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Economic development according to Friedrich List

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Economic development according to Friedrich List

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Abstract:

In this paper, we develop a Listian model of economic development. The economy consists of a primary sector and a potential industrial sector that can arise via industrialization. Industrialization however depends on if the primary sector specializes on the primary product, which can lead to a division of labor between the primary and the industrial sector. In this case, the industrial sector will use a modern technology to produce industrial goods. If such does not occur, the primary sector continues to produce all goods with a traditional technology of production. In addition, the industrial sector has to decide if it concentrates production in one location or if it disperses production in two locations. We show that the level of transport costs matters for division of labor and for the degree of manufacturing agglomeration if and only if the refinement of the primary input is strong, i.e., if the raw material loses a lot of weight through industrial transformation. Otherwise, if the industrial process is not so much “weight-losing”, industrialization can begin with a decentralized symmetric spatial pattern independently of the transport costs level.

Keywords: Friedrich List; Economic Development; Industrial Agglomeration; Division of Labor.

JEL Classification: O14, R11, R30

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Introduction

Friedrich List is mostly known for the infant industry argument of protection³. However, everyone that reads his main opus *The National System of Political Economy* (List, 1841), will easily realize that the main focus in List's philosophy is how to develop economically a nation. In particular, List main concern is how a country can transform its economy from an agricultural one to an industrial one.

In this paper, we develop a *Listian* model of economic development. The economy consists of a primary sector and an industrial sector that can potentially arise via industrialization. Industrialization however depends on if the primary sector specializes on the primary product, which can lead to a division of labor between the primary and the industrial sector. In this case, the industrial sector will use a modern technology to produce industrial goods. If such does not occur, the primary sector continues to produce all goods with a traditional technology of production. In addition, the industrial sector has to decide if it concentrates production in one location or if it disperses production in two locations.

In this sense, this paper combines the ideas of List on economic development with those of Adam Smith (1786) on the division of labor, and of Krugman (1991) on economic agglomeration⁴.

Although List recognizes the importance of Adam Smith's concept of "division of labor", he defends that Adam Smith ignores the idea of "productive power", i.e.: the potential that a country has to develop and industrialize. In other words, a country could for instance abdicate of some gains in the present accruing from trade in order to reap the future gains brought by economic development and industrialization.

In the same, way List seems to anticipate the ideas latter developed in spatial economics and economic geography. He for example states that:

"Compare, on the one hand, the value of landed property and rent in a district where a mill is not within reach of the agriculturist, with their value in those districts where this industry is carried on in their very midst, and we shall find that already this single industry has a considerable effect on the value of land and on rent; that there, under similar conditions of

³ See for instance Harlen (1999); Levi-Faur (1997a,b); and Sai-wing Ho (2005). Modern views on protection can be found in Krugman (1984, 1993), and Francois and van Ypersele (2002).

⁴ On the concept of division of labor see Pontes (1992), Stigler (1951), Williamson (1981), Young, (1928), and Becker and Murphy (1992). On the economics of agglomeration see Pais and Pontes (2008), Scott (1983), Scott (1986), Glaeser (1989), and Glaeser and Gottlieb (2009).

natural fertility, the total value of the land has not merely increased to double, but to ten or twenty times more than the cost of erecting the mill amounted to; and that the landed proprietors would have obtained considerable advantage by the erection of the mill, even if they had built it at their common expense and presented it to the miller. [...] As it is in the case of the corn mill, so is it in those of saw, oil, and plaster mills, so is it in that of iron works; everywhere it can be proved that the rent and the value of landed property rise in proportion as the property lies nearer to these industries, and especially according as they are in closer or less close commercial relations with agriculture. And why should this not be the case with woolen, flax, hemp, paper, and cotton mills? Why not with all manufacturing industries? We see, at least, everywhere that rent and value of landed property rise in exactly the same proportion with the proximity of that property to the town, and with the degree in which the town is populous and industrious.”

Furthermore, List defends that the gains from co-location are specific to the industrial sector. The same does not occur in the agricultural sector:

“Agriculture can only progress, the rent and value of land can only increase, in the ratio in which manufactures and commerce flourish; and manufactures cannot flourish if the importation of raw materials and provisions is restricted.”

In this sense, while List clearly argues against protection in agriculture, he seems to defend that tariffs on the industrial goods can either be dispensed in the starting stages of industrialization or not, depending on if the region has already a sufficient mass of industry to promote further industrial development.

Hence, List takes as a departure point the Adam Smith’s (1776) notion of “occupational” division of labor. Let us assume that a productive process, which was formerly achieved by undifferentiated workers, is split in heterogeneous tasks, each task being assigned to a different worker. Then, it can be shown that on account of several factors, a strong increase of labor productivity follows. This occupational specialization is, in Smith’s own words, “limited by the extent of the market”, by the number of workers that can be engaged in the specialization process. This set of potential participants is bounded from above by the population density and by the state of transport and communication technology.

By comparison with Adam Smith (1776), Friedrich List focuses the geographical dimension of the division of labor. Not only complementary tasks are performed by different workers, but

also they can be done in different regions/countries, which then specialize in heterogeneous sets of productive tasks.

