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ABSTRACT

In this paper we attempt to model virtual trade resulting from time zone differences in an otherwise Heckscher-Ohlin set up which is absent in the literature. So, this paper tries to add some value to the existing stuff on the trade theory and the role of time zones. In doing so, it has been proved that exploitation of time zone difference benefits skilled labor only under reasonable assumption. Contrarily, in output font, time zone difference exploiting sector expands and the other sector contracts irrespective of any factor intensity assumption. The model has been extended to examine how distance may also lead to similar outcomes. In addition, the model is further extended to explore the effect of virtual trade on an economy also endowed with a huge supply of unskilled labor causing the occurrence of informality and associated corruption. Interestingly trade turns out to be beneficial to unskilled workers and lead to a fall in the number of workers engaged in corrupt activities in the economy though the informal sector expands.

JEL Classification: F1, F11, E26, J31, D73

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1 Introduction

Very recently the composition of trade has changed to a significant extent in favor of exchange of services predominantly done 'virtually' in a sense. Virtual trade[1] mainly includes business services such as engineering, software development, call centre, insurance claim settlements, medical advice etc. This type of trade provides us the opportunity of utilizing time zone difference beneficially by adopting the time saving, follow-the-sun system of service provision/development.[2] The creation of service is divided into multiple sequential stages and assigned to groups located in different time zones. The process is accomplished with each group working in regular office hours on the allotted task, and transferring the same to the other group at the end of their working hours. One common element of all such activities is the non requirement of physical transportation of the product, be it intermediate or final, and non requirement of physical presence of sellers and buyers at the time of transaction. But it certainly requires high bandwidth internet or Information Communication Technology (ICT). Thanks to the information technology revolution the cost of ICT has gone down drastically making room for virtual transaction to be done almost costlessly. To exploit this possibility, however, time zones (TZ) of trading partners or countries must be non-overlapping[3]. This issue has been explained very nicely in Marjit (2007), Kikuchi (2011), Kikuchi and Marjit (2011), Kikuchi et al. (2013), Anderson (2014), Dettmer (2014), Head et al. (2009), Matsuoka and Fukushima (2010), Nakanishi and Long (2015), Mandal et al. (2018b), Fink et al. (2005), Mandal (2015), Marjit and Mandal (2017) etc.[4] For the purpose of current essay we focus only on the cost associated with delay in delivery that can be avoided when virtual trade is appropriated. Kikuchi (2006) and Marjit (2007) are two papers that deal with such concern. Although issues in and around this

[1] Virtual trade refers to the exchange of services done using the communication technology like e-mail, teleconferencing, video conferencing and many other information sharing tools.

[2] For example, India's service sector has grown rapidly after liberalization and this is particularly because of software exports whose transactions require a virtual platform. Marjit and Mandal (2017) points out that this growth in service exports is to a great extent a result of India's geographical location which makes it to be in a different time zone from its major partners.

[3] By non-overlapping time zone we mean, one country's day does not coincide with the other i.e. when there is day in one country its night in the other. If time zones are non-overlapping, working hours are also different. In this paper, we have considered working hours to be of 12 hours, so the terms non-overlapping time zones and non-overlapping working hours have been used interchangeably.

[4]A brief review of literature in this connection can be found in Prasad et al. (2017).

concern are gradually gaining more importance, to the best of our knowledge, we have not seen any attempt to bring in time zone (TZ) related phenomena in a standard Heckscher-Ohlin kind of general equilibrium model of trade (Jones, 1965). Therefore, this paper is a humble effort to fill up this caveat. There are two formal sectors, and two factors—skilled labor and capital. The model aims to find the effect of virtual trade on the two sectors and the involved factors. Virtual trade alone does not depend on the distance as such, but when virtual trade occurs in order to exploit the difference in time zones, east-west distance between the partners does matter. Mandal (2015) briefly and nicely elaborates the relation between time zone difference and distance. Following this paper we also try to incorporate distance in the proposed framework to examine the effect of east-west distance on virtual trade that is undertaken to exploit the time zone difference, and its subsequent effect on the economy.

Another important issue which is a major concern in many developing parts of the world is the presence of informality in the economy. The issue becomes more serious when informal sector is beset with corrupt activities. Informality could be described in many different ways. In this paper we consider the view points of Marjit and Kar (2011), Mandal (2011), Mandal et al (2018a) etc. Following these papers, informal sector arise as the formal sector cannot absorb the entire labor pool available in the economy. In order to survive these people organize some productive units which are not formal in nature. This means they violate some government rules, they are not registered, they do not pay tax, do not follow minimum wage regulations, their wage is less compared to the formal sector, etc. It has also been observed that because of their illegal/extralegal nature extortionists exploit them and collect extortion fees (see Mandal et al., 2018a). These extortionists are unproductive in line with Bhagwati (1982). However, they save these informal units whenever they are trapped in legal issues by negotiating with the legal authorities. Therefore, the informal sector cannot get rid of these corrupt people and have to pay a part of their income to these intermediaries. So, this paper is also extended by considering some unpraised aspects of developing economies—huge supply of unskilled labor, presence of informal sector and informality related corruption—in the constructed framework and tries to figure out whether the effect of trade driven by non-overlapping time zones benefits the economy.

Remaining paper is arranged as follows. Section 2 builds the basic model using Heckscher-Ohlin set up. Then it examines the changes that take place in the economy when one of the sectors opts for trade across different TZs. Output of the sector engaged in virtual trade expands while that of the other sector contracts. Similarly, return to the factor used intensively in the production of TZ utilizing sector rises and the return to the factor used intensively in the other sector falls. Section 3 introduces distance in the model and shows its impact on factor prices and output. The results are seen to be analogous to the previous section indicating a positive effect of distance. In section 4 the model is further extended to a four sector-three factor economy, where we introduce informality using the difference between pre-negotiated fixed and variable wage for unskilled labor (Marjit and Kar, 2011).The objective of the extension is to see whether time zone differences help to truncate the intermediation sector that provides support to the informal production units. Finally, section 5 concludes the paper. Mathematical derivations are, however, relegated to the Appendices.

