{ if } \gamma(1-\gamma)A(B1+B2)\frac{C1}{C2} + \gamma(1-\gamma)A(A1+A2+A3+A4) < 1$$

$$\frac{d\theta_h}{d\phi} < 0 \text{ if } \gamma(1-\gamma)A(B1+B2)\frac{C1}{C2} + \gamma(1-\gamma)A(A1+A2+A3+A4) > 1$$

For the case of $d = 0$ where we get an interior solution even for arbitrarily large ϕ, using the expressions for Ai, Bi, and Ci defined earlier obtain the following result.

$$\begin{aligned}\frac{d\theta_h}{d\phi} &> 0 \text{ if } (4p_f\phi g)(1-\gamma) < \left(\frac{w_h'}{\gamma A}\right)^{\frac{2(\gamma-2)}{\gamma-1}} \frac{(\gamma(1-\gamma)A)^2}{p_f\phi g} + \left(4-2\gamma-\gamma^2\right)\gamma A\left(\frac{w_h'}{\gamma A}\right)^{\frac{\gamma-2}{\gamma-1}} \\ \frac{d\theta_h}{d\phi} &< 0 \text{ if } (4p_f\phi g)(1-\gamma) > \left(\frac{w_h'}{\gamma A}\right)^{\frac{2(\gamma-2)}{\gamma-1}} \frac{(\gamma(1-\gamma)A)^2}{p_f\phi g} + \left(4-2\gamma-\gamma^2\right)\gamma A\left(\frac{w_h'}{\gamma A}\right)^{\frac{\gamma-2}{\gamma-1}}\end{aligned}$$

Note from above that as $\phi \to 0$, $\frac{d\theta_h}{d\phi} > 0$ and as $\phi \to \infty$, $\frac{d\theta_h}{d\phi} < 0$ since w_h' is bounded below at b_h and above at the autarky value. Using a continuity argument we claim that the results hold even for small positive values of d as is verified numerically.

9.7 Proof of Proposition 3

9.7.1 Change in b_h

Taking the total derivatives of (53), (55) and (58) with respect to b_h obtain

$$\frac{dM}{db_h} = \frac{1}{2gp_f\phi}\left(\frac{dw_h}{db_h} + C4\frac{d\theta_h}{db_h}\right) \tag{71}$$

$$(C3 + C1C4)\frac{d\theta_h}{db_h} = -C1\frac{dw_h}{db_h} \tag{72}$$

$$\frac{dw_h}{db_h} = 1 + \gamma(1-\gamma)A\left(\frac{dw_h}{db_h} + C4\frac{d\theta_h}{db_h}\right)(A1 + A2 + A3 + A4) \tag{73}$$

It is easily verified that the above three imply

$$\frac{dw_h}{db_h} = \frac{1}{1 - \gamma(1-\gamma)A(A1 + A2 + A3 + A4)\left(\frac{C3}{(C3+C1C4)}\right)} > 0 \tag{74}$$

$$\frac{d\theta_h}{db_h} = -\frac{C1}{C3(1 - \gamma(1-\gamma)A(A1 + A2 + A3 + A4)) + C1C4} < 0 \tag{75}$$

$$\frac{dM}{db_h} = \frac{1}{2p_f\phi g}\frac{C3}{(C3 + C1C4)}\frac{dw_h}{db_h} > 0 \tag{76}$$

where the inequality follows from (74).

9.7.2 Change in c_h

Taking the total derivatives of (53), (55) and (58) with respect to c_h obtain

$$\frac{dM}{dc_h} = \frac{1}{2p_f\phi g}\left(\frac{dw_h}{dc_h} + C4\frac{d\theta_h}{dc_h} + \frac{(\rho+\lambda_h)}{\mu_h\theta_h^{\delta_h-1}}\right) \tag{77}$$

$$(C3+C1C4)\frac{d\theta_h}{dc_h} = -C1\frac{dw_h}{dc_h} - C1\frac{(\rho+\lambda_h)}{\mu_h\theta_h^{\delta_h-1}} \tag{78}$$

$$\frac{dw_h}{dc_h} = \gamma(1-\gamma)A(A1+A2+A3+A4)\left(\frac{(\rho+\lambda_h)}{\mu_h\theta_h^{\delta_h-1}} + \frac{dw_h}{dc_h} + C4\frac{d\theta_h}{dc_h}\right) \tag{79}$$

It is easily verified that the above three imply

$$\frac{dw_h}{dc_h} = \frac{\gamma(1-\gamma)A(A1+A2+A3+A4)\frac{C3}{C3+C1C4}\frac{(\rho+\lambda_h)}{\mu_h\theta_h^{\delta_h-1}}}{1-\gamma(1-\gamma)A(A1+A2+A3+A4)\frac{C3}{C3+C1C4}} > 0 \tag{80}$$

$$\frac{d\theta_h}{dc_h} = -\frac{C1}{(C3+C1C4)}\left(\frac{dw_h}{dc_h} + \frac{(\rho+\lambda_h)}{\mu_h\theta_h^{\delta_h-1}}\right) < 0 \tag{81}$$

$$\frac{dM}{dc_h} = \frac{1}{2p_f\phi g}\frac{C3}{(C3+C1C4)}\left(\frac{dw_h}{dc_h} + \frac{(\rho+\lambda_h)}{\mu_h\theta_h^{\delta_h-1}}\right) > 0 \tag{82}$$

9.8 Derivation of wage in the Individual Bargaining case

The wage is determined through Nash bargaining and is obtained by the following.

$$\arg\max_{w_h}(E_h-U_h)^{\beta_h}\left(\frac{\gamma A(L_h+M)^{\gamma-1} - w_h - L_h\frac{dw_h}{dL_h}}{\rho+\lambda_h}\right)^{1-\beta_h} \tag{83}$$

In the above $E_h - U_h$ is the surplus of a worker from employment where the expressions for E_h and U_h are given in the text in equations (9) and (10), respectively. $\frac{\gamma A(L_h+M)^{\gamma-1}-w_h-L_h\frac{dw_h}{dL_h}}{\rho+\lambda_h}$ is the surplus of a firm from hiring an extra worker. Therefore, the expression for the bargained wage is given by

$$(1-\beta_h)(E_h-U_h) = \beta_h\left(\frac{\gamma A(L_h+M)^{\gamma-1} - w_h - L_h\frac{dw_h}{dL_h}}{\rho+\lambda_h}\right) \tag{84}$$

