Time Zones as
a Source of Comparative Advantage

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Abstract

This note proposes a three-country model of monopolistic competition that captures the role of time zones in the division of labor. The connectivity of business service sectors via communications networks (e.g., the Internet, satellite communications systems) is found to determine the structure of comparative advantage. That is, two countries with connected service sectors have a comparative advantage in the good that requires business services. It is also shown that the third unconnected country inevitably specializes in the good that does not require business services.

Keywords: time zones, outsourcing, comparative advantage

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1 Introduction

Two of the most important trends in the global economy in recent decades have been (1) the dramatic increase in the role of information-intensive inputs in economic activities, and (2) the decline in transaction costs such as transport and communication costs. In particular, advances in digital technology have driven large decreases in the costs of data transfer and telecommunications. To put it plainly, globalization is closely related to the increased connectivity of individuals and organizations achieved through improved communications networks such as the Internet. There is a consequent increase in many kinds of international trade, particularly in business service sectors such as banking, engineering, and software development, which do not require physical shipments of products. The rise of the Indian software industry provides a prime example. One of the fastest-growing parts of this industry is ‘remote maintenance’ whereby Indian companies debug software for companies in other parts of the world, often taking advantage of the time difference to offer overnight service. For instance, 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. By the time the offices reopen in the U.S., the solutions have already arrived, mainly as e-mail attachments. This type of trade
in business services requires two basic conditions: a difference in time zones between the trading partners and good connections via communications networks (e.g., the development of the Internet and satellite communications systems).\(^1\) Related to these phenomena, Cairncross (2001) wrote:

> In some parts of the world, communications offer a new competitive advantage: time zones. It becomes possible to take advantage not only of geography but of the full twenty-four hours of the world’s working day. ...that means more efficient use of global resource (Cairncross 2001, p. 202).

In other words, due to the communications revolution, time differences may become a primary driving force behind business-services trade.

In the existing literature on trade theory, however, relatively few attempts have been made to address the theme of communications networks and the role of time zones. In a seminal contribution, Marjit (2006) examined the role of international time differences in a vertically integrated Ricardian framework. He suggested that countries located in opposite time zones can save time and costs if they can produce various stages of a commodity. However, the role of communications networks is downplayed in the analyses. Related to the role of communications networks, Harris (1998) used the term virtual

\(^1\) See Marjit (2006) or the less formal account in Friedman (2006).
economic integration to refer to situations in which communications networks make trade possible in business services. Along this line, this note focuses on another important practice: the utilization of time differences via communications networks which allow business-service producers in one country to collaborate with (or outsource to) those in another country efficiently. The utilization of time differences plays a crucial role in economic activities in the world economy: if producers in one country fail to exploit differences in time zones, they may be excluded from the internationally connected network that is essential to certain types of trade. In other words, the neglect of time differences might work as a trade barrier for business services. The main purpose of this note is to illustrate, with a simple three-country model of monopolistic competition, how the utilization of time differences can affect the structure of comparative advantage.

For this purpose, the present note builds a three-country model of monopolistic competition with a single production factor (i.e., labor). The model has two goods. The first is a homogeneous good (Good Y), the production of which does not require communications network services. The production of the other good (Good X) consists of assembling business services. The business services sector is characterized by monopolistically competitive firms. The central assumption is that one unit of a business service requires
production in two stages, each of which requires one working day: the utilization of time differences (i.e., the outsourcing of one of the stages to another country) reduces total production costs.

On the basis of the model outlined above, this study demonstrates how the differences in time zones determine the nature of the trading equilibrium. Two countries that are virtually integrated via the communications network acquire a comparative advantage in the business-service intensive good, Good X. This is because, in these countries, the Good X sector works efficiently through the expansion of the range of available business services. It is also demonstrated that a third country which is not connected to the interconnected networks may become worse off as the result of trade.

The next section presents the basic model. The nature of the trading equilibrium is considered in Section 3, followed by concluding remarks in Section 4.

