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ABSTRACT

The purpose of this paper is to propose a model where trade has a direct and positive impact on growth rate of two trading nations beyond the level effect. We use the idea of virtual trade in intermediates induced by non- overlapping time zones and show how trade can increase the equilibrium optimal rate of growth. In this structure the trade impact goes beyond the level effect and directly causes growth. Typically standard models of trade cannot generate an automatic growth impact. Virtual trade may allow production to continue for 24x7 in separated time zones such as between US and India and that can lead to higher growth for both countries. Later we extend the model to incorporate accumulation of skill which becomes necessary for sustaining steady state growth.

Key Words – International Trade, Time Zone, Growth

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[1] This is a revised version of a paper (with a different title) presented in a conference at the University of Kobe in November, 2014,on "Fragmentation, Time Zone and their Dynamic Consequences" in memory of Prof. Toru Kikuchi. I have learnt a great deal from my research collaboration with Prof. Kikuchi and this paper is a tribute to him. Comments from conference participants have been helpful. This research is funded by the RBI endowment at CSSSC. The usual disclaimer applies.

Section 1 **Introduction**

In his well-known monograph on growth Lucas (2002) rightly points out that removing barriers to trade do not necessarily lead to a rise in the growth rate. Standard neo classical models of trade cannot generate a direct growth impact of a more open trade regime. He was commenting on the pioneering work on trade reform by Krueger (1983) and Harberger (1984). The observation made by Lucas tells us about a key problem in having a growth model where gains from trade naturally lead to a higher growth rate. This is the reason that there is no generic model of trade and growth with clear predictions. Typically trade leads to reallocation of resources and such reallocation may not either increase rate of investment or lead to permanent increase in productivity, the two sources through which long run growth can increase. Unfortunately the current literature does not refer to the well-known work of David Ricardo as elaborated in Findlay (1974) which clearly exhibits a direct relation between trade and growth by increasing the rate of profit. In fact Ricardo's argument for import of corn was related to making a critical input for production, labor, less expensive for the capitalists, the drivers of growth and industrial development. Trade in final goods thus reduced the cost of an input raising the rate of profit and growth. Our paper is also in similar tradition where virtual trade naturally increases the efficiency of an intermediate input. Two elegant recent papers on Ricardo and growth are by Naito (2012) and Kaneko (2013). But they do not discuss the separated time zones induced mechanism between the level effect and growth effect of trade that we discuss here. Also they do not consider the problem of skill accumulation and labor market issues that may potentially block growth when intermediates are produced by skill, a focal point of this paper.

More recent work on trade and growth such as Grossman and Helpman (1990) and Rivera Batiz and Romar (1991) relate trade to innovation, growth and increasing returns. Interesting papers by Ventura (1997) and Acemoglu and Ventura (2002) discuss the case where small economies when exposed to international capital flow, can grow avoiding diminishing returns to capital accumulation as the world rate of return is held fixed. But their work is not related to any standard model of production and trade. Summary of the existing literature in a pedagogic form is available in Donaldson (2011). In an interesting paper Baldwin and Robert-Nicoud (2008) discuss at length the growth implications of recent genre of firm-heterogeneity models. They conclude that freer trade raises productivity in a level sense, but slows measured productivity growth. This set of well-known contributions provides rich insights as to how trade models can be extended to generate a growth impact. But the fact remains that trade is essentially about more efficient allocation of existing resources and trade by itself cannot lead to an increase in growth rate, though it definitely increases real income. Given this backdrop we present a simple framework and extend it to fit the literature on optimal endogenous growth where trade has level as well as growth effects. This is also a departure from Kikuchi and Marjit (2011) where time zone differences and growth has been discussed, but not in terms of an optimal growth model and more importantly the labor market issue was not discussed at all. Since the possibility of steady state growth hinges very much on the availability of skill, this issue is of prime importance. Also the labor market story clearly demonstrates the separation of level effect through a one shot rise in the wage rate and a permanent change in the growth rate where subsequently the wage rate remains unchanged.

