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ABSTRACT

Based on Helpman *et al.* (2004) we propose a simple two-country (Home and Foreign) model with heterogeneous firms to 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 serve the Home market.

JEL classification: **F12**

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ABSTRACT

Based on Helpman *et al.* (2004) we propose a simple two-country (Home and Foreign) model with heterogeneous firms to 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 serve the Home market.

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1. Introduction

Since 1980s foreign direct investment (FDI) has grown astonishingly fast, even faster than international trade. Not only did the overall level of FDI increase, it has also been 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 that do not require physical shipments of products, have been playing major roles[1].

Following these changes, new types of FDI and service trade surfaced in the recent past. Such investment and trade are taking advantage of time zone differences between countries emerge. The semiconductor industry provides a prime example of this kind of trade. 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 (starting around 5 pm

[1] A substantial amount of empirical research has also emerged very recently revolving around the idea of time zones and trade. This further strengthens the underlying encouragement to write this paper. A representative sample of empirical papers consists of Anderson (2012), Christen (2012), Costinot et al (2012), Dettmer (2011) etc.

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 also prefer to consume services early taking the 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 for 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 the 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 there that time zone differences emerge as an independent driving force of international trade besides taste, technology and resource endowment.[2]

What remains, however, unanswered is the relationship between firm-productivity and FDI with time zone difference. Based on casual

[2] Jones *et al.* (2005) also emphasize the role of time zone differences as a determinant of efficient worldwide division of labor. Furthermore, 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).

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 FDI and firm heterogeneity, however, relatively few attempts have been made to address the role of time zone differences on FDI decisions[3]. This seems to suggest that the focus on "trade using different time zones" should be accompanied by a focus on firms' FDI decisions. Therefore, 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. We further assume that both countries are small in nature. The key assumption of our model is that domestic service production requires two consecutive workdays and that products are ready for sale after two workdays- domestic delivery bears significant costs in terms of delay[4]. In contrast to this, the utilization of communications networks allows production in a foreign country with 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

[3] In an important contribution, Helpman *et. al.* (2004) show that the productivity of the firms undertaking FDI is higher than the productivity of the exporters. Following this, Mukherjee (2010) shows that the theoretical prediction of Helpman *et al.* (2004) may not hold. In addition, Helpman (2006) provided an excellent survey on the literature on FDI with heterogeneous firms.

[4] For related issues and modelling of such cost in time zones and trade context see Marjit (2007), Kikuchi et. al. (2013), Mandal et. al. (2014).

from time zone differences, provide higher value than domestically produced service.

Based on the model outlined above, this study shows that productivity of the firms undertaking FDI is 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 serve the Home market. In other words, in the sense of timeliness, building Foreign subsidiaries via FDI implies building subsidiaries closer to the Home market (see, Figure 1).This result is in contradiction with the conventional wisdom that asserts why foreign subsidiaries of high productive domestic firms via FDI serve the Foreign market. Whereas, in this paper, we primarily focus on how productivity of firms determines location of their production for serving their domestic market.

2. The Model and Basic Results

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's 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 demand the homogeneous good.

The preference of the representative Home consumer are given by

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

Where z is the consumption of the homogeneous good, $x(v)$ is the

consumption of variety v, $\alpha = \frac{(\varepsilon-1)}{\varepsilon}, \varepsilon > 1$ is the elasticity of substitution between varieties. Thus we have the following demand function for x:

$$x(v) = A[p(v)]^{-\varepsilon} \tag{2}$$

$$A = \frac{BE}{\int_0^n [p(v)]^{1-\varepsilon} dv} \tag{3}$$

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's price of variety v.

The homogeneous good is produced with constant returns, using labor as input. Units are chosen in such a way 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, wages (hereafter set to unity) across countries are identical and constant.

Now let us turn to the differentiated services. To simplify the analysis, we assume that the difference in productivities of firms exists only for Home firms. 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 to produce. If it chooses 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 two workdays

and that service is ready for sale after two workdays - the delivery of domestic product or service involves significant costs in terms of delay. In contrast to this, utilization of communications networks allows part-production in Foreign country with non-overlapping work hours, and trade via networks/Internet enables quick delivery. For these reasons, imported service products, whose production benefit from time zone differences provide higher value than domestically produced services.

In order to capture this point, we assume that shipment of products incurs the "iceberg" effect of delivery costs: to sell one unit of Foreign products in the Home market, τ ($\tau > 1$) units must be shipped. Thus, the price of the Foreign services becomes τ times higher than its original price. One can interpret τ as a measure of the inverse of the "delivery timeliness" of Foreign products in the *Home* market: a lower value of τ implies a quicker delivery.

