Communication Networks, Offshoring and Welfare

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VERY PRELIMINARY

Abstract

This paper develops a simple general equilibrium model of monopolistic competition in the presence of offshoring. The model embeds the role of communication networks and offshoring costs in the North-South manufacturing offshoring activity. The domestic welfare consequences of an improvement in communication networks and a falling in offshoring costs have been investigated. The improvement in communication networks can increase the domestic welfare. While, the falling in offshoring costs may decrease the domestic welfare if a productivity gap between two countries is relatively low. Therefore, to rise domestic welfare, North's government should impose a policy to limit offshoring or provide production subsidy.

Keywords : offshoring, communication networks, offshoring costs, productivity gap, welfare, trade policies
JEL classification : F12, F21, F23, D43

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1 Introduction

Due to the advance in information and communication technologies over the past decades, the necessary to perform production processes closed to each other has nearly ended. This phenomenon has raised the rapid growth in the trade in intermediate goods and manufacturing offshoring activities. More recently, this advancement has made it increasingly possible to offshore production processes in service sectors, for example; call centers, back office, accounting and computer programming. This trend has generated mounting concerns among politicians and media reporters in the developed nations about the consequences of offshoring.

The implication of offshoring on advanced countries has became an area of interest among trade economists in recent decades. There are two opposite views related with this problems. The first view is a positive view. Offshoring entails more trade. Trade benefits involved countries, then offshoring is also good. According to Mankiw(2004)'s speech, " more things are tradable than were tradable in the past, and that's a good thing. (Mankiw and Phillip Swagel, 2006). The second view is a negative view. Offshoring and lower trade costs limit allow the world to reach an "integrated equilibrium" in which wages for identical workers in different countries would necessarily be equalized. In other words, wages would no longer be affected by the location of workers. For example, Ron Hira and Anil Hira(2005) stated that " offshoring affects American workers by undermining their primary competitive advantage over foreign workers: their physical presence in the US". Other noneconomists writing about offshoring have expressed similar concerns[1]. However, there are still lack of theoretical papers that can explain the effects of offshoring on the domestic welfare. Therefore, The welfare consequences of offshoring and policy implication will be investigated in this paper.

From a firm's level prospective, there are many economics reasons why a firm does offshore its production processes. The primary objective of firms to offshore is cost optimization in developing a global initiative. With so much media discussion of the wage rate difference that forms the basic leverage in global sourcing, firms frequently set expectations of cost saving entirely on wage rate arbitrage. Of course, the wage rate differential between countries is the most important cost saving opportunity from offshoring. However, there is evidence showing that a firm only achieves saving ranging from 25 to 30 percent annually not 70 to 90 percent, as the pure wage rate differential would suggest. This is because the firm has to pay additional costs in order to offshore to foreign country. Those costs are referred as communication network costs and offshoring costs[2].

Communication networks are required to connect and communicate production activities performed at a remote distant. Therefore, offshoring unavoidably requires a significant investment in reliable communication infrastructure. Typical components a firm requires include leased circuits with enough dedicated bandwidth to carry simultaneous voicer and data traffic between countries without latency. Lack of this interconnection become a trade barrier for offshoring. Communication network costs are the investment costs in constructing network and routing equipment (switching, routers, LAN infrastructure, etc.). In developed countries, the communication networks are mostly provided by competitive providers.

[1]See Craig John Roberts (2004) and Thomas Friedman (2005)

[2]See Offshore Insights White Paper Series Volume2, Issue 4, May 2004

According to Harris'91, the characteristics of communication networks are that they are skilled intensive, high fixed costs and average costs pricing. The communication networks costs are approximately 6,000-8,000 dollars per month in the US to India.[3] They can be 30 to 60 percents of total costs of production. However, the cost of bandwidth is constantly dropping. Global Bandwidth Research Service revealed that the average price of wholesale circuits in most markets dipped 10-20 percent in 2007.

Offshore production involves certain additional costs. Some of these costs are related to technology. For example, managers in one country have to give orders and guidance over the phone and the internet, using emails, facsimile, or other means. These are more costly if they have to cross international borders. In addition, offshoring also involves managerial costs. The extra time needed to codify information to distant workers, especially if they operate in different time zones. And, more intangible costs like cultural barriers and the misunderstandings that can also result from using different languages (Leamer and Storper 2001, Fujita and Thisse 2006). These costs are collectively grouped as "offshoring costs". Difference from the communication networks, these types of costs are task-dependent and have experienced a steady decline over the last century and especially in the last decade.

To investigate the welfare consequences of offshoring to an advanced country, we develop a model to incorporate the communication networks into Grossman and Rossi-Hansberg-type offshoring with Krugman-Helpman-type monopolistic competition. We model offshoring as it can combine cheap unskilled foreign labor with superior technology from a advanced country. However, there are some costs associated with foreign labor, which deteriorate the better technology when they are associated with foreign labors called the offshoring costs and, to connect with networks, firms have to pay fees for communication networks as fixed costs . As a consequence, only the tasks in which the wage gap is large enough to offsets the offshoring costs get offshored, giving rise to global production disintegration.

A number of studies have examined the effect of offshoring on skill premiums that is not directly investigated the welfare effect(e.g. Jones and Kierzkowski, 2001; Grossman and Rossi-Hansberg, 2006). However, they are all based on a framework of perfect competition, and so have ignored the impact of globalization on competition. The seminal contribution on the role of communication networks and international trade are Harris(1995) and Kinuchi(2003). Harris(1995) was perhaps the first to investigate the role of communication networks in international trade. He focused on the case in which all manufacturers of traded goods in the world used services provided by a single communication network industry(not country-specific). Kikuchi(2003) extended by studying a multi-country model of trade that captures the role of country-specific communication network interconnectivity, which enhances trade in intermediate services. To the best of my knowledge, there is no research paper that explains the relationship between communication networks, offshoring costs and welfare. Therefore, the objective of this paper is to study the effect of improvement in the communication network and falling in offshoring costs to the marginal task, relative unskilled labor wages, numbers of firm, price, outputs, price index, aggregate outputs and domestic welfare.

The structure of this paper is as follows. A basic model will be presented in the fol-

[3]IP Leased Circuit(IPLC) from Point-of-Presence(POP)

lowing section. The comparative statics analysis of decrease in communication network costs, offshoring costs on each economics outcomes will be shown in section 3. The policy implication will be proposed in section 4. And, concluding remarks are presented in Section 5.

2 Basic Model

The model assumes two countries, North and South (indicated with superscript $'*'$). North's economy is composed of two industries, X and Y. South's economy has only Y industry. The industry X produces imperfectly substitutable varieties under monopolistic competition and increasing returns to scale. The industry X is produced from a measure of tasks and consumed within country. The required set of tasks of different producers is identical, but their resulting outputs are differentiated in the eyes of consumers. The tasks can be performed close to a firm's national headquarters or at a foreign location. The industry Y is marked by perfect competition, constant returns to scale and produces an homogeneous goods. The goods from industry Y is freely traded internationally.

North has two factors of production, unskilled (S) and skilled labors(L). South has only unskilled labors available. The industry X employs both factors while the industry Y employs only unskilled labors to produce a goods. Both factors are supplied inelastically and unskilled labors can mobile across sectors.

Rule out the possibility of offshoring tasks for the time being. We assume that the North's technology in the industry Y is a Hicks-neutral improvement upon Foreign's technology: specifically, denoting a_{ly} and a^*_{ly} as an unit unskilled labor requirement to produce one unit of good Y at North and South, respectively. We let,

$$a^*_{ly} = \alpha a_{ly}, \alpha > 1 \tag{1}$$

where α is a mnemonic for productivity gap.

The industry Y is produced by constant returns to scale and freely traded internationally, it is natural numeraire. By free trade, we obtain

$$w_l a_{ly} = 1 = w_{fl} \alpha a_{ly} \tag{2}$$

In words, the model yields effective factor price equalization (the productivity-adjusted wage rate is equalized across country). Without loss of generality, we assume a_{ly} equals to 1. From eq. (2), we also get $w_l = 1$ and $w^*_l = 1/\alpha$ that is $w_l > w^*_l$. It is reasonable for North to offshore some tasks to perform at South to gain lower costs of production.