From (9) obtain

$$E_h - U_h = \frac{w_h - \rho U_h}{\rho+\lambda_h} \tag{85}$$

Using (85) in (84) we obtain

$$w_h = (1-\beta_h)\rho U_h + \beta_h\left(\gamma A(L_h+M)^{\gamma-1} - L_h\frac{dw_h}{dL_h}\right) \tag{86}$$

The solution to the above differential equation is

$$w_h = (1-\beta_h)\rho U_h + L_h^{-\frac{1}{\beta_h}}\gamma A \int_0^{L_h} (x+M)^{\gamma-1} x^{\frac{1}{\beta_h}-1} dx \tag{87}$$

Next, recall from (10) that

$$\rho U_h = b_h + \mu_h \theta_h^{\delta_h}(E_h - U_h) \tag{88}$$

Using (84) to substitute out $(E_h - U_h)$ in the above expression to obtain the following.

$$\rho U_h = b_h + \mu_h \theta_h^{\delta_h} \frac{\beta_h}{1-\beta_h}\left(\frac{\gamma A(L_h+M)^{\gamma-1} - w_h - L_h \frac{dw_h}{dL_h}}{\rho+\lambda_h}\right) = b_h + \frac{\beta_h c_h \theta_h}{1-\beta_h} \tag{89}$$

where the last equality follows from (21). Next, using (89) the equation for wage in (87) can be written as

$$w_h = (1-\beta_h)b_h + \beta_h c_h \theta_h + L_h^{-\frac{1}{\beta_h}}\gamma A \int_0^{L_h} (x+M)^{\gamma-1} x^{\frac{1}{\beta_h}-1} dx \tag{90}$$

In the myopic firm case, the surplus of a firm from hiring a worker is simply $\gamma A(L_h+M)^{\gamma-1} - w_h$. Therefore, Nash bargaining implies

$$w_h = (1-\beta_h)\rho U_h + \beta_h \gamma A(L_h+M)^{\gamma-1} \tag{91}$$

Next, use (89) to substitute out ρU_h and obtain

$$w_h = (1-\beta_h)b_h + \beta c_h \theta_h + \beta_h \gamma A(L_h+M)^{\gamma-1} \tag{92}$$

9.9 Proof of Proposition 4

Gather the 4 key equations determining L_h, M, θ_h, and w_h below.

$$\begin{aligned}
\gamma A(L_h+M)^{\gamma-1} &= w_h + \frac{(\rho+\lambda_h)c_h}{\mu_h \theta_h^{\delta_h-1}} && (93)\\
\gamma A(L_h+M)^{\gamma-1} &= p_f \phi(h(M) + Mh'(M)) && (94)\\
w_h &= (1-\beta_h)b_h + \beta_h c_h \theta_h + \beta_h \gamma A(L_h+M)^{\gamma-1} && (95)\\
L_h &= \overline{L}_h\left(\frac{\mu_h \theta_h^{\delta_h}}{\lambda_h + \mu_h \theta_h^{\delta_h}}\right) && (96)
\end{aligned}$$

Use (93) and (94) to obtain

$$p_f \phi(h(M) + Mh'(M)) = w_h + \frac{(\rho+\lambda_h)c_h}{\mu_h \theta_h^{\delta_h-1}} \tag{97}$$

Use (93) and (95) to obtain

$$w_h = b_h + \frac{\beta_h}{1-\beta_h} c_h \theta_h + \frac{\beta_h}{1-\beta_h} \frac{(\rho + \lambda_h) c_h}{\mu_h \theta_h^{\delta_h - 1}} \tag{98}$$

In addition to the compact notation defined earlier, define the following additional notations to reduce clutter.

Definition 4

$$H = h(M) + M h'(M); H' = 2h'(M) + M h^{''}(M); C5 = \gamma(1-\gamma) A (L_h + M)^{\gamma - 2}$$

Now, take the total derivatives of (95), (97), (98), and (96) with respect to ϕ and use the compact notation to obtain

$$\begin{aligned} \frac{dw_h}{d\phi} &= \beta_h c_h \frac{d\theta_h}{d\phi} - \beta_h C5 (\frac{dL_h}{d\phi} + \frac{dM}{d\phi}) && (99) \\ p_f H + p_f \phi H' \frac{dM}{d\phi} &= \frac{dw_h}{d\phi} + C4 \frac{d\theta_h}{d\phi} && (100) \\ \frac{dw_h}{d\phi} &= \left(\frac{\beta_h c_h}{1-\beta_h} + \frac{\beta_h}{1-\beta_h} C4 \right) \frac{d\theta_h}{d\phi} && (101) \\ \frac{dL_h}{d\phi} &= C3 \frac{d\theta_h}{d\phi} && (102) \end{aligned}$$

Using (100) and (102) in (99), and re-arranging terms obtain

$$\left(1 + \frac{\beta_h C5}{p_f \phi H'}\right) \frac{dw_h}{d\phi} = \frac{\beta_h C5 H}{\phi H'} + \beta_h \left(c_h - C5 \left(C3 + \frac{C4}{p_f \phi H'} \right) \right) \frac{d\theta_h}{d\phi} \tag{103}$$

Now, we have two equations (101) and (103) in two unknowns: $\frac{d\theta_h}{d\phi}$ and $\frac{dw_h}{d\phi}$. Substituting out $\frac{dw_h}{d\phi}$ in (103) using (101) and re-arranging obtain

$$\left[\left(1 + \frac{C5}{p_f \phi H'}\right) \left(\frac{\beta_h c_h}{1-\beta_h} + \frac{C4}{1-\beta_h} \right) + C3C5 \right] \frac{d\theta_h}{d\phi} = \frac{C5 H}{\phi H'} \tag{104}$$

Now, assume that $H' = 2h'(M) + M h^{''}(M) > 0$, which requires the $h(M)$ function to be not too concave. In this case, since all the terms in the square bracket in (104) are positive and the term on the r.h.s is positive, we get $\frac{d\theta_h}{d\phi} > 0$. Note from (101) that $\frac{d\theta_h}{d\phi} > 0$ implies $\frac{dw_h}{d\phi} > 0$.

