# A Simple Model of Service Offshoring with Time Zone Differences*

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**Abstract**

We propose a two-country monopolistic competition model of business service offshoring that captures the advantage conferred by time zone differences. We emphasize the role of the *entrepreneurs*, who decide how to produce business services (i.e., domestic service provision or service offshoring). It is shown that the utilization of communication networks induces a dramatic change in industrial structure due to entrepreneurial relocation (i.e., service offshoring) to take advantage of time zone differences. We also show that in the presence of moving costs for entrepreneurs, technological improvements and the resulting increase in service offshoring may reduce a country's welfare.

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# 1 Introduction

Offshoring of information and communication technology (ICT) services and business process outsourcing (BPO, which includes call centers, data entry firms, and other back-office operations) are revolutionizing international trade in services, which do not require physical shipments of products.[1] The past decade has seen substantial growth in international outsourcing (offshoring) of business services, admittedly from a low baseline (Amiti and Wei, 2005, 2009, Head, Mayer and Ries, 2009). It is well recognized that the utilization of new types of communication network (e.g., the Internet) plays a major role in these trends.[2] The rise of India's software industry provides a prime example. The programming problems of some U.S. corporations are e-mailed to India at the end of the U.S. workday. Indian software engineers work on them during their regular office hours and provide solutions.[3] By the time the offices reopen in the U.S., the solutions have already arrived, mainly as e-mail attachments. Ireland, pitching to host Europe's main international call centers, offers another example. Cairncross (1997, p. 219) emphasizes the rise of the call-center service industry in Ireland, which is taking geographical advantage of being between the U.S. and Europe.

These types of business service offshoring require two basic conditions. Firstly, there must be a difference in time zones between the trading partners: having a wide time zone difference makes it possible for a company to operate a 24-hour business day. Second, there must be good connections via communication networks which enable the business service to be "trans-

[1] In what follows, for brevity, we will refer to both ICT services and BPO as "business services." Also, we use the term "offshoring" to denote the outsourcing of business services to foreign locations.

[2] Freund and Weinhold (2002) found that Internet penetration, as measured by the number of Internet hosts in a country, has a positive and significant effect on service trade. See also Hanley and Ott (2009).

[3] According to a recent McKinsey report, India contributed about two-thirds of global ICT outsourcing and about a half of global BPO offshoring in 2004 (*The Economist*, June 3-9, 2006).

ported" quickly with little marginal cost. Thanks to the communication revolution, time zone differences can become a primary driving force behind service offshoring. To provide an adequate assessment of the rise of business service offshoring one must not neglect the division of business activities across different time zones.

Relatively few attempts have been made to model the role of time zone differences in business service offshoring. In a pioneering paper, Marjit (2007) examined the role of international time zone differences in a vertically integrated Ricardian framework under perfect competition. He showed that time-difference emerges as an independent driving force of international trade besides taste, technology and endowment.

Pursuing this line of research, we propose a two-country monopolistic competition model of business service offshoring that captures the advantage conferred by time zone differences.[4] Following Marjit (2007), we consider two countries located in different time zones. Unlike Marjit who assumed perfectly competitive markets, we examine the role of time zone differences under monopolistic competition. This formulation allows us to emphasize the importance of a scarce factor, *entrepreneurs*, who decide whether to produce business services domestically or to offshore them.[5] The degree of substitutability between domestically provided services and offshored services plays an important role in our analysis. Furthermore, by introducing differentiated business services, we will be able to analyze the impact of technological change on the expansion of offshored service varieties.

[4] The fragmentation of production stages and of service provision has been studied within a trade-theoretic framework by Jones and Kierkowski (1990, 2001), Grossman and Helpman (2005), Long, Riezman and Soubeyran (2005), Do and Long (2008), Mitra and Ranjan (2008). Feenstra and Spencer (2005) dealt with both theory and empirical analysis. Spencer (2005) provided an excellent survey of the literature on outsourcing. Kikuchi and Iwasa (2010) presented a different type of monopolistic competition trade model with time zone differences in which services are assumed to be a final good.

[5] On role of entrepreneurship in international trade, see e.g., Yu (2002). Schmitt and Yu (2001) developed a model with heterogeneous fixed export costs, which can be interpreted as differences in entrepreneurship.

Our main building block is the concept of multi-stage production that takes place in real time. For concreteness, consider a non-traded final good in the home country ($H$). We posit that the production of this good necessarily involves two stages. The second-stage production, which can only be done in $H$, takes one whole working day (say 12 hours) and consists of "assembling" business services received at the beginning of the day. The first-stage is the production of various business services, each being provided by a specialised firm. The provision of each business service also takes the whole working date. Thus, to have a unit of the final good ready in $H$ on Tuesday evening, the business services that it embodies must be produced during day time on Monday in $H$, or in the foreign country ($F$) on Monday evening ($H$'s time), which is day time in $F$.

We assume the final good producers value the continuity of production activities. If they utilize domestic business services, on top of the price they pay for them, they also incur an inconvenience cost (or "interest cost") because of the time lag between the provision of those services and their assembling into the final good. On the other hand, if they utilize offshored services there exists no time lag (or only a negligible one) between service provision and the transformation.

