Time Zones and FDI with Heterogenous Firms

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Abstract

Based on Helpman et al. (2004), we propose a simple two-country (Home and Foreign) model with heterogeneous firms that capture the role of FDI via utilizing time zone differences. Two countries are located in different time zones and there is no overlap in daily working hours. It will be shown that productivities of the firms undertaking FDI are higher than the productivities of non-FDI firms. Although the results look quite similar with Helpman et al. (2004), the direction of service trade flow is totally different: Foreign subsidiaries of high-productivity firms provide services for the Home market.

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1 Introduction

Since the 1980s foreign direct investment (FDI) has grown astonishingly fast, even faster than international trade. Not only did the overall level of FDI increase, it also changed from investments in manufacturing to investment in services. Related to these, intra-firm trade of business services such as engineering, consulting, and software development, which do not require physical shipments of products, have been playing major roles in today’s world trade. Reducing cost by FDI has become much more feasible with the availability of the global high-bandwidth network infrastructure.

According to these changes, new types of FDI and service trade which are taking advantage of time zone differences between countries emerge. The semiconductor industry provides a prime example. Brown and Linden (2009, pp. 87–91) wrote:

“Some chip companies with foreign design subsidiaries value the opportunity to design on a 24-hour cycle because of the enormous pressure to reach the market ahead of, or no later than, competitors. One established US chip company adopted a rolling cycle between design centers in the United States, Europe, and India. More common is the bi-national arrangement used by a Silicon Valley start-up that had all of its design beyond the initial specification done by a China subsidiary established within months of the company’s founding.... The Silicon Valley staff would review Beijing’s work from the previous day, then spend up to three hours on the phone (stating around 5 pm California time) providing feedback and reviewing assignments for that day in Beijing. In a single-location firm this work-feedback cycle take
two days instead of one.”

Not only firms, but also consumers prefer to consume services taking advantage of time zone differences. Ireland, pitching to host Europe’s main international call centers, offers another example. Cairncross (1997, p. 219) emphasized the rise of the call-center service industry in Ireland, which is taking geographical advantage of being in between the U.S. and Europe.

To summarize above arguments, due to the communications revolution, time zone differences may become a primary driving force behind service trade. Furthermore, these kinds of service trade invite new types of incentives for FDI. From home consumers’/firm’s viewpoints, it is preferable that some subsidiaries locate at distant areas to serve for home market. Although this point is at odds with the “proximity advantages” of FDI (e.g., Brainard, 1997), it seems to be important to consider these new types of FDI incentives. Related to these phenomena, Marjit (2007) examined the role of international time zone differences in a vertically integrated Ricardian framework. It has been shown that time zone differences emerge as an independent driving force of international trade besides taste, technology and resource endowment.¹

What remains unanswered is what is the relationship between firm-productivity and FDI with time zone difference. Based on casual empiricism, we believe that time-saving technological improvement (e.g., utilization of communications networks such as the Internet) can trigger a series of events that leads to reallocations of industry structure via FDI. In the existing literature on

¹Jones et al. (2005) also emphasize the role of time zone differences as a determinant of efficient worldwide division of labor. Furthermore, the fragmentation of production stages and of service provision has been studied within a static trade-theoretic framework by Jones and Kierzkowski (1990), Grossman and Helpman (2005), Long, Riezman and Soubeyran (2005), Do and Long (2008).
FDI and firm heterogeneity, however, relatively few attempts have been made to address the role of time zone differences on FDI decisions.\(^2\) This seems to suggest that the focus on “trade using different time zones” should be accompanied by a focus on firms’ FDI decisions. The main purpose of this study is to illustrate, with simple FDI model with heterogeneous firms, how a time-saving improvement in service trade using different time zones can have a huge impact on firms’ FDI decisions.

For these purposes, based on Helpman et al. (2004), we propose a simple two-country model with heterogeneous firms that capture the role of FDI via utilizing time zone differences. Two countries (Home and Foreign) are assumed to be located in different time zones and there is no overlap in daily working hours. The key assumption of our model is that domestic service production requires one workday and that products are ready for sale after one workday: domestic delivery bears significant costs in terms of delay. In contrast to this, the utilization of communications networks allows production in a foreign country where non-overlapping work hours and service trade via networks enable a quick delivery and low shipping costs. In other words, imported services whose production benefits from time zone differences provide higher value than domestically produced services.

Based on the model outlined above, this study shows productivities of the firms undertaking FDI are higher than the productivities of non-FDI firms. Although the results look quite similar with Helpman et al. (2004), the direction of service trade flow is totally different: Foreign subsidiaries

\(^2\)In their important contribution, Helpman et al. (2004) show that the productivities of the firms undertaking FDI are higher than the productivity of the exporters. According to this point, Mukherjee (2010) show that the theoretical prediction of Helpman et al. (2004) may not hold. Helpman (2006) provided an excellent survey on the literature on FDI with heterogeneous firms.
of high-productivity firms provide services for the Home market. In other words, in a sense of timeliness, building Foreign subsidiaries via FDI implies building subsidiaries closer to the Home market (see, Figure 1).

