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THE EFFECTS OF TRANSPORT COSTS WITHIN THE NEW ECONOMIC GEOGRAPHY [#]

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Summary

In the last few years a great number of works, involved in what has been called the New Economic Geography, have been focused on explaining the causes of agglomeration in a framework of monopolistic competition *à la* Dixit-Stiglitz. The purpose of this paper is to analyze, in the light of these theories, the spatial consequences of reductions in transport costs between locations (cities, regions and countries), showing the key assumptions which explain the differences between the results obtained in some of these works. The results show that the spatial pattern of production after these reductions strongly depend on the population's mobility/immobility, on the dispersion force considered in the model and also on trade cost modeling.

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1. INTRODUCTION

According to United Nations estimates, in the year 2000 47.2% of the world's population lived in urban areas, a percentage which is expected to rise to above 60% in 2030. Furthermore, if we focus on the developed world, the ratio of urbanization is even higher: in 2000, the percentage was approximately 75.4%. To what is this high level of agglomeration due?

It is reasonable to think that if urban areas exist it is because people find some kind of advantage in carrying out different activities in a limited spatial area. The reasons for such spatial concentration have not been the same throughout history. If we look back, for example, at the Middle Ages, we realize that many cities were of a mainly defensive nature: the more concentrated the people were in a given area, the less difficult it was to defend them. In other cases cities began as religious centers, whereas others experienced important development when political or military leaders established their headquarters there. However, at present, the growth of the majority of cities is not due to military, religious or administrative reasons, but to simple market forces. Job opportunities, the variety of consumer goods, face-to-face contacts, etc. are greater in cities. According to this concentration of population there is also concentration of production. Advantages in access to the labor market, proximity between final and intermediate producers, faster information exchange and technological diffusion, access to a wider market, etc. foster the agglomeration of firms in a few locations. As a matter of fact, Ellison & Glaeser (1997), for example, show evidence of the high concentration level in US manufacturing industries, whereas Amitie (1999) and Brulhart (2001) analyze the European case.[1]

One of the crucial reasons behind the agglomeration phenomenon is the existence of economies of scale, an affirmation usually referred to as the *Folk* theorem of Economic Geography (Fujita and Thisse, 1996). In the absence of these economies, goods and services could be produced on an arbitrarily small scale, therefore satisfying the needs

[1] Maurel and Sédillot (1999) also show evidence of concentration in France and Alonso-Villar *et al.* (2004) in Spain.

of small groups of consumers. In other words, we would find a uniform distribution of economic activity.

In fact, following Starrett (1978), Gabszewicz *et al.* (1986) establish that: if individuals can choose their location freely, all the immobile resources are uniformly distributed over space, there is no trading with the rest of the world and there exist all markets for all goods at all locations, then there is no competitive equilibrium with positive transport costs. Therefore, in a world of constant returns and perfect competition we would find a uniform distribution of economic activity. All goods would be produced in each location, so that the population would be provided for without transport costs being incurred. The agglomeration phenomenon could not, therefore, be explained.

Since the mid-1970s a large number of studies have offered different explanatory theories of the agglomeration of economic activity. Basically, two types of models explaining this phenomenon exist: some use the competitive paradigm, introducing increasing returns derived from externalities between firms,[2] and others opt to abandon perfect competition in order to be able to tackle the existence of increasing returns at firm level.

Although perfect competition and agglomeration are not incompatible if economies of scale external to the firm are introduced, when increasing returns occur at firm level it is necessary to use an imperfect competition framework: monopolistic competition and oligopolies.[3] In the last few years a great number of works, involved in what has been called the New Economic Geography, have been focused on explaining the causes of this phenomenon in the context of monopolistic competition, as it is easier to tackle the problem from this perspective than in a oligopolistic context.[4]

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[2] Within the non-price interaction models, we underline the line of research begun by Henderson (1974) in which the competitive market structure is used, and where returns to scale, external to firms and internal to the industry (localization economies), are used in a manner coherent with the empirical evidence derived from his studies (Henderson, 1986; Henderson *et al*., 1995, Henderson, 2003, among others).

[3] Combes and Lafourcade (2002), for example, analyze location in a duopoly context with Cournot competition.

[4] Fujita *et al.* (2000) offer a thorough analysis of the main contributions in the field. A review of this literature can be also seen in Schmutzler (1999), Neary (2001), and Ottaviano and Thisse (2004), among others. For a survey of the empirical literature in the field see Head and Mayer (2004). In particular, computable general equilibrium models have been constructed to simulate the effects of cohesion fund projects (Venables and Gasiorek, 1999) and economic integration (Forslid *et al*., 2002).

The purpose of this paper is to analyze, in the light of the theories of the New Economic Geography, the spatial consequences of reductions in transport costs between locations (cities, regions and countries), showing the key assumptions which explain the differences between the results obtained in some of these works.

With this aim in mind, this paper is organized as follows. In Section 2, we look at the different economic arguments that justify the interest of agents in choosing their location near others, in the light of these theories (market access, preference for variety in consumption, input-output linkages, local human capital externalities, etc.). In particular, the core-periphery model of Krugman (1991) is shown. We also set out the effects of improvements in transportation between locations when the industrial labor force can move around looking for higher real wages. The relevance of the different dispersion forces assumed by these models is emphasized, showing that the results of those improvements can strongly depend on the centrifugal force considered. In Section 3, we show the results of this literature when workers are restricted in movement, but not so firms, which might be attracted toward areas where wages are lower. As we can see in this section, the results can change considerably in comparison with those obtained in the previous section. Furthermore, the different effects of improvements in transporting final goods and intermediates are analyzed. Section 4 presents the consequences of transport cost reductions depending on whether they affect domestic or international infrastructures. Lastly, in Section 5, we end by showing the regularities that exist in the results of the previous studies presented, which could be grouped together in accordance with three criteria: the centrifugal force considered in the model, the mobility/immobility of the industrial labor force and transport cost modeling.

2. MODELING AGGLOMERATION WHEN LABOR IS MOBILE

The core-periphery model

In his 1991 study, Krugman opens a new line of research that includes ideas of earlier scholars such as Marshall, Christaller, Lösch or von Thünen, which, in spite of their enormous relevance, had not been dealt with formally.

The model assumes an economy with two locations and two sectors (agriculture and manufacturing). Farmers produce an homogenous good, that is costless tradeable between locations, [5] under constant returns to scale. Manufactures are, however, produced under increasing returns to scale, due to the existence of fixed costs in production, where labor is the only input. All firms in this sector have the same technology and compete in a monopolistic competitive framework *à la* Dixit-Stiglitz (1977), so that each company produces a different variety, but there is a certain degree of substitution among them. Manufactured goods can be transported to another location at a cost. These transport costs take the convenient iceberg form, so that a part of the good "melts" away in transit. That is, transport costs are incurred in the good being shipped, so that no specific sector is necessary to be included. In this economy, individuals have Cobb-Douglas preferences between the agricultural good and an aggregate of manufactures. This aggregate is actually a CES subutility, which means preference for variety. Farmers are not allowed to move between locations and are equally dispersed between locations, while workers can move looking for higher real wages. Individuals obtain their earnings in the location where they live, while they can consume goods from both locations.