List regards the geographical division of labor as a socially **negative** phenomenon for two kinds of reasons. First, it makes the constraint that market size exerts upon industrialization more binding, since upstream and downstream tasks are now performed over long distances in different regions or countries. Second, he considers that geographical specialization leads inevitably to cumulative development asymmetries across regions and countries. List's argument is the following. The separate tasks that result from the division of labor have different degrees of "capitalization", i.e., intensity in the use of capital, both physical and human.⁵ Hence, national or regional specialization in subsets of tasks leads to different degrees of capital intensity across space. As market forces tend to reward basically physical and human capital rather than "raw" labor force, spatial inequalities in "capitalization" will reinforce themselves in a cumulative way.

List then proceeds to enumerate the policy tools that can prevent the geographical division of labor to arise, the most obvious one being high tariffs. However, List's discussion goes far beyond an argument in favor of trade protectionism as we shall see ahead.

The rest of the paper is organized as follows. In the next section, we describe the basic assumptions of the model. Then we introduce the rules of the game of the spatial economy. We then derive the equilibrium of the game. We conclude by discussing the main findings.

⁵ Friedrich List seems to be the first economist to use the concept of human capital, which he labels as "mental capital".

Assumptions of the model

We assume a spatial economy that is described by the following assumptions:

There are two countries, Home (H) and Foreign (F), that are completely symmetric in number of consumers/workers, land endowment and available technologies of production.

The economy entails the production of an agricultural (or “primary”) good, which is transformed to give a manufactured composite consumer product. The two goods are strictly complementary in production, in the sense that there is a fixed proportion between the rate of output of agriculture and manufacture. W. l. g., we assume that this proportion is “one to one”.

The technology of agricultural production is constant returns to scale, and we can model it through a Cobb-Douglas production function:

$$Q = AL^\alpha S^{1-\alpha} \quad (1.1)$$

where

$Q \equiv$ Agricultural output

$A \equiv$ Productivity parameter

$L \equiv$ Labor input

$S \equiv$ Land input

α is a parameter such that $0 < \alpha < 1$

We assume that each country has the same fixed amount of agricultural land that is used in production. For instance, we may assume that each country contains n farms, each having one unit of extent. Hence, each country uses an amount of land $S = n$.

By choosing adequate unit measures for the agricultural output, A reduces to unity. Furthermore, if the production function (1.1) is divided by S , it becomes

$$q = l^\alpha \quad (1.2)$$

where

$q \equiv \frac{Q}{S}$ is the productivity per unit of land

$l \equiv \frac{L}{S}$ is the intensity of cultivation, i.e. the amount of labor used per unit of land

It is then clear that the marginal returns of applying labor to land are decreasing.

We also assume that the number of farmers, n , is high enough so that they work under conditions of perfect competition. The competitive price of the composite consumer good is labeled as p_c and is taken by all farmers.

The technology of transforming the agricultural good in order to produce a consumer good depends on the existence of vertical integration between the successive production stages.

If the agricultural good is processed “in-house” by the farmers themselves, the production entails only variable costs, the average labor productivity in refining being labeled θ . Given the complementarity between the two tasks, agriculture and manufacture, the intensive (per unit of land) production function is given by:

$$q = \text{Min}_l \{l^\alpha, l\theta\} = l^\alpha \quad (1.3)$$

By solving the inequality

$$\theta l > l^\alpha$$

It is easy to realize that production function (1.3) holds if

$$\theta > l^{(\alpha-1)} \quad (1.4)$$

Otherwise, if $\theta < l^{(\alpha-1)}$ holds, the labor productivity in agriculture exceeds the productivity in the task of refining the input. Hence, less than the whole agricultural output can be transformed, thus preventing the fixed proportion between the output rates of the two tasks to hold. Condition (1.4) is more binding if the productivity of the manufacturing activity θ is low.

By contrast, if input transformation is vertically disintegrated, it will be performed by a monopolist firm with a fixed equipment (a machine) embodying F units of labor in its

construction. It is assumed for simplicity that the working of the machine requires no variable costs. Hence, the intensive production function that concerns the collaboration of independent firms (farmers and a manufacturing factory) is, if we assume that the fixed cost is already sunk:

$$q = \text{Min}_l \{l^\alpha, +\infty\} = l^\alpha \quad (1.5)$$

Transport costs of goods within each country are zero. Both the primary input and the consumer goods have an “iceberg” transport cost $\tau > 1$. It is necessary to dispatch an amount $\tau > 1$ from the origin country in order that one unit amount arrives in the host country. We also assume that the transport cost is paid by the purchaser, so that a *job mill pricing regime* holds in this spatial economy.

The rules of the game

In Figure 1, we plot the extensive form of the game that models our spatial economy.