Next, upon substituting out $\frac{d\theta_h}{d\phi}$ and $\frac{dw_h}{d\phi}$ using (101) and (104) in (100) and canceling terms obtain

$$\frac{dM}{d\phi} = - \frac{\frac{H}{\phi H'} \left(\frac{\beta_h c_h}{1-\beta_h} + \frac{C4}{1-\beta_h} + C3C5 \right)}{\left[\left(1 + \frac{C5}{p_f \phi H'}\right) \left(\frac{\beta_h c_h}{1-\beta_h} + \frac{C4}{1-\beta_h} \right) + C3C5 \right]} < 0 \tag{105}$$

Since autarky equilibrium is obtained by setting $M = 0$ which obtains at a high level of ϕ, we conclude from $\frac{d\theta_h}{d\phi} > 0$ and $\frac{dw_h}{d\phi} < 0$ that the offshoring equilibrium unemployment is higher and wage is lower than in autarky. Q.E.D

9.10 Determination of Wage in Foreign

$$\arg\max_{w_f}(E_f - U_f)^{\beta_f}\left(\frac{p_f - w_f}{\rho + \lambda_f}\right)^{1-\beta_f} \tag{106}$$

where E_f and U_f are defined exactly in the manner in which they were defined for Home, that is simply by replacing the subscript h by f in (9) and (10). The first order condition for the above maximization is given by

$$(1-\beta_f)(E_f - U_f) = \beta_f\left(\frac{p_f - w_f}{\rho + \lambda_f}\right) \tag{107}$$

Next, substitute out $E_f - U_f$ in the above using (85) to obtain

$$w_f = (1-\beta_f)\rho U_f + \beta_f p_f \tag{108}$$

Next, from (85) and (88) obtain

$$\rho U_f = b_f + \frac{\beta_f c_f \theta_f}{1-\beta_f} \tag{109}$$

Substituting (109) in (108) obtain the expression for wage below.

$$w_f = (1-\beta_f)b_f + \beta_f c_f \theta_f + \beta_f p_f \tag{110}$$

9.11 Proof of Proposition 6

Gather the two key equations (28) and (29) determining w_f and θ_f below.

$$\begin{aligned} p_f &= w_f + \frac{(\rho+\lambda_f)c_f}{\mu_f \theta_f^{\delta_f - 1}} && (111) \\ w_f &= (1-\beta_f)b_f + \beta_f(p_f + c_f\theta_f) && (112) \end{aligned}$$

Substitute out w_f in (111) using (112) to obtain

$$p_f = b_f + \frac{\beta_f c_f \theta_f}{1-\beta_f} + \frac{\theta_f^{1-\delta_f}}{1-\beta_f}\frac{(\rho+\lambda_f)c_f}{\mu_f} \tag{113}$$

9.11.1 Change in c_f

Taking the partial derivative of (113) with respect to c_f (that is, holding p_f constant) obtain

$$\left(\beta_f c_f + (1-\delta_f)\,\theta_f^{-\delta_f}\frac{(\rho+\lambda_f)c_f}{\mu_f}\right)\frac{\partial\theta_f}{\partial c_f} = -\left(\beta_f\theta_f + \frac{(\rho+\lambda_f)}{\mu_f}\theta_f^{1-\delta_f}\right) < 0 \tag{114}$$

Taking the partial derivative of (112) with respect to c_f (that is, holding p_f constant) obtain

$$\frac{\partial w_f}{\partial c_f} = \beta_f\left(\theta_f + c_f\frac{\partial\theta_f}{\partial c_f}\right) = -\left(\frac{\beta_f\delta_f\theta_f^{1-\delta_f}\frac{(\rho+\lambda_f)}{\mu_f}}{\left(\beta_f + (1-\delta_f)\,\theta_f^{-\delta_f}\frac{(\rho+\lambda_f)}{\mu_f}\right)}\right) < 0 \tag{115}$$

where the last equality follows from substituting out $\frac{\partial\theta_f}{\partial c_f}$ using (114).

9.11.2 Change in b_f

Taking the partial derivative of (113) with respect to b_f obtain

$$\left(\beta_f c_f + (1-\delta_f)\,\theta_f^{-\delta_f}\frac{(\rho+\lambda_f)c_f}{\mu_f}\right)\frac{\partial\theta_f}{\partial b_f} = -(1-\beta_f) < 0 \tag{116}$$

Taking the partial derivative of (112) with respect to b_f and substituting (116) obtain

$$\frac{\partial w_f}{\partial b_f} = (1-\beta_f) + \beta_f c_f\frac{\partial\theta_f}{\partial b_f} = \frac{(1-\beta_f)\,(1-\delta_f)\,\theta_f^{-\delta_f}\frac{(\rho+\lambda_f)c_f}{\mu_f}}{\beta_f c_f + (1-\delta_f)\,\theta_f^{-\delta_f}\frac{(\rho+\lambda_f)c_f}{\mu_f}} > 0 \tag{117}$$

Figure 1: Unemployment, Wage, and Offshoring (Linear adaptation cost)

