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ABSTRACT

Temporary Shocks and Offshoring: The Role of External Economies and Firm Heterogeneity*

We construct a model of offshoring with externalities and firm heterogeneity. Due to the presence of externalities, temporary shocks like the Y2K problem can have permanent effects, i.e., they can permanently raise the extent of offshoring in an industry. Also, the initial advantage of a country as a potential host for outsourcing activities can create a lock in effect, whereby late movers have a comparative disadvantage. Furthermore, the existence of firm heterogeneity along with externalities can help explain the dynamic process of offshoring, where the most productive firms offshore first and the others follow later. Finally, we work out some unexpected welfare implications which show that net industry profits can be lower in an outsourcing equilibrium than in a regime of no outsourcing. Consumer welfare rises, and under fairly plausible conditions this effect can offset the negative impact on profits.

JEL Classification: F12, F23, O19

Keywords: offshoring, outsourcing, Y2K, complementarity

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1 Introduction

In recent years, we have seen many firms in developed countries move some of their production activities to developing countries where wages and costs of production are much lower. This offshoring of production, in many cases, has taken place within the same firm that already is or becomes a multinational. In many other cases, certain activities have been contracted out or "outsourced" to other firms in developing countries. This phenomenon has given rise to a whole new literature in international trade theory.

Grossman and Helpman (2002) focus on the tradeoff between integration and outsourcing without being explicit about offshoring. In their model, vertical integration has a high cost of governance, while outsourcing involves costly search for partners with input suppliers facing a hold up problem due to imperfect contracting. They show how the optimal organizational form depends on the efficiency of search technology, distribution of bargaining power, degree of substitutability between products etc. In another paper, Grossman and Helpman (2005) study the determinants of the location of outsourced activity (domestic versus foreign). They show that the extent of international outsourcing depends on the thickness of domestic and foreign markets for input suppliers, the relative costs of searching in each market, the relative cost of customizing inputs, and the nature of the contracting environment. Grossman and Helpman (2003) combine elements of Grossman and Helpman (2002) and Grossman and Helpman (2005) to study the determinants of the choice between offshore outsourcing and foreign direct investment (FDI). Antras (2003) studies how the choice between offshore integration and offshore outsourcing is affected by industry characteristics. Most importantly, he shows that the benefits of integration outweigh the benefits of outsourcing in capital-intensive industries. Antras and Helpman (2004) expand the set of organizational forms to four: domestic vertical integration, domestic outsourcing, offshore vertical integration, and offshore outsourcing, and show how variations in industry characteristics affect organizational choice. Feenstra and Hanson (2005) study the determinants of plant ownership and control of inputs in a simple model of international outsourcing with applications to processing trade in China.

What remains unanswered is what starts this process of offshore outsourcing, and thereafter what determines its dynamics. Besides, we also need to look at the welfare implications of this whole process for both developed and developing countries. Based on casual empiricism, we believe that temporary shocks can trigger this process but the effects of such shocks can be permanent. For example, a few home-grown Indian IT groups, namely companies such as Wipro, TCS and Infosys, have become powerful players in the market for offshore IT services. After getting their big breaks from the subcontracting by overloaded western firms during the Y2K software crisis at the turn of the millennium, they are now beginning to "expand beyond core IT maintenance and support work into helping multinationals, for instance, to roll out new software applications"(The Economist, December 11, 2003).[1] The Y2K crisis can be viewed as a temporary shock which increased the net benefits to American firms from outsourcing, due to a shortage of programmers in the US. This led firms to outsource to India which had a vast available pool of programmers. This outsourcing kept increasing well after the Y2K problem became a thing of the past.

The fact that a temporary shock had a permanent effect on outsourcing suggests the existence of externalities (external economies). We believe that as more firms from the North offshore their production activities to a country in the South, productivity in such activities of workers in the Southern country increases. The possible explanations for this increase in productivity are the standard ones for external economies, based on labor-market pooling, knowledge spillovers and learning by doing.[2]

[1] See also Arora and Gambardella (2004).

[2] See Bresnahan, Gambardella and Saxenian (2001). In their case studies of the "new silicon valleys" in India, Israel, Ireland and China, they clearly recognize "external effects among the technology firms located there" as a central feature of their activities. NASSCOM figures show that revenue per worker in the Indian software industry has been increasing very rapidly from $14833 in 1997 to $37242 in 2000 (Athreye, 2004), which in the presence of increasing employment is suggestive of at least some industry-level increasing returns to scale. Arora and Gambarella (2004), in their case study of the Indian software industry, mention the possibility of "spillovers or scale economies, associated with agglomeration of human capital". For survey evidence on the importance of labor-market pooling in the Indian software industry see Balasubramaniam (2004).

In our analysis, we incorporate these external economies.[3] Northern firms choose between offshoring their input production to the South and at the other extreme, staying fully domestic. As more firms offshore, productivity of labor in this activity in the South increases. We allow firms in the North to differ in their productivity levels in converting their inputs into final output.[4] The offshore outsourcing in our model is subject to incomplete contracting between the final output firm and the input supplier as in the work of Grossman and Helpman (2002, 2003 and 2005), Antras (2003) and Antras and Helpman (2004).[5,6]

We find that, due to the externalities in the production of inputs, there are multiple equilibria - a no offshoring equilibrium and another with offshoring by the most productive firms. Once we introduce some simple dynamics (similar to those based on adaptive expectations), we find that an implication of the presence of multiple equilibria is that a temporary shock can have a permanent effect, i.e. it can move the economy from a no offshoring equilibrium to one with a substantial amount of offshoring, which is consistent with what we see in the case of the Indian IT industry. The firms that offshore are firms with a higher intrinsic productivity level in the production of the final good. Due to the heterogeneity in the productivity levels of the final output firms in the

[3]See Eaton and Panagariya (1979), Panagariya (1980, 1981), Ethier (1982), Rodrik (1996), and Rodriguez-Clare (1996a) for earlier trade models with external economies of scale.

[4]Several recent papers such as Bernard, Eaton, Jensen and Kortum (2003), Eaton, Kortum and Kramarz (2004), and Melitz (2003) have explored the implications of firm heterogeneity for international trade. Further, Helpman, Melitz and Yeaple (2004) incorporate firm heterogeneity into a model with endogenous firm choice between exports and FDI.

[5]We assume labor productivity in input production to be higher in the North than in the South, with the wages lower in the latter. In this context, we refer the interested reader to Pack and Saggi (2001) for an in-depth analysis of the implications of technology diffusion from a firm in the North to an input supplier in the South through outsourcing. Furthermore, the reverse effects, namely those of outsourcing from the North to the South on Northern innovation, is analyzed by Glass and Saggi (2001). Also, see Sener and Sayek (2004).

[6]In a working paper version of this paper, we also perform an analysis of the effects of complementarity between FDI and offshore outsourcing (See Mitra and Ranjan, 2005). The results of that analysis are summarized later in this paper.

North, the first to offshore are the most productive firms, followed by the next most productive ones and so on.

We believe that the main feature of the dynamics generated by our model is the continuation of offshoring well after the temporary shock hits the economy. Figure 1 shows recent computer and business services insourcing (exports) and outsourcing (imports) for India and Ireland.[7] While in India, things were initiated by the Y2K crisis and the dotcom bubble, in Ireland in addition certain tax breaks given in the late nineties were responsible for the surge in the exports of business and computer services. Figure 2 shows the movements in software exports as a share of sales for India for the period 1993-2002. After remaining roughly constant until 1997, this share has continued to rise.[8] As we see from figures 1 and 2, the growth in these exports has not been reversed in India or in Ireland so far even though the Y2K and the dotcom were temporary shocks, and the tax breaks to insourcing into Ireland were very partially reversed in response to protests from other European countries.