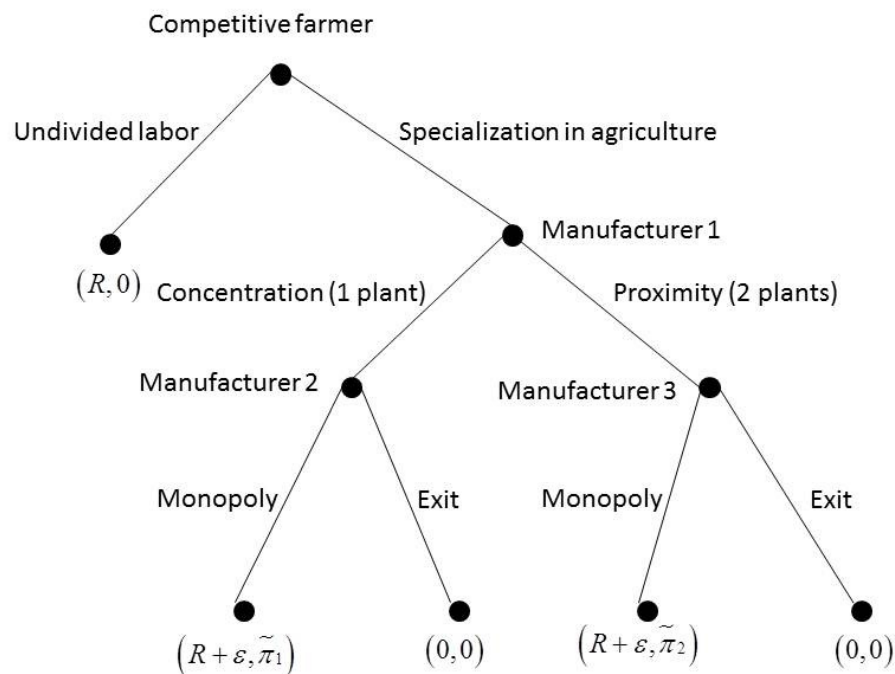


Figure 1: Game in extensive form

In words, each competitive farmer decides first whether to transform the agricultural product in-house or sell it in the market thus letting another firm to perform the transformation into a finished consumer good. All farmers take the same decision concerning vertical integration, since they are symmetric.

If the farmers decide to specialize in agriculture, a manufacturing firm makes the processing. This firm makes first a location decision: either to concentrate geographically production by setting up only one plant in a country (Country F, w.l.g.) and serving the other market through exports; or setting up two plants, one in each country in order to serve the local demand thus achieving proximity between production and customers. The former strategy entails positive transport costs of the consumer good, while saving on fixed costs if it is compared with the latter strategy.

If condition (1.4) holds, the profit function of the vertically integrated farmer is:

$$\pi = p_c l^\alpha - (w + \theta)l - R \quad (2.1)$$

Profit function (2.1) implicitly assumes that labor is not divided. The same workers perform both productive tasks: land cultivation, with wage rate w ; and agricultural good processing, with wage rate equal to θ , the labor productivity in this task. R is the land rent which we assume to be earned by the farmers themselves, so that they are also land owners. Since farmers work under competitive conditions, the profit is kept at a zero level and land rent can be written from (2.1) as

$$R = p_c l^\alpha - (w + \theta)l \quad (2.2)$$

Henceforth, we will assume that the land rent R in (2.2) is the farmer's payoff in the game depicted in Figure 1.

Let us consider now the outcome of vertical integration by the farmers. By maximizing the rent function (2.2) in relation to l , we obtain the optimal intensity of cultivation l^* :

$$l^* = \left(\frac{p_c \alpha}{w + \theta} \right)^{\frac{1}{1-\alpha}} \quad (2.3)$$

The optimal cultivation intensity increases with the competitive price of the consumer good and decreases with labor rewards both in cultivation and in processing. Combining (1.3) and (2.3), we obtain the productivity per unit of area (or the output of each farm):

$$q^* = (l^*)^\alpha = \left(\frac{p_c \alpha}{w + \theta} \right)^{\frac{\alpha}{1-\alpha}} \quad (2.4)$$

The output of each farm varies similarly to the optimal intensity of cultivation.

It is also clear that the transformation of the agricultural input is a refinement, in the sense that it brings about a loss of volume/weight by the raw material. Hence, if the farmer specializes in primary production and is paid a price k for the raw product, the optimal intensity of cultivation is

$$l^0 = \left(\frac{k \alpha}{w} \right)^{\frac{1}{1-\alpha}} \quad (2.5)$$

In turn, the productivity per unit of area becomes

$$q^0 = \left(\frac{k \alpha}{w} \right)^{\frac{\alpha}{1-\alpha}} \quad (2.6)$$

From (2.4) and (2.6), we simplify inequality

$$q^* < q^0$$

To get the condition

$$\frac{\theta}{w} > \left(\frac{p_c}{k} - 1 \right) \quad (2.7)$$

Usually, we have $p_c > k$ because the former price covers both raw food production and transformation, whereas the latter only pays for agricultural costs. Hence, transformation will be weight-losing if the labor cost of processing is a significant share of total wage costs. We can assume this condition to hold.

A monopolist firm now makes the transformation of the input. This change goes together with a technological shift in transformation. The unit variable cost of manufacturing, which was $\frac{1}{\theta} > 0$ in the former production regime switches to zero, while a fixed cost $F > 0$ emerges.

This latter cost was absent before and its arise means that manufacturing ceases to done in the context of a “cottage” and it becomes performed in a large “factory”.

As it is depicted in Figure 1, the monopolist manufacturing firm has two available locational strategies.