2 The Basic Model

We consider two countries and rest of the world. The two countries are identical in all respect except their geographical locations on the globe. They are located in such a way that their time zones are completely non-overlapping. Since the two countries are identical, both will experience the same kind of effect. Therefore, we focus on only one country. The concerned economy produces two commodities X and Y. X is a service while Y is a tangible good. Each good is produced using skilled labor (S) and capital (K) under constant returns to scale (CRS) and diminishing marginal productivity (DMP) of factors and are sold in a perfectly competitive market.[5] Markets open in every 24 hours. Prices are set in the world market and the economy which we consider to be small cannot alter them. To produce a unit of Y, a_{SY} units of skilled labor and a_{KY} units of capital are engaged. Production is accomplished in one working day. One working day consists of 12 hours of work during daytime; the night time is the leisure time. Production of X requires 24 hours of work. Therefore, following Marjit (2007) we assume the

[5] The symbols that has been used in this paper are given as follows: S = (total supply of) skilled labor; K= (total supply of) capital; L= (total supply of) unskilled labor; X= service output; Y= physical good produced in formal environment; Z= informal sector output; N= corrupt sector; L_N= total amount of L engaged in N; a_{ij} =amount of i^{th} factor used in production of one unit of j^{th} commodity ($i = S, K, L$ and $j = X, Y, Z, N$); w_s= wage of skilled labor; w = wage of unskilled labor; $\overline{w}$ = unionized wage; r = rent; P_j= price of j^{th} commodity; δ = the discount factor; θ_{ij}= distributive share of i^{th} factor in j^{th} commodity; λ_{ij} = employment share of i^{th} factor in j^{th} commodity; σ_Y= elasticity of substitution between S and K in Y; σ_Z= elasticity of substitution between L and K in Z; D = aerial distance.

production of X to be divided into two stages; each stage requiring one working day and each working day utilizing one unit of both labor and capital. Thus the service is ready, engaging two units of labor and capital, in two days and the consumer receives it on the third day. With this much time taken for production and delivery the price that the producer receives is δP_X, with P_X being the price of X and δ the discount factor. The discount factor δ $(0 < \delta \leq 1)$ captures the time preference of the consumers. The consumers are eager to get the product earlier and for that they are ready to pay more. So if the service is delivered late the value of δ falls and if it is delivered earlier δ rises. As perfect competition exists per unit cost will be equal to its price. Therefore, the cost-price equations are given by

$$2w_S + 2r = \delta P_X \tag{1}$$

$$w_S a_{SY} + r a_{KY} = P_Y \tag{2}$$

w_S and r are wage and rent, respectively. P_X and P_Y in the same way denote prices of good X and good Y. The technological coefficients are fixed for the production of X while a_{SY} and a_{KY}, the technological coefficients for Y production, are considered to be variable.[6] In the concerned economy skilled labor is used intensively in X whereas Y is a capital intensive good. Factors are fully employed within both the sectors.

The full employment equations are given by

$$2X + a_{SY}Y = S \tag{3}$$

$$2X + a_{KY}Y = K \tag{4}$$

Solution of the model is quite well known in the trade literature. Interested readers may go through Jones (1965). We have four unknown variables w_S, r, X and Y to solve from equation (1)–(4). Given commodity prices factor prices are determined from (1) and (2). Once factor prices are solved we have the values of technological coefficients through CRS assumption. Once a_{ij}s are known we can calculate X and Y from (3) and (4). So, the system is solvable.

[6] Technological coefficients are functions of factor prices and can change when there is any change in factor price. Here, this is possible for Y but not for X. The rationale comes from the assumption that the production of service takes two consecutive working days, each day requiring one unit of skilled labour and capital. Therefore, 2 units of S and K are required to prepare the service and this requirement cannot be changed even if factor prices change.

2.1. Effect of Utilization of Time Zone Differences

One way for the producers of X to realize the full value of their service is to reduce the time required for production. This can be achieved when production is fragmented between two countries with non overlapping working hours i.e. situated in different time zones. With this, production process continues for 24 hours as when working hours ends in one country, it starts in the other. The first stage is produced within 12 hours of working day in one country and the semi-finished task is delegated to the other country at the end of the day where the second stage is completed. Thus production process takes two working days as before but because the process is separated between non overlapping time zones, two working days are achieved within a single calendar date. As a result consumers receive the product on the second day—one day earlier. Following Mandal (2015), since the time zones of the two countries are completely non-overlapping, this pushes up the value of δ to 1 and the producers obtain full value of the service. This change of δ from less than 1 to equal to 1 benefits individual producers and also affects factor prices and outputs.

2.1.1 Effect on Factor Prices

Taking total differential of equation (1) and (2), and expressing percentage change with '^' we get,

$$\hat{w}_S\theta_{SX} + \hat{r}\theta_{KX} = \hat{\delta}\delta \qquad (5)$$

$$\hat{w}_S\theta_{SY} + \hat{r}\theta_{KY} = 0 \qquad (6)$$

With a relatively high effective price (because of rise in δ) of X, as production of X becomes more lucrative, demand for factors used in X increases. This increases the factor prices in the economy. Since the price of Y has not changed, with rise in input prices, producing the existing level of output becomes unviable for Y producers. Y reduces its output releasing skilled labor and capital. Y being capital intensive releases more of K than S. Released S gets employed in X but all the released K cannot. This leads to excess demand for S and excess supply of K. Eventually, wage rises and rent falls[7]. This result is quite apparent.

Using equation (5) and (6) we get the changes in wage and rent as (see Appendix A):

[7] Similar to standard Stolper- Samuelson arguments.

$$\widehat{w}_S = \hat{\delta}\delta\left(\frac{\theta_{KY}}{|\theta|}\right) > 0 \quad (7)$$

$$\hat{r} = (-)\left(\frac{\theta_{SY}}{|\theta|}\right)\hat{\delta}\delta < 0 \quad (8)$$

$$|\theta| = \theta_{SX}\theta_{KY} - \theta_{SY}\theta_{KX} > 0; \text{ since}, \theta_{SX} > \theta_{SY} \text{ and } \theta_{KX} < \theta_{KY}$$

Note that the direction of changes depends on the factor intensity of the goods in addition to the change in the discount rate. Thus we have the following proposition

Proposition 1*: Exploitation of TZ differences benefits the factor used intensively in the service sector while the other factor suffers a loss.*

Proof: *See discussion above*.