2.1 Consumer Behaviors

In North, all consumer shares the same preference, which are defined over a continuum of differentiated varieties indexed by n. The consumer's preference is represented by Dixit-Stiglitz type of utility function of the form:

$$U = X^{\mu} Y_c^{1-\mu} \tag{3}$$

and $X \equiv (\int_0^n x(i)^{1-\frac{1}{\sigma}} di)^{1/(1-\frac{1}{\sigma})}$

where $x(i)$ and Y_c indicate an individual's consumption of variety i of goods X and Y respectively. $\sigma > 1$ is the elasticity of substitution between varieties and μ is the share of income spent on aggregate of varieties X. Given income E and set of prices $p_y = 1$ for the homogeneous good and $p(i)$ for each variety of x, the consumer's problem is to maximize eq.(3) subject to the budget constraint,

$$Y_c + \int_0^n p(i)x(i)di = E = w_s S + w_l L \tag{4}$$

Utility maximization leads to demand functions for individual varieties, which are depend on own price $p(i)$ and in total spending E, both deflated by a price index P :

$$x(i) = \frac{p(i)^{-\sigma} E}{P^{1-\sigma}} \tag{5}$$

where

$$P = \left(\int_{i=1}^n p(i)^{1-\sigma} \right)^{\frac{1}{\sigma-1}} \tag{6}$$

and demand for homogeneous good Y is

$$Y_c = (1-\mu)E \tag{7}$$

2.2 Producer Behaviors

Technology in the industry Y is simple. In order to produce a unit of goods Y at North(South), $a_{ly}(a^*_{ly})$ units of unskilled labors are needed. The characterization of firm's technology in the industry X is that each firm active in the X-industry needs a_{lx} units of unskilled labors and a_{sx} units of skilled labor to produce each unit of X outputs including θ units of (fixed) communication networks.

Note that only unskilled labors are available in the South. Therefore, firms in North can possibly offshore unskilled tasks. The unskilled task involves a continuum of tasks (of mass one), each of them denoted by z and each of them equally needed. The production processes of goods X can be summarized as:

$$a_{lx} = \int_0^1 a_{lx} dz \tag{8}$$

Next, assume that tasks can be offshored at a cost called 'offshoring costs'. It costs the equivalent of $\beta(z)$ hours of work on task z to get a worth of one hour of work when task z is offshored ($\beta(z) > 0$)[4]. Following Grossman and Rossi-Hansberg(2008) as refered later

[4]Some tasks are easier to perform in the South than North because of weather, geographical advantage etc.

as GRH, we assume that $\beta(z)$ is continuously differentiable and we order tasks so that the costs of offshoring are non-decreasing: $\beta'(z) \geq 0$. Crucially, as in GRH, a domestic firm gets to use their own technology when it offshores a task to South. The marginal costs of performing unskilled tasks at North and South are $w_l a_{lx}$ and $\beta(z) w_l^* a_{lx}$, respectively. Thus, the decision to offshore a particular task Z is at the point that both marginal costs are equal:

$$w_l a_{lx} = \beta(Z) w_l^* a_{lx} \tag{9}$$

Moreover, to offshore tasks to the South, communication networks(as referred later as networks) are necessary to connect an operation performed at a remote distant. The networks are constructed from skilled and unskilled labors. Each firm purchases θ units of networks from network providers. So manufacturers incur θp_N to obtain the networks, where p_N is the price of networks. Since the market for networks is competitive, the price charged equals its unit production costs.

$$p_N = (w_s a_{sn} + w_l a_{ln})$$

Some empirical evidences suggest that the communication networks are highly skilled-labor intensive than manufacturing goods [5]:

$$\frac{a_{sn}}{a_{ln}} > \frac{a_{sx}}{a_{lx}}$$

According to Harris(1991), the network costs have very low marginal costs of sending massage so they are almost the fixed costs. We, therefore, assume marginal costs of network are zero, so they only have to pay to the network service providers as the fixed costs. Then, the total costs of representative firm are composed of network fixed costs, costs of performing skilled tasks at North, costs of performing unskilled tasks at North with fraction $1 - Z$ and costs of performing tasks at South with fraction Z including the costs of the extra inputs that are needed to do their jobs from distance or offshoring costs :

$$TC_i = \theta p_N + \left(a_{sx} w_s + a_{lx} w_l (1 - Z) + w^* a_{lx} \int_0^Z \beta(z) dz \right) x \tag{10}$$

As it is well-known in monopolistic competition, profit-maximizing firms choose production prices as a fixed mark-up over marginal costs:

$$p = \left(\frac{\sigma}{\sigma - 1} \right) \left(a_{sx} w_s + a_{lx} w_l (1 - Z) + w^* a_{lx} \int_0^Z \beta(z) dz \right) \tag{11}$$

Next, the equilibrium number of varieties, n, at North is given by free entry condition. At equilibrium, firms make zero pure profit, yielding

$$px = \theta (a_{ln} w_l + a_{sn} w_s) + \left(a_{sx} w_s + a_{lx} w_l (1 - Z) + w^* a_{lx} \int_0^Z \beta(z) dz \right) x \tag{12}$$

[5] For example, Miner(1991),OECD(2001) and Findley(1997)

On the other hand , we can summarize condition in eq. (11) and (12) in a form of the the degree of economies of scale and degree of monopoly power. Recall that the degree of economies of scale is the ratio of average to marginal cost,

$$\phi(w,x) \equiv \frac{TC(w,x)/x}{MC(w,x)}$$

Analogously to the degree of scale economies, we have a measure of monopoly power , $R(.)$, which equals to the ratio of average to revenue:

$$R \equiv \frac{p}{MR} = [1 - \frac{1}{\sigma}]^{-1}$$

Therefore, the condition in eq.(11) can be rewritten as

$$\frac{R}{\phi(.)} = \frac{p(w)x}{TC(.)}$$

We combine with the condition in eq. (12), $p = AC$, then at equilibrium

$$R = \phi(w_s, w_l, x) \tag{13}$$

Aggregate output of X industry in the economy is given by

$$X = nx \tag{14}$$

Assume all outputs are available at the same price, the price index becomes

$$P = pn^{\frac{1}{1-\sigma}} \tag{15}$$

North's and South's product market equilibrium in the industry Y, respectively, implies that

$$\begin{aligned} (1-\mu)(npx + Y) &= Y_c & (16)\\ Y_c^* &= w_l^* L^* & (17) \end{aligned}$$

Next we will consider the labor market. The North's unskilled labors are employed to produce goods in the industry X with a fraction $1 - Z$, goods Y and the θ units of communication networks. While, the North's skilled labors are employed to produce goods x and to operate θ units of communication networks. Then, the unskilled labors and skilled labors clearing condition are given, respectively, by

$$\begin{aligned} (1-Z)na_{lx}x + a_{ly}Y + \theta a_{ln}n &= L & (18)\\ a_{sx}nx + \theta a_{sn}n &= S & (19) \end{aligned}$$

Recall that South has only unskilled labors available. The South's unskilled labors are employed to produce goods in industry Y and the fraction Z of unskilled tasks offshored from Home. The labor market clearing for unskilled labors is given by

$$\alpha a_{ly}^* Y^* + \beta \frac{Z^2}{2} n a_{lx} x = L^* \tag{20}$$

Trade balance condition is given by

$$Y_c = Y - Y_T \tag{21}$$
$$Y_c^* = Y^* + Y_T \tag{22}$$

where Y_T is an amount of good Y exported or imported from North to South. It has a positive(negative) value if it is exported(imported).