Virtual trade is possibly the most innovative form of market transaction the world has seen in recent times. Thanks to the growth of satellite and computer technology, online transactions have flooded the global market. For an overview of this radical phenomenon readers are referred to Lehdonvirta & Castronova (2014). By now it is well recognized that India's phenomenal growth in the turn of the century outstripping the legacy of the so called Hindu rate of growth owes a great deal to the growth in the service sector of which IT services is extraordinarily important.

Das, Banga and Kumar (2011) describes the rise of the India's services and software sector in clear terms. Since 1995, a few years after the reform process was initiated in India more than 60% of the GDP growth rate was contributed by the service sector. The share of the services in GDP grew from 50% in 1995 to around 65% in 2008-2009. The trend continues more or less unabated even in the midst of global financial crisis of 2007-2008. Since 2001-2002 to 2007-2008, the year on year growth of software exports was more than 30 % on average. It constitutes more than 50% of India's service sector exports. It will be difficult not to agree with the claim that India's rise as an economic power does have a lot to do with its performance in the IT related services. Sahoo (2013) relates the growth in the service sector with the TFP growth of the new firms created near the technology frontier. In fact it is quite clear that India's agriculture and manufacturing did not perform commendably over the last two decades and never looked impressive. India could exploit the opportunity offered by global revolution in information technology starting 80s being endowed with a substantial reservoir of low cost skilled labor, reasonably well versed with English language and as we shall argue in this paper, being *strategically located in the virtual value chain.*

Countries located in separated and non-overlapping time zone have a natural tendency to trade on virtual platform. In the 80s Bangalore in India emerged as the Silicon Valley of the east developing a working relation with the legendary Silicon Valley of California. Tasks generated in USA during working hours could be completed in India when USA will rest in bed, offices will open in Bangalore and the world effectively worked for 24 hours. Such outsourcing or exchange of tasks according to the static interpretation of Grossman and Rossi-Hansberg (2008) naturally generates gains from trade. Thus for countries exactly identical in all respects but located in separated time zones with non-overlapping normal working hours could gain from trade by completing a task quicker, by exchanging services in processes like intermediates and delivering the final product more efficiently. The benefit could be reaped because technology was available to exploit natural geographic conditions. Hence time became a cause for trade apart from the usual trinity- technology, endowment and preference. This was first posed in terms of a simple Ricardian model of comparative advantage by Marjit (2007) and immediately followed up by many papers of Toru Kikuchi, now collated in Kikuchi (2013) in terms of network formation. One issue that seems to be of critical theoretical importance is the relationship of such a pattern of trade with growth.

The effect of trade on growth as studied in the literature has turned out to be an empirical question. Recent contributions starting with a critical overview of Fernández & Rodrik (1990) evolve around evaluating the hypothesis whether trade has impacted on growth of developing countries. In an interesting paper reflecting on Indian experience Goldberg et al. (2010) have rigorously demonstrated how imported inputs have contributed to Indian growth rate in the post reform period. In spite of the positive effects of liberal trade policies on India's growth, one does not find a significant change in the manufacturing to GDP ratio in India in a regime when the standard measures of openness show profound transformation. For example the trade volume to GDP has increased from around 15% in pre-refom to more than 35 % in the post reform era. Also the remarkable growth of the services and software sectors cannot be explained by increasing import of physical inputs. India's rise in services had to do with the rise of the virtual world and technologies that facilitated trade across virtual platforms and in particular India's global location vis a vis USA with normal working hours in each country coinciding with the resting period in the other. Not only this is an interesting story to tell, but it breaks a theoretical impasse between trade and growth by accommodating the level and growth effect of trade in the same model and in simplest possible terms.

Trade induced by separated time zones has a natural impetus for growth because it allows the countries to work double shift with lower cost. In a way there is a permanent change in level of productivity. Think of a situation when one unit of the product requires two inputs each of which can be produced over twelve hour cycle. Therefore, if we work for twelve hours, do not work overnight and we start the day at six in the morning, we shall get one unit the next day at six in the evening. Now if we could get another country produce one of the inputs and that they start working at six in the morning their time which is six in the evening our time, one unit will be done when we wake up and start the next day. We get the product twelve hours earlier and get more than one unit. Output per unit of time has gone up raising the growth rate. This is one type of interpretation.