2.1.2 Effect on Output

As Y production is characterized by variable coefficient technology, amount of factors (labor and capital) used in its production can be altered and the relatively costly skilled labor can be replaced by cheaper capital. To spot the variation in the coefficients we use elasticity of substitution between two factors which is expressed as (for details see Appendix B)

$$\sigma_Y = \frac{\hat{a}_{SY} - \hat{a}_{KY}}{\hat{r} - \widehat{w_S}} \quad (9)$$

Using Envelope condition one gets

$$\hat{a}_{KY} = (-)\frac{\theta_{SY}}{\theta_{KY}}\hat{a}_{SY}$$

Substituting this in equation (9) and putting the value of $(\hat{r} - \widehat{w_s})$, (relevant mathematical expression is given in Appendix A) we get,

$$\hat{a}_{SY} = (-)\delta\hat{\delta}\frac{\theta_{KY}}{|\theta|}\sigma_Y < 0 \quad (10)$$

$$\hat{a}_{KY} = \delta\hat{\delta}\frac{\theta_{SY}}{|\theta|}\sigma_Y > 0 \quad (11)$$

The above equations exhibit the change in the amount of factors employed in production of one unit of Y when the other sector (X) utilizes the time zone differences between two countries. This phenomenon can be diagrammatically represented as follows:

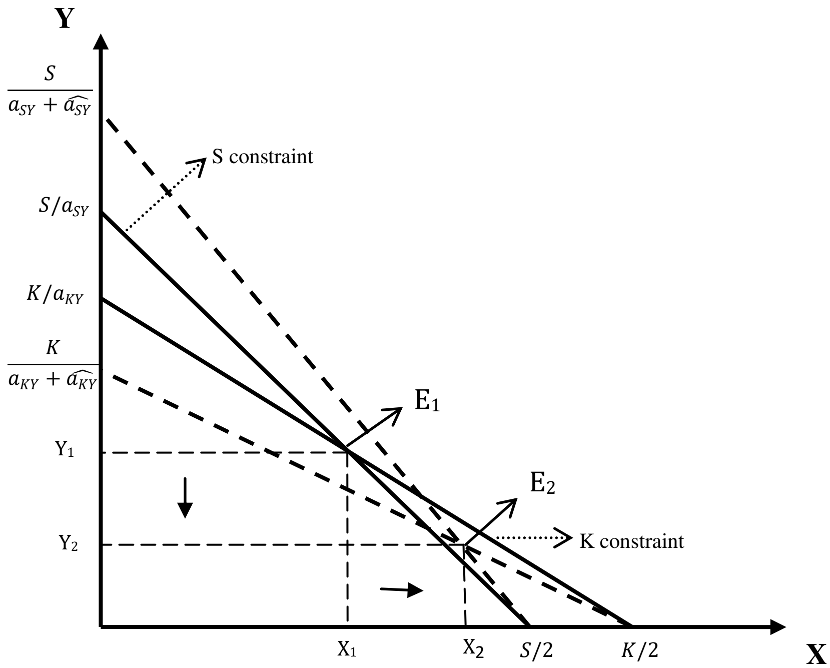

Figure 1

In Figure 1, equation (3) has been plotted as S constraint while equation (4) has been plotted as K constraint. The initial equilibrium is shown to be at E_1 where the economy produces X_1 and Y_1 units of X and Y, respectively. When effective price of X rises because of the rise in δ, the production of X becomes more lucrative. As explained earlier, factor intensity assumptions cause an excess demand for S and excess supply of K. As a result wage rises and rent falls. Since factor requirements are function of factor prices, rise in wages leads to a fall in its usage in production of one unit of Y ($\widehat{a_{SY}} < 0$). On the other hand, per unit requirement of K rises ($\widehat{a_{KY}} > 0$). We can see in Figure 1, change in a_{SY} and a_{KY} moves the labor and capital constraints along the Y-*axis* which changes the equilibrium level of X and Y. S-constraint moves outward while K-constraint moves inward. The new equilibrium is at E_2, which shows higher output of X (at X_2) and a lower Y (at Y_2). To mathematically elucidate the changes in the equilibrium level of X and Y we take total differential of (3) and (4)

$$\hat{X}\lambda_{SX} + \hat{Y}\lambda_{SY} + \lambda_{SY}\hat{a}_{SY} = 0$$

$$\hat{X}\lambda_{KX} + \hat{Y}\lambda_{KY} + \lambda_{KY}\hat{a}_{KY} = 0$$

Substituting the values of $\hat{a}_{SY}$ and $\hat{a}_{KY}$ given by equation (10) and (11); and applying the Cramer's rule (see Appendix C) we have

$$\hat{X} = \frac{1}{|\lambda|}\frac{1}{|\theta|}(\theta_{KY}\lambda_{SY}\lambda_{KY} + \theta_{SY}\lambda_{KY}\lambda_{SY})\sigma_Y\delta\hat{\delta} > 0 \quad (12)$$ [8]

$$\hat{Y} = (-)\frac{1}{|\lambda|}\frac{1}{|\theta|}(\theta_{SY}\lambda_{SX}\lambda_{KY} + \theta_{KY}\lambda_{KX}\lambda_{SY})\sigma_Y\delta\hat{\delta} < 0 \quad (13)$$

Note that both $|\lambda|$ and $|\theta|$ are positive owing to assumed factor intensity of X and Y. $\hat{X} > 0$ as $\hat{\delta} > 0$. This confirms that there is a rise in X (as shown in Figure 1) due to utilization of time zone difference. Correspondingly we experience a reduction in Y. Interestingly, the direction of change is independent of the factor intensity assumption as both $|\lambda|$ and $|\theta|$ have the same sign. Thus we have Proposition 2 as follows;

Proposition 2*: Due to TZ difference exploitation X expands and Y contracts irrespective of factor intensity assumption.* ■