As mentioned above, domestic production are ready for sale after two workdays, whereas imported services whose production benefits from time zone differences are available sooner (see Figure 1). To parameterize 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 τ)[5]. Let us denote the Foreign services' delivery timeliness before technological change as τ_1 and that after change as τ_2. τ represents the cost of communication which is required when TZ difference is exploited. Then the following condition holds:

[5] τ depends only on ICT. ICT revolution reduces τ and opens up the possibility of utilizing TZ difference.

$$\tau_1 > \tau_2 \geq 1 \qquad (5)^6$$

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 $Ap^{-\varepsilon}$ 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 offers the price $p = \frac{\delta a}{\alpha}$ where $\delta > 1$ represents the loss of valuation from consumer's perspective due to untimely delivery and *1/a* represents the markup factor. So essentially producers get a price equal to $\frac{p}{\delta} < p$. δ gradually falls if consumers get the product early. This is a natural preference behavior of the consumers. As a result, the effective consumer price is $\frac{\delta a}{\alpha}$ for domestically produced services, and is $\frac{\tau_i a}{\alpha}$ for imported services.

Operating profits from domestic production for a firm with a labor-output coefficient a is

$$\pi_D = a^{1-\varepsilon}B - f_D \qquad (6)$$

$$B = \frac{(1-\alpha)A}{\alpha^{1-\varepsilon}} \qquad (7)$$

On the other hand, the operating profit from FDI (serving Home market via communication network) is

$$\pi_{Ii} = (\tau_i a)^{1-\varepsilon}B - f_I, \qquad i = 1, 2 \qquad (8)$$

These profit functions are depicted in Figure 2. In this figure, $a^{1-\varepsilon}$ is

[6] In one extreme $\tau_2 = 1$ indicating zero communication cost.

represented on the horizontal axis. Since $\varepsilon > 1$, 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 these two activities.

The least productive firms expect negative operating profits and therefore exit the industry. This happens to all firms with productivity levels below $(a_D)^{1-\varepsilon}$. The slope of π_1 equals$(\tau_i)^{1-\varepsilon}B$, $i = 1, 2$, which depends on the technological condition of communication network (see (5)). When $\tau_1 > \delta > 1$, FDI is always unprofitable (a dotted line). If $\tau_1 > \delta > \tau_2 > 1$, firms with productivity above $(a_I)^{1-\varepsilon}$ gain more from FDI[7]. For this reason, given that $1 < \tau_2 < \delta$, firms with productivity levels between $(a_D)^{1-\varepsilon}$and $(a_I)^{1-\varepsilon}$ 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 denoted by δ.

Proposition 1: *Given that* $1 < \tau_2 < \delta < \tau_1$, *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

$$(\delta a_D)^{1-\varepsilon}B = f_D \quad (9)$$

$$[{\tau_2}^{1-\varepsilon} - \delta^{1-\varepsilon}](a_I)^{1-\varepsilon}B = f_I - f_D \quad (10)$$

[7] τ_1 and τ_2 are the cost of communication in pre and post technological revolution phase, respectively with the condition that $\tau_2 < \tau_1$.

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

$$\left([(\tau_2)^{1-\varepsilon} - \delta^{1-\varepsilon}]V(a_I) + V(a_D)\right)B - [G(a_I)(f_I - f_D) + G(a_D f_D)] = f_E \quad (11)$$

$$V(a) = \int_0^a y^{1-\varepsilon}\, dG(y) \quad (12)$$

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:

$$\frac{a_D}{a_I} = \tau_2 \left(\frac{f_I - f_D}{f_D}\right)\left(\frac{\delta^{1-\varepsilon}}{{\tau_2}^{1-\varepsilon} - \delta^{1-\varepsilon}}\right)^{1/(\varepsilon-1)} \quad (13)$$

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

$$\frac{S_D}{S_I} = \frac{\int_{a_I}^{a_D} (\delta a)^{1-\varepsilon} B}{\int_0^{a_I} (\tau_2 a)^{1-\varepsilon}} = \left(\frac{\delta}{\tau_2}\right)^{1-\varepsilon}\left[\frac{V(a_D)}{V(a_I)} - 1\right] \quad (14)$$

