Trade Policy and Mega-Cities in LDCs: A General Equilibrium Model with Numerical Simulations

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Abstract: This paper follows the new economic geography approach to model the relationships between trade policy and spatial agglomeration of production in the context of a small open developing economy. We construct a general equilibrium model with interactions between centripetal forces and centrifugal forces that determine linkages between urban and rural regions. Centripetal forces such as labor migration, increasing returns, and transport costs tend to concentrate economic activities and population in the urban region. This causes the inequality between urban and rural areas to increase. On the other hand, centrifugal forces such as congestion and urban land rents favor dispersion of firms and workers. This favors a balanced urban system that is conducive for rural development. We concentrate on explaining how trade policy affects the interactions between these forces by implementing the theoretical model through numerical simulations. The results suggest that trade liberalization can improve urban-rural inequalities as long as the country that implements trade policy reform does not face any trade restrictions in the external market.

Keywords: *agglomeration; urban-rural inequalities; trade policy; trade costs*

1. INTRODUCTION

Less developed countries have experienced a rapid urbanization process during the last few decades. Half a century ago just 41 of the world's 100 largest cities were in less developing countries (LDCs). This number had increased to 64 by 1995. This proportion is predicted to rise with more people moving from rural to urban areas and nearly 90 percent of the world's future urban population living LDCs (World Bank, 1999). Moreover, there is a growing body of empirical literature indicating the structures of cities in LDCs are much more dominated by metropolitan regions compared to the experiences of developed countries (DCs) at similar stage of economic development (Puga, 1996).

The motivation for this paper comes from Krugman and Livas (1996) that developed a formal model and demonstrated the effect of trade policy on the third world metropolis. The Krugman and Livas' model (henceforth the KL model) was inspired by the experience of Mexico City, the world's largest city. "Prior to the late 1980s, Mexico followed a classic strategy of industrial development through import-substitution industrialization; the result was the emergence of an inward-looking economic base; much of it concentrated in the immediate vicinity of Mexico City." (Fujita, Krugman and Venables (1999, p. 329). According to Krugman and Livas, the concentration of industries in Mexico City was the result of an inward-looking industrialization strategy. The advantages from backward and forward linkages in Mexico City have outweighed the disadvantages of high land rents, wages, congestion and pollution. Thus, the KL model was developed to formalize the observation of Mexico City's experience.

This paper examines the applicability of the KL model to other LDCs. While retaining the structure of the KL model intact, we relax one critical assumption of the KL model regarding export trade costs. Given the circumstance of Mexico whose trade liberalization culminated with the establishment of North American Free Trade Agreement (NAFTA), the zero-export trade cost assumption in the KL model could be realistic in the context it is set-up. However, these conditions may not apply to other LDCs.

2. THE MODEL

A fuller version of the model with detailed derivations of utility function and production function is available in the original paper by Krugman and Livas (1996) as well as further extensions by Gelan (2002) and Paluzie (2001). Here it proves useful concentrate on a salient view of the issues involved and few equations that incorporate key relationships. We represent regions generically by *r* (the reference region) and *s* (the other regions) or we denote the designation of a region signing subscripts as *1, 2, 0* to mean the centre, the periphery or the rest of the world respectively.

2.1. Overview

We imagine a small open economy with two domestic regions, urban and rural, and an external region. Each region has a single monopolistically competitive industry producing a composite good using one factor of production, labor. The labor force is fixed, fully employed and mobile between domestic regions but not internationally. All regions interact in the product market with shipments of goods from one region involving costs that are broadly understood as "trade costs". The latter includes transport costs as well as any other barrier to trade that businesses face to access the external market. As in most new economic geography (NEG) models, the dynamics of this model depends on tensions between "centripetal" and "centrifugal" forces.

Centrifugal forces could be pure external diseconomies such as congestion, pollution, urban land rents, the attraction of moving away from highly competitive urban locations to less competitive rural ones (Krugman and Livas, 1996, p. 141). In this model, we allow only one centrifugal force, commuting cost or land rent. The notion of a mono-centric city structure is employed to show the relationships between wages, commuting cost and labor time (Krugman and Livas 1996; Fujita and Krugman, 1995).

