Time Zones, Shift Working and International Outsourcing

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Abstract
We build a trade model with two identical countries located in different time zones and one sector with intermediate differentiated goods produced in two successive stages. We introduce shift working disutility that raises night wage and firms that “virtually” outsource foreign labor. We found that firms only outsource if outsourcing costs are relatively low and shift disutility is high. When outsourcing occurs, it generates the highest level of welfare among production modes. Intermediate values of shift working disutility generate the lowest level of welfare. Outsourcing and domestic labor are substitutes at the firm level and complements at the economy level.

Keywords: Shift working, time zones, outsourcing, monopolistic competition

JEL classification: F12, F16

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1 Introduction

The costs of time and distance have remarkably been reduced because of the recent developments in information and communications technology (ICT). Internet, for instance, allows the instantaneous exchange of information by e-mail between people located thousands of miles away from each other. Such technology creates the possibility of trade in services that take advantage of differences in time zones. For example, when the workday ends to American workers, it starts to Indian workers. If there are efficient communications networks linking these two countries, services, such as call centers, can be provided to the American market during the night by Indian workers at their normal working hours, and *vice versa*. If wages are sufficiently cheap in India, call centers providing services twenty four hours a day in the US may opt for outsourcing such services from India and reduce costs.\(^1\) Likewise, production that would take two normal working days in the US might take only one day if half of the work is outsourced from a country located in a different time zone.

The use of outsourcing at industries supplying 24-hour services, however, is not limited to call centers, an industry characterized by intensive use of unskilled labor.

\(^1\) Head, Mayer and Ries (2009) find that the volume of trade in services is still subject to physical distance.
The health care industry has used outsourcing as a way to cut costs and cover shortage of specialized labor. Hospitals have increasingly outsourced medical services during the night or weekend (when costs are higher) to English-speaking countries located at different time zones such as Australia, Malaysia, India and South Africa.\(^2\) Also, in the electronics industry, some chip manufacturers keep global 24-hour chip design systems with engineering teams located in different parts of the globe such as the US, India and Europe in order to respond to rapid changes in demand and cut costs. Each team works at its normal working hours, but the system works 24 hours a day.\(^3\) In principle, all services that do not require the presence of labor (skilled or unskilled) at the location of supply and present higher costs during the night have the possibility of being outsourced through communications networks. That applies to online schools for language teaching, media companies for supply of international news or firms in the hospitality industry for online reservations, etc.

In such industries a pattern of comparative advantage arises when countries

\(^2\) One example is the outsourcing of radiology services. See Forbes Magazine (July 23, 2003) and Wachter (2006) for example.

\(^3\) Gupta and Seshasai (2007) use the term “24-hour knowledge factory” for such systems. See also Brown and Linden (2009, p. 87).
are located in different time zones as Marjit (2007) argues using a Ricadian model. Cost and time can be saved if countries outsource production during the time labor in their countries is not working. If trade costs are too high than outsourcing may be not advantageous but if trade costs are almost inexistent then trade is probably beneficial.

On the other hand, efficient communications networks, as pointed out by Harris (2001), can create “virtual” mobility of factors at very low costs. If countries are connected through communications networks, then services can be provided by foreign labor located at a different time zone and the outsourcing firm can save time. In this context, communications networks play an important role as determinant of trade patterns as Kikuchi (2006, 2009) and Kikuchi and Iwasa (2010) argue. As such, most of the literature related to time zones has mainly focused on the time-reduction aspect of outsourcing.

Time, however, is also related to labor supply and consumption decisions. Twenty-four hour services, for instance, require the supply of labor during the whole time of service provision, that is, production and consumption must take place simultaneously. In that case, time-reduction is not possible and labor is necessary at day and at night. Workers, however, are likely to face disutility from working at a night shift due to various factors such as health problems, incompatibility with leisure time of
the family, availability of services during nighttime, etc. As a result, wages paid for day shift work and for night shift work are supposed to differ (Eels, 1956). Consumers usually demand higher wages for working at night, thus firms that operate twenty-four hours a day have increased costs for night production. If communications networks allow for virtual outsourcing of foreign labor during night production, then trade liberalization might be beneficial. Firms can reduce costs of production by shifting stages of production to cheaper countries. This is our departure point.

