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ABSTRACT

Agglomeration and Trade Revisited*

The purpose of this paper is two-fold. First, we present a model of agglomeration and trade that displays the main features of the recent economic geography literature, while allowing for the derivation of analytical results by means of simple algebra. Second, we show how this framework can be used to tackle the following important issues: (i) the impact on agglomeration of alternative pricing policies used in the space-economy, with a special focus on the distinction between segmented and integrated markets; (ii) a forward-looking approach to the dynamics of migration in the process of agglomeration, instead of the simple Marshallian model used so far in the economic geography literature.

JEL Classification: F12, L13, R13
Keywords: agglomeration, trade, spatial price policy, monopolistic competition

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NON-TECHNICAL SUMMARY

The agglomeration of activities in a few places is probably the most distinctive feature of the economic space. It is only recently that economists have become able to provide an analytical framework, explaining the emergence of economic agglomerations in an otherwise homogeneous space. The tool used in the 'new economic geography' is the Chamberlinian model of monopolistic competition, as developed by Dixit and Stiglitz. There is no doubt that this has allowed for the development of many new and relevant results. It is fair to say, however, that the Dixit-Stiglitz model suffers from several deficiencies, when it is used as the main building block of a general equilibrium model. In addition, the spatialized version of the Dixit-Stiglitz model imposes some special assumptions that lead to a very peculiar result, namely separated markets (or discriminatory pricing) provide the same market outcome as integrated markets (or mill pricing). Such a feature makes it very problematic to use this framework to evaluate the impact of alternative spatial pricing schemes on regional equilibria and the intensity of trade. This turns out to be a severe limitation, because firms do use specific policies that differ vastly, while antitrust authorities, governments or international bodies may be inclined to favour the use of some policies, because they want to foster a better allocation of resources or promote what they call 'fair competition'. One must also be aware that, in all this literature, economic integration is interpreted as a fall in trade costs only. This is a relatively narrow view of the integration process, because it puts aside the possibility of studying the social desirability of fostering integrated markets, in which firms set a common free on board (FOB) price for all markets, against segmented markets, in which firms set a specific fob price for each market, even under low trade costs. By contrast, our model allows for a clear distinction between the two approaches.

Spatial pricing policies, such as discriminatory pricing, mill pricing or uniform delivered pricing, are likely to impact on the regional pattern of production and trade. Indeed, unlike general beliefs, transport costs and, more generally, all the costs borne by firms for doing business in a distant market, are not negligible. Once the transport sector is modelled, in a way that deals with various pricing rules, one can check that very different patterns emerge under the different pricing regimes. This is in accordance with industrial organization models, where the choice of a spatial price policy is shown to have a strong impact on firms' locations and on the intensity of competition.

We are then equipped to go one step further and discuss the role of spatial pricing policies for regional planning. Indeed, one observes that firms are

sometimes forced by the public authorities to refrain from using spatial discriminatory pricing in favour of either mill or uniform delivered pricing. Two justifications are analysed. The first one is based on the need to promote an even spatial distribution of economic activities. The other accounts for the existence of regional imbalances, but stresses the need to take care of those who cannot move and are left behind in abandoned areas.

Finally, the stability analysis of spatial equilibria conducted within the Dixit-Stiglitz model so far rests on standard Marshallian techniques, where consumers' migration is driven by differences in current utility levels. Yet, forward-looking dynamics should be applied to describe the migration process. Indeed, locational decisions are often made once-and-for-all, thus implying that consumers/workers should also account for their future flows of earnings and not only for their current ones.

The purpose of this paper is two-fold. First, we present a model of agglomeration and trade that displays the main features of the work developed since Krugman developed his core-periphery model, while being sufficiently simple to be solved by means of simple analytical tools. Second, we wish to find a framework, which is tractable enough to tackle the issues discussed in the foregoing without long and painstaking formal developments. To this end, we consider another popular model, also used in industrial organization and international trade, that is, the quadratic utility model which neatly captures the idea of product differentiation in imperfect markets. We show that such a formulation of preferences leads to a richer set of results through a more sophisticated market structure. Yet, our model is very much in the tradition of the new economic geography. In particular, it has a lot to share with models that explain economic agglomeration through demand linkages between firms and supply linkages via scale economies. Our model also retains several of the connections economic geography models have with the new theories of international trade, while at the same time offering an alternative framework to study some questions untouched so far in this field.

