The effects of transport costs revisited[#]

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Abstract

The aim of this paper is to study the location decisions of upstream and downstream industries when transport costs in each sector are analyzed separately. By using a new economic geography model built on Venables (1996), it will be shown that the effects of cost reductions in transporting final goods are different from those in intermediate goods. Our analysis suggests that regional convergence is more the consequence of improvements in transportation between upstream and downstream firms than those between firms and consumers. This will help us to better understand the forces driving this kind of model while giving an additional explanation to the differences between Krugman's (1991) results and those of Venables (1996).

Keywords: location of firms, monopolistic competition, input-output linkages, transport costs

JEL classification: F12; R12

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1. Introduction

In the last few years a great number of works have been focused on analyzing the effects of transport costs on the agglomeration of economic activity.[1] In this vein, Krugman's (1991) seminal paper considers a model with a perfectly competitive sector, agriculture, a monopolistically competitive sector, manufacturing, and two locations. Workers in the manufacturing sector are allowed to move between locations so long as there is a real wage gap between them, while farmers are tied to land and obtain the same salary everywhere. This paper concludes that reductions in transport cost foster the concentration of manufacturing firms. So long as transport costs are low, firms can benefit from concentrating in a single location and delivering products to farmers in the other location.

Labor force mobility is an assumption that is reasonable and realistic if we want to study the agglomeration phenomenon in the context of the United States. In Europe, however, this inter-regional movement cannot be observed, in spite of the fact that regional wage differences are, in some cases, sizeable.[2] In this vein, Venables (1996) considers that workers are not allowed to move between locations and incorporates the existence of two industries vertically linked through an input-output structure.[3] Given that now wage differences between locations are not brought down by migration, firms might be interested in moving to less industrialized areas in which the wages offered are lower.

Therefore, wage differences would act as a dispersion force, while the links between firms derived from their input-output relationships would counteract the previous phenomenon.[4] Thus, in this new approach three types of elements are involved: the demand effect, which implies the interest of final-product manufacturing firms in being near the consumer, vertical linkages, and wage costs. As opposed to Krugman (1991), the relationship between agglomeration and transport costs is not monotonic. Thus, if

[1] A review of this literature can be seen in Fujita et al. (2000), Neary (2001), and Ottaviano and Thisse (2004), among others.
[2] Ottaviano and Puga (1998) point out that "only about 1.5 per cent of EU citizens live in a Member State different from where they were born."
[3] See also Krugman and Venables (1995).

transport costs are significant, proximity to final demand represents the factor which determines spatial configuration and, therefore, the corresponding dispersion of economic activity, brought about by the dispersion of the population itself. For intermediate transport costs, vertical linkages make up spatial distribution, leading to the concentration of production. Finally, the dispersion of economic activity appears once more insofar as small trade costs are concerned, in this case brought about by the high wage costs that a high level of industrialization implies. However, transport costs on final and intermediate goods are not analyzed separately, so that we do not know the contribution of each of them to the spatial distribution of production.[5]

Puga (1999) offers a general framework that combines Krugman and Venables (1995) and Krugman (1991) and shows that, at low transport costs, dispersion only emerges as a possible equilibrium when workers are not allowed to move towards locations with higher real wages. It follows, therefore, that the assumption about labor mobility seems to be crucial to explain the differences between the above papers.

Recently, Reading and Venables (2004) show empirical evidence of the importance of access to markets and suppliers in explaining cross-country differences in income per capita by using specific measures for each of them. They also suggest that remoteness from markets and suppliers is one of the reasons for "the reluctance of firms to move production to low wage locations."

In this vein, the aim of this paper is to study the location decisions of upstream and downstream industries when transport costs in each sector are analyzed separately.[6] It will be shown that regional convergence is more the consequence of improvements in transportation between upstream and downstream firms than those between the latter

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[4] De Vaal and van den Berg (1999) have also found that input-output linkages promote concentration of economic activity, using a model à la Krugman (1991) with labor mobility.

[5] Forslid and Midelfart Knarvik (2002) analyze a related topic when considering that both trade costs affect industrial policy.