North's welfare can be expressed as real national income[6] :

$$W = \frac{w_L L + w_S S}{P^\mu} \tag{23}$$

Without loss of generality, we assume $\beta(z) = \beta z$. The equilibrium marginal task is determined by eq.9, we get

$$Z = \frac{\alpha}{\beta} \tag{24}$$

Thus , we obtain the following lemma and proposition:

Lemma 1 *Since* $0 \leq Z \leq 1$ *, then* $1 \leq \alpha \leq \beta$

Proposition 1 *The extent of offshoring positively depends upon the productivity gap and negatively depends upon the offshoring costs*

When the industry X and Y are active, the zero profit condition(eq 12) , (constant) mark-up pricing condition (eq 11), the product (eq 16) and factor-market conditions (eq. 18 , **??** and 20) and trade balance (eq. 21) allow us to solve for the equilibrium of outputs, price, and relative skilled-labor wages, number of varieties, aggregate output, price index and North's welfare . However, the model is too large and non-linear. Without loss of generality, We will solve the solutions by expressing in term of relative skilled labor wages and exogenous variables as follows :

$$\begin{aligned} w_s = & \frac{1}{4S\beta\theta(-1+\mu)\sigma a_s a_{sn}}(-2L\beta\theta\mu\sigma a_s a_{sn} - S\theta(2\beta(\mu(-1+\sigma)-\sigma)a_{ln}a_s + (\alpha(-1+\mu)\sigma a_L + (2\beta(\mu-\sigma) + \\ & \alpha(1-2\mu+\sigma))a_s)a_{sn}) + \sqrt{(\theta^2(8\beta\mu(-2L\beta\mu + S(\alpha-2\alpha\mu+2\beta\mu))(-1+\sigma)a_s^2 a_{sn}(Sa_{ln} - La_{sn}) + \\ & (2S\beta(\mu+\sigma-\mu\sigma)a_{ln}a_s + (S\alpha(-1+\mu)\sigma a_L + (2L\beta\mu(-2+\sigma) + S(2\beta(\mu-\sigma) + \alpha(1-2\mu+\sigma)))a_s)a_{sn})^2)))) \end{aligned} \tag{25}$$

[6]South's welfare can be expressed by $W^* = w^* L^*$

$$n = \frac{\mu(w_s S + L)}{\theta\sigma(a_{ln} + a_{sn}w_s)} \tag{26}$$

$$p = \left(\frac{\sigma}{\sigma - 1}\right)\left(a_{sx}w_s + a_{lx}(1 - \frac{Z}{2})\right) \tag{27}$$

$$= \frac{\sigma\left((-\alpha + 2\beta)a_{lx} + 2\beta a_{sx}w_{sx}\right)}{2\beta(-1 + \sigma)} \tag{28}$$

$$x = \frac{-2\beta\mu(-1 + \sigma)\left(L + Sw_s\right)}{n\sigma\left((\alpha - 2\beta)a_{lx} - 2\beta a_s w_S\right)} \tag{29}$$

$$X = \frac{-2\beta\mu(-1 + \sigma)\left(L + Sw_s\right)}{\sigma\left((\alpha - 2\beta)a_{lx} - 2\beta a_s w_s\right)} \tag{30}$$

$$P = \frac{\sigma\left(-(\alpha - 2\beta)a_{lx} + 2\beta a_{sx}w_s\right)\left(\frac{L\mu + S\mu w_s}{\theta\sigma a_{ln} + \theta\sigma a_{an}w_s}\right)^{\frac{1}{1-\sigma}}}{2\beta(-1 + \sigma)} \tag{31}$$

$$W = 2^{\mu}\left(L + Sw_s\right)\left(\frac{\sigma\left(-(\alpha - 2\beta)a_{lx} + 2\beta a_s w_s\right)\left(\frac{L\mu + S\mu w_s}{\theta\sigma a_{ln} + \theta\sigma a_{sn}w_s}\right)^{\frac{1}{1-\sigma}}}{\beta(-1 + \sigma)}\right)^{-\mu} \tag{32}$$

Figure 1 illustrates the initial equilibrium outcomes in this model. The zero profit condition is drawn in the most upper figure and the equilibrium price level and numbers of firm are determined. While, the lower figure illustrates the equilibrium between the degree of monopoly power and degree of economies of scale. It shows the equilibrium numbers of firm and quantities of production of each firm. The lowest upper shows the labor market equilibrium determining the equilibrium relative skilled wage rate.

[Figure 1 is here]

3 Comparative Statics

In this section, we explore the relationship between the equilibrium outcomes and some of the key parameters of the model. In particular, we focus on the effects of improvement in communication network as captured by a decrease in θ and decrease in offshoring costs as captured by β.

3.1 Effects of an Improvement in Communication Networks

Improvement in communication networks are related to an increase in a productivity of networks. So a firm can purchase less of network goods to get a previous performance. Many evidences also have supported that these costs have experienced a steady decline over the last century[7]. In this section, we study the effects of improvement in communication networks on the relative unskilled wages, number of firms, outputs and price, aggregate outputs, price index and domestic welfare. Its improvement can be interpreted by decrease in its fixed costs or parameter θ in the model.

[Figure 2 is here]