3 Extended Model with Distance

In Section 2 we have explained that value of δ falls if the service is delivered late. Production and delivery can be done faster when time zone difference is utilized. It will be done in minimum time when TZs of partner countries are completely non-overlapping. Alongside, two countries' TZs become more and more non-overlapping when their distance[9] becomes larger and larger. Therefore, δ is a function of distance, D (Mandal, 2015) i.e.

$$\delta = \delta(D) \quad (14)$$

Taking total differential we have,

[8] $|\lambda| = \begin{vmatrix} \lambda_{SX} & \lambda_{SY} \\ \lambda_{KX} & \lambda_{KY} \end{vmatrix}$ and [$\lambda_{SX} = \frac{2X}{S}$; $\lambda_{SY} = \frac{Ya_{SY}}{S}$; $\lambda_{KX} = \frac{2X}{K}$; $\lambda_{KY} = \frac{Ya_{KY}}{K}$]

[9] Distance here refers to the shortest aerial distance between two concerned places calculated using their geographical coordinates (latitude and longitude). It is to be noted here that in this paper we are concerned of the east-west distance of the two countries.

$$\hat{\delta} = \delta'(D)\frac{dD}{\delta} \tag{15}$$

The above equation shows the relation between δ and distance. $\delta'(D)$ is positive as with rise in distance TZ differences can be exploited more aptly and δ rises to raise the effective commodity price that is realized by the producer.

Now to see the effect of distance on factor prices and output of the economy we put the value of $\hat{\delta}$ in equation (7), (8), (12) and (13). The results are as shown below:

$$\widehat{w_s} = \delta'(D)dD\left(\frac{\theta_{KY}}{|\theta|}\right) > 0$$

$$\hat{r} = (-)\left(\frac{\theta_{SY}}{|\theta|}\right)\delta'(D)dD < 0$$

$$\hat{X} = \frac{1}{|\lambda|}\frac{1}{|\theta|}(\theta_{KY}\lambda_{SY}\lambda_{KY} + \theta_{SY}\lambda_{KY}\lambda_{SY})\sigma_Y\delta'(D)dD > 0$$

$$\hat{Y} = (-)\frac{1}{|\lambda|}\frac{1}{|\theta|}\left(\theta_{sy}\lambda_{SX}\lambda_{KY} + \theta_{ky}\lambda_{KX}\lambda_{SY}\right)\sigma_Y\delta'(D)dD < 0$$

So, the effects are similar to that in the previous section. However, the results contradict the conventional understanding of the role of distance in trade as depicted by the gravity theory. This is because, the reason for which distance was assumed to deter trade does not arise in our model. In gravity model distance is taken to hinder trade as with rise in distance the transportation cost and transaction cost also rises. However, in our model of service trade transporting services is done virtually which is independent of distance between two countries. Secondly, the production process is considered to be sequential so that interaction between the affiliates is rarely required. Thus here we notice increasing distance to benefit the sector that undertakes trade across significant distance.[10] Rise in distance also leads to a positive change in wage rate and a negative

[10] Empirical works like Head et al. (2009) and Dettmer (2014), using augmented forms of gravity model, show service trade being encouraged due to time zone difference.

change in rent as before. The direction of change of factor prices is such, as skilled labor is intensively used in X relative to Y.

4 Inclusion of Informal Sector

In this section we extend our model by adding an informal sector which is often present in developing and even in developed countries (Mandal et al., 2018a). We follow Mandal et al. (2018a), Mandal (2011), and Mandal and Chaudhuri (2011) where the informal sector consists of a productive segment and a profit seeking directly unproductive unit as termed in Bhagwati (1982). Informal segment of the economy exists violating some government prescribed rules for example, they do not pay tax, are not registered, do not follow minimum wage law, exploit their workers, occupy government land for production etc. Because of its extralegal nature whenever legal issues arise they need to take help of some people who negotiate with the legal officials and free them from penalizing charges. In return these people appropriate a part of the income of the informal units.[11] So, informal units suffer from extortion irrespective of whether the need for intermediation arises or not. We term these people engaged in intermediation as extortionists or intermediators. The extortionists get wage equal to the competitive wage of workers engaged in the productive informal segment as labor is perfectly mobile between these activities. Again informal wage is less than the formal wage where minimum wage rule is followed (for detailed argument see Marjit and Kar (2011)). We consider corruption to be present only in informal sector. Therefore, along with the sectors X and Y, there are two more sectors, Z and N. X and Y are formal sectors, Z is an informal sector and N sector helps the informal sector to subsist. Further we assume now that there are three factors of production, skilled labor (S), capital (K) and unskilled labour (L), with sector X using S and K as before; sector Y using L at a pre-negotiated wage rate along with S and K; sector Z using L and K and finally sector N using only L. Unskilled labor who do not get employed in Y has to survive by working in either Z or N. We assume sector Z to be unskilled labor intensive. In this backdrop, we try to check whether trade across time zone differences has some effect on the size of informal sector and associated corruption. This is our prime focus. We will, however, look at the effects on factor prices and wage disparity between skilled and unskilled workers.

[11] Interested readers are requested to check Mandal et al. (2018a) for a clear exposition of such phenomenon.

The modified price equations are given as:

$$2w_S + 2r = \delta P_X \tag{16}$$

$$a_{LY}\overline{w} + w_S a_{SY} + r a_{KY} = P_Y \tag{17}$$

$$a_{LZ} w + r a_{KZ} = P_Z(1-\alpha) \tag{18}$$

a_{ij} s $(i = L, S, K;\ j = X, Y, Z)$ are technological coefficients. The wage for unskilled labor in Y, $\overline{w}$, is institutionally fixed. α is the proportion of price, P_Z, paid to the extortionist as a fee for intermediation.