[6] Transport costs in intermediates may imply not only moving physical goods but also people. Many firms may require the services of highly-skilled workers, such as attorneys in law, computer expertise, etc., at a higher level than individual consumers. Since some infrastructures allow the transportation of both people and commodities, such as conventional rail and roads, while other, such as high-speed rail, are not suitable for goods, the transport costs of final goods and intermediates are not necessarily the same. Besides, there is empirical evidence of substantial differences on transport costs across sectors (see Anderson and Wincoop, 2004) so that considering different transport cost for the two sectors is not an unusual assumption.

and consumers. This will help us to better understand the forces driving this kind of models while giving an additional explanation to the differences between Krugman's (1991) results and those of Venables (1996). As opposed to Puga (1999), a full input-output structure, instead of a single aggregate sector that uses its own output as input, is considered. This framework will allow us to better analyze the effect of each transport cost separately.

The paper is organized as follows. Section 2 describes the assumptions of the model, which is built on Venables (1996), differentiating between three sectors: agriculture, final manufactures and intermediates. The equilibrium is characterized in Section 3, and the main results are presented in Section 4, distinguishing between the effects of transport costs on final goods as opposed to those of intermediates over the agglomeration of economic activity. Finally, Section 5 concludes.

2. The model

Consider a world consisting of two locations, labeled *1* and *2*, which are populated respectively with L_1 and L_2 individuals. This economy has three sectors: agriculture, final manufactures and intermediates. The former is perfectly competitive and the other two are imperfectly competitive and vertically linked. The two industries produce differentiated varieties under increasing returns to scale and firms are assumed to compete in a monopolistic regime of the Dixit and Stiglitz (1977) type. Labor is used by the three sectors and is mobile between them. However, labor is not mobile across locations. We denote by w_j the wage rate in *j*.

Following Venables (1996), two assumptions will be made with respect to transport costs between the two locations. Firstly, trade in agricultural output will be assumed to be costless. Secondly, we assume ad valorem trade cost for intermediates/producer services (*s*) and final goods (*i*), so $p_{rj}t^r_{jk}$ is the price paid per unit of good *r* $(r=s,i)$ produced at location *j* and sold at location *k*, and p_{rj} is its free-on-board (f.o.b.) price. $t^r_{jk}=1$, if $k=j$, otherwise $t^r_{jk}>1$.

We assume that final goods and intermediates are affected by different transport costs, so that we can analyze the effect of each of them separately. However, in each industry there is no difference between varieties' transportation, so that $t_{jk}^{i} = t_{jk}$ for any variety *i* in the final-product sector and $t_{jk}^{s} = t_{jk}^{'}$ for any variety *s* in the intermediates sector.[7]

2.1 Preferences

Consumers have Cobb-Douglas preferences over the agricultural good and a constant-elasticity-of-substitution (CES) aggregate of manufacturing goods,

$$U = z_M^{\beta} z_A^{1-\beta},$$

where z_A is consumption of the agricultural good and z_M is consumption of the manufactures aggregate, which is defined by

$$z_M = \left(\sum_i z_i^{(\varepsilon-1)/\varepsilon} \right)^{\varepsilon/(\varepsilon-1)},$$

where ε is the elasticity of substitution between any two varieties, $\varepsilon > 1$.[8] Following Dixit and Stiglitz (1977), the price of this aggregate for individuals living at location *j* is

$$P_j = \left[\sum_{k=1}^{2} \sum_{i=1}^{n_k} \left(p_{ik} t_{kj} \right)^{1-\varepsilon} \right]^{1/(1-\varepsilon)}, \quad j = 1, 2, \tag{1}$$

where p_{ik} is the f.o.b. price of variety *i* produced at location *k*, and t_{kj} refers to the transport cost between *k* and *j*. The number of varieties in location *k* is endogenously determined and denoted by n_k.

Each individual supplies one unit of labor non-elastically, and owns an equal proportion of the agricultural profits, which will be obtained in what follows.

2.2 Agriculture

Agriculture is perfectly competitive, producing a costlessly tradeable good that we choose as the numeraire. This sector is described by a strictly concave technology

[7]Hereafter, the intermediates sector is denoted by subscript *S* and we drop subscript for the final-product sector. Furthermore, subscript *s* (respectively *i*) will refer to a particular intermediate good (respectively final good) variety. We choose to keep superscripts for parameters.