The purpose of this note is to illustrate with a simple two-country model how the introduction of disutility caused by shift working affects trade and production patterns between countries located in different time zones. Production requires two successive stages of production such that both day and night labor supply is necessary. We assume the existence of shift disutility that forces firms to pay higher wages to night supply of labor, which, in turn, raises firms costs. Under free trade, communications networks allow firms to outsource production stages from a country located in a different time zone and reduce costs.

We conclude that firms only outsource if relative costs of outsourcing are relatively low and shift disutility is sufficiently high. When outsourcing occurs under

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4 See Kostiuk (1990) and Lanfranchi et al. (2002) for example.
free trade, it generates the highest level of welfare among production modes. An intermediate range of shift working disutility can generate the lowest level of welfare and be not affected by the reduction of outsourcing costs. In our model, outsourcing substitutes domestic labor at the firm level, but at the economy level, outsourcing complements domestic labor. We provide a very tractable framework that relates shift working disutility, time zones, and international outsourcing. To the best of our knowledge, this paper is first to focus on the issue of shift working decisions in trade models.

This note is structured as follows. In Section 2 we present the basic model, in Section 3 we analyze the outsourcing decision, and in Section 4 we see the implications of shift working and disutility on welfare. Section 5 concludes this work.

2 The Model

In this section we present the basic framework, which is similar to the model of Krugman (1981). There are two identical countries, Home and Foreign (of which variables are denoted by the superscript *), each with a mass \( \Omega \) of consumers that are endowed with \( L \) individual amount of labor. Each country is located in different time zones such that when it is daytime at Home it is nighttime at Foreign and vice versa.
There is one competitive sector producing a final good that is not traded. This final good is produced using intermediate differentiated goods that can be produced at Home or at Foreign. International outsourcing is enabled by communications services provided through communications infrastructure.

2.1 Consumption

Each consumer is endowed with $L$ units of available time that is spent in labor and leisure. Consumers derive utility $U$ from the amount consumed of the final good, $C$, and from leisure time, $l$. The level of utility also depends, however, on the time the consumer works, i.e., the time consumption occurs. In our model, working at night causes disutility in consumption, thus consumers value day and night shifts differently in the following way:5

$$U = \frac{1}{\epsilon} \left( \frac{C}{h_s} \right) + l, \quad 0 < \epsilon < 1. \quad (1)$$

Here, $h_s$ denotes a disutility parameter that depends on the time of work $s$ chosen by

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5 Note that no significant changes would occur if the disutility coefficient affected leisure instead of consumption.
the consumer and \( \epsilon \) is a parameter that guarantees quasilinearity. A consumer can choose to work at a day shift (\( s = d \)), or at a (mid)night shift (\( s = m \)). It is intuitive to assume that a night shift causes higher disutility, thus we assume \( h_m > h_d \). Note that it is possible to consider heterogeneous consumers that differ in terms of shift preferences, but we restrict our analysis to homogeneous workers. Denoting the price of the final good as \( P \) and the wage rate paid at shift \( s \) as \( w_s \), the budget constraint is given by:

\[
PC + w_s l = w_s L. \tag{2}
\]

Solving the utility maximization problem, we obtain the demand function for final goods and the supply function of labor \( L - l \) of consumers working at shift \( s \):

\[
C_s = \left( \frac{w_s}{P} \right)^{1-\epsilon} h_s^{\frac{\epsilon}{\epsilon+1}} \tag{3}
\]

\[
L - l_s = \left( \frac{w_s}{P} \right)^{1-\epsilon} h_s^{\frac{\epsilon}{\epsilon+1}} \tag{4}
\]

Note that both the demand for the final good and the supply of labor depend negatively