Next we analyze the welfare effects of offshoring in our model. There are different channels through which welfare could be affected in the North and in the South. It turns out that aggregate net industry profits (after taking into account the fixed costs incurred in offshoring) in the North are lower in the offshoring regime than when no offshoring takes place. While in the case of heterogeneous firms, the relatively more productive firms can be better off in this offshoring equilibrium, the less productive firms will be made worse off relative to where they were in the no-offshoring regime. In the homogeneous productivity case, we clearly have a prisoner's dilemma problem since each firm ends up being worse off in the offshoring equilibrium. However, a decrease in the aggre-

[7] These figures are from the point of view of Ireland and India. For example, the figures on insourcing reported for India will consist of outsourcing by the US (and other countries) to India.

[8] The source of the data for this figure is Arora and Gambardella (2005). While Figure 2 does not show figures for Ireland, the interested reader might want to know that such a clear trend was not there for Irish exports of software. [Again, the source is Arora and Gambardella (2005).] There was a steady rise in this share in Ireland from 1991 all the way through 1997, a fairly large fall between 1997 and 1998, after which it remained constant until 2000 and then there was an increase for the next two years.

gate price index due to a fall in production costs resulting from offshoring is a source of welfare gain. The net effect on the welfare of a representative agent in the North depends on the relative strengths of these opposing effects. It is positive when the fixed costs of offshoring are small, or the South has a relatively much lower labor cost than in the North. The Southern consumers also gain from the lower price of the final non-numeraire goods. In addition, the specialized input producers in the South get a share of the surplus which is an additional source of gain for the South. In general, the greater the amount of offshoring the greater the gains to the South.

Finally, it is important to mention the paper by Markusen and Venables (1999) that is related to our work in that they develop an analytical framework to examine how an FDI project affects local firms in the same industry through backward linkages that strengthen supplier firms.[9], [10] Our paper differs substantially from the Markusen-Venables paper in that we do not explicitly model linkage effects like they do. However, while they focus on FDI, we look mainly at offshore outsourcing (with incomplete contracting between the Northern final output and Southern input firms). Moreover, while the focus of the effects of FDI in Markusen and Venables is exclusively on the host country, the home country plays an important role in our analysis. Additionally, we incorporate firm heterogeneity, which they do not. This firm heterogeneity, based on productivity differences, in conjunction with external economies can generate our dynamics in which firms offshore in decreasing order of productivity. The only other paper, to our knowledge, that has looked at agglomeration economies in the context of heterogeneous firms is a recent paper by Baldwin and Okubo (2005). They integrate a standard Melitz-type model of monopolistic competition with a "new economic geography" model, and show that the more productive firms locate in the bigger regions.

The rest of the paper is organized as follows. In the next section , we set up the basic model

[9] In a recent paper, Alfaro and Rodriguez-Clare (2004) find stronger linkage effects created by foreign firms than domestic ones in Brazil, Chile and Venezuela.

[10] In this context, it is also appropriate to mention the important contribution of Rodriguez-Clare (1996b) who works out conditions under which multinationals have favorable linkage effects and those under which they create enclave economies in developing countries.

where firms have a choice between producing an essential input domestically or procuring it from abroad. We capture offshore outsourcing (with contracting costs) using an incomplete contracts framework. In section 3. we derive some dynamic implications of the model. Section 4 derives welfare implications. Section 5 concludes.

2 The Model

2.1 Consumption

Let us assume the following utility function for a representative consumer in both the North and the South:

$$U = \frac{\sigma}{\sigma - 1} \ln \left[\int_{i \in \Omega} d(i)^{\frac{\sigma-1}{\sigma}} di \right] + x_N, \sigma > 1 \tag{1}$$

where $d(i)$ is the consumption of the non-numeraire good i and x_N is the consumption of the numeraire good. The measure of set Ω represents the mass of available non-numeraire goods which we assume to be fixed. Assuming that each individual in the North and South has income of at least 1 which allows him/her to consume all the differentiated goods, the utility function in (1) implies the following demand function for good i by an individual consumer.

$$d(i) = \frac{p(i)^{-\sigma}}{\int_{j \in \Omega} p(j)^{1-\sigma} dj} \tag{2}$$

We use superscript N to denote North and S to denote South and assume that the number of consumers in the North and South are H^N and H^S, respectively. We use the following definitions in rest of the paper.

Definitions : $H \equiv H^N + H^S, \quad A \equiv \left[\int_{j \in \Omega} p(j)^{1-\sigma} dj \right]^{-1}, \quad A' \equiv AH.$

In the absence of any trading costs facing differentiated goods[11], the aggregate demand for good-i can be written as

$$x(i) = A' p(i)^{-\sigma} \tag{3}$$

The inverse demand function facing each firm can be written as

$$p(i) = \left[\frac{x(i)}{A'}\right]^{-1/\sigma} \tag{4}$$

Also, note that the expressions for the welfare of the representative consumers in the North and South are given by

$$V^N = \frac{1}{1-\sigma}\ln A + I^N - 1 \tag{5}$$

$$V^S = \frac{1}{1-\sigma}\ln A + I^S - 1 \tag{6}$$

where I^N and I^S are the incomes of the representative individuals in the North and South, respectively. Therefore, welfare is inversely related to A.

2.2 Production

Suppose that one unit of labor can produce w_N units of the numeraire good in the North. Therefore, the wage rate there is fixed at w_N in equilibrium.

We use α to denote the productivity of a firm where $\alpha \in [\underline{\alpha}, \overline{\alpha}]$. The distribution function of firm productivities is denoted by $G(\alpha)$. Let us assume that for each of the non-numeraire goods above, one unit of a specialized input, y, produces α units of the final good. Thus α may reflect the quality of management in that firm. We represent this relationship by the following production function:

$$x(\alpha) = \alpha y \tag{7}$$

[11] We have verified that introducing trading cost for differentiated goods does not affect the qualitative results in the paper. The results are available upon request. To conserve space, we report results with no trading costs.

While the final output of any non-numeraire good can only be produced in the North, the specialized input can either be produced domestically in the North or its production can be outsourced to a producer in a foreign country called the South. We do not explicitly model contract incompleteness associated with input production that is done in the North.[12] We assume that one unit of home labor can make one unit of the input. Therefore, the cost of producing one unit of the input domestically is w_N . The unit cost of non-numeraire good, when the input is produced domestically, for a firm with productivity α is

$$c(\alpha) = \frac{w_N}{\alpha} \tag{8}$$

Therefore, the objective function of a firm, that produces the specialized input domestically, is given by

$$\pi_D(\alpha) = p(\alpha)x(\alpha) - \frac{w_N\, x(\alpha)}{\alpha} = (A')^{1/\sigma} x(\alpha)^{\frac{\sigma-1}{\sigma}} - \frac{w_N\, x(\alpha)}{\alpha} \tag{9}$$

Maximization of this objective function with respect to $x(\alpha)$ gives us

$$x(\alpha) = A' \left(\frac{\sigma - 1}{\sigma}\right)^{\sigma} \alpha^{\sigma} w_N^{-\sigma} \tag{10}$$

The equilibrium price of the output under domestic production of the input can then be given as

$$p_D(\alpha) = \frac{\sigma w_N}{\alpha(\sigma - 1)} \tag{11}$$

[12] Effectively, we do not distinguish between transactions inside a Northern firm (vertical integration) and those outside its boundaries but still within the North (domestic outsourcing). Relatively speaking, the problem of incompleteness of contracts is far more severe in the South. This makes perfect transactions in the North a useful simplifying assumption. Under such an assumption, outsourcing and vertical integration within the North will look exactly the same. See Antras (2005) for a similar approach and argument based on the perfect verfiability by a third party of input quality (and hence on the perfect enforcement of quality-contingent contracts) in the North. It is important here to note that, as explained later, outsourcing input production to the South in our model will be subject to contract incompleteness. While offshoring in this model involves outsourcing and not vertical integration, the case of international vertical integration or FDI has also been thoroughly analyzed in a working paper version of this paper, namely Mitra and Ranjan (2005).

