

Mandal, Biswajit

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## Distance, Production, Trade and Growth—A Note

*Biswajit Mandal*

**Abstract**

This short note tries to argue that distance is not necessarily harmful for 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. It is also shown that exploitation of time zone difference raises welfare and ensures capital accumulation. The note 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](mailto:bmandal@albany.edu)

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## **I. Introduction**

Typically physical distance between trading nations restricts trade. This statement is unquestionably true as far as the volume of trade (measured in any normalized units e.g. size of the country, trade-GDP ratio etc.) in tangible goods or services requiring physical presence of supplier are concerned. These concerns have been explored nicely in the existing literature. Transportation and trading cost are the prime trade deterring factors. Trade restriction related transaction cost of corruption is another obstacle. Ricardian model with trading cost, Heckscher-Ohlin model with transport sector, Intra-industry trade model with traders and Gravity model of trade corroborate the claim. Falvey (1976), Cassing (1978), Deardorff (2004), Feenstra (2004), Anderson (2000), Anderson and Wincoop (2004), Davis (1998), Trefler (1995), Laussel and Riezman (2008), Bernard, Jensen and Schoot (2006), Limao and Venables (2001), Chakrabarti (2004) etc. are some of the noted contributions in this literature.

In recent times the composition of trade has changed to a certain extent. Trade in business services has emerged as the new trend, where offshoring of business services such as engineering, consulting and software development are major ones. The striking feature of service trade is the non-necessity of physical shipment of product and non-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 service trade in services has become relatively less costly. To exploit this possibility, time zones of two different 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. Till date only a handful of work is done in the interface of trade and distance related time zone such as Marjit (2007), Kikuchi (2009), Kikuchi and Marjit (2011), Kikuchi (2013), Anderson (2013), Dettmer (2013), Head et al (2009), Matsuoka and Fukushima (2010), Kikuchi et al (2013). In fact Kikuchi (2013) is a nice compilation of different works done in this area so far.

In a two-country Ricardian framework Marjit (2007) introduced the role of time zones 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 absence of time zone difference and outsourcing possibility 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 rate associated discount rate. In such a set up Marjit (2007) showed how time zone can emerge as another determinant of trade independent of endowment, technology and preference. It has also been shown in the paper that for a negligible shipment cost (communication revolution made that possible) trade is gainful across different time zones. The necessary requirement is that trade has to be 'virtual' in a sense, i.e. in business services. He then extended the model for general equilibrium set up and validated the basic results. In terms of Marjit (2007) the difference in time zones is 'natural'. Kikuchi (2009) proposed a three country monopolistically competitive model of virtual trade with different time zones. He showed that under a reasonable condition outsourcing is 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 further for deriving the condition 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 network such as internet can lead to a permanent increase in productivity and hence growth. The intuition is that trade across time zones increases working hours permanently 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 note is on the relationship between virtual trade and distance. This part is relatively less explored.

The rest of the note runs as follows: next section talks about the story and formulation of the model. Section III focuses on the effect of distance on production and virtual trade. Effect on growth is indicated, in brief, in Section IV. Some concluding remarks are provided in the last section.

## II. The Story and A Simple Model

Drawing from Kikuchi and Marjit (2011) 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:

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

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 nemeraire 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'.<sup>1</sup> Untimely delivery of final good/service is not desired by the consumers' which is reflected in the 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 with the consumers' valuation of the good. Taking clue from Marjit (2007) let us denote the time preference by  $\delta$  ( $> 1$ ). Therefore the consumers' price would be  $\frac{P_S}{\delta}$ .

The cost function for S is:

$$C = m + m \quad (2)$$

For brevity I assume capital as costless

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<sup>1</sup> At night nobody works. Labor takes 12 hr rest and starts working again in the next day 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 wastage. This wastage induces the untimely delivery.

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  $\pi$  implies profit.

First order condition for profit maximization leads to

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

Plugging (3) into (1) we get

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

It is apparent from (4) that  $\delta$  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 country(ies) exploit the opportunity of non-overlapping time zone with others, they could get any one stage of input processing done in other country's workday. Note that other country's work day coincides with the former country's night. Hence non-overlapping time zones induce utilization of even night time for the purpose of production.<sup>2</sup> This makes the producers capable of delivering the final output in 'due time', i.e. second day morning. The cost equation remains same, but the profit equation would change.

$$\pi_t = P_S S - (m + m) \quad (5)$$

$\pi_t \Rightarrow$  profit when time zone opportunity is exploited.

Therefore, profit-maximized production equation is:

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

Comparing (4) and (6) it is evident that for given K and L quantity of S would be higher if 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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<sup>2</sup> Cost of communication for sending (exporting) and recollecting (importing) unfinished and finished service respectively can easily be brought into the analysis. However, this will not imply any qualitative change in the note.

### III. Distance and Trade

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

$$\delta = \delta(d); \quad (7)$$

$\delta = 1$  when countries are located in overlapping time zones. I further assume that in order to exploit the benefit of time zone difference it has to be exactly non-overlapping. Note that  $\delta$  takes any value greater than unity when virtual trade occurs between countries located in two non-overlapping time zones.  $\delta$  takes the value  $\bar{\delta} > 1$  for all such countries. When  $\delta = \bar{\delta} = 1$ , no virtual trade takes place.

Using the 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. Because, a part of  $S$  (after the first stage) is first exported. Then imports it back after the final stage. 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 internet communication revolution.<sup>3</sup>

Now let us modify equation (7) and make it a continuous function

$$\delta = \delta(d) \quad (8)$$

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

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

Equation (9) yields that as distance rises  $\delta$  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.

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

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<sup>3</sup> This is done in Kikuchi (2009) but in a different structure.

gone up implying an unambiguous increase in welfare. Even if the countries are large and trade in final goods/services is not allowed, the volume of trade effect 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 increases as  $\delta'(d) < 0$  and  $\delta > 1$ .* ■

#### IV. Distance and Growth

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

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

Here  $\rho$  indicates constant savings rate and  $\varphi$  represents the rate of depreciation of capital  $K$ . Therefore,  $\dot{K}$  is the growth rate of capital. So,

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

It is apparent from (10) that as distance ( $d$ ) goes up the value of  $\delta$  goes down implying an increase in capital accumulation or growth.

#### V. Concluding Remarks

In this note I have constructed a model using Cobb-Douglas production function to check how distance is related with time zones and production. It has been shown that time zone exploitation directly raises production and volume of trade. Therefore welfare must increase due to time zone exploitation. I have further shown that this also helps capital accumulation and growth of the economy.

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