

Resource Effects in the Core-Periphery Model

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The new economic geography (NEG) studies the causes of the uneven geographical distribution of the economic activity and its evolution through time. To explain large economies of scale, those exceeding the borders of a country, a type of technological externalities that does not decrease much with distance, or pecuniary externalities are necessary. NEG's models formalises these kinds of externalities (cumulative causation mechanisms) to explain how similar regions can endogenously differentiate into a rich "core" and a poor "periphery" (Ottaviano et. al. 1997).

Krugman's model (1991) can somehow be considered the first NEG model. It consists in a two region and two sector model. On the one hand, there is an industrial sector that operates in monopolistic competition (Dixit and Stiglitz, 1977). Firms in this sector are subject to fixed costs and uses only labor as productive factor. By incurring in iceberg transportation costs, industrial goods are tradable between regions. On the other hand, there is a perfectly competitive traditional sector, which also uses labor. The traditional good is freely tradable between regions. There is no labor mobility between sectors; that is, each sector has an specific factor. While the labor employed in the industry can move from one region to the other, the labor employed in the traditional sector is "attached" to the region. As a result of this setting, agglomeration and dispersion forces arise in the model. The final spatial distribution depends on what forces dominates.

The traditional sector plays a key role in Krugman's core-periphery model. Under certain conditions, this sector is the only one which can ensure that the forces of agglomeration not always dominate over the dispersion forces, which contributes to the appearance of stable symmetric solutions. Otherwise, only agglomeration equilibria would be stable. Despite it's importance, Krugman's model and the follow-up literature usually focuses on the industrial sector, treating the traditional sector as residual, and often calling it primary or "agricultural" sector.

This paper focus on how the agglomeration and dispersion effects of the core-periphery model changes after incorporating a more real primary or agricultural sector instead of the residual traditional sector. In order to do so, the original core-periphery model is modified by introducing two features of the primary sector. First, the dynamics of the natural resources used or depleted to produce the primary good is taken into account; in accordance with the environmental economic literature. Second, the double function of primary goods either as an input for industrial production and as a consumption good for households is considered.

This paper develops an extension of Krugman's model (1991) in an attempt to overcome the usual residual form of the traditional sector. The incorporates two key features of the agricultural sector: the dynamics of the natural renewable resources, and the possibility of

using raw materials as inputs in the industrial production. A non-tradability assumption of the primary good is made in search of a more tractable model. Nevertheless, raw material are considered as inputs in the production of tradable final goods, which allows an indirect tradability of the resources. The other major difference with the original model is the free labor mobility between sectors.

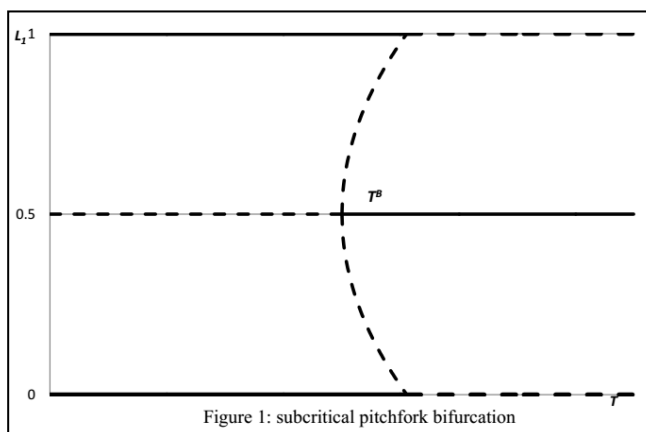
This configuration of the core-periphery model has all the effects of the traditional NEG modes: home market effect, industrial price index effect, and competition effect. However, due to the non-tradability assumption and the free labor mobility, the symmetric equilibrium in Krugman's model would always be unstable. This is because the home market effect always dominates over the competition effect, regardless of the value of the parameters.

Once the dynamics of the natural resources are taken into account, two new dispersion forces arise: the primary price index effect and the resource effect. These effects illustrates two very common facts: non-tradable goods also have an impact over real wages; and firms take into consideration the proximity of raw materials, as a way of reducing costs. Furthermore, under certain conditions, these dispersion forces overcome the agglomeration ones driven by the industrial price index and the home market, making the symmetric equilibrium stable.

One of the main results that stands out is that the stability pattern of the traditional core-periphery models is reversed. As transportation cost decreases the symmetric equilibrium becomes stable and agglomeration equilibria becomes unstable. Because there is no fixed income or fixed market, as in Krugman (1991), the only role of transport costs is to reinforce the home market effect. The latter loses strength with the decrease of transport costs. This reversed pattern is consistent with the empirical findings of Barrios and Strobl (2004) for European Union.