It differs, however, from the existing literature in five major respects. First, the functional form used for the utility is not the same as that used by Krugman and others, though it also encapsulates a preference for variety, as does a constant elasticity of substitution. Specifically, we are able to show that the main tendencies toward agglomeration are robust against alternative specifications of demand, so that our results strengthen the existing literature which no longer depends on a particular specification of preferences. Second, closed analytical solutions are obtained. This means that we do not have to appeal to numerical resolution unlike many papers in economic geography.

This again gives makes our results more robust. Third, our model allows for asymmetry between own price and cross price effects. In particular, the price elasticity is no longer equal to the elasticity of substitution and both may vary with prices. Fourth, transportation is modelled as a costly activity that uses other resources than the transported good itself. This is a more natural approach than using the iceberg transport cost. This will also allow us to study the impact of various spatial price policies and the respective role of history and expectations in the agglomeration process. Last, the equilibrium concept used is broader than that employed by Dixit and Stiglitz in the sense that it agrees with Chamberlin, while yielding prices depending on all the fundamentals of the market. This permits a more detailed analysis of the forces at work as well as more explicit connections to the industrial organization literature, where there has been less emphasis on monopolistic competition *à la* Dixit-Stiglitz.

We then apply our framework to different pricing policies used in trade and location theories, evaluating the impact of these pricing strategies on the process of regional agglomeration and determining endogeneously the nature of the trade pattern. In particular, our results allow for a ranking of the above three price policies in terms of welfare and trade intensity. It is shown that uniform delivered pricing is the best policy for those who are left in the rural region.

Our framework also allows for a neat and simple comparison of both history and expectations in the formation of economic agglomeration, a task which has not yet been successfully accomplished within the standard core-periphery model. Specifically, we show that expectations influence the agglomeration process in a totally unsuspected way, in the sense that they have an influence on the emergence of a particular agglomeration for intermediate values of the transport cost only.

1 Introduction

The agglomeration of activities in a few locations is probably the most distinctive feature of the economic space. Despite some valuable early contributions made by Hirschman, Perroux or Myrdal, this fact remained unexplained by mainstream economic theory for a long time. It is only recently that economists have become able to provide an analytical framework explaining the emergence of economic agglomerations in an otherwise homogeneous space. As argued by Krugman (1995), this is probably because economists lacked a model embracing both increasing returns and imperfect competition, the two basic ingredients of the formation of the economic space, as shown by the pioneering work of Hotelling (1929), Lösch (1940) and Koopmans (1957).

If the distribution of resources is uniform, the standard assumption that production technologies are convex implies that the economy reduces to a Robinson Crusoe-type economy where each person produces for his own consumption (backyard capitalism). Each location could thus be a base for an autarchic economy where goods are produced on an arbitrarily small scale, except possibly, as in the neoclassical theory of international trade, that trade might occur when the geographic distribution of resources is nonuniform. While pertinent, unequal distribution of resources seems weak as the only explanation for agglomeration and trade. Hence, increasing returns to scale are essential for explaining the geographical distribution of economic activities. Once this point is recognized, we must then cope with the question posed by Sraffa (1926): to what extent is price-taking compatible with increasing returns to scale? A price-taking equilibrium could not have 'many' firms producing a homogeneous good, each operating at inefficiently small scale, because each such firm would have a profit incentive to increase its output. Hence, for each good, the market can only accommodate a 'few' firms of efficient size. But with only a few firms, how does one justify the hypothesis that firms treat prices as given since firms must realize that their size permits them to influence prices to their own advantage.