Krugman's seminal paper, which has been applied to international as well as regional and urban contexts, has certain advantages over earlier studies as he makes no prior assumptions about externalities in industries and, furthermore, all the variables are determined endogenously. In this framework, agglomeration arises from the existence of increasing returns not at industry level but at firm level, from strong preference for variety in consumption and from the mobility of the manufacturing labor force. On one hand, increasing returns at firm level force the production of each good to be concentrated in a single location. On the other hand, the CES utility function means that there is preference for variety in consumption. Thus, individuals' real income increases in large agglomerations as they have access to more goods without transporting them from outside.[6] This encourages more individuals to migrate there

[5] Davis (1998) suggests that this assumption is important in the analysis. He shows that when both manufactured goods and agriculture have identical transport costs, the home market effect vanishes. This means that the location in the larger country will be no longer preferred by firms unless the relative trade costs of manufactures are high enough. However, Fujita *et al*. (2000) sustain that to allow for transport costs on agriculture does not change the most important results.

[6] Nominal wages in these models are endogenous. Krugman (1980) shows that, *ceteris paribus*, the largest agglomeration also has the highest nominal wage.

(forward linkage). In turn, this increase in the number of consumers will create a greater demand for goods, which makes it feasible to sustain a greater number of firms (backward linkage).[7] Therefore, agglomeration would be the result of interactions between the different economic agents, interactions which would occur through the market, that is, externalities would be of a pecuniary, not technological, nature.

In this way, a circular and accumulative phenomenon takes place, along the lines of what was proposed by Myrdal (1957): once a location reaches a certain level of development, in this case, of industrialization, the process increases insofar as a greater demand generates the attraction of new firms which, in turn, attract more individuals. This generates a core-periphery system between locations which originally were the same and, therefore, had the same possibilities.

However, in Krugman (1991) not all factors are mobile. More specifically, farmers, who work producing an agricultural good under constant returns to scale, halt agglomeration as they represent a disperse and immobile demand towards which firms would also like to turn.

We will now go on to show the basic behavior of the model by studying the numerical examples obtained with different transport/trade costs ($\tau \geq 0$).[8] These costs represent the difficulties of trading between locations, both those that arise from the problem of distance (information, transport) as well as possible trade barriers if the two locations are in different countries.[9] Let us assume, therefore, that in the economy there are two

[7] Redding and Venables (2004) provide evidence of the importance of access to markets to determine the factor prices that manufacturing firms can afford to pay. For example, access to the coast raises per capita income by 20%. Radelet and Sachs (1998) also find that access to the sea and distance to major markets affect manufactured export growth.

[8] Forslid and Ottaviano (2003) develop an analytically solvable version of Krugman (1991). To this end, they introduce differences in skill and mobility among workers. In particular, the fixed cost of manufacturing firms involves skilled and mobile workers, whereas the variable cost involves unskilled and immobile labor. This difference with respect to Krugman (1991), where the same mobile labor force was used for both fixed and variable costs, allows for price equalization between locations, which makes the model more tractable. Their results mirror those of Krugman (1991).

[9] Glaeser and Kohlhase (2004) show evidence of the decline of transportation costs in the US throughout the twentieth century. They suggest that transporting goods should no longer be an important matter to explain location. However, Radelet and Sachs (1998) suggest that this is still an important issue for less developed countries. Also, McCann and Shefer (2004) point out that the present increase in the quantity, variety and complexity of information makes spatial transaction costs increase. They also suggest that, in many industries, the complexity of the logistics operations may lead to higher transaction costs in shipping goods over space.

possible locations and let us see what equilibrium would be reached if workers can move between the two locations looking for higher real wages. On the horizontal axis the proportion of workers in location 1 is represented. On the vertical axis, the real wage differential between locations 1 and 2 is shown. Any point where the wage differential is zero is an equilibrium. There may also be corner equilibria: concentration in location 1 (or respectively 2) when the wage differential curve is positive (or respectively negative).[10] An interior equilibrium is stable if the curve is downward-sloping and unstable if it is upward-sloping, whereas a corner equilibrium is always stable.[11]

[insert Figure 1]

[insert Figure 2]

In Figure 1, the only stable equilibrium is given by an even distribution of population between both locations ($\lambda_1 = 0.5$), whereas in Figure 2, two stable equilibria are possible, each representing concentration in one region ($\lambda_1 = 0$ and $\lambda_1 = 1$).

We can also see that the lower the transport costs, the more likely it is to find agglomeration in one location. The reason is that if the transport costs are low then firms can benefit from concentrating their production in the larger market while delivering the goods to farmers in the other location. However, if transport costs are high, firms are more interested in reaching the dispersed rural market, so that an even distribution of production between both locations emerges.[12]

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[10] A population distribution between the two locations is said to be in equilibrium when no worker wants to move to the other location, that is, when she does not earn a higher wage by moving to a different place. This happens either when the two locations offer the same wage (in real terms) or when the alternative location cannot offer a higher wage. This means that a symmetrical distribution of population between the two locations is always an equilibrium.

[11] An equilibrium is (locally) stable when a small change in the proportion of population between the two locations causes movements in the population which lead to the initial situation.

[12] Bjorvatn (1999) proposes an alternative approach to economic geography models by considering a framework where goods can be produced by means of two technologies: constant returns (informal sector production) and increasing returns to scale (formal sector production), and where mobile and immobile labor exists. Besides, only two goods are produced in the economy and new firms can compete with the existing ones by using a different technology for the same good, rather than using the same technology for a different good, as in models *à la* Dixit-Stiglitz. As in Krugman (1991), immobile labor is the centrifugal force of the model. However, as opposed to this, reductions in transport costs foster convergence instead of halting it.

Ottaviano *et al*. (2002) present an alternative framework which leads to analytical results which mirror those of Krugman (1991), so that as transport costs decrease, agglomeration is more likely.[13] This paper suggests that the results of the core-periphery model are quite robust against alternative formulations of preferences (quasi-linear with a quadratic subutility instead of a Cobb-Douglas with a CES subutility) and transportation (measured in terms of a numéraire instead of the own good). However, when they include commuting and land costs in the model the results substantially change. In particular, as transport costs fall, the economy moves from dispersion to agglomeration, and later to dispersion again. This suggests that the economy involves dispersion when commuting costs are high enough with respect to trade costs, a matter we will return to later in this section.

Input-output relationships

In addition to the elements mentioned above, linkages between upstream and downstream industries can also favor the agglomeration of economic activity.[14] Downstream firms create the market for the upstream firms, so that upstream firms want to locate where there are many downstream firms (demand linkage). Also, downstream firms have lower costs if they locate where there are many upstream firms (cost linkage). This element is introduced by Puga (1999) in a model which allows for labor (industrial and agricultural) movement between locations. Therefore, this new approach includes three elements which lead to concentration: increasing returns to scale at firm level; the demand effect, which implies the interest of manufacturing firms in being near their consumers; and vertical linkages. When transport costs between locations are high, industrial activity tends to disperse in order to move closer to its markets, while if these costs are low, vertical linkages will cause concentration of economic activity. The similarity of this behavior with respect to Krugman (1991), might be due to the fact that in Puga (1999) the agricultural sector strongly depends on the immobile land factor. This factor is spread out spatially and, thus, in spite of the fact that farmers are mobile,

[13] See Ottaviano and Thisse (2004) for a survey of the literature within this alternative framework.

[14] Redding and Venables (2004) also show that access to suppliers appears as an important factor in firms' location, as it explains much of the cross-country variation in per capita income.

the immobility of the land factor used by them leads to the same results (see also Puga, 1998).[15]

Human capital

In addition to the aforementioned factors favoring the agglomeration of economic activity, mainly linked to proximity to consumers and suppliers, there are other important elements which so far have not been mentioned, one of which is undoubtedly the human factor. In Lucas (1988, p.38) we can read the following: "Of course, people like to live near shopping and shops need to be located near their customers, but circular considerations of this kind explain only shopping centers, not cities". Lucas suggests that the central role of cities derives from the externalities caused by human capital and that the main reason why people are willing to pay high housing prices in city centers is simply to be near other people.