$F\left(L_A\right)=aL_A^{\alpha}$, where labor is the only factor of production, $\alpha<1$.[9] This assumption will allow us the possibility of different wages between locations. Otherwise, wages in both locations would be equal. Salary differentials between locations will allow us to analyze the effects of labor costs on firm locations, which appears as a crucial factor in the analysis, as will be shown. The profit function in location *j* is then given by

$$\Pi_{A_j}=F\left(L_{A_j}\right)-w_j L_{A_j},$$

where L_{A_j} and w_j are the number of farmers and salary in location *j*, respectively. The first-order condition yields

$$L_{A_j}^{*}=\left(\frac{w_j}{a\alpha}\right)^{1/(\alpha-1)}, \tag{2}$$

so that

$$\Pi_{A_j}^{*}=a^{1/(1-\alpha)}\left(1-\alpha\right)\left(\frac{1}{\alpha}\right)^{\alpha/(\alpha-1)} w_j^{\alpha/(\alpha-1)}>0. \tag{3}$$

To simplify the analysis, we assume that these profits are equally shared among consumers. Since there is no labor mobility between locations, this sector is necessary in the model. If we want to study why one region is more industrialized than another, we need a sector from which to take the workers required by the two industries in that location. The existence of this pool of agricultural workers seems to be crucial to explain industrialization.[10]

2.3 Downstream industry

We assume Cobb-Douglas technology between labor and an aggregate of differentiated intermediate goods, which requires fixed (*f*) and variable (x_{ij}) quantities of the inputs,

$$AL_{ij}^{1-\mu}\left(\sum_{s} z_s^{\frac{(\varepsilon-1)}{\varepsilon}}\right)^{\frac{\varepsilon}{(\varepsilon-1)}\mu}=f+x_{ij},$$

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[8] It can be shown that ε is also the elasticity of demand: see Dixit and Stiglitz (1977).

[9] Strict concavity can be interpreted as the presence of a sector-specific factor. Puga (1999) explicitly considers this input in the production technology of the agricultural sector.

[10] In fact, the large pool of farmers available to work in the industrial sector has been stressed as the main reason for the existence of megacities in the less-developed countries - See Puga (1998).

where L_{ij} and z_s are, respectively, the labor and the amount of good *s* used in producing x_{ij} units of variety *i* at location *j*. μ denotes the intermediate share, while the elasticity of substitution between any two varieties is assumed to be equal to ε, as usual in this kind of models (Fujita et al, 2000; Venables, 1996). There is, therefore, love of variety for inputs in the production of final goods in a similar way to what happens in consumption. However, as opposed to Krugman and Venables (1995) and Puga (1999), we follow Venables (1996) and work with a complete input-output structure with two different sectors.

From the minimization-cost problem of a downstream firm it follows that the aggregate of intermediate goods that solves that problem is equal to $\mu w_j^{1-\mu} P_{Sj}^{\ \mu-1}\left(f + x_{ij}\right)$, and the optimal labor level is $\left(1-\mu\right) w_j^{-\mu}\left(P_{Sj}\right)^{\mu}\left(f + x_{ij}\right)$. Therefore, the cost function of a firm producing variety *i* at location *j* is[11]

$$C_{ij} = w_j^{1-\mu}\left(P_{Sj}\right)^{\mu}\left(f + x_{ij}\right),$$

where P_{Sj} is the intermediates price index at location *j* and is defined by [12]

$$P_{Sj} = \left[\sum_{k=1}^{2}\sum_{s=1}^{n_{Sk}}\left(p_{sk} t_{kj}^{'}\right)^{1-\varepsilon}\right]^{1/(1-\varepsilon)}, \quad j = 1,2. \tag{4}$$

As we can see, the price index depends on the f.o.b. prices of individual varieties and their transport costs between locations. The number of intermediates at location *j* is endogenously determined and denoted by n_{Sj}.

2.4 Upstream industry

We assume that the production of a single intermediate variety *s* involves a fixed and a marginal cost in terms of labor, so that the technology of production is given by

$$L_{sj} = f + x_{sj}, \quad j,k = 1,2,$$

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[11] Actually, we have considered *A* as $\left(1-\mu\right)^{\mu-1}\mu^{-\mu}$ in the technology function so as to obtain a simpler expression for the cost function.