2 The Model

In this model there are three countries: Country 1, Country 2 and Country 3. Each country is endowed with $L$ units of labor, which is the only primary factor of production. The countries have identical technologies and the only differences are in time zones. There is no overlap in working hours: when
Country 1’s workday ends, Country 2’s workday begins, and so on (See Figure 1). Each country produces two consumption goods, Good $X$ and Good $Y$, and one intermediate business-services good, Good $Z$. Good $X$ and Good $Y$ are tradeable, while Good $Z$ is nontradeable. Goods $X$ and $Y$ are sold in perfectly competitive markets. Good $Y$ is produced under constant returns using only labor; units are chosen such that one unit of labor produces one unit of output. Wage rates are normalized to unity.

Good $X$ is produced under constant returns using only differentiated business services as inputs. The production and unit-cost functions for Good $X$ are respectively:

$$X = \left( \sum_{i=1}^{n} z_i^\rho \right)^{1/\rho}, \quad 0 < \rho < 1,$$

$$C = \left( \sum_{i=1}^{n} p_i^{\rho/(\rho-1)} \right)^{(\rho-1)/\rho},$$

where $n$ is the number of available business services, $z_i(p_i)$ is the quantity (price) of service $i$, and $\sigma \equiv 1/(1 - \rho) > 1$ is the elasticity of substitution between every pair of services. This production function has the property that as input differentiation increases, the unit production cost falls. In fact, a large number of existing studies are based on similar assumptions. These studies include Ethier (1982), Markusen (1989), Harris (1998), Kikuchi (2003), and Long, Riezman and Soubeyran (2005).

Differentiated business services (Good $Z$) are supplied by monopolisti-
cally competitive service firms. Before starting production, α units of labor are required as a fixed cost of production. The central assumption is that each unit of a business service requires production in two stages: the second stage must start after the first stage has been completed. Each stage requires one unit of labor. If production occurs within a country, there is no need for a communications network: communications networks are needed only when the international outsourcing of a production process occurs. Thus, the cost function of the i-th service firm becomes

\[ TC^C_i = w(\alpha + 2x_i), \quad i = 1, \ldots, n, \]  

where \( w \) is the wage rate and superscript \( CA \) denotes the case of a ‘communications autarky’ (i.e., no outsourcing).

Given a Dixit-Stiglitz specification with constant elasticity \( \sigma \), each service firm sets its price as

\[ p^C = 2\sigma w/(\sigma - 1). \]  

With free entry and exit, the level of output that generates zero profits is given by

\[ z^C = (\alpha/2)(\sigma - 1). \]  

Alternatively, each firm can ‘outsource’ the second stage to the next country. By doing so, a firm can complete its production earlier and reduce its working hours. It is assumed that \( 1 + \beta \) (\( \beta < 1 \)) units of labor are required.
for one unit of service. This captures the idea that specialization to take advantage of time differences reduces marginal production costs.\(^2\) Although I do not explicitly model the time aspect of production, this seems to be a reasonable assumption.\(^3\)

Another important assumption is that outsourcing requires communications between the outsourcing country and the insourcing country via a communications network: each service firm has to both send and receive its intermediate good via a network. To get on the network, each service firm has to pay a fixed fee (\(\gamma\)). This implies (a) that there are aggregate constant returns to scale in providing communications services, and (b) that the pricing of communications services is done on an average-cost basis. It may be natural to assume that the connection fee is a function of factors such as the number of users, market structure, and so forth.\(^4\) In this study, to make the model tractable, the assumptions about network technology are drastically simplified. These assumptions are summarized in the following cost function:

\[
TC_i^O = w[\alpha + \gamma + (1 + \beta)z_i], \quad i = 1, ..., n, \tag{6}
\]

\(^2\) In what follows, I use the terms ‘outsourcing’ and ‘the utilization of time differences’ interchangeably.

\(^3\) In an alternative approach, Marjit (2006) incorporated a rate of discount due to delayed product completion.

where superscript $O$ denotes the case of ‘outsourcing.’ The costs of communicating across national borders can be offset by a lower marginal production cost.$^5$

With outsourcing, each service firm sets its price as

$$p^O = \frac{[2 - \delta] \sigma w}{(\sigma - 1)},$$

(7)

where $\delta \equiv (1 - \beta)$ represents the reduction in marginal cost. With free entry and exit, the level of output that generates zero profits is given by

$$z^O = \frac{[(\alpha + \gamma)/(2 - \delta)](\sigma - 1)}{\sigma - 1}. $$

(8)

Now consider the supply function of Good $X$. Making use of (2), in a communications autarky, this supply function becomes$^6$

$$C^{CA} = n^{1/(1-\sigma)}p^{CA} = [p^{CA}(z^{CA})^{1/\sigma}X^{-1/\sigma}].$$

(9)

The supply curve $SS$, showing the above condition, is depicted in FIGURE 2(a). Note that this curve is truncated because labor endowments limit the number of business services.