Most of what we know is the result of interactions with other people, through formal as well as informal channels and, if geographical proximity facilitates this transfer of ideas, it would seem reasonable that those externalities were stronger in cities, given the greater probability of contact with other individuals. A great number of empirical studies confirm this idea. Thus, for example, Rauch (1993) and Simon (1998) find that the effects of human capital are localized at city level. Besides, Jaffe *et al.* (1993) present empirical evidence of the importance of distance in the flow of ideas, showing that patent citations are more likely to come from patents geographically nearby.

These externalities deriving from communication between individuals have been presented by some authors as the cause of urban growth, both in American and British contexts (see Glaeser *et al*, 1992; and Simon and Nardinelli, 1996). In fact, Simon and Nardinelli go so far as to affirm that the growth of cities in England between 1861 and 1961 was due to conversations among those belonging to the middle-class and not the smoke of factories.

[15] Ekholm and Forslid (2001) consider the possibility of horizontal and vertical multi-region firms and suggest that the former mitigates the agglomeration effect found at low transport costs, while the latter has opposite effects. On one hand, it makes the symmetric equilibrium unstable even for very high

In spite of the numerous empirical studies that maintain the importance of distance in spillovers deriving from information and knowledge, to date not much effort has been made to model those externalities in an urban context.[16] Fujita and Krugman (2004, p. 160) point out that "Advancing the microfoundations of knowledge diffusion and information externalities is a future research direction of major importance".[17] Combining on the one hand the externalities generated by human capital with increasing returns to scale, transport costs and the mobility of the labor force, human capital appears as a factor which favors both agglomeration and growth in cities (Alonso-Villar, 2002).[18]

Baldwin and Forslid (2000) also extend Krugman (1991) by introducing growth *à la* Romer (1990), so that the production of human capital is subject to technological externalities. However, these externalities are not localized, as in Alonso-Villar (2002), but they are of an interregional nature. They find that lowering the transport costs of commodities encourages agglomeration, as in Krugman (1991), while lowering the costs of trading ideas has the opposite effect.[19] It seems, therefore, that reductions in the cost of distance have a dispersion effect when learning externalities between locations are present.

Congestion costs versus agricultural workers

In a purely regional/international context, to assume the existence of an immobile demand, such as that represented in Krugman (1991) by farmers, is reasonable, at least in Europe, given that inter-regional mobility in the last two decades has been notably low. However, if we focus on an urban context, it would not be reasonable to assume that population is immobile. Large cities have other elements which limit their growth,

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transport costs. On the other hand, it weakens agglomeration for low transport costs.

[16] Exceptions would be Benabou (1993), Eaton and Eckstein (1997), Glaeser (1999) and Black and Henderson (1999).

[17] Duranton and Puga (2001) develop some of these microfoundations .

[18] In this paper, the introduction of human capital allows for new stable equilibria in which different-sized cities coexist, which is the typical spatial configuration of metropolitan areas. In a regional context this type of configuration is also obtained in Brakman *et al.* (1996) considering the negative effects deriving from industrial concentration. Lanaspa and Sanz (1999) also obtain similar configurations introducing in Krugman (1991) asymmetries in the number of agricultural workers between locations.

[19] Martin and Ottaviano (2001) also combine the tradition of the new economic geography with growth models, but in the absence of technological spillovers and labor mobility. They find also that a decrease in transaction costs between regions encourages agglomeration.

such as: high housing prices, city traffic or environmental pollution. All of these factors make smaller-sized cities comparatively more attractive places to live in, as discussed in Krugman and Livas Elizondo (1996), and Alonso Villar (2001a, b). To assume that dispersion is due to these congestion costs and not to the existence of an immobile agricultural sector is not irrelevant since the effects of improvements in transport can be considerably different.

In Figure 3 we keep the value of the transport cost at $\tau = 0.26$ and vary the congestion cost, $\gamma \geq 0$, which ranges from low to high values: 0, 0.25, 0.5 and 1.

[insert Figure 3]

We can observe that for high congestion values (γ= 1, and 0.5) concentration does not emerge as an equilibrium, given that if the entire population is in location 1, λ_1=1, the real wage difference would be negative, so that population would move towards location 2. For these values of γ it is also easy to see that a symmetrical distribution of the population between the two cities, λ_1=1/2, is a stable equilibrium, as the wage differential curve has a negative slope at this point. However, if congestion costs are low (γ= 0.25, 0) an even distribution of population between both locations becomes unstable. It follows, then, that the higher the congestion costs, the more likely it is to find an even distribution of population.

[insert Figure 4]

In Figure 4 we fix the parameter which corresponds to congestion at $\gamma = 1$ and consider three different transport costs: 0.26 (low costs), 0.6 (intermediate costs) y 1.5 (very high costs). We can see that, as the transport cost decreases, it is more difficult that concentration emerges as a possible equilibrium (there is a clockwise turn in the curve which represents the wage differential).[20] Therefore, unlike the model with the

[20] As mentioned above, in their alternative framework, Ottaviano *et al.* (2002) also point out that when considering commuting and land costs, dispersion emerges when trade costs are low. Tabuchi and Thisse (2002) find similar results when considering that individuals have heterogeneous tastes with respect to the attributes of regions. They also show that this heterogeneity acts as "a strong dispersion force that dramatically affects the core-periphery structure" (p. 174). Picard and Zeng (2004) also extend Ottaviano *et al*. (2002) and show that when agricultural transport costs are large, the manufacturing industry tends to

immobile agricultural sector, when considering congestion costs, improvements in the transport systems between cities generate a greater dispersion of the population. When communications between locations are good, individuals can enjoy the advantages of proximity to a large city (in particular, the numerous commodities available) while living in smaller cities where the congestion costs (which include housing prices and urban traffic) are lower. Therefore, it is important to know what type of context we want to analyze (metropolitan, regional, national or international) and, in consequence, what type of assumption is the most suitable, if we intend to analyze the possible functioning of the economy in the face of improvements in transport, a matter we will come back to later.

Other immobile demands

In Krugman (1991), farmers represent an immobile demand toward which firms may be interested in moving when transport cost are low enough. He also shows that the larger this immobile demand, the larger the dispersion effect. These farmers produce an homogenous agricultural good, which constitutes a constant expenditure share of individuals' income (utility is of a Cobb-Douglas type between the agricultural good and an aggregate of manufacturing goods). This agricultural good is costless tradeable, so that individuals demand the same amount, irrespective of its location. All this means that when a firm moves closer to farmers, the good it produces does not directly compete with the agricultural good produced there. However, the effects of proximity can be different when competition between similar goods comes into play, as discussed below.

Alonso-Villar (2001b) considers a long and narrow economy with four locations and three countries. Population in countries A and C are assumed to be concentrated in a single city. However, country B, which is located between countries A and C, has two possible locations, between which individuals can move without restriction. In this

disperse because of wages. However, when agricultural transport costs are low, the spatial distribution of manufacturing is again bell-shaped with respect to reductions in its own transport costs. All the above suggests that when considering dispersion forces other than the existence of immobile consumers represented by farmers, the effects of reductions in transport costs are substantially affected.

paper, the immobile demand represented by the two foreign markets ($1-\lambda_B$) consists of workers who also produce manufactured goods, with which firms in country B will have to compete. As opposed to Krugman (1991), she finds that when this immobile demand (the two foreign markets) is very large, production in country B tends to agglomerate in a single city, since any deviating firm would have to compete with a large number of foreign firms and would lose part of its national market. This suggests that the effect of an immobile demand on the concentration of production is not always the same. The fact that the potential market does, or does not, produce other varieties with which to compete appears to be a crucial factor.