Consider first the strategy that consists in setting up a single plant in the Foreign country in order to serve the local market and export back to the Home country. This geographic concentration strategy allows the firm to save on fixed costs but incurs on higher transport (trade) costs related with moving the consumer goods across the countries.

The profit function of this concentration strategy is:

$$\pi_1 = (p_m - k\tau)Q + (p_m - k)Q - F \quad (2.8)$$

where

p_m is the fob mill price of the consumer good

k is the fob mill price of the agricultural input

Q is the total output of the consumer good in each country

Since we assume that the two goods (agricultural and manufactured) are complementary, the proportion between their rates of output is fixed. Hence, Q stands for the output of both goods. Difference in weight between input and output is reflected in the respective prices, k and p_m .

In profit function (2.8), τ stands for the “iceberg” transport (trade) cost between the two countries. It is necessary to dispatch exactly $\tau > 1$ units of a good from the home country so that exactly one unit arrives to destination. A share $\frac{\tau - 1}{\tau}$ of the sent good is lost in transit.

We also define the following prices,

$p_f \equiv$ fob mill price

$p_d \equiv$ delivered (full) price

The relation between p_f and p_d is given by

$$p_d = \tau \cdot p_f \leftrightarrow \frac{p_d}{p_f} = \frac{\text{amount dispatched from origin}}{\text{amount arriving to destination}} = \tau > 1 \quad (2.9)$$

In addition, it is assumed that each seller uses a spatial price policy consisting **in charging the same fob mill price to all its customers.**

If the industrial firm decentralizes production by setting up two plants, one in each country, his profit function is

$$\pi_2 = 2[Q(p_m - k) - F] \quad (2.10)$$

Where k , p_m and Q have the same meaning as in (2.8).

The following stage in the game whose extensive form is plotted in Figure 1 entails the selection of prices by the manufacturer both for the intermediate good, k , and for the consumer good p_m . We suppose here that the processing firm has two available actions, namely, either to behave as a monopolist or exiting the market.

If the manufacturer intends to be a monopolist, it is aware that it faces elastic demands, in the form of a lower bound for the agricultural input and a higher bound for the price of the final consumer good. Were these bounds not respected, the competitive farmers would have an incentive to switch to vertical integration of primary production and manufacturing, refining the input in-house and selling the consumer good directly to the consumers.

Nevertheless, if the manufacturer sets these limiting prices, it may happen that its profit is negative. Then, the refiner has an incentive to exit the market. A non-coordination situation (a sort of "poverty trap") arises, the output of the consumer good being reduced to zero.

Let us consider first that the manufacturer has previously decided to set up a unique plant in the foreign country, thus concentrating geographically the production. Its profit function is expressed in (2.8). We have to calculate the prices of the input and the final good, k and p_m respectively that maximize its profit, while deterring farmers to return to vertical integration.

Clearly, each consumer should be able to purchase the manufactured good at a price p_m not higher than the competitive price p_c . Hence, p_m fulfills the condition

$$p_m \leq \frac{p_c}{\tau} \quad (2.11)$$

It appears as self-evident that the monopolist maximizes profits in (2.8) by quoting output price as

$$p_m = \frac{p_c}{\tau} - \varepsilon, \text{ where } \varepsilon > 0, \text{ arbitrarily small} \quad (2.12)$$

Derivation of the limit price for the agricultural product is more involved. Let $R(\cdot)$ be the land rent as a function of the price that each farmer receives for his output. Then, intermediate good price k should lead each farmer to have a rent level at least as high as the level that he would get by integrating vertically in the context of a competitive market, i.e.

$$R(p_c) \leq R(k) \quad (2.13)$$

$$R(p_c) = p_c q^* - (w + \theta) l^* \quad (2.14)$$

$R(p_c)$ is the land rent under vertical integration. q^* and l^* are the optimal output and input under vertical integration, being given by (2.4) and (2.3), respectively. It is not difficult to conclude that the land rent is given by:

$$R(p_c) = p_c^{\frac{1}{1-\alpha}} \left(\frac{\alpha}{w + \theta} \right)^{\frac{\alpha}{1-\alpha}} (1 - \alpha) > 0 \quad (2.15)$$

Moreover, the land rent of a farmer that only cultivates the land and receives a price k for the raw agricultural product can be shown to be:

$$R(k) = k^{\frac{1}{1-\alpha}} \left(\frac{\alpha}{w} \right)^{\frac{\alpha}{1-\alpha}} (1 - \alpha) > 0 \quad (2.16)$$

Equating (2.15) and (2.16), we have:

$$R(p_c) = R(k) \quad (2.17)$$

We solve this equality for price of the input k according to the following steps:

1. Substitute (2.15) and (2.16) into (2.17), and cut the common term $(1-\alpha)$, yielding:

$$p_c^{\frac{1}{(1-\alpha)}} \left(\frac{\alpha}{w+\theta} \right)^{\frac{\alpha}{(1-\alpha)}} = k^{\frac{1}{(1-\alpha)}} \left(\frac{\alpha}{w} \right)^{\frac{\alpha}{(1-\alpha)}}$$