Alternatively, with international outsourcing, the supply function becomes

$$C^O = n^{1/(1-\sigma)}p^O = [p^O(z^O)^{1/\sigma}]X^{-1/\sigma}.$$ 

(10)

$^5$ Note that this corresponds to Jones and Kierzkowski’s (1990, 2001) concept of ‘fragmentation.’

$^6$ Note that $w = 1$ holds because Good $Y$ is produced domestically.
Comparing (9) and (10), one can obtain the relative cost of Good $X$:

$$
\frac{C^O}{C^{CA}} = \left( \frac{2 - \delta}{2} \right)^{1 - (1/\alpha)} \left( \frac{\alpha + \gamma}{\alpha} \right)^{1/\sigma}.
$$  \hspace{1cm} (11)

This index captures important aspects of the utilization of time differences. While the reduced prices of services due to outsourcing have a positive effect, the reduced range of services due to additional fixed connection costs have a negative effect. The overall effects are determined by the tension between these two countervailing effects. Note also that the degree of substitution between business services ($\sigma$) determines the relative impact of these effects: as input differentiation matters less (i.e., $\sigma$ grows), the effect of a reduced price due to outsourcing becomes more important. Now it is possible to state the important conditions for international outsourcing.

**Proposition 1:** If $C^O/C^{CA} < 1$ holds, it is more profitable to outsource than to maintain a communications autarky.

Before turning to the trading equilibrium, consider the situation in which there is no trade in goods or business services (i.e., no outsourcing). In this case, each country must produce all of the goods and services it will use, which means that the price of Good $X$ ($P$) must be equal to the cost $C^{CA}$:

$$
P = C^{CA} = [p^{CA}(x^{CA})^{1/\sigma}]X^{-1/\sigma}.
$$  \hspace{1cm} (12)
On the demand side, it is assumed that the representative consumer has Cobb-Douglas preferences:

\[ U = X^\mu Y^{1-\mu}. \]

Thus, \( PX = \mu L \) must be satisfied. The curve \( DD \) showing this condition is also depicted in FIGURE 2(a). Clearly the autarky equilibrium without outsourcing occurs at point \( A \). The autarky number of service firms becomes\(^7\)

\[ n^{CA} = \mu L/\alpha \sigma. \]

Thus, the autarky price and quantity of Good \( X \) are as follows:

\begin{align*}
    P^{CA} &= \left(\frac{\mu L}{\alpha \sigma} \right)^{1/(1-\sigma)} \frac{2\sigma}{(\sigma - 1)}, \\
    X^{CA} &= \left(\frac{\mu L}{\sigma} \right)^{\sigma/(\sigma - 1)} \frac{\alpha^{1/(1-\sigma)}[(\sigma - 1)/2]}{\sigma}. \tag{13} \tag{14}
\end{align*}

### 3 A Trading Equilibrium with Outsourcing

In this section, three countries are assumed to open their goods markets. Also, assume that every country continues to produce Good \( Y \).\(^8\) Furthermore, the business service sectors in Country 1 and Country 2 are assumed to be connected via communications networks while Country 3 is not connected. Let us call the former two ‘connected countries.’ Between the connected

\(^7\) Note that the wage rate is equal to 1.

\(^8\) Technically, I assume that \( \mu \) is sufficiently small.
countries, middle-process of business services are traded virtually through
the network: utilization of the network implies the virtual integration of two
countries' business-service sector. These connected countries can take advan-
tage of time differences: if Country 1 specializes in the first stage, it becomes
the most efficient to outsource the second stage to Country 2, not Country
3. Assume also that $C^O < C^{CA}$ holds.