The tool used in the 'new economic geography' is the Chamberlinian model of monopolistic competition in which firms do not interact strategically (see Fujita *et al.*, 1998, ch.4). The prototype of this model has been developed by Dixit and Stiglitz (1977). These authors describe monopolistic competition as a market structure determined by consumers' preference for variety and firms' fixed requirements for limited productive resources. Each firm produces one variety and, with freedom of entry, profits are just sufficient to cover average costs which are decreasing in output. Consumers distinguish varieties of the same type of good produced by different firms, and utility is increasing in the number of varieties. The varieties are demanded by each consumer to maximize utility represented by a constant elasticity of substitution (CES) function over the varieties. Finally, one firm's price reduction is supposed to affect marginally the demand served by other firms; thus, other firms do not react to the negligible decrease in their sales.

There is no doubt that this model has allowed for the development of many new and relevant results in economic geography (see Fujita and Thisse, 1996, for a survey of what has been accomplished in the economics of agglomeration, and Matsuyama, 1995, for a broader review of the applications of the Dixit-Stiglitz model). However, it is fair to say that this model suffers from several deficiencies when it is used as the main building block of a general equilibrium model (d'Aspremont *et al.*, 1996). The same holds regarding welfare analysis conducted within the spatialized Dixit-Stiglitz model because the marginal utility of the numéraire is not constant and varies across consumer groups.

In addition, the spatialized version of the Dixit-Stiglitz model imposes some special assumptions that lead to a very peculiar result, namely separated markets (or discriminatory pricing) provide the same market outcome as integrated markets (or mill pricing). Besides being unrealistic, this result makes it very problematic to use this framework in evaluating the impact of alternative spatial pricing schemes on regional equilibria and the intensity of trade. This turns out to be a severe limitation because firms do use specific policies that vastly differ (Greenhut, 1981; Phlips, 1983a; Scherer, 1980), while antitrust authorities, governments or international bodies may be inclined to favor the use of some policies because they want to foster a better allocation of resources or promote what they call 'fair competition' (see, e.g. Carlton, 1983; Tharakan, 1991).

Having said that, one must also be aware that in all this literature economic integration is interpreted as a fall in trade costs only. This is a relatively narrow view of the integration process in that it puts aside the possibility of studying the social desirability of fostering *integrated markets*, where firms set a common fob price for all markets, against *segmented markets*, where firms set a specific fob price for each market, even under low trade costs

(Smith and Venables, 1988), such as the possible future decision of abolishing exemptions to Article 85 to the Treaty of Rome (Ginsburgh, 1994). By contrast, our model allows for a clear distinction between the two approaches. Among other things, we will see that the main results obtained since Krugman (1991a) are driven by the implicit assumption of integrated markets.

Spatial pricing policies, such as discriminatory pricing, mill pricing or uniform delivered pricing, are likely to impact on the regional pattern of production and trade. Indeed, unlike general beliefs, transport costs, and more generally all the costs borne by firms for doing business in a distant market, are not negligible (Fujita *et al.*, 1998). For example, in the case of trade between the US and Japan, Rauch (1996) estimates transport costs of around 6% of value for differentiated products. Once the transport sector is modeled in a way that permits to deal with various pricing rules, one can check whether very different patterns emerge under the different pricing regimes. Specifically, we will see that *the choice of a particular spatial price policy matters for the organization of the economic space as well as for the nature and intensity of trade.* This is in accordance with what is known in industrial organization models where the choice of a spatial price policy is shown to have a strong impact on firms' locations (Hwang and Mai, 1990; Anderson *et al.*, 1992) as well as on the geographical distribution of production and the intensity of competition (Norman and Thisse, 1996). We are then equipped to go one step further and discuss the role of spatial pricing policies for regional planning. Indeed, one observes that firms are sometimes forced by the public authorities to refrain from using spatial discriminatory pricing in favor of either mill or uniform delivered pricing (Greenhut, 1981). Two justifications are analyzed. The first one is based on the need to promote an even spatial distribution of economic activities. The other accounts for the existence of regional imbalances, but stresses the need to take care of those who cannot move and are left behind in abandoned areas.