2. Take logs and simplifying gives:

$$\ln k = \ln p_c - \alpha \ln \left(1 + \frac{\theta}{w} \right)$$

3. We assume that the productivity of the transformation task is not much higher than the reward of the land cultivation task, so that, $\frac{\theta}{w} > 1$ but it is small. Then, we can use the Maclaurin approximation, i.e., $\ln(1+x) \approx x$, for a small x , and obtain:

$$\ln k \approx \ln p_c - \alpha \frac{\theta}{w}$$

4. Taking exponentials, simplifying and solving for k , we obtain the input price k that solves equation (2.17),

$$k \approx \frac{p_c}{e^{\alpha \left(\frac{\theta}{w} \right)}} \quad (2.18)$$

Since $e^{\alpha \left(\frac{\theta}{w} \right)} > 1$, then $k < p_c$. The manufacturing firm quotes a price $k + \varepsilon$, $\varepsilon > 0$, arbitrarily small, for the intermediate good. This price is lower than the competitive price for vertically integrated farms.

The output of a farm that only performs agriculture and receives a price slightly higher than (2.18) for its output is, by analogy with (2.6), close to

$$q = \left(\frac{k\alpha}{w} \right)^{\frac{\alpha}{1-\alpha}} \quad (2.19)$$

Substituting (2.18) in (2.19), the farm output becomes

$$q = \left(\frac{p_c \alpha}{e^{\alpha \left(\frac{\theta}{w} \right)} w} \right)^{\frac{\alpha}{(1-\alpha)}} \quad (2.20)$$

Since each country has n farms, the output of the consumer good in both the Home and Foreign countries will be

$$Q = nq = n \left(\frac{p_c \alpha}{e^{\alpha \left(\frac{\theta}{w} \right)} w} \right)^{\frac{\alpha}{(1-\alpha)}} \quad (2.21)$$

Then, we have seen before in (2.8) that the profit function of a monopolist manufacturer that sets a single plant in the Foreign country is:

$$\pi_1 = (p_m - k\tau)Q + (p_m - k)Q - F$$

Where the first term stands for operating profits in the Home country, the second term represents profits in the Foreign country (where the single plant is located) and the third term is minus the fixed cost. This profit function may also be written as:

$$\pi_1 = Q[2p_m - k(1 + \tau)] - F \quad (2.22)$$

Plugging expressions (2.12), (2.18) and (2.21) into the profit function (2.22), the latter becomes

$$\pi_1 = n \left[\frac{p_c \alpha}{e^{\alpha \left(\frac{\theta}{w} \right)} w} \right]^{\frac{\alpha}{(1-\alpha)}} \left\{ \frac{2p_c}{\tau} - \left[\frac{p_c}{e^{\alpha \left(\frac{\theta}{w} \right)} w} \right] (1 + \tau) \right\} - F$$

Dividing by $2n$, we obtain the profit per inhabitant/farmer:

$$\tilde{\pi}_1 \equiv \frac{\pi_1}{2n} = \frac{1}{2} \left[\frac{p_c \alpha}{e^{\alpha \left(\frac{\theta}{w} \right)} w} \right]^{\frac{\alpha}{(1-\alpha)}} \left\{ \frac{2p_c}{\tau} - \left[\frac{p_c}{e^{\alpha \left(\frac{\theta}{w} \right)} w} \right] (1 + \tau) \right\} - \frac{F}{2n} \quad (2.23)$$

Henceforth, we adopt the notation,

$$\tilde{\pi}_i \equiv \frac{\pi_i}{2n}, i = 1, 2 \quad (2.24)$$

Hence, $\widetilde{\pi}_i$ stands for the per capita profit generated by a monopolist that sets up a number i (either one or two) of plants.

Consider now the subgame where the manufacturer has previously decide to establish two plants, so that its profit function is given by (2.10),

$$\pi_2 = 2[Q(p_m - k) - F]$$

In this case, Q and k are still given by (2.21) and (2.18), while the fob mill price of the final good is now equal to p_c since customers live in the neighborhood of a plant. Thus, the aggregate profit of a manufacturer that achieves proximity to consumers is

$$\pi_2 = 2n \left[\frac{p_c \alpha}{e^{\alpha \left(\frac{\theta}{w} \right)}} \right]^{\frac{\alpha}{(1-\alpha)}} \left[p_c - \frac{p_c}{e^{\alpha \left(\frac{\theta}{w} \right)}} \right] - 2F$$

Dividing π_2 by $2n$, we obtain the profit per inhabitant as:

$$\widetilde{\pi}_2 \equiv \frac{\pi_2}{2n} = \left[\frac{p_c \alpha}{e^{\alpha \left(\frac{\theta}{w} \right)}} \right]^{\frac{\alpha}{(1-\alpha)}} \left[p_c - \frac{p_c}{e^{\alpha \left(\frac{\theta}{w} \right)}} \right] - \frac{F}{n} \quad (2.25)$$

Finding the equilibrium of the game

The class of games depicted in Figure 1 contains purely sequential, perfect information games, whose subgame perfect equilibrium (SGPE henceforth) can be found very simply by means of backward induction.

We will reduce this class of games to one defined over three parameters:

- $\theta \equiv$ labor productivity in the refinement of the agricultural input when the processing is made by the farmers themselves, under vertical integration.
- $\widehat{F} \equiv \frac{F}{2n} \equiv$ per capita (“per farmer”) fixed cost whenever transformation of the input occurs under vertical disintegration.
- $\tau > 1$, “iceberg” transport (trade) costs across the two countries.