In short, domestic delivery bears significant time costs (i.e., discontinuity of production processes). In contrast to this, the utilization of communication networks allows the production of some business services in the foreign country with non-overlapping work hours. This, together with business service transmission via networks, enables a quick delivery: this is a more efficient (i.e., non-disrupted) production process.[6] Although this cost-saving feature seems at odds with the usual assumption that foreign products are disadvantaged by transport costs, it captures the idea that final-good producers would like to have business services without discontinuity. In fact, a recent empirical study by Head, Mayer, and Ries (2009) found that in OCS ("Other

[6] Harrigan and Venables (2006) and Hummels (2001) also considered the time element in trade and discussed the uncertainty aspect of trade from a distant area.

Commercial Services" in the OECD's classification) trade, the continuity effect (ability to operate around the clock) dominates the synchronization effect (need to coordinate during business hours).[7]

While offshoring can benefit from the technology-induced time-zone advantage, entrepreneurs that offshore their business services have to incur other costs which we call "moving costs." This term represents the cost of doing business in a foreign environment. For example, the entrepreneur must learn how to deal with foreign bureaucrats, foreign legal system, and also incur the significant costs of development of interconnected communication networks over vast distances.[8] Some authors regard such cost as fixed costs of offshoring (Do and Long, 2008, Mitra and Ranjan, 2008). We find it more plausible to treat them as a "leakage" in the profit flow of the offshored business. While the reduction in delivery costs made possible by taking advantage of time zone differences has a positive effect on profit, the moving costs due offshoring have a negative effect. The overall effects of offshoring are determined by the tension between these countervailing effects.

Using a model based on the ideas outlined above, we will show that the utilization of communication networks induces a dramatic change in industrial structure due to entrepreneurial relocation to take advantage of time zone differences. Concerning the welfare effects of service offshoring, there are some interesting results. Given the existence of moving costs for entrepreneurs, we will show that a technological improvement in communication and the resulting increase in service offshoring may reduce a country's welfare, even though it is individually rational for each entrepreneur to choose to offshore services and to take advantage of time zone differences.

In Section 2 we present the basic model. In Section 3 we deal with the effects of technological change on service offshoring and welfare. Section 4 provides some concluding remarks.

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[7] Freeman (2002) and Jones et al. (2005) also emphasized the role of time zone differences as a determinant of efficient worldwide division of labor.

[8] The difficulty of of doing business across borders also suggests the importance of business and social networks. See Rauch (2001) for a survey.

## 2 The Model

There are two countries, Home and Foreign. They are located in different time zones and there is no overlap in daily working hours: when Home's daytime working hours end, Foreign daytime working hours begin (Figure 1).

In Home, there are $E$ individuals, each owning one unit of labor and $N/E$ units of entrepreneurship. All individuals in Home have the same utility function over two consumption goods: a nontradable Good $X$ (which uses as inputs a number of differentiated business services) and a tradable numeraire Good $Y$. Good $Y$ is competitively produced under constant-returns-to-scale technology, using labor as the only input. Assume the utility function is

$$u = \log x + y, \tag{1}$$

where $x$ and $y$ denotes the consumption of Good $X$ and Good $Y$, respectively.

Let $P$ denote the price of Good $X$, and $e$ denote the Home consumer's total expenditure on Good $X$. Equation (1) can be written as $u = \log e - \log P + y$. Maximizing this with the budget constraint $e + y \leq I$, where $I$ denotes the individual's income (which is the sum of her labor income and the income from her entrepreneurship), we obtain $e = 1$. That is, each individual spends $e = 1$ on Good $X$. Thus Home's aggregate expenditure on Good $X$ is equal to the number of individuals, $E$.

In Home, Good $X$ producers, who are perfectly competitive, buy business services which they combine and transform into the final good. This transformation can only start *after* each business service provision has been completed. The central assumption is that the *continuity* between business service provision and final good production is important: if there exists a lag between those two activities, the values of business services are diminished. Thus the timely delivery of business services is important.

Suppose there are two groups of services: domestically produced services with an aggregator denoted by $h$, and offshored services which utilize Foreign's daytime work (together with international communication networks) with an aggregator denoted by $f$. The production function Good $X$ is

$$X = \left(\alpha_h X_h^{\frac{\varepsilon-1}{\varepsilon}} + \alpha_f X_f^{\frac{\varepsilon-1}{\varepsilon}}\right)^{\frac{\varepsilon}{\varepsilon-1}}, \tag{2}$$

where $\varepsilon > 1$ is the elasticity of substitution between groups, $X_i$ $(i = h,\ f)$ is the quantity index of each group of services, and $\alpha_h/\alpha_f$ measures the relative attractiveness of domestically provided services. The corresponding unit cost function for good $X$ is

$$P = \left(\alpha_h^{\varepsilon} P_h^{1-\varepsilon} + \alpha_f^{\varepsilon} P_f^{1-\varepsilon}\right)^{\frac{1}{1-\varepsilon}}, \tag{3}$$

where $P_i$ is the price index for group $i$ services. Since Good-$X$ producers are perfectly competitive, the unit cost function $P$ is exactly equal to the price of Good $X$. Cost-minimization by final good $X$ producers implies that the relative demand for the two service aggregates is

$$\frac{X_h}{X_f} = \left(\frac{\alpha_h}{\alpha_f}\right)^{\varepsilon} \left(\frac{P_h}{P_f}\right)^{-\varepsilon}. \tag{4}$$

Recall that Good $X$ is not internationally traded. The value of sectoral output of the non-traded Good $X$ is $PX$, which must equal the total expenditure on it, $E$

$$PX = E$$

which is constant and equals the number of individuals in Home.

