Y2K and Offshoring: The Role of External Economies and Firm Heterogeneity*

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Abstract

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 show the possibility of complementarity between two modes of offshoring: FDI and offshore outsourcing.

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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. The key questions here are: (1) What type of firms offshore and which among them actually outsource? (2) What industry characteristics result in the incentives to offshore and outsource? Recent work by Grossman and Helpman (2002, 2003 and 2005), Antras (2003) and Antras and Helpman (2004) have provided us with deep insights into these issues.

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. Grossman and Helpman, in that paper, 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.[1]

What remains unanswered is what starts this process of offshore outsourcing, and thereafter what determines its dynamics. 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).[2] 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. Bresnahan, Gambardella and Saxenian (2001), in their case studies of the "new silicon valleys" in India, Israel, Ireland and China clearly recognize "external effects among the technology firms located there" as a central feature of their activities. They define a local external effect as "anything that raises the return to particular firms located in a region as a result of the location of other firms in the same region." They believe that such effects are direct and indirect. While direct effects take place "when managers and technologists learn about market or technical

[1] For a simple overview, within a unified framework, of the property rights approach applied to international trade settings and its insights, see Antras (2005).

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

developments from colleagues in neighboring firms, when firms in closely related industries serve as one another's suppliers and so on," indirect effects "arise from increasing returns to scale in the supply of key inputs", a "thick labor market" etc. 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.[3] This increase in productivity in the presence of rising employment and output in this industry should be indicative of at least some industry-level increasing returns to scale.[4, 5]

In our analysis, we incorporate these external economies.[6] Northern firms choose between

[3] See Athreye (2004).

[4] Arora and Gambarella (2004), in their case study of the Indian software industry, write "In addition to the standard benefits from specialization according to comparative advantage, one must also reckon the benefits from increasing returns to scale and from possible productivity increases as Indian firms learn and gain experience." They further write "Moreover, the growth of the software industry has provided the basis for the growth of a new entrepreneurial model, which has in turn had spillovers for related activities, such as business services and even some types of R&D tasks." They also mention the possibility of "spillovers or scale economies, associated with agglomeration of human capital".

[5] Another source of external economies is labor market pooling. The importance of labor-market pooling in the Indian software industry also needs to be emphasized. Balasubramaniam (2004) mentions a survey of 52 software firms in Bangalore, India in which almost 50% believed that the availability of high-tech professionals and the presence of research institutes was the most important reason for their decision to locate there. In his case study of the Bangalore cluster, he emphasizes the extreme importance of the "Marshallian type scale economies or externalities". The reason, according to him why most young software engineers like to work in Bangalore is not better employment opportunities but "the opportunity to commune with other software engineers located in the city". This provides them with opportunities to remain up to date with the latest scientific developments and learn from each other. Also, turnover rates of employees are reported to be as high as 30 percent, which promote knowledge spillovers in the industry.

[6] In a series of papers, Eaton and Panagariya (1979) and Panagariya (1980, 1981, 1986a and b) analyze the positive and normative implications of introducing external economies in different types of trade models. Ethier (1982) provides microfoundations for external economies based on division of labor through the expansion of the market for nontradable, differentiated inputs whose production is subject to firm-level increasing returns to scale. An application of this approach is a model with two final goods - a high-tech good (produced using nontradable, differentiated inputs in turn produced under firm-level increasing returns to scale) and a low-tech good (produced

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.[7] While in one model, we allow offshoring to take place within each firm, in the second, in place of FDI, we allow for true offshore outsourcing with the problem of incomplete contracts between the final output firm and the input supplier fully modeled, as in the work of Grossman and Helpman (2002, 2003 and 2005), Antras (2003) and Antras and Helpman (2004). We present also a third model where we allow both FDI and offshore outsourcing (in addition, of course, to the domestic production of inputs). We assume in that model that Southern productivity in input production increases in aggregate FDI and outsourcing, resulting in a complementarity between the two forms of offshoring.

In our models, due to the externalities in the production of inputs, there are multiple equilibria - a no offshoring/outsourcing equilibrium and another with offshoring/outsourcing 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/outsourcing equilibrium to one with a substantial amount of offshoring/outsourcing, 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 North, the first to offshore are the most productive

using capital and labor under constant returns to scale), in Rodrik (1996). In that model, he finds the possibility of the existence of coordination failures (multiple equilibria), which can be tackled using investment subsidies or a minimum wage policy. Similar arguments using a similar model have been made independently by Rodriguez-Clare (1996a).

[7] Several recent papers such as Bernard, Eaton, Jensen and Kortum (2003), Eaton, Kortum and Kramarz (2004), Melitz (2003) and Melitz and Ottaviano (2005) 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. See also Yeaple (2005).

firms, followed by the next most productive ones and so on.

The dynamics generated in our model are roughly consistent with the numbers shown in the table below. A temporary or a permanent shock in the example we work out leads to acceleration in offshoring until about the middle of the process and then things start slowing down as we approach the new steady state.

Table: Growth of Indian ITES-BPO Exports

Year	US$billion	growth rate
1999-00	0.6	
2000-01	0.9	64.6%
2001-02	1.5	60.8%
2002-03	2.5	67.2%
2003-04	3.6	44.0%
2004-05	5.1	41.7%

Source: NASSCOM

We believe that the main feature, to be taken really seriously, 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.[8] 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 us 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.[9] As we see from these charts, the growth in these exports has not been reversed in India or in Ireland so far even though the Y2K and the dotcom

[8] 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.

[9] The source of the data for this figure is Arora and Gambardella (2005). While table 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.

were temporary shocks, and the tax breaks to insourcing into Ireland were very partially reversed in response to protests from other European countries. Another interesting thing to note here is that outsourcing (imports) of these services from these countries to other countries shows a declining trend during the same period, probably confirming our belief regarding positive external economies due to which the dependence of these countries on foreign computer and business services declined.

Another result in our paper, which we find interesting, is the one that looks at the implications of the complementarity between FDI and outsourcing. Let us suppose that we are stuck in the "no outsourcing" equilibrium to begin with when firms are not allowed the option of FDI. When the option of both FDI and offshore outsourcing are available, we move to an equilibrium in which FDI and outsourcing are going on at the same time in addition to full domestic production by some firms.[10] Also, in equilibrium high productivity firms do FDI while somewhat lower productivity firms do outsourcing. The least productive firms procure their inputs domestically. These results are also consistent with our experience in recent years. 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

[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.

[10] Patibandla and Peterson (2002) argue that the increase in labor productivity in the Indian software industry has happened through learning and spillover effects of multinational enterprises in this industry, Athreye (2004) considers this to be conscious R&D and investment in physical capital in response to a labor shortage. In any event, this increase in productivity is significant and in the presence of a rapid increase in overall output, we do not believe we can rule out economies of scale at the industry level.

sectors.[11]

In this context of complementarity between FDI and offshore outsourcing, it is useful to mention the case study by Athreye (2002) on the role of multinational firms in the evolution of the Indian software industry. She discusses two ways in which the multinationals contributed to an overall increase in productivity in this industry. She argues that while their direct contribution was in pioneering business models that Indian firms successfully imitated, their indirect contribution was through the creation of labor shortages and through that "the emergence of a professional 'culture' which put the onus of retaining competitiveness upon organizational learning and the development of distinctive capabilities by domestic firms." A subsidiary of Citibank, namely Citibank Overseas Software, which was established in India to carry out Citibank's worldwide computerization showed actual and potential domestic firms "the possibility of offshore computerization with the main software written in India and travelling to onsite locations only to implement the computerization." Also, the "repeatability of certain aspects of computerization" was an attractive feature that added to the profitability of the industry. Similar knowledge also flowed from the Indian subsidiary of Texas Instruments. Infosys and Tata Consultancy Services (TCS) were the first domestic firms to incorporate this offshoring model of doing business with tremendous success.[12, 13]

Finally, it is important to mention the paper by Markusen and Venables (1999) that is related

[11] 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

[12] In addition, Arora and Athreye (2002) provide examples of how innovative models of organization and entrepreneurship from the software industry are spreading to other sectors of the Indian economy. This an economywide productivity spillover.

[13] See also 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 effects of outsourcing from the North to the South on Northern innovation is analyzed by Glass and Saggi (2001). Also, see Sener and Sayek (2004).

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.[14], [15] 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 at both FDI and offshore outsourcing (with incomplete contracting between the Northern final output and Southern input firms) separately and then together, analyzing the complementarities between the two modes of offshoring. 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. Finally, 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 where firms have a choice between producing an essential input domestically or procuring it from abroad. Offshoring, in that basic model, does not involve any contracting costs, therefore, it can be viewed as FDI. In section 3 we capture offshore outsourcing (with contracting costs) using an incomplete contracts framework. In section 4 we derive some dynamic implications of the model. In section 5 we let firms choose between FDI and offshore outsourcing, and show complementarity between the two. Section 6 concludes.

[14] 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.

[15] 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.

2 The Model

2.1 Consumption

Let us assume the following utility function for a representative consumer in a typical Northern country:

$$U = \frac{\sigma}{\sigma - 1} \ln \left[\int_0^1 x(i)^{\frac{\sigma-1}{\sigma}} di \right] + x_N, \qquad \sigma > 1 \tag{1}$$

where $x(i)$ is the consumption of the non-numeraire good i and x_N is the consumption of the numeraire good. We assume there is a continuum of non-numeraire goods and we normalize this measure of the different types of these goods to unity. The above utility function results in the following demand function for good i:

$$x(i) = \frac{p(i)^{-\sigma}}{\int_0^1 p(i)^{1-\sigma} di} \tag{2}$$

Let $\left[\int_0^1 p(i)^{1-\sigma} di \right]^{-1} \equiv A$, which we assume is taken as given by each firm but will be determined in equilibrium. Therefore, the inverse demand function facing each firm can be written as

$$p(i) = \left[\frac{x(i)}{A} \right]^{-1/\sigma} \tag{3}$$

2.2 Production

Suppose that one unit of the numeraire good requires one unit of labor. Therefore, the wage rate is 1.