The model also gives insights of the transition between agglomeration and dispersion. The conditions for a pitchfork bifurcation and a Hopf bifurcation are determined. The former one implies two non-symmetric equilibria around the symmetric one. Depending on the productivity of the primary sector, the pitchfork bifurcation can be subcritical or supercritical. These two patterns illustrates different processes.

The process depicted by the subcritical case implies a sudden change in the agglomeration-dispersion pattern (Krugman et. al. (1999)). In this case, the bifurcation diagram has a Krugman's 'tomahawk' shape but the stability is inverted (Figure 1). The non-symmetric interior equilibria connecting the agglomeration and symmetric solutions are unstable; thus, the



change in the spatial configuration is sudden.

Starting from a low value of the primary productivity (subcritical bifurcation case) where dispersion forces are weak, and high transport costs, economies lies outside the stability region. As transportation cost decreases we move to the right in Figure 1, and at T^B a subcritical bifurcation take place. The peculiarity of this pattern is that for a $T \in (T^B, T^S)$ both agglomeration and dispersion equilibria are locally stable. This occurs precisely because dispersion forces are weak, so when the distribution of the economic activity is near to be fully agglomerated, the size of the market can still overcome the dispersion forces even at relatively low transportation costs. However, when the distribution of the economic activity is near the symmetric equilibrium the home market effect is not too strong because the difference between the sizes of the markets is small; then, dispersion forces can overcome agglomeration forces.

When the bifurcation is supercritical (Figure 2), the change from agglomeration to dispersion of economic activity is smooth. The bifurcation diagram closely resembles the one derived by Helpman (1997). The interior non-symmetric equilibria are stable, and connects the agglomeration and dispersion solutions, given rise to a smooth path between these two spatial configurations.

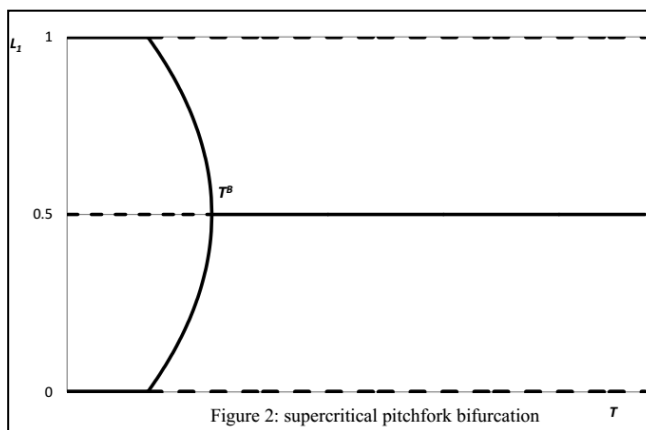


Figure 2: supercritical pitchfork bifurcation

When the productivity of the primary sector is high, and the transportation cost is high, the economies are outside the stability region and at T^B a supercritical bifurcation take place. In this case ε is relatively high; dispersion forces are stronger, so T^S and T^B are lower than in the subcritical case. The main difference is that for a $T \in (T^S, T^B)$ both agglomeration and dispersion equilibria are now locally unstable while the other two non-symmetric interior equilibria are locally stable. Why this pattern take place? Dispersion forces are strong, so agglomeration equilibria became unstable at a low value of T . In this point however, the home market effect is still strong due to high transportation cost and the size of the market, then, the symmetric solution is also unstable. While the non-symmetric equilibria are stable because, if a new firm decide to move to the most populated region, the high productivity in the resource extraction causes a sharp increase in the primary prices and dispersion forces activates; and if a firm decide to move to the less populated region, this firm will have to pay high transportation cost to have access to the larger market and agglomeration forces are set in motion.

The shape of the bifurcation patterns depicted in this paper reinforce the one found by Helpman (1997), although the forces working are not the same. On the other side, if the model presented had an stronger competition competition effect, the outcome would be a combination of Krugman's diagram and the ones derived from the model developed in this

paper (Figures 1 and 2). Then, the results presented, rather than opposite, are complementary with Krugman's findings; similarly to the diagram presented in Puga (1998).

Regarding the depletion of natural resources, three intervals for the parameters can be identified to understand the sustainability of the equilibria. In this point the productivity of extraction turns out to be a key parameter again. Some relations between others parameters of the model and the sustainable level are derived in order to understand why an equilibrium can become unsustainable. If for any reason a solution becomes unsustainable, it can not longer be an equilibrium.

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