The quantity index for group $i$ takes the Dixit-Stiglitz (1977) form

$$X_i = \left[\int_0^{n_i} x_i(j)^{\frac{\sigma-1}{\sigma}} dj\right]^{\frac{\sigma}{\sigma-1}},\ i = h, f, \tag{5}$$

where $\sigma > 1$ is the elasticity of substitution between any pair of services within the same group, $x_i(j)$ is the quantity of service $j$ in group $i$, and $[0,\ n_i]$ represents group $i$'s range of varieties. The corresponding price index for the group $i$ is:

$$P_i = \left[\int_0^{n_i} p_i(j)^{1-\sigma} dj\right]^{\frac{1}{1-\sigma}},\ i = h, f, \tag{6}$$

where $p_i(j)$ is the price of service $j$ in group $i$.

The demand function for service $j$ in group $i$ satisfies

$$x_i(j) = \left[\frac{p_i(j)}{P_i}\right]^{-\sigma} X_i,\ i = h, f, \tag{7}$$

In each group, differentiated business services are produced by monopolistically competitive service firms. One of the central assumptions is that each service firm needs to be set up and managed by one unit of *entrepreneurship*. Since each individual provides $N/E$ units of entrepreneurship, there are $N$ units of entrepreneurships in Home.[9] Each entrepreneur has to decide what type of business service to provide. They have two options: (1) to set up a domestic firm by hiring Home labor at the wage rate $w_h$ and provide a service $h$ for Home Good-$X$ producers; or (2) to set up an intermediary and utilize Foreign's daytime labor at the wage rate $w_f$ and, via communication network, provide service $f$ for Home Good-$X$ producers.[10] Note that the wage rates in both countries are exogenously given by the labor productivity in Good $Y$ sector. It is assumed that Foreign does not have any business service firms of its own, and does not have demand for business services. Any business service variety produced in Foreign is made possible only by Home entrepreneurs that set up intermediaries to take advantage of time zone differences. As in Martin and Ottaviano (1999), the operating profits in Foreign (i.e., the rewards for entrepreneurs who decide to offshore) are assumed to be repatriated to Home.

To produce one unit of service, one unit of labor (with one working day) is required. Given a Dixit-Stiglitz specification with constant elasticity $\sigma$, and the wage rate $w_i$, each service firm in group $i$ ($i = h, f$) sets its "mill price" $\rho_i$ by adding a constant mark-up over marginal cost

$$\rho_i = \frac{\sigma w_i}{\sigma - 1},\ \ i = h, f. \tag{8}$$

[9] In what follows, an "entrepreneur" means "one unit of entrepreneurship."

[10] In what follows, we use the terms "service offshoring" and "the utilization of time zone differences via communication networks" interchangeably.

where $\sigma/(\sigma - 1)$ is the mark-up factor. While Home final good-$X$ producers pay $\rho_i$ per unit of service from source $i$ ($i = h, f$), the actual cost to them is greater by a factor $t_i$ because of inconvenience cost arising from the lag between the completion time of the service provider and the time the service is actually utilized as an input in final good production.[11] Thus, from the view point of Home Good-$X$ producers, the full cost of a unit of service $i$ is

$$p_i = t_i \rho_i, \quad i = h, f.$$

Bearing in mind the time element of the model, we can interpret $(t_i - 1)/t_i$ as a rate of discount.

Recall that our key assumption is that domestic service production requires one workday and that the second-stage production can only begin the following workday. Thus domestic service delivery bears significant time costs. In comparison, offshored services, as soon as they are completed, are immediately usable due to the utilization of rapid communication networks (Figure 1). In other words, offshored services whose production benefits from time zone differences realize higher value (or lower discount rate) than domestically produced services. Interestingly, this assumption is contrary to the familiar "trade cost" of the standard monopolistic competition model which penalizes firms that ship goods from the periphery to the center. However, it seems only natural that final goods producers would like to have services sooner than later.

We treat the improvement of communication networks as a reduction in delivery costs of offshored services ($t_f$). Let us denote the delivery cost of offshored services before the technological change by $t_f^1$ and denote that after the change by $t_f^2$. We assume the following condition holds:

$$t_f^1 > t_h > t_f^2 \geq 1. \tag{9}$$

[11] There is an obvious parallel between this formulation of inconvenience costs and the ice-berg transportation costs in the standard trade model that generates the well-known home market effect. According to the ice-berg formulation, for every $t_i$ ($t_i > 1$) units shipped, only one unit arrives.

Note that this effect comes not from lower production costs in Foreign but from faster delivery. In the next section, we examine the impact of technological improvement in communication technologies, which is captured by a reduction in $t_f$.