Therefore, the maximized profit of a firm that produces the specialized input domestically, is given by

$$\pi_D(\alpha) = A'\sigma^{-\sigma}(\sigma-1)^{\sigma-1}w_N^{1-\sigma}\alpha^{\sigma-1} \tag{12}$$

Assume that in the South $\phi(0) > 1$ units of labor are required to produce a unit of specialized input when no firm has begun offshoring. The labor requirement when a fraction n of firms offshore is denoted by $\phi(n)$, where $\phi'(n) < 0$ captures the externalities in the production of inputs in the South[13]. To avoid clutter, we will write ϕ without its argument, except when talking about the dynamic implications of our model. Given the above definition of ϕ, $1/\phi$ is the South's productivity relative to the North. On the other hand, we assume that the wage in the South is $w_S < w_N$ because one unit of labor in the South can produce w_S units of the numeraire good. As long as $\phi w_S < w_N$, which is what we assume throughout the paper, the South has a comparative advantage in the production of the specialized inputs.[14]

We now allow each firm in the North the option to outsource the production of its specialized input to a firm in the South.[15] However, there is incomplete contracting between the final goods producer in the North and the input producer in the South who has to produce a customized input that is of use only to the particular final good producer who placed the order. Once the input is produced, the payment for it is determined through generalized Nash bargaining.[16] We assume that β and (1-β) are the bargaining weights for the input producer and the final goods producer

[13] An alternative way to model externality would be to make ϕ a function of the total amount of inputs produced in the offshore facilities in the South. This yields qualitatively similar results, however, the algebraic expressions are slightly more complicated. Therefore, we decided to take the simpler route of making ϕ a function of the number of firms offshoring.

[14] However, all these inputs are not always imported by the North from the South due to the presence of the fixed costs of offshoring and the implicit costs of contract incompleteness.

[15] The other option stilll remains the domestic production of the input (without any frictions).

[16] Neither the quality of input nor the amount of resources going into the production of the input is verifiable to third parties. Therefore, no ex-ante contracts can be written to produce inputs. The reward for input production must be determined through ex-post bargaining.

respectively in this bargaining game. Due to the highly customized nature of the input (that cannot be used to produce a final product other than the one it was meant for and cannot be replaced by another input to produce the output it was meant for), the threat point of the bargaining game is one where the payoffs of both the final and intermediate goods producers equal zero. We assume that there is a large number of potential input producers in the South and every firm in the North that attempts to find an input producer can find one by incurring a fixed cost. Let us assume that the total fixed cost of offshore outsourcing for a final goods producer in the North is F_O. This consists of search cost, cost of writing a contract etc.

Recall from (4) that the inverse demand function facing a final good producer with productivity α is

$$p(\alpha) = \left[\frac{x(\alpha)}{A'}\right]^{-1/\sigma} = \left[\frac{\alpha y(\alpha)}{A'}\right]^{-1/\sigma} \tag{13}$$

Since the payment that is going to be made to the input producer is only $\beta p(\alpha)x(\alpha)$, we can write the input producer's objective function once she has decided to provide the input as:

$$\pi_I(\alpha) = \beta p(\alpha)x(\alpha) - \phi w_S y(\alpha) = \beta A'^{1/\sigma}(\alpha y(\alpha))^{\frac{\sigma-1}{\sigma}} - \phi w_S y(\alpha) \tag{14}$$

Maximizing this objective function with respect to $y(\alpha)$ gives us

$$y(\alpha) = A' \, (\phi w_S)^{-\sigma} \, (\frac{\sigma}{\sigma-1})^{-\sigma} \beta^{\sigma} \alpha^{\sigma-1} \tag{15}$$

Plugging the above back into the inverse demand function, we get the equilibrium price of the final product under outsourcing as

$$p_O(\alpha) = \frac{\sigma \phi w_S}{(\sigma-1)\beta\alpha} \tag{16}$$

The final goods producer's total profits can now be given as

$$\pi_O(\alpha) = (1-\beta)p(\alpha)x(\alpha) = (1-\beta)A' \, (\phi w_S)^{1-\sigma} \, (\frac{\sigma}{\sigma-1})^{1-\sigma} \beta^{\sigma-1} \alpha^{\sigma-1} \tag{17}$$

Note from the above expression that the level of β that maximizes the profit of final goods producers equals $\frac{\sigma-1}{\sigma}$. Therefore, if $\beta < \frac{\sigma-1}{\sigma}$ it would be in the interest of the final good producer to write a contract committing to give the input producer a share $\beta = \frac{\sigma-1}{\sigma}$ of the revenue. Thus, in the analysis below we restrict our attention to the case of $\beta \geq \frac{\sigma-1}{\sigma}$. Formally,

Restriction 1 : $\beta \geq \frac{\sigma-1}{\sigma}$

2.3 Equilibrium

2.3.1 Homogeneous firms case

Let us first discuss the equilibrium of the model for the homogeneous firms case where productivity $\alpha = \widehat{\alpha}$ for all firms. Later we will derive implications of firm heterogeneity. The expression for the benefit from offshoring, gross of fixed costs, for a representative firms is given by

$$\pi_O - \pi_D = A'\sigma^{-\sigma}(\sigma-1)^{\sigma-1}\widehat{\alpha}^{\sigma-1}\left[\sigma(1-\beta)\beta^{\sigma-1}\left(\phi w_S\right)^{(1-\sigma)} - w_N^{(1-\sigma)}\right] \tag{18}$$

A firm offshores if $\pi_O - \pi_D > F_O$. To determine the equilibrium and to see the role of external economies in this case we write the benefit from offshoring for a representative firm when a fraction n of firms offshores as follows.

$$\widetilde{B}(n) = \frac{H\left[\sigma(1-\beta)\left(\frac{\phi w_S}{\beta}\right)^{(1-\sigma)} - w_N^{(1-\sigma)}\right]}{\sigma\left[\left[\left(\frac{\phi w_S}{\beta}\right)^{(1-\sigma)} - w_N^{(1-\sigma)}\right]n + w_N^{(1-\sigma)}\right]} \tag{19}$$

The equilibrium fraction of firms offshoring is given by a solution to the following equation.

$$\widetilde{B}(n) = F_O$$

It is easy to verify that, for a constant ϕ, we get $\widetilde{B}\ '(n) < 0$ from the above expression. This captures the competitive effect of offshoring. As a firm moves from domestic input production to offshoring, its marginal cost of production and hence the price it charges decreases, which decreases the aggregate price index. The profit and hence the benefit for an individual firm from offshoring are increasing in the aggregate price index. Therefore, as more and more firms offshore, the benefit from offshoring for the marginal firm keeps decreasing. However, in the presence of external economies the negative competitive effect is opposed by the positive effect coming from an increase in labor productivity in the South since Southern labor productivity is increasing in the number of firms offshoring. Because of these two opposite effects the sign of $\widetilde{B}'(n)$ is ambiguous in the presence of external economies. Due to the ambiguity in the sign of $\widetilde{B}'(n)$, we need to resort to simulations to study the shape of the benefits curve. In the simulations we assume $\phi = be^{-n}$. The plot of $\widetilde{B}(n) - F_O$ with respect to n is shown in Figure 3 where the curve labeled homogeneous is the one for homogeneous productivity[17]. The benefits curve $\widetilde{B}(n)$ is inverted U shaped for a wide range of reasonable parameter values. The equation $\widetilde{B}(n) = F_O$ has a unique solutions in Figure 3 denoted by n_1^*. However, n_1^* is an unstable equilibrium. Since for $n = 1$, $\widetilde{B}(n) > F_O$, $n = 1$ is a stable equilibrium[18] In this stable, interior equilibrium all firms offshore. Whether all firms offshore or only a fraction of firms offshore in a stable interior equilibrium depends on parameters. However, there is another stable equilibrium with $n = 0$ where no firm offshores. Since the benefit from offshoring is below the fixed cost F_O when no firms offshore, the industry could be stuck in a zero offshoring equilibrium.