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\( ^6 \) The budget constraint could include the profits of firms, but we omit them here because in the long run they are driven down to zero, as it will become clear later on.
Given the optimal amount of $C_s$ and $L - l_s$ under a given wage rate $w_s$, consumers choose between day and night shift based on the level of utility, that is, consumers prefer to work in the shift that gives them the highest level of utility. We can also derive the indirect utility function that depends positively on wage rate $w_s$ and negatively on price $P$ and disutility coefficient $h_s$:

$$V(w_s, P, h_s) = \left(\frac{1-\epsilon}{\epsilon}\right) \left(\frac{w_s}{P h_s}\right)^{\frac{\epsilon}{1-\epsilon}} + L. \quad (5)$$

A closer look at the above equation reveals that night wages should be higher than day wages in order to compensate for the night shift disutility.

### 2.2 Production

Now let us turn to the supply side. As in Ethier (1982), the final good is produced under constant returns to scale in a competitive sector that utilizes intermediate differentiated goods (varieties) produced under monopolistic competition. Denoting the input of a variety $i(i^*)$ produced at Home (Foreign) as $x_i(x_{i^*})$, the number of Home varieties as $n$ and Foreign varieties as $n^*$, then the level of production of the final good,
\( X \), is given by the following Dixit-Stiglitz (1977) type CES production function:

\[
X = \left( \sum_{i=1}^{n}(x_i) + \sum_{i'=1}^{n'}(x_{i'})^{\theta} \right)^{\frac{1}{\theta}}, \quad 0 < \theta < 1. \tag{6}
\]

In this setting, the cost of production decreases with the number of differentiated intermediate goods employed. Moreover, the price of the final good \( P \) is equal to its cost of production, which depends on the price \( p_i \) of each variety \( i \):

\[
P = \left( \sum_{i=1}^{n}(p_i initi) + \sum_{i'=1}^{n'}(p_{i'})^{\theta-1} \right)^{\frac{1}{\theta-1}}. \tag{7}
\]

It is well-known that assuming a CES production function as (6) and large number of varieties, \( \sum_{i=1}^{n} p_i x_i + \sum_{i'=1}^{n'} p_{i'} x_{i'} = PX \) (=total cost) holds.

We, then, derive the demand of final good producer for Home and Foreign varieties or intermediate goods:

\[
x_i = \frac{p_i}{P} \frac{1}{\theta-1} X \tag{8}
\]

\footnote{Note that, under autarky, no Foreign variety is employed in the production of the final good, thus Foreign variables vanish.}
\[ x_i^* = \left( \frac{p_i}{p} \right)^{\frac{1}{\vartheta-1}} X. \] (9)

In the intermediate goods sector, a variety \( i \) needs to be produced in two successive stages, each taking half a day to be performed. This assumption denotes the time constraint present in services, that is, supply and consumption must take place at the same time, thus it is not possible to shrink the time necessary to produce one variety (for example, call centers).

Under autarky (denoted by the superscript \( A \)), intermediate goods firms need to perform both stages domestically. Each stage (day and night) requires the use of a fixed amount \( \alpha^D \) and a variable amount \( \beta x_i^D \) of labor. Thus the profit of the producer of variety \( i \) is:

\[
\pi_i^A = p_i^A x_i^A - w_d \beta x_i^A - w_d \alpha^D - w_m \beta x_i^A - w_m \alpha^D.
\] (10)

The cost of each stage is subtracted from revenues. The pricing rule is the standard monopoly price:

\[
p_i^A = \frac{(w_d + w_m) \beta \vartheta}{\vartheta}.
\] (11)
Note that both day and night wages affect prices. With free entry and exit in the long run, the output of variety \( i \) is given by:

\[
X^A_i = \frac{\alpha^D \theta}{\beta(1-\theta)}.
\] (12)

Next, we examine how production takes place under free trade. One of our central assumptions is that, under free trade, producers of differentiated products can sell to both domestic and foreign final producers and choose to produce each stage either domestically or by outsourcing foreign labor through communications services.\(^8\) An intermediate good firm, then, will choose the cheapest place of production for each stage.