Figure 1a: offshoring and unemployment with collective bargaining

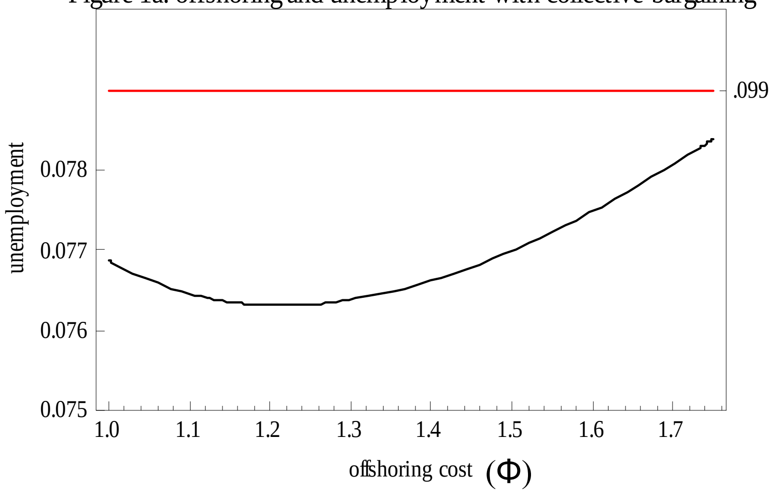

Figure 1b: offshoring and wage with collective bargaining

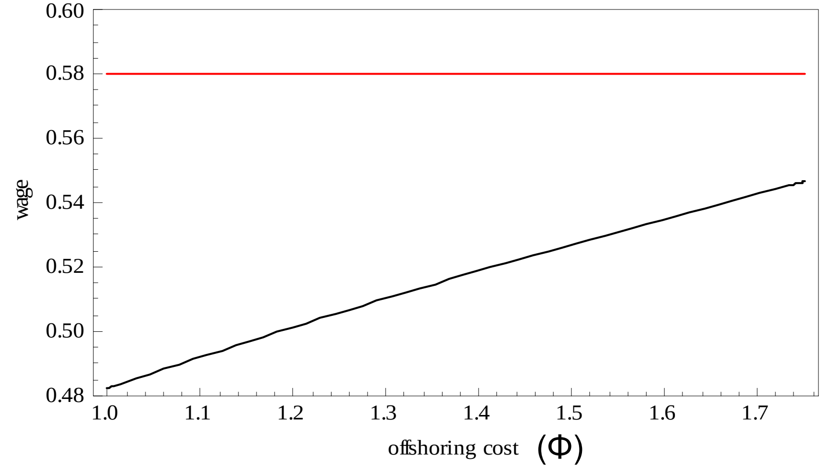

Figure 1c: offshoring and unemployment with individual bargaining

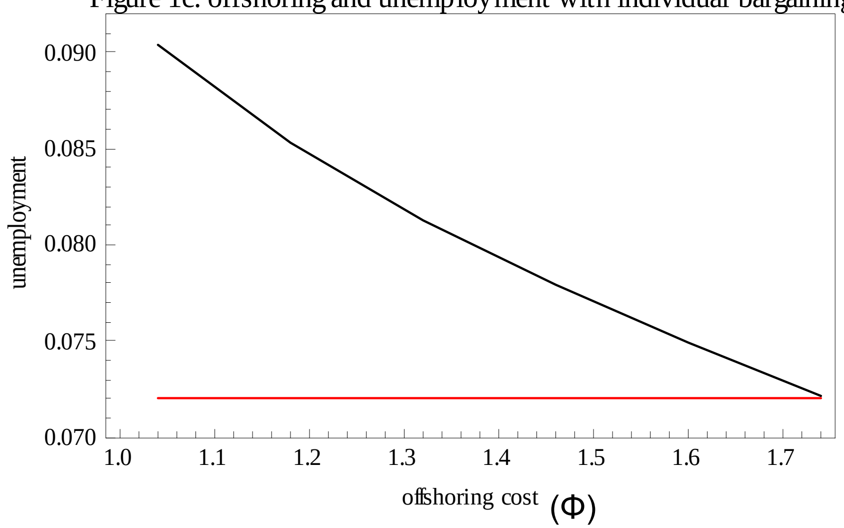

Figure 1d: offshoring and wage with individual bargaining

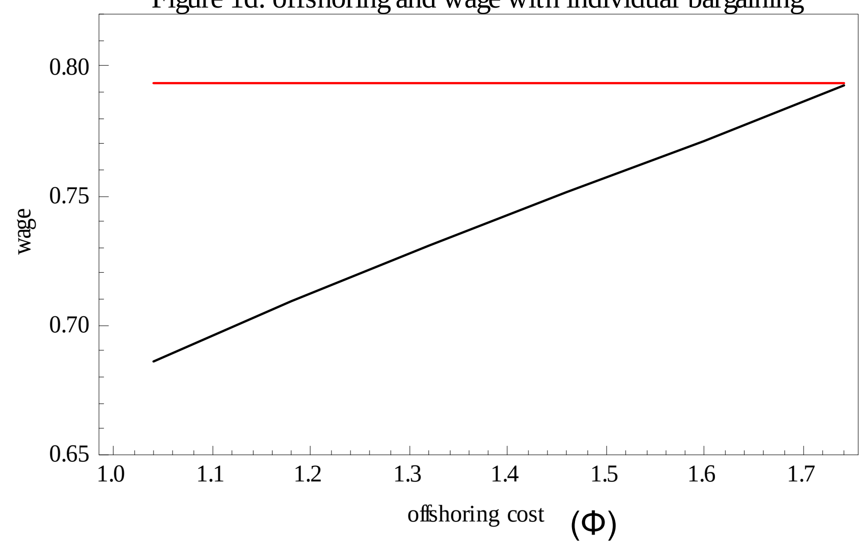

Figure 2: Unemployment, Wage, and Offshoring (Convex adaptation cost)