2 The Model

Suppose there are two countries, Home and Foreign, which are endowed with one factor of production (labor). 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).

There are two types of goods: a homogeneous good and a large variety of differentiated services. Only Home consumers demand the differentiated services, while both countries’ consumers demand the homogeneous good. The preference of the representative Home consumer are given by

$$u = (1 - \beta) \log z + \frac{\beta}{\alpha} \log \left( \int_v [x(v)]^\alpha dv \right),$$

(1)

where $z$ is consumption of the homogeneous good, $x(v)$ is consumption of variety $v$, $\alpha = (\epsilon - 1)/\epsilon$, $\epsilon > 1$ is an elasticity of substitution between varieties. These preferences imply the following demand function,

$$x(v) = A[p(v)]^{-\epsilon},$$

(2)

$$A = \frac{\beta E}{\int_0^n [p(v)]^{1-\epsilon} dv},$$

(3)

where $E$ is the aggregate level of spending in Home, $n$ is the measure of service varieties available in Home, and $p(v)$ is the consumer price of variety $v$.

The homogeneous good is produced with constant returns, using labor as an input. Units are chosen so that one unit of labor produces one unit of
output. As usual, no transport costs exist for the homogeneous good, which serves to tie down the wage rate. Also assume that the parameters of the model are such that both countries produce the homogeneous good; thus, constant, identical wages hold (hereafter set to unity).

Now let us turn to the differentiated service sector. To simplify the analysis, we assume that the difference service firms exist only in Home. To enter the industry, a firm bears the fixed costs of entry $f_E$, measured in labor units. An entrant then draws a labor-per-unit-output coefficient $a$ from a distribution $G(a)$. Upon observing this draw, a firm may decide to exit and not produce. If it choose to produce domestically, however, it bears additional fixed overhead labor costs $f_D$. On the other hand, if it chooses to serve the domestic (Home) market via foreign direct investment (FDI), it bears additional fixed costs $f_I$ (e.g., build up communications networks between two countries). We assume

$$f_I > f_D. \tag{4}$$

The key assumption is that domestic production requires one workday and that service products are ready for sale after one workday: the delivery of domestic products involves significant costs in terms of delay. In contrast to this, the utilization of communications networks (i.e., FDI) allows production in a foreign country where non-overlapping work hours and trade via networks enable quick delivery and low shipping costs. For these reasons, imported service products whose production benefits from time zone differences provide higher value than domestically produced services.

In order to capture this point, we assume that shipments of products incur the “iceberg” effect of delivery costs: to sell one unit of Foreign products in the Home market, $\tau$ units must be shipped. Thus, the price of Foreign services becomes $\tau$ times higher than its original price. One can interpret $\tau$
as a measure of the inverse of the “delivery timeliness” of Foreign products in the Home market: a lower value of \( \tau \) implies a quicker delivery.

As mentioned above, domestic production are ready for sale after one workday, whereas imported services whose production benefits from time zone differences are available sooner (see Figure 1). To parametrize the timing of delivery, we treat the utilization of communications networks (i.e., technological improvement) as a reduction in the delivery time of imported products (i.e., a decrease in \( \tau \)). Let us denote the Foreign services’ delivery timeliness before technological change as \( \tau_1 \) and that after change as \( \tau_2 \). Then the following condition holds:

\[
\tau_1 > 1 > \tau_2.
\]  

(5)

Note that this effect comes not from lower production costs in Foreign, but from faster delivery. In other words, in a sense of timeliness, building Foreign subsidiaries via FDI implies building subsidiaries closer to the Home market (see, Figure 1).

As noted above, preferences (1) generate a demand function \( A p^{-\epsilon} \) for every brand of the service products, where the demand level \( A \) is exogenous from the point of view of the individual supplier. In this case, the brand of a monopolistic producer with labor coefficient \( a \) is offered for sale at the price \( p = a/\alpha \), where \( 1/\alpha \) represents the markup factor. As a result, the effective consumer price is \( a/\alpha \) for domestically produced services, and is \( \tau_i a/\alpha \) for imported services.

Operating profits from domestic production are

\[
\pi_D = a^{1-\epsilon} B - f_D,
\]

(6)

\[
B = \frac{(1-\alpha)A}{\alpha^{1-\epsilon}},
\]

(7)
for a firm with a labor-output coefficient $a$.

On the other hand, the operating profits from FDI (serving Home market via communications network) are

$$\pi_{I_i} = (\tau_i a)^{1-\epsilon} B - f_I, \ i = 1, 2$$

These profit functions are depicted in Figure 2. In this figure, $a^{1-\epsilon}$ is represented on the horizontal axis. Since $\epsilon > 1$, this variable increases monotonically with labor productivity $1/a$, and can be used as a productivity index. Two profit functions are increasing linear functions of this index. More productive firms are therefore more profitable in all two activities.