[12] This price index works as the price of the aggregate (see Dixit and Stiglitz, 1977).

where L_{sj} is the labor used in producing x_{sj} units of good *s* at location *j*. The cost function for any firm in this sector is therefore

$$C_{sj} = w_j L_{sj} .$$

3. Solving the model

Individuals in this economy must decide their consumption, taking into account that some final goods are produced in their region, but others have to be transported from outside. The maximization problem of an individual located at *k* yields the following first order condition

$$\left(\sum_i z_i^{\frac{(\varepsilon-1)}{\varepsilon}} \right)^{\frac{\varepsilon}{\varepsilon-1}-1} z_i^{\frac{(\varepsilon-1)}{\varepsilon}-1} = \lambda p_{ij} t_{jk} ,$$

where variety *i* is produced at *j* and shipped to *k*. Since this expression holds for any variety, we can also write it for variety 1.[13] By comparing both equations, it follows that

$$z_i = \left(\frac{p_{11} t_{1k}}{p_{ij} t_{jk}} \right)^{\varepsilon} z_1 .$$

By substituting z_i in the budget restriction of this individual and rearranging, we obtain

$$z_1 = e P_k^{\varepsilon-1} \left(p_{11} t_{1k} \right)^{-\varepsilon} ,$$

ie., her consumption on good 1 can be written in terms of her expenditure on final goods, the price index at that location, and the price of good 1 (including transport costs). Since the same steps apply for any other variety, and taking into account that all consumers in *k* have the same individual demand function, total demand for any variety produced at location *j* and sold at *k* is given by

$$x_{jk} = e_k P_k^{\varepsilon-1} \left(p_j t_{jk} \right)^{-\varepsilon} , \quad j,k = 1,2, \tag{5}$$

where x_{jk} is the quantity of a particular variety produced in location *j* and sold in *k*, and e_k is the expenditure on final products at location *k*.[14]

Any downstream firm has Cobb-Douglas technology that depends on labor and on an aggregate of intermediates. This means that in order to minimize its costs, the downstream firm must decide the amount of each intermediate good so as to maximize

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[13] For the sake of simplicity, we assume that variety 1 is produced at location 1.

the aggregate of intermediates for a given expenditure level. Taking into account the similarity between this problem and that of the consumer, it follows that the demand for any intermediate good is also given by

$$x_{Sjk} = e_{Sk} P_{Sk}^{\varepsilon-1} \left(p_{Sj} t'_{jk} \right)^{-\varepsilon}, \quad j,k = 1,2, \tag{6}$$

where x_{Sjk} is the quantity of a intermediate good produced in location *j* and sold in *k*, and e_{Sk} is the expenditure on intermediates at location *k*.

The profit of a single downstream firm in location *j* can be written in terms of two demands, the demand of consumers located in *j* and the demand of consumers from outside:

$$\Pi_j = p_j \left(x_{jj} + x_{jk} \right) - w_j^{1-\mu} \left(P_{Sj} \right)^{\mu} \left(f + x_{jj} + x_{jk} \right).$$

The profit-maximization problem of this firm yields to the following f.o.b. price

$$p_j = \frac{\varepsilon}{\varepsilon - 1} c_j, \qquad j = 1,2, \tag{7}$$

where c_j is the marginal cost in *j*, $c_j \equiv w_j^{1-\mu} \left(P_{Sj} \right)^{\mu}$. As usual, this price is a constant markup over marginal cost. Monopolistic competition means that firms enter the market until profits become zero. This implies that the amount of any final good produced by a firm located at *j* is given by

$$x_{jj} + x_{jk} = f \left(\varepsilon - 1 \right), \quad j,k = 1,2. \tag{8}$$

From the cost-minimization problem, the number of workers that each firm need can now be obtained

$$L_j^{*} = \left(1 - \mu \right) w_j^{-\mu} \left(P_{Sj} \right)^{\mu} \left(f + x_{jj} + x_{jk} \right). \tag{9}$$

