Time Zones, Shift Working and Outsourcing through Communications Networks.

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Abstract

We build a trade model with two countries located in different time zones, a monopolistically competitive sector in which production requires differentiated goods produced using day and night labor, and shift working disutility. Consumers choose between working at a day shift or a night shift and firms may choose to "virtually" outsource foreign day time labor by using communications services. We found that the higher the disutility of working at night is, the smaller is the number of varieties produced. Trade is beneficial only under certain concavity and cost conditions. The higher the disutility of working at night, the larger can be the gains from trade.

Keywords: Communications networks, shift work, time zones, outsourcing

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1. Introduction

The costs of time and distance have remarkably been reduced because of the recent development of information technology (IT). 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. 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.

In this logic, a pattern of comparative advantage arises when countries are located in different time zones as Marjit (2007) argues with a Ricadian model. Cost and time can be saved if countries outsource production during the time their countries are 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. 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 (See Kikuchi, 2006).

Time, however, is 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. Workers, however, are likely to face disutility from working at a night shift due to various factors such as health problems, family composition, availability of services during leisure time, etc. As a result, wages paid for *day shift* work and for *night shift* work are supposed to differ (Eels, 1956). Consumers will demand higher wages for working at night[1] and, if communications networks allow for virtual outsourcing of foreign labor, then trade liberalization might be beneficial. This is our departure point.

The purpose of this note is to illustrate with a simple model how the introduction of disutility caused by shift working affects trade patterns between countries located in different time zones. We assume the existence of shift disutility that forces consumers to demand higher wages to supply labor at night, which, in turn, gives an incentive to firms to outsource their night production. A two-country-one-sector trade model is built featuring monopolistic competition and love of variety (Krugman, 1979). Communications networks enable countries to trade and outsource foreign labor. We conclude the following. First, the higher the shift disutility, the higher is the shift premium and the smaller is the number of varieties produced and the lower is welfare. Second, the liberalization of trade increases the number of varieties only under a middle range of concavity of the utility derived from the consumption of the final good and under low extra costs incurred from outsourcing. And third, a higher shift disutility induces higher gains from trade only if the concavity of the utility derived from the consumption of the final good is

[1]See Kostiuk (1990) and Lanfranchi et al. (2002) for example.

sufficiently high. We provide a very tractable framework that relates time disutility, time zones, communications networks and trade. 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 autarkic equilibrium and in Section 4 we analyze the free trade equilibrium with outsourcing. Section 5 concludes this work.

2. The Model

In this section we present our basic framework. There are two identical countries, Home and Foreign (of which variables are denoted by the superscript *), each endowed with total amount of labor L. Each country is located in different time zones, such that, when it is day at Home it is night at Foreign and *vice versa*. There is one competitive sector producing a final good. The final good is produced using intermediate differentiated goods that can be produced at Home or at Foreign. Trade between countries is possible only through communications services provided by a communications network.

2.1 Consumers

Each consumer is endowed with one unit of available time spent in labor or leisure and derives utility U from the amount consumed of the final good, C, and from leisure time, l. The level of utility 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:[2]

$$U = \frac{C^{\epsilon}}{\epsilon h_s} + l \qquad 0 < \epsilon < 1. \tag{1}$$

Here, h_s denotes a disutility parameter that depends on the time of work s chosen by the consumer. A consumer can choose to work at a day shift, $s = d$, or at a (mid)night shift, $s = m$. Denoting the price of the final good as P and the wage rate paid at shift s as w_s, the budget constraint becomes:

$$PC + w_s l = w_s. \tag{2}$$

From (1) and (2) we obtain the demand function for final goods and the supply function of labor $1 - l$, respectively:[3]

$$C_s = \left(\frac{w_s}{Ph_s}\right)^{\frac{1}{1-\epsilon}} \tag{3}$$

$$1 - l_s = \left(\frac{w_s}{P(h_s)^{\frac{1}{\epsilon}}}\right)^{\frac{\epsilon}{1-\epsilon}}. \tag{4}$$

Note that both the demand for the final good and the supply of labor depend on the wage rate and the level of disutility.

[2]Disutility from working at night shift includes health problems, incompatibility with leisure time of the family, availability of services, etc. See Eels (1956) for example.

[3]We restrict our analysis to the case of $0 \leq l \leq 1$.

Given the optimal amount of C_s and $1-l_s$ under a given wage rate w_s and, consumers choose between day and night shift based on the level of utility. Consumers prefer to work in the shift that gives them the highest level of utility. Therefore, in order to have positive labor supply at day and night, wage rates should be set so as to equalize the levels of utility of day-shift and night-shift consumers, that is:

$$U(C_d, l_d, w_d) = U(C_m, l_m, w_m). \tag{5}$$

Under the above condition, consumers are indifferent between working at day or at night. From (1), (3), (4) and setting $h_d = 1$, the shift premium is, then, determined:

$$\frac{w_m}{w_d} = h_m^{\frac{1}{\epsilon}}. \tag{6}$$

It is intuitive to consider the disutility from working at night to be higher than that of daytime, that is, $h_m > 1$, thus the shift premium is always higher than one.