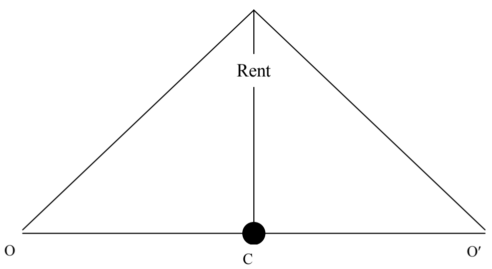

Figure 1 Mono-centric city structure

This relies on a simplified spatial model that assumes a long and narrow economy, one dimensional, with a central business district (CBD) with workers' residential places spreading on both sides of the CBD and a unit of land per worker (see Figure 1). On the one hand, the highest land rent is paid at the centre where commuting cost is negligible. The level of land rent declines with distance from the CBD with the commuting distance of the last workers living at the outskirts of the city being given as $0.5d$, where d is the total distance between O and O'. This means that the last worker who lives at the outskirts of the city pays the lowest land rent but the highest commuting cost. In this model, commuting cost is incurred in terms of potential labor earnings. Note that it takes time to travel the distance to work from residence. If a worker has a unit of labor available for work and if she commutes between a place of residence and a place of work in the CBD, then she arrives with a net amount of labor to sell of only $1-2\gamma d$, where γ is the ratio of labor time spent per unit distance. With a given regional wage rate (W_r), a worker commuting to a CBD receives a net wage of only $(1-\gamma L_r)W_r$. A worker who lives closer to the CBD, however, receives almost the full amount of the regional wage rate, W_r, but she pays a land rent that exactly offsets the amount she has saved by avoiding commuting. Thus, the wage net of commuting and land rents is $(1-\gamma L_r)W_r$ for all workers. The total labor input (net of commuting time) in each region, Z_r , is given as $L_r(1-0.5\gamma L_r)$, where L_r is the labor force in region *r*.

Centripetal forces include both pure external economies and market size effects (forward and backward linkages). Shipments of goods between locations involve costs through which centripetal forces operate. Transport costs are the most commonly cited costs of moving goods between locations. In order to avoid modeling a separate transport industry, the "iceberg" formulation is most commonly used in NEG literature. This formulation expresses transport cost in terms of the fraction of goods melting away with distance. For instance, if a unit of a variety of good is shipped from region *r* to region *s*, then only $1/T_{rs}$ of the original unit actually arrives at the destination. A broader view of shipment cost includes all of the costs of doing business at a distance (Fujita, Krugman, and Venables, 1999, p. 98). We adopt this broader definition of trade costs incurred in moving goods between different locations. Accordingly, we use the term "trade cost" rather than "transport cost".

2.2. Determination of instantaneous equilibrium for the model

The instantaneous equilibrium of the model can be determined by simultaneously solving for four sets of equations for each region: the income equations, the price index equations, the nominal wage equations, and the real wage equations (Krugman and Venables 1999, pp. 331-332). We distinguish between trade barriers that the rest of the world faces in accessing the domestic market, T_m, and those that the domestic economy faces in the external market, T_e. We assume that foreign firms face the same trade cost in both domestic regions. Similarly, we assume equal export trade cost for both internal locations implying that we do not allow one domestic region to have the advantage of proximity to the rest of the world.

The income equations are straightforward. Since labor is mobile only between the domestic regions, we take the labor force in the external region as given, Z_0. We choose units in such a way that the domestic labor force is given as 1; hence λ_1 and λ_2 are labor force shares of the central and peripheral regions. Thus, regional income, Y_r, is given as a function of labor force and nominal wage rate (eqs. 1-3).

Table 1 Equations of the system

$$Y_0 = Z_0 W_0 \tag{1}$$
$$Y_1 = \lambda_1 W_1 \tag{2}$$
$$Y_2 = \lambda_2 W_2 \tag{3}$$
$$G_0 = \left[Z_0 W_0 + \lambda_1 \left(W_1 T_e \right)^{1-\sigma} + \lambda_2 \left(W_2 T_e \right)^{1-\sigma} \right]^{\frac{1}{1-\sigma}} \tag{4}$$
$$G_1 = \left[Z_0 \left(W_0 T_m \right)^{1-\sigma} + \lambda_1 W_1^{1-\sigma} + \lambda_2 \left(W_2 T_d \right)^{1-\sigma} \right]^{\frac{1}{1-\sigma}} \tag{5}$$
$$G_2 = \left[Z_0 \left(W_0 T_m \right)^{1-\sigma} + \lambda_1 \left(W_1 T_d \right)^{1-\sigma} + \lambda_2 W_2^{1-\sigma} \right]^{\frac{1}{1-\sigma}} \tag{6}$$
$$W_0 = \left[Y_0 G_0^{\sigma-1} + Y_1 G_1^{\sigma-1} T_m^{1-\sigma} + Y_2 G_2^{\sigma-1} T_m^{1-\sigma} \right]^{\frac{1}{\sigma}} \tag{7}$$
$$W_1 = \left[Y_0 G_0^{\sigma-1} T_e^{1-\sigma} + Y_1 G_1^{\sigma-1} + Y_2 G_2^{\sigma-1} T_d^{1-\sigma} \right]^{\frac{1}{\sigma}} \tag{8}$$
$$W_2 = \left[Y_0 G_0^{\sigma-1} T_e^{1-\sigma} + Y_1 G_1^{\sigma-1} T_d^{1-\sigma} + Y_2 G_2^{\sigma-1} \right]^{\frac{1}{\sigma}} \tag{9}$$
$$\omega_0 = W_0 \left(1 - \gamma \lambda_0 \right) / G_0 \tag{10}$$
$$\omega_1 = W_1 \left(1 - \gamma \lambda_1 \right) / G_1 \tag{11}$$
$$\omega_2 = W_2 \left(1 - \gamma \lambda_2 \right) / G_2 \tag{12}$$