We can obtain the profit level for the service firm in group $i$:

$$\pi_i = \frac{1}{n_i \sigma} P_i X_i, \quad i = h, f. \tag{10}$$

Then the relative profit is

$$\begin{aligned} \frac{\pi_f}{\pi_h} &= \frac{n_h}{n_f} \left( \frac{P_f}{P_h} \right) \left( \frac{X_f}{X_h} \right) = \frac{n_h}{n_f} \left( \frac{\alpha_f}{\alpha_h} \right)^{\varepsilon} \left( \frac{P_f}{P_h} \right)^{1-\varepsilon} \\ &= \left( \frac{\alpha_f}{\alpha_h} \right)^{\varepsilon} \left( \frac{n_f}{n_h} \right)^{\frac{\varepsilon - \sigma}{\sigma - 1}} \left( \frac{w_h t_h}{w_f t_f} \right)^{\varepsilon - 1}. \end{aligned} \tag{11}$$

Assume $\sigma > \varepsilon$ (i.e., substitutability within a group is greater than between groups). The ratio of profits is thus inversely proportional to the ratio of number of service varieties.[12]

Suppose that to become an offshored business service provider, an entrepreneur must incur *moving cost*. These costs include, for example, the fixed costs of interconnection and of setting up intermediaries, as well as the costs of dealing with foreign bureaucrats.[13] To represent these additional moving costs, we assume that when an entrepreneur moves from group $h$ to group $f$, her net earning is only a fraction $1/(1+\delta)$ of the profit in the new sector. The other fraction, $\delta/(1+\delta)$, represents "leakages,"or deadweight losses. The case $\delta = 0$ corresponds to the usual monopolistic competition model (Matsuyama 1995).

To offset these moving costs, profits of service-$f$ provider must be higher compared to service-$h$ provider. Thus, in the long run, the following equilib-

[12] See Matsuyama (1995, p. 714) on this point.

[13] Kikuchi (2003) discusses implications of the interconnection of communication networks. Hanley and Ott (2009) argue that the costs of incomplete contracts, plus monitoring and search costs also constitute a significant part of costs of offshoring.

rium condition must hold:

$$(1+\delta)\tilde{\pi}_h = \tilde{\pi}_f, \tag{12}$$

where the "tilde" indicates the long-run equilibrium value. In other words, the costs of communicating across national borders are offset by the advantages of quicker delivery. In the long run, the distribution of service firms is determined by the movement of entrepreneurs such that (12) holds.

Figure 2 shows the determination of the relative number of service firms in the long run. The horizontal axis shows the relative number of service firms ($n_f/n_h$), while the vertical axis shows the relative profit level ($\pi_h/\pi_f$). Given that $\sigma > \varepsilon$, equation (11) is shown as a downward-sloping curve.

Suppose the initial position is at point $I$. Then some entrepreneurs will move from group $h$ to group $f$. In the long run, the equilibrium is obtained at point $E$, the intersection of the curve representing (11) and the line $(1+\delta)\tilde{\pi}_h = \tilde{\pi}_f$. The long-run relative size of service offshoring (measured in terms of number of business service firms) is

$$\frac{\tilde{n}_f}{\tilde{n}_h} = \frac{N-\tilde{n}_h}{\tilde{n}_h} = \left[\left(\frac{1}{1+\delta}\right)\left(\frac{\alpha_f}{\alpha_h}\right)^{\varepsilon}\left(\frac{w_h t_h}{w_f t_f}\right)^{\varepsilon-1}\right]^{\frac{\sigma-1}{\sigma-\varepsilon}}. \tag{13}$$

**Proposition 1:** *In the long run, the share of business service offshoring is positively related to its relative attractiveness ($\alpha_f/\alpha_h$) and negatively related to both its relative costs (inclusive of delivery costs $t_i$) and the costs of movement $\delta$.*

This implies that, without sophisticated communication networks, a strong preference in favor of domestically provided services and the existence of significant costs of movement would result in a low long run level of service offshoring.

# 3 The Impact of a Technological Advance in Communication Networks

## 3.1 Profits

In this section, we examine the impact of a technological advance in communication technologies, which is captured by a reduction in delivery costs $t_f$ for service $f$. From (6),

$$P_h = n_h^{\frac{1}{1-\sigma}}(t_h \rho_h),$$
$$P_f = n_f^{\frac{1}{1-\sigma}}(t_f \rho_f).$$

Let $r_h$ denote the cost (to final good producers) of the bundle of domestically produced services relative to that of the offshored ones. Then we obtain

$$r_h \equiv \frac{P_h}{P_f} = \left(\frac{n_h}{n_f}\right)^{\frac{1}{1-\sigma}} \left(\frac{t_h \rho_h}{t_f \rho_f}\right), \tag{14}$$

$$\hat{r_h} = -\frac{1}{\sigma - 1}\widehat{\left(\frac{n_h}{n_f}\right)} + \widehat{\left(\frac{t_h \rho_h}{t_f \rho_f}\right)}. \tag{15}$$

where the hat denotes the percentage rate of change. Hence a reduction in $t_f$ increases the buyer's relative input cost $r_h$. In order to examine the impact of a technological advance, it is useful to express the profit level of each service firm ($\pi_h$ and $\pi_f$) in terms of the relative price $r_h$. Using (10), we get

$$\pi_h = \frac{1}{n_h \sigma} P_h X_h = \frac{1}{n_h \sigma}\left[1 - \mu_f(r_h)\right] E, \tag{16}$$

$$\pi_f = \frac{1}{n_f \sigma} P_f X_f = \frac{1}{n_f \sigma}\mu_f(r_h) E, \tag{17}$$

where $\mu_f(r_h)$ is the relative expenditure share for group-$f$ services:

$$\mu_f(r_h) \equiv \frac{\alpha_f^{\varepsilon} P_f^{1-\varepsilon}}{\alpha_h^{\varepsilon} P_h^{1-\varepsilon} + \alpha_f^{\varepsilon} P_f^{1-\varepsilon}} = \frac{\alpha_f^{\varepsilon}}{\alpha_h^{\varepsilon}(r_h)^{1-\varepsilon} + \alpha_f^{\varepsilon}}, \tag{18}$$

$$\mu_f'(r_h) = \frac{(\varepsilon - 1)\alpha_h^\varepsilon \alpha_f^\varepsilon (r_h)^{-\varepsilon}}{\left[\alpha_h^\varepsilon (r_h)^{1-\varepsilon} + \alpha_f^\varepsilon\right]^2} > 0.$$