Thus, we have shown the possibility of multiple offshoring equilibria in the presence of external economies of scale. This has important policy implications. Suppose the initial situation is that given by the curve labeled homogeneous in Figure 3 and no firms are offshoring in the initial equilibrium ($n = 0$). Now the industry is hit by a positive shock. The shock could either be a

[17]The parameters underlying Figure 3 were chosen as follows. $\sigma = 3.8$ is the same as used in Bernard, Eaton, Jensen and Kortum (2003); the southern productivity parameter $b = 1.75$ which along with the Southern wage assumed to be 40% of the Northern wage implies that the effective labor cost in the South is 70% of that in the North when no firm offshores and 26% when all firms offshore. This range of relative labor cost covers the range of estimates of unit labor costs relative to the US in some countries attracting US offshoring business. For example, the unit labor cost in Mexico was 50% of the US level in 2002(van Ark et al. (2005)) while in Ireland it was approximately 45% of the US level in 2005 (Economist, October 19th, 2006).

[18]Stability here is based on what happens when there is a small deviation from an equilibrium. The assumption here is that the benefit exceeding the fixed cost (positive net benefit) leads to more firms offshoring, while when the benefit is less than the fixed cost (negative net benefit), we get a movement away from offshoring.

policy shock or a technological shock. An example of a policy shock in our setting would be a wage subsidy by the South leading to a decrease in w_S. Another type of policy shock could be a tax break in the North which can be captured by introducing a rate of taxation of t on the profits of Northern firms in the model. The examples of technological shock would include a decrease in telecommunication cost reducing the trading cost of importing specialized inputs which is equivalent to a decrease in w_S or an increase in the labor productivity in the South (which would increase ϕ for each n). In all these cases, the curve representing the benefit from offshoring in Figure 3 will shift up. Therefore, a small positive shock can move the industry equilibrium from one with no offshoring to one with a lot of offshoring. Therefore, a small positive shock can have large effects on the volume of offshoring.

The existence of multiple equilibria due to external economies also gives rise to a *lock in* effect of the following kind. Suppose there are two countries in the South: A and B. The firms in the North are offshoring to country A in the initial equilibrium. Now, even if another country B, with the same β, becomes a potential source of offshoring with $w_B < w_A$ (but with same $\phi(.)$ function), no Northern firm has an incentive to switch sources to B as long as $\phi(0)w_B > \phi(n^*)w_A$, where n^* is the fraction of firms offshoring to A in the initial equilibrium.

2.3.2 Equilibrium with heterogeneous firms

Next, we derive the implications of firm heterogeneity in the context of offshoring. The expression for the benefit from offshoring, gross of fixed costs, for a firm with productivity α is given by

$$B(\alpha) = \pi_O(\alpha) - \pi_D(\alpha) = A'\sigma^{-\sigma}(\sigma-1)^{\sigma-1}\alpha^{\sigma-1}\left[\sigma(1-\beta)\beta^{\sigma-1}\left(\phi w_S\right)^{(1-\sigma)} - w_N^{(1-\sigma)}\right]$$

A firm with productivity α will offshore if $B(\alpha) \geq F_O$. Thus, clearly if any firm with productivity α' decides to offshore its production, it must be the case that any other firm with productivity $\alpha'' > \alpha'$ will also offshore. Suppose α_O is the cutoff level of productivity such that firms with $\alpha \geq \alpha_O$ offshore. As mentioned earlier, we denote the distribution function of α by $G(\alpha)$. Now, the benefit of a firm with productivity α from offshoring can be written as

$$B(\alpha, \alpha_O) = \frac{H\alpha^{\sigma-1}\left[\sigma(1-\beta)\left(\frac{\phi(1-G(\alpha_O))w_S}{\beta}\right)^{(1-\sigma)} - w_N^{(1-\sigma)}\right]}{\sigma\left[\left(\frac{\phi(1-G(\alpha_V))w_S}{\beta}\right)^{(1-\sigma)}\int\limits_{\alpha_O}^{\overline{\alpha}}\alpha^{\sigma-1}dG(\alpha) + w_N^{(1-\sigma)}\int\limits_{\underline{\alpha}}^{\alpha_O}\alpha^{\sigma-1}dG(\alpha)\right]} \tag{20a}$$

The equilibrium level of α_O is obtained as a solution to the following equation:

$$B(\alpha_O, \alpha_O) \equiv \widetilde{B}(\alpha_O) = F_O$$

It is easy to verify that $\widetilde{B}(\alpha_O)$ is non monotonic in α_O. Therefore, the possibility of multiple equilibria exists with firm heterogeneity as well. To simplify the analysis in the case of firm heterogeneity, we make a specific distributional assumption on α in the rest of the paper.

Let us index firms by i where $i \in [0,1]$ and arrange them in decreasing order of productivity. We assume the distribution of firm productivities to be uniform $U\left[\underline{\alpha}, \overline{\alpha}\right]$ so that

$$\alpha(i) = \overline{\alpha} - \lambda i \tag{21}$$

where $\lambda \equiv \overline{\alpha} - \underline{\alpha}$, $\alpha(0) = \overline{\alpha}$ and $\alpha(1) = \underline{\alpha}$. With this distributional assumption, the fraction of firms with productivity above $\alpha(n)$ is exactly equal to n. If n firms end up outsourcing their production, they must be the n most productive firms (the n firms with the highest α's). Now, the n^{th} firm's benefit from outsourcing when the first n firms have outsourced is given by

$$B(n,n) = \frac{H\alpha(n)^{\sigma-1}\left[\sigma(1-\beta)\left(\frac{\phi w_S}{\beta}\right)^{(1-\sigma)} - w_N^{1-\sigma}\right]}{\sigma\left[\left(\frac{\phi w_S}{\beta}\right)^{(1-\sigma)}\int\limits_0^n \alpha(j)^{\sigma-1}dj + w_N^{1-\sigma}\int\limits_n^1 \alpha(j)^{\sigma-1}dj\right]} \tag{22}$$

Numerical simulations using uniform distribution show an inverted U-shape for the net benefit from outsourcing. An implication of firm heterogeneity is that an increase in heterogeneity makes no offshoring equilibrium less likely. To see this, start with an industry with homogeneous firms which is stuck in a no offshoring equilibrium. Now, an increase in heterogeneity (mean-preserving spread) implies that it is likely that some high productivity firms will find it profitable to offshore even when no other firms in the industry are offshoring. Once a handful of firms offshore, it will have a cascade effect leading to an equilibrium with a lot of offshoring. Therefore, *ceteris paribus,* industries with high degree of firm heterogeneity are less likely to be stuck in a no offshoring equilibrium. This result is verified in Figure 3 where the curve labeled heterogeneous is the plot of $\widetilde{B}(n) - F_O$ for heterogeneous productivity with other parameters held the same as in the case of the curve with homogeneous productivity[19]. There is a unique stable interior equilibrium in the heterogeneous productivity case with a fraction 0.53 of most productive firms offshoring, while multiple equilibria obtain in the case of homogeneous productivity.