The following specifications of other parameters are made:

$$\alpha = \frac{1}{2} \quad (3.1)$$

$$p_c = 1 \quad (3.2)$$

$$w = 1 \quad (3.3)$$

We also give another form to parameter θ , through defining

$$\delta \equiv e^{\alpha\left(\frac{\theta}{w}\right)} = e^{\left(\frac{\theta}{2}\right)} \quad (3.4)$$

It can be seen very easily that δ has the following properties: it is greater than 1, it is strictly increasing and convex in θ .

δ can be directly interpreted as the “refining rate”, thus given the number of physical units (e.g., weight units) of the input should be consumed in processing in order to yield one unit of the final good.

This can be understood easily if we bear in mind the definition of the price of the intermediate good, k , in (2.18), together with definition (3.2), as we have that

$$\frac{p_c}{k} = e^{\alpha\left(\frac{\theta}{w}\right)} = \delta = \frac{\text{amount of input consumed}}{\text{amount of consumer good manufactured}}$$

With the numerical specifications (3.1), (3.2), (3.3) and the definition made in (3.4), it is clear that the profit function of a manufacturer that sets only one plant (written in (2.23)) simplifies to

$$\tilde{\pi}_1 = \frac{1}{4\delta} \left(\frac{2}{\tau} - \frac{1+\tau}{\delta} \right) - \hat{F} \quad (3.5)$$

If the manufacturer opts by settling two plants, then its profit function (written in (2.25)) simplifies to

$$\tilde{\pi}_2 = \frac{1}{2\delta} \left(1 - \frac{1}{\delta} \right) - 2\hat{F} \quad (3.6)$$

Since we have a class of games defined in three parameters and two-dimensional plots allow only to examine game situations in two parameters, we have chosen to assign two different values for the “iceberg” transport cost τ .

In empirical studies, it is usual to estimate trade costs as a 20% share of total exports or imports value. Hence, we will assume first that

$$\frac{\tau-1}{\tau} = \frac{1}{5} \leftrightarrow \tau = \frac{5}{4} \quad (3.7)$$

$\tau = \frac{5}{4}$ will be taken as the “normal” or “low” level for transport (trade) costs. By contrast, if trade relations between the countries deteriorate, the trade cost will be raised to the double of the level shown in (3.7), i.e.

$$\frac{\tau-1}{\tau} = \frac{2}{5} \leftrightarrow \tau = \frac{5}{3} \quad (3.8)$$

The case with low transport (trade) costs.

Substituting $\tau = \frac{5}{4}$ in profit function (3.5), condition $\tilde{\pi}_1 > 0$ is regarded to mean the same as

$$\hat{F} < \frac{32\delta - 45}{80\delta^2} \quad (3.9)$$

Furthermore, considering profit function (3.6), condition $\tilde{\pi}_2 > 0$ is equivalent to

$$\hat{F} < \frac{\delta - 1}{4\delta^2} \quad (3.10)$$

Let us assume now that $\tilde{\pi}_1$ and $\tilde{\pi}_2$ are both positive. Bearing in mind (3.5) and (3.6), with $\tau = \frac{5}{4}$, condition $\tilde{\pi}_2 > \tilde{\pi}_1$ can be seen to mean that

$$\hat{F} < \frac{8\delta + 5}{80\delta^2} \quad (3.11)$$

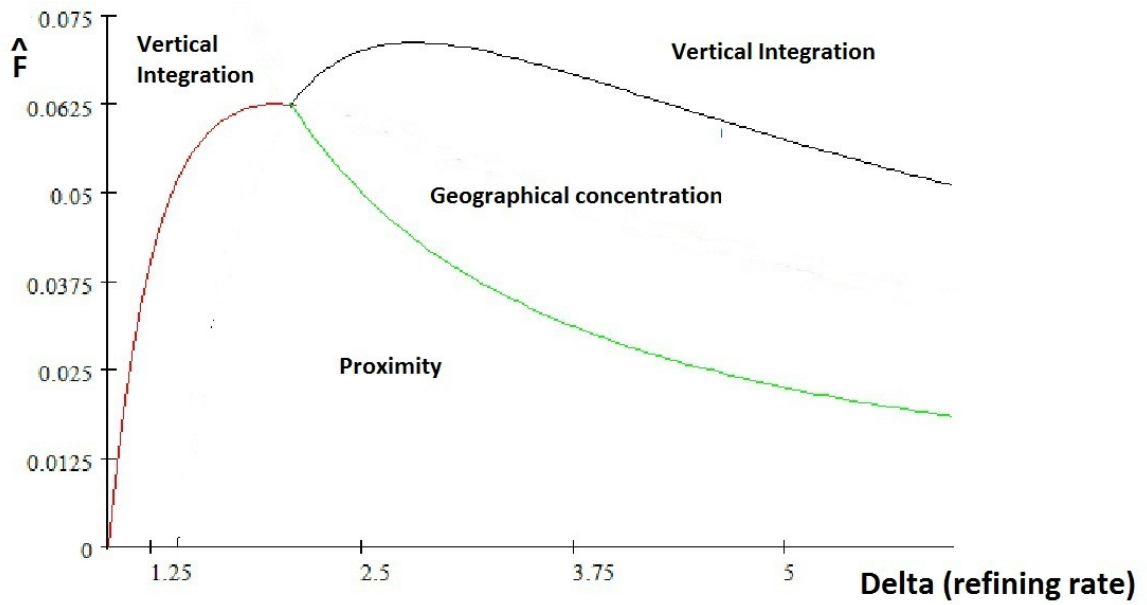


Figure 2: Industrialization under low transport (trade) costs

Figure 2 depicts the regions where inequalities (3.9), (3.10) and (3.11) are satisfied in parameter space (δ, \hat{F}) for low transport costs $\left(\tau = \frac{5}{4}\right)$.