The following equation gives the cost-value equation for the corrupt sector.

$$wL_N = \alpha P_Z Z \tag{19}$$

Unskilled labor engaged in intermediation activities are paid competitive wage w. Multiplying this with the total amount of L engaged in N (L_N), we get the total cost of this sector. Perfect competition ensures this cost to be equal to total fee received from the production of Z $(\alpha P_Z Z)$. The full employment conditions are

$$2X + a_{SY} Y = S \tag{20}$$

$$2X + a_{KY} Y + a_{KZ} Z = K \tag{21}$$

$$a_{LY}\, Y + a_{LZ} Z = L - L_N \tag{22}$$

Here we have seven unknown variables $(w_S, r, w, X, Y, Z \text{ and } L_N)$ and seven equations. Given the values of P_X, P_Y, P_Z, δ and α; solutions for w_S, r and w are obtained using equations (16), (17) and (18). Employing equation (19) to substitute the value of L_N in (22) and using this modified equation with (20) and (21) we get the values of X, Y and Z. Putting the values of Z and w in (19), L_N is determined. Thus, the system is solvable.

4.1 Effect on Factor Prices

With X utilizing the time zone difference, now we check what happens to the factor prices when the economy is characterized by the presence of informality and corruption.

Taking total differential of equations (16), (17) and (18) and using Cramer's rule, we have[12]

$$\left.\begin{aligned}
\widehat{w_s} &= \frac{1}{|\theta_1|}\theta_{KY}\theta_{LZ}\delta\hat{\delta} \\
\hat{r} &= (-)\frac{1}{|\theta_1|}\theta_{SY}\theta_{LZ}\delta\hat{\delta} \\
\widehat{w} &= \frac{1}{|\theta_1|}\theta_{SY}\theta_{KZ}\delta\hat{\delta} \\
(\widehat{w_s} - \widehat{w}) &= \frac{1}{|\theta_1|}\delta\hat{\delta}(\theta_{KY}\theta_{LZ} - \theta_{SY}\theta_{KZ})
\end{aligned}\right\} \quad (23)^{13}$$

Wage of both skilled and unskilled workers are seen to rise whereas rent falls when one of the sectors exploits time zone differences for production. Effect on w_S and r are quite apparent. Interesting part is the increase in w. When δ rises, producers attempt to produce more X as loss induced by δ gradually falls. X demands both S and K raising skilled wage and rent in the economy. Consequently, since price of Y and Z has not changed, higher input prices dwindle outputs of Y and Z. When Y and Z shrink, S, K and L are released. Available S and some of the released K gets employed in X. Given the factor intensity of Y and Z, there is excess supply of L and K in the economy which lowers both rent and wage. Lower wage and rent will encourage Z producers to expand their output and since Z is L intensive there will be a rise in the demand of L leading to a hike in unskilled wage. The difference between the relative change in skilled and unskilled wage seems to be positive as Y and Z respectively, are K and L intensive. We must note here that similar to previous sections the direction of changes also depends on factor intensity. Therefore, we have following proposition.

Proposition 3*: A rise in δ leads to*

a) Increase in w_S

b) Fall in r

c) Increase in w

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[12] Calculation process is similar to that provided in Appendix A.

[13] $|\theta_1| = \theta_{LZ}(\theta_{SX}\theta_{KY} - \theta_{KX}\theta_{SY}) > 0$

d) *Wage disparity between skilled and unskilled workers increases if X is S intensive and* $\theta_{KY}\theta_{LZ} > \theta_{KZ}\theta_{SY}$ ■

As the wage of unskilled labor has risen we can say that the cost burden on sector N rises.We use equation (19) to examine the effects of a rise in δ on the size of the N. From (19)

$$\widehat{L_N} = \hat{Z} - \hat{w} \quad (24)$$

Though N is not directly related to the discount factor, it gets affected through changes in Z and w. As we already have the value of $\hat{w}$, to know more about the effect on the size of N we have to find out the effect on Z. To calculate this, first we have to understand how the technological coefficients $(a_{ij}\,s)$ are getting altered. As there are changes in factor prices, to minimize cost, per unit factor requirements will also adjust. Using the formula for elasticity of substitution between S and K in $Y(\sigma_Y)$ and between L and K in Z (σ_Z) together with CRS assumptions, we have[14]:

$$\left.\begin{aligned} \hat{a}_{KY} &= \frac{\sigma_Y\theta_{SY}\theta_{LZ}}{|\theta_1|}\delta\hat{\delta} > 0 \\ \hat{a}_{SY} &= \frac{-\sigma_Y\theta_{KY}\theta_{LZ}}{|\theta_1|}\delta\hat{\delta} < 0 \end{aligned}\right\} \quad (25)^{15}$$

Equation (25) shows a fall in the use of S and a rise in K requirements in Y. On the other hand, production of Z now requires more K and less L. This is revealed by the following equations:

$$\left.\begin{aligned} \hat{a}_{KZ} &= \frac{\sigma_Z\theta_{SY}\theta_{LZ}}{|\theta_1|}\delta\hat{\delta} > 0 \\ \hat{a}_{LZ} &= \frac{-\sigma_Z\theta_{SY}\theta_{KZ}}{|\theta_1|}\delta\hat{\delta} < 0 \end{aligned}\right\} \quad (26)$$

[14] Performing similar calculations as in Appendix B.

[15] For simplicity we assume, $\hat{a}_{LY} = 0$.

4.2 Change in Output

As we have mentioned before, the exact effect on L_N can be delineated once we know the effects of X, Y and Z since these outputs are interconnected through similar factor requirements. To have a fair mathematical idea about $\hat{X}$, $\hat{Y}$ and $\hat{Z}$ we differentiate (20), (21) and (22).

$$\lambda_{SX}\hat{X} + \lambda_{SY}\hat{Y} = -\lambda_{SY}\widehat{a_{SY}}$$

$$\lambda_{KX}\hat{X} + \lambda_{KY}\hat{Y} + \lambda_{KZ}\hat{Z} = -\lambda_{KY}\widehat{a_{KY}} - \lambda_{KZ}\widehat{a_{KZ}}$$

$$\lambda_{LY}\hat{Y} + \lambda_{LZ}\hat{Z} = -\lambda_{LY}\widehat{a_{LY}} - \lambda_{LZ}\widehat{a_{LZ}} - \lambda_{LN}\widehat{L_N}$$

Using (24) we have

$$\lambda_{LY}\hat{Y} + (\lambda_{LZ} + \lambda_{LN})\hat{Z} = -\lambda_{LY}\widehat{a_{LY}} - \lambda_{LZ}\widehat{a_{LZ}} + \lambda_{LN}\hat{w}$$