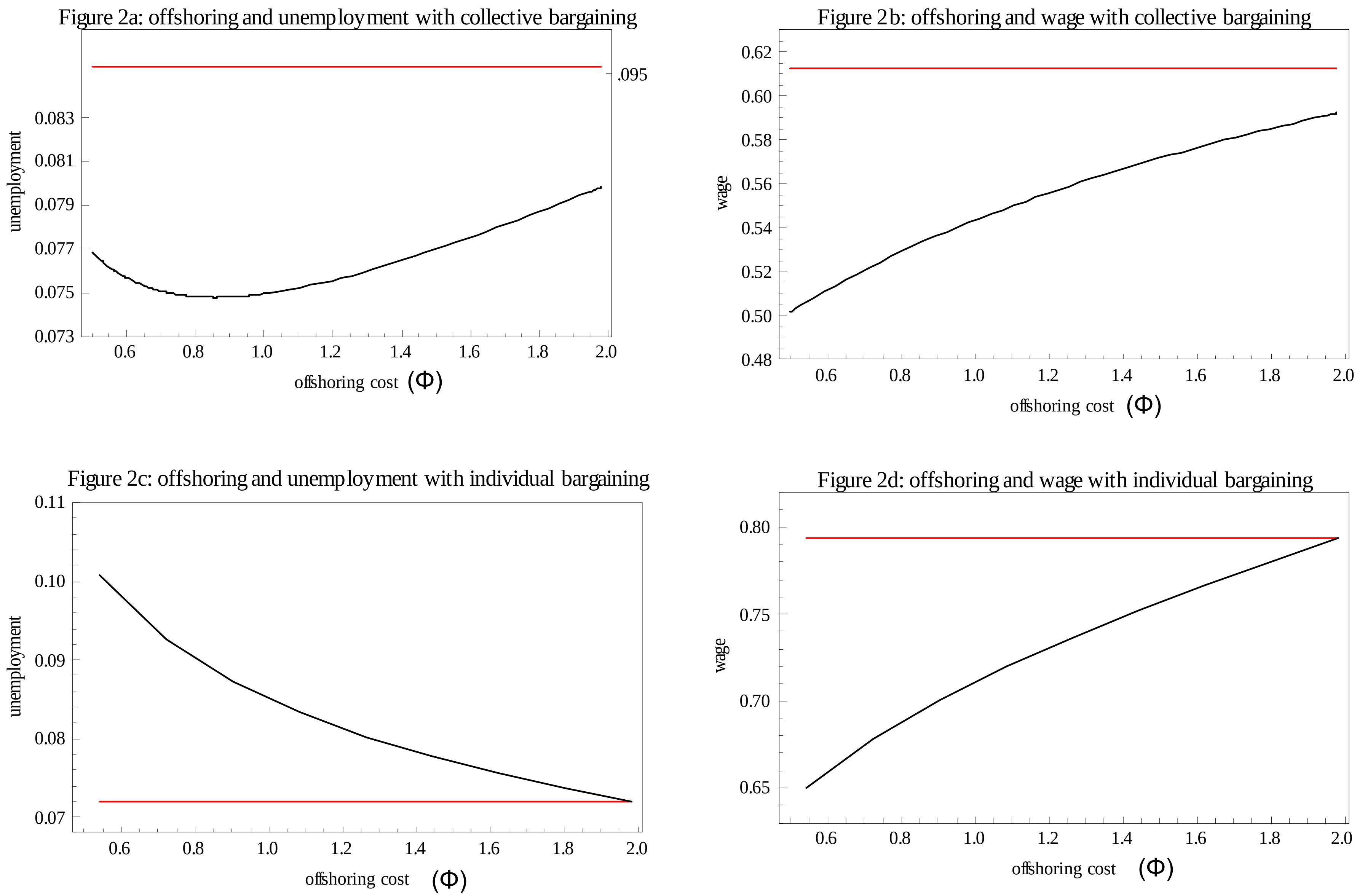

Figure 3: Unemployment, Wage, and Offshoring (Concave adaptation cost)