The profits of a firm in the intermediates sector can be written as

$$\Pi_{Sj} = p_{Sj} \left(x_{Sjj} + x_{Sjk} \right) - w_j \left(f + x_{Sjj} + x_{Sjk} \right).$$

As in the final-product case, prices in the intermediates sector are given by

$$p_{Sj} = \frac{\varepsilon}{\varepsilon - 1} c_{Sj}, \qquad j = 1,2, \tag{10}$$

where the marginal cost is instead $c_{Sj} \equiv w_j$. Supply, which comes from a zero-profit condition, is also given by

[14] From now on, we drop subscript *i* when referring to a particular final product is unnecessary.

$$x_{Sjj} + x_{Sjk} = f\left(\varepsilon - 1\right), \quad j,k = 1,2\,. \tag{11}$$

Since the level of production is already determined and labor is the only factor used, the number of workers hired by each firm is

$$L_{Sj}^{*} = f + x_{Sjj} + x_{Sjk}\,. \tag{12}$$

Intermediates account for share μ of final-product industry costs, so expenditure at location *j* on intermediates is

$$e_{Sj} = \mu n_j c_j\left(f + x_{jj} + x_{jk}\right) = \mu n_j p_j\left(x_{jj} + x_{jk}\right), \quad j,k = 1,2. \tag{13}$$

Cobb-Douglas preferences with manufacturing share β mean that consumers' expenditure in location *j* is

$$e_j = \beta\left(w_j L_j + \Pi_{A_j}^{*}\right), \quad j = 1,2, \tag{14}$$

where $\Pi_{A_j}^{*}$ are the profits in the agricultural sector at location *j*.

There are separate labor markets at each location since we ignore migration, so wages in this economy come from the labor-market clearing

$$L_j = n_{Sj} L_{Sj}^{*} + n_j L_j^{*} + L_{A_j}^{*}, \quad j = 1,2, \tag{15}$$

where each term represents the number of workers in intermediates, final products and agriculture in j, respectively.

Equilibrium is reached when all markets clear (labor, agriculture, final and intermediate products), and no further firms can enter the market. Equations (1)-(15) characterize the equilibria: f.o.b. prices (p_j, p_{Sj}), quantities (x_{jk}, x_{Sjk}), number of firms (n_j, n_{Sj}) and wages (w_j) in each location.

4. The effects of reductions in transport costs

This section is devoted to analyzing how transport costs shape the spatial configuration of economic activity. As usual in this kind of model, the system of equations that determines the equilibrium of the economy is strongly non-linear, so that the use of simulations is required. The model is solved for different values of transport costs and the spatial distribution of firms reached in equilibrium is shown.[15] Each equilibrium represents the number of firms in the downstream industry and also the number of firms in the upstream industry.

In the following figures, dash lines are simply lines of reference with which to compare the equilibria of the economy. $n_1 = n_2$ represents a spatial distribution where each location has the same number of firms, whereas $n_1 = 0$ and $n_2 = 0$ mean full concentration of firms in locations 2 and 1, respectively. Above the line $n_1 = n_2$ we can find spatial distributions where location 2 has more firms than location 1, $n_1 < n_2$, and below that line the opposite holds, $n_1 > n_2$. Only stable equilibria are plotted in the figures.[16]

To understand the main forces at work, we distinguish two cases. Firstly, we analyze how this spatial configuration changes when transporting final goods becomes cheaper. In doing so, we keep the transport costs of intermediates, *t'*, as constant, and plot the number of firms in each location as a function of t. Secondly, we focus on the effects of reductions in transporting intermediates, *t'*, while keeping t as constant.

4.1 The effects of transport costs in final products

Figure 1 shows the equilibria of the economy, for the upstream industry, with different values of final-goods transport costs, *t*, when delivering intermediates is expensive ($t' = 1.5$).