Another type of interpretation is when we do work overnight at a premium to compensate us for the normal resting time. Once we have another trading partner across a non-overlapping time zone, both of us can sleep well. Firms can hire workers without a premium. Inputs are available at a lower cost increasing the incentive for the firms to invest more leading to a higher rate of growth. This is a natural process by which the level effect and growth effect hold simultaneously.

The paper is laid out as follows. The second section describes the autarkic equilibrium. Section three deals with trade and growth and four with the labor market issues. The last one concludes.

Section 2 Autarky

Consider two symmetric countries, identical in all respects, but located in two non-overlapping time zones. Therefore, autarkic equilibrium in one will be replicated in another. We have a single final good Y which uses capital K and intermediates m_1 and m_2 and they need two twelve hour cycles to be produced. One unit of Y produces one unit of $m_1$and m_2. Also we choose Y as the numeriare. Hence all prices are unity. Figure-1 depicts the time line of production.

Figure-1

We rule out the nightly production assuming that it is immensely costly. For production of the final good one unit of time is denoted by the phase AB, when m_1, m_2 and K are used to produce Y via the following production function.

$$Y = A\, m_1^{\frac{1-\alpha}{2}}\, m_2^{\frac{1-\alpha}{2}}\, K^{\alpha} \qquad \ldots (1)$$

Since m_2 is available only in the first half of tomorrow, Y can not delivered early and / or there may be carryover costs of m_1 up to m_2. We take up the second interpretation, although the first has been dealt with in Marjit (2007). The delay or carryover cost is denoted by $(1+\mu)$ with $\mu > 0$ denoting a premium over unit cost.

It is straight forward to argue that optimal $m_1$and m_2 are given by …………..

$m_{10} = \frac{1-\alpha}{2} . \frac{y}{1+\mu}$ and $m_{10} = \frac{1-\alpha}{2} . y$

Substituting in (1) we get

$y_0 = A^{\frac{1}{\alpha}} \left(\frac{1-\alpha}{2}\right)^{\frac{1-\alpha}{\alpha}} . \left[\frac{1}{(1+\mu)}\right]^{\frac{1-\alpha}{2\alpha}} . K$ where K is aggregate capital.

Where $\tilde{A}_0 = A^{\frac{1}{\alpha}} \left(\frac{1-\alpha}{2}\right)^{\frac{1-\alpha}{\alpha}} . \left[\frac{1}{(1+\mu)}\right]^{\frac{1-\alpha}{2\alpha}} \qquad \ldots (2)$

Given K and other parameters. (1) and (2) determine Y_0. From (2) it is obvious that μ has a negative effect on $\tilde{A}_0$ and y_0.

The simple Autarkik growth problem is described by the following representative agent problem with per capita capital stock k.

$$Max \sum_{t=0}^{\alpha} \beta^t u(c_t), \quad \beta = \frac{1}{1+\rho}, \quad \rho > 0$$

$$\text{s.t. } [y_t - c_t - (k_{t+1} - k_t)] = 0 \qquad \dots (3)$$

We assume zero depreciation of capital.

Bellman's equation

$$MaxZ_t = u(c_t) + \beta V(k_{t+1}) + \lambda_t[y_t - c_t - (k_{t+1} - k_t)] \qquad \dots (4)$$

It is easy to demonstrate the following Euler relationship

$$\frac{u'(c_t)}{u'(c_{t+1})} \simeq \tilde{A} - \rho \qquad \dots (5)$$

With specific structure on $u(c_t)$, $\tilde{A} - \rho$ captures the steady state endogenous growth in a typical Ak model a la Rebello (1991), etc.

m_{10}, m_{20}, y_0, k all will grow at the same rate ($\tilde{A} - \rho$). Note that $\tilde{A}$ does not have a time dimension and greater μ will reduce the growth rate. Two economies located in non-overlapping time zones will grow at the same rate $\left(\tilde{A}_0 - \rho\right)$.

