Distance, Production, Virtual Trade and Growth: A Note

Biswajit Mandal

Abstract

This paper argues that distance is not necessarily harmful to trade. It is shown that there may be an increase in the production and volume of trade if time zones of the trading nations are non-overlapping. This implies a positive effect of distance on the volume of trade in general and virtual trade in particular. It is also shown that exploitation of time zone differences raises welfare and ensures capital accumulation. The paper builds on the emerging literature on time zones and pure theory of international trade.

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Authors

Biswajit Mandal, ✉ University at Albany-SUNY, Albany, NY, USA; and Visva-Bharati University, Santiniketan, India, bmandal@albany.edu

1   Introduction

Typically, physical distance between trading nations restricts trade. In regard to the volume of trade in tangible goods or services requiring the physical presence of the supplier, there exists no room whatsoever for any further clarification. In this context, trade restriction, transportation cost and trading cost are the prime trade-deterring factors. In addition, trade restriction related transaction cost of corruption is another obstacle. The Ricardian model with trading cost, the Heckscher–Ohlin model with transportation sector, the intra-industry trade model with traders and the gravity model of trade all corroborate this claim. Falvey (1976), Cassing (1978), Deardorff (2004), Feenstra (2004), Anderson (2000), Anderson and Wincoop (2004), Davis (1998), Trefler (1995), Laussel and Riezman (2008), Bernard et al. (2006), Fink et al. (2005), Limao and Venables (2001), Chakrabarti (2004), etc., are among the noted contributors in this line of research.

In recent years the composition of trade has changed to a certain extent. Trade in business services has emerged as the new trend, with off-shoring of business services such as engineering, consulting and software development as major factors. The striking feature of such trade is the non-necessity of physical shipment of product and no requirement of physical presence of supplier. Coupled with this possibility comes the issue of separated or non-overlapping time zones. With the advent of high bandwidth Internet, trade in services which are virtual in nature has become relatively less costly. To exploit this possibility, time zones of two nations have to be non-overlapping, i.e., the working hours should be complementary with each other over a day-night cycle. We know that the difference in time zones depends only on physical distance (in terms of latitude). Thus, whether distance is a hindering factor for trade has become an issue of serious research again. To date only a handful of work has been done in the interface of trade and distance related time zones. This includes Marjit (2007), Kikuchi (2009), Kikuchi and Marjit (2011), Kikuchi (2013), Anderson (2014), Dettmer (2013), Head et al. (2009), Matsuoka and Fukushima (2010), and Kikuchi et al. (2013). In fact, Kikuchi (2013) is a nice compilation of different works done in this area so far. However, most of the papers look at the effect of non-overlapping time zones on the pattern of trade, volume of trade, and welfare implications of such trade.

Marjit (2007) introduced the role of time zones in a two-country Ricardian framework by means of a rate of discount on the price of the final commodity.

This discount rate captures the consumers' preference for a commodity. In the absence of time zone difference and outsourcing possibilities, the production of a good requires two consecutive workdays, implying a negative effect on consumers' valuation of the good. The negative effect would vanish if time zone difference is exploited by using the workday of another country. This makes the commodity available earlier and hence reduces/eliminates the time preference-associated discount rate. In such a setup Marjit (2007) showed how differences in time zones can emerge as another determinant of trade independent of endowment, technology and preference for variety. It has also been shown that for a negligible shipment cost (communication revolution made that possible), trade is gainful across different time zones. Even though he did not use any such identifying terminologies for service trade that takes advantage of the non-overlapping time zones, it should be noted that the kind of trade the author stressed is absolutely virtual in nature. He then extended the model for general equilibrium set up and validated the basic results. Marjit (2007) argues that the difference in time zones is 'natural'. Later, Kikuchi (2009) proposed a three country monopolistically competitive model of virtual trade with different time zones. He showed that under reasonable conditions, outsourcing is more profitable than communication autarky. He further explored how outsourcing increases the division of labor and initiates a cumulative process, implying further specialization in the business service sector. This model has been extended again for deriving the conditions under which trading countries would gain if comparative advantage is driven by time zone difference.

In a very recent paper Kikuchi and Marjit (2011) framed a dynamic model of growth with time zone. They have shown how utilization of communication networks such as the Internet can lead to a permanent increase in productivity and hence growth. Their theory is that trade across time zones increases working hours in an integrated world.