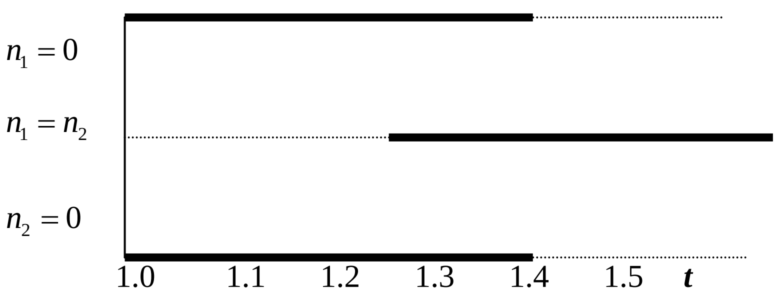

Figure 1. Location of upstream firms when $t' = 1.5$

[15] In order to compare our results with those of Venables (1996), we have considered the same parameters values, which are, $\alpha = 10/11, \beta = 0.2, \varepsilon = 6, \mu = 0.5, L_1 = L_2 = 20,$ and $a = 1.2$.

[16] Equilibrium is (locally) stable if a small deviation in the distribution of firms in equilibrium does not hamper the economy from reaching the same equilibrium again.

At high values of *t*, $t = 1.5$ for example, an even distribution of economic activity between both locations emerges as equilibrium. At intermediate transport costs, $t = 1.3$ for example, three stable equilibria emerge in the economy: one where firms are evenly distributed between the two regions, and the other two where firms concentrate in only one location. At lower values of *t*, $t = 1.2$, for example, only concentration is possible. Depending on whether firms concentrate in region 1 or in region 2, two stable equilibria are possible.

The corresponding figure for the downstream industry (Figure 2) is similar

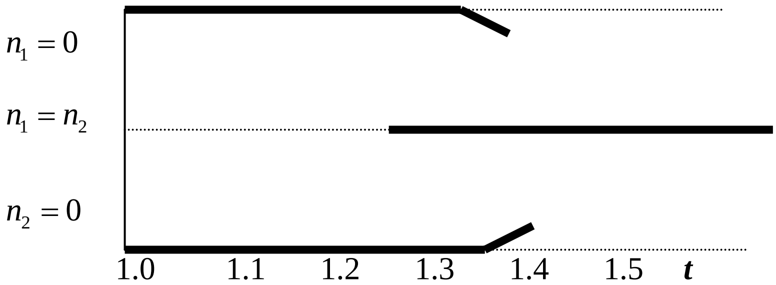

Figure 2. Location of downstream firms when $t' = 1.5$

We find that the spatial distribution of both sectors is basically the same. The only difference between them is that the change, as transport costs decrease, from an equilibrium where there is an even distribution of firms to another where firms tend to concentrate in a single location is smoother in the downstream industry than in the other; i.e., we can find that in the downstream industry, most firms are located in one region, instead of all of them being in the same location, which is what happens in the upstream industry in the corresponding equilibrium.

The results suggest that when final goods are affected by high transport costs, proximity to demand induces firms in this sector to be close to their markets, which also fosters the dispersion of intermediates because of their vertical links. Upstream firms want to locate near downstream firms because they are their demand, and the latter choose to locate where there are many of the former because they are their supply. As Venables (1996) points out, demand and cost linkages between both sectors encourage them to locate close to each other. Venables (1996) also suggests that, at low transport costs (of both final and intermediate goods), dispersion of economic activity is the only stable equilibrium since wage differentials induce firms to locate on the periphery because of its lower salary level. However, as opposed to Venables (1996), we find that cost reductions in transporting final goods between locations favor the concentration of economic activity, instead of halting it. It seems, then, that wage differentials between locations do not play an important role when only final goods experience lower transport costs. So long as intermediates are expensive to transport, vertical linkages between both sectors hinder dispersion between locations to emerge as a stable equilibrium.

Since both sectors have a similar spatial pattern when transport costs decrease, from now on we opt to present the information on only one of them, that of intermediates.

When considering lower transport costs for intermediates, $t' = 1.1$, a similar spatial configuration is reached, where dispersion emerges as a stable equilibrium for a wider range of t (see Figure 3).