Writing these equations in matrix form and using Cramer's rule we get the required values as

$$\begin{aligned}\hat{X} = \frac{1}{|\lambda_1|}[&-\lambda_{SY}\widehat{a_{SY}}\{\lambda_{KY}(\lambda_{LZ} + \lambda_{LN}) - \lambda_{LY}\lambda_{KZ}\} \\ &+ \lambda_{SY}(\lambda_{KY}\widehat{a_{KY}} + \lambda_{KZ}\widehat{a_{KZ}})(\lambda_{LZ} + \lambda_{LN}) \\ &+ \lambda_{SY}\lambda_{KZ}(\lambda_{LY}\widehat{a_{LY}} + \lambda_{LZ}\widehat{a_{LZ}} - \lambda_{LN}\hat{w})] > 0\end{aligned} \qquad (27)[16]$$

Change in X is positive as $|\lambda_1| > 0; \lambda_{KY} > \lambda_{KZ}$ and $(\lambda_{LZ} + \lambda_{LN}) > \lambda_{LY}$. Thus when X utilizes the time zone difference, it expands even in the presence of corruption. This result is consistent with the arguments we have mentioned before. Again similar to the previous sections Y sector contracts. This is because $\widehat{a_{LZ}}$ and $\widehat{a_{SY}}$ both are negative together with $\widehat{a_{KZ}}$ and $\widehat{a_{KY}}$ being positive.

$$\begin{aligned}\hat{Y} = \frac{1}{|\lambda_1|}[&\lambda_{SX}\{-(\lambda_{KY}\widehat{a_{KY}} + \lambda_{KZ}\widehat{a_{KZ}})(\lambda_{LZ} + \lambda_{LN}) \\ &+ \lambda_{KZ}(\lambda_{LZ}\widehat{a_{LZ}} - \lambda_{LN}\hat{w})\} + \lambda_{KX}\{\lambda_{SY}\widehat{a_{SY}}(\lambda_{LZ} + \lambda_{LN})\}] \\ &< 0\end{aligned} \qquad (28)$$

[16] $|\lambda_1| = \lambda_{SX}\{\lambda_{KY}(\lambda_{LZ} + \lambda_{LN}) - \lambda_{LY}\lambda_{KZ}\} - \lambda_{SY}\{\lambda_{KX}(\lambda_{LZ} + \lambda_{LN})\} > 0$ as X is S intensive; Y is K intensive and Z is L intensive.

$$\hat{Z} = \frac{1}{|\lambda_1|}[-\lambda_{SX}\lambda_{KY}(\lambda_{LZ}\widehat{a_{LZ}} - \lambda_{LN}\widehat{w}) + \lambda_{SX}\lambda_{LY}(\lambda_{KY}\widehat{a_{KY}} + \lambda_{KZ}\widehat{a_{KZ}}) + \lambda_{KX}\lambda_{SY}(\lambda_{LZ}\widehat{a_{LZ}} - \lambda_{LN}\widehat{w}) + \{-\lambda_{SY}\lambda_{KX}\lambda_{LY}\widehat{a_{SY}}\}] > 0 \quad (29)$$

Given the factor intensity assumptions and changes in the factor requirements as given by equations (25) and (26); output of the informal sector rises. Intuitively the changes in outputs can be explained as follows. With rise in the discount factor, production of X becomes lucrative. With the aim of expanding the production of X, the economy experiences an increase in w_S, a fall in r and an increase in w as mentioned in the preceding section. Correspondingly there was a reduction in the use of S and L and a rise in the use of K in the productive sectors. Since r is low, Y and Z will try to substitute K for skilled/unskilled labor. However, Y requires some amount of S which is not available due to expansion of X. S cannot move out of X either. As a result, Y contracts and releases K, S and L. S gets fully employed in X; K and L get employed in Z. This leads to expansion of Z. As Z is L intensive it will require huge amount of L. This suggests inflow of some L from N reducing the amount of extortionists. To identify this now we move to another interesting implication of our paper: effect on corruption or intermediation sector associated with Z. For this we use equation (24) and substitute the values of $\widehat{Z}$ and $\widehat{w}$:

$$\widehat{L_N} = \hat{Z} - \widehat{w}$$

$$=> \widehat{L_N} = \frac{1}{|\lambda_1|}[-\lambda_{SX}\lambda_{KY}(\lambda_{LZ}\widehat{a_{LZ}} - \lambda_{LN}\widehat{w}) + \lambda_{SX}\lambda_{LY}(\lambda_{KY}\widehat{a_{KY}} + \lambda_{KZ}\widehat{a_{KZ}}) + \lambda_{KX}\lambda_{SY}(\lambda_{LZ}\widehat{a_{LZ}} - \lambda_{LN}\widehat{w}) + \{-\lambda_{SY}\lambda_{KX}\lambda_{LY}\widehat{a_{SY}}\}] - \widehat{w}$$

Manipulating and plugging the values of $a_{ij}\,s$ and $\widehat{w}$:

$$\widehat{L_N} = \frac{\delta\hat{\delta}}{|\theta_1||\lambda_1|}[\{(\lambda_{SX}\lambda_{KY}\lambda_{LZ}\theta_{KZ}\theta_{SY} + \lambda_{SX}\lambda_{LY}\theta_{SY}\theta_{LZ})\sigma_Z + \lambda_{KX}\lambda_{SY}\lambda_{LY}\theta_{KZ}\theta_{LZ}\sigma_Y + \lambda_{SX}\lambda_{KY}\lambda_{LN}\theta_{SY}\theta_{KZ}\} - \{(\lambda_{SX}\lambda_{LY}\lambda_{KX}\theta_{SY}\theta_{LZ} + \lambda_{KY}\lambda_{SY}\lambda_{LZ}\theta_{KZ}\theta_{SY})\sigma_Z + \lambda_{KX}\lambda_{SY}\lambda_{LN}\theta_{SY}\theta_{KZ} + 1\}] \quad (30)$$

In the right hand side of the above equation, we have two positive expressions within the squared brackets; if the first expression is smaller (greater) than the second, $\widehat{L_N}$ will be negative (positive). It is most likely that the second part will exceed the first as one of its expressions is a whole number while in the first part all expressions are fractions. Therefore, trade between non-overlapping time zones causes a reduction in the number of intermediators. Thus, we propose that

Proposition 4: *Exploitation of TZ differences causes informal sector to expand but the number of associated intermediators will decline.* ■

This result seems a little misleading: The size of Z is increasing whereas L_N is declining. Apparently, we understand that there should be a direct relationship between Z and L_N as Z activity is supported by the intermediators which are defined as L_N. However, what we miss here is the productivity argument for L_N. Not to forget that w has already gone up implying a more productive L irrespective of the sector they are employed in. When productivity rises, certain amount of any works requires less factor. This is precisely why we may end up with a decrease in L_N in spite of the fact that Z inflates.