In the short run $n_f$ and $n_h$ are fixed, hence the changes in profit levels come only from the change in the relative expenditure share induced by a rise in relative cost $r_h$ of the domestic bundle:

$$\begin{aligned} \frac{\partial \pi_f}{\partial r_h} &= \frac{\mu_f'}{n_f \sigma} E > 0, \\ \frac{\partial \pi_h}{\partial r_h} &= -\frac{\mu_f'}{n_h \sigma} E < 0. \end{aligned}$$

By shifting expenditure away from domestically produced services, a reduction in delivery costs of offshored service $t_f$ increases the profit of group-$f$ firms, while reducing the profit of group-$h$ firms. In Figure 2, this change is shown as an upward shift of the downward-sloping curve (i.e., from point $E$ to point $I'$).

Suppose that before the technological advance, $n_f$ is smaller than $n_h$ because the initial $t_f$ is high. Then we can prove the following result:

**Proposition 2:** *In the short run, given that $n_f < n_h$, the change in each group-$f$ firm's profit due to technological change is larger (in absolute value) than the change in each group-h firm's profit:*

$$\left|\frac{\partial \pi_f}{\partial t_f}\right| > \left|\frac{\partial \pi_h}{\partial t_f}\right|.$$

In the intermediate run, entrepreneurs respond to the change in relative profit, and gradually move from group $h$ to group $f$, which results in increased service offshoring. This is shown as a move from point $I'$ to $E'$ in Figure 2. It tends to reduce the profit of group-$f$ firms. Note that the increase in the number of offshored services causes a second-round reduction in the price index $P_f$. Since the range of offshored services has widened, the bundle of offshored services becomes more attractive to Home final-good producers.

From (14) and (15), the relative cost of group $h$ increases with $n_f$, and mitigates the negative effect on $\pi_f$ of an increasing number of service firms in group $f$. The bigger is the inter-group substitution $\epsilon$, the larger is this effect.

Now let us consider the change in the long-run profit levels. From (10), one obtains

$$\tilde{n}_h \tilde{\pi}_h + \tilde{n}_f \tilde{\pi}_f = \frac{E}{\sigma}. \tag{19}$$

Given that $(1+\delta)\tilde{\pi}_h = \tilde{\pi}_f$ holds in the long run, we can obtain the profit for each group-$h$ firm as follows:

$$\tilde{\pi}_h = \frac{(E/\sigma)}{(1+\delta)N - \delta \tilde{n}_h}, \qquad \frac{\partial \tilde{\pi}_h}{\partial \tilde{n}_h} > 0. \tag{20}$$

This implies that the long-run profit of each group-$h$ firm is decreasing in the level of group-$f$'s delivery costs. As $t_f$ falls, it becomes more profitable for entrepreneurs to switch location, and to take advantage of time zone differences. Since offshored service providers earn higher (gross) profits in the long-run equilibrium, this switch tends to reduce the profit of remaining group-$h$ service providers.

**Proposition 3:** *In the long run, from each group-h firm's viewpoint, the negative effect of technological change is magnified due to entrepreneurs' switching from home services toward offshored services.*

The gradual switching of entrepreneurs results in increased service offshoring: more entrepreneurs utilize time zone differences as a result of improved communication networks.

## 3.2 Welfare

Now let us examine the welfare effects of a technological change that results in a fall in $t_f$. Let us begin by examining the short-run effect of the technological change. In the short run, the number of services in each group is constant.

Differentiating (3) with respect to $t_f$ yields, after making use of (14) and (15) with $\widehat{(n_h/n_f)} = 0$,

$$\left(\frac{t_f}{P}\right)\left(\frac{dP}{dt_f}\right) = (\alpha_f)^{\epsilon}(r_h)^{1-\epsilon} > 0. \tag{21}$$

Equation (21) shows that the price of Good $X$ immediately becomes lower after the technological change.

Next let us consider the aggregate net profit for Home entrepreneurs. Using (16) and (17),

$$\begin{aligned} \Pi &\equiv n_h\pi_h + \frac{1}{1+\delta}n_f\pi_f \qquad (22)\\ &= \frac{E}{\sigma}\left(1 - \frac{\delta\mu_f}{1+\delta}\right). \qquad (23)\end{aligned}$$

Thus, differentiating (23) with respect to $t_f$ yields, we obtain the short-run effect on net aggregate profit[14]

$$\left(\frac{t_f}{\Pi}\right)\left(\frac{d\Pi}{dt_f}\right) = \frac{\delta\mu'_f r_h}{1+\delta(1-\mu_f)} > 0. \tag{24}$$

Equations (21) and (24) show that in the short run, there are two conflicting effects on welfare. On the one hand, lower delivery costs leads to lower final good price, increasing consumers' welfare. On the other hand, increasing the group-$f$ firms' gross profits leads to reduced aggregate net profit when the leakage of offshore profits is positive ($\delta > 0$). The larger the leakage parameter $\delta$, the greater the negative impact of technological change on total profits.