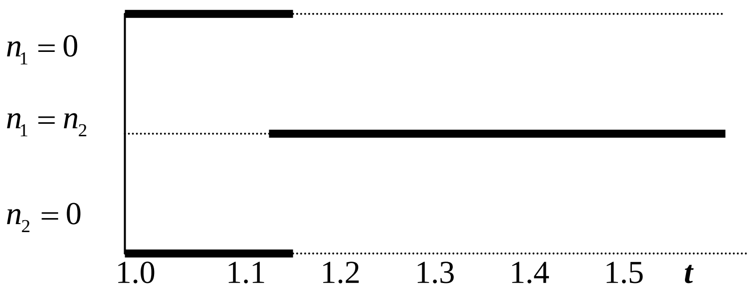

Figure 3. Location of upstream firms when $t' = 1.1$

This suggests that reductions in transporting intermediates can, instead, foster the dispersion of economic activity, as discussed in the next section.

4.2. The effects of transport costs in intermediate goods

In this section we are interested in analyzing the spatial distribution of economic activity as a function of $t´$. In Figure 4 we assume that transporting final goods has a low cost ($t = 1.1$).

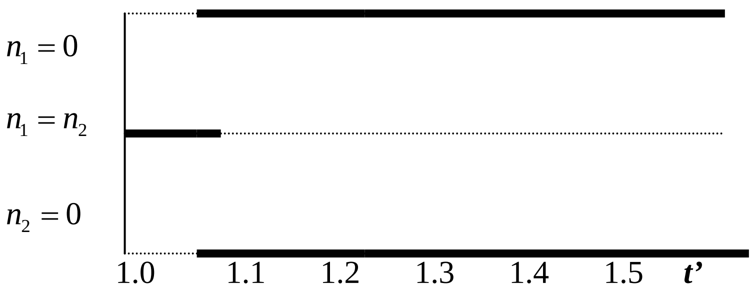

Figure 4. Location of upstream firms when $t = 1.1$

At high values of *t'*, as in $t' = 1.5$ for example, two stable equilibria emerge in the economy, each representing concentration of firms in one region. As *t'* decreases ($t' = 1.09$), three stable equilibria emerge: concentration in either of the regions and dispersion between both locations. At lower transport costs in intermediates ($t' = 1.03$ for instance), firms are located in both regions and concentration is no longer a possible equilibrium.

Why does the economic activity agglomerate in only one location when *t'* takes a high value? When delivering intermediates is expensive, upstream and downstream firms need to be close to each other in order to minimize the intermediates transport costs; i.e., high trade costs on intermediates intensify vertical linkages between sectors. Upstream firms want to locate near their demand and downstream firms near their supply. However, once these demand and cost effects between sectors become weaker, due to transport costs reductions, wage differentials between locations become more important, inducing firms to disperse to peripheral regions where labor is cheaper.

A small increase in the cost of transporting final goods makes dispersion of economic activity easier to reach, as Figure 5 shows.

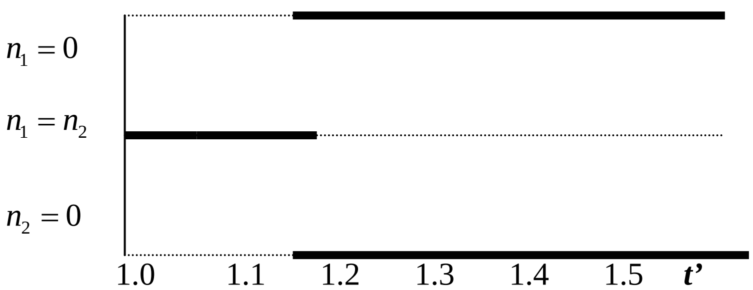

Figure 5. Location of upstream firms when $t = 1.2$

As a matter of fact, if we increase *t* a little more, $t = 1.2$, dispersion emerges as the only equilibrium of the economy for a wider range of values for *t'*, since proximity to consumers would become the most import factor in location decisions, as mentioned above.

We can, therefore, conclude that reductions in trade costs between locations lead to different spatial distribution of economic activity depending on whether they affect final or intermediate goods. A decrease in transporting final goods fosters the agglomeration of economic activity, while a decrease in delivering intermediates leads to the opposite result. This helps us to better explain the differences between Krugman's (1991) results and those of Venables (1996). Krugman (1991) shows that in a world of labor mobility, reductions in transport costs of goods foster concentration. Venables (1996) adds new elements in the model allowing for vertical linkages between sectors in a world of immobile labor.