By this time it is perhaps clear that total volume of trade has two components: physical trade and virtual trade. Physical trade falls with distance. But my focus in this paper is on the relationship between virtual trade and distance. The idea of virtual trade is essentially trade in services or trade in labor tasks that can be exchanged via Internet. This aspect is relatively less explored in the existing literature. So here I strive to add some value to the existing material, which is yet to be highly researched. In doing this I attempt to relate physical distance

influencing (non)overlapping time zones between two trading partners with virtual trade. Notice that this kind of trade became a central issue of research only after the information technology revolution. So a reduction in the cost of communication is the primary driving force for virtual trade. Hence I start with a negligible cost of communication.

The world being circular, time zones are essentially the reflection of aerial distance. Therefore, in a finer sense distance between two places is exhibited by the difference in time zones or calendar dates. And hence, in the hindsight of time zone and trade literature there is physical distance that triggers virtual trade positively, which is quite contradictory to the standard 'distance and goods' trade' arguments. Taking a cue from this baseline wisdom I move forward to check how distance can impact volume of production and trade. Then I briefly attempt to determine if such trade caused by difference in time zones that are in turn led by distance may induce any change in capital accumulation or output growth.

The rest of the paper runs as follows. Section 2 outlines the story and formulation of the model. Section 3 focuses on the effect of distance on production and virtual trade. Effect on capital accumulation and growth is indicated, in brief, in Section 4. Some concluding remarks are provided in the last section.

2   The Story and a Simple Model

Drawing from Kikuchi and Marjit (2011),[1] I consider a Cobb–Douglas production function for service output (S), which requires capital (K) and intermediate input (m). The production function is given by the following equation:

$$S = K^{\alpha}(m)^{\frac{1-\alpha}{2}}(m)^{\frac{1-\alpha}{2}} = K^{\alpha}m^{1-\alpha} \tag{1}$$

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[1] Kikuchi and Marjit (2011) are concerned about how growth is associated with time zone difference. They formulated a dynamic model of growth following AK structure, where it has been argued that exploitation of time zone difference through communication networks can lead to growth for both the trading partners simultaneously. But they did not consider the distance issue explicitly. So their paper was based on growth theory and focused on productivity concern. In this note I borrow the simple Cobb–Douglas production function that had been used in Kikuchi and Marjit (2011) and then invoke the issue of distance captured by difference in time zones. I thank the referee for asking me to provide the brief idea of Kikuchi and Marjit (2011).

Note that $0 < \alpha < 1$.

For simplicity, I assume that one unit of L is required to produce one unit of m, which is assumed as the numeraire good/service. Production of S requires two consecutive stages or workdays. Thus in-home or within country production of S requires two m. But as in-home production needs two workdays, goods cannot be delivered 'timely'.[2] Untimely delivery of final good/service is not desired by the consumers, which is reflected in the effective price of the final good or service, P_S. Note that this does not imply any change in the cost of production. The extent of delay in delivery is negatively related to the consumers' valuation of the good. Taking a clue from Marjit (2007) let us denote the time preference by δ (> 1). Therefore, the consumers' price (effective price of the product or service) would be $\frac{P_S}{\delta}$.

The cost function for S is:

$$C = m + m \tag{2}$$

For brevity I assume capital as costless.

The demand for intermediate service input is determined by the profit maximization problem of S. The profit equation is (for simplicity one can assume $P_S = 1$):

$$\pi = \frac{P_S}{\delta} S - (m + m)$$

where π implies profit.

First order condition for profit maximization leads to

$$m = K \left(\frac{P_S}{2\delta}\right)^{\frac{1}{\alpha}} (1 - \alpha)^{\frac{1}{\alpha}} \tag{3}$$

Plugging (3) into (1) we get

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[2] At night nobody works. Labor takes 12 hr rest and starts working again the next morning. Hence the final good is ready for sale at the end of second workday or in the second day evening. Hence, in between two workdays one night is wasted. This wastage induces the untimely delivery.

$$S = K(P_S)^{\frac{1-\alpha}{\alpha}} \left(\frac{1-\alpha}{2}\right)^{\frac{1-\alpha}{\alpha}} (\delta)^{\frac{\alpha-1}{\alpha}} \tag{4}$$

It is apparent from (4) that δ has a negative connotation for the volume of S. This is the cost of untimely delivery for not utilizing the time zone difference.