[14]Note that the following conditions hold:

$$\begin{aligned} \left(\frac{t_f}{n_h\pi_h}\right)\left[\frac{d(n_h\pi_h)}{dt_f}\right] &= \frac{\mu'_f r_h}{1-\mu_f} > 0,\\ \left(\frac{t_f}{n_f\pi_f}\right)\left[\frac{d(n_f\pi_f)}{dt_f}\right] &= \frac{\mu'_f r_h}{\mu_f} < 0.\end{aligned}$$

Next, let us consider the long-run impact of the technological change, after the relocation of entrepreneurs has taken place to equalize the net returns to entrepreneurship. Since some group-$h$ firms switch to group-$f$ status, the number of offshored services increases. This induces a further reduction in the price $P$ (see (15)): with an enlarged range of offshored services, the price of Good $X$ becomes lower still, which increases the welfare gains for consumers. At the same time, however, increased switching implies greater aggregate moving costs, hence a negative impact on total net profits (and hence consumers' income). Thus, if moving costs are sufficiently high, the technological change and the resulting increase in service offshoring may actually cause welfare to fall because the efficiency effect of lower delivery costs is dominated by the increased waste due to moving costs. Hence, the successful movement of some entrepreneurs, while a profit-maximizing move from their viewpoint, is not Pareto-improving from the viewpoint of the country as a whole.

Let us examine the change in consumers' utility level. From (1), the indirect utility function of each individual is given as follows:[15]

$$\begin{aligned} u &= \log e - \log P + \left[ w_h + \left(\frac{N}{E}\right)\left(\frac{\Pi}{N}\right) - e \right] \\ &= -\log P + \frac{1}{\sigma}\left(1 - \frac{\delta \mu_f(r_h)}{1+\delta}\right). \end{aligned} \tag{25}$$

The plot of $u$ with respect to $1/t_f$ (i.e., the degree of technological change) is shown in Figure 3.[16] This curve is inverted U shaped for a wide range of reasonable parameter values.

**Proposition 4:** *In the presence of moving costs for entrepreneurs, a country may suffer a welfare loss as a result of an increase in service offshoring induced by a technological advance in communication networks.*

[15] Note that $e = 1$. Furthermore, to simplify the mathematical expressions, we set $w_h = 1$ without loss of generality.

[16] Parameter values for Figure 3 are as follows: $w_h = w_f = 1$, $t_h = 1$, $\alpha_f = \alpha_h = 1$, $\epsilon = 2$, $\sigma = 1.5$, $N = 1$.

The intuition behind this result is as follows. If the initial level of delivery costs $t_f$ is high, then the share of offshored services is relatively small (see (13)) and hence the negative impact of moving costs is relatively small. In this case, the efficiency effect dominates and the technological change increases welfare. If the level of delivery costs is sufficiently lower, however, the share of offshored service becomes larger and an increase in wasteful use of resources (i.e., moving costs) dominates the other favorable effects. As a result, a technological advance in the form of lowering delivery costs of offshored services and the resulting increased service offshoring can be harmful. Figure 3 also displays several cases with different values of $\delta$. As $\delta$ becomes larger, the curve representing the utility will shift down. This confirms the intuition that a greater leakage $\delta$ implies a larger negative effect of increased wastes.[17]

Our result on welfare is in sharp contrast to popular discussions about the winners of service offshoring. Many people would think that the winners of service offshoring are owners of firms (i.e., entrepreneurs) that offshore services. Given the existence of moving costs, however, service offshoring by Home entrepreneurs may worsen the welfare of Home and reduce the net profits of all entrepreneurs, even though it is individually rational for entrepreneurs to choose to offshore in order to take advantage of international time zone differences.

# 4 Concluding Remarks

In this study, by constructing a simple model of service offshoring under monopolistic competition, we have examined how a technological change that results in a decline in delivery costs of offshored services affect domestic en-

[17]It may be worth noting that there is a parallel between the present model and the "reciprocal dumping" trade model of Brander and Krugman (1983) which also emphasizes both the positive pro-competive effect of trade liberalization and negative effect associated with increased aggregate transport cost.

trepreneurs' offshoring decisions to take advantage of international time zone differences. We have demonstrated that, as the delivery costs of offshored services become lower, more entrepreneurs choose to utilize communication networks and provide offshored services. Also, in the presence of costs of movements, the impact of technological change on profit levels becomes larger as more entrepreneurs switch to become offshored service providers.

Furthermore, we have shown that there are conflicting effects of a technological change on welfare. While efficient utilization of offshored services (taking advantage of time zone differences) has a direct positive impact on welfare, the increased waste in entreprenuers' movement has a negative impact. Our analysis indicates that a technological advance which leads to increased service offshoring may actually reduce welfare because the efficiency effect is dominated by the increased waste due to moving costs. Service offshoring with time zone differences is not necessarily profit-enhancing in equilibrium, even though it is individually rational for each entrepreneur to take advantage of time zone differences.