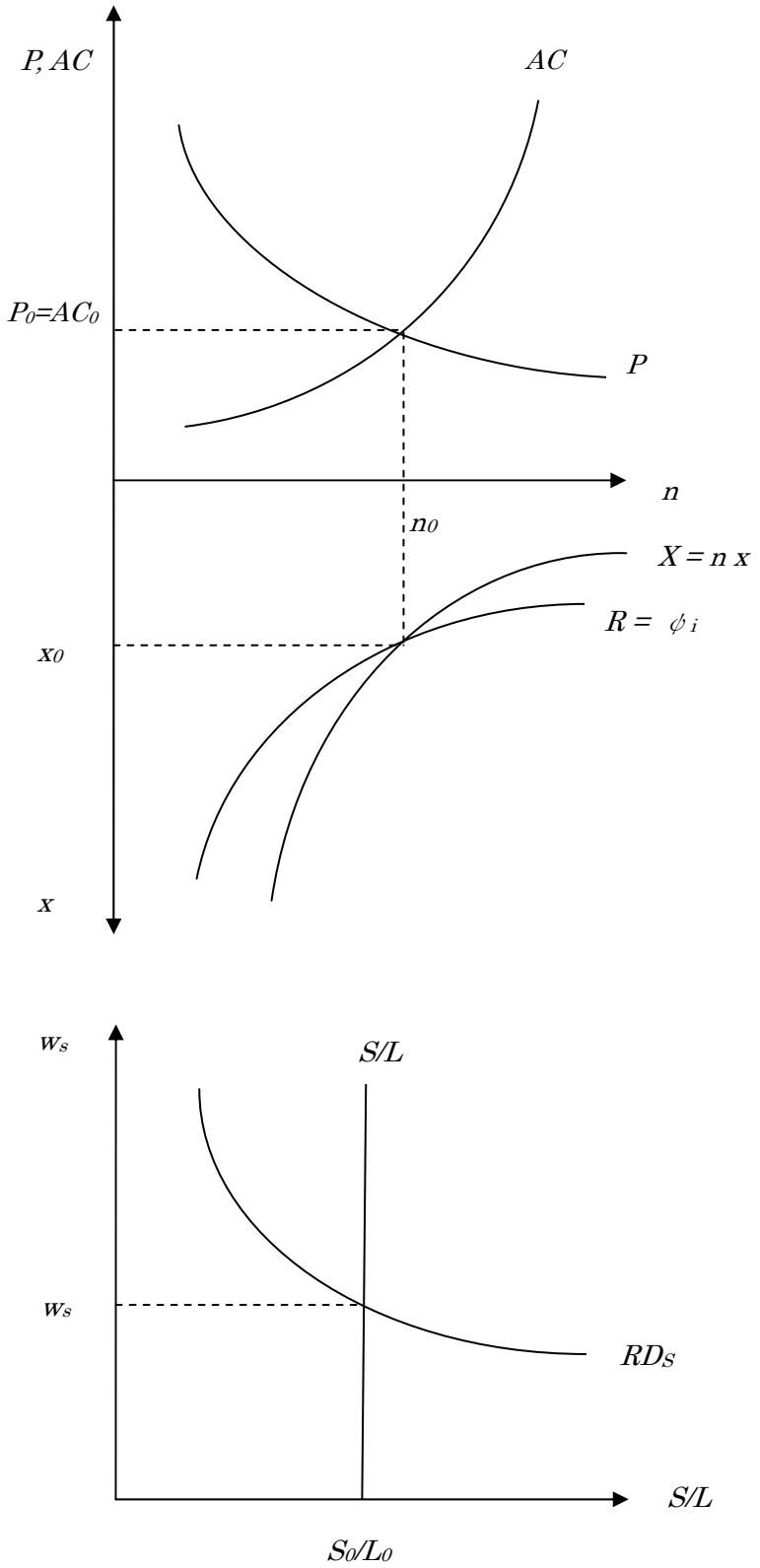


Figure 1: Initial Equilibrium

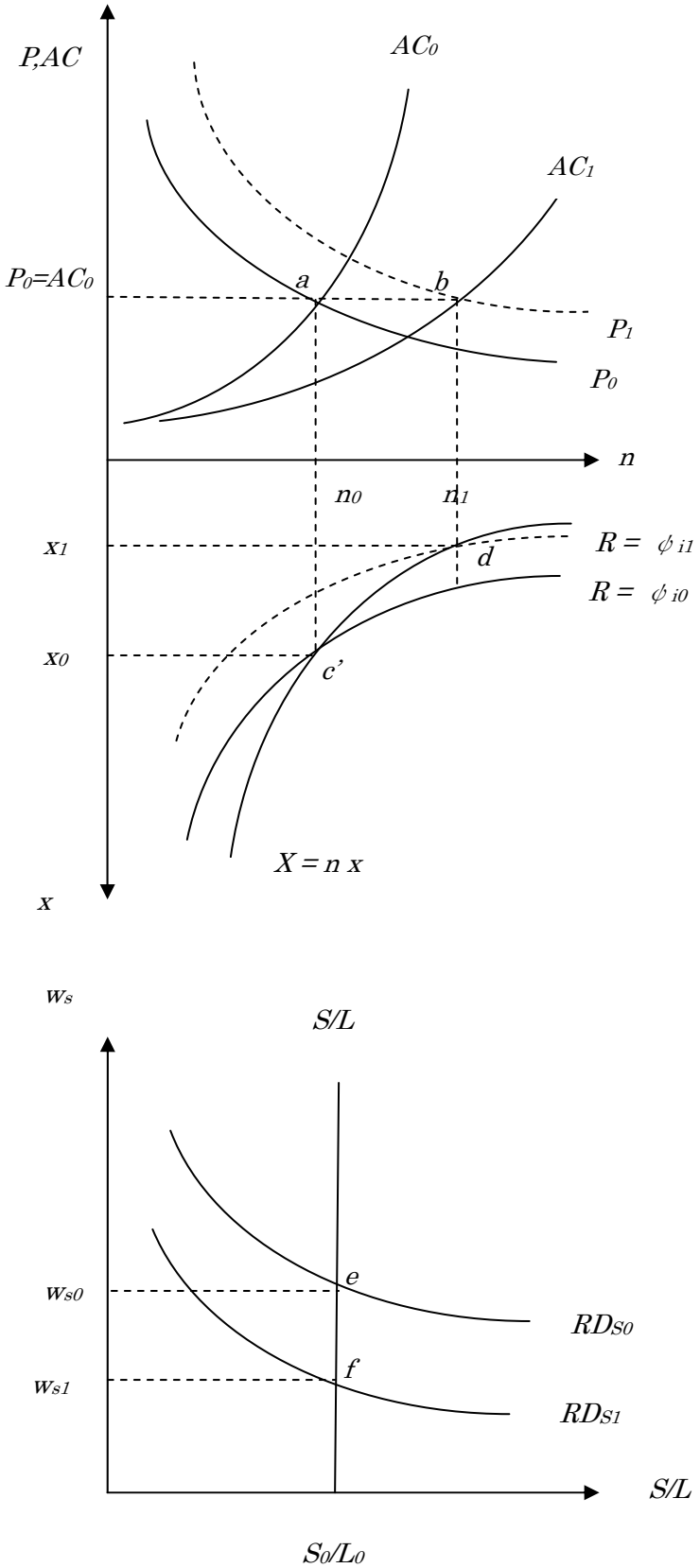


Figure 2: Effects of Improvement in Communication Networks

Figure 2 shows a change in the equilibrium when the communication networks improve(decrease in θ). There are two opposing effects on the relative demand for skilled labors. Firstly, a decrease stemming directly from an improvement in the communication networks. This is because the communication networks are a skilled labor intensive(RD_{s0} shifts down to RD_{s1}). Secondly, an increase stems from an entry of new firms. Since the communication networks are the fixed cost by nature. Its decrease induces an increase of the profits of firm. These excess profits attract an entry of new firms into this industry. The increase in numbers of firm rises the relative skilled labor demand (RD_{s1} shifts back to RD_{s0}). The two effects are perfectly offset so the relative skilled labor wages are unchanged. Note that the unskilled wages are fixed at 1, therefore, the nominal national income ($\bar{E}$) is also unchanged.

By nature the communication network costs are fixed costs, it does not affect the marginal costs of performing tasks at North and South. Therefore, firms do not change the extent of offshoring or the marginal task($\bar{Z}$) is unchanged. As a result of constant in the relative skilled labor wages and marginal task, the marginal costs of production are unaffected. This makes the price level is unchanged. The most upper level of figure 1 shows that when θ decreases, AC_0 shifts to AC_1 and P_0 shifts to P_1. This makes the price level is still at P_0 and the numbers of firm increase from n_0 to n_1.

Resulting from the increase in the numbers of firm together with unchanged in the price level and nominal national income, the share of outputs of differentiated goods produced by each firm decreases. However, the aggregate output is still unchanged. The middle level of figure 1 shows that when θ decrease, an average cost is lower while a marginal cost is unaffected so it makes the degree of economies of scale is lower so ϕ_0 shifts down to ϕ_1 . The numbers of firm increase, the outputs of each firm decrease and the aggregate outputs are unchanged.

The price index is decreased because the increase in the numbers of firm and unaffected of price level. Due to the improvement in communication networks lead to the lower price index but not the nominal income, the real national income or domestic welfare always increase.(See mathematic prove in Appendix)

Proposition 2 *The improvement in the communication networks decrease the outputs per firm and the price index. On the other hand, it raises the number of firms and the domestic welfare*

3.2 Effects of Falling in Offshoring Costs

Offshoring costs relate to the costs of monitoring and the coordination of activities that are located apart. Similar to network costs, these types of costs also have experienced a steady reduction over the last century. In the last decade, the fall appears to have been dramatic. To study the impact of the decline in offshoring costs on the marginal task, relative unskilled wage, number of firms, outputs and price, aggregate output, price index and domestic welfare, we analyze the effect of lowering β.

Reducing the offshoring costs lowers the marginal costs of performing tasks at South. This actuates Northern firms to offshore some of tasks to the South more. The marginal

[7]For example Cairncross(1997), Harris(1998) etc.

task increases. Then, the skill intensity in the North manufacturing sector associated with the relative demand for skilled labors increases. It raises the relative skilled wages. This rising in relative skilled labor wages also causes operation profits and fixed network costs increase. However, some excess profits still exist. This attracts an entry of new firms. The relative skilled labor demand from new firms also raises the relative skilled labor wages. Therefore, the two supporting ways raise the relative skilled labor wages and also North's nominal income.

Consequently, two opposing forces will affect the marginal costs of production. The first force is the decrease of unskilled labor costs caused from offshoring and the second force is the increase in skilled labor wages. Whether the offshoring leads to lower marginal costs will be determined by the productivity gap between North and South. Figures 3 and 4 show the case in which productivity gap is high and low, respectively.

In the case of high productivity gap, offshoring leads to lower marginal costs because the lower unskilled labor costs outweighs the higher skilled labor costs. The decrease of marginal costs exerts a downward pressures on manufacturing prices and increase the outputs per firm. Figure 3 shows when the offshoring costs are lower, the relative demand for skilled labors shifts upper from RD_0 to RD_1. The relative skilled wages rise from w_{s0} to w_{s1}. As the result of decreasing in marginal costs, in the uppermost figure 3 AC_0 rotates clockwise to AC_1 and P_0 shifts lower to P_1 . The new equilibrium is that price level decreases and number of firms increases. In the lower panel of figure 3, both X and $R = \theta_i$ shift upward from X_0 to X_1 and $R = \theta_{i0}$ to $R = \theta_{i1}$. The outputs per firm also increase.