[Figure 5]

In summary, from what has been discussed so far, it follows that any economic model that tries to explain the agglomeration of economic activity must consider the tension between two forces working together: **centripetal forces,** made up of all the elements which favor concentration, and **centrifugal forces,** which halt the size of such agglomerations and cause dispersion.

In the former we have included the preference for variety in consumption, proximity to the market, vertical linkages and increasing returns at firm level. We have also mentioned those generated by externalities, which are deliberately neglected in most of the new economic geography models since these focus mainly on pecuniary externalities. In the latter we have mentioned commuting costs, housing prices, agricultural transport costs, taste heterogeneity, and the existence of immobile demands scattered spatially and producing a non-manufactured good.

Whether we use one type of centrifugal force or another will depend on the specific phenomenon we want to study, as in some contexts one assumption will be more suitable whereas in others a different one will. Thus, if in a regional or an international context we can assume that a part of the population is immobile, in a purely metropolitan context this assumption would not seem reasonable, the congestion costs (which include the costs deriving from agglomeration, such as the costs of commuting and of housing) being much more suitable and realistic. Thus, the effects of improvements in transport will differ depending on the specific phenomenon which is

being analyzed and, therefore, on the underlying assumption. In a regional context, improvements in transport networks or, in general, in all the elements which facilitate trading between locations, can lead to greater concentration, but the above-mentioned results show that in a metropolitan context, the opposite will happen. Besides, we have also shown that when global learning externalities exist, the effects of reductions in the cost of distance may be different depending on whether they affect commodities or ideas, so that improvements in trading ideas would halt the agglomeration effect caused by improvements in trading goods.

3. MODELING AGGLOMERATION WHEN LABOR FORCE IS IMMOBILE

Krugman's approach assumed that the industrial labor force could move between locations in search of higher real wages. However, in many cases this mobility either does not exist or is limited by the governments. In this section we show how the effects of transport cost reductions, presented above, change when this element is taken into account.

Krugman (1991) assumed that workers had incentives to move between different locations so long as there was a significant real wage difference between them. This assumption is quite reasonable and realistic if our intention is 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. Krugman and Venables (1995) and Venables (1996) propose introducing new elements into Krugman's methodology which adapt better to the European reality, thus excluding the possibility of labor mobility between the two locations. As did Puga (1999), they also consider the existence of two industries vertically linked through an input-output structure, as well as the agricultural sector. Given that now wage differences between locations are not reduced by migration, firms might be interested in moving to less industrialized areas in which the wages offered are lower.[21]

[21] In these models the number of firms in each location is always endogenous. However, the labor force can move between locations or remain immobile depending on the model and also on the skill level.

Therefore, wage differences would be acting as a dispersion force, while the links between firms derived from their input-output relationships would counteract the previous phenomenon. Thus, in this new approach three types of elements are involved: the demand effect, which implies the interest of final manufacturing firms in being near the consumer (an element already existing in Krugman, 1991); vertical linkages and wage costs. The result of the interaction of these forces depends on how high trade costs between the different locations are.

[Figure 6]

Figure 6 represents the equilibria reached in the economy when transport costs (which affect both intermediate and final goods) take not a few values, as in previous figures, but a continuum of values (see Venables, 1996). [22] 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 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 figure.

We can see that when transport costs are significant, firms tend to disperse between both locations due to the dispersion of the population itself. Proximity to final demand represents, in this case, the factor which determines the spatial configuration. For intermediate transport costs, vertical linkages make up the spatial distribution, leading to the concentration of production. Finally, the dispersion of economic activity appears once more, insofar as small transport costs are concerned, in this case brought about by the high wage costs that a high level of industrialization implies.

Differences in migration can also depend on individuals preferences, as shown by Tabuchi and Thisse (2002).

[22] Actually, Venables (1996) only shows the equilibria of the final-goods sector. Here, that model has been simulated for the intermediate sector in order to compare this figure with the following ones. The spatial distribution of both sectors is qualitatively similar.

However, as mentioned above, the results obtained by Puga (1999) in a model similar to the previous one suggest that, when labor mobility is allowed in this framework, reductions in transport costs tend to favor economic concentration rather than halting it. This means that the advantages in labor costs, that peripheral regions can offer, disappear when wage differences are reduced by the mobility of workers. Thus, the consequences of improvements in transport/trade costs seem to depend on whether mobility of the labor force exists.

Production services

Without undermining the role that manufacturing firms can play in the development of a region, it is important to underline that services, especially producer services, are a sector which is becoming more and more important for stimulating regional growth. At present, manufacturing firms strongly depend on services such as logistics, technological transfer, marketing, finance, industrial engineering, etc., thus, the expansion that the service sector has undergone in recent years is extraordinary (Hansen, 1990).

Venables' (1996) model, presented above, focused on the location of manufacturing production, while firms producing intermediate goods were only a necessary element for explaining the high level of industrial concentration, under the assumption of inter-regional immobility of the workforce. However, other studies emphasize the importance of a special class of intermediate goods, producer services, in explaining why some regions grow more than others. In this vein, Alonso-Villar and Chamorro-Rivas (2001) analyze the elements involved in the location decisions of producer services and how they affect the location of manufacturing firms. As is well known, services are an information-oriented sector (Tofflemire, 1992; and Warf, 1995) and, therefore, this is another factor to bear in mind insofar as explaining their location is concerned. In contrast to Venables (1996), they find that reductions in transport costs can finally lead to specialization (producer services being in core regions and manufacturers in the periphery) rather than to convergence.[23] Thus, reductions would also cause initially a greater concentration of economic activity since proximity to a

[23] Krugman and Venables (1996) also find specialization when trade costs are low in a model with two

final demand would not be so necessary; while afterwards the wage advantages of the peripheral regions/countries would not cause greater dispersion, as Venables (1996) suggested, but would only attract the more routine industrial activity, while information-oriented sectors would choose those central locations with better access to information.[24]

The transport costs of final goods *versus* intermediates

Krugman and Venables (1995) and Venables (1996) suggest that regional policies interested in regional converge should improve transport infrastructures highly enough 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. Alonso-Villar (2004) suggests that in these kinds of models regional convergence is more the consequence of improvements in infrastructures which facilitate trade between intermediates and final goods (Figure 7) than those which facilitate transport between firms and consumers (Figure 8). Thus, the non-monotonic relationship between agglomeration and transport costs described in Venables (1996) could be the consequence of two transport costs having opposite effects on the spatial distribution of production.

[Figure 7]

[Figure 8]

It follows then that even in a framework of labor immobility and salary differentials between locations, Krugman's (1991) results can still be obtained by considering the case where only final goods undergo a reduction in transport costs. Therefore,

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different industries which produce both final and intermediates.