The present analysis must be regarded as very tentative. Hopefully it provides a stimulus for studying how a technological advance (or trade liberalization) affects both the degree of service offshoring and welfare.

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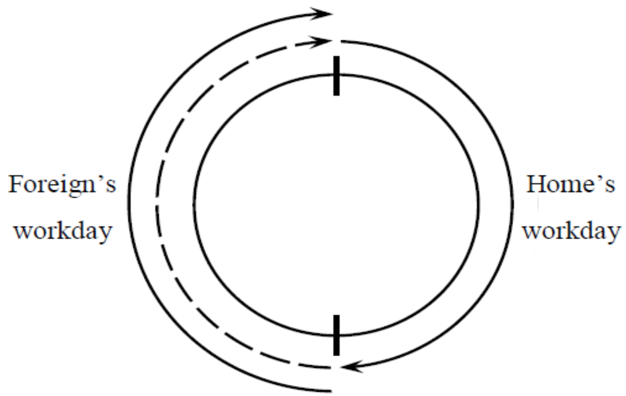
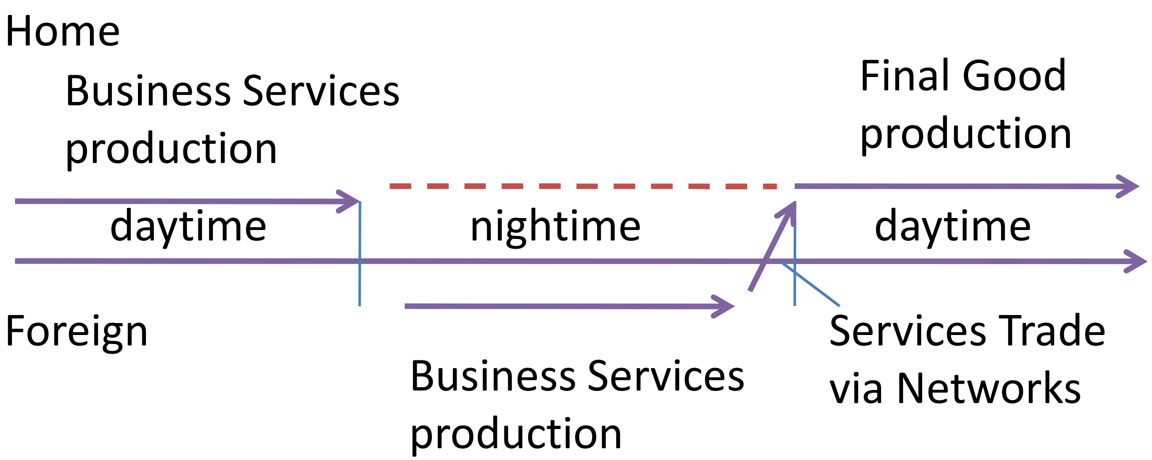
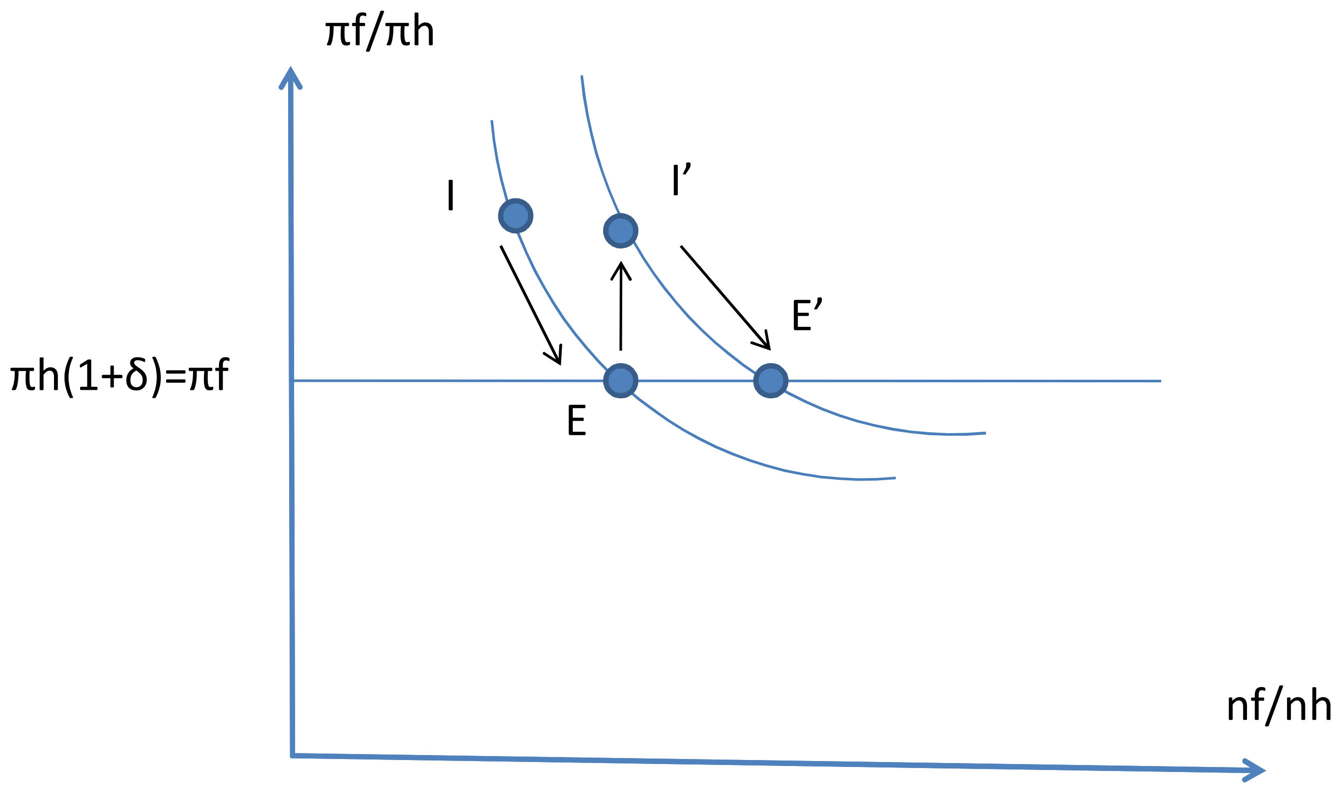
# Figure 1