If the countries exploit the opportunity of non-overlapping time zones, they could get any one of the two stages of input processing done during the other country's workday. Note that the other country's workday coincides with the former country's night. Hence non-overlapping time zones induce utilization of even night-time for the purpose of production.[3] This makes the producers capable of delivering the final output in 'due time', i.e., second day morning. Therefore, in this backdrop, the cost equation remains the same, but the profit equation would change:[4]

$$\pi_t = P_S S - (m + m) \tag{5}$$

$\pi_t \Rightarrow$ profit when time zone opportunity is exploited.
Therefore, profit-maximized production equation is:

$$S_t = K(P_S)^{\frac{1-\alpha}{\alpha}} \left(\frac{1-\alpha}{2}\right)^{\frac{1-\alpha}{\alpha}} \tag{6}$$

Comparing (4) and (6) it is evident that for given K and L, quantity of S would be higher if the time zone benefit is exploited.

$$S_t = K(P_S)^{\frac{1-\alpha}{\alpha}} \left(\frac{1-\alpha}{2}\right)^{\frac{1-\alpha}{\alpha}} > S = K(P_S)^{\frac{1-\alpha}{\alpha}} \left(\frac{1-\alpha}{2}\right)^{\frac{1-\alpha}{\alpha}} (\delta)^{\frac{\alpha-1}{\alpha}}$$

$$(\text{as } \delta > 1 \text{ and } 0 < \alpha < 1)$$

Proposition I: Utilization of time zone difference increases production if $\delta > 1$. ∎

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[3] Cost of communication for sending (exporting) and collecting (importing) unfinished and finished service, respectively, can easily be brought into the analysis. However, this will not imply any qualitative change in the result.

[4] Subscript 't' indicates exploiting the benefit rendered by time zone difference and Internet connectivity.

3   Distance and Trade

I have mentioned earlier that difference in time zones depends on physical distance, *d*, i.e.,

$$\delta = \delta(d) \tag{7}$$

$\delta \geq 1$ and $\delta' < 0$. $\delta = 1$ when countries are located in non-overlapping time zones (maximum aerial distance) and $\delta > 1$ for overlapping time zones. When overlapping time stretch increases (aerial distance falls), δ goes up. Nevertheless, δ remains greater than unity as long as there is any overlapping time in the calendar date. The argument is built on the assumption that the globe is circular and the distances between places are measured aerially. And I further consider that the distance between two places can be covered along the diameter of the globe (circle[5]). I also assume that in order to exploit the benefit of time zone difference it must be exactly non-overlapping. Note that δ takes any value greater than unity when virtual trade occurs between countries located in two overlapping time zones, i.e., δ takes the value $\bar{\delta} > 1$ for all such countries. When $\delta = \bar{\delta} = 1$, virtual trade is most beneficial in that the loss injected by untimely delivery of the final output completely vanishes.

Using this thought process one can easily understand that not only the final good production (possibility of trade as supply becomes greater than demand) increases; along with it a double (at most) amount of *m* compared to *S* is also traded. A careful investigation of the arguments I made here makes it clear that the trade is taking place for both the intermediate inputs and the final output (assuming that trade is balanced) as a part of *S* (after the first stage) is exported first and then it is imported back after the final stage is completed. A similar pattern of trade can be experienced for both the trading partners, as countries are free to allocate resources between intermediate input and final output production. Here it is worth mentioning that we have implicitly assumed identical factor

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[5] If we consider the story of covering the linear distance or travelling through the circumference of the circle, the relationship between distance and trade in labor task or services or virtual trade will exhibit an inverted U-shape. Volume of virtual trade will increase (when δ is continuous) with distance first indicating an increase in non-overlapping stretch of time (day or night) and hence δ approaches unity. Thereafter, δ again goes up, inflicting a negative effect on virtual trade. I thank an anonymous referee for clarifying this issue.

endowment and technology of production in order to rule out Heckscher–Ohlin and Ricardian comparative advantage principles. For both the countries the final output is, in fact, "timely" delivered on identical calendar dates, though there would be a difference in the time of delivery due to time zone difference.[6] This implies a surge or abrupt increase in trade volume. It is interesting to note that this hike in trade volume is only because of virtual trade, which is made possible through the Internet communication revolution.[7]