If both stages are performed in the country of origin of the intermediate good producer, that is, there is free trade with domestic production (denoted with the superscript \( D \)), again each stage requires the use of a fixed amount \( \alpha^D \) and a variable amount \( \beta x^D_i \) of labor. Then the profit \( \pi^D_i \) of Home variety \( i \) selling to domestic and foreign final producers with both stages being domestically produced is given by:

\(^8\) This is referred by Harris (2001) as “virtual mobility” of factors.
We obtain the pricing rule under domestic production from the above equation:

\[ p_i^D = p_i^D x_i^D + p_i^D \tilde{x}_i^D - w_d \beta (x_i^D + \tilde{x}_i^D) - w_d \alpha^D - w_m \beta (x_i^D + \tilde{x}_i^D) - w_m \alpha^D. \]  

(13)

Considering zero profits in the long run due to free entry and exit of firms, we obtain the output of Home variety \( i \) producing only domestically:

\[ x_i^D + \tilde{x}_i^D = \frac{\alpha^D \theta}{\beta (1 - \theta)^2}. \]  

(15)

which is equivalent to the output level under autarky.

Now we turn to the outsourcing case. Outsourcing is only possible if the firm is connected to an international communications network that allows trade and virtual mobility of labor across countries to occur. We assume that the fixed cost coefficient incurred in outsourcing, \( \alpha^O \), includes an additional fixed amount of labor incurred from the use of communications services such that \( \alpha^O > \alpha^D \). The extra fixed cost can be
interpreted as the cost of connection, such as additional labor employed in training, translation or coordination between headquarter and subsidiary firms, which increases the fixed costs of all stages. Then generally, firms will have an incentive to produce using the cheapest labor available at the time of production. Note that both stages can be outsourced, but as we assume identical economies, wages are equalized over countries and day-time labor is always cheaper than night-time labor in any country. Thus, if a firm outsources, it will always domestically produce the first stage at daytime and outsource the second stage at nighttime (daytime at the other country). Then, the profit $\pi_i^o$ of Home variety $i$ that outsources becomes:

$$\pi_i^o = p_i^o x_i^o + p_i^o x_i'^o - w_d \beta (x_i^o + x_i'^o) - w_d \alpha^o - w_d' \beta (x_i^o + x_i'^o) - w_d' \alpha^o.$$ (16)

Under free trade, the pricing rule becomes:

$$p_i^o = \frac{(w_d + w_d') \rho}{\theta},$$ (17)

and the output of variety $i$ is given by:
Before turning to the outsourcing decision problem, we analyze how equilibrium is characterized under the two production modes. As a benchmark, we first analyze the autarkic equilibrium, then proceed to free trade without outsourcing and, finally, free trade with outsourcing. We compare the three equilibria and check the consistency of outsourcing and welfare-improving conditions.

2.3 The Autarkic Equilibrium

Under autarky, the final good producer utilizes only Home varieties, which requires domestic day-time and night-time labor to be produced. In order to have positive labor supply at both day and night, however, wage rates should be set so as to equalize the levels of utility of day-shift and night-shift consumers, that is:

\[ x_1^O + x_1^{1O} = \frac{a^O \theta}{\theta (1-\theta)} \]  

(18)

Under the above condition, consumers are indifferent between working at day or at night. Then, from (19) the shift premium \( w_m/w_d \) is determined:

\[ V(P, w_d) = V(P, w_m). \]  

(19)
\begin{equation}
\frac{w_m}{w_d} = \frac{h_m}{h_d}
\end{equation}

We take day labor as the numeraire (\(w_d = 1\)) and assume \(h_d = 1\), thus \(w_m = h_m\). Denoting the number of workers as \(\Omega\), the share of consumers working at a day shift as \(\delta\) and consumers working at a night shift as \(1 - \delta\), then the day-time and night-time market clearing conditions are given by:\footnote{Conditions for Foreign are analogous.}

\begin{align}
\delta \Omega (L - l_d) &= n\beta x_i^A + n\alpha^D \\
(1 - \delta) \Omega (L - l_m) &= n\beta x_i^A + n\alpha^D.
\end{align}