[24] By studying industrial location in Japan after the Second World War, Fujita and Tabuchi (1997) found that improvements in transport and telecommunications reinforced the agglomeration of activities devoted to information in the central regions of Japan, whereas manufacturing activities tended to disperse towards non-metropolitan regions of the country, as well as to other countries. Also, Warf (1995) presents numerous examples of firms in rich countries which have transferred plants where administrative tasks were carried out to places where wages where lower. Coffey and Polèse (1989) also include numerous examples of the high level of centralization of producer services in the large cities of countries such as Canada, Great Britain, France and the United States. These authors argue that factors relating to information and knowledge could be behind such centralization.

Krugman's (1991) results are not only the consequence of considering labor mobility between locations, as Puga (1999) suggests, but also the consequence of considering only transport costs of final goods. On one hand, Puga (1999) finds that labor mobility facilitates concentration, since labor differentials are reduced by migration. On the other hand, Alonso-Villar (2004) shows that salary differential does not play an important role, either, when intermediates are expensive to transport. It seems, therefore, that different elements can reduce the dispersion effect caused by wage differentials: labor mobility and high transport costs on intermediates.

A possible consequence of considering different kinds of transport costs in this framework is that improvements in transporting people, so long as they can benefit producer services, could foster inter-regional convergence. Also, improvements in other infrastructures that facilitate the connection between intermediates and final goods, as may be the case of telecommunications, could favor convergence. However, improvements in transporting physical goods have opposite consequences, favoring the concentration of economic activity.

4. INTERNATIONAL VERSUS DOMESTIC INFRASTRUCTURES

Papers presented in previous sections assumed that the economy consisted of two locations so that transport improvements affected communications between them. Depending on whether these locations were considered as cities, regions or countries, infrastructures' improvements could favor, respectively, intra-metropolitan trade, regional trade or international trade, but only one of them. However, there are other studies which distinguish between domestic infrastructures, i.e. those which connect cities or regions in a country, and those which connect different countries.

Even though most of these works consider an economy with three or four locations, there are some exceptions. So, for example, Martin and Rogers (1995) provide a model *à la* Krugman with two locations, which includes another factor of production (capital) and where the two locations (countries) differ in their capital and domestic infrastructure levels. Although workers are assumed to be immobile between countries, there are no wage differentials between them, so that farmers are again the only dispersion force in the model. Then, it is not surprising that their results mirror those of

Krugman (1991). In this vein, they show that improvements in international infrastructures favor the concentration of firms. However, since countries differ in their infrastructure level, they find that this concentration will take place in the country with the best domestic infrastructure. They also suggest that in order to favor convergence between countries, regional policies should improve domestic rather than international infrastructures.[25]

Inspired by the case of Mexico, Krugman and Livas Elizondo (1996) also analyze the effects of reducing international transport costs on domestic agglomeration. To this end, they consider an economy with three locations, two of them being in the same country and the other representing the rest of the world. Individuals are assumed to move between locations in the same country, but not to the rest of the world. While centripetal forces are the same as in Krugman (1991), the centrifugal force in this model is no longer due to immobile farmers, but to the high costs of commuting and land prices in large cities. As opposed to Martin and Rogers (1995), they find that reductions in international transport costs foster the dispersion of economic activity. They suggest that agglomeration can be fostered by manufacturers mainly serving the domestic market, so that when international trade costs decrease the agglomeration process becomes weaker.[26]

Also, Paluzie (2001) addresses this topic in a framework with three locations but more closely connected to Krugman (1991), so that farmers, rather than commuting costs and housing, halt the concentration of economic activity. As opposed to Krugman and Livas Elizondo (1996), her results suggest that improvements in international transport costs facilitate the concentration, instead of the dispersion, of economic activity. Once again, the centrifugal force appears as a relevant factor to explain the effects of reductions in transport costs. Depending on which centrifugal force is included in the model, i.e. farmers or housing/commuting, reductions in international transport costs can lead to different spatial patterns.

[25] Monfort and van Ypersele (2003) also support these results in a model with two countries and four regions.

[26] In Alonso-Villar (2001b) the analysis goes further by emphasizing that megacities are not only the result of protective trade policies, but also the consequence of the relative position of a country, in terms of industrialization, with respect to the rest of the world. Since goods produced by the less developed countries have to compete with products of the rest of the world, it would be not profitable for firms to choose locations more distant from their national market and closer to the international ones.

In a similar framework, Monfort and Nicolini (2000) also extend Krugman (1991) by considering an economy with two countries and two regions in each of them. Their simulations suggest that the effects of reducing interregional transport costs are similar to those of international transport costs, fostering the concentration of production.

More recently, Mansori (2003) has brought a new element to the debate. He extends Krugman and Livas Elizondo (1996) by allowing increasing returns to scale in transportation. This means that the same centrifugal (commuting costs and housing) and centripetal forces (forward and backward linkages) apply. He finds that as the domestic infrastructure improves, the dispersion equilibrium becomes more likely, even though the presence of increasing returns mitigates this effect.[27] However, as opposed to Krugman and Livas Elizondo (1996), he finds that, when there are increasing returns to scale in transportation, reductions in international transport costs cause the economy to move to concentration, since international trade becomes more important and concentration in a single city facilitates transportation.

It follows, then, that the impacts of decreasing international transport costs depend on the centrifugal force and on transportation returns, but also that the effects of reducing international trade costs are not necessarily the same as those of domestic trade costs. In this vein, Behrens (2003a,b) goes further and develops a three-region model based on Ottaviano *et al.* (2002), where individuals can move between the two regions of the country but not to the rest of the world, to analyze the relative effect of domestic and international trade costs. As previously mentioned, this framework differs from the usual Dixit-Stiglitz-Iceberg one in preferences and transport costs (which is measured in terms of the numéraire). He shows that the relative level of international to interregional trade costs is important to explain the spatial distribution of production. In particular, he finds that improvements in international trade costs in developing countries with poor domestic infrastructures foster regional divergence, while the opposite holds for countries with good internal infrastructures. This suggests that international integration can lead to a balanced distribution of production only when there already exists integration within developing countries. As opposed to Mansori (2003), Behrens (2003a) also shows that, in the context of developed countries,

[27] In particular, he finds that the range of domestic transport costs which allows dispersion to emerge as

reductions on interregional trade costs foster the agglomeration of economic activities, while reductions in international trade costs have the opposite result, halting that agglomeration.

To explain the differences with respect to previous works, he points to the fact that this alternative framework allows the modification of the share of interregional trade costs when international trade costs decrease. In this vein, Behrens (2003b, p.21) shows that "a decrease in international trade costs, by decreasing equilibrium prices, leads to a relative increase in interregional trade costs". Therefore, changes in international trade costs may induce firms to relocate in order to save on trade costs. In particular, competition becomes fiercer when international trade costs decrease, which lead to the redispersion of firms if internal infrastructures are good enough. However, when internal infrastructures are poor, "local firms care more about market size, which triggers a process of cumulative regional divergence that leads to a core-periphery structure", Behrens (2003b, p.20).

We can conclude that, on one hand, within the Dixit-Stiglitz-Iceberg framework the effects of reducing transport costs do depend on the centrifugal force, as mentioned above, but also on how trade costs are modeled. In fact, when considering the possibility of increasing returns in the transportation sector, the results are significantly affected. On the other hand, even though in a two-location model the results obtained by Krugman (1991) seem to be quite robust against alternative specifications of preferences and transport costs, as shown in previous sections, when considering a three-location model, the results are substantially affected by these assumptions. Behrens (2003b) suggests that some of the results in the Dixit-Stiglitz-Iceberg approach strongly depend on the fact that in such framework "decreasing international trade costs do not modify the share of interregional trade costs in consumer prices", while this is not the case in alternative frameworks such as that proposed by Ottaviano *et al.* (2002). It seems, therefore, that transport cost modeling also plays a crucial role in this literature.