Let us assume that for each of the non-numeraire goods above, one unit of a specialized input, $y(i)$, produces $\alpha(i)$ units of the final good. Thus $\alpha(i)$ is the productivity of firm i in final good production, which, for example, may reflect the quality of management in that firm. We represent this relationship by the following production function:

$$x(i) = \alpha(i)y(i) \tag{4}$$

The input can either be produced domestically in the North or can be obtained from (produced in) a foreign country called the South. Suppose 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 1. We do not allow for domestic outsourcing. We assume that domestic production of the specialized input is done only through vertical integration because our focus is on the possible offshoring of input production either through foreign direct investment (FDI) or through offshore outsourcing. The unit cost of the ith non-numeraire good when the input is produced domestically is

$$c(i) = \frac{1}{\alpha(i)} \tag{5}$$

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

$$\pi_D(i) = p(i)x(i) - \frac{x(i)}{\alpha(i)} = A^{1/\sigma}x(i)^{\frac{\sigma-1}{\sigma}} - \frac{x(i)}{\alpha(i)} \tag{6}$$

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

$$x(i) = A\left(\frac{\sigma-1}{\sigma}\right)^{\sigma}\alpha(i)^{\sigma} \tag{7}$$

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

$$p_D(i) = \frac{\sigma}{\alpha(i)(\sigma-1)} \tag{8}$$

The equilibrium, maximized profits for such a firm is

$$\pi_D(i) = A\sigma^{-\sigma}(\sigma-1)^{\sigma-1}\alpha(i)^{\sigma-1} \tag{9}$$

Assume that in the South $\phi(n) > 1$ units of labor are required to produce a unit of specialized input, where n is the fraction of firms offshoring to the South. That is, the Northern labor is

$\phi(n) > 1$ times as efficient as the Southern labor in input production, $\phi'(n) < 0$ captures the externalities in the production of inputs in the South[16]. 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 $w < 1$ because one unit of labor in the South can produce w units of the numeraire good. As long as $\phi w < 1$, which is what we assume throughout the paper, the South has a comparative advantage in the production of the specialized inputs.[17]

Let F_V be the the firm-level fixed cost of offshoring production to the South. We assume this fixed cost to be the same across all firms. We first analyze the case in which there are no contracting costs of offshoring, and therefore, can be viewed as foreign direct investment (FDI). With offshoring of the specialized input to the South (but with management in the North), the unit cost becomes:

$$c^o(i) = \frac{\phi w}{\alpha(i)} = (\phi w)\, c(i) \tag{10}$$

Therefore, the maximized profit of a firm offshoring the production of specialized input is given by

$$\pi_V(i) = A\sigma^{-\sigma}(\sigma-1)^{\sigma-1}\,(\phi w)^{1-\sigma}\,\alpha(i)^{\sigma-1} \tag{11}$$

[16] 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.

In appendix B we provide a slightly different model where externality arises due to presence of economies of scale in the training of workers in the South. In this case, the training cost per worker ϕ is decreasing in the number of workers producing the specialized input in the South. The qualitative results are the same.

[17] However, all these inputs are not always imported by the North from the South due to the fixed costs of offshoring.

2.3 Equilibrium

The expression for the benefit from offshoring, gross of fixed costs, for firm i is given by

$$B(i) = \pi_V(i) - \pi_D(i) = \frac{\alpha(i)^{\sigma-1}\{(\phi w)^{(1-\sigma)} - 1\}}{\sigma\left[(\phi w)^{(1-\sigma)} \int\limits_{j\epsilon V} \alpha(j)^{\sigma-1}dj + \int\limits_{j\epsilon NV} \alpha(j)^{\sigma-1}dj\right]} \tag{12}$$

where V represents the set of firms that have offshored using FDI (international vertical integration) as the mode and NV is the set of firms that have not offshored. Firm i will offshore if $B(i) \geq F_V$. Thus, clearly if any firm i decides to offshore its production, it must be the case that any other firm j, such that $\alpha(j) \geq \alpha(i)$, will also offshore. In that case, if n firms end up offshoring their production, they must be the n most productive firms (the n firms with the highest α's). Let us then arrange firms in decreasing order of productivity. We assume the distribution of firm productivities to be uniform $U\left[\underline{\alpha}, \overline{\alpha}\right]$ so that

$$\alpha(i) = \overline{\alpha} - \lambda i \tag{13}$$

where $\lambda \equiv \overline{\alpha} - \underline{\alpha}$, and $\overline{\alpha}$ and $\underline{\alpha}$ are the highest and lowest levels of firm productivity. In that case, firm i's benefit from offshoring when the n most productive firms have offshored is given by

$$B(i,n) = \frac{\alpha(i)^{\sigma-1}\{(\phi w)^{(1-\sigma)} - 1\}}{\sigma\left[(\phi w)^{1-\sigma} \int\limits_0^n (\overline{\alpha} - \lambda j)^{\sigma-1}dj + \int\limits_n^1 (\overline{\alpha} - \lambda j)^{\sigma-1}dj\right]} \tag{14}$$

where the terms under the integral can be expanded to the following

$$\int\limits_0^n (\overline{\alpha} - \lambda j)^{\sigma-1}dj = \frac{(\overline{\alpha})^{\sigma} - (\overline{\alpha} - \lambda n)^{\sigma}}{\lambda\sigma}, \int\limits_n^1 (\overline{\alpha} - \lambda j)^{\sigma-1}dj = \frac{(\overline{\alpha} - \lambda n)^{\sigma} - \underline{\alpha}^{\sigma}}{\lambda\sigma} \tag{15}$$

From the above, we can write

$$B(n,n) = \widetilde{B}(n) = \frac{\alpha(n)^{\sigma-1}\{(\phi w)^{(1-\sigma)} - 1\}\lambda}{(\phi w)^{(1-\sigma)}\left(\overline{\alpha}^{\sigma} - (\overline{\alpha} - \lambda n)^{\sigma}\right) + (\overline{\alpha} - \lambda n)^{\sigma} - \underline{\alpha}^{\sigma}} \tag{16}$$

It is easy to see that for a constant ϕ, i.e., for $\phi' = 0, \widetilde{B}\ '\ (n) < 0$ [Proof in Appendix A].

When $\lambda \rightarrow 0$, i.e., when we have no heterogeneity in unit costs, the benefit from offshoring can be derived from (12) as follows.

$$\widetilde{B}(n) = \frac{\{(\phi w)^{(1-\sigma)} - 1\}}{\sigma \left\{ \left[(\phi w)^{(1-\sigma)} - 1 \right] n + 1 \right\}} \tag{17}$$

The above expression, under no heterogeneity, but under strong enough external economies in production in the South ($\phi' < 0$ and $|\phi'|$ large enough) results in an upward sloping $\widetilde{B}(n)$ with respect to n [Proof in Appendix A]. Clearly, the above expression is negatively related to n if $\phi' = 0$, i.e., if there are no external economies and $\lambda = 0$, no heterogeneity at the same time.

Thus, while the external economies in production in the South make the benefits curve upward sloping, the heterogeneity, with firms lined up in ascending order of their unit costs (decreasing order of productivity), makes the benefits downward sloping. Thus, in figure 3, we focus on the pure strong external economies case with no firm heterogeneity. With an intermediate level of fixed costs of producing in the South, we see there are multiple equilibria - either no firm offshores or all firms offshore. The benefit is less than fixed costs when $n = 0$ and is greater than fixed costs when $n = 1$. The point of intersection between the F_V and the B curves is an unstable equilibrium. In figure 4, there are no external economies, but there is heterogeneity and firms are arranged in descending order of their productivities. The point of intersection between the F_V and the B curves gives us our unique equilibrium in this case. The n^* most productive firms (the ones with the lowest unit costs) offshore.

Clearly, when we have both firm heterogeneity and external economies in the South, there are two simultaneous forces generated by offshoring. If offshoring is done in decreasing order of firm productivity, then net benefit falls due to this reason but rises due to the external economies generated. When both these forces are present, 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 $\widetilde{B}(n)$ with respect to n is shown in figure 5. This is an inverted U. Figure 5 shows us two equilibria in such a case. In one equilibrium, no firms offshore, i.e., $n = 0$ since fixed costs exceed benefits. n_1^* is an unstable equilibrium, while n_2^* is a stable equilibrium.[18] In this stable, interior equilibrium the n_2^* most productive firms offshore.

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 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.

3 Foreign Outsourcing under Incomplete Contracting

In contrast to the previous section where firms in the North could directly produce the specialized input in the South after incurring a fixed cost F_V, we now instead allow each firm in the North the option to outsource the production of its specialized input to a firm in the South.[19] 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 goods producer who placed the order. Once the input is produced, the payment for it is determined through generalized Nash bargaining[20]. We assume that β and (1-β) are the bargaining weights for the input producer and the final goods producer respectively in this bargaining game. Due to the highly customized nature of 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

[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.

[19] The other option stilll remains the domestic production of the input through vertical integration.

[20] 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.

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.

The production function for the final good remains the same as in the previous section which we recall is

$$x(i) = \alpha(i)y(i) \tag{18}$$

Again the wage in the South is w, while in the North it is 1. As before, we assume that $w < 1$. At home, a unit of labor can produce a unit of the specialized input while in the South $\phi > 1$ units of labor are required to produce a unit of the input.

Recall from (3) that the inverse demand function facing each final good producer is

$$p(i) = \left[\frac{x(i)}{A}\right]^{-1/\sigma} = \left[\frac{\alpha(i)y(i)}{A}\right]^{-1/\sigma} \tag{19}$$

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

$$\pi_I(i) = \beta p(i)x(i) - \phi w y(i) = \beta A^{1/\sigma}(\alpha(i)y(i))^{\frac{\sigma-1}{\sigma}} - \phi w y(i) \tag{20}$$

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

$$y(i) = (\phi w)^{-\sigma} \left(\frac{\sigma}{\sigma-1}\right)^{-\sigma} \beta^{\sigma} A\alpha(i)^{\sigma-1} \tag{21}$$

Plugging the above back into the inverse demand function in (19), we get the equilibrium price of the final product under outsourcing as

$$p_O(i) = \frac{\sigma\phi w}{(\sigma-1)\beta\alpha(i)} \tag{22}$$

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

$$\pi_O(i) = (1-\beta)p(i)x(i) = (1-\beta)\,(\phi w)^{1-\sigma}\,(\frac{\sigma}{\sigma-1})^{1-\sigma}\beta^{\sigma-1}A\alpha(i)^{\sigma-1} \tag{23}$$

The equilibrium, maximized profits for a firm obtaining the specialized input domestically is given by (9).