The least productive firms expect negative operating profits and therefore exit the industry. This fate befalls all firms with productivity levels below $(a_D)^{1-\epsilon}$. The slope of $\pi_I$ equals $(\tau_i)^{1-\epsilon}B$, $i = 1, 2$, which depends on the technological condition of communications networks (see (5)). When $\tau_1 > 1$, FDI is always unprofitable (a dotted line). If $\tau_2 < 1$, firms with productivity above $(a_I)^{1-\epsilon}$ gain more from FDI. For this reason, given that $\tau_2 < 1$, firms with productivity levels between $(a_D)^{1-\epsilon}$ and $(a_I)^{1-\epsilon}$ choose domestic production while those with higher levels build subsidiaries in Foreign and produce Foreign services. In other words, via time-saving technological improvement, firms with higher productivity begin to build Foreign subsidiaries. The (fixed) costs of building Foreign subsidiaries can be offset by a lower delivery (time) costs of services.

**Proposition 1:** Given that $\tau_2 < 1$, firms with higher productivity choose to FDI and provide Foreign services for Home market.
It is evident from the figure that the cutoff coefficients are determined by

\[
(a_D)^{1-\epsilon}B = f_D, \tag{9}
\]

\[
[(\tau_2)^{1-\epsilon} - 1](a_I)^{1-\epsilon}B = f_I - f_D. \tag{10}
\]

Free entry ensures equality between the expected operating profits of a potential entrant and the entry costs \(f_E\). This condition can be expressed as

\[
[(\tau_2)^{1-\epsilon} - 1)V(a_I) + V(a_D)]B - [G(a_I)(f_I - f_D) + G(a_Df_D)] = f_E; \tag{11}
\]

\[
V(a) = \int_0^a y^{1-\epsilon}dG(y). \tag{12}
\]

Equations (9) – (11) provide implicit solutions for the cutoff coefficients \(a_D\), \(a_I\), and the demand level \(B\).

Combining (9) and (10), the following must be hold:

\[
\frac{a_D}{a_I} = \tau_2 \left( \frac{f_I - f_D}{f_D} \right) \left( \frac{1}{\tau_2^{1-\epsilon} - 1} \right)^{1/(\epsilon-1)}. \tag{13}
\]

From (13), we can obtain the ratio of domestic production relative to FDI sales:

\[
\frac{s_D}{s_I} = \frac{\int_0^{a_D} a^{1-\epsilon}B}{\int_0^{a_I} (\tau_2 a)^{1-\epsilon}} = (\tau_2)^{\epsilon-1} \left[ \frac{V(a_D)}{V(a_I)} - 1 \right]. \tag{14}
\]

### 3 Comparative Statics

In order to explore the effects of productivity dispersion on the ratio \(s_D/s_I\), we parametrize \(V(a)\) by parametrizing the distribution \(G(a)\). For expositional purposes, let us use a Pareto distribution with the shape parameter \(k\).\(^3\) Then, we can obtain

\[
V(a) = \int_0^a y^{1-\epsilon}dG(y) = ca^{k-(\epsilon-1)}, \tag{15}
\]

\(^3\)See, for example, Helpman et al. (2003, 2004).
where $c$ is constant and it is assumed that $k > \epsilon + 1$ Plugging back in (14), we can obtain

$$s_D = (s_2)_t^{-1} \left[ \left( \frac{f_I - f_D}{f_D} \frac{1}{\tau_2^{\frac{k}{\epsilon - 1}}} - 1 \right) ^{\frac{k}{\epsilon} - 1} \right].$$

(16)

It is then straightforward to see that the ratio of domestic production to FDI is decreasing in delivery timeliness of imported services. It is also decreasing in productivity dispersion, as parametrized by lower $k$.

**Proposition 2:** A decrease in one country’s delivery costs for imported services decreases the relative sales of domestic production. Also, an increase in productivity dispersion decreases the relative share of domestic production.

Let us suppose that Home is a developed country, while Foreign is a developing country. Our result suggests that a time-saving technological change improvement in the developed country, which then requires more services provided with the benefit of time zone differences, triggers high-productivity firms’ FDI toward the developing country. Jones and Marjit (2001) argue that, in a world in which the costs of service links are falling drastically, fragmentation of production process offers new opportunities to developing countries. The present result on FDI with high-productivity firms provide some theoretical grounds for such a development process.

**References**


Figure 1

Foreign’s workday

Home’s workday

Home

Foreign

FDI

Domestic production

Services production
daytime

nightime

Services consumption
daytime

Services Trade via Networks

Services production
Figure 2

\[
\pi_d - f_d \quad (a_i)^{1-\epsilon} \quad (a_D)^{1-\epsilon}
\]