Eqs 4-6 display the determination of regional price index, G_r. The parameter σ represents the degree of substitutability between monopolistically competitive manufacturing varieties (Dixit and Stiglitz, 1977). If we assume that wage rates are equal in both domestic regions, then the price index of a particular region would be lower the higher the share of economic activity in that region. The reason is that a larger proportion of locally consumed goods does not bear trade costs. If the local price index is relatively low, then the region becomes an attractive place for workers. Thus, business and household location decisions tend to re-enforce each other.

The nominal wage equations (eqs.7-9) exhibit an important property of the model. Other things being equal, the higher nominal wage rate in a region the higher level of income in the region. This means that a location with larger home market has a more than proportionate share in the number of businesses and hence it is in a position to export goods and services to other regions.

In eqs. (10-12), the determination of real wage, ω_r, take into account the price index, the nominal wage rate, and the commuting cost (land rent). The changes in relative real wages cause labor mobility across regions. This leads to variations in the distribution of economic activity across locations over time, then $d\lambda_1 = \theta(\omega_1 / \omega_2)$, where *d* denote time derivative and θ represents speed of labor mobility that depend on such conditions as movement costs and forward-looking behavior of migrants.

Although the logic of this model is intuitive, the relationships between the variables are complicated enough to make it impossible to solve for it analytically. At this point we resort to numerical simulations.

3. NUMERICAL SIMULATIONS

We use graphical methods to display numerical solutions. The real wage differential between the two domestic regions, given as ω_1 / ω_2, is plotted against the labor force share of region 1, λ_1. Any point where $\omega_1 / \omega_2 = 1$ and $\lambda_1 = 0.5$ represents an equilibrium condition because it satisfies the condition for an even distribution of the labor force between the two domestic regions. This equilibrium is stable if the curve is downward sloping because it represents an inverse relationship between the real wage differentials and the labor force shares. Whenever a region takes a lead in terms of its share of the labor force, the real wage there falls below that of the other region and hence workers would migrate from the former to the latter region thereby removing the wage differential.

In contrast, if the curve slopes upwards, when ω_1/ω_2 is positively related to λ_1, then the equilibrium is unstable because workers would migrate to the region that has already more workers. This may lead to a corner solution, where workers fully concentrate in one region and stay there as long as the real wage there remains higher than that of the other region. The exogenous variables take the following values: σ=7, $\gamma = 0.2$, $T_d = 1.5$, $Z_0 = 10$, and $\theta = 1$. The wage rate of the external sector is used as a numeraire, i.e., $W_0 = 1$. We vary the trade cost parameters that stand for barriers between the domestic economy and the external region. We proceed to presenting simulation results initially focussing on the effect of changes in T_m on the labor force distribution. Here we effectively mimic results from the KL model. This illuminates the arguments involved and explains the properties of the model. We then relax the KL model assumption of $T_e = 1$ and repeat the simulation runs. We begin concentrating on Figure 2, which has three panels.