We can extend our model to allow for both FDI (international vertical integration) and offshore outsourcing. When we allow firms the option of both FDI and offshore outsourcing, numerical simulations provide some interesting results. In particular, FDI by some firms may facilitate outsourcing by others. The assumption here is that the productivity of Southern workers involved in offshored (outsourced or through vertical integration) activity is increasing in the proportion of Northern firms offshoring by either mode (outsourcing or FDI). We allow contracting issues to affect outsourcing but not FDI or international vertical integration.[20] We assume that the fixed cost F_V of FDI is greater than the fixed cost of outsourcing, F_O. For any given configuration of firms doing FDI, offshore outsourcing, and domestic sourcing, firm i chooses the organizational form that maximizes its profit net of fixed costs.

We are able to analyze the consequences of complementarity between FDI and outsourcing as

[19] Under heterogeneous productivity, this shape can be obtained under fairly general distributional assumptions on productivity. For example, when the productivity is assumed to be uniform over $[0, \overline{\alpha}]$, the shape of the net benefit curve is completely independent of $\overline{\alpha}$ (and therefore is also completely independent of the mean and standard deviation of productivity).

[20] This should be treated as a simplification of the more realistic case where contracting issues are important for both (e.g. Antras and Helpman (2004)), however, the incompleteness of contracts affects outsourcing more than vertical integration.

follows. Suppose initially the possibility of FDI does not exist, say due to an explicit restriction by the host country, however, outsourcing is permitted. Due to the existence of multiple equilibria, the industry may be trapped in a zero outsourcing equilibrium. Now, if FDI is allowed and some high productivity firms find it individually optimal to do FDI even if no other firms do FDI, then we get an equilibrium where some high productivity firms are doing FDI while others that are somewhat less productive are doing outsourcing. The possibility of FDI, through external economies generated, makes a substantial amount of offshoring feasible[21]. An example of this kind of phenomenon would be the setting up of captive BPO units by several multinationals in India in the early 1990s, e.g. British airways, General Electric etc. which spurred the development of domestic firms like Daksh, ICICI one source, etc. which provide outsourcing services to foreign firms in arm's length transaction.[22]

Introducing some rudimentary dynamics in the model with heterogeneous firms generates some additional implications which are consistent with empirical evidence. Next we turn our attention to the dynamic implications of the model.

[21]See our working paper version Mitra and Ranjan (2005) for numerical examples showing this pattern.

[22]The business of shifting back-office functions offshore began in earnest in the early 1990s when companies such as American Express, British Airways, General Electric, and Swissair set up their own "captive" outsourcing operations in India (Economist, Dec 11, 2003). This "captive" outsourcing is nothing but FDI. In other words, each of these firms set up a wholly owned subsidiary to get their back-office functions done in India. This FDI was followed by the emergence of the provision of these services at arm's length by domestic Indian firms. Additionally, if we look at the type of MNCs that have captive units (for IT enabled services) in India we find that they tend to be the larger (more productive) firms in their respective sectors. Examples of large firms engaging in FDI in India are the following: (1) Banking and Finance - Fidelity, JP Morgan, Bank of America, American Express, HSBC, Standard Chartered Bank, ABN AMRO, Goldman Sachs, Prudential, Morgan Stanley, Deutsche Bank, Lloyd TSB, Lehman brothers. (2) Technology and Telecom - HP, IBM, Dell, Samsung, Honeywell. (3) Automotive and Heavy Machinery: - GM, Ford, Daimler-Chrysler, Hyundai, Caterpillar, Bechtel. (4) Pharmaceuticals/Biotech and Healthcare - Visionhealth source, Eli Lilly, Astra Zeneca, Pfizer.(Source: NASSCOM). For evidence on the complementarity between FDI and offshore outsourcing, we refer the interested reader to the case study by Athreye (2002) on the role of multinational firms in the evolution of the Indian software industry.

3 Dynamic Implications

To analyze the dynamic implications we return to the case of offshore outsourcing. In order to study the dynamic response of firms to a shock, we assume that a firm makes its decision regarding offshoring on the basis of foreign labor productivity, $1/\phi$, in the last period (previous to the present period) which in turn depends on the number of firms that had outsourced by the end of the previous period as follows.

$$\phi_t = \phi(n_{t-1}) = be^{-n_{t-1}}$$

where the last equality follows from our specific functional form.[23] We focus here on the heterogeneous productivity case, since only then do we have something to say about the sequence in which different firms offshore.

Now, suppose the initial situation is that given by figure 4 and no firms are outsourcing in the initial equilibrium ($n = 0$). Now the industry is hit by a positive shock which could be either policy induced or technological. This shifts the benefit from outsourcing curve up. Now, some high productivity firms find it profitable to outsource even if they do not expect any other firm to outsource. The downward sloping dotted lines plotted in figure 4 are the benefit curves drawn for given levels of foreign labor productivity (the productivity based on the number of firms that outsourced by the end of the last period) given as follows.

$$B(n, n_{t-1}) = \frac{H\alpha(n)^{\sigma-1}[\sigma(1-\beta)\left(\frac{\phi(n_{t-1})w_S}{\beta}\right)^{(1-\sigma)} - w_N^{1-\sigma}]}{\left(\frac{\phi(n_{t-1})w_S}{\beta}\right)^{(1-\sigma)} \int\limits_0^{n_t} \alpha(j)^{\sigma-1}dj + w_N^{1-\sigma} \int\limits_n^1 \alpha(j)^{\sigma-1}dj}$$

It is easy to verify that the above is decreasing in n for a given n_{t-1}. The first dotted line shows benefits from outsourcing for different firms, in decreasing order of their productivity, but under the labor productivity corresponding to no outsourcing, i.e $n_0 = 0$. Similarly, the second dotted

[23] Dynamics similar to those we generate can also result from other kinds of frictions, such as adjustment costs that are convex in the number of firms that start offshoring every period.

line is drawn under the assumption that labor productivity in the South equals the level seen under n_1 firms outsourcing, where n_1 is the fraction of firms obtained from the intersection of the F_O curve and the first downward sloping dotted line. It is important to note that even in this dynamic context F_O is not a sunk cost but a fixed cost, that is incurred every period. Algebraically then, for a given n_{t-1}, n_t in each period is obtained as a solution to the following equation.

$$\frac{H\alpha(n_t)^{\sigma-1}[\sigma(1-\beta)\left(\frac{\phi(n_{t-1})w_S}{\beta}\right)^{(1-\sigma)} - w_N^{1-\sigma}]}{\left(\frac{\phi(n_{t-1})w_S}{\beta}\right)^{(1-\sigma)}\int\limits_0^n \alpha(j)^{\sigma-1}dj + w_N^{1-\sigma}\int\limits_n^1 \alpha(j)^{\sigma-1}dj} = F_O$$

This way we will reach the new long-run equilibrium where n^* firms outsource. In this dynamic process of convergence to this new, outsourcing equilibrium, it is interesting to note that initially, a small number of the most productive firms outsource. This triggers outsourcing by a larger and larger number of less productive firms. The process then ends with smaller and smaller number of relatively less productive firms outsourcing until we reach our new steady state equilibrium where the n^* most productive firms have outsourced. Therefore, a small shock can take the industry/economy from a no outsourcing equilibrium to one with a large amount of outsourcing. Note that due to multiple equilibria a small shock will have a large effect even in the case with no heterogeneity in productivity. The difference in the heterogeneous productivity case comes from the fact that the timing of the outsourcing decision is correlated with firm productivity. That is more productive firms outsource first, while others follow later. This is an empirical prediction of the model which can be tested using data. Therefore, firm heterogeneity gives a deterministic sequential process of outsourcing within an industry. As mentioned earlier, case study evidence is consistent with this dynamic pattern of outsourcing.

