An Economic Geography Model with Natural Resources

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Introduction

One of the surprising features of modern economic growth is that economies abundant in natural resources have tended to grow lower than economies without substantial natural resources (Sachs and Warner). This paper analyzes the "resource curse" of the New Economic Geography, which was initiated by P. Krugman in the early 1990’s. The Economic Geography studies the causes of the uneven geographical distribution of economic activities and its evolution through time.

The model is a variant in the monopolistic competition framework initially proposed by Dixit and Stiglitz (1977). It is a dynamic version of the two-region model by Krugman (1991) which incorporates differences between the natural endowments of two regions with the aim of studying the causes of a resource curse. It can also be seen as an open-economy version of the growth model by Grossman and Helpman (1991) which incorporates natural resources as consumption good. The main elements of the new economic geography like transportation costs and economies of scale are also present.

Although there is abundant literature, theoretical and empirical, on the resource curse, the issue has not been addressed from the spatial perspective, as we do in this paper. In that context, imperfect market competition and migratory flows (of labor and firms) can affect the economic growth rate, and the distribution of the industrial activity. We study the effects of an unexpected increase in the natural resource sector in one of the countries. This is what happened in Venezuela with the Mene Grande discoveries in 1914; in Nigeria with the discoveries of oil in the Niger Delta (1956) and during the seventies in Northway, when the magnitude of its oilfields was discovered; among others. In all these examples, the resource curse hypothesis was satisfied. The countries experimented a decrease in the growth rates.

The Model

We consider a model of two regions. In this model there are assumed to be two kinds of goods: manufactures, which are tradable goods produced by an increasing-returns sector that can be located in either region, and agricultural good, that have the characteristic of being non-tradable across regions. Each region possesses a natural resource endowment to produce the agricultural good.

Households

All individuals in this economy are assumed to share the intertemporal utility function, that they seek to maximize, (as in Krugman 1991). Households (or individuals) can consume an agricultural good and manufactured goods, that are produced in the region or in the foreign.
The latter must be imported, incurring in transportation costs, that will be assumed to take Samuelson’s “iceberg” form, in which transport costs are incurred in the good transported.

**Industrial Sector**

We can now turn to the behavior of firms. Industrial firms seek to maximize their profits, in a context of monopolistic competition. The production of an individual manufactured good “i” involves a fixed cost and a constant marginal cost, giving rise to economies of scale:

$$x_i = \frac{(l_{x_i} - \varphi_i)^2 \mu_i^{1-\varepsilon}}{\rho}$$

where $l_{x_i}$ is the labor used to produce, and $x_i$ is the good’s output. The fixed cost $\varphi_j$ depends on the region $j$ and it is defined as $\varphi_j = \rho / n_j$, that is, the higher the number of firms in a region $n_j$, the lower the fixed cost. The production function is similar to the one proposed by Krugman (1980, 1991).

**R&D Sector**

At a point in time, the technology exists to produce $u_1$ (in country 1) and $u_2$ (in country 2) varieties of industrial goods. An expansion of these numbers requires a technological advance in the sense of an invention that permits the production of the new kind of industrial goods. Following Romer/Crossman-Helpman/Aghion-Howitt, the change in $n_j$, with $j = 1,2$, will be equal to the number of people attempting to discover new ideas, $I_{n_j}$, multiplied by the rate at which R&D generates new ideas, $n_{n_j}$. Any individual is allowed to enter the R&D sector and prospect for new designs, so that labor must receive the same compensation in its two uses.

**Natural Resource Sector**

While in the natural resource sector, a typical primary firm will maximize their benefits, choosing the amount of labor to employ in the extraction of the resource, subject to the extraction function. The extraction (or harvesting) of the resource is a direct function of: the available stock of the natural resource in the region, $S_j$, the labor employ in the extraction, $l_{x_j}$, and $\xi_j$, that is a productivity parameter. We consider are new ablere source, wich reproduction depends on the rate, $g_j$, the stocks of resources at each moment of time, $S_j$, and the carring capacity, $C_j$, through a logistic function.

**Short-Run Equilibrium**

Now we can ask to our model: What happens when new sources of natural resources are discovered, or when the state of the environment facilitates its regeneration? The following Propositions shed some light on this:

**Proposition 1:** Starting from a position of symmetry between the two countries ($L_1 = L_2$ and $S_1 = S_2$, so $w_1 = w_2$), when the natural resource is devoted only to
final consumption, a shock of natural resources that takes place in one of the two regions, such that $S_1 > S_2$, will not modify the equilibrium wage rate, and hence $W_1 = W_2$.

If a suddenly increase of $S_1$ happens, since it is not a tradable good, the excess of natural resource supply in region 1 will generate a decrease in the price of this resource until the population of the same country be willing to consume all of it, so their incomes will not be affected by this shock. But, if the primary good is used as an input, changes in the price of there source will affect the price of industrial goods, and wages will change due to the resource effect.

**Proposition 2:** When the natural resource is devoted to final consumption as well as to industrial production, an increase in there source endowment of one of the regions, will increase the wage of this same region.