5 Conclusion

In this paper we started with the idea that the utilization of time zone differences between two countries reduces the time taken for production and hence can benefit the producers by raising the effective price of their product. Following this, we have shown its effect on the factor prices and output. Output of the sector utilizing TZ differences expands and the factor used intensively in its production gains. Impact on factor price is subject to the factor intensity assumption whereas impact on output is independent of factor intensity. In the next section, we introduced distance in the model to check its effect on factor prices and output. Increasing distance is seen to have similar effect as with increasing TZ differences. Then we extend the model to include informality. With the inclusion of an informal sector in the model, again the time zone difference utilizing sector is seen to flourish while the other formal sector dwindles. In addition to this, the sector facilitating intermediation activities contracts in terms of employment while the informal sector experiences an expansion. Interestingly, both skilled and unskilled labor benefit under reasonable factor intensity assumption though much debated wage inequality may be widened under the same condition.

Appendices

Appendix A

With rise in the right hand side of (1) there will be changes in its left hand side. As both w_S and r can vary, we need to examine in which direction the change occurs. w_S and r are also present in equation (2) so changes in (1) will induce changes in (2). To understand the simultaneous effect on both the equations we first take total differential of equation (1)

$$dw_S 2 + dr 2 = P_X d\delta$$

$$\frac{dw_S}{w_S}\frac{2w_S}{P_X} + \frac{dr}{r}\frac{2r}{P_X} = \frac{d\delta}{\delta}\frac{\delta P_X}{P_X}$$

$$\widehat{w_S}\theta_{SX} + \hat{r}\theta_{KX} = \hat{\delta}\delta \tag{A.1}$$

Similarly for (2) we get,

$$\widehat{w_S}\theta_{SY} + \hat{r}\theta_{KY} = 0 \tag{A.2}$$

$$\Rightarrow \hat{r} = (-)\frac{\theta_{SY}}{\theta_{KY}}\widehat{w_S}$$

Thus, it is apparent that change in rent depends on change in skilled wage and the ratio of value share of S to K in Y. There is a negative relation between rent and skilled wage.

Putting the value of $\hat{r}$ in (A.1)

$$\widehat{w_S}\theta_{SX} + (-)\frac{\theta_{SY}}{\theta_{KY}}\widehat{w_S}\theta_{KX} = \hat{\delta}\delta$$

$$\Rightarrow \widehat{w_S} = \hat{\delta}\delta\left(\frac{\theta_{KY}}{\theta_{SX}\theta_{KY} - \theta_{SY}\theta_{KX}}\right)$$

$$\Longrightarrow \widehat{w_S} = \hat{\delta}\delta\left(\frac{\theta_{KY}}{|\theta|}\right) > 0$$

As $\theta_{SX} > \theta_{SY}; \theta_{KX} < \theta_{KY}; \theta_{SX}\theta_{KY} - \theta_{SY}\theta_{KX} = |\theta| > 0$ and as exploitation of TZ differences lead to an increase in δ. Change in skilled wage is seen to be positively affected by the discount factor and also the value share of capital in Y. This means higher the share of K in Y higher will be the rise in w_S.

Using the value of $\widehat{w_S}$ we have,

$$\hat{r} = (-)\frac{\theta_{SY}}{\theta_{KY}}\left(\frac{\theta_{KY}}{|\theta|}\right)\hat{\delta}\delta < 0$$

$$\hat{r} = (-)\left(\frac{\theta_{SY}}{|\theta|}\right)\hat{\delta}\delta < 0$$

Rent is negatively affected by the discount factor and also the value share of S in Y. This indicates higher the share of S in Y, higher will be the fall in r. Again Y is also K intensive. Therefore, change in w_S will be more than change in r

The difference between the changes in factor price is

$$(\hat{r} - \widehat{w_S}) = (-)\frac{\theta_{SY}}{\theta_{KY}}\frac{\theta_{KY}}{|\theta|}\delta\hat{\delta} - \frac{\theta_{KY}}{|\theta|}\delta\hat{\delta}$$
$$= (-)\delta\hat{\delta}\frac{1}{|\theta|}(\theta_{SY} + \theta_{KY})$$
$$= (-)\delta\hat{\delta}\frac{1}{|\theta|} < 0$$

Appendix B

Change in factor prices will induce changes in input coefficient to minimize cost of production. Costly factors will be substituted by relatively cheaper ones. The rate by which substitution will take place is given by the elasticity of substitution between S and K.