The case with high transport (trade) costs

We now deal with the case with high transport (trade) costs, where $\tau = \frac{5}{3}$. Substituting this value of τ in profit function (3.5), the per capita profit of a firm setting up a unique plant is

$$\tilde{\pi}_1 = \frac{3}{10\delta} - \frac{2}{3\delta^2} - \hat{F} \quad (3.12)$$

The profit of a manufacturer which establishes two plants is still given by (3.6), since no transport costs are incurred here.

The condition $\tilde{\pi}_1 > 0$ is seen to be equivalent to

$$\hat{F} < \frac{9\delta - 20}{30\delta^2} \quad (3.13)$$

Condition $\tilde{\pi}_2 > 0$ is still equivalent to (3.10). Moreover, condition $\tilde{\pi}_1 < \tilde{\pi}_2$ has the same meaning as

$$\hat{F} < \frac{6\delta + 5}{30\delta^2} \quad (3.14)$$

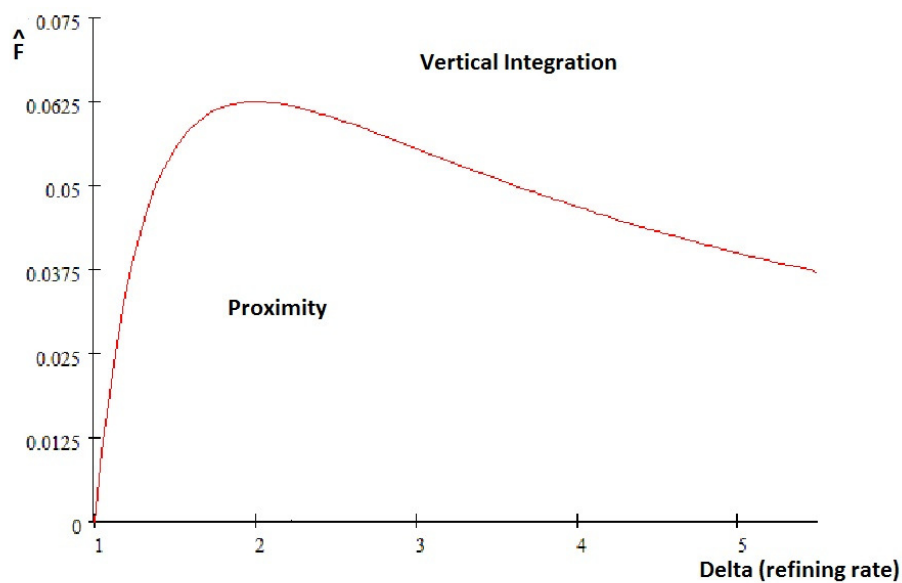


Figure 3: Industrialization under high transport (trade) costs.

Figure 3 shows the regions where inequalities (3.10), (3.13) and (3.14) are satisfied in parameter space (δ, \hat{F}) for high transport costs $\left(\tau = \frac{5}{3}\right)$.

Transport costs and the degree of industrial transformation as causes of industrial agglomeration

In this subsection, we assess the impact of transport costs and the degree of input refinement on the spatial concentration of manufacturing. Taking into account the profit function in (3.5) concerning the case where a single plant is set up by the industrial firm, we have

$$\tilde{\pi}_1 = \frac{1}{4\delta} \left(\frac{2}{\tau} - \frac{1+\tau}{\delta} \right) - \hat{F} \quad (3.15)$$

The partial first derivative of $\tilde{\pi}_1$ in relation to the transport cost “iceberg” rate, τ , is negative

$$\frac{\partial \tilde{\pi}_1}{\partial \tau} = -\frac{1}{4\delta} \left(\frac{2}{\tau^2} + \frac{1}{\delta} \right) < 0 \quad (3.16)$$

This result is natural since decreasing transport costs raises the profit of concentrating production in a single point in space. If we compute the cross partial derivative in relation to δ , we obtain

$$\frac{\partial \tilde{\pi}_1}{\partial \delta} = \frac{1}{\delta^2} \left(\frac{1}{\tau^2} + \frac{1}{\delta} \right) > 0 \quad (3.17)$$

Consequently, increasing the refining rate δ dampens the negative effect that increasing transport costs has upon the profit of a firm, which transacts its input and output across countries.