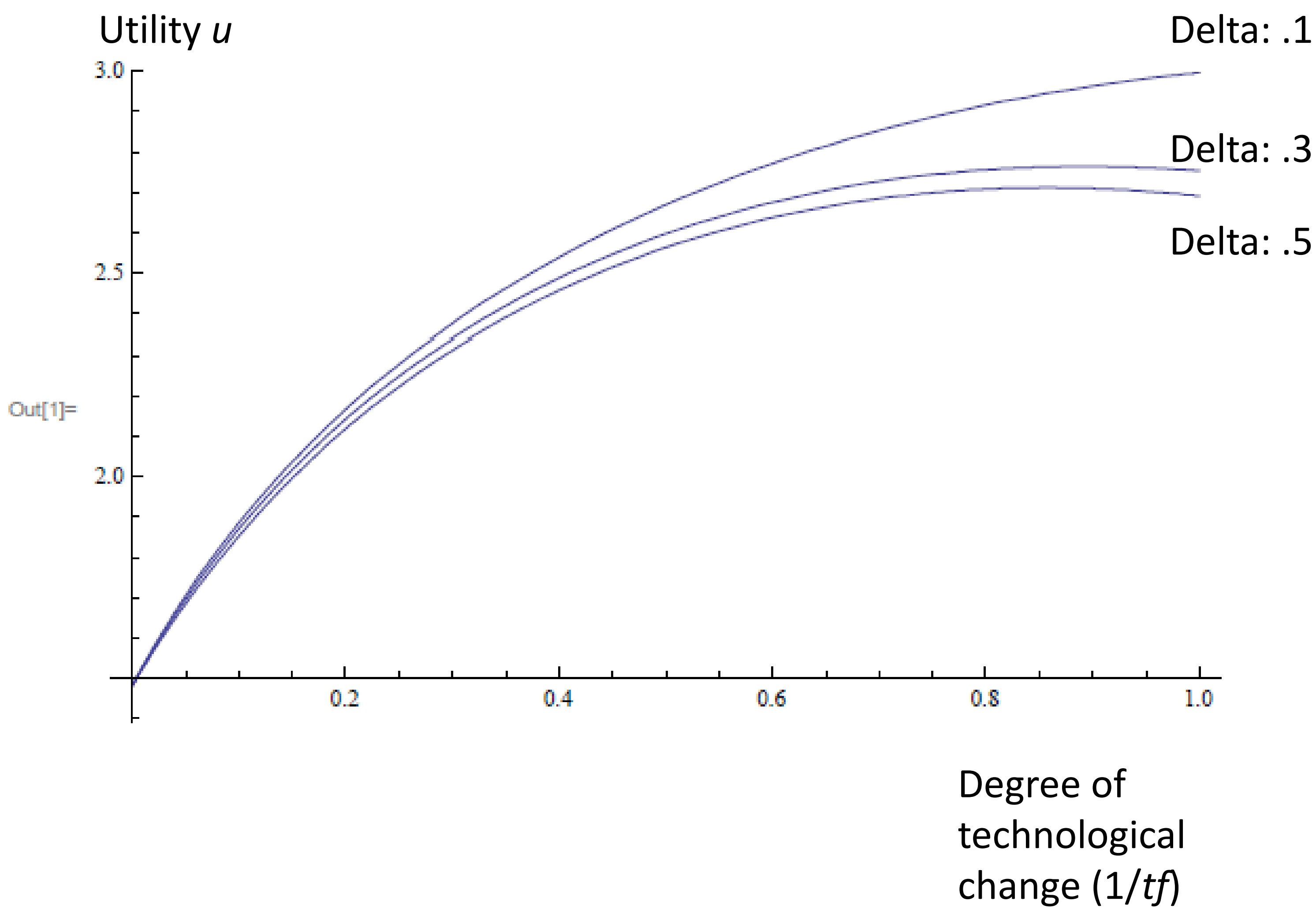

Foreign's
workday
Home's
workday


Home
Business Services
production
Final Good
production
daytime
nightime
daytime
Foreign
Services Trade
via Networks
Business Services
production

# Figure 2



# Figure 3



Utility $u$
Delta: .1
Delta: .3
Delta: .5
3.0
2.5
2.0
Out[1]=
0.2
0.4
0.6
0.8
1.0
Degree of technological change ($1/tf$)