Section 3 Trade and Growth

Looking back at figure-1, it is simple to demonstrate that if the other country, the foreign, which wakes up at A_1, could provide m_2 to the home country, Y will be available at A_2 instead of at B. Similarly at point A when the foreign country is asleep, m_1 could be produced and shipped to the foreign country ready to go with m_2 at A_1. Remember that we are talking of virtual trade through computerized network. Even that may entail some trading cost; let's call this τ. So the effective price is $(1 + \tau)$ even if there is no delay or carryover cost. So long as $\tau < \mu$, home country will import m_2 from the foreign country and the foreign country will import m_1 from the home country.

(2) now reads as (6) and $\tilde{A}_F$ denotes the free trade level of $\tilde{A}$.

$$\tilde{A}_F = A^{\frac{1}{\alpha}}\left(\frac{1-\alpha}{2}\right)^{\frac{1-\alpha}{\alpha}}\left[\frac{1}{1+\tau}\right]^{\frac{1-\alpha}{2\alpha}} \qquad \ldots (6)$$

And $\tilde{A}_F > \tilde{A}_0$ iff $\tau < \mu$

Therefore the following proposition is immediate.

Proposition-1

If $\tau < \mu$, mutually gainful trade will take place raising Y in both countries. But as $\tilde{A}_F > \tilde{A}_0$, such trade will increase the growth rate also.

Check that the balance of trade condition is given by

$$\frac{1-\alpha}{2}.\frac{y^F}{1+\tau} = \frac{1-\alpha}{2}.\frac{y^{F*}}{1+\tau} \qquad \ldots (7)$$

Since $y^F = y^{F*}$, it trivially holds.

If we work with the delay in delivery of the final good as in Marjit (2007) and the discount rate applied is δ (< 1) on the price of Y, then $m_1 = m_2 = \frac{1-\alpha}{2}.\delta y$ and

$\tilde{A}_F = A^{\frac{1}{\alpha}}\left(\frac{1-\alpha}{2}\right)^{\frac{1-\alpha}{\alpha}}[\delta]^{\frac{1-\alpha}{2\alpha}}$, trade will increase the value of δ to 1 and will tend to raise the level of y and the growth rate.

International trade, by reducing the delay in the production process has a positive impact on the productivity and growth. Note that both μ and δ have to be compared with τ. If τ is very high, as was the case when the virtual platform was not available, growth rate suffered. Once such platform was made available, τ dropped substantially and virtual trade became a reality.

In the process it radically transformed the way a task is performed globally. Thus trade not only raised the value of output but brought onto a higher growth path.

Section 4 Growth with Labor Market

We try to introduce labor market in the model we have been discussing so far. This is important in the sense that increasing demand for skill may raise its price and block the possibility of a steady state. Existence of steady state growth path becomes conditional on skill accumulation.

Consider the home and the foreign country has same endowments of human capital, call it H. Autarkic equilibrium will be recast under the assumption that to produce one unit of m_1 and m_2, labourers have to be paid w which is the real wage in terms of Y. Y can be consumed, saved as k and now also can be invested to augment H. That is even if the population size remains fixed, either the skill content can be increased to increase H or the proportion of skilled workers needed to produce m can be increased. We will return to the growth question little later.

Now optimum quantity of m_1 and m_2 chosen are

$$m_1 = \frac{1-\alpha}{2} . \frac{y}{w(1+\mu)} \qquad \ldots (8)$$

$$m_2 = \frac{1-\alpha}{2} . \frac{y}{w} \qquad \ldots (9)$$

Nothing changes much

$$y = \tilde{A}K \text{ where } \tilde{A} = A^{\frac{1}{\alpha}} \left(\frac{1-\alpha}{2}\right)^{\frac{1-\alpha}{\alpha}} . \left[\frac{1}{w^2(1+\mu)}\right]^{\frac{1-\alpha}{2\alpha}} . K$$

Before we proceed to the labor market, let us reflect on the above expression.