FIGURE 2 demonstrates how outsourcing affects the production structure
of the world economy. FIGURE 2(a) shows the situation before outsourcing
takes place, while FIGURE 2(b) shows the situation afterward. The effect
of using time differences is shown by the change in the supply curve. The
extended curve $S'S'$ in FIGURE 2(b) reflects the enhanced division of labor
between connected countries, while the curve for the third country remains
unchanged. This figure shows that there are two sources of gains. First,
in the connected countries, the Good $X$ sector purchases services from all
service firms located in the connected countries and the number of available
business services increases. Second, due to the efficient utilization of time
differences, each service firm within the connected countries can supply its
service at a lower cost, $p^O$, which also reduces the production cost of Good
$X$. By taking into account a simple entry-exit process, connected counties
will specialize in both Good $X$ and business service $Z$. 
Proposition 2: A comparative advantage in Good X is acquired by connected countries that can take advantage of time differences.

Let us consider this more closely. In connected countries, the network provides opportunities for entry into the service sector because, with the increased division of labor due to outsourcing, the average cost of Good X becomes lower and the export of Good X is enhanced.\(^9\) Thus, the size of connected countries’ business-service sectors will expand, while the size of the third country’s service sector will shrink. The point is that there will be a cumulative process in which the increased connectivity via a network will enhance exports, and exports will enhance further specialization in the business-service sector.

Now turn to the welfare effects of trade. The equilibrium point is located on the curve \(S'S'\) (e.g., at point \(T\)) and the equilibrium price and quantity for Good X become, respectively:\(^{10}\)

\[
P^T = \frac{3\mu L}{(\alpha + \gamma)\sigma} \left\{ \frac{1}{(1-\sigma)} \right\} \left\{ \frac{(2-\delta)\sigma}{\sigma-1} \right\}, \quad (15) \\
X^T = \frac{(3\mu L)}{\sigma^{\sigma/(\sigma-1)}} (\alpha + \gamma)^{1/(1-\sigma)} \left\{ \frac{(\sigma-1)/(2-\delta)}{\sigma-1} \right\}, \quad (16) 
\]

where superscript \(T\) denotes the trading equilibrium. Making use of (13) and

\(^9\) This is shown as a movement in the direction of the arrow along the curve \(S'S'\) in FIGURE 2(b).

\(^{10}\) Note that, in the trading equilibrium, the expenditure on Good X is \(3\mu L\).
(15), we can show that price of Good $X$ decreases if the following condition holds.

$$
\left( \frac{3\alpha}{\alpha + \gamma} \right)^{1/(1-\sigma)} \left( \frac{2 - \delta}{2} \right) < 1. \quad (17)
$$

It is notable that, given that each country continues to produce Good $Y$ and condition (17) holds, each country will gain from trade (i.e., the utilization of time differences) regardless of its connectivity and location.

**Proposition 3:** *If the expenditure share for Good $X$ is sufficiently small and condition (17) holds, each country in the world will gain from trade.*

Before closing this section, it is worthwhile to note about the potential for multiple equilibria. To simplify the argument, we have assumed that Country 1 (when completing the first stage of production) and Country 2 (when completing the second stage) are exogenously connected via a network and specialize in Good $X$. However, it should be clear by now that Country 2 (first stage) and Country 3 (second stage) may specialize in Good $X$. The case of Country 3 (first stage) and Country 1 (second stage) is also possible. Thus, there are multiple equilibria. An important conclusion that can be drawn from our analysis is that the countries should not complete both of the stages on their own.\textsuperscript{11} Therefore, a natural extension would be to include

\textsuperscript{11} This point corresponds to Marjit’s (2006) argument.
the endogenous formation of the network connection, which needs further consideration.

4 Concluding Remarks

This note highlights the role of time zones as a driving force behind trade. It is shown that a comparative advantage in the good provided using business services is held by the countries that utilize time differences and outsource (or insource) their production processes. Even more noteworthy is the finding that there is a circular causation between increased connectivity via a network and trade creation. Although these results are derived under the specific assumptions that there is only one factor of production and the type of connection is exogenously given, it appears that a more general setting would yield similar results.

References


Figure 1
FIGURE 2(a)

FIGURE 2(b)