The total amount of labor (time) is equal to the sum of the variable and fixed amount of labor demanded by each variety producer. The aggregate demand for the final good is represented by total demand from day-shift and night-shift consumers:

\begin{equation}
X = \delta \Omega C_d + (1 - \delta) \Omega C_m.
\end{equation}

Now we are ready to calculate the price index under autarky, \(P^A\). From (3), (4),
(6), (7), (8), (9) to (12) and (20) to (23), and assuming symmetry of firms in the intermediate sector, we obtain:  

$$ p^A = \left[\frac{2\alpha^0 p^A p^{\pi} q^{\sigma}}{\beta(1-\theta)}\right]^{(1-\theta)/(1-\epsilon)} (1-\epsilon), $$  

(24)  

with $p^A = (1 + h_m)\beta/\theta$. As expected, under autarky, the higher the night shift disutility is, the higher is the wage rate for night shift. This increases the price of each variety and consequently, the price index and lowers individual welfare. Also, higher price $P$ also lowers the real wage decreasing labor supply, and thus, total production. Note that labor demand (and supply) is equally divided into day and night shift ($\delta = 0.5$).

### 2.4 The Free Trade Equilibrium

Now suppose countries can trade freely but firms in the intermediate sector do not outsource foreign labor. With completely symmetric countries, day-time labor can be taken as the numeraire ($w_d = w_d^* = 1$ and $w_m = w_m^* = h_m$). Then the market-clearing

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10 We assume throughout the paper that $\theta > \epsilon$ to ensure that varieties are substitutes to each other.

conditions change to:

\[ \delta \Omega(L - l_d) = n \beta (x_t^D + x_t^{D'}) + n \alpha^D \]  \hspace{1cm} (25)

\[ (1 - \delta) \Omega(L - l_m) = n \beta (x_t^D + x_t^{D'}) + n \alpha^D, \]  \hspace{1cm} (26)

and the aggregate demand for varieties becomes:

\[ X = \frac{\sigma}{2} C_d + \frac{\sigma}{2} C_m = \frac{\sigma (1 + h_m)}{2 \pi \Gamma} \]  \hspace{1cm} (27)

From (3), (4), (6) to (9), (13) to (15), (20) and (25) to (27), the equilibrium price index under free trade with domestic production is obtained:

\[ p^D = \left[ \frac{\alpha^D p^D \theta (1 - \epsilon)}{\alpha (1 - \theta)} \right]^{(1 - \theta)(1 - \epsilon)} \theta^{-\epsilon}, \]  \hspace{1cm} (28)

with \( p^D = p^A = (1 + h_m) \beta / \theta \).

Next, we examine the equilibrium under free trade with outsourcing. When wages are equalized, if outsourcing occurs, then it occurs for both Home and Foreign variety producers. There is mutual outsourcing of day-time labor of the other country,

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11 Here again, labor demand (and supply) is equally divided into day and night shift (\( \delta = 0.5 \)).
and there is no demand for night-time labor in either economy. The market clearing condition at Home is now:

\[ \Omega(L - l_d) = n\beta(x_i^0 + x_i^O) + n^*\beta(x_i^0 + x_i^O) + n^*a^O + n^*a^O, \quad (29) \]

and the aggregate demand for varieties becomes:

\[ X = \Omega C_d = \frac{\Omega}{p^{1-\theta}}, \quad (30) \]

When there are no trade restrictions and wages are equalized, the number of varieties produced and consumed is completely equalized across countries, trade is balanced and labor demand (and supply) is completely concentrated at day shift. From (3), (4), (6) to (9), (16) to (18), (20), (29) and (30), the equilibrium price index under free trade with outsourcing is calculated:

\[ p^O = \left[ \frac{\alpha_1}{\alpha_1 + \alpha_2} \right]^{\frac{\theta}{1-\theta}} \left[ \frac{\theta(1-\theta)}{(1-\theta)} \right]^{-\frac{1-\theta}{\theta}}, \quad (31) \]

with \( p^O = 28/\theta \). Note that, once both domestic and foreign firms outsource, the price
index is not dependent on the level of shift disutility.