Therefore, the benefit from offshore outsourcing gross of fixed costs is given by

$$B(i) = \pi_O(i) - \pi_D(i) = \frac{\left[\sigma(1-\beta)\left(\frac{\phi w}{\beta}\right)^{(1-\sigma)} - 1\right]\alpha(i)^{\sigma-1}}{\sigma\left[\left(\frac{\phi w}{\beta}\right)^{(1-\sigma)}\int\limits_{j\epsilon O}\alpha(j)^{\sigma-1}dj + \int\limits_{j\epsilon NO}\alpha(j)^{\sigma-1}dj\right]} \tag{24}$$

where O is the set of firms that have outsourced input production to the South and NO is the set of firms procuring input domestically. Firm i will outsource if $B(i) \geq F_O$. Thus, from the above equation, again clearly if any firm i decides to outsource its production of input, it must be the case that any other firm j, such that $\alpha(j) \geq \alpha(i)$, will also outsource. In that case, 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, firm i's benefit from outsourcing when the first n firms have outsourced is given by

$$B(i,n) = \frac{\left[\sigma(1-\beta)\left(\frac{\phi w}{\beta}\right)^{(1-\sigma)} - 1\right]\alpha(i)^{\sigma-1}}{\sigma\left[\left(\frac{\phi w}{\beta}\right)^{(1-\sigma)}\int\limits_0^n(\overline{\alpha}-\lambda j)^{\sigma-1}dj + \int\limits_n^1(\overline{\alpha}-\lambda j)^{\sigma-1}dj\right]} \tag{25}$$

Thus we can now write

$$B(n,n) = \widetilde{B}(n) = \frac{\alpha(n)^{\sigma-1}\{\sigma(1-\beta)\left(\frac{\phi w}{\beta}\right)^{(1-\sigma)} - 1\}\lambda}{\left(\frac{\phi w}{\beta}\right)^{(1-\sigma)}(\overline{\alpha}^{\sigma} - (\overline{\alpha}-\lambda n)^{\sigma}) + (\overline{\alpha}-\lambda n)^{\sigma} - \underline{\alpha}^{\sigma}} \tag{26}$$

Inspection of (16) and (26) shows the similarity in the two expressions. Again, the presence of external economies causes the net benefit from outsourcing to be increasing in the number of firms up to a point. Numerical simulations show an inverted U-shape for the net benefit from outsourcing in the case of incomplete contracts. Therefore, the results derived earlier for complete contracts go through in this case as well. In figure 6, we present the benefit curves for different values of β. The recent literature on bargaining theory shows that the value of β can depend on the relative negotiating skills or the relative marginal rates of time preference of the bargaining parties. From figure 6, we see that for a large majority of values of n (from 0.36 through 1), the benefit curve under $\beta = 0.5$ (intermediate value) dominates the benefit curves for lower ($\beta = 0.25$) as well as higher values ($\beta = 0.75$) of β. This can be explained using the above profit and benefit expressions for a final output firm in the North, which clearly shows that a higher β has two effects - a negative effect through a lower share for the final output producer in a given joint surplus and a positive effect through a larger joint surplus from higher incentives for input production. Given the fixed cost F_O assumed in figure 6, with $\beta = 0.25$, we have a unique equilibrium of no outsourcing, while in the other two cases with higher values of β, we have multiple equilibria - one stable equilibrium with no outsourcing and another stable, interior equilibrium ($n^* < 1$) where the downward sloping portion of the benefit curve intersects the fixed cost where a fairly large proportion of firms (the relatively more productive ones) outsource. The point of intersection of the upward sloping part of the curve and the fixed cost represents an unstable equilibrium. While the interior, stable equilibrium under $\beta = 0.5$ represents more firms outsourcing than in the same equilibrium under $\beta = 0.75$, the coordination problem is less severe under the latter than under the former in the sense that a smaller minimum number of the most productive firms need to coordinate on the outsourcing to move the industry to the stable, interior outsourcing equilibrium. This minimum number is given by the number of firms corresponding to the unstable equilibrium. In other words, a large share going to the input producers can provide an initial impetus to outsourcing but will not lead ultimately to a lot of outsourcing.

One possible extension here could be endogenizing β. A Northern firm can invest resources in acquiring good negotiation skills or gaining more information about the institutions in the South, which will lead to an increase in its bargaining power, given by $\delta = 1 - \beta$. Let us say the marginal cost of increasing δ is constant. We know that because of the opposing effects created by δ, the benefits, $B(i,n)$, to a Northern firm for a given n are maximized at an interior value of δ. Thus, the benefit function is locally, if not globally, concave in δ. Therefore, with the marginal benefit of δ being downward sloping in the relevant region, its intersection with the constant marginal cost curve will give us the endogenous level of δ. For a given n, a higher productivity of a firm will shift the marginal benefit curve to the right, resulting in different δ's (β's) for different firms, with the more productive final output firms grabbing a higher share in their joint surplus with the input producers. Similarly, a tax break will result in an increase in δ for all firms. While such a break for a given δ, as explained in the next section, leads to an increase in n in the outsourcing equilibrium, the resultant increase in the endogenous δ here will lead to a further increase in n - an indirect effect of the tax break on the extent of outsourcing. For the remainder of the paper, we now revert back to the assumption of an exogenous β.

Next we turn our attention to the dynamic implications of the model.

4 Some Rudimentary Dynamics and Policy Implications

As discussed in the previous section, in the presence of external economies the model exhibits multiple equilibria. This has important policy implications. Since the equilibria in the FDI and outsourcing cases are qualitatively similar, we limit the algebra in this section to that of outsourcing, however, all the qualitative results are valid for FDI as well. Suppose the initial situation is that given by figure 7 and no firms are outsourcing in the initial equilibrium ($n = 0$). Now the industry is hit by a positive shock. In the case of functional form assumed for ϕ ($= be^{-n}$) a positive shock can be captured by a decrease in b. Alternatively, a decrease in w can capture the effect of a subsidy in the South or a reduction in the trading cost of importing inputs from abroad. A tax break in the home country can be captured by introducing a rate of taxation of τ on the profits of Northern firms in the model. This will imply that the benefit from outsourcing is multiplied by (1-τ). Now a decrease in τ will capture the effect of a tax break in the home country. In figure 7, let the light inverse-U shaped curve be the benefit from outsourcing prior to the shock. A permanent shock of any of the above kind shifts the benefit curve permanently to the bold one. The important thing to note is that the benefit from outsourcing for the most productive firm, when no one else is outsourcing, now exceeds the cost of outsourcing. Therefore, some firms will start outsourcing after the shock.

To study the dynamic response of firms to a shock, we assume that a firm makes its decision regarding outsourcing 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.[21] The downward sloping dotted lines plotted in figure 7 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.

$$B(n, n_{t-1}) = \frac{\alpha(n)^{\sigma-1}\{\sigma(1-\beta)\left(\frac{\phi(n_{t-1})w}{\beta}\right)^{(1-\sigma)} - 1\}\lambda}{\left(\frac{\phi(n_{t-1})w}{\beta}\right)^{(1-\sigma)}(\overline{\alpha}^{\sigma} - (\overline{\alpha} - \lambda n_{t-1})^{\sigma}) + (\overline{\alpha} - \lambda n_{t-1})^{\sigma} - \underline{\alpha}^{\sigma}}$$

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 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,

[21] 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.

for a given n_{t-1}, n_t in each period is obtained as a solution to the following equation.

$$\frac{(\overline{\alpha}-\lambda n_t)^{\sigma-1}\{\sigma(1-\beta)\left(\frac{\phi(n_{t-1})w}{\beta}\right)^{(1-\sigma)}-1\}\lambda}{\left(\frac{\phi(n_{t-1})w}{\beta}\right)^{(1-\sigma)}(\overline{\alpha}^{\sigma}-(\overline{\alpha}-\lambda n_{t-1})^{\sigma})+(\overline{\alpha}-\lambda n_{t-1})^{\sigma}-\underline{\alpha}^{\sigma}}=F_O$$

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 large amount 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 8. 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.

5 Complementarity between FDI and outsourcing

When we allow firms the option of both FDI and offshore outsourcing, we get some interesting results, in particular, FDI by some firms may facilitate outsourcing by others. We assume that the fixed cost of FDI is greater than the fixed cost of outsourcing: $F_V > F_O$. For any given configuration of firms doing FDI, offshore outsourcing, and domestic sourcing, firm i chooses the organizational form that maximizes its profit, where the profit in each case is given by the expressions in (9), (11) and (23), respectively. Using(11) and (23), it can be shown that firm i chooses FDI over outsourcing if the following condition is satisfied.

$$A\sigma^{-\sigma}(\sigma-1)^{\sigma-1}\alpha(i)^{\sigma-1}(\phi(n)w)^{1-\sigma}(1-\sigma(1-\beta)\beta^{\sigma-1}) > (F_V - F_O) \tag{27}$$

where n is the fraction of firms offshoring. In order for any firm to prefer FDI over offshore outsourcing when the fixed cost of former is greater than that of latter, it must be the case that $\sigma(1-\beta)\beta^{\sigma-1} < 1$. This is true for any $\sigma > 1$. Also note that the l.h.s of the above expression is increasing in $\alpha(i)$, which simply means that the extra benefit from FDI compared to outsourcing is proportional to firm productivity. Therefore, as productivity declines the extra benefit from FDI shrinks, while the extra cost of FDI is constant. This implies that if firm i with productivity $\alpha(i)$ prefers FDI over outsourcing, then any other firm j, such that $\alpha(j) \geq \alpha(i)$, will also prefer FDI over outsourcing. Moreover, in an equilibrium where both FDI and outsourcing obtain, higher productivity firms will be doing FDI, while lower productivity firms will be doing outsourcing.