Next, we will consider the effect on the domestic welfare. The price index decreases as the price level decreases and number of firms increases. Recall that the domestic welfare measured from the real national income. As price index decreases and nominal income increases, the domestic welfare increases. Figure 5 show the effects of falling in offshoring costs on the price index and domestic welfare in the case of high productivity gap.

[Figure 3 is here]

[Figure 4 is here]

Contrary to the case of high productivity gap, the marginal costs might increase as the extent of offshoring increases if productivity gap is relatively low. This is because the lower unskilled labor costs are outweighed by the higher skilled labor costs. It raises the manufacturing price and lower outputs per firm. Figure 4 shows that when the offshoring costs are lower, the relative demand for skilled labor shifts upper from RD_0 to RD_1 that same as the previous case. The relative skilled wages rise from w_{s0} to w_{s1}. As the result of increasing in marginal costs, in the uppermost figure 3 AC_0 rotates counterclockwise to AC_1 and P_0 shifts higher to P_1 . The new equilibrium is that price level and number of firms increase. In the lower panel of figure 5, both X and $R = \theta_i$ shift downward from X_0 to X_1 and $R = \theta_{i0}$ to $R = \theta_{i1}$. The outputs per firm decrease. At some specific threshold of productivity gap, the price index increases because the rate of change in the price level is higher than that of numbers of firm. The domestic welfare deteriorates because the rate of increase in nominal income is lower than that of price index. Figure 6 shows the effects of falling in offshoring costs on the price index and domestic welfare in the case of low productivity gap.

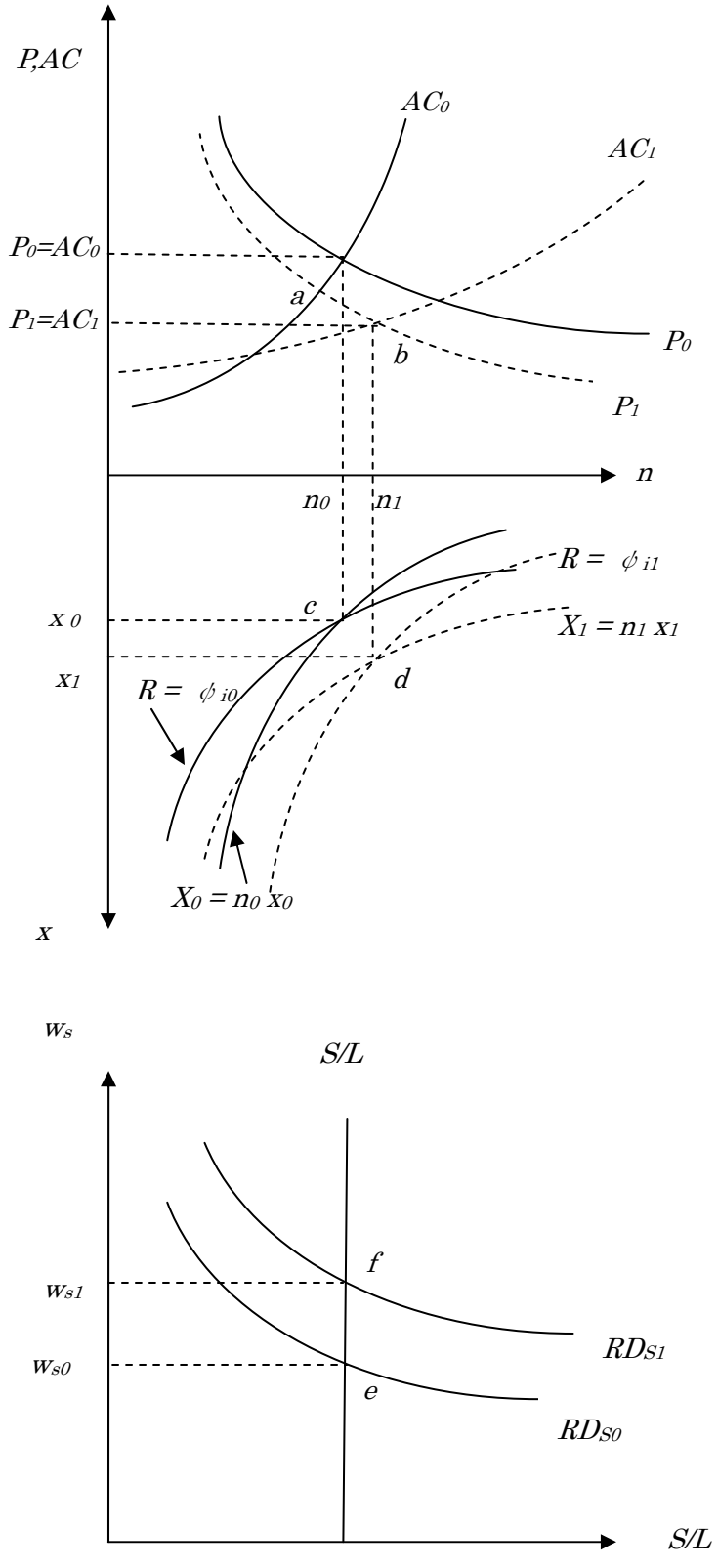


Figure 3: Effects of Falling in Offshoring Costs (High α)

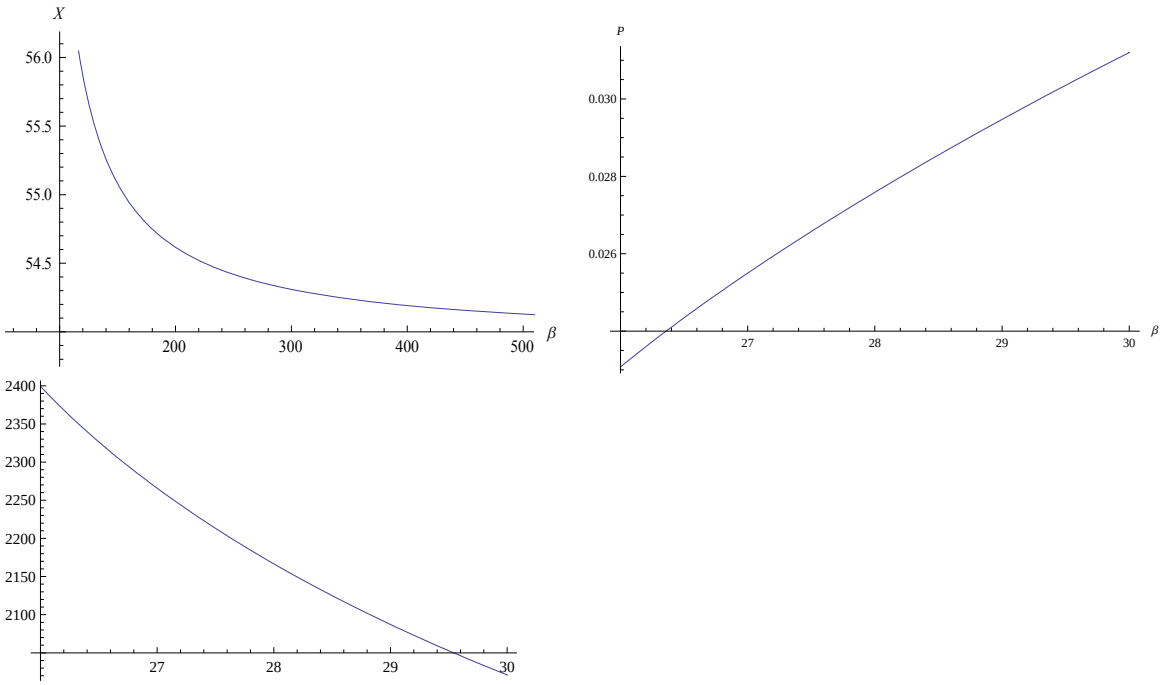


Figure 4: Effects of falling in offshoring costs on the aggregate outputs, price index and domestic welfare in the case of high productivity gap

[Figure 5 is here]

[Figure 6 is here]

Proposition 3 *The decrease in offshoring costs raises the relative skilled labor wages, and number of firms. However, it could increase(decrease) both the price level and index, decrease(increase) the outputs per firm and deteriorate(improve) the domestic welfare if the productivity gap is sufficiently low(high).*

4 Policy Implications

We have already known that the decrease in offshoring costs could deteriorate the domestic welfare if the productivity gap between two countries is relatively low. This section attempts to introduce trade policies to alleviate this problem. There are two trade policies to be considered here: the limited offshoring policy and production subsidy. The model is however too large and too non-linear to solve explicitly. Therefore , to explore these policies we will have to rely on numerical simulation.