Figure 3a: offshoring and unemployment with collective bargaining

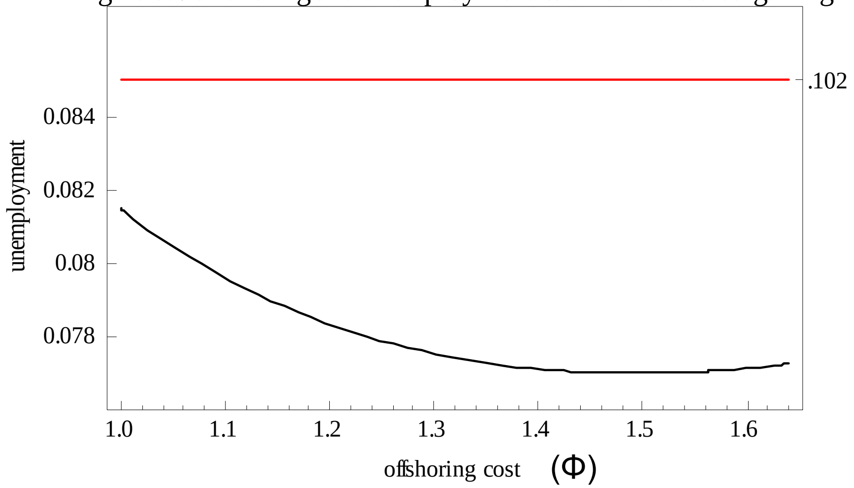

Figure 3b: offshoring and wage with collective bargaining

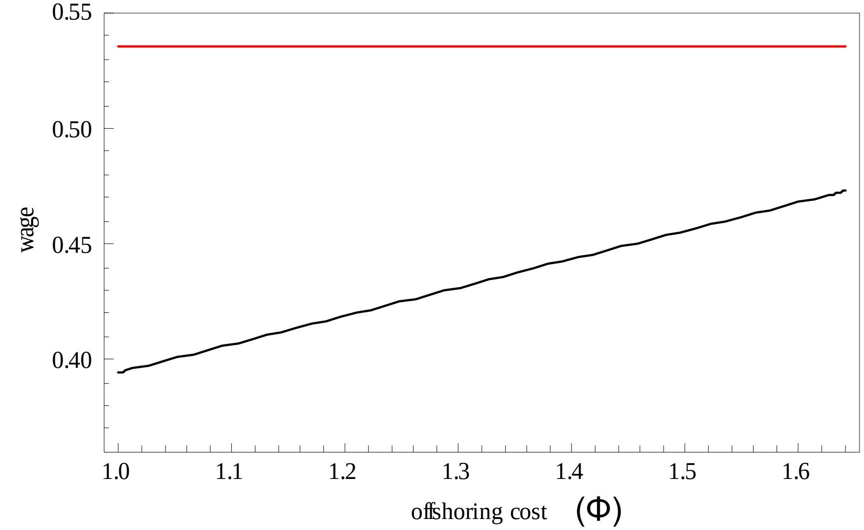

Figure 3c: offshoring and unemployment with individual bargaining

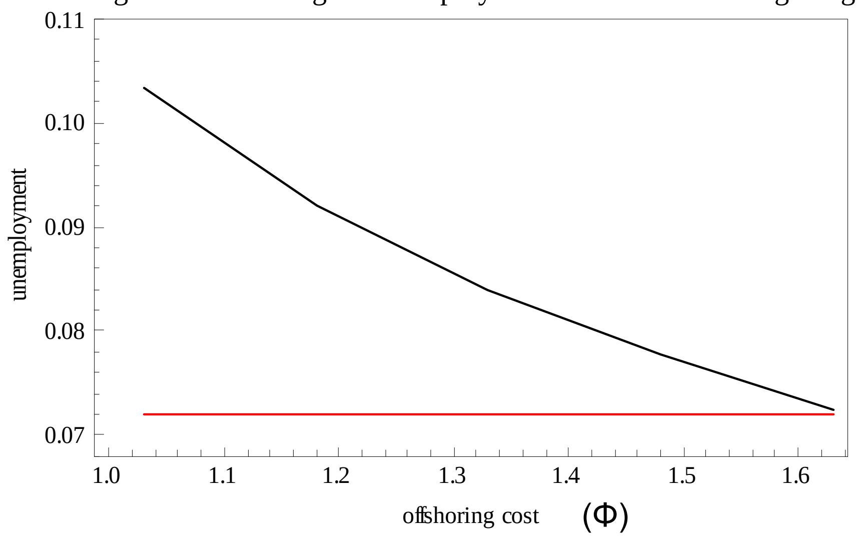

Figure 3d: offshoring and wage with individual bargaining

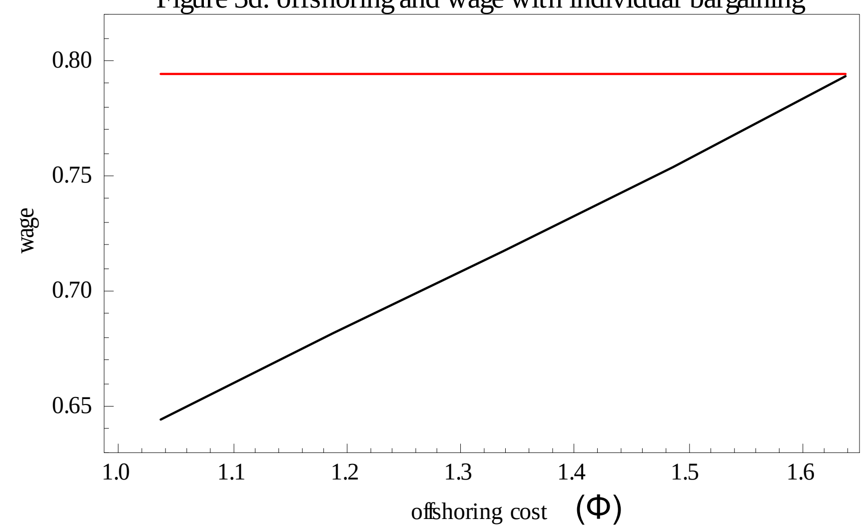