A set of sufficient conditions to ensure that some firms are doing FDI while some others are doing offshore outsourcing is

$$\begin{aligned} \overline{\alpha}^{\sigma-1} &> \frac{(\phi(0)w)^{\sigma-1}(F_V - F_O)}{(1-\sigma(1-\beta)\beta^{\sigma-1})} \\ \underline{\alpha}^{\sigma-1} &< \frac{(\phi(1)w)^{\sigma-1}(F_V - F_O)}{(1-\sigma(1-\beta)\beta^{\sigma-1})} \end{aligned}$$

Suppose the fraction of firms doing FDI is denoted by n_V, the fraction outsourcing is n_O, and the total fraction of firms offshoring is $n(= n_V + n_O)$. Now, n_V and n are obtained by solving the following two equations simultaneously.

$$\frac{(\overline{\alpha}-\lambda n_V)^{\sigma-1}(\phi(n)w))^{1-\sigma}(1-\sigma(1-\beta)\beta^{\sigma-1})}{\sigma\left[(\phi(n)w)^{(1-\sigma)}\left(\int_0^{n_V}(\overline{\alpha}-\lambda j)^{\sigma-1}dj+\beta^{\sigma-1}\int_{n_V}^{n}(\overline{\alpha}-\lambda j)^{\sigma-1}dj\right)+\int_n^1(\overline{\alpha}-\lambda j)^{\sigma-1}dj\right]}$$
$$= F_V - F_O \qquad (28)$$

$$\frac{(\overline{\alpha}-\lambda n)^{\sigma-1}((\phi(n)w)^{1-\sigma}\sigma(1-\beta)\beta^{\sigma-1}-1)}{\sigma\left[(\phi(n)w)^{(1-\sigma)}\left(\int_0^{n_V}(\overline{\alpha}-\lambda j)^{\sigma-1}dj+\beta^{\sigma-1}\int_{n_V}^{n}(\overline{\alpha}-\lambda j)^{\sigma-1}dj\right)+\int_n^1(\overline{\alpha}-\lambda j)^{\sigma-1}dj\right]} = F_O \qquad (29)$$

The first equation above is the indifference condition for the n_Vth firm between FDI and offshore outsourcing. The second equation is the indifference condition of the nth firm between offshore outsourcing and domestic sourcing.

Now, 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 discussed in the previous section, 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 remaining firms, the least productive, produce inputs domestically. This result follows straightaway from the results established in the previous paragraph. Below is a numerical example showing this explicitly.

Numerical Example: $\sigma = 4; w = .5; b = 1.5; \overline{\alpha} = 4; \lambda = 1; \beta = .75$. Furthermore, the fixed cost of FDI is .3, while the fixed cost of outsourcing is .1. The net benefits from outsourcing (FDI) for the n^{th} firm when n firms are offshoring are plotted in figure 9. The net benefit from outsourcing is negative as long as the fraction of firms outsourcing is $< .08$, therefore, the initial equilibrium is one with no offshore outsourcing. Instead, if FDI was the only option then the fraction of firms doing FDI would be 0.58.

When both FDI and outsourcing are possible, then the equilibrium fraction of firms doing FDI and outsourcing are found by solving (28) and (29) simultaneously, which turn out to be 0.49 and 0.32, respectively. The remaining 0.19 firms do domestic sourcing. The net benefit of each firm in the final equilibrium when 0.49 firms do FDI while 0.32 firms do outsourcing is shown in Figure 10. It can be seen that the net benefit from FDI is higher than that from outsourcing for firms $i \in [0, .49)$, while the net benefit from outsourcing is higher for $i \in [.49, .81)$. The net benefit from offshoring is negative for firms $i \in [.81, 1]$.

Therefore, the possibility of FDI makes a substantial amount of offshoring feasible. 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.

6 Welfare Implications of Offshoring

So far we have not discussed the welfare implications of offshoring. It is easy to see that the North gains from offshoring because it can get the specialized input at a lower cost from the South. As far as the South is concerned, in the model with FDI as the sole mode of offshoring, the South plays the passive role of location of production for specialized inputs. Since there is no change in the Southern wage consequent upon FDI by the Northern firms, there are no gains for the South. However, in the case of outsourcing, the input suppliers in the South engage in Nash bargaining and hence get a surplus. Therefore, even though workers keep getting a wage of w, the input producers get a surplus which is a source of gain for the South. Moreover, the surplus of input producers is increasing in the Southern productivity $\frac{1}{\phi}$. Thus, the greater the amount of offshoring the greater the gains to the South. Alternatively, one can change the model slightly to allow the workers in the South to bargain with the specialized input producers (integrated vertically with their respective final output producers in the North) over their wage. (Such a model is presented in Appendix B.)

Their wage in the numeraire sector, w, will serve as their reservation wage. In this setting, workers producing specialized inputs will get a higher wage, and therefore, offshoring will provide gains to workers as well. This extension will also capture the empirical regularity of higher wages paid to workers in the South who either work directly for a subsidiary of a multinational or for a specialized input producer who produces under a contract with a multinational firm. (See Appendix B.)

7 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. Finally, we show the possibility of complementarity between two modes of offshoring: FDI and offshore outsourcing.

Appendix A

To Prove: With $\lambda > 0$,for a constant ϕ, i.e., for $\phi' = 0, \widetilde{B}\ '\ (n) < 0$.

Proof: $\widetilde{B}(n) = \frac{\alpha(n)^{\sigma-1}\{(\phi w)^{(1-\sigma)}-1\}\lambda}{\left\{\left[(\phi w)^{(1-\sigma)}\right](\overline{\alpha}^{\sigma}-(\overline{\alpha}-\lambda n)^{\sigma})+(\overline{\alpha}-\lambda n)^{\sigma}-\underline{\alpha}^{\sigma}\right\}}$.

Since $\alpha'(n) < 0$, the numerator is decreasing in n. The derivative of the denominator with respect to n equals

$\left[(\phi w)^{(1-\sigma)} - 1\right] \sigma\lambda(\overline{\alpha} - \lambda n)^{\sigma-1} > 0$. Therefore, $\widetilde{B}'(n) < 0$.

To Prove: With $\lambda = 0$, $\phi' < 0$, and with external economies fairly strong , we have $\widetilde{B}'(n) > 0$.

Proof: In this case, $\widetilde{B}(n) = \frac{\{(\phi w)^{(1-\sigma)}-1\}}{\sigma\left\{\left[(\phi w)^{(1-\sigma)}-1\right]n+1\right\}}$

Let $D = \left\{ \left[(\phi w)^{(1-\sigma)} - 1 \right] n + 1 \right\}$.

We can now write

$\widetilde{B}'(n) = \frac{\left\{-(\sigma-1)(\phi w)^{-\sigma}\right\} w\phi' - \left[(\phi w)^{(1-\sigma)} - 1\right]^2}{\sigma D^2}$.

$\widetilde{B}'(n) > 0$ when $\left|\phi'\right| > \frac{\left[(\phi w)^{(1-\sigma)} - 1\right]^2}{(\sigma-1)(\phi w)^{-\sigma}}$, i.e., when external economies are fairly strong.

Appendix B

A Model of Offshoring with Wage Bargaining in the South

Let us assume exactly the same set up for the North as in the main text. Recall that the equilibrium, maximized profit for a Northern firm when it procures specialized input domestically is $\pi_D(i) = A\sigma^{-\sigma}(\sigma - 1)^{\sigma-1} 1\alpha(i)^{\sigma-1}$. Northen firms can alternatively procure input from the South through a fully owned subsidiary after incurring a fixed cost of F_V.

As in the text, one unit of labor in the South can produce w units of the numeraire good. Therefore, the reservation wage of a worker producing the specialized input is going to be w. In addition, in order to produce the specialized input the worker has to undergo training. The cost of training for a worker is ϕ which is taken as given by a firm. However, ϕ depends on the total number of workers working to produce specialized inputs: $L_V \equiv \int_{i \in V} l(i)di$, where $l(i)$ is the number of workers required to produce the specialized input for firm-i and V represents the set of firms that have offshored using FDI (vertical integration). It is further assumed that $\phi'(L_V) < 0$, which happens because of economies of scale in training activity. Presumably, there are some overhead costs of training because of which training cost per unit of labor declines as more workers get trained.

The wage of a worker producing specialized input in the South is determined by a process of Nash bargaining between the worker and the subsidiary of the multinational in the South. The value of output from hiring one worker to produce the specialized input is $p(i)\alpha(i)$. The firm also has to pay the training cost ϕ for each worker. If the firm procures the input domestically (in the North), then its profit per worker employed is $p(i)\alpha(i) - 1$ since the Northern wage is 1 by assumption.

Therefore, $p(i)\alpha(i)-1$ is the threat point of the firm in bargaining with a worker in the South. Thus, the surplus from the relationship is $p(i)\alpha(i)-\phi-(p(i)\alpha(i)-1)-w = 1-(\phi+w)$. Let the worker's share of this surplus be θ. Therefore, the wage of a worker working to produce the specialized input in the South is $w_S = (1-\theta)w + \theta(1-\phi)$. The profit from hiring $l(i)$ workers to produce $l(i)$ units of the specialized input is $p(i)\alpha(i)l(i)-(w_S+\phi)l(i)$. Since $x(i) = \alpha(i)l(i)$ and $p(i) = A^{1/\sigma}x(i)^{-1/\sigma}$, the profit of a firm from offshoring can be written as $A^{1/\sigma}(\alpha(i)l(i))^{(\sigma-1)/\sigma} - (w_S+\phi)l(i)$. The firm chooses $l(i)$ optimally to maximize the above expression. The first order condition is given by $l(i) = (\frac{\sigma}{\sigma-1})^{-\sigma}A\alpha(i)^{\sigma-1}(w_S+\phi)^{-\sigma}$ and thus the expression for the maximized profit under offshoring is given by

$$\pi_V(i) = A\sigma^{-\sigma}(\sigma-1)^{\sigma-1}(w_S+\phi)^{1-\sigma}\alpha(i)^{\sigma-1} \tag{30}$$

The expression for the benefit from offshoring, gross of fixed costs, for firm i is given by

$$B(i) = \pi_V(i) - \pi_D(i) = \frac{\alpha(i)^{\sigma-1}\{(w_S+\phi)^{1-\sigma}-1\}}{\sigma\left[(w_S+\phi)^{1-\sigma}\displaystyle\int_{j\epsilon V}\alpha(j)^{\sigma-1}dj + \int_{j\epsilon NV}\alpha(j)^{\sigma-1}dj\right]} \tag{31}$$

where V represents the set of firms that have offshored using FDI (vertical integration) and NV is the set of firms that have not offshored. The above expression is similar to (12) in the text. Assuming the same distribution of firm productivity as in the text, we get the following benefit from offshoring for the nth firm when n firms have offshored.

$$B(n,n) = \widetilde{B}(n) = \frac{\alpha(n)^{\sigma-1}\{(w_S+\phi)^{1-\sigma}-1\}\lambda}{(w_S+\phi)^{1-\sigma}(\overline{\alpha}^{\sigma}-(\overline{\alpha}-\lambda n)^{\sigma}) + ((\overline{\alpha}-\lambda n)^{\sigma}-\underline{\alpha}^{\sigma})} \tag{32}$$

The equilibrium with offshoring is given by

$$\widetilde{B}(n) = F_V \tag{33}$$

where w_S is given by

$$w_S = (1-\theta)w + \theta(1-\phi(L_V)) \tag{34}$$

and L_V is given by

$$L_V \equiv \int_{i=0}^{n} l(i)di = \frac{(\sigma-1)(w_S+\phi)^{-\sigma}\int_{i=0}^{n}\alpha(i)^{\sigma-1}di}{\sigma\left[(w_S+\phi)^{1-\sigma}\int_{0}^{n}(\overline{\alpha}-\lambda j)^{\sigma-1}dj+\int_{n}^{1}(\overline{\alpha}-\lambda j)^{\sigma-1}dj\right]} \tag{35}$$

Equations (33)-(35) determine n, w_S, and L_V simultaneously.