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an equilibrium is wider with constant returns than with increasing returns on transportation.

5. CONCLUSIONS

Among the elements which favor the concentration of economic activity, the theories of the New Economic Geography emphasize those derived from market interactions: preference for variety in consumption, proximity to consumers, vertical linkages and returns to scale at firm level. In the opposite direction are those other factors which halt agglomeration: commuting costs and housing prices for individuals within a city, taste heterogeneity in labor mobility, agricultural transport costs, the pull of dispersed rural markets and wage differences between locations.

We can conclude that within the Dixit-Stiglitz-Iceberg framework the effects of reducing transport costs between locations strongly depend on: a) the centrifugal force, b) how transport costs are modeled and c) the mobility of the labor force.

a) If the centrifugal force considered is commuting/housing and people are allowed to move between locations in a country, but not to the rest of the world, reductions either in international or domestic transport costs would cause a greater dispersion of economic activity (Krugman and Livas Elizondo, 1996; Alonso-Villar, 2001a). If the dispersion force used derives from an immobile demand, reductions in domestic/international transport costs would foster, instead, a greater concentration of industrial activity (Krugman, 1991; Paluzie, 2001; Monfort and Nicolini, 2000). In the former type of models, access to a wider range of goods in larger cities tends to lose influence when transport costs between locations are low. In the latter, however, at low transport costs, firms are less interested in their proximity to the dispersed rural market, since they can easily provide them from a single location.

b) More recent papers suggest that the effects of reductions on transport costs can also depend on how these costs are modeled. In this vein, Mansori (2003) shows that when considering the possibility of increasing returns to scale in the transportation sector, the results are significantly affected. Thus, even in a context of commuting/housing costs, improvements in international transport costs favor the agglomeration of production. So long as international transport costs decrease, international rather than domestic trade becomes more important for firms. Thus, economic activity tends to agglomerate in a

single location to facilitate transportation. However, the effects of improvements in domestic infrastructures still have the expected effect, driving firms to disperse between locations. This suggests that the effects of improvements in transportation may also differ depending on whether they facilitate trade within or between countries. Moreover, Behrens (2003b) points out that the relative level of international versus domestic transport costs is also important to explain the spatial distribution of production. He also shows that some of the results obtained in the Dixit-Stiglitz-Iceberg approach are not robust against alternative specifications of transport costs. In particular, he finds that the interplay between international and domestic transport costs in that approach is affected by the assumption of the multiplicative iceberg form in transportation. However, so far only a few papers have addressed this topic, and more research is required in order to reach more general conclusions.

c) When the dispersion force is due to wage differentials between locations, results differ depending on whether there is labor mobility. Thus, if wage differences are reduced by the mobility of the labor force, transport cost improvements foster inter-territorial divergences, favoring the emergence of a core-periphery pattern (Puga, 1999). However, if the labor force is not allowed to move, reductions in transport costs initially foster the concentration of production, and later drive firms towards the periphery, because of the advantage in salary costs (Venables, 1996). This non monotonic behavior is the result of two transport infrastructures having opposite effects, those which connect intermediate and final goods, and those which connect firms and consumers (Alonso-Villar, 2004). Therefore, Krugman's finding is not only the consequence of considering labor mobility, but also that of considering the transport costs of final goods exclusively. This redispersion effect found in some of these papers at low transport costs could, however, involve specialization rather than total convergence. In fact, the most routine activities could be those carried out in peripheral areas whereas the central areas would absorb knowledge-oriented activities, which include most producer services (Alonso-Villar and Chamorro-Rivas, 2001).

The aforementioned bell-shaped relationship between the spatial distribution of production and transport costs can also be obtained in frameworks other than that of the Dixit-Stiglitz-Iceberg. As a matter of fact, when using the approach of Ottaviano *et al.* (2002), many papers yield the same result by considering a large variety of centrifugal

forces —commuting/land costs, wage differentials, agricultural transport costs, taste heterogeneity— and labor mobility between locations (see Picard and Zeng, 2004; and Tabuchi and Thisse, 2002). It seems, therefore, that the bell-shaped relationship between agglomeration and transport costs is a pattern commonly found under a wide range of assumptions. However, more work remains to be done to explain why such different frameworks can lead to similar conclusions, given that within the Dixit-Stiglitz-Iceberg framework, there is a substantial effect on the results depending on a wide range of well-examined assumptions.

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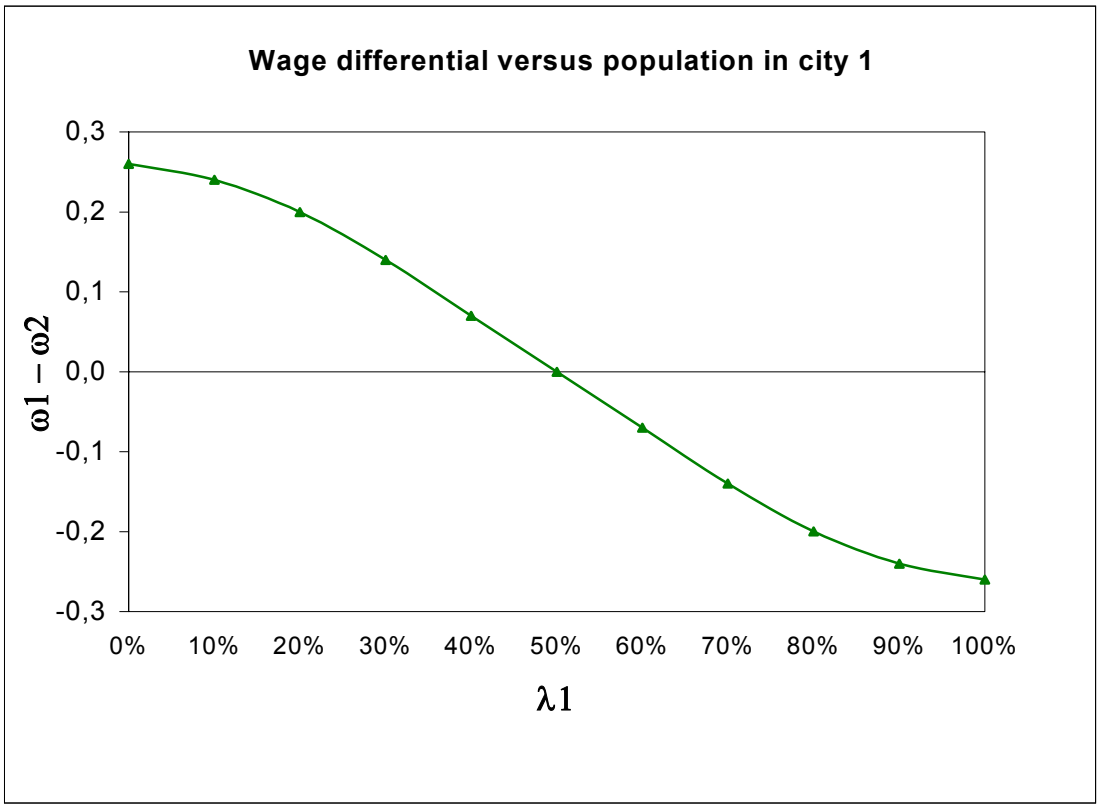

Figure 1. High transport costs in Krugman (1991, 1992)