We can rationalize (3.17) by recalling that, under the “iceberg” technology, transport costs are amounts of goods (both manufactured goods and raw materials) that are “lost in transit” between production and consumption sites. Consequently, increasing the “refining rate”, δ , decreases the amount of input that must be carried between the farm and the factory in

order to produce one unit of manufactured good. For a given “iceberg” rate, τ , it also decreases the amount that is “lost in transit”

Another way of expressing this is to say that the transport cost of the input outweighs the freight cost of the manufactured product, since the industrial process consists in “refining” a raw material, converting it in a “lighter” product. As we have seen before, the transport cost of the input is $k(\tau-1)$. Since k , the fob mill price of the input, decreases with δ (see (2.18) and (3.4)), the total transport cost decreases with the “refining rate”, δ .

Hence, rising the degree of industrial transformation also favors the agglomeration of manufacturing in a single plant, in a single country, thus making a geographical division of labor to emerge.

Main conclusions

Four main conclusions arise:

- a) Division of labor, both occupational and geographical, is caused by low transport costs (low τ) and high population density (high n). Together these two factors bound the “extent of the market” from above, i.e., they limit the number of workers that are potentially available to engage in a specialization process⁶.
- b) Geographical division of labor, i. e., concentration of manufacturing in a single plant in a single country, implies both low transport costs (low τ) and intermediate population density (intermediate n). If density is too small, there will be no vertical disintegration. By contrast, if the number of inhabitants in each country is too high, the industrial output will be produced in both countries.
- c) The size of “iceberg” transport costs depends on two factors: the rate of the intermediate good “lost in transit”, $\tau - 1$, and its price k . This price is inversely related with the “refining rate” δ (see (2.18) and (3.4)), because this is the number of input units that must be used to produce one unit of consumer good with a fixed parametric price. If δ is low, then k will be high, so that transport costs will be high independently of the transport rate τ . Consequently, if the “refinement rate” is low, manufacturing can start in each country even if transport costs are low.
- d) A normative conclusion, stressed by Friedrich List himself, is that geographical division of labor is socially negative. Indeed “Proximity” yields a higher agricultural output for each farm and country than “Concentration”. The reason is that “Concentration” is economical if and only if transport costs are low, as it implies moving inputs and outputs across countries. “Concentration” is more profitable than “Proximity” as a location strategy for the monopolist provided that transport costs and the price k of the raw material are low. The latter condition implies a low intensity of land cultivation and a small agricultural output in each farm and country. Furthermore, the land rent expressed in (2.16) decreases with k and becomes lower if the manufacturer installs only one plant.

⁶ Amador and Caldeira Cabral (2014) observe that after 2003 Portugal had a sustained surge in exports, which cannot be easily explained, since the Euro was strong and the oil prices were on the rise. Our result that a reduction in trade costs conduces to a division of labor between the primary sector and the industrial sector, can help to explain this occurrence. In fact, in 2003, the EU’s Common Agricultural Policy (CAP) shifted from product support to producer support, which in practice conduce to a reduction in the level of protection in the agricultural sector (European Commission, 2012).

Discussion

In this paper, we have developed a Listian model of economic development, where the economy is made up of an primary sector that produces good using a traditional technology and an industrial sector that can arise if the primary sector specializes in the primary good, i.e.: if division of labor arises in equilibrium. If division of labor does not occur, the economy is stuck in an underdevelopment trap. If division of labor does occur, which is limited as in Adam Smith by the “extent of the market”, industrialization can arise with either industrial dispersion or agglomeration, i.e., either with or without geographical division of labor.

Geographical labor division is seen to arise if transport costs are low and the “refining rate” in manufacturing is high. The latter condition implies that the price of the agricultural input is low, thus diminishing the intensity of its cultivation. In this case, both sectors in the economy – agriculture and manufacturing – will produce smaller outputs than those that would prevail if industrial production were decentralized between the two countries.

Otherwise, if the industrial process is not so much “weight-losing”, industrialization can begin with a decentralized symmetric spatial pattern independently of the transport costs level.

In future work, we wish to look at one of the most innovative ideas by List: economic agents have incomplete information about trade costs, especially in what concerns trade costs in international trade. The “randomness” of trade costs can arise because of disruptions in international trade. These disruptions can be caused for example in extreme cases by wars or environmental disasters (such as the one in the nuclear plant in Fukushima that putted at risk the “just in time” system of production of Japanese manufacturers). But the disruptions in international trade can also be due to more “normal” causes such as different legal systems, different institutions, or even different culture and language that makes international trade rules more uncertain.

This line of research is in our opinion very promising, in particular for two reasons. First, to our knowledge there is very little research on the effects of uncertain trade costs on economic activity, trade, and location of production. Second, the randomness on trade costs can in our

view help to partially explain one of the most important puzzles in international and macroeconomics: the border puzzle⁷.

The “border puzzle” refers to the empirical evidence that equally distant regions, trade much more with each other, even after correcting for trade barriers, if they are located in the same country than if they are located in different countries. For instance, McCallum (1995) finds that in 1988, trade between Canadian provinces was 2,200 percent larger than the trade between U.S. states and Canadian provinces.

In this way, a border between two countries might just introduce an uncertainty that reduces international trade across borders. In future work, we will try to verify this assertion.

⁷ Obstfeld and Rogoff (2001) defend that the border puzzle is one of the six puzzles of open economy macroeconomics.

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