4.1 Limited offshoring policy

Figure 7 shows the relationship between the domestic welfare and the marginal task at different levels of offshoring costs. From these graphs, we can see that the social optimal

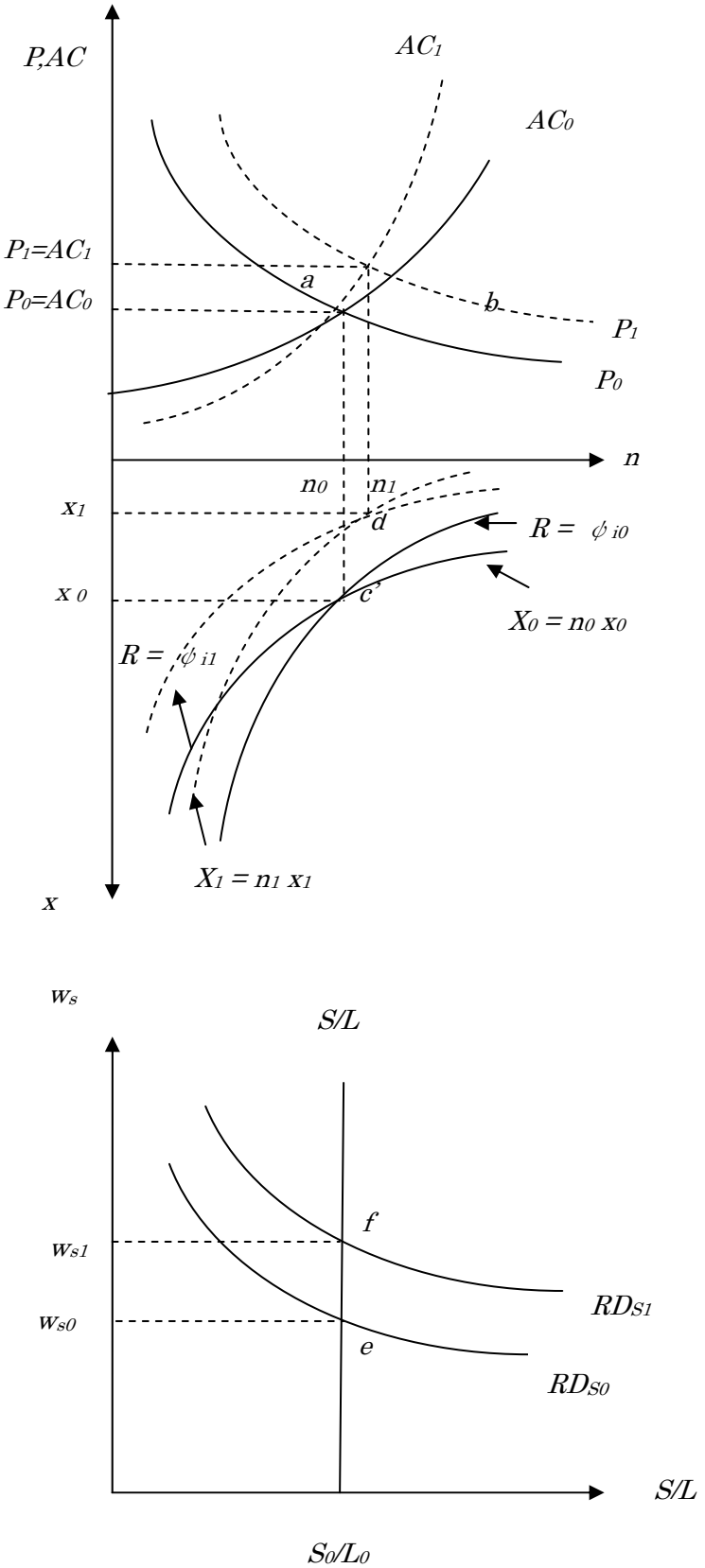


Figure 5: Effects of Falling in Offshoring Costs (Low α)

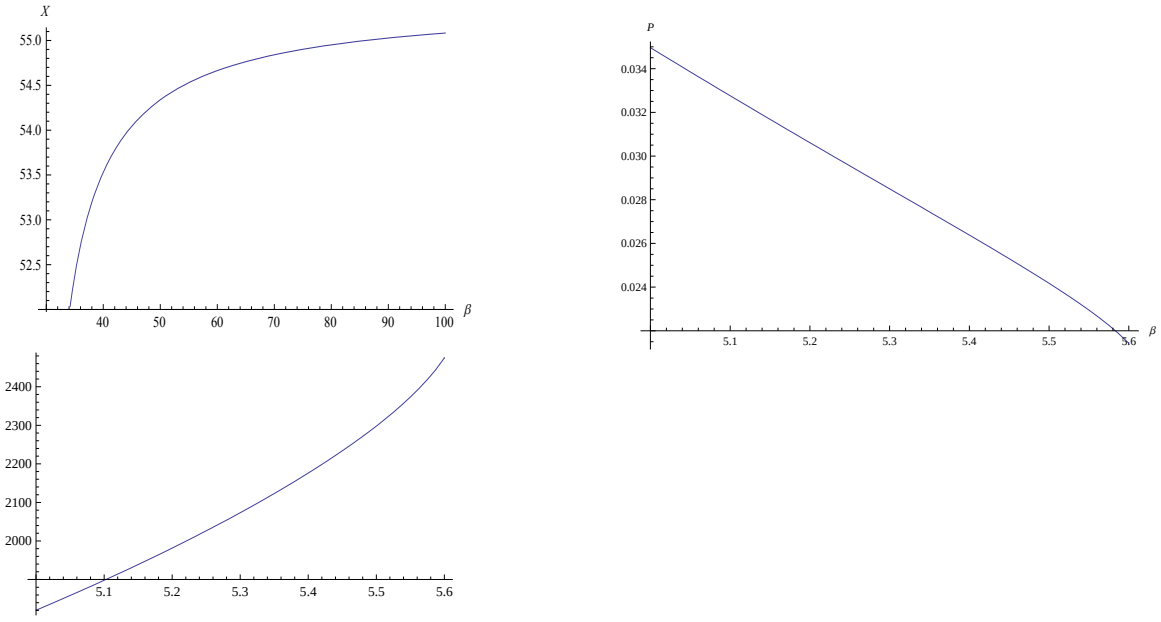


Figure 6: Effects of falling in offshoring costs on the aggregate outputs, price index and domestic welfare in the case of low productivity gap

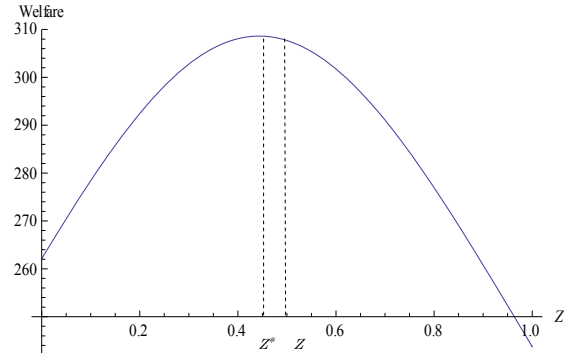
level of offshoring is always lower than the actual level firms offshore. If the offshoring costs are lower, firms will expand the extent of offshoring to the South and the welfare of the North will be worsened. Therefore, Northern government should impose the limited of offshoring policy to control the extent of offshoring of each firm at the social optimal level. For example, regarding with concerns about the effect on US economy, some members of Congress and state legislators have focused attention on the offshoring of service jobs and production by introducing legislation to limit the offshoring of jobs to other countries.