It is obvious that w enters with a square in A since two intermediate inputs are put together for the final product. Even we forget about the time zone effect as such and consider any pair of intermediate goods we are likely to derive a similar expression without delay costs or carryover costs. Now consider this small open economy faces a rest of the world wage rate w*(1+z) < w(1+a) where z is some sort of trading costs or outsourcing costs and a represents production costs at home. It will gain from importing the intermediate from abroad and export Y. That will immediately increase the long run rate of growth. If z is prohibitively high as in the case with virtual trade when communication costs were too high, such trade and growth will not take place. The concept of time zone clearly manifests a situation when z is low enough to cause trade and growth even if w is the same across borders. Thus trade in intermediates leads naturally to an increase in the growth rate.

Now we turn to the equilibrium in the labor market.

Labor market must clear

Therefore,

$$H = \frac{1-\alpha}{2w} . \tilde{A} . K . \left[1 + \frac{1}{1+\mu}\right] \qquad \ldots (10)$$

Or $w = \frac{1-\alpha}{2} . \frac{\tilde{A}K}{H} . \left[1 + \frac{1}{1+\mu}\right] K$

$$= \frac{A^{\frac{1}{\alpha}}\left(\frac{1-\alpha}{2}\right)^{1+\frac{1-\alpha}{\alpha}}}{H} . \left(\frac{1}{1+\mu}\right)^{\frac{1-\alpha}{2\alpha}} . \left(1 + \frac{1}{1+\mu}\right) . (w)^{-\frac{1-\alpha}{\alpha}} . K$$

$$w = \left(\frac{B}{H} K\right)^{\alpha} \qquad \ldots (11)$$

Where $B = A^{\frac{1}{\alpha}} \left(\frac{1-\alpha}{2}\right)^{\frac{1}{\alpha}} . \left[\frac{1}{(1+\mu)}\right]^{\frac{1-\alpha}{2\alpha}} . (1 + \frac{1}{1+\mu})$ $\qquad \ldots (12)$

Note that a decline in μ will surely increase w given k and H.

Following the argument in last section it is straightforward to argue that trade will increase w in both countries. We now turn to the growth issue. It is obvious that steady state growth is impossible if H does not increase over time.

A representative agent is endowed with k and h, the per capita endowments. She faces the following dynamic choice problem expressed through Bellman's equation

$$\text{Max}_{\{c_t,k_{t+1},h_{t+1}\}} Z\,(c_t, k_t, h_t) = u(c_t) + \beta V(k_{t+1}, h_{t+1}) + \lambda_t[y_t - (k_{t+1} - k_t) - (h_{t+1} - h_t)]$$

… (13)

We could have introduced the special effect of h_t on the accumulation process of h_t as per Lucas (1988). But here we focus on the trade induced impact and abstract from more complex human capital issue. Also note that in equilibrium

$y = \tilde{A}.k$

Where $\tilde{A} = A^{\frac{1}{\alpha}}\left(\frac{1-\alpha}{2}\right)^{\frac{1-\alpha}{\alpha}}.\left[\frac{1}{\left(\frac{B}{H}.K\right)^{2\alpha}(1+\mu)}\right]^{\frac{1-\alpha}{2\alpha}}.k$ … (14)

Therefore,

$y = \tilde{B}k^{\alpha}h^{1-\alpha}$ … (15)

Where,

$\tilde{B} = A^{1/\alpha}.\left(\frac{1-\alpha}{2}\right)^{\frac{1-\alpha}{\alpha}}.[B^{2\alpha}(1+\mu)]^{-\left(\frac{1-\alpha}{2\alpha}\right)}$ … (16)

Note that (h, k) are variables relevant for the representative agent and

$\frac{\delta[B^{2\alpha}(1+\mu)]}{\delta(1+\mu)} > 0$ (See Appendix)

Note that (15) can be rewritten as

$y = \tilde{B}.\left(\frac{h}{k}\right)^{1-\alpha}.k$ … (17)

If k and h grow at the same rate effectively (17) assumes the 'Ak' form.