For example, assuming that we start form a symmetric position between regions, if the ratio of resource endowments increases, due an external shock, since the resource is not tradable, the ratio of resource-prices will fall, and initially, the aggregate expenditure will not be affected. However, the industrial firms in region 1 will benefit from a cheaper input. This will allow them to reduce the price of industrial goods, increasing sales at expense of firms in region 2, causing an increase of the exports and a reduction of the imports of region 1. This increased demand for industrial goods in region 1, generate supward pressure over the price-ratio and wage-ratio, that will increase until the pressure disappears, ie when the trade balance again be in equilibrium.

**Long-Run Equilibrium and Transitional Dynamics**

In the balance growth path (BGP), the expenditures and wages grow at the same rate, while the stocks of natural resources are constants over time; we are in a sustainable path. The differential growth rate, between the economies, is:

$$\dot{y} = \frac{\gamma_1 - \gamma_2}{\sigma - 1} = \frac{\eta_1 L_1 - L_2}{\sigma - 1}$$

A few things can be said of distribution of the labor force between sectors and the growth rate. When the economies of scale increases (a reduce of $\sigma$), the industrial sector is more efficient and the labor force, released by this sector, can be devoted to research activities; although both regions will increase their work in research, it increases more in the most populous country, acelereting it's growth. If what rise sis the proportion of the expenditure in industrial goods ($\eta$), the demand for this goods will be greater, and more labor will be devoted to production and research of new varieties of goods; the primary sector will decline, and the largest region will benefit again, in terms of growth rates. If ($\eta$) is bigger, the rate of succes of the research is greater, other thingsequal, the R&D sector is more productive, attracting labor force from the others sectors, promoting he growth. Thus, when he productive structure favors the industrial sector (low value of $\sigma$ and high value of $\eta$) and
innovation (high value of \( \eta \)), the region with the largest populations can gain a greater advantage, in terms of growth.

We have no wall the elements to study the consequences of a resource shock. It is evident from the last equation, that a shock in then dowment of natural resources, does not affect growth in the balance growth path. However, it does have effect son wage levels, and the transition to the long-run equilibrium.

Because we are interested in there source curse; assume that economies are in the irrespective balanced growth path, and that at time, a positive shock take place, such that region 1 have, a resource stock greater than the equilibrium level. In the short-run, there source effect take place. But, instead of thinking in as an increase in the ratio of wages from the path in which it was; what happens is that the path moves downwards.

The effects over the transition to the balance growth path, however, are more complex. Lets call \( \gamma^T \) to differential growth rates in transición towards the long-run equilibrium:

\[
\gamma^T = (1 - \alpha)(\gamma_x - \gamma_f) + \frac{\gamma_{s1} - \gamma_{s2}}{u - 1}, \quad \Delta S_{1}^{B1} = \frac{\eta_{s1} L_{1} - L_{2} C_{1}}{u - 1} \frac{\eta_{s2}}{1 - u}
\]

Lets focus on the more interesting case, when \( L_{1} > L_{2} \). In this case, we have two alternative scenarios, depending on the size of the resource shock \( \Delta S_{1}^{B1} \). When the shock is lower than certain threshold \( \Delta S_{1}^{B1} \), we can observe a jump of the wage-ratio due to the resource effect, follow by a transition towards the BGP, where: \( \gamma > \gamma^T > \gamma_{B1} \). In the second scenario (Figure), the shock is bigger, such that \( \Delta S_{1}^{B1} > \Delta S_{1}^{B2} \), so the jump of the wage ratio is greater too, and the transition have two faces. When the initial shock is larger than the threshold, the wage ratio is much larger than it's long-run value, due to there source effect; so that the economy begins to experience negative growth rates \( \gamma^T > 0 > \gamma^F \), in a first face. While the wages diminish, the initial shock start to vanishes, until it becomes lower than the threshold. At this point, the economy, again begin to grow, albeitat a lower rate than in the BGP \( \gamma^T > 0 \). Finally, the transition growth rate converges to the long-run rate. However, the ratio of wages in each moment of time is now lower than before the shock.

Certain regularities are observed with respect to pro-industry and pro-primary economies. When the values of the parameters are such that favor the primary activity, the growth during the transition to the BGP will be lower than if the production structure favors the industrial sector.
Allowing Migratory Flows

Until this point, we had analyze a model where people work in the same region where they were "born". In this section, we want to change this assumption, allowing migratory flows between regions. We need to model this flows. Following Krugman (1991), workers will move to the region with higher real wages.

Proposition 3: In the BGP, both economies grow at the same rate. But, the economy with greater stock of natural resources will have lower wages and less variety of industrial goods.

Suppose that region 1 have a greater natural resource stock. The supply of primary goods will be greater too, making its price lower. The nominal wages should be higher in the region with the lowest natural endowment to maintain the balance of real wages, and to avoid migratory flows. However, with the things equal, the highest nominal wage create a trade imbalance between regions. Exports of region 1, exceed imports. To prevent his imbalance, region 2 must have a greater variety of industrial goods, to attract the excess demand.

Conclusions

We have studied a model of trade between two countries. Both regions are endowed with a renewable natural resource which is used as input and it is also a final consumption good. The natural resource . The model has the main elements of the new economic geography like transportation costs and economies of scale.

In the model with outmigration, a positive shock in there source sector, causes lower growth rates, or even negative, during the transition to the long-run equilibrium, and a lower level of wages, due to there source effect. While, in the model that allow migratory flows, both economies grow at the same rate, but, there is a negative relationship between natural endowment and industrialization. This comes as a result of the interaction of the resource, expenditure and variety effects, together with the real wage equalization.

References