[Figure 7 is here]

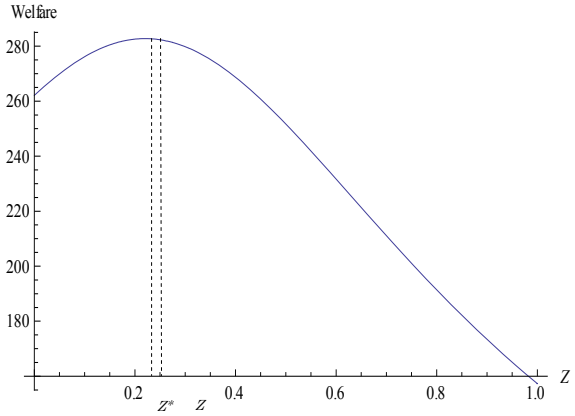
Proposition 4 *Northern government should limit the extent of offshoring of each firm to rise the domestic welfare if the productivity gap is relatively low*

4.2 Production subsidy

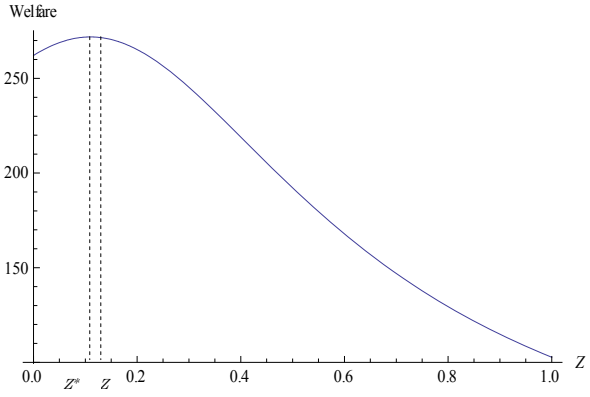
Next, we will consider the production subsidy policy to deal with the problem of a fall in domestic welfare. When the specific production subsidy is imposed, the pricing rule, zero profit condition and domestic welfare will be changed to the following equations:



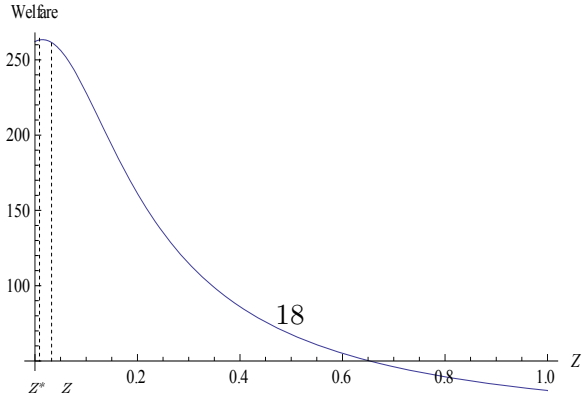
(a) Z = 0.5, Z* = 0.44, β =10



(b) Z = 0.25, Z* = 0.22, β =20



(c) Z = 0.125, Z* = 0.11, β = 40



(d) Z = 0.01, Z* = 0.00, β =500

Figure 7: Limited Offshoring Policy

$$p = \left(\frac{\sigma}{\sigma-1}\right)(a_{sx}w_s + a_{lx}w_L(1-z) + w^* a_{lx}\int_0^Z \beta(z)dz - s) \quad (33)$$

$$px = \theta(a_{ln}w_l + a_{sn}w_s) + (a_{sx}w_s + a_{lx}w_l(1-z) + w^* a_{lx}\int_0^Z \beta(z)dz - s)x \quad (34)$$

$$W = \frac{L + w_S\ S}{P^{\mu}} - snx \quad (35)$$

[Figure 8 is here]

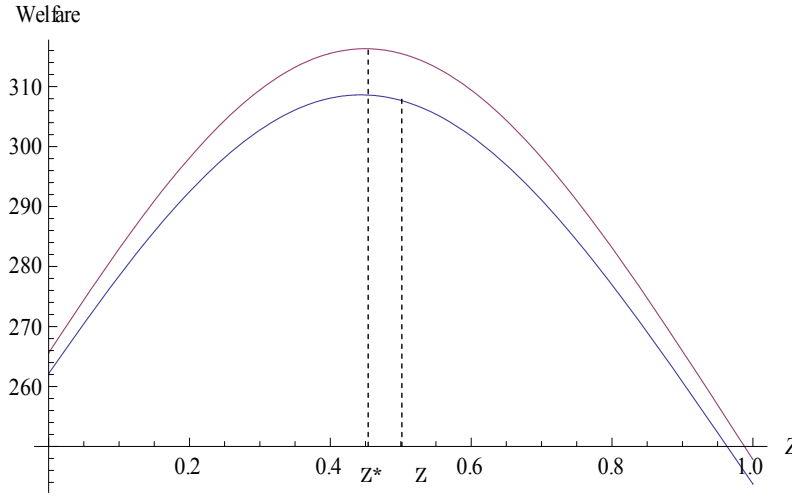
Figure 8 shows the domestic welfare at difference levels of production subsidy. We can see that if Northern government impose an optimal production policy(s = 0.9 in this case) , the actual extent of offshoring will equal to the social optimal level offshoring.

Proposition 5 *Northern government can impose production subsidy to rise the domestic welfare if the productivity gap is relatively low*

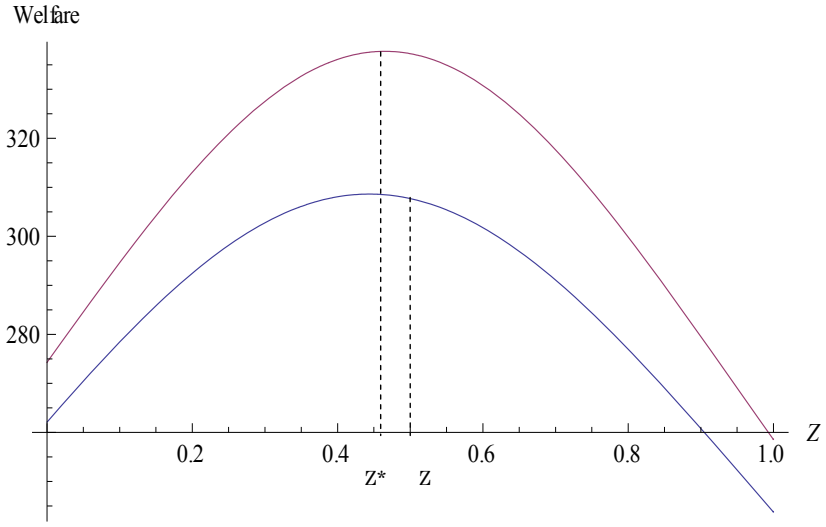
5 Concluding Remarks

The trend of offshoring manufacturing production process put pressure on the welfare of advanced countries. The model of offshoring in this paper is based on Grossman and Rossi-Hansberg(2009)'s model and monopolistic competition of Krugman and Helpman(1985). Offshoring, trade in tasks, requires the communication network to connect and communicate with remote-distance arm-length or subsidiary producers performing tasks at different countries. The communication networks are characterized by large fixed costs, low marginal costs of sending messages and average costs pricing. Additionally, offshoring bears some task-dependent costs trading off with lower wage rate. This paper studies the comparative statics analysis of decreasing in communication network costs and offshoring costs on the marginal task, relative skilled labor wages, outputs per firm, number of firms, price level, aggregate outputs, price index and domestic welfare.