Finally, the stability analysis of spatial equilibria conducted within the Dixit-Stiglitz model so far rests on standard Marshallian techniques where consumers' migration is driven by differences in current utility levels (see, e.g. Fujita *et al.*, 1998). Yet, forward-looking dynamics have been proposed in related domains (Krugman, 1991b; Matsuyama, 1991) and should be applied to describe the migration process. Indeed, locational decisions are often made once-and-for-all, thus implying that consumers/workers should also account for their future flows of earnings and not only for their current ones.

The purpose of this paper is twofold. First, we want to present a model of agglomeration and trade that displays the main features of the work developed since Krugman (1991a) presented his core-periphery model, while being sufficiently simple to be solved by means of simple analytical tools. Second, we wish to find a framework which is tractable enough to tackle the issues discussed in the foregoing without going into long and painstaking formal developments. To this end, we consider another popular model, also used in industrial organization (Dixit, 1979; Vives, 1990) and international trade (Anderson *et al.,* 1995; Krugman and Venables, 1990) as well as in demand analysis (Phlips, 1983b), that is, the *quadratic utility* model. It is well known that this model allows one to capture in a neat way the idea of product differentiation in imperfect markets. We will argue below that such a formulation of preferences allows for a richer set of results through a more sophisticated market structure.

In many respects, our model is very much in the tradition of the new economic geography. In particular, it has a lot to share with models that explain economic agglomeration through demand linkages between firms and supply linkages via scale economies (Krugman, 1991a). Our model also retains several of the connections economic geography models have with the new theories of international trade (Helpman and Krugman, 1985), while offering at the same time an alternative framework to study some questions untouched so far in this field. However it will be shown to differ from the existing literature in five major respects. First, the functional form used for the utility is not the same as that used by Krugman and others, though it also encapsulates a preference for variety as does the CES. Specifically, we are able to show that the main tendencies toward agglomeration are robust against alternative specifications of demand, so that our results strenghten the existing literature which no longer depends on a particular specification of preferences. Second, closed analytical solutions are obtained. This means that we do not have to appeal to numerical resolution unlike many papers in economic geography. This again gives more robustness to our results. Third, our model allows for asymmetry between own price and cross price effects. In particular, the price elasticity is no longer equal to the elasticity of substitution and both may vary with prices. Fourth, transportation is modeled as a costly activity that uses other resources than the transported good itself. This is a more natural approach than using the iceberg transport cost. This will also allow us to study the impact of various spatial price policies as well as the respective role of history and expectations in the agglomeration process. Last, the equilibrium concept used is broader than that employed by Dixit and Stiglitz in that it agrees with Chamberlin (1933) while yielding prices depending on all the fundamentals of the market (see also Spence, 1976, for a related approach). This permits a more detailed analysis of the forces at work as well as more explicit connections to the industrial organization literature where less emphasis has been put on monopolistic competition à la Dixit-Stiglitz.

Once this objective is reached, we can proceed further and apply our framework to different pricing policies used in trade and location theories. We are thus able to evaluate the impact of these pricing strategies on the process of regional agglomeration and to determine endogeneously the nature of the trade pattern. In particular, our results allow for a ranking of the above three price policies in terms of welfare and trade intensity. It is shown that uniform delivered pricing is the best policy for those who are left in the rural region.

We will also see how our framework allows for a neat and simple comparison of both history and expectations in the formation of economic agglomeration (Krugman, 1991b), a task which has not yet been successfully accomplished within the standard core-periphery model (see, however, Ottaviano, 1998, for the analysis of a special case). Using our model allows us to determine the exact domain for which expectations matter for agglomeration to arise. Specifically, we show that expectations influence the agglomeration process in a totally unsuspected way in that they have an influence on the emergence of a particular agglomeration for intermediate values of the transport cost only. It seems fair, therefore, to claim that our model provides a unifying framework of existing results as well as new results which are especially difficult to obtain within the Dixit-Stiglitz model of monopolistic competition.