Given the above results, we need to discuss under which conditions firms will outsource foreign labor before we compare the price indices we obtained.

3 The Outsourcing Decision

In this section we analyze the choice of production mode of variety producers under free trade. As we have seen, outsourcing may reduce marginal costs by employing cheaper foreign labor at the second stage but, at the same time it increases fixed costs. Thus firms will engage in outsourcing only if the change in profits is non-negative. In analyzing the decision of production mode, firms take the total number of firms in the market as given, that is, fixed. Also, each firm knows that all firms are symmetric and that if it chooses one production mode, all other firms should choose the same production mode. Under these assumptions, \( P = N^{\theta-1} p_i \) holds with \( N \) as the sum of Home and Foreign varieties.

First, let us derive the profit of the firm producing only domestically. From (3), (13) to (15) and (23) we obtain

\[
\pi_i^D = (1 - \theta) \Omega N^{\frac{\epsilon - \theta}{(1 - \epsilon)(1 + h_m)}} \left( p_i^D \right)^{\frac{\epsilon}{\epsilon - 1}} - (1 + h_m) \alpha^D. \tag{32}
\]
Analogously, from (3), (16) to (18) and (30), we derive the profit of the outsourcing firm:

\[
\pi^0_i = (1 - \theta)\Omega N \frac{r - \theta}{\theta r} 2 \left( p^0_i \right)^{\frac{\epsilon}{\epsilon - 1}} - 2 \alpha^0.
\]  

(33)

Firms will outsource production if and only if \( \pi^0_i - \pi^D_i \geq 0 \), that is:

\[
\pi^0_i - \pi^D_i = \frac{(1 - \theta)\Omega}{\theta r} \left( \frac{\hat{\pi}^0}{\hat{\pi}^D} \right)^{\frac{\epsilon}{\epsilon - 1}} \left[ 2 ^{\frac{1}{1 - \epsilon}} - (1 + h_m)^{\frac{1}{1 - \epsilon}} \right] + [(1 + h_m)\alpha^0 - 2\alpha^D] \geq 0.
\]  

(34)

The outsourcing decision is taken based on relative lower marginal costs and increased fixed costs. Since the price index in the long run equilibrium with outsourcing is given by (31), the outsourcing condition can be represented in terms of relative costs of outsourcing and relative variety prices (level of shift disutility). We obtain the following lemma:

**Lemma 1.** Under free trade, firms outsource if and only if \( \frac{\alpha^0}{\alpha} \leq \left( \frac{1 + h_m}{2} \right)^{\frac{\epsilon}{\epsilon - 1}} \) holds.
Firms find it profitable to outsource if extra costs incurred in outsourcing are not too high or the shift disutility (night wage) is sufficiently low.

4 Welfare Analysis

As we have seen, individual welfare can be denoted by (5) and depends on the price index level. In this section we compare the equilibrium price index of each equilibrium to derive changes in welfare. Comparing the price indices of the trade equilibrium with domestic production, (28), and of the autarky equilibrium, (24), we obtain:

\[
\frac{p^D}{p^A} = \left( \frac{1}{2} \right)^{\frac{(1-\theta)(1-\epsilon)}{\theta - \epsilon}} < 1. \quad (35)
\]

Thus, trivially, trade liberalization with domestic production equilibrium is welfare-enhancing when compared to autarky as Foreign varieties become available to the Home producer of the final good and the price index decreases.