Thus, while the external economies in production in the South make the benefits curve upward sloping, the heterogeneity, with firms lined up in ascending order of their unit costs, makes the benefits downward sloping. As in the case of the model in the main text, the benefit function is upward sloping with respect to n in the pure strong external economies case with no firm heterogeneity. It is downward sloping when there are no external economies. Clearly, when we have both firm heterogeneity and external economies in the South, we need to resort to simulations to study the shape of the benefits curve. Assuming $\phi = be^{-L_V}$, the plot of $\widetilde{B}(n)$ with respect to n, under plausible parameter values, is an inverted U, and we get similar multiple equilibria as in the main text.

It can be shown that in this model offshoring benefits both the North and the South. The gains to the North are obvious as they result from the lower cost of producing the specialized intermediate good. In the South the gains come from the higher wages of workers working in the production of specialized intermediate goods for the Northern multinationals. As discussed above, the wage of a worker producing the specialized intermediate good is

$$w_S = (1-\theta)w + \theta(1-\phi(L_V)) > w$$

The total gain to the South is given as follows.

$$(w_S - w)L_V = \theta(1-\phi(L_V) - w)L_V$$

Therefore, the greater the offshoring the greater the welfare gains for South. Thus, if South is stuck in a no offshoring equilibrium due to coordination failure among Northern firms, then a small subsidy to the Northern firms can cause a large change in the welfare of South. For example, subsidizing the training cost by giving a payroll subsidy can move the equilibrium from one with no offshoring to one with a lot of offshoring. The model also shows that wage inequality is going to increase in the South as a result of offshoring. Before offshoring the wage in South is w, however, after offshoring L_V workers working for multinational firms earn $w_S > w$, while the others continue to earn w.

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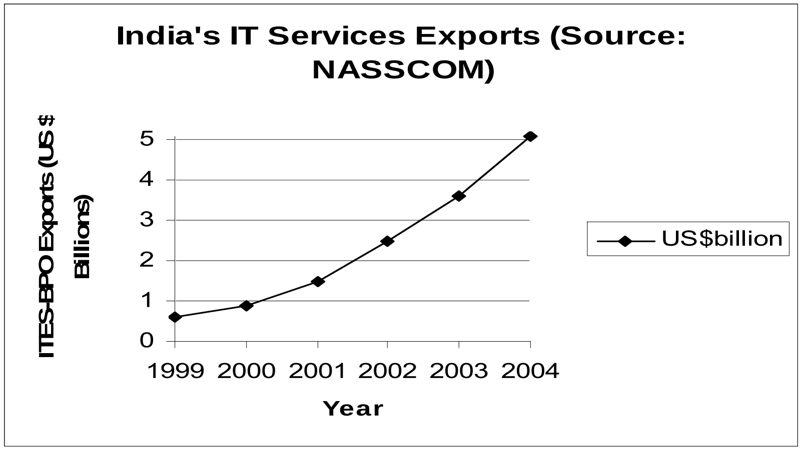
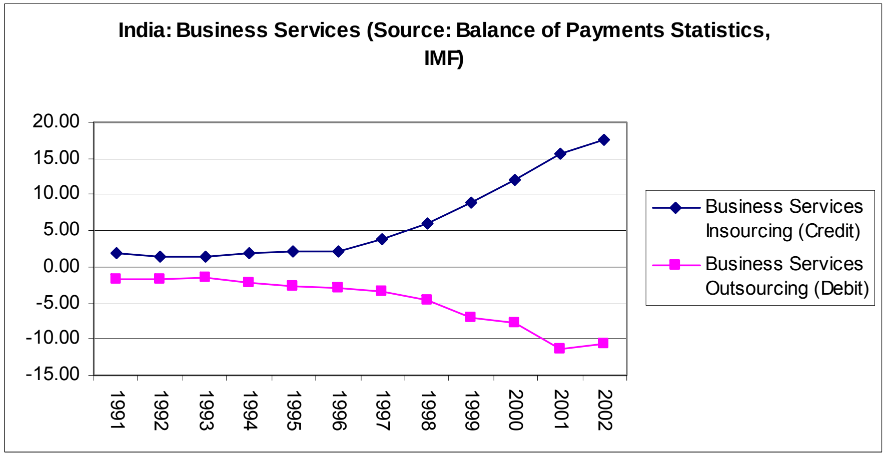
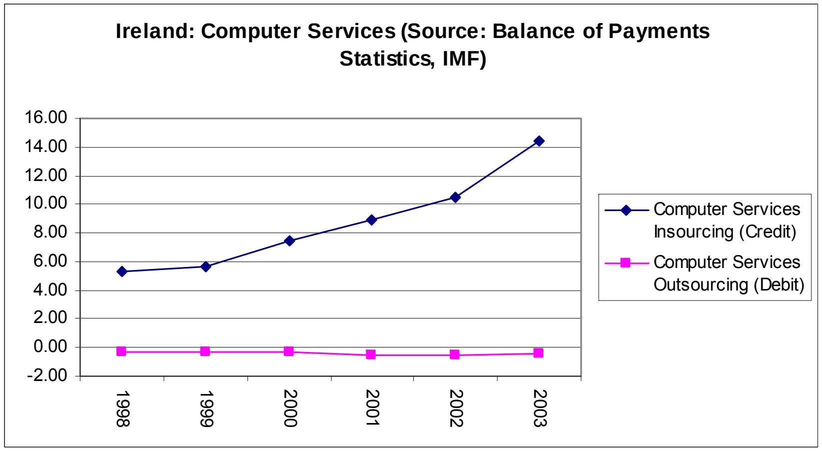
Figure 1:Export and Import of Services by India and Ireland (in billions of US dollars)







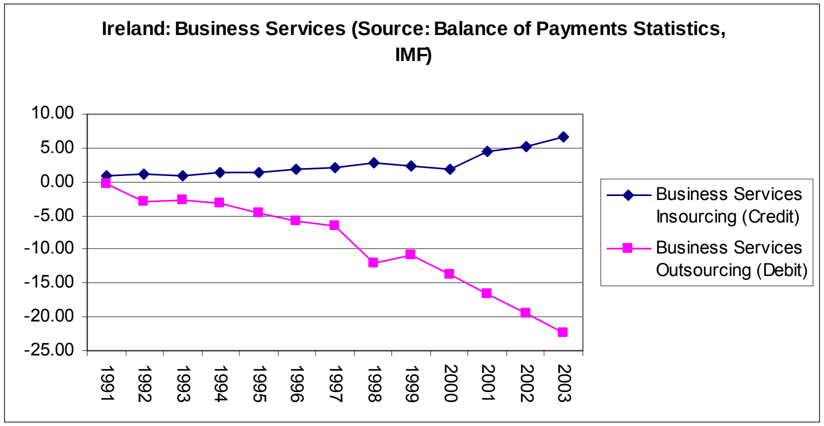
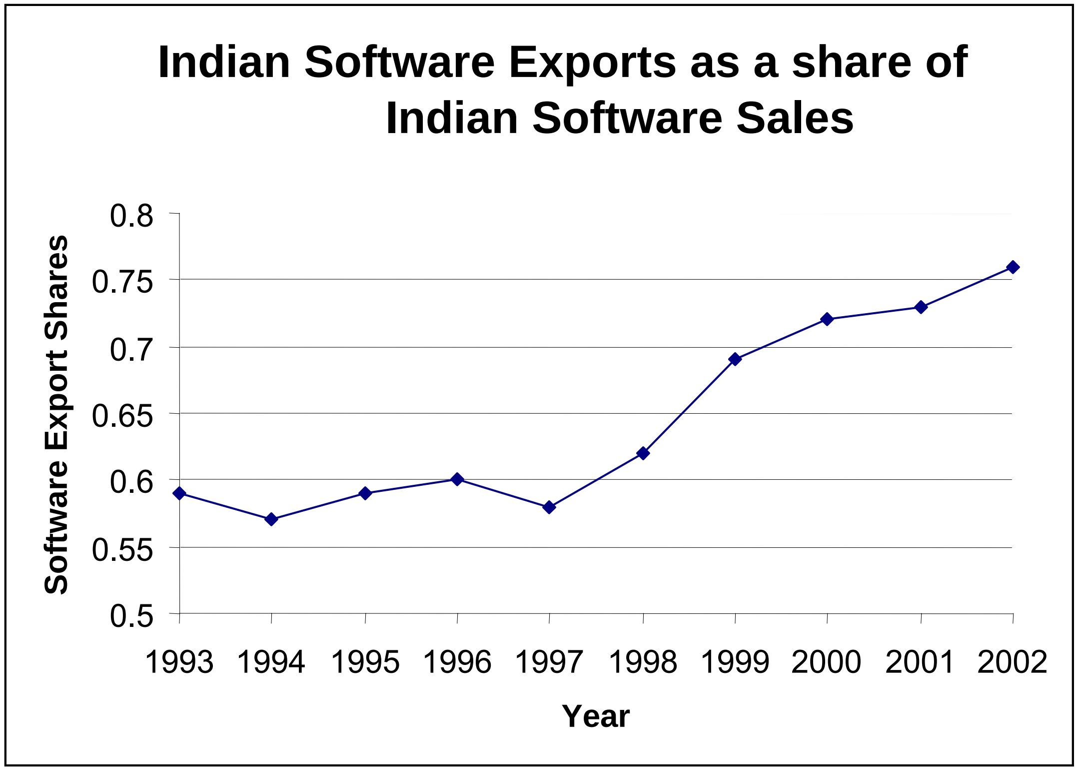


Figure 2: Indian software exports as a share of software sales



Source: Arora and Gambardella (2005)

Figure 3: Multiple Equilibria Under External Economies in Offshoring (No heterogeneity case)