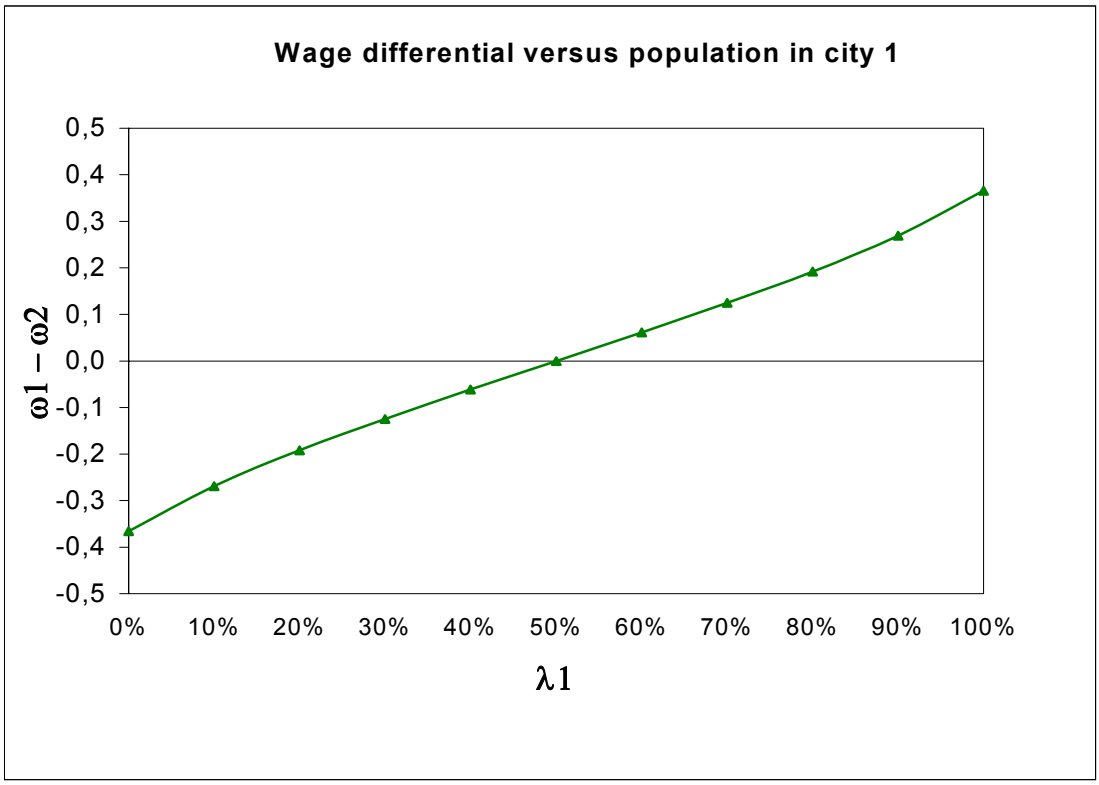

Figure 2. Low transport costs in Krugman (1991, 1992)

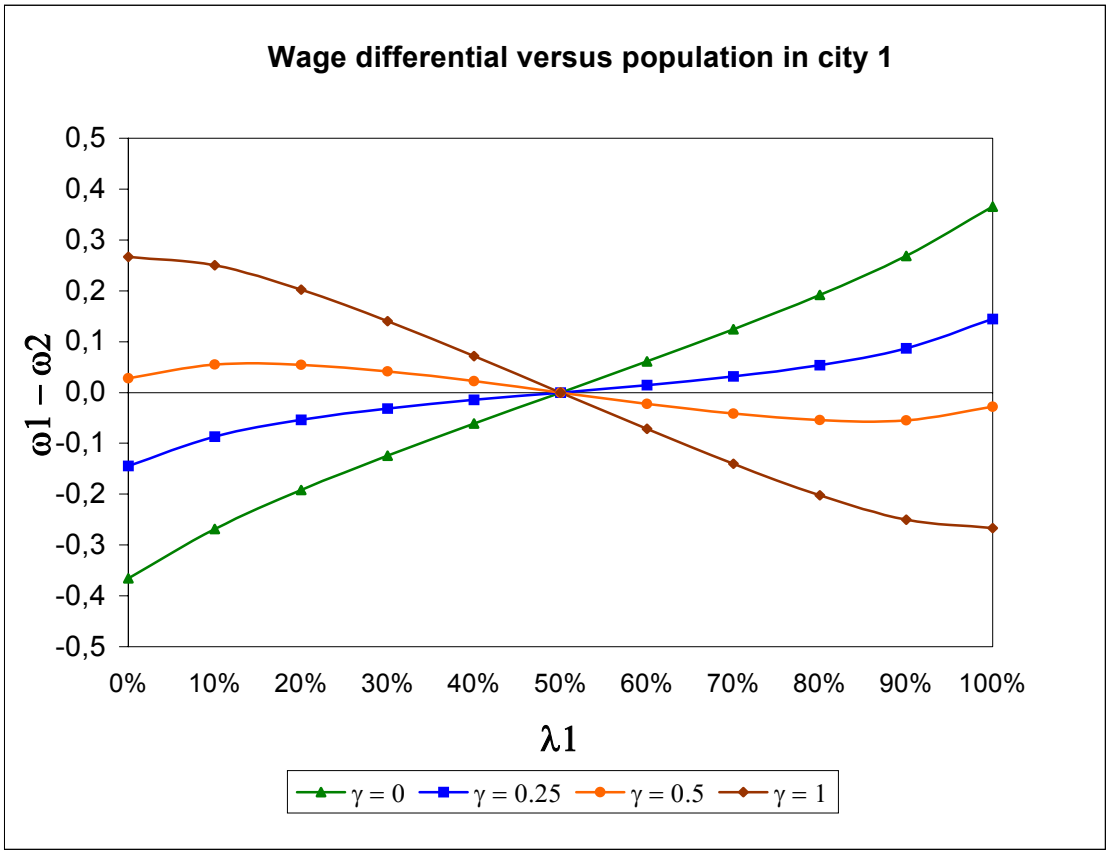

Figure 3. Only the congestion parameter varies in Alonso-Villar (2001b)