Figure 4: Offshoring and Unemployment with CES Production Function

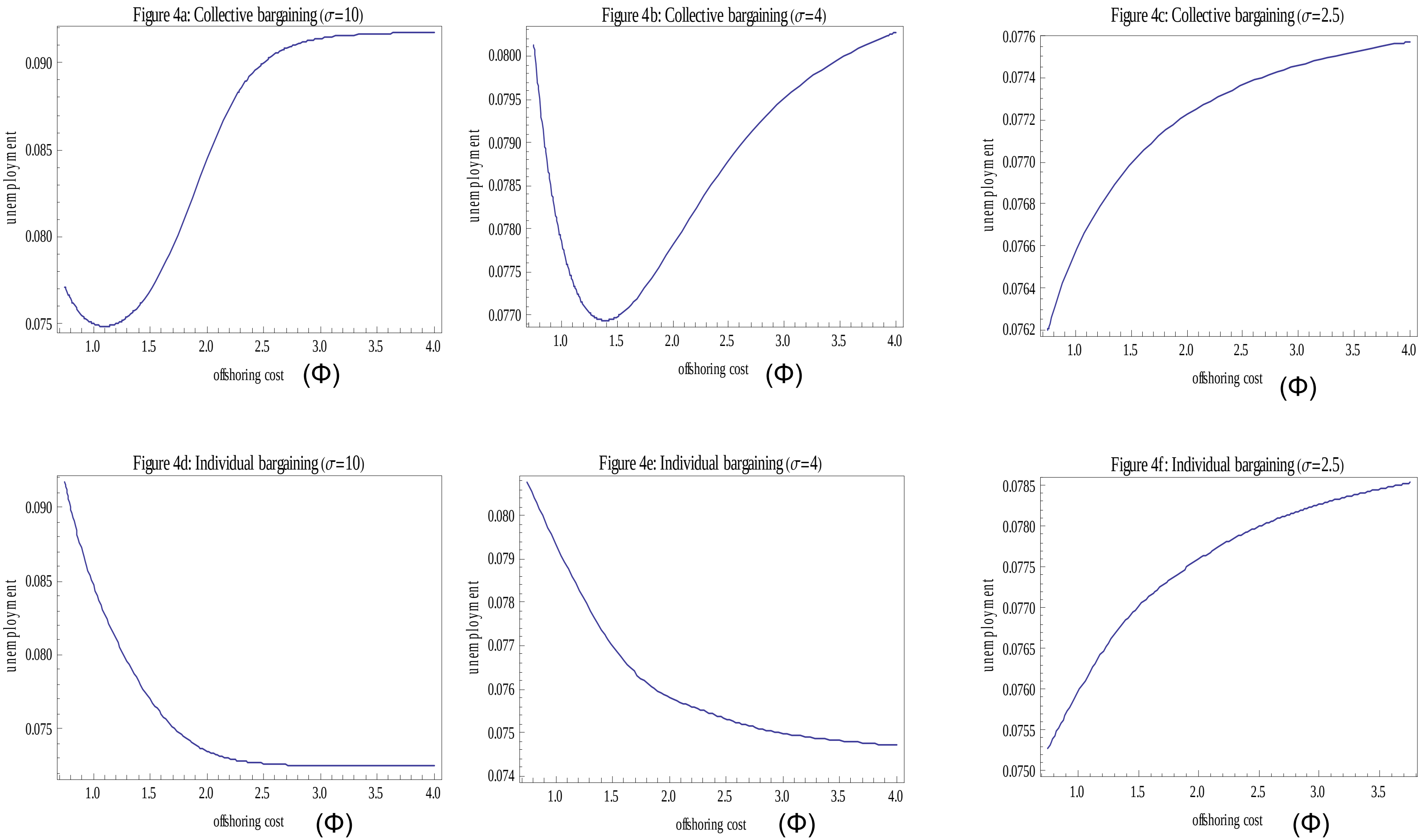

Figure 5a: Labor Market Equilibrium in Foreign

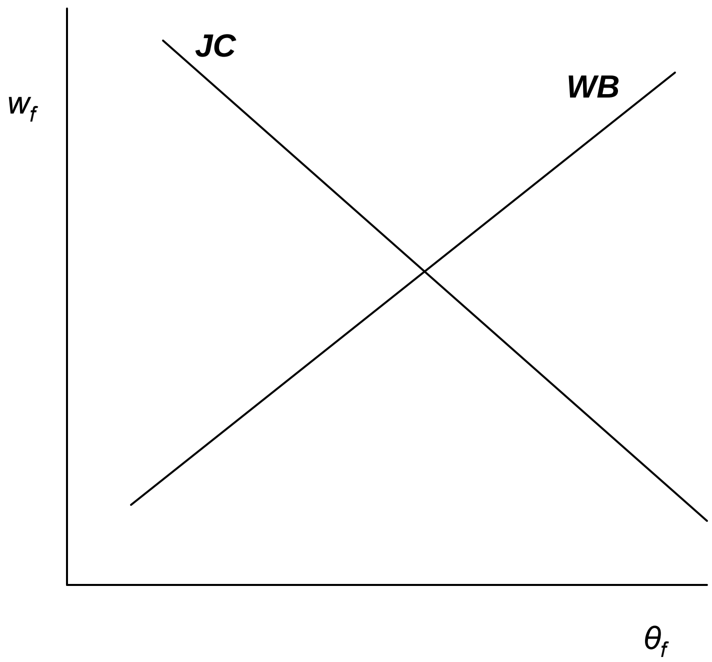

Figure 5b: Determination of World Price

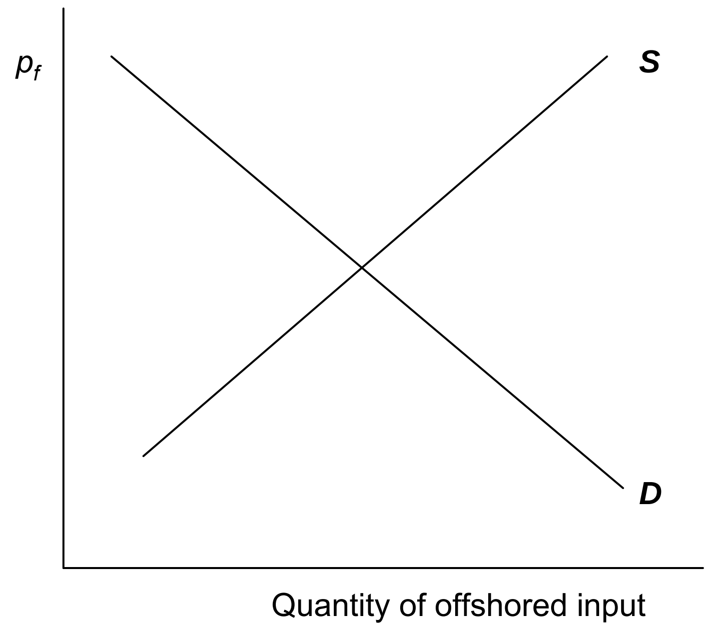

Figure 6: Gross Offshoring as a function of offshoring cost

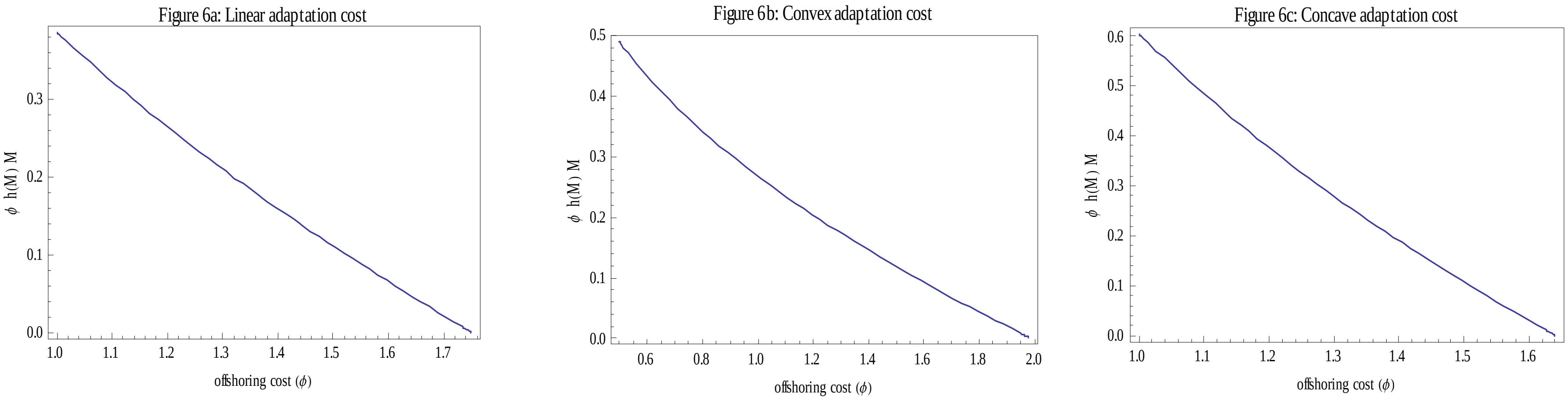

Figure 7: Offshoring and Home unemployment with endogenous p_f