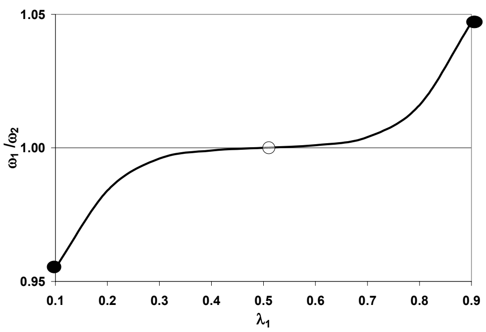

Figure 2a. Closed economy: Tm=2.25, T_e = 1.0

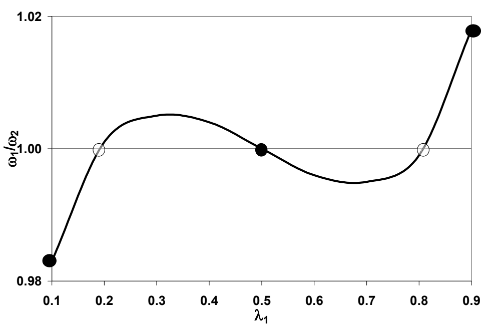

Figure 2b. Slightly open econ.:T_m=2.0, T_e = 1.0

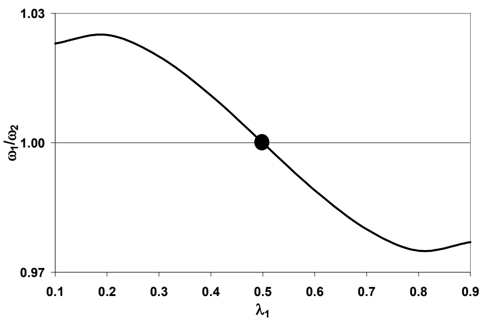

Figure 2c. Open economy: Tm = 1.75, , T_e = 1.0

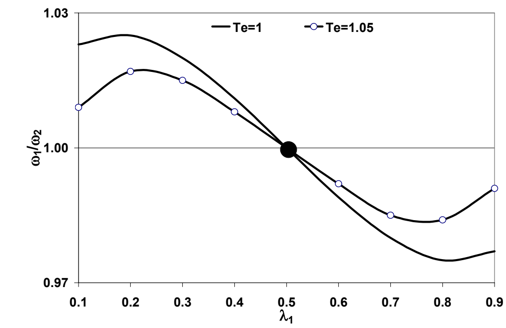

Figure 3a. Open economy with small export trade cost: T_m = 1.75, Te = 1.05

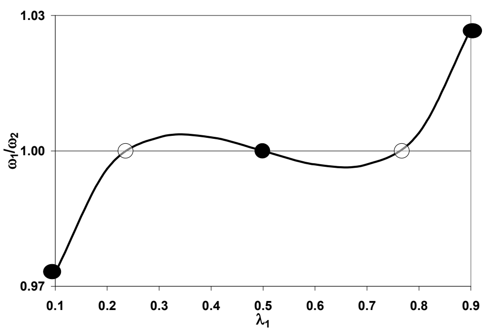

Figure 3b. Open economy with moderately high export trade cost: T_m = 1.75 Te = 1.20

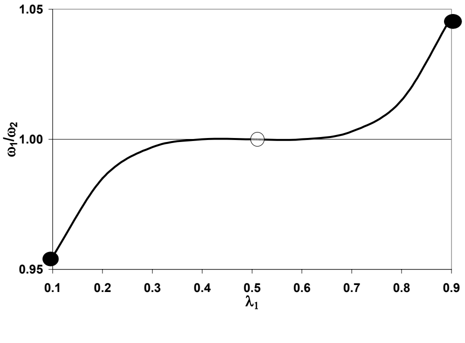

Figure 3c. Open economy with relatively high export trade cost: T_m = 1.75, Te = 1.30

In Figure 2a, we assume a relatively high import tariff of $T_m = 2.25$. Such a high trade cost represents a closed economy, reminiscent of the import substitution industrialization strategy in LDCs. The equilibrium condition that allows even distribution of population between the two locations is unstable because the curve slopes strictly upwards indicating a strong agglomeration. The only stable equilibria are the corner solutions, i.e., full concentration in one region or the other.

Panel 2b represents the intermediate case with $T_m = 2.0$. This amounts to slightly opening the economy. It shows a rather complicated picture. As in panel 2a, the symmetric equilibrium (even population allocation) is stable but this is surrounded by two unstable equilibria. If the share of the labour force in one region starts from a sufficiently high or a sufficiently low initial value, then the economy converges not to the symmetric equilibrium but to a core-periphery pattern with all production in only one region. There are five equilibria that characterise this intermediate case: three stable (one at the point of symmetry and two corner solutions) and two unstable. The key point here is that the agglomeration force (denoted by the intermediate size of T_m) is still too weak to destabilize the symmetric equilibrium. However, it is strong enough to ensure that if all firms were concentrated in one region this would be a locally stable equilibrium as well (Puga, 1999, p. 334). Panel 1c is plotted for a relatively low trade cost parameter, $T_m = 1.75$. This gives a unique and stable equilibrium with even distribution of population between the two locations. This implies trade liberalization leads to even distribution of population between domestic regions and hence reduces regional inequalities.