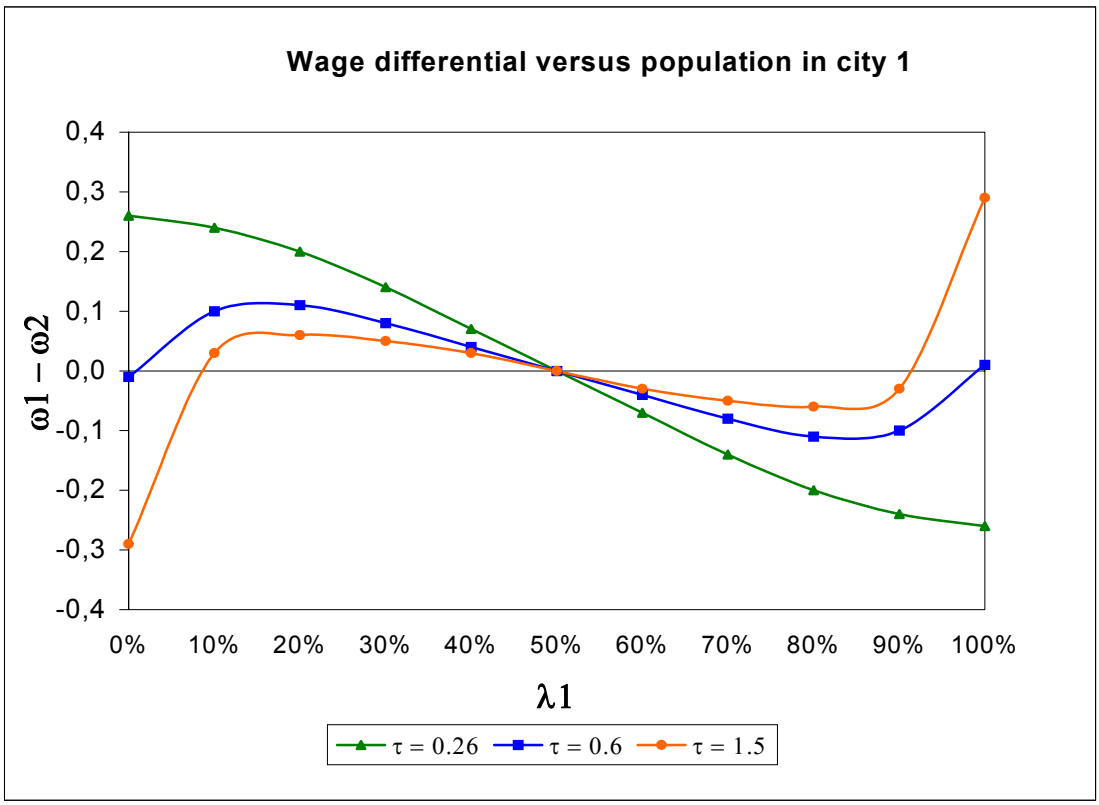

Figure 4. Only the transport parameter varies in Alonso-Villar (2001b)

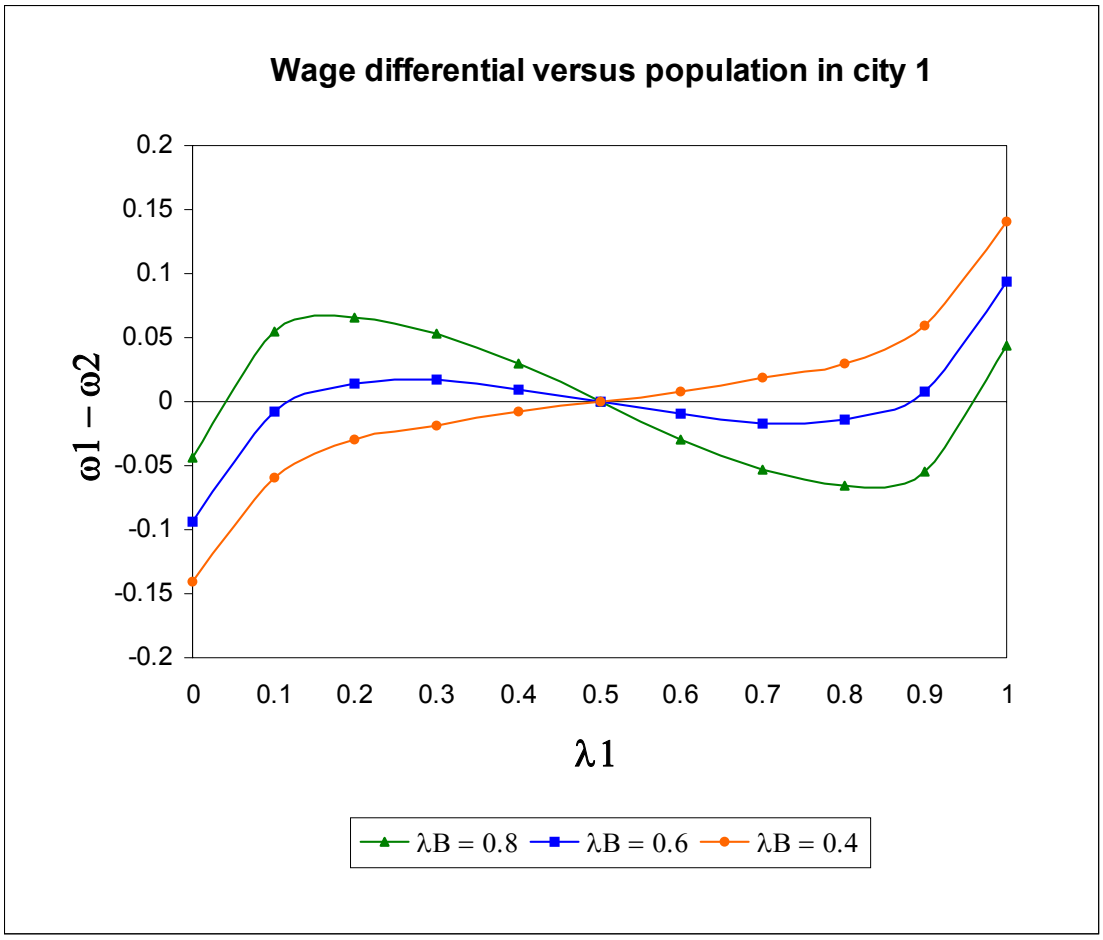

Figure 5. The relative size of country B varies , Alonso-Villar (2001b)

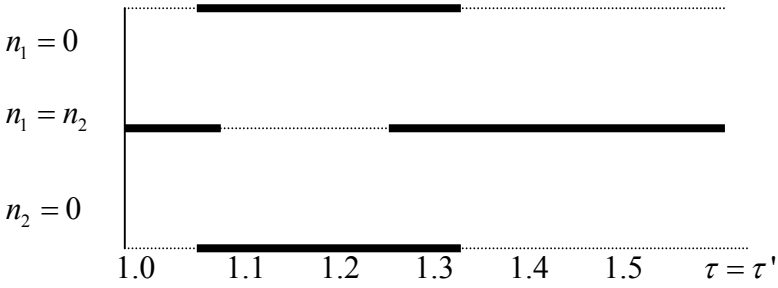

Figure 6. Location of intermediates in Venables (1996)

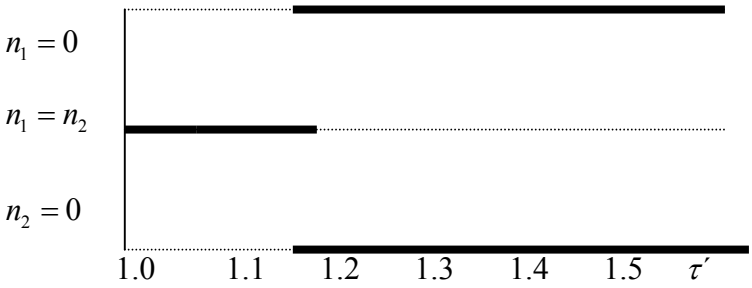

Figure 7. Location in Alonso-Villar (2004) when only τ' varies

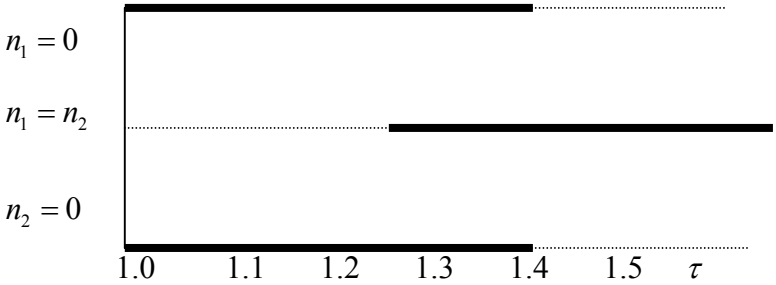

Figure 8. Location in Alonso-Villar (2004) when only τ varies

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