2.2 Production

Now let us turn to the supply side. As in Ethier (1979), 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^*}), then number of Home varieties as n and Foreign varieties as n^*, the level of production of the final good, X, is given by the following Dixit-Stiglitz type CES production function:

$$X = \left(\sum_{i=1}^{n} (x_i)^{\theta} + \sum_{i^*=1}^{n^*} (x_{i^*})^{\theta} \right)^{\frac{1}{\theta}}, \qquad 0 < \theta < 1. \tag{7}$$

The price of the final good is equal to its cost of production, which depends on the price p_i of each variety i:[4]

$$P = \left(\sum_{i=1}^{n} (p_i)^{\frac{\theta}{\theta-1}} + \sum_{i^*=1}^{n^*} (p_{i^*})^{\frac{\theta}{\theta-1}} \right)^{\frac{\theta-1}{\theta}}. \tag{8}$$

We, then, derive the following demand for Home and Foreign varieties:

$$x_i = \left(\frac{p_i}{P}\right)^{\frac{1}{\theta-1}} X \tag{9}$$

$$x_{i^*} = \left(\frac{p_{i^*}}{P}\right)^{\frac{1}{\theta-1}} X. \tag{10}$$

In the intermediate sector, a variety i is produced in two stages (day and night). Producers can choose between producing domestically and outsourcing foreign labor by paying for communications services. In the case of domestic production, each stage requires the use of a fixed amount of labor α and a variable amount of labor βx_i.[5] The

[4] Under this setting, it is clear that the cost of production decreases with the number of varieties.

[5] Similar assumption is taken by Harris (2001), for example.

profit π_i^D of variety i producing domestically is given by:

$$\pi_i^D = p_i^D x_i - (w_d + w_m)\beta x_i - (w_d + w_m)\alpha. \tag{11}$$

From the above equation, the pricing rule becomes:

$$p_i^D = \frac{(w_d + w_m)\beta}{\theta}. \tag{12}$$

Considering zero profits in the long run due to free entry and exit of firms, we obtain the output of variety i:

$$x_i^D = \frac{\alpha\theta}{\beta(1-\theta)}. \tag{13}$$

A variety can be produced by outsourcing foreign labor. Outsourcing, however, is only possible if the firm is connected to a communications network that allows trade and "virtual" mobility of labor across countries to occur.[6] Moreover, outsourcing incurs an additional amount μ of labor as fixed cost in all stages of production.[7] Only variable inputs of labor can be outsourced, that is, labor required as fixed inputs need to be domestic. Note that, in our setting, daytime labor is always cheaper than nighttime labor in either country, thus all firms would employ only daytime labor of both countries. Since Home and Foreign are symmetric, we derive the profit π_i^O of variety i that outsources labor and sells x_i units domestically at price p_i and x_i^* units abroad at price p_i^*:

$$\pi_i^O = p_i x_i + p_i^* x_i^* - (w_d + w_d^*)\beta(x_i + x_i^*) - (w_{d+} w_m)(\alpha + \mu). \tag{14}$$

Under free trade, the pricing rule becomes:

$$p_i^O = p_i^{*O} = \frac{(w_d + w_d^*)\beta}{\theta}, \tag{15}$$

and the output of variety i becomes:

$$x_i^O = \frac{(\alpha + \mu)\theta(1 + w_m)}{4\beta(1-\theta)}. \tag{16}$$

3. The Autarkic Equilibrium

Under autarky the final good producer utilizes only Home varieties, which requires both daytime and nighttime labor to be produced. Denoting the number of consumers working at a day shift as L_d and consumers working at a night shift as L_m, then the

[6] See Harris (2001).

[7] The fixed cost coefficient μ can be interpreted as the cost of connection or, for example, additional labor employed in training, translation or coordination between headquarter and subsidiary firms.

daytime and nighttime market clearing conditions are given by:

$$L_d(1-l_d) = n\beta x_i + n\alpha \tag{17}$$
$$L_m(1-l_m) = n\beta x_i + n\alpha. \tag{18}$$

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 can also be represented by:

$$X = L_d C_d + L_m C_m, \qquad L_d + L_m = L. \tag{19}$$

Now we are ready to calculate the number of varieties under autarky, n_A. Assuming symmetric firms in the intermediate sector, we obtain:[8]

$$n_A = \left[\frac{L(1-\theta)}{2\alpha}\left(\frac{\beta(1+h_m^{\frac{1}{\epsilon}})}{\theta}\right)^{\frac{\epsilon}{\epsilon-1}}\right]^{\frac{\theta(1-\epsilon)}{\theta-\epsilon}}. \tag{20}$$

From (20) we conclude the following:

Proposition 1. *The higher the disutility of working at nighttime is, the lower is the number of varieties produced under autarky.*

This stems form the fact that more shift disutility (higher h_m) increases the price of varieties and, consequently, the price of the final good. A higher final good price lowers demand and, consequently, the number of varieties produced.