Next we explore the dynamic implications of a temporary shock. In this case, there is a temporary shift in the benefit from outsourcing shown in figure 5. In the figure the shock lasts for 3 periods. Again the sequence of dynamics, starting from the most productive and ending with the least productive, is the same. Such temporary shocks can move us from the no-outsourcing equilibrium to the outsourcing equilibrium. In other words, these dynamics show that while outsourcing can be brought about by tax breaks and subsidies, it cannot be reversed by reversing these policies. Thus temporary policies can have permanent effects in our model.

As mentioned in the introduction, an example of a temporary shock would be the Y2K problem which led a lot of firms to outsource their IT related jobs to India. The amount of IT related jobs outsourced to India kept increasing well after the Y2K problem became a thing of the past.

4 Welfare Implications of Offshore Outsourcing

Recall from (5) that a Northern representative agent's indirect utility function is $V^N = \frac{1}{1-\sigma} \ln A + I^N - 1$. In other words, welfare of this agent is decreasing in A (since $\sigma > 1$), where A is the price index of the differentiated goods. Also, it is increasing in her income I^N. Using A_{NO} and A_O to denote the price indexes in the no offshoring and offshoring case, respectively, it can be shown that

$$\frac{A_{NO}}{A_O} = \frac{(\phi(n^*)w_S/\beta)^{(1-\sigma)} \int_0^{n^*} \alpha(j)^{\sigma-1} dj + (w_N)^{(1-\sigma)} \int_{n^*}^{1} \alpha(j)^{\sigma-1} dj}{(w_N)^{(1-\sigma)} \int_0^1 \alpha(j)^{\sigma-1} dj} \tag{23}$$

Next, from (18) in order for a firm to prefer outsourcing over domestic sourcing the following must be true:

$$\sigma(1-\beta)\left(\frac{\phi w_S}{\beta}\right)^{(1-\sigma)} > w_N^{1-\sigma} \tag{24}$$

which in turn, in the presence of Restriction 1 ($\beta \geqq \frac{\sigma-1}{\sigma}$) implies$\left(\frac{\phi w_S}{\beta}\right) < w_N$. Thus, from (23), the aggregate price index is lower in an outsourcing equilibrium compared to the no offshoring case: $A_O < A_{NO}$. The next determinant of welfare is income I^N which is the sum of wage income and profits. Denote the total amount of labor in the North by L^N. Wage income $\frac{w_N L^N}{H^N}$of a representative individual remains unchanged when we move from domestic sourcing to offshore outsourcing, while her profits change. Using (12) into which we plug in the value of A' in terms of H and unit costs, we find that $\frac{H}{\sigma}$ is the aggregate profit in the case of no offshore outsourcing (and $\frac{H}{\sigma H^N}$ the representative agent's profit). The aggregate gross profit is unchanged ($\beta = \frac{\sigma-1}{\sigma}$) or goes down ($\beta > \frac{\sigma-1}{\sigma}$) in the outsourcing equilibrium compared to the no outsourcing case. This can be verified by using equation (17) into which we plug in the value of A' in terms of H and unit costs. The net aggregate profit must be lower in outsourcing equilibrium because of the fixed cost of outsourcing. Therefore, the income of the representative agent, I^N, decreases upon offshoring. Thus, the net impact on welfare depends on the relative strengths of the positive effect arising from a lower aggregate price index and the negative effect from a decline in income. It is easy to verify that if the fixed cost of offshoring is small or the wage in the South is small, then the welfare of the representative agent increases in the North.

While offshoring leads to a reduction in aggregate net profits, it is possible for some high productivity Northern firms to gain. Since the firms that are unable to offshore charge the same price they would have charged when offshoring was not allowed and since A' (which is a measure of market size for each firm) becomes smaller due to lower prices charged by offshoring firms, the fully domestic firms now make lower profits. When $\beta = \frac{\sigma-1}{\sigma}$, since the aggregate gross profit remains unchanged, the gross profits of some high productivity offshoring firms must increase (if every firm does not end up offshoring in equilibrium). However, their profits net of the fixed costs of offshoring may or may not increase. Even among the offshoring firms, there are always some (the least productive ones) that lose and depending on parameters it is possible that there are others (the most productive ones) that ultimately may gain from offshoring.

From the case of heterogeneous firms, if we move to homogeneous firms, it is easy to see that all firms lose in an offshoring equilibrium as compared to a no-offshoring equilibrium. Thus there is a prisoner's dilemma problem here. Also in the heterogenous case, if in equilibrium all firms end up offshoring it is easy to show that each of these firms ends up losing.

Next, it is easy to verify that the Southern welfare increases unambiguously because of two reasons: lower prices of differentiated goods and a part of the surplus captured by the input producing firms which didn't exist in the no offshoring case. Therefore, we conclude that while consumers in both the North and South gain from offshoring, the impact on the net (of fixed costs) aggregate profits of firms in the North is negative in the logarithmic utility case.

Before ending this section, it should be noted that the results on the aggregate gross profit remaining unchanged for $\beta = \frac{\sigma-1}{\sigma}$ or decreasing for $\beta > \frac{\sigma-1}{\sigma}$ is a consequence of the logarithmic utility function which fixes the total expenditure on differentiated goods to unity. In general, if the demand for the aggregate of differentiated goods is price elastic then the total expenditure on differentiated goods will increase after offshoring leading to an increase in the aggregate gross profit. In the opposite case of an inelastic demand, there would be a decrease in the gross aggregate profit upon offshoring. It is possible for the aggregate profit net of the fixed cost of offshoring to go down even in more general cases.

5 Concluding Remarks

In this paper, we present a model of offshoring in the presence of externalities and firm heterogeneity. We show that the incorporation of externalities in a general equilibrium model of offshoring yields some interesting insights. The externalities give rise to multiple offshoring equilibria. Due to the presence of externalities, temporary shocks like the Y2K problem can have permanent effects, i.e., they can permanently raise the extent of offshoring in an industry. Moreover, the initial advantage of a country as a potential host for outsourcing activities can create a lock in effect, whereby late movers have a comparative disadvantage. Also, the existence of firm heterogeneity along with externalities can help explain the dynamic process of offshoring where the most productive firms offshore first and others follow later. Furthermore, there exists the possibility of complementarity between two modes of offshoring: FDI and offshore outsourcing. Finally, we work out in detail some unexpected, but fairly intuitive, welfare implications of offshoring. Consumers in both the North and the South gain, while the profits of Northern firms can actually go down as a result of outsourcing. The South also gains from getting a share in Northern profits upon offshoring.