In order to explore the effects of productivity dispersion on the ratio $\frac{S_D}{S_I}$, we parametarize *V(a)* by parametarizing the distribution *G*(*a*). For expositional purposes, let us use a Pareto distribution with the shape parameter *k*.[8] Then, we can obtain

$$V(a) = \int_0^a y^{1-\varepsilon}\, dG(y) = c a^{k-(\varepsilon-1)} \quad (15)$$

where *c* is constant and it is assumed that $k > (\varepsilon - 1)$ Plugging back in (14), we can obtain

$$\frac{S_D}{S_I} = \left(\frac{\delta}{\tau_2}\right)^{1-\varepsilon}\left[\left\{\left(\frac{f_I - f_D}{f_D}\right)\left(\frac{\delta^{1-\varepsilon}}{{\tau_2}^{1-\varepsilon} - \delta^{1-\varepsilon}}\right)\right\}^{\frac{k-(\varepsilon-1)}{\varepsilon-1}} - 1\right] \quad (16)$$

[8] See, for example, Helpman *et al.* (2003, 2004)

It is then straightforward to see that the ratio of domestic production to FDI is decreasing in delivery timeliness of imported services as δ is assumed to be a constant because people's valuation for waiting time does not change very quickly. 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 in FDI with high-productivity firms provides some theoretical grounds for such a development process.

3. Conclusions

In line with Helpman et al (2004) here we have developed a two country model to check if productivity determines the trade pattern in presence of on-overlapping time-zones between trading countries. It has been shown here that, even in absence of any wage differential, a fall in communication cost itself may trigger trade in finished and unfinished services. The pattern of trade we

describe is different from what is explained in the existing literature. In the same line we also explain why high productive firms opt for FDI in trading countries and import back the finished product. This argument does not naturally go with the traditional arguments for FDI and trade pattern where foreign subsidiaries serve the foreign market. Therefore, introduction of non-overlapping time zones with low communication cost adds an interesting dimension to the FDI and trade pattern literature. Our results would be strengthened further if one introduces wage differential as predicted in Jones and Marjit (2001).

References

Anderson, E. (2012) "Longitude matters II: time differences, communication and trade", *Unpublished manuscript*, School of International development, University of East Anglia.

Brainard, S. Lael (1997) "An Empirical Asessment of the Proximity-Concentration Trade-off Between Multinational Sales and Trade," *American Economic Review*, Vol. 87, pp. 520–544.

Brown, Clair and Linden, Greg (2009) *Chips and Change: How Crisis Reshapes the Semiconductor Industry.* Cambridge, MA: MIT Press.

Cairncross, Frances (1997) *The Death of Distance.* Boston, MA: Harvard Business School Press.

Christen, E. (2012) "Time zones matter: The impact of distance and time zones on services trade," *Working Papers 2012-14,* University of Innsbruck.

Costinot, A, J. Vogel and S. Wang (2012) " An elementary theory of global supply chains" *CESifo working paper series 3402*.

Dettmer, B (2011) "International service transactions: Is time a trade barrier in a connected world?, *Jena Economic Research Papers 2011-003*.

Do, Viet and Long, Ngo Van (2008) "International Outsourcing under Monopolistic Competition: Winners and Losers," in Marjit, Sugata and Yu, Eden (Eds.), *Contemporary and Emerging Issues in Trade Theory and Policy*. Emerald Group, Bingly, UK, pp. 345–366.

Grossman, Gene M. and Helpman, Elhanan (2005) "Outsourcing in a Global Economy," *Review of Economic Studies,* Vol. 72, pp. 135–159.

Helpman, Elhanan (2006) "Trade, FDI, and the Organization of Firms," *Journal of Economic Literature,* Vol. 44, pp. 589–630.

Helpman, Elhanan, Melitz, Marc J., and Yeaple, Stephen R. (2003) "Ex- port Versus FDI," National Bureau of Economic Research (Cambridge, MA) Working Paper No. 9439.

Helpman, Elhanan, Melitz, Marc J., and Yeaple, Stephen R. (2004) "Export Versus FDI with Heterogeneous Firms," *American Economic Review,* Vol. 94, pp. 300–316.

Jones, Ronald and Kierzkowski, Henryk (1990) "The Role of Services in Productions and International Trade: a Theoretical Framework," in Jones, Ronald and Kruger, Anne (Eds.), *The Political Economy of In- ternational Trade.* Blackwell, Oxford, pp. 31–48.

Jones, Ronald, Kierzkowski, Henryk and Lurong, H. (2005) "What does Evidence Tell Us about Fragmentation and Outsourcing?," *International Review of Economics and Finance,* Vol. 14, pp. 305–316.