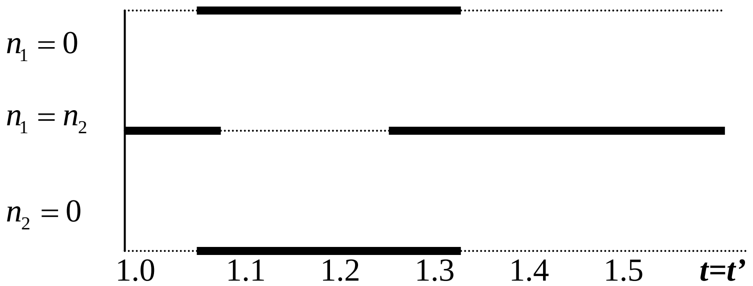

Figure 6. Location of upstream firms in Venables (1996)[17]

He obtains the result that a fall in transport costs (which affect both intermediates and final goods) first leads to more concentration, while later to dispersion. Our results suggest that dispersion is not the result of low transport costs on final goods, but that of low transport costs on intermediates. In fact Figure 6 (obtained from Venables, 1996, for the upstream industry) results from combining figures in Section 4.1 and 4.2. The analysis allows us to show that the spatial pattern described in Venables (1996) is the consequence of two different elements moving together: final-product transport costs

[17] Actually, Venables (1996) shows only the equilibria of the final-goods sector. Here, that model has been simulated for the intermediates sector. As mentioned before, the only difference between both sectors is that the change from concentration to dispersion (or vice versa) is smoother in the downstream case.

and intermediate transport costs, each of them having opposite effects on the spatial distribution of production.

5. Implications and Conclusions

Krugman (1991) points out that economies of scale at firm level, labor migration and transport costs are revealed as important factors in explaining the existence of clusters of industrial production. The existence of transport costs implies that the best locations for a firm are those with easy access to markets, and the best locations for workers are those with easy access to goods. He shows that when transport costs are low, firms are more interested in agglomerating in one region, since they can compete in distant markets producing at the core.

Puga (1999) introduces vertical linkages through a single aggregate sector that uses its own output as input. Downstream firms create the market for the upstream firms, so that the latter want to locate where there are many of the former (demand linkage). In addition to this, downstream firms have lower costs when they locate where there are many upstream firms (cost linkage). He also finds that low transport costs induce firms to agglomerate in a single location when workers are allowed to move between locations, so that adding input-output linkages with a single aggregate sector to Krugman (1991) does not change the relationship between transport costs and agglomeration.

Venables (1996) also addresses the relationship between transport costs and regional disparities but in a framework with a full input-output structure, where labor is not allowed to move between locations. Venables (1996) finds that the relationship between transport costs and agglomeration is no longer monotonic, so that when these costs fall low enough, the periphery can attract more firms because of their lower salaries. This result is also obtained by Puga (1999), when considering labor immobility, instead of mobility, between the two locations, which suggests that the assumption about migration seems to be crucial.[18]

[18] Puga (1999) combines Krugman and Venables' (1995) and Krugman's (1991) models to analyze the effects of considering either free labor mobility or labor immobility. He finds that, when workers can move to locations with higher real wages, this intensifies agglomeration.

The above papers suggest that regional policies interested in regional converge should improve transport infrastructures enough in order to take advantage of the low salaries in the less developed regions. However, these papers do not discriminate between transport infrastructures that benefit final-product firms from those that benefit intermediates. We have shown that these transport costs shape the spatial distribution of production in opposite directions. In particular, we have found that in this kind of models regional convergence is more the consequence of improvements in infrastructures which facilitate trade between upstream and downstream firms than those which facilitate transport between firms and consumers. It follows, then, that salary differential does not play an important role either when labor gaps are reduced by migration, as in Puga (1999), or when intermediates are expensive to transport. It seems, therefore, that different elements can cancel the dispersion effect caused by wage differentials: labor mobility and high transport costs on intermediates.

The analysis also suggests that Krugman's (1991) results are not only the consequence of considering labor mobility between locations, as Puga (1999) points out, but also the consequence of considering only transport costs on final goods. As a matter of fact, we have shown that the effects of reducing transport costs in Krugman (1991) are analogous to those obtained in a full input-output framework with labor immobility when only transport costs on final goods decrease.

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