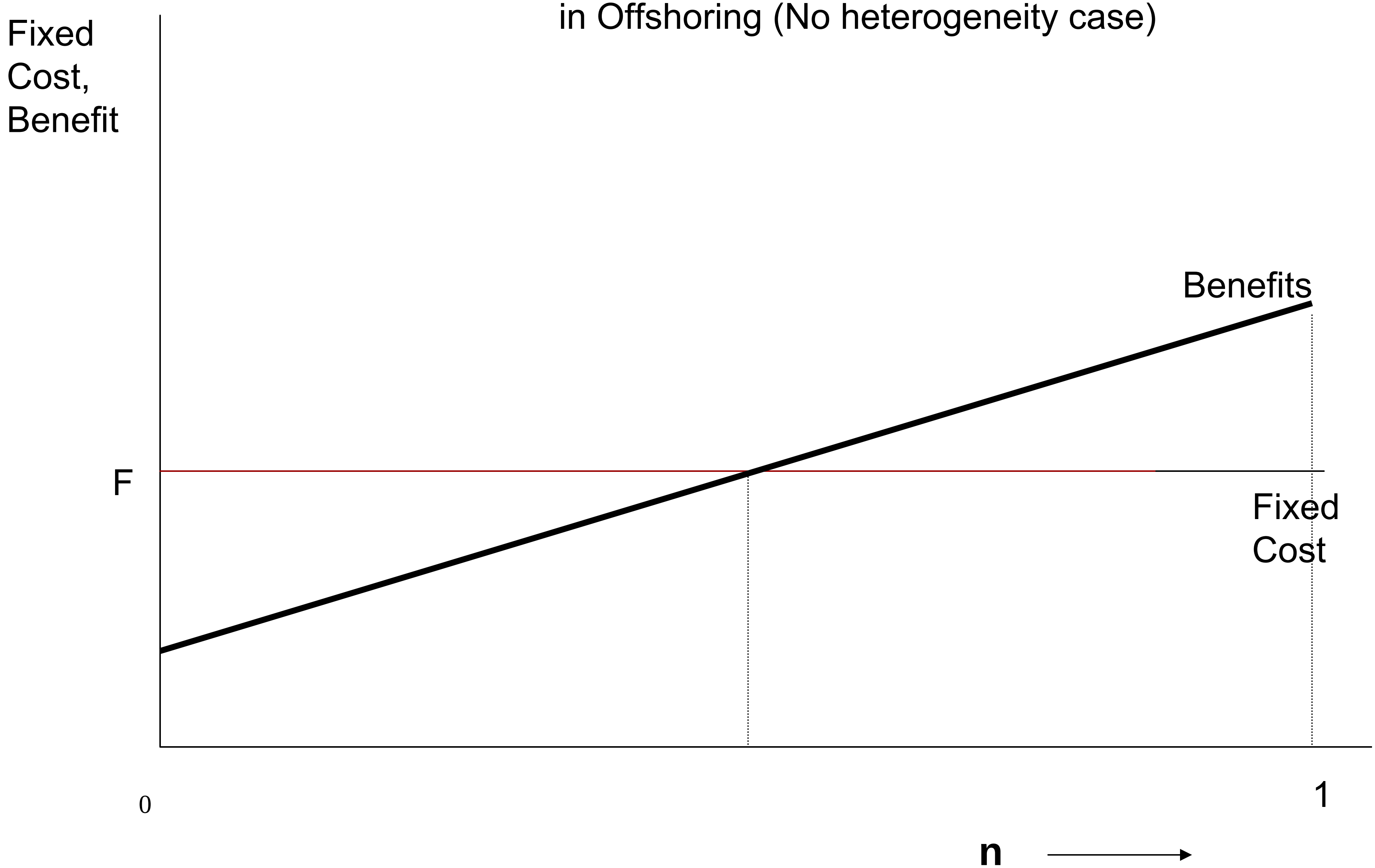


Figure 4: Unique Equilibrium Under Heterogeneity and No External Economies

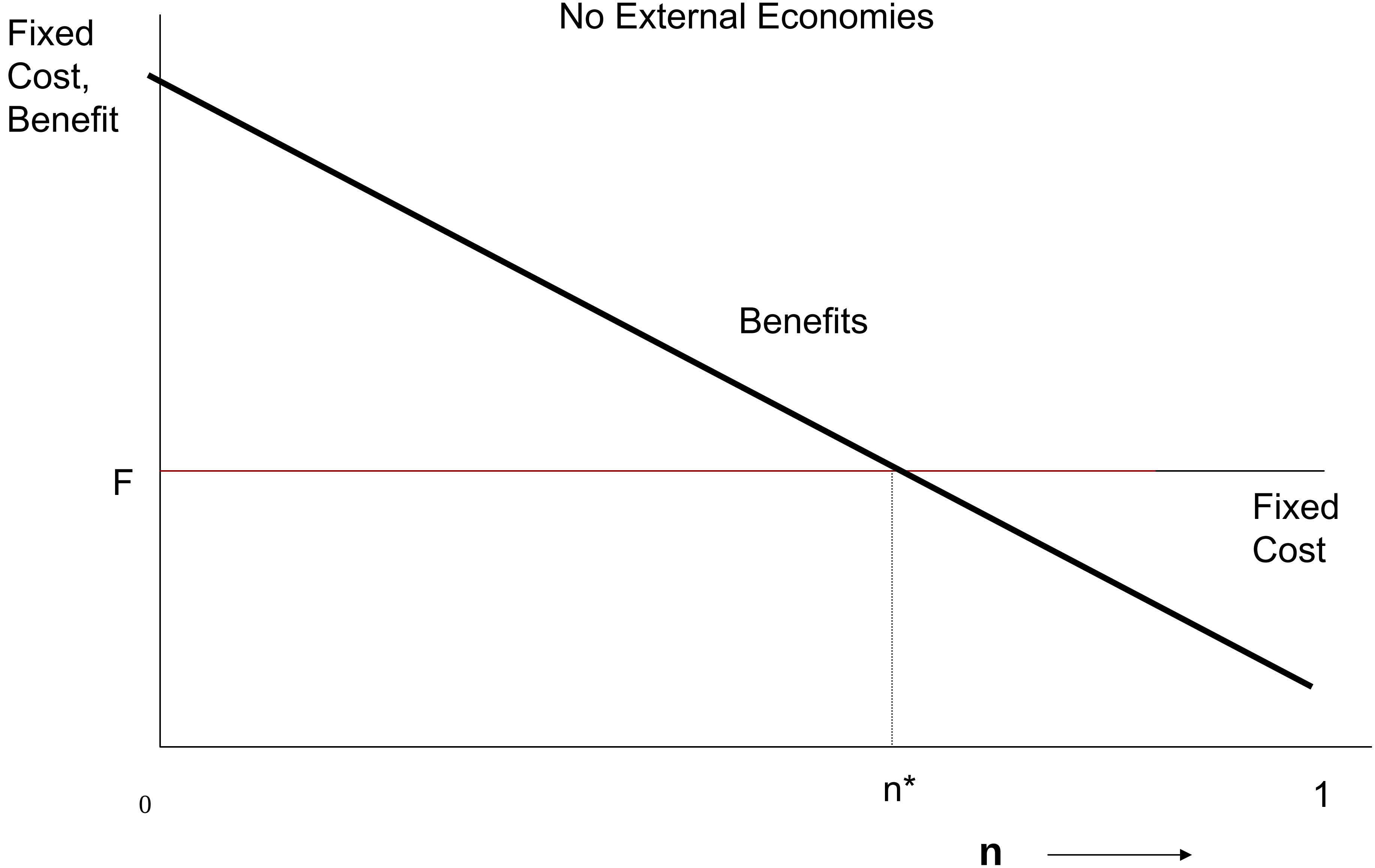
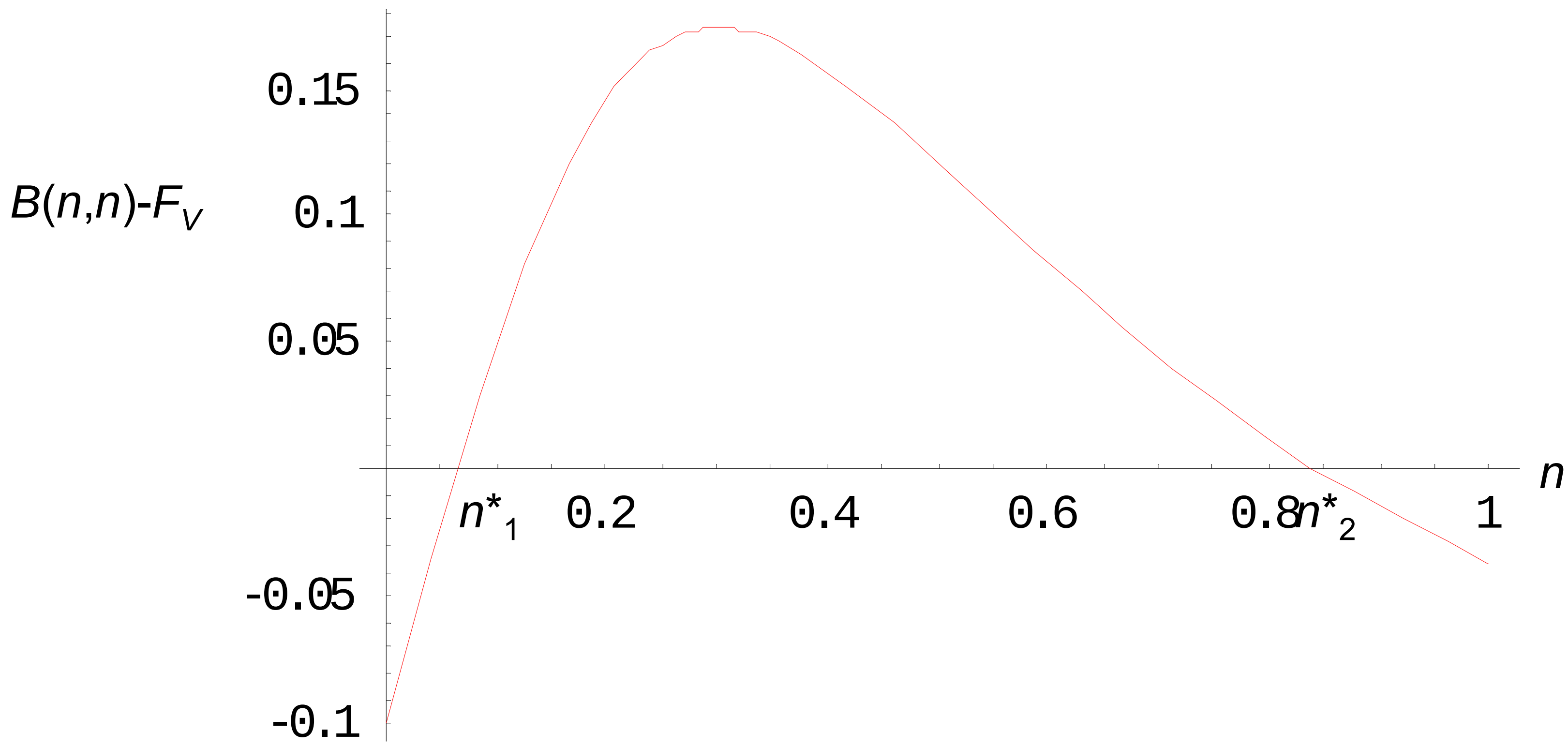
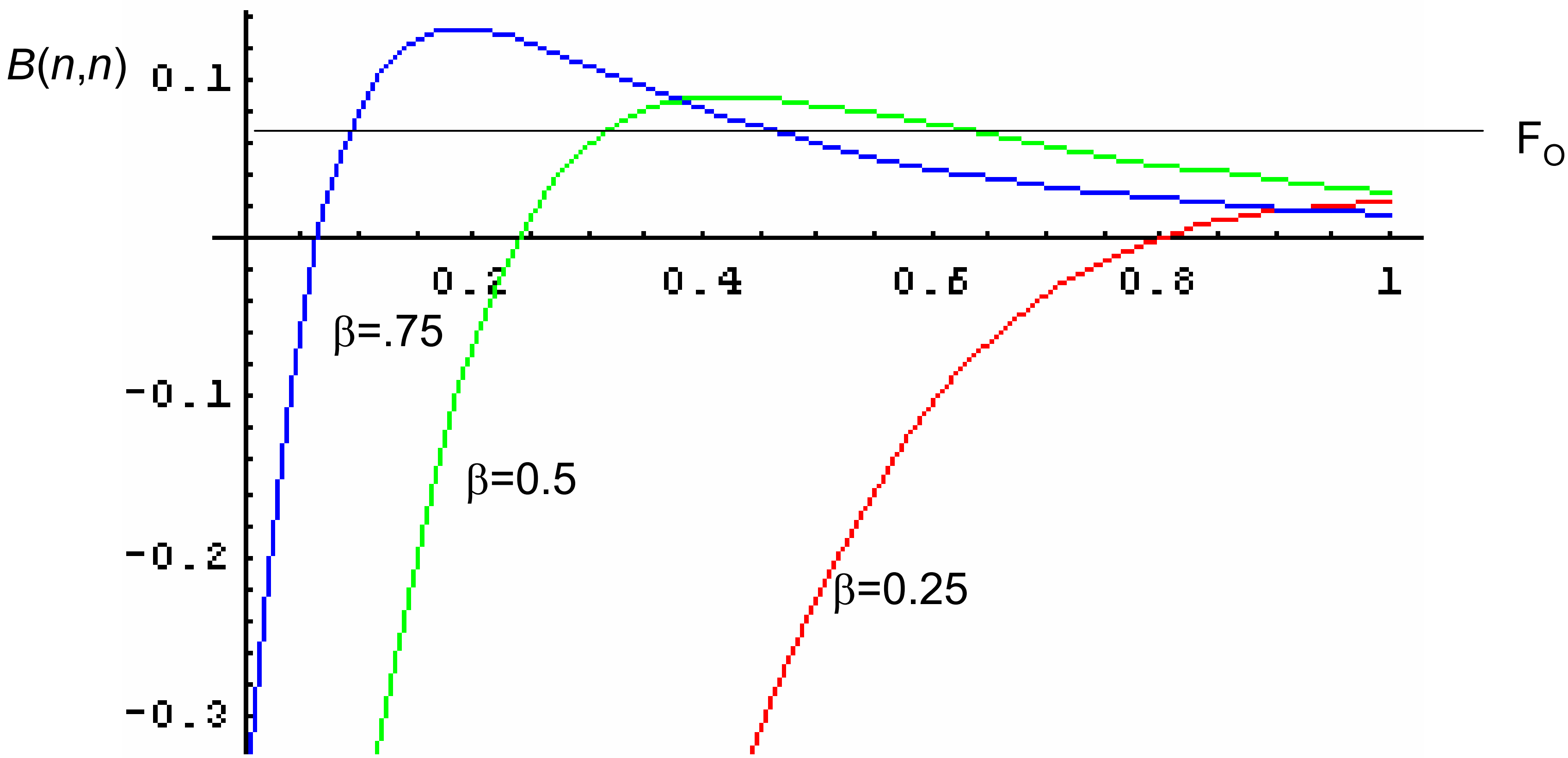