Jones, Ronald and Marjit, Sugata (2001) "The Role of International Fragmentation in the Development Process," *American Economic Re- view,* Vol. 91, pp. 363–366.

Kikuchi, T., Marjit, S., & Mandal, B. (2013). Trade with time zone differences: factor market implications. *Review of Development Economics*, *17*(4), 699-711.

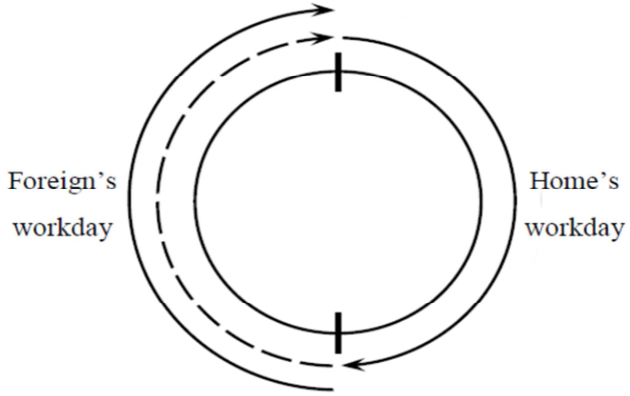
Long, Ngo Van, Riezman, Raymond, and Soubeyran, Antone (2005) "Fragmentation and Services," *North American Journal of Economics and Finance,* Vol. 16, pp. 137–152.

Mandal, B., Marjit, S., & Nakanishi, N. (2014). Time Zones, Factor Prices and Inflow of Educational Capital: Changing Sectoral Composition, mimeo, University at Albany-SUNY.

Marjit, Sugata (2007) "Trade Theory and the Role of Time Zones," *International Review of Economics and Finance,* Vol. 16, pp. 153–160.

Mukherjee, Arijit (2010) "A Note on Firm-Productivity and Foreign Direct Investment," *Economics Bulletin,* Vol. 39. pp. 2107–2111.

Figure 1


Foreign's
workday
Home's
workday

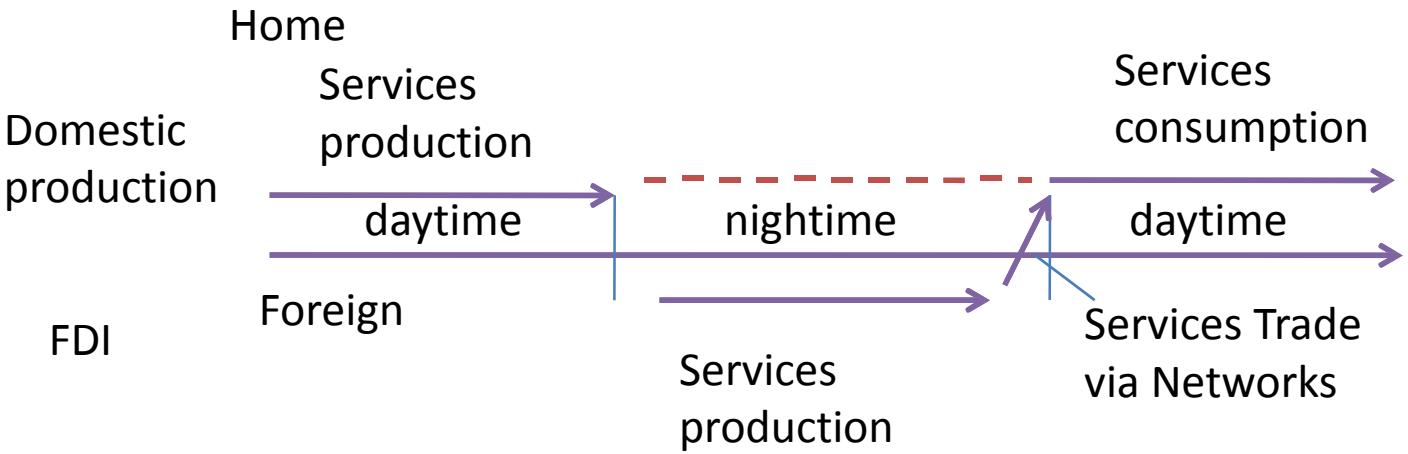

Home
Services
production
Domestic
production
daytime
nightime
Services
consumption
daytime
Foreign
FDI
Services
production
Services Trade
via Networks

Figure 2