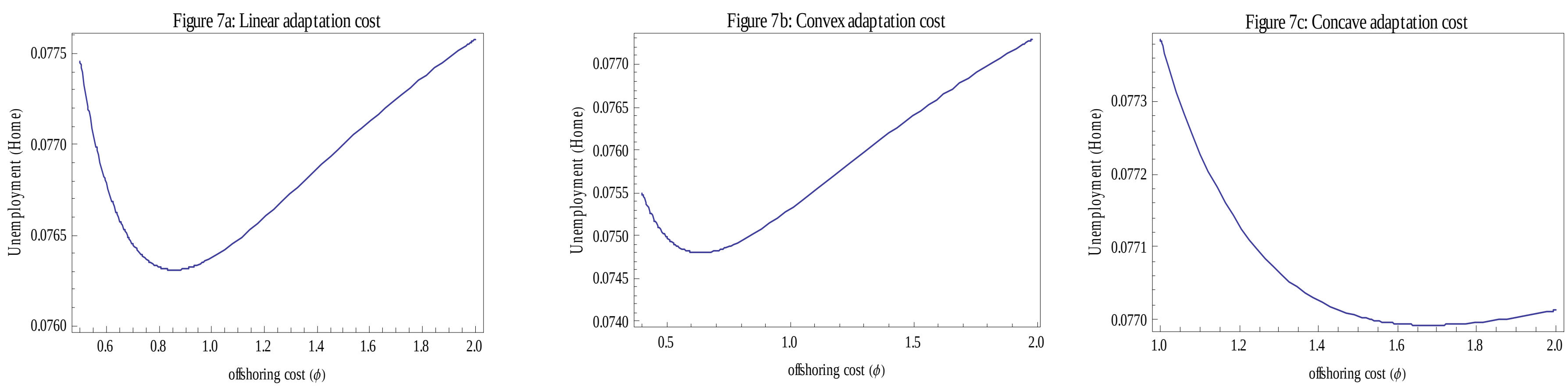

Figure 8: Foreign unemployment benefit and Home and Foreign Labor Markets

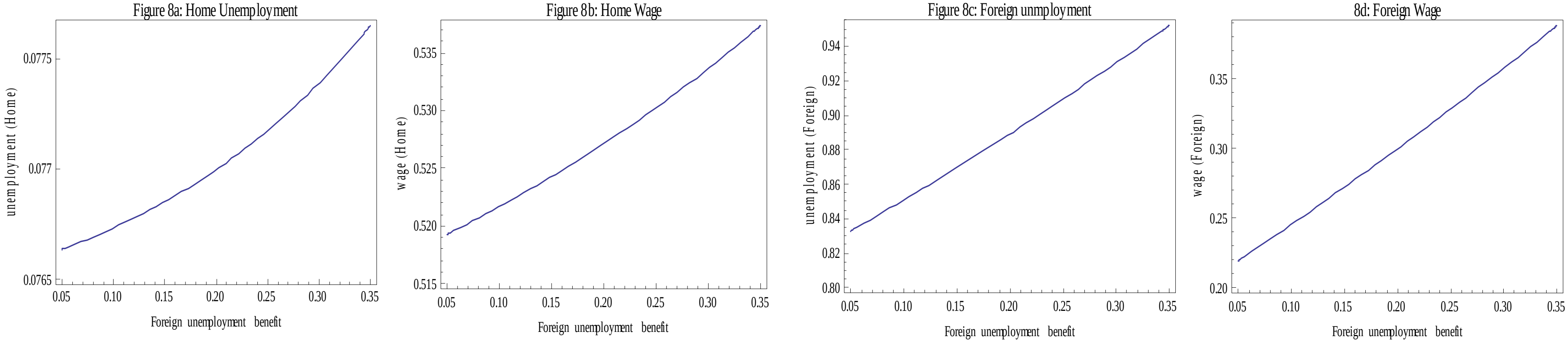

Figure 9: Foreign recruitment cost and Home and Foreign Labor Markets

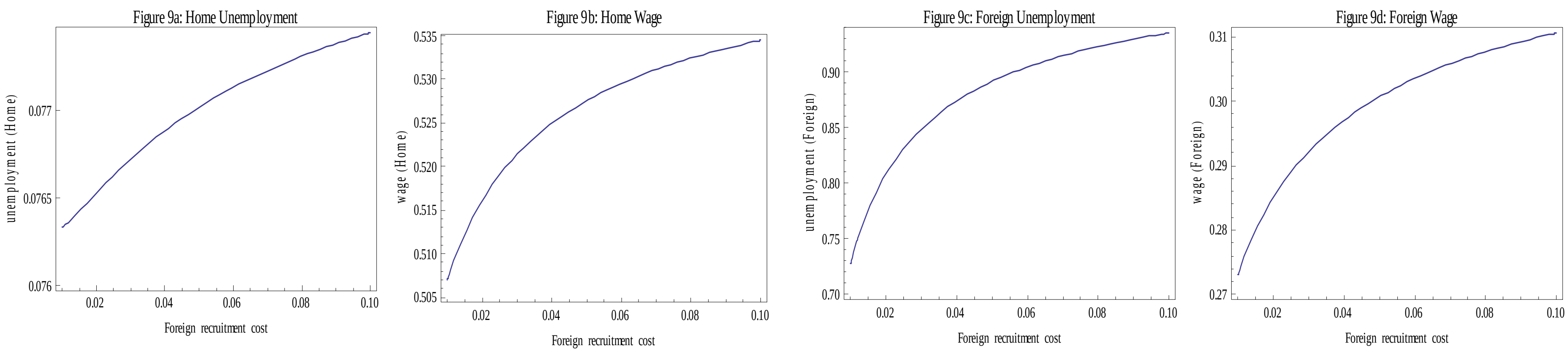

Figure 10: Home unemployment benefit and Home and Foreign Labor Markets

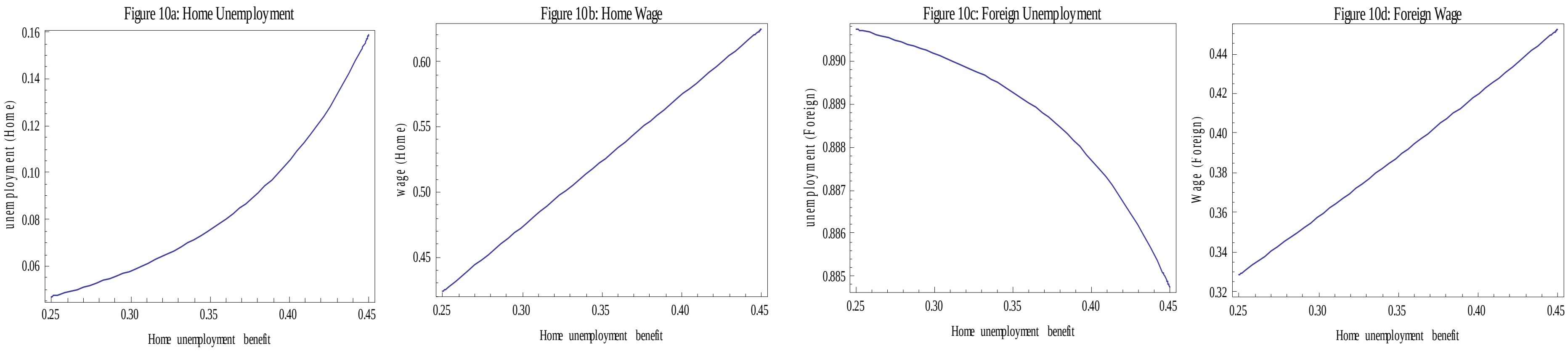

Figure 11: Home recruitment cost and Home and Foreign Labor Markets