Conversely, comparing the price levels of the outsourcing equilibrium, (31), and of the autarky equilibrium, (24), we obtain:

\[
\frac{p^D}{p^A} = \frac{a^D}{2a^A} \left( \frac{2}{1+h_0} \right)^\theta \frac{(1-\theta)(1-\epsilon)}{\theta - \epsilon}, \quad (36)
\]
which can be either larger or smaller than one depending on the value of the term inside the brackets. Particularly, an outsourcing equilibrium is welfare-enhancing when compared to the autarky equilibrium if the following condition holds:

\[
\frac{a^0}{a^0} \leq 2 \left( \frac{1+b_m}{2} \right)^{\frac{\theta}{1-\theta}}.
\]  

(37)

Again, it is possible to obtain a relation between the relative cost of outsourcing and relative variety prices.

Lastly, we compare free trade equilibria with domestic production and outsourcing. From (28) and (31) we obtain:

\[
\frac{p^0}{p^0} = \frac{a^0}{a^0} \left( \frac{2}{1+b_m} \right)^{\frac{\theta}{1-\theta}}^{1-\theta} \theta^{1-\theta}.
\]  

(38)

Thus, when it occurs, an outsourcing equilibrium leads to a higher welfare level than the domestic production equilibrium if the following condition holds:
Conditions (37), (39) and Lemma 1 are depicted in Figure 1 as curves A, B and C, respectively. A firm only chooses outsourcing in equilibrium in the area below curve C. In the area below curve A outsourcing increases welfare as compared to the autarkic equilibrium, and in the area below curve B outsourcing increases welfare as compared to the free trade equilibrium with domestic production.\textsuperscript{12}

\begin{align}
\frac{\omega}{\alpha} & \leq \left( \frac{1+h_m}{2} \right)^{\frac{6}{1-\eta}}. 
\end{align}

\textbf{Insert Figure 1 here}

Note that in the area between curves B and C outsourcing does not occur, but if it did so, welfare would be higher. It is possible to conclude that, when it occurs, outsourcing always increases welfare when compared to autarky and free trade domestic production since the area below curve C is always contained in the area below curve B. The higher the shift disutility and the lower is the relative cost of outsourcing, the more likely is outsourcing to take place. We summarize our results in the following proposition.

\textsuperscript{12} Note that there are other configurations for the three curves, but their relative position never changes, that is, they never cross each other nor their order changes.
Proposition 1. Suppose a communications network allows two identical countries located in different time zones to virtually utilize each other’s labor. If outsourcing takes place, it generates a higher welfare level than both the autarkic equilibrium and the free trade equilibrium with domestic production.

Trade liberalization that leads to outsourcing has several effects in the economy. Besides increasing the number of varieties available in the economy, outsourcing enhances firms’ productivity by lowering marginal costs. Both effects work to lower the price index, which, in turn, increases real wages and, hence, labor supply. Again, an enlarged labor supply affects the number of varieties as the economy is able to accommodate more varieties. Outsourcing improves welfare also by directly eliminating shift disutility as it diminishes the necessity of night shift labor.

Figure 2 illustrates how welfare level changes according to the level of shift disutility and production modes taking the cost of outsourcing as fixed: curve O for outsourcing under free trade (independent of \( k_m \)), curve D for domestic production under free trade and curve A for autarky. Point \( b \) delimits the range in which firms outsource (shift disutility level above \( b \)). The thick parts of the curves denote welfare levels achieved in equilibrium. Welfare under autarky is always inferior to free trade
with domestic production and, in the range between the origin and point $b$, domestic production prevails under free trade. Outsourcing provides the highest level of welfare for disutility levels above point $a$, although it only takes place in the range above point $b$.

**Insert Figure 2 here**

As can be inferred from Figure 2, intermediate values of shift disutility result in the lowest levels of welfare in equilibrium. In the range between points $a$ and $b$ shift working disutility is not sufficiently high to trigger outsourcing. We summarize this result in Proposition 2.

**Proposition 2.** *Levels of shift working disutilities that are immediately inferior to the minimum level that triggers outsourcing generate the lowest levels of welfare.*

This result is important from a policy point of view as disutility from shift work is not easily observable and shift premium is usually set by labor standards. Regulation may hurt consumers if it is set at intermediate levels as we have seen.