4. The Free Trade Equilibrium

Now we examine the equilibrium under free trade. As we have seen, being connected to a communications network allows final producers in both countries to import foreign varieties, and variety producers to outsource foreign labor. The market clearing conditions for Home are now:

$$L_d(1-l_d) = n\beta(x_i + x_i^*) + n^*\beta(x_{i^*} + x_{i^*}^*) + n(\alpha+\mu) \tag{21}$$
$$L_m(1-l_m) = n(\alpha+\mu). \tag{22}$$

When there are no trade restrictions, the wage rate paid for day and night workers, the price of varieties and the number of varieties produced and consumed are completely equalized across countries and trade is balanced. Denoting the number of varieties produced at a Home under free trade as n_T, we obtain:

$$n_T = \left[\frac{L(1-\theta)}{(\alpha+\mu)[2+\theta(h_m^{\frac{1}{\epsilon}}-1)]}\left(\frac{\beta 2^{\frac{2\theta-1}{\theta}}}{\theta}\right)^{\frac{\epsilon}{\epsilon-1}}\right]^{\frac{\theta(1-\epsilon)}{\theta-\epsilon}}. \tag{23}$$

[8]Here, we assume $\theta > \epsilon$ to have varieties substitutes to each other. See Fukushima and Kikuchi (2009) for details.

Note that, under free trade, the number of varieties is also negatively related to the level of disutility h_m. Calculating the ratio of the number of varieties under autarky, n_A, and the number of total varieties under free trade, $N_T = 2n_T$, we obtain:

$$\frac{N_T}{n_A} = \left[\frac{\alpha}{(\alpha + \mu)} \times \frac{(1 + h_m^{\frac{1}{\epsilon}})^{\frac{\epsilon}{1-\epsilon}}}{(2 + \theta h_m{}^{\frac{1}{\epsilon}} - \theta)} \times 2^{\frac{2-3\epsilon}{1-\epsilon}} \right]^{\frac{\theta(1-\epsilon)}{1-\epsilon}}. \tag{24}$$

The total number of varieties under free trade can be either larger or smaller than one. The first item of the expression in parentheses is smaller than one, but if ϵ is large enough, the second item can be larger than one, and if $\epsilon < 2/3$, the last term is also larger than one. We obtain the following result.

Proposition 2. *Suppose a communications network allows two identical countries located in different time zones to trade with each other and "virtually" utilize each other's labor. If $\epsilon < 2/3$ but is sufficiently large, and costs incurred from outsourcing foreign labor is low, then trade increases the number of varieties consumed and is beneficial to both countries.*

Conversely, if ϵ is too small, then the number of varieties consumed under free trade is smaller than under autarky and both countries can be worth off.

Now let us see how the disutility arising from shift work affects the trade equilibrium. We log-differentiate (24) in relation to h_m to see whether the relative number of varieties increases or decreases:

$$\frac{\partial[lnN_T/n_A]}{\partial h_m} = \frac{\theta(1-\epsilon)}{\epsilon(\theta - \epsilon)} h_m^{\frac{1-\epsilon}{\epsilon}} \left[\frac{\epsilon}{(1-\epsilon)} \times \frac{1}{(1 + h_m^{\frac{1}{\epsilon}})} - \frac{1}{(\frac{2}{\theta} - 1 + h_m^{\frac{1}{\epsilon}})}. \right], \tag{25}$$

The above equation can be positive or negative depending on the relative size of ϵ. If we ignore the item $\frac{\epsilon}{(1-\epsilon)}$, the expression in parentheses is always positive. Thus if ϵ is sufficiently large, (25) is positive. We can conclude the following:

Corollary 1. *If ϵ is sufficiently large, then the higher the disutility from working at a night shift is, the larger are the gains from trade.*

Although the number of varieties diminish with a higher h_m in both autarky and trade equilibria, the relative gains from trade can be larger with a higher h_m.

5. Concluding Remarks

We built a trade model with two 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 a disutility element that arises from working at night shifts so that the higher the shift work disutility is, the higher is the night wage. We conclude that, first, the higher the disutility of working at night is, the smaller is the number of varieties consumed in equilibrium. Second, trade liberalization only increases the number of varieties if the concavity of the utility derived from the consumption of the final good is not too high or too low, and the extra costs incurred from outsourcing is sufficiently low. Third, if the concavity of the utility derived from the consumption of the final good is sufficiently high, the higher the disutility of working at night, the larger are the gains from trade. Possible extensions of the model could include more countries in different time zones and heterogeneity of tastes for shift working.

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