Figure 5:Multiple equilibria with firm heterogeneity and Externalities



Parameters: F_V=.1,σ =4,β =(σ-1)/ σ, λ =1, α =2, b=2,w=.5

Figure 6: Benefit from outsourcing



σ =4, λ =2, α =2.5, b=2, w=.4

Figure 7: Dynamics after a permanent shock

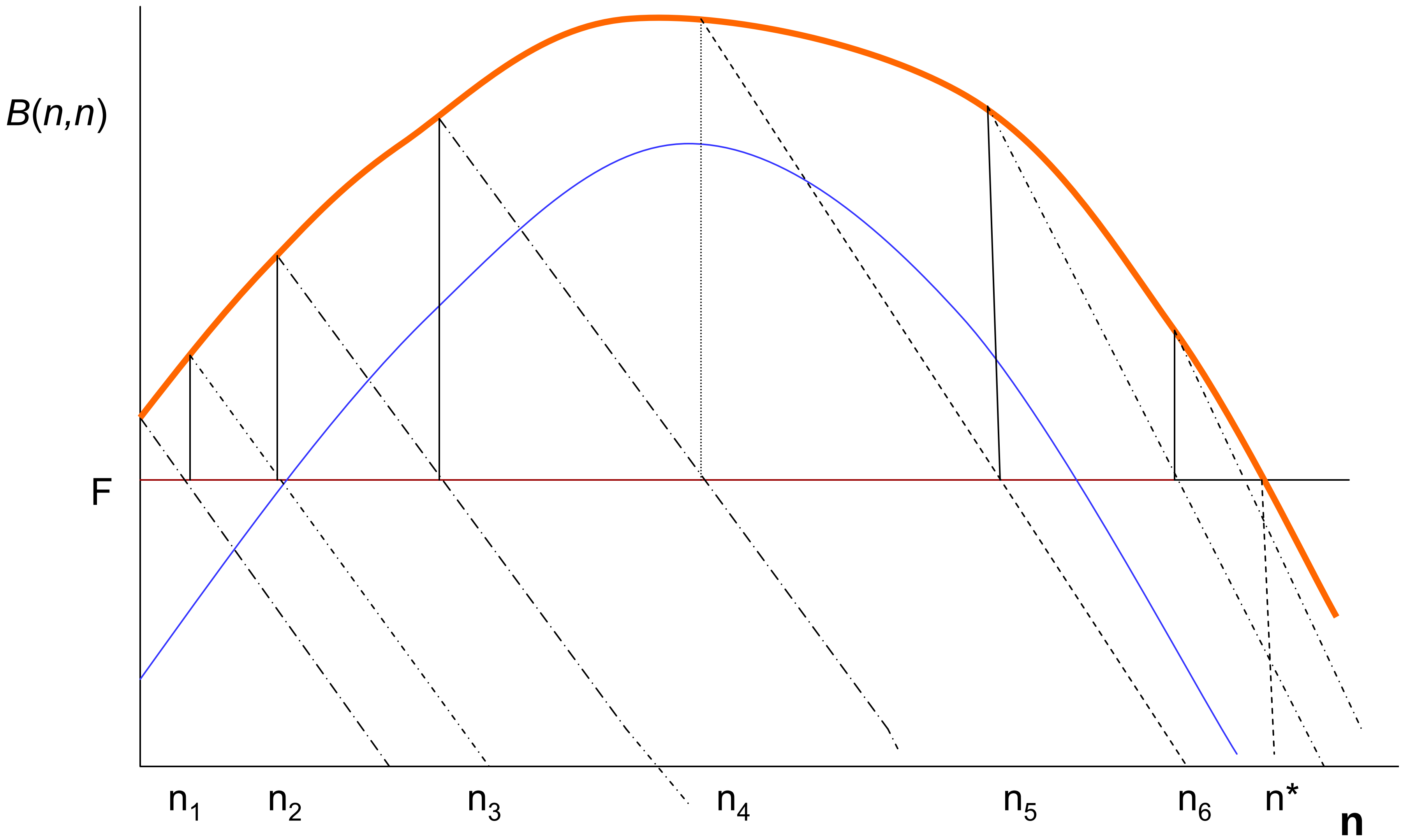


Figure 8: Dynamics after a temporary shock