Now let us modify Equation (7) and make it continuous and plug it into the profit maximizing level of output.

$$\delta = \delta(d) \tag{8}$$

Note that $\delta'(d) < 0.$ Therefore,

$$S_t = K(P_S)^{\frac{1-\alpha}{\alpha}} \left(\frac{1-\alpha}{2}\right)^{\frac{1-\alpha}{\alpha}} \left(\delta(d)\right)^{\frac{\alpha-1}{\alpha}} \tag{9}$$

Equation (9) yields that as distance rises δ gradually falls (but it still takes a value greater than unity) and S goes up. S reaches the maximum when d corresponds to exactly non-overlapping time zones associated with maximum distance along the diameter of the globe.

The welfare implication for virtual trade is very easy to understand. For a small country framework, without changing the terms of trade, the volume of trade has gone up, implying an unambiguous increase in welfare. Even if the countries are large and trade in final goods/services is not allowed, an increase in the volume

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[6] I thank an anonymous referee for asking me to clarify this point.

[7] This is done in Kikuchi (2009) but in a different structure. Kikuchi (2009) used a three country framework to analyze how internet connection translates the time zone difference into comparative advantage. So the unconnected country fails to exploit the time zone related natural difference. Therefore Internet connectivity leads to trade creation. In this paper, though I indirectly hint at trade creation proposition, I do not consider a three country model that can easily be extended. Further, I attempted to go slightly beyond the time zone argument by bringing the issue of distance to the forefront. Here Internet connectivity is a necessary condition, but to fully extract benefit from Internet connection the countries need to be located at a distance. To be more precise, the distance consistent with non-overlapping time zones is most advantageous.

of trade due to trade in intermediate input will raise the welfare. Along with it, domestic production of consumable S goes up. Therefore, an increase in welfare is unambiguous.

Proposition II: With distance both volume of trade and welfare increase as $\delta'(d) < 0$ *and* $\delta > 1$. ∎

4 Distance, Capital Accumulation and Growth

Now I focus on the impact of distance on growth. I assume a constant savings rate so that we can have the following capital equation:

$$\dot{K} = \rho S_t - \varphi K$$

Here ρ indicates constant saving rate and φ represents the rate of depreciation of capital K. Therefore, $\dot{K}$ is the growth rate of capital. So,

$$\dot{K} = \rho K(P_S)^{\frac{1-\alpha}{\alpha}}\left(\frac{1-\alpha}{2}\right)^{\frac{1-\alpha}{\alpha}}\left(\delta(d)\right)^{\frac{\alpha-1}{\alpha}} - \varphi K$$

$$\text{Or, } \frac{\dot{K}}{K} = \rho(P_S)^{\frac{1-\alpha}{\alpha}}\left(\frac{1-\alpha}{2}\right)^{\frac{1-\alpha}{\alpha}}\left(\delta(d)\right)^{\frac{\alpha-1}{\alpha}} - \varphi \qquad (10)$$

It is apparent from (10) that as distance (d) goes up the value of δ goes down, implying an increase in capital accumulation or eventually leading to continuous output growth.

5 Concluding Remarks

In this note I have constructed a theoretical model using a Cobb–Douglas production function to examine how distance is related to time zones and production. It has been shown that time zone exploitation directly raises production and volume of trade in general and virtual trade in particular. Here virtual trade is defined as trade in intermediate or final services, which is essentially trade in labor services of different countries. So welfare must increase due to time zone exploitation. I have further shown that this also helps capital

accumulation and output growth of the economy. The basic results of the paper may have some interesting implications for the existing FTA (Free Trade Agreement) literature. Conventionally, ideas about FTA formation are primarily based on trade costs increasing in distance, implying a higher probability of forming FTA and trade creation if the partners are located in close proximity. Conversely, an increase in service trade, and thus of potential gains from cross-time-zone trade, suggests a contrary force in importance. Therefore, virtual trade analysis following geographical distance and time zone differences may produce some interesting dimensions for the formation of FTA.[8]

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[8] I am immensely thankful to an anonymous reader for pointing out this possibility.

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