$$\sigma_Y = \frac{\widehat{a_{SY}} - \widehat{a_{KY}}}{\hat{r} - \widehat{w_S}} => \widehat{a_{SY}} = \widehat{a_{KY}} + (\hat{r} - \widehat{w_S})\sigma_Y \quad \text{(B.1)}$$

$$=> \widehat{a_{KY}} = \widehat{a_{SY}} - (\hat{r} - \widehat{w_S})\sigma_Y$$

Using Envelope condition

$$\widehat{a_{SY}}\theta_{SY} + \widehat{a_{KY}}\theta_{KY} = 0$$

Thus

$$\widehat{a_{SY}} = (-)\frac{\theta_{KY}}{\theta_{SY}}\widehat{a_{KY}}$$

and

$$\widehat{a_{KY}} = (-)\frac{\theta_{SY}}{\theta_{KY}}\widehat{a_{SY}}$$

Substituting,

$$\widehat{a_{SY}} = \widehat{a_{KY}} + (\hat{r} - \widehat{w_S})\sigma_Y$$

$$=> \widehat{a_{SY}} = (-)\frac{\theta_{SY}}{\theta_{KY}}\widehat{a_{SY}} + (\hat{r} - \widehat{w_S})\sigma_Y$$

$$=> \widehat{a_{SY}}\left(\frac{\theta_{KY} + \theta_{SY}}{\theta_{KY}}\right) = (\hat{r} - \widehat{w_S})\sigma_Y$$

$$=> \widehat{a_{SY}} = (\hat{r} - \widehat{w_S})\sigma_Y\theta_{KY}$$

Again,

$$\widehat{a_{KY}} = \widehat{a_{SY}} - (\hat{r} - \widehat{w_S})\sigma_Y$$

$$=> \widehat{a_{KY}} = (-)\frac{\theta_{KY}}{\theta_{SY}}\widehat{a_{KY}} - (\hat{r} - \widehat{w_S})\sigma_Y$$

$$=> \widehat{a_{KY}}\left(\frac{\theta_{SY} + \theta_{KY}}{\theta_{SY}}\right) = (-)(\hat{r} - \widehat{w_S})\sigma_Y$$

$$=> \widehat{a_{KY}} = (-)(\hat{r} - \widehat{w_S})\sigma_Y\theta_{SY}$$

Using the value of $(\hat{r} - \widehat{w_s})$ we get,

$$\widehat{a_{SY}} = (-)\delta\hat{\delta}\frac{\theta_{KY}}{|\theta|}\sigma_Y < 0 \quad \text{(B.2)}$$

$$\widehat{a_{KY}} = \delta\hat{\delta}\frac{\theta_{SY}}{|\theta|}\sigma_Y > 0 \quad \text{(B.3)}$$

Thus we have a positive change in input coefficient of K and a negative change in the per unit requirement of S. The changes again, in addition to the discount factor, depend on the intensity of factors used in production. In the current case, factor intensity assumption makes the denominator positive.

Appendix C

The full employment equations are

$$a_{SX}X + a_{SY}Y = S \;\; => 2X + a_{SY}Y = S$$

$$a_{KX}X + a_{KY}Y = K \;\; => 2X + a_{KY}Y = K$$

Taking total differential

$$\hat{X}\lambda_{SX} + \hat{Y}\lambda_{SY} + \lambda_{SY}\widehat{a_{SY}} = 0$$

$$\hat{X}\lambda_{KX} + \hat{Y}\lambda_{KY} + \lambda_{KY}\widehat{a_{KY}} = 0$$

$$[\, \lambda_{SX} = \frac{2X}{S};\; \lambda_{SY} = \frac{Ya_{SY}}{S}; \lambda_{KX} = \frac{2X}{K}; \lambda_{KY} = \frac{Ya_{KY}}{K}]$$

Using (B.2) and (B.3),

$$\hat{X}\lambda_{SX} + \hat{Y}\lambda_{SY} = (-)\lambda_{SY}\widehat{a_{SY}} = \delta\frac{\theta_{KY}}{|\theta|}\sigma_Y\lambda_{SY}\hat{\delta}$$

$$\hat{X}\lambda_{KX} + \hat{Y}\lambda_{KY} = (-)\lambda_{KY}\widehat{a_{KY}} = (-)\delta\frac{\theta_{SY}}{|\theta|}\sigma_Y\lambda_{KY}\hat{\delta}$$

Now the only unknowns are $\hat{X}$ and $\hat{Y}$. To solve for the changes in X and Y we write the above equations in matrix form

$$\begin{pmatrix} \lambda_{SX} & \lambda_{SY} \\ \lambda_{KX} & \lambda_{KY} \end{pmatrix} \begin{pmatrix} \hat{X} \\ \hat{Y} \end{pmatrix} = \begin{pmatrix} \delta \frac{\theta_{KY}}{|\theta|} \sigma_Y \lambda_{SY} \hat{\delta} \\ (-)\delta \frac{\theta_{SY}}{|\theta|} \sigma_Y \lambda_{KY} \hat{\delta} \end{pmatrix}$$

Applying Cramer's rule,

$$\hat{X} = \frac{1}{|\lambda|} \left\{ \delta \frac{\theta_{KY}}{|\theta|} \sigma_Y \lambda_{SY} \lambda_{KY} \hat{\delta} + \delta \frac{\theta_{SY}}{|\theta|} \sigma_Y \lambda_{KY} \lambda_{SY} \hat{\delta} \right\}; \qquad |\lambda| = \begin{vmatrix} \lambda_{SX} & \lambda_{SY} \\ \lambda_{KX} & \lambda_{KY} \end{vmatrix}$$

$$\Rightarrow \hat{X} = \frac{1}{|\lambda|} \frac{1}{|\theta|} (\theta_{KY} \lambda_{SY} \lambda_{KY} + \theta_{SY} \lambda_{KY} \lambda_{SY}) \sigma_Y \delta \hat{\delta} \tag{C.1}$$

$\hat{X} > 0$ as $\hat{\delta} > 0$ and since $|\theta|$ and $|\lambda|$ both are positive by the factor intensity assumptions. Similarly for Y we have

$$\hat{Y} = \frac{1}{|\lambda|} \{ (-)\delta \hat{\delta} \frac{\theta_{SY}}{|\theta|} \sigma_Y \lambda_{SX} \lambda_{KY} - \delta \hat{\delta} \frac{\theta_{KY}}{|\theta|} \sigma_Y \lambda_{KX} \lambda_{SY} \}$$

$$\Rightarrow \hat{Y} = (-) \frac{1}{|\lambda|} \frac{1}{|\theta|} (\theta_{SY} \lambda_{SX} \lambda_{KY} + \theta_{KY} \lambda_{KX} \lambda_{SY}) \sigma_Y \delta \hat{\delta} < 0 \tag{C.2}$$

Output of X (Y) changes positively (negatively) with the discount factor. However, the direction of change does not depend on factor intensity, but the magnitude does.

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