If we solve the problem specified by (13), we get the following conditions, as before,

$\frac{\tilde{B}\alpha k_t^{\alpha-1}h_t^{1-\alpha}+1}{1+\rho} = \frac{\lambda_t}{\lambda_{t+1}} = \frac{u'(c_t)}{u'(c_{t+1})} = \frac{\tilde{B}(1-\alpha)k_t^{\alpha}h_t^{-\alpha}+1}{1+\rho}$ …

(18)

From (18) it is obvious that

$$\frac{k_t}{h_t} = \frac{\alpha}{1-\alpha} \qquad \dots (19)$$

As before with log linear contemporaneous utility function

$$\tilde{B}\alpha h^{1-\alpha}k^{\alpha-1} - \rho = \tilde{B}(1-\alpha)h^{-\alpha}k^{\alpha} - \rho \simeq \frac{c_{t+1}-c_t}{c_t} = g_c \qquad \dots (20)$$

c_t, k_t, h_t all will grow at the same rate, so will y. From (11) we know w will remain same over time. Following similar logic as in earlier section, we know a drop in μ upto τ with $\tau < \mu$, will increase B and $\tilde{B}$, raising the rate of growth. In the primitive production function m_1, m_2, k all will grow at the same rate as in (20). hence, Y. Growth in H will keep w in check. MP_k and MP_H will remain constant along the path of steady state growth. As we shift from μ to τ, w will go up. This is the level effect, but then it remains the same. Thus we have the following proposition.

Proposition 2 - Trade across time zones will lead to higher steady state growth. The level effect will lead to one shot rise in w, but in the new growth path w remains constant guaranteeing steady state growth.

Section 5 Conclusion

The purpose of this paper has been to demonstrate how time zone led virtual trade can naturally and easily generate both level and growth effects of international trade. Typically trade generates level effect on income but not growth effects which need further structure on the static model. Virtual trade made possible through separated time zones increases productivity permanently by allowing the world to work round the clock. Thus gains from trade and increase in the growth rate happen simultaneously. Availability of skilled labor can be a problem and the growth impact of trade needs skill accumulation at the same rate, which may not be forthcoming. Thus balanced growth path we discuss in this paper might get disturbed if two countries have skill constraints.

Appendix

$$B = A^{1/\alpha}\left(\frac{1-\alpha}{2}\right)^{\frac{1}{\alpha}}.\left(\frac{1}{1+\mu}\right)^{\frac{1-\alpha}{2\alpha}}.\left(1+\frac{1}{1+\mu}\right)$$

$$B^{2\alpha} = A^2\left(\frac{1-\alpha}{2}\right)^2.\left(\frac{1}{1+\mu}\right)^{1-\alpha}.\left(1+\frac{1}{1+\mu}\right)^{2\alpha}$$

$\downarrow$

X and $(1+\mu) = a$

$$B^{2\alpha}(1+\mu) = X\left(\frac{1}{a}\right)^{1-\alpha}.\left(1+\frac{1}{a}\right)^{2\alpha}.a$$

$$= X.a^{-1+\alpha}.\left(1+{}^{1}/_{a}\right)^{2\alpha}.a$$

$$= X.a^{\alpha-1}\left(1+{}^{1}/_{a}\right)^{2\alpha}.a$$

$$= Xa^{\alpha}.\left(\frac{a+1}{a}\right)^{2\alpha}$$

$$= Xa^{\alpha}.(a+1)^{2\alpha}.a^{-2\alpha}$$

$$= Xa^{-\alpha}(a+1)^{2\alpha}$$

$$\frac{d[B^{2\alpha}(1+\mu)]}{d(1+\mu)} = \frac{d(B^{2\alpha}.a)}{da} > 0$$

iff $[2\alpha(a+1)^{2\alpha-1}.a^{-\alpha} - \alpha a^{-\alpha-1}.(a+1)^{2\alpha}] > 0$

or $\alpha(a+1)^{2\alpha-1}.a^{-\alpha}[2 - a^{-1}.(a+1)] > 0$

or $2 - \left(1+\frac{1}{a}\right) > 0$

as $a = 1 + \mu$, it holds.

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