These results explain the line of argument developed and the simulation results obtained using the KL model, whose overall conclusion was that the forward and backward linkages are strong enough to create and support a single metropolis in a relatively closed economy. As the economy is opened, these forces are weakened and the offsetting centrifugal forces make the less concentrated urban systems first possible and them necessary.

Note that, following the KL model, we have assumed that $T_e = 1$ in Figures 2a-2c. Now we turn our attention to the alternative simulation results whereby domestic firms encounter trade barriers in the external region ($T_e > 1$). We keep the import trade cost parameter at the sufficiently low level of $T_m = 1.75$, as in figure 2c, suggesting that the economy is assumed to remain open in this simulation run. We then examine the effect of changes in T_e on the distribution of economic activity between the two domestic regions.

In Figure 3a, we have plotted results of two simulation runs. The solid line is the same as the result displayed in Figure 2c, where $T_m = 1.75$ and $T_e = 1$. For the broken line, however, $T_e = 1.05$. Both curves represent a stable equilibrium with even distribution of population between the two domestic locations. However, the broken line is flatter than the solid line, tending to be less stable than the solid line. In Figure 3b, we slightly raise the value of T_e to 1.2. The result here is similar to that displayed in Figure 2b but for entirely different reasons. Here although the domestic market is sufficiently liberalized to guarantee even distribution of population between the two locations, the existence of trade barriers in the external market inhibits balanced development the domestic economy. In Figure 3c, we assume a relatively high external trade cost of 1.3. This shows a complete unraveling of the results from the KL model. As long as there are some trade restrictions that hinder access of domestic firms to the external market, trade liberalization is not likely to affect the current spatial pattern in LDCs. A comparison of Figures 3c with 2a brings an interesting point to light. Both figures represent a core-periphery relationship. However, Figure 2a suggests that a closed economy with a protectionist trade policy experiences uneven spatial development or a polarized pattern of relationship between rural and urban areas. On the other hand, Figure 3c implies that a small open economy with a relatively low tariff rate may have a polarized regional development if it encounters a market access problem for its output in the rest of the world.

4. CONCLUSIONS

There has been a growing interest in trade policy reforms in LDCs. The KL model is an influential piece of work that has illuminated the relationship between spatial agglomeration and trade policy in this context. It was inspired by the impact of Mexico's trade liberalization on the county's regional inequalities. This study is set out with a modest objective of examining the relevance of the KL model to the conditions of other LDCs.

The numerical simulations suggest that trade liberalization can contribute to the objective of reducing regional inequalities in a LDC. However, we have shown that the KL model's conclusion critically depends on the assumption of "zero-export trade costs". Given that Mexico's trade liberalization was accompanied by the establishment of NAFTA, the KL model could be suitable to explain similar situations where a LDC may enjoy free access to a large external market.

In order to capture the conditions of trade reforms, we began with a relatively high external trade barrier in a hypothetical LDC and reduced tariffs unilaterally and gradually in two scenarios. In the first scenario, as in the KL model, we have assumed that there were no restrictions for domestic firms to access the external market. The results from our numerical simulations are similar to those from the KL model in that trade liberalization reduces inequalities between the domestic regions. In the second scenario, we have assumed the existence of trade barriers in the external region. In this case, our numerical simulations have shown an outcome diametrically opposite to that of the KL model. Although the size of the export trade cost parameter imposed is relatively low, this was strong enough to upset and reverse the KL model results with trade liberalization not being able to improve regional inequalities.

This study draws attention to the potential of reciprocal policy reforms in trading arrangements, particularly between LDCs and advanced economies, to ameliorate core-periphery relationships between urban and rural areas in LDCs. We have argued that market access problems faced by LDCs is an issue that cannot be ignored in evaluating the success of economic reforms. Hoekman (2001, p.3) observes that despite the low average manufacturing tariff rates that apply in LDCs, tariffs for some commodities are over 100 percent, with most tariff peaks often concentrating in products that are of exporting interest to LDCs, (e.g. textiles and clothing). Hoekman cites a specific case of the US trade during 1999, when imports originating from LDCs generated tariff revenue amounting to 11.6 percent of the value of their exports to the US and 15.7 percent of dutiable imports. Eliminating such market access barriers can help boost investment incentives, expand trade related employment opportunities, reduce urban-rural imbalances and contribute to poverty alleviation programmers.

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