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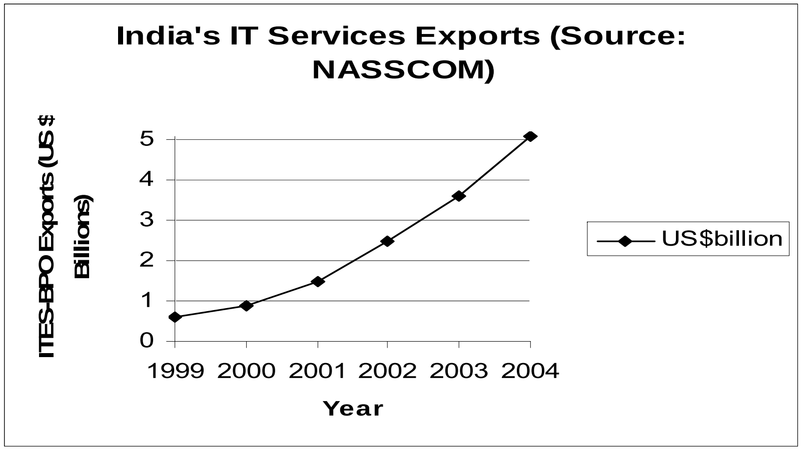
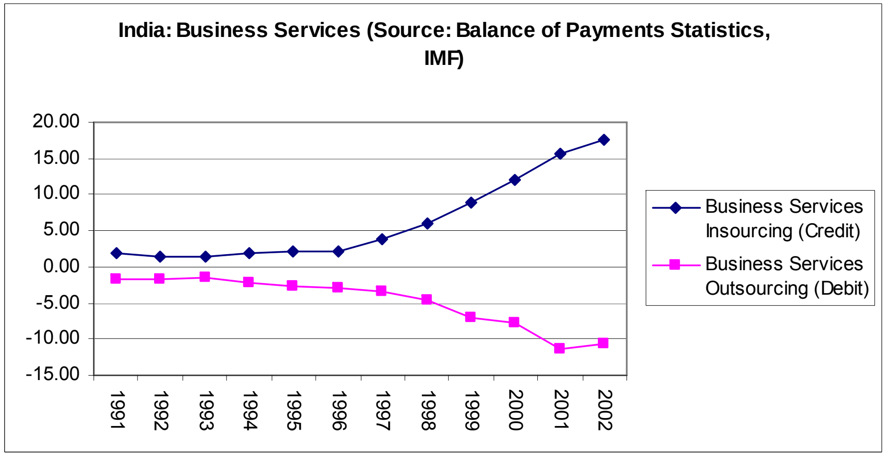
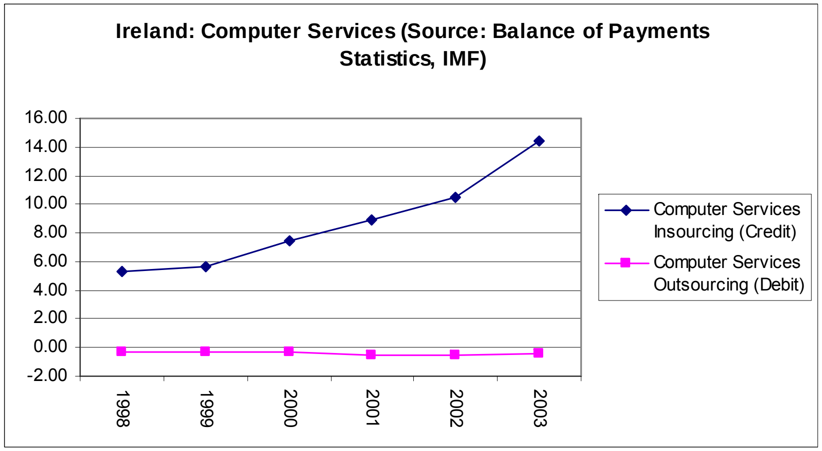
Figure 1:Export and Import of Services by India and Ireland (in billions of US dollars)







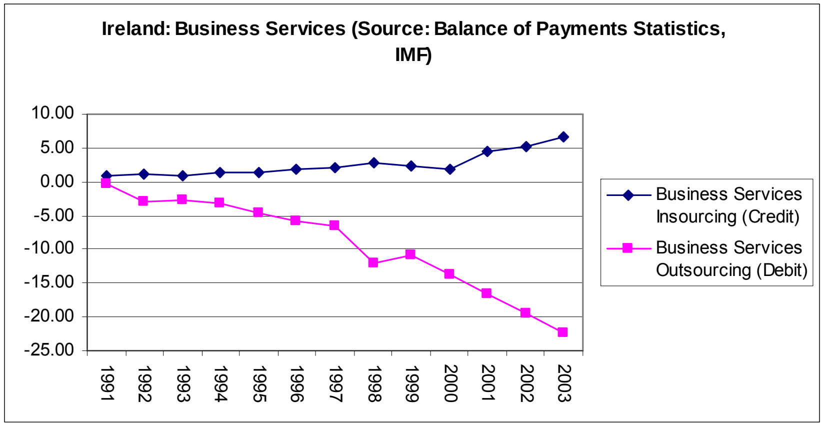
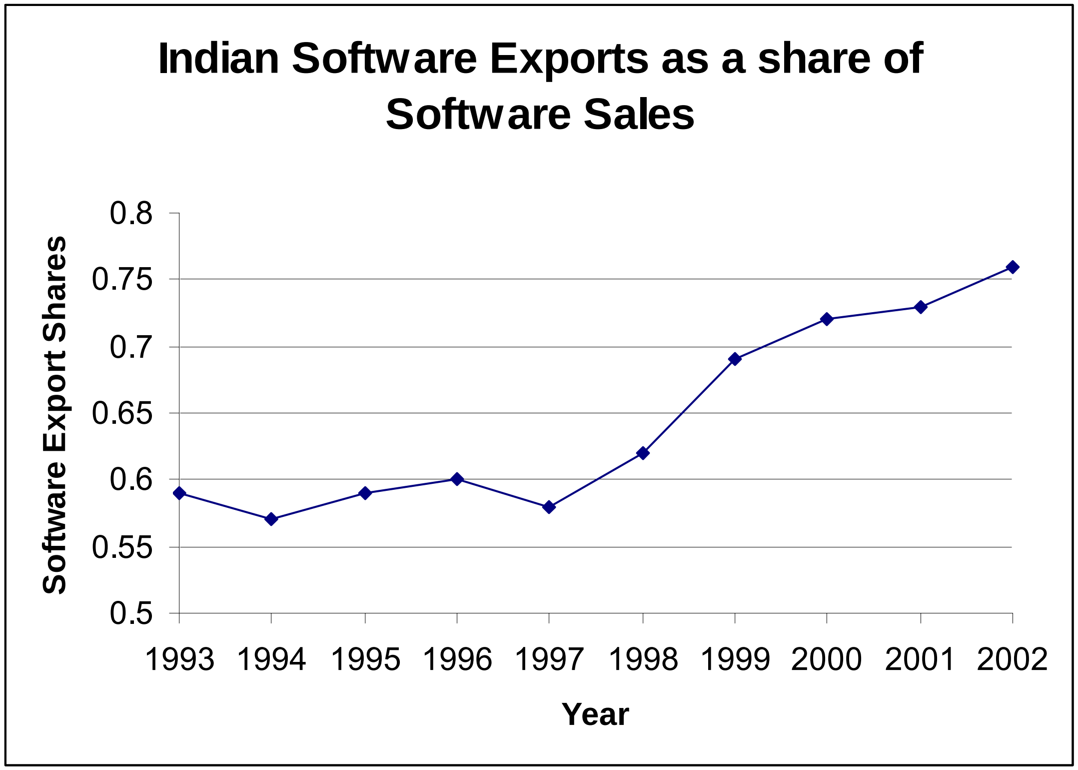
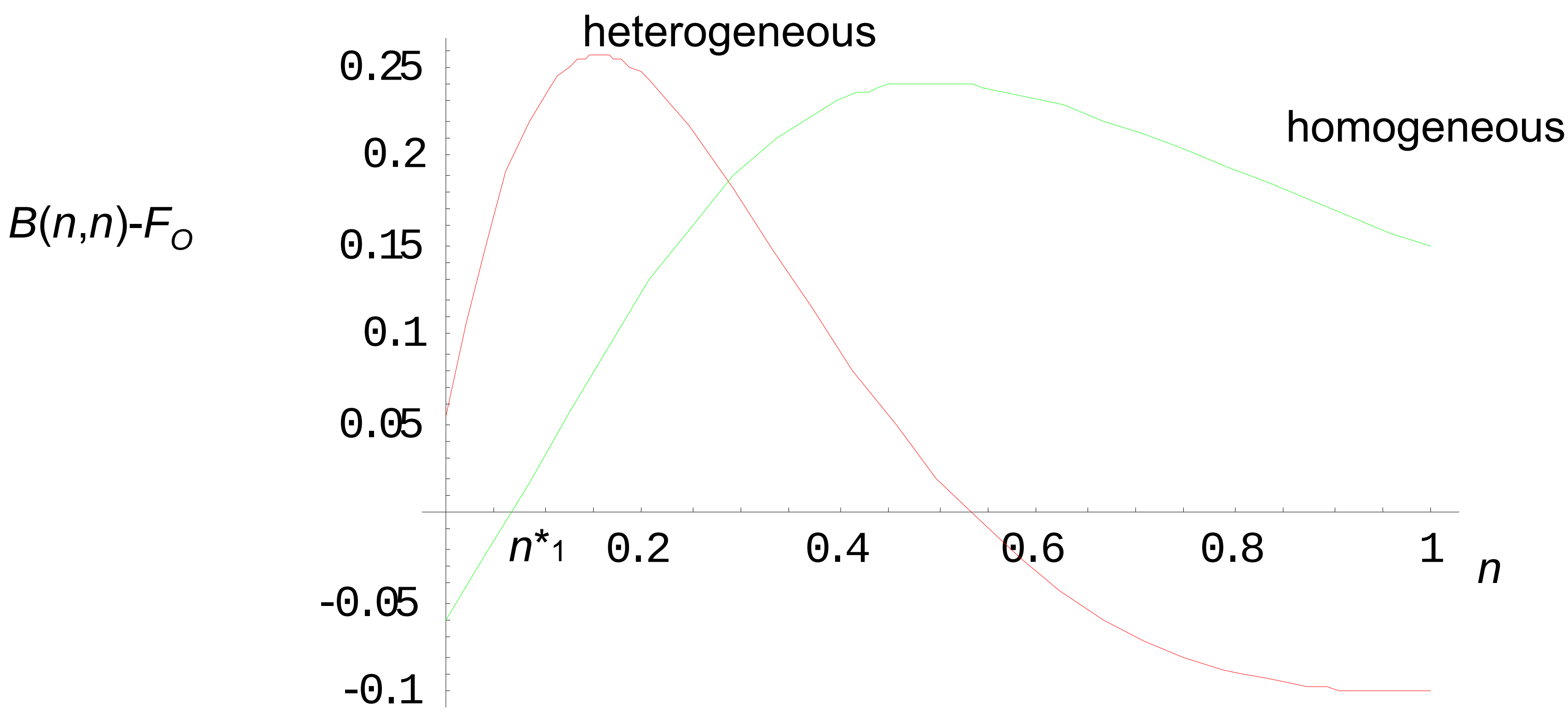