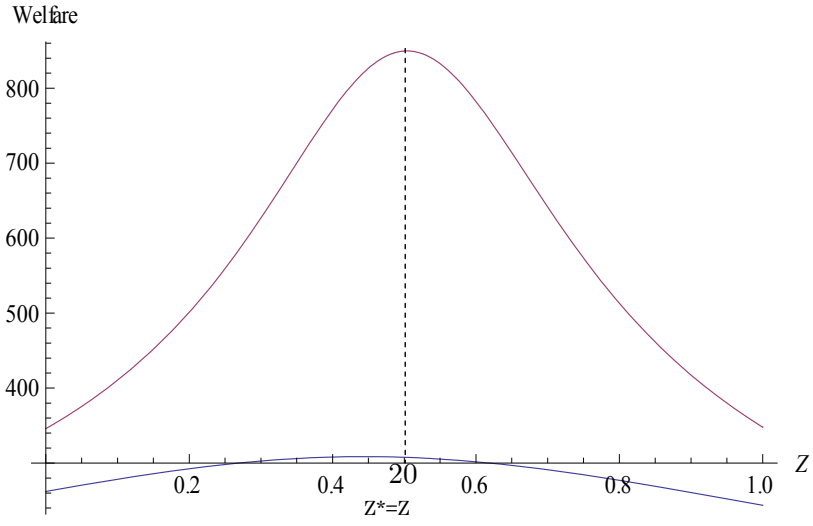
In the model, unskilled labors are available only in the South, offshoring can occur in unskilled-labor tasks. The marginal costs are unaffected even the communication networks is cheaper. This is because the lower fixed communication network cost is not affected the marginal task and relative skilled labor wages. When offshoring costs decreases, it creates two opposing effects on marginal costs of production: lower unskilled labor costs and higher skilled labor costs. Depending on these two forces, marginal costs can decrease or increase. Contrast to what was believes, a decrease in offshoring costs can lower the marginal costs of production and price level if productivity gap is relatively low. This is because the lower unskilled labor costs are outweighed by the higher skilled labor costs. If the productivity gap is highly enough, the lower unskilled labor costs can outweigh the higher skilled labor costs. Therefore the marginal cost and price level are lower.



(a) S = 1



(b) S = 3



(c) S = 9

Figure 8: Production Subsidy

The domestic welfare determined from real national income is always Pareto improvement in case of the decrease in communication networks. This is because it lowers the price index but not nominal income. While, the decrease in offshoring costs can deteriorate the domestic welfare if the productivity gap between two countries is relatively low. To raise the domestic welfare, North's government has to limit offshoring or impose production subsidy. However, in this paper the problem of comparison between two policies is left for further research.

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[18] OECD(2001) Employment Outlook

Appendix

A Prove for slope of $R = \theta_i$

We know that at equilibrium $R = \theta(w_s, n, x)$. Total differentiate this equation, we obtain,

$$\begin{aligned}\frac{dn}{dx} &= -\frac{dw_s/dx}{dw_s/dn} \\ &\quad -\frac{n\left(pS + S(-1+Z)a_{lx} + La_S\right)}{pSx - S\theta a_{\mathrm{LN}} + Sx(-1+Z)a_{lx} + Lxa_S + L\theta a_{sn}} < 0\end{aligned}$$

B Prove for Preposition 2

We differentiate eq. (26) -(33) with respect to θ, we obtain :

$$\begin{aligned}\frac{dw_s}{d\theta} &= 0 \\ \frac{dn}{d\theta} &= -\frac{\mu\theta^2\left(L + Sw_s\right)}{\sigma(a_{ln} + a_{sn}w_s)} < 0 \\ \frac{dp}{d\theta} &= 0 \\ \frac{dx}{d\theta} &= -\frac{2\beta(-1+\sigma)\left(a_{ln} + a_{sn}w_S\right)}{(\alpha - 2\beta)a_{lx} - 2\beta a_S w_S} > 0 \\ \frac{dX}{d\theta} &= 0 \\ \frac{dP}{d\theta} &= \frac{p}{1-\sigma}n^{\frac{\sigma}{1-\sigma}}\frac{dn}{d\theta} > 0 \\ \frac{dW}{d\theta} &= -\frac{E}{P^{2\mu}}\frac{dP}{d\theta} < 0\end{aligned}$$

C Prove for Preposition 3

From eq. 26, we can solve for the differentiation of w_S with respect to β. We can get

$\frac{dw_s}{d\beta} = \frac{1}{4S\beta^2\theta(-1+\mu)\sigma a_S a_{\mathrm{SN}}}(2L\beta\theta\mu\sigma a_S a_{\mathrm{SN}} + S\theta(2\beta(\mu(-1+\sigma)-\sigma)a_{\mathrm{LN}}a_S + (\alpha(-1+\mu)\sigma a_L + (2\beta(\mu-\sigma)+\alpha(1-2\mu+\sigma))a_S)a_{\mathrm{SN}}) - \sqrt{(\theta^2(8\beta\mu(-2L\beta\mu + S(\alpha-2\alpha\mu+2\beta\mu))(-1+\sigma)a_S^2 a_{\mathrm{SN}}(Sa_{\mathrm{LN}} - La_{\mathrm{SN}}) + (2S\beta(\mu+\sigma-\mu\sigma)a_{\mathrm{LN}}a_S + (S\alpha(-1+\mu)\sigma a_L + (2L\beta\mu(-2+\sigma) + S(2\beta(\mu-\sigma) + \alpha(1-2\mu+\sigma)))a_S)a_{\mathrm{SN}})^2)) + \beta\theta a_S(-2L\mu\sigma a_{\mathrm{SN}} + 2S((\mu+\sigma-\mu\sigma)a_{\mathrm{LN}} + (-\mu+\sigma)a_{\mathrm{SN}}) + (\theta(4\mu(-2L\beta\mu + S(\alpha-2\alpha\mu+2\beta\mu))(-1+\sigma)a_S a_{\mathrm{SN}}(Sa_{\mathrm{LN}} - La_{\mathrm{SN}}) + 8(L-S)\beta\mu^2(-1+\sigma)a_S a_{\mathrm{SN}}(-Sa_{\mathrm{LN}} + La_{\mathrm{SN}}) + 2(S(\mu+\sigma-\mu\sigma)a_{\mathrm{LN}} + (S(\mu-\sigma)+L\mu(-2+\sigma))a_{\mathrm{SN}})(2S\beta(\mu+\sigma-\mu\sigma)a_{\mathrm{LN}}a_S + (S\alpha(-1+\mu)\sigma a_L + (2L\beta\mu(-2+\sigma) + S(2\beta(\mu-\sigma) + \alpha(1-2\mu+\sigma)))a_S)a_{\mathrm{SN}})))/(\sqrt{(\theta^2(8\beta\mu(-2L\beta\mu + S(\alpha-2\alpha\mu+2\beta\mu))(-1+\sigma)a_S^2 a_{\mathrm{SN}}Sa_{\mathrm{LN}} - La_{\mathrm{SN}}) + (2S\beta(\mu+\sigma-\mu\sigma)a_{\mathrm{LN}}a_S + (S\alpha(-1+\mu)\sigma a_L + (2L\beta\mu(-2+\sigma) + S(2\beta(\mu-\sigma) + \alpha(1-2\mu+\sigma)))a_S)a_{\mathrm{SN}})^2)))) < 0$

The effect of the offshoring costs on the number of firms is

$$\frac{dn}{d\theta} = \frac{dn}{dw_s}\frac{dw_s}{d\beta} < 0$$

$$\frac{dn}{dw_s} = -\frac{\theta\mu(-1+\nu)\left(Sa_{\mathrm{LN}} - La_{\mathrm{SN}}\right)}{\left(a_{\mathrm{LN}} + a_{\mathrm{SN}}w_s\right)^2} > 0$$

The effect of the offshoring costs on the price level is

$$\frac{dp}{d\theta} \gtrless 0 \Leftrightarrow$$

$\alpha \gtrless \frac{-2}{S^2(-1+2\mu)(1+\mu(-2+\sigma))^2 a_{sn}^2}(\sqrt{(S^2\beta^2\mu(-1+2\mu)(1-2\sigma+\mu(-2+3\sigma))^2 a_{sn}^2(Sa_{ln} - La_{sn})(S(-1+2\mu)(1+\mu(-1+\sigma))a_{ln} + (-S(-1+\mu)(1+\mu(-2+\sigma)) - L\mu^2\sigma)a_{sn})) + S\beta(-1+2\mu)a_{sn}(S(-\sigma+\mu(1+\sigma-\sigma^2+\mu(-2+\sigma+\sigma^2)))a_{ln} + (-S(1+\mu(-2+\sigma))(\mu-\sigma) + L\mu\sigma(1-\mu\sigma))a_{sn}))$