Now we examine how the equilibrium changes with an exogenous decrease in $\alpha^0$. We assume that the cost of outsourcing is dependent on the communications
infrastructure shared by both countries.\textsuperscript{13} We know from (31) that the welfare level in
the outsourcing mode increases and, from Lemma 1, we know that point $b$ shifts
leftward to point $b'$ as depicted in Figure 3. If $h_m < b'$ there is no change in welfare but,
if $h_m > b$, then there is an increase in welfare due to a change in the number of firms in
equilibrium and, if $b' < h_m < b$, then there is an increase in welfare due to a shift in
production mode.

Insert Figure 3 here

Thus an exogenous decrease in outsourcing costs can improve welfare through gains in
productivity and a change in the production mode as far as the resulting equilibrium is
the outsourcing one.

As we have seen, in our setting, trade liberalization is always
welfare-enhancing. When exogenous shift disutility is considered, however, it becomes
clear that the production mode heavily influences the level of welfare. Particularly, if

\textsuperscript{13} More sophisticated infrastructure, such as satellites, cables, transmission towers, decreases
communications costs and the cost of outsourcing, thus countries that develop more sophisticated
communications infrastructure have higher possibility of outsourcing.
shift disutility takes intermediate values that are not able to force firms to shift their production modes, there is a possibility that the economy ends up with the lowest levels of welfare. In this context, although an improvement in technology (particularly, in fixed costs of outsourcing), can improve welfare not only by increasing the number of varieties consumed in equilibrium but also by causing shifts to more efficient production modes, it may not take place in certain intermediate ranges. This result may be particularly relevant in terms of policy considering that shift premia and communications infrastructure are usually subject to governmental control.

Note that in our model outsourcing takes two different aspects concerning substitutability and complementarity of labor. At the firm level outsourcing substitutes domestic night labor (and possibly day labor as well), whereas at the economy level outsourcing of foreign night labor works as a complement to domestic day labor.\textsuperscript{14}

Although we have worked with completely identical economies in this model, much richer patterns can be achieved through asymmetries of countries including population size, marginal productivities and shift preferences. In this paper we just gave a first step to include shift disutility, but cross-country differences in wages are

\textsuperscript{14} See Koskela and Stenbacka(2009) and Lommerud et al. (2009) for further discussions in the issue of outsourcing and complementarity of labor.
crucial in the decision of outsourcing and a more realistic model would include it in the analysis.

5 Concluding Remarks

The role of time zones in international trade has recently being focused in the literature as a new phenomenon. There is, however, an inherent difficulty in introducing time (not in the dynamic sense) into formal models. This paper aimed at introducing time in the consumption side so as to analyze the effects of time in labor markets and industries that make use of time differences. We built a trade model with two identical countries located in different time zones, a monopolistically competitive sector, and communications network services that enable countries to trade with each other and “virtually” outsource labor from other countries. We introduced shift working disutility such that night shift workers are paid a shift premium that raises production costs. Firms take advantage of time differences to decrease marginal costs by outsourcing foreign labor but have to pay extra fixed costs in order to do so.

We concluded that outsourcing takes place only under certain conditions and it generates higher welfare levels than other production modes. Specifically, firms choose to outsource when the relative cost of outsourcing is low and the shift disutility is high.
Generally, the higher the shift working disutility is, the lower is welfare under domestic production. Above a certain level of shift disutility, however, firms shift production to outsourcing and welfare reaches a higher level, which is independent of the level of shift disutility. Intermediate values of disutility in which firms have no incentive to outsource generates the lowest welfare level and may be immune to reduction of outsourcing costs.

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Figure 1: Outsourcing and Welfare \((\theta > \frac{1}{2}, \varepsilon < \frac{1}{2})\)
Figure 2: Welfare and Shift Disutility ($\alpha^0$ fixed)
Figure 3: Decrease in Outsourcing Costs