Figure 2: Indian software exports as a share of software sales



Source: Arora and Gambardella (2005)

Figure 3:Equilibria with and without firm heterogeneity



Parameters: Parameters: F_O =.1,σ =3.8, b =1.75,w_S =.4,w_N =1, β=(σ-1)/σ
Heterogeneous productiivty: uniform over $[0,\bar{\alpha}]$ where $\bar{\alpha} \in (0,\infty)$

Figure 4: Dynamics after a permanent shock

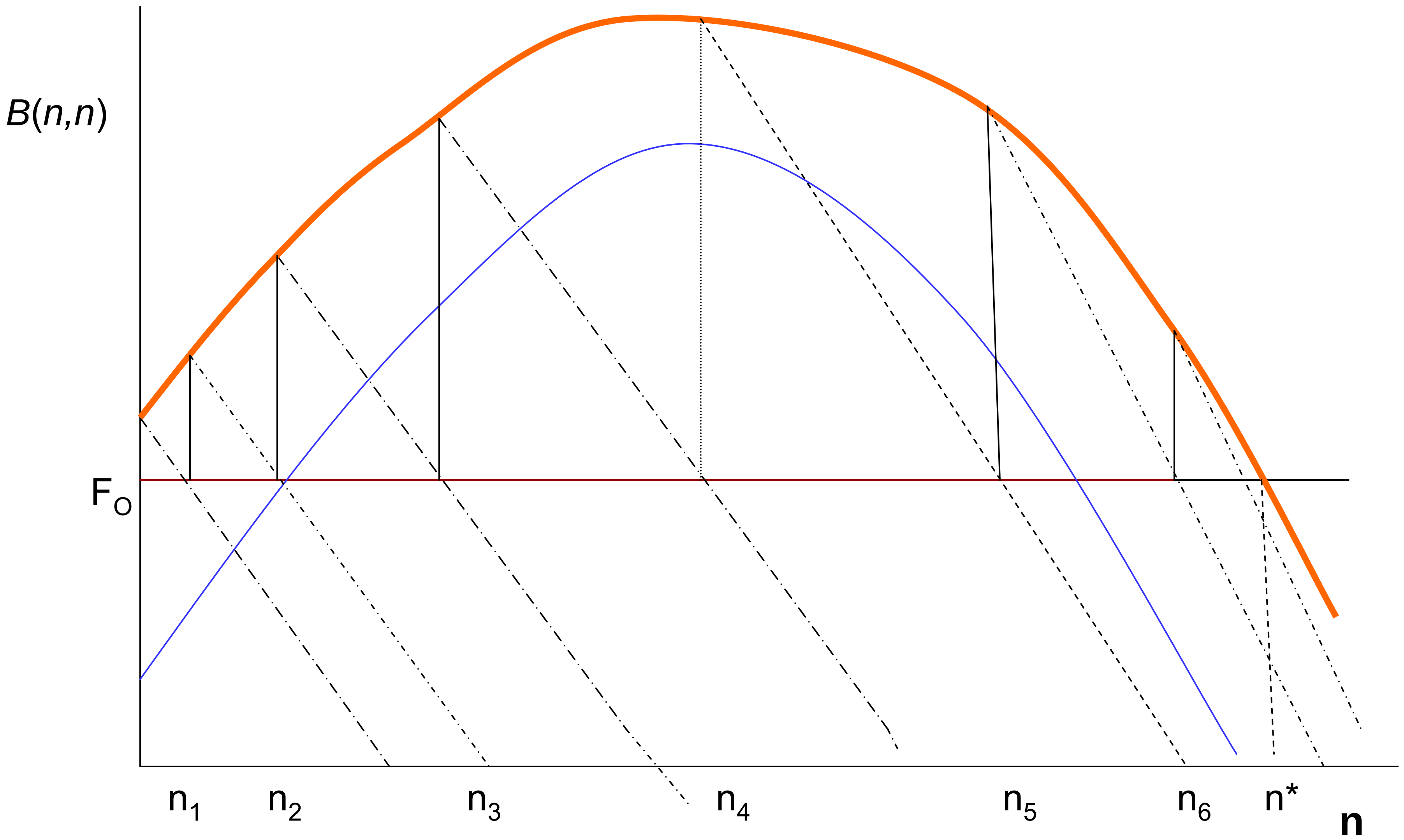


Figure 5: Dynamics after a temporary shock