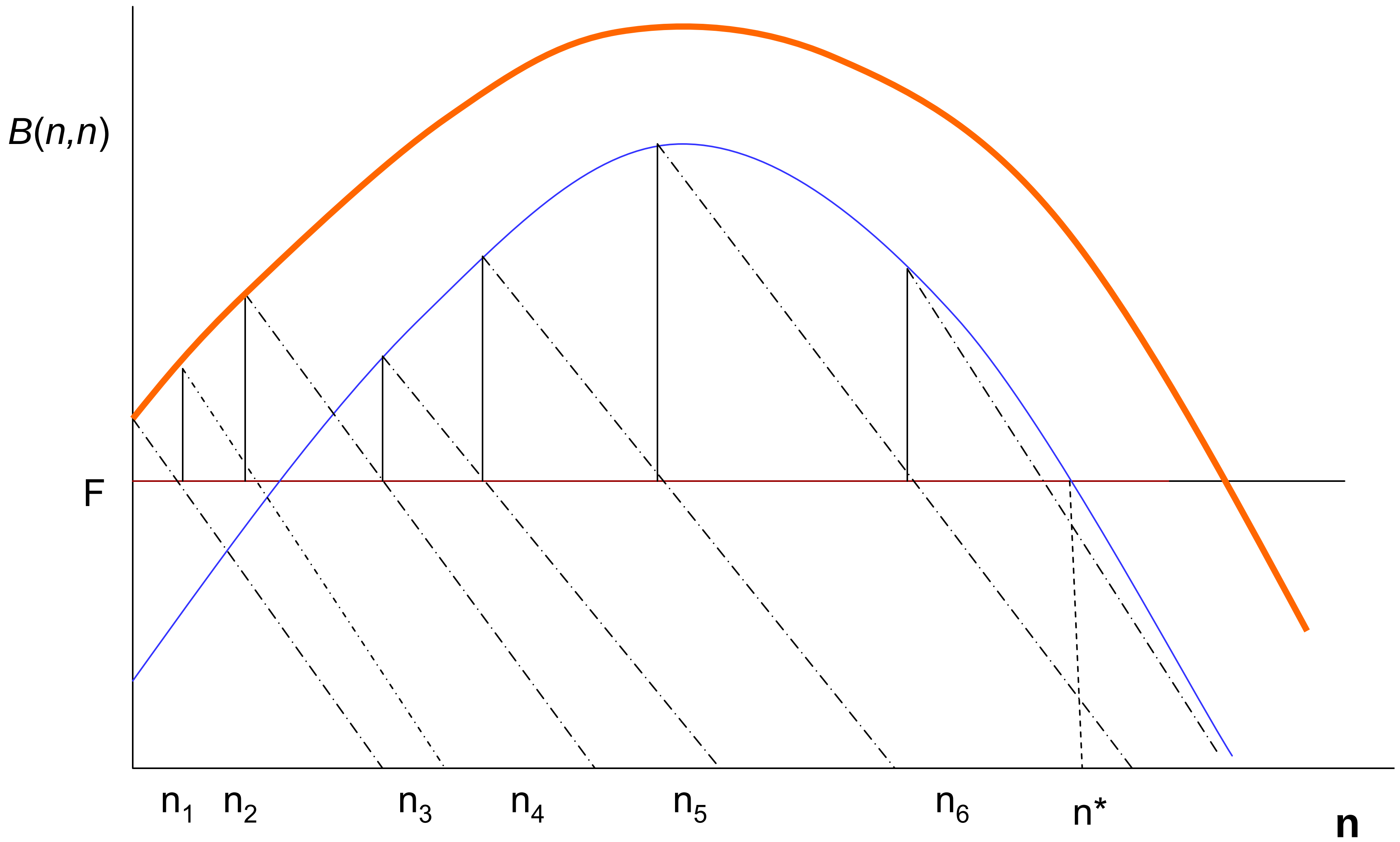
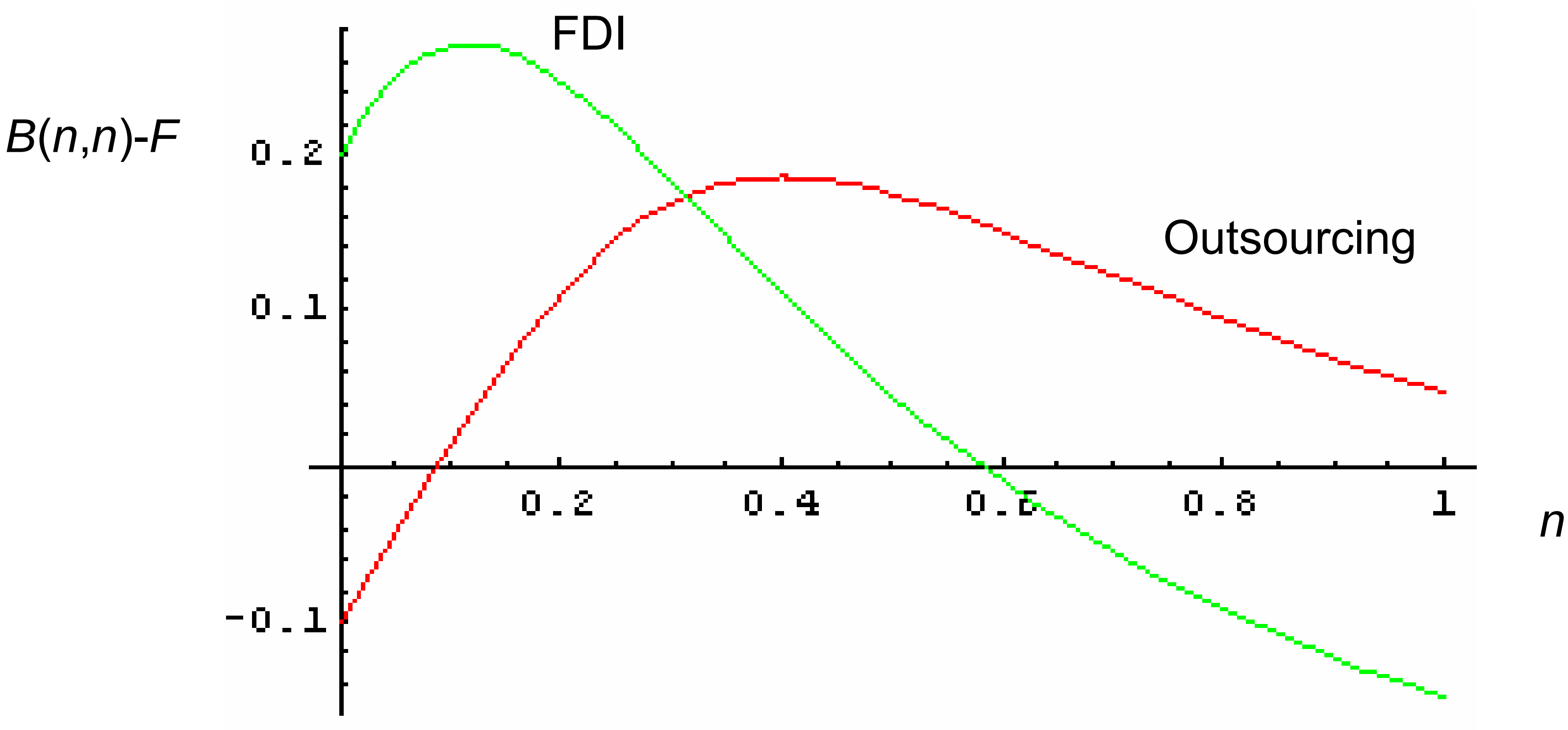
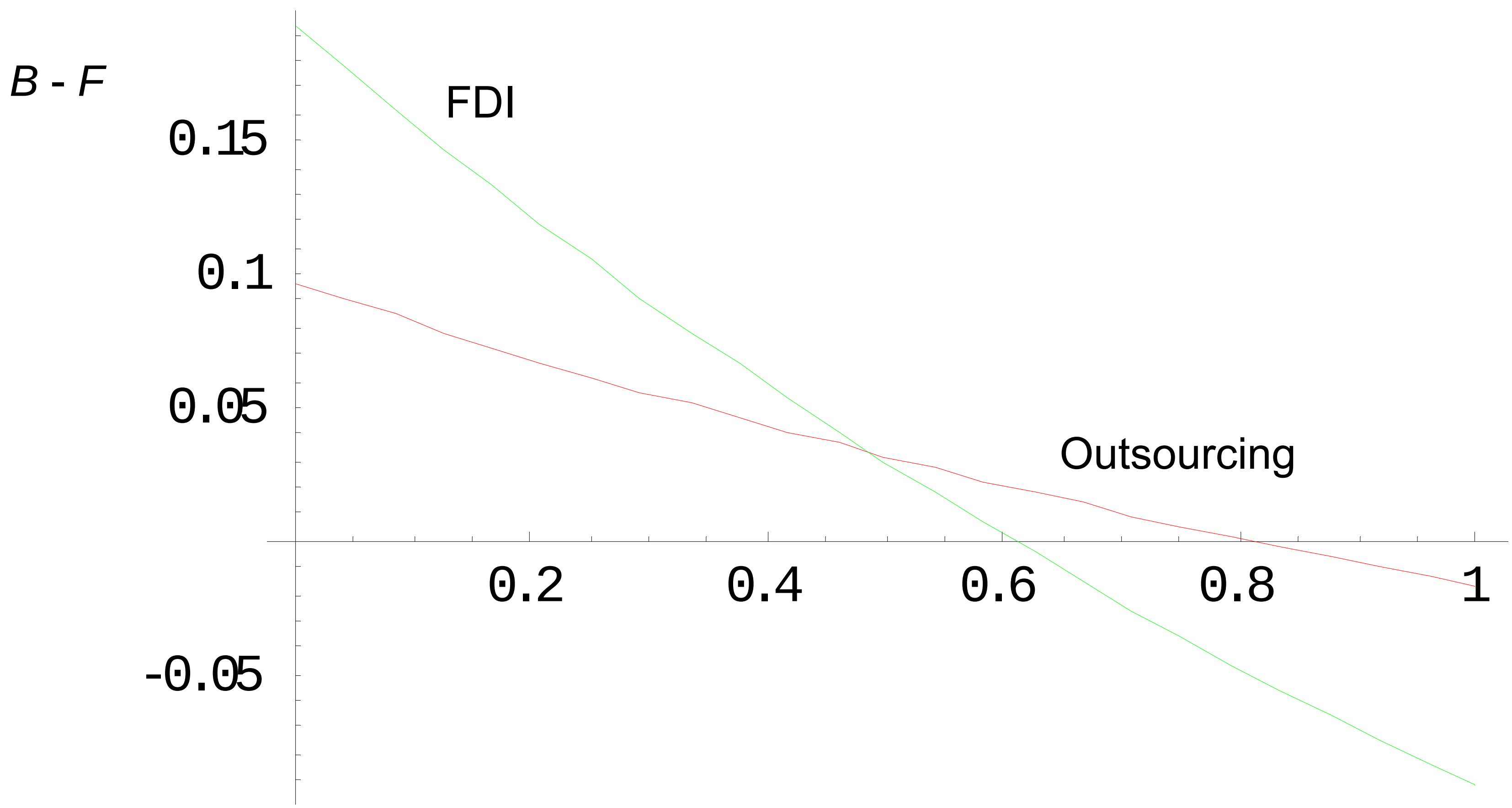


Figure 9: FDI and Outsourcing



Parameters: F_V=.3,F_O=.1,σ =4,β =(σ-1)/ σ, λ =1, α =4, b=1.5,w=.5

Figure 10: Equilibrium with FDI and Outsourcing



Parameters: F_V=.3,F_O=.1,σ =4,β =(σ-1)/ σ, λ =1, α =4, b=1.5,w=.5