The organization of the paper reflects what we have said in the foregoing. The model is presented in the next section while the equilibrium prices are determined for segmented markets (discriminatory pricing) in Section 3. The corresponding process of agglomeration is analyzed in Section 4 by using the Marshallian approach in the stability analysis. Extensions to alternative pricing policies, such as mill and uniform delivered pricing, are dealt with in Section 5. We will see that pricing policies have very different impacts on the formation of agglomeration, thus showing how the choice of a price policy in the interregional market place changes the regional economic structure and the nature of trade. In particular, the spatial pattern of production and trade emerging under mill pricing is very similar to that uncovered by Krugman (1991a) and Fujita *et al.* (1998, ch.5) whereas it may vastly differ under the other two pricing regimes. Section 6 pursues our investigation of the role of spatial pricing policies by developing a political economy analysis of these policies from different perspectives. In Section 7, we show how our model can be used to compare history and expectations in the emergence of an agglomeration. We restrict ourselves to the case of separated markets though our analysis could be extended to the case of other pricing policies. Section 8 concludes.

2 The model

The economic space is made of two regions, called H and F. There are two factors, called A and L. Factor A is evenly distributed across regions and is spatially immobile. Factor L is perfectly mobile between the two regions and $\lambda \in [0, 1]$ denotes the share of this factor located in region H. There are two goods in the economy. The first good is homogeneous. Consumers have a positive initial endowment of this good[1] which is also produced using factor A as the only input under constant returns to scale and perfect competition. This good can be traded freely between regions and is chosen as the numéraire.[2] The other good is a horizontally differentiated product which is produced using L as the only input under increasing returns to scale and imperfect competition. For expositional purposes, we refer to the homogeneous good sector as 'agriculture' and the differentiated product sector as 'manufacturing'. Accordingly, we call 'farmers' the immobile factor A and 'workers' the mobile factor L.[3]

As in most economic geography models, we want each firm in the manufacturing sector to have a negligible impact on the market outcome in the sense that it can ignore its impact on, and hence reactions from, other firms. To this end, we assume that there is a continuum N of firms. In addition, since each firm sells a differentiated variety, it faces a downward sloping de-

[1] This is different from the assumption made in standard models of economic geography where consumers have a positive endowment in labor only. It implies that income equals wage. We will see below why we depart here from this assumption.

[2] As in Fujita *et al.* (1998, ch.6), we could relax this assumption without affecting our main conclusions.

[3] Note that an alternative interpretation is to consider A as being land.

mand, so that our model is a 'true' model of monopolistic competition (Hart, 1985) in which all the unknowns are described by density functions.[4] There are no scope economies so that, due to increasing returns to scale, there is a one-to-one relationship between firms and varieties.

Each variety can be traded at a positive cost of τ units of the numéraire for each unit transported from one region to the other, regardless of the variety, where τ accounts for all the impediments to trade. This is a significant departure from Krugman's analysis in that this specification allows for the study of the various spatial pricing policies one encounters in trade and location theories. Indeed, under the iceberg transport cost, the CES utility and monopolistic competition implies that spatial price discrimination is equivalent to mill pricing. In addition, the assumption of an iceberg transport cost function is not innocuous in that it also implies that any increase in the mill price is accompanied with a proportional increase in transport cost, which seems both unrealistic and undesirable. It is worth recalling here that there has been a debate in international trade about the iceberg approach versus an explicit modeling of the transport sector which has been strangely enough forgotten. What is important for us is that the two approaches do not necessarily lead to the same results (Bottazzi and Ottaviano, 1996).

Preferences are identical across individuals and described by the following quasi-linear utility function which is supposed to be symmetric in all varieties:

$$\begin{aligned} U(q_0; q(i), i \in [0, N]) &= K + \alpha \int_0^N q(i)di - \frac{1}{2}\beta \int_0^N q(i)^2 di \\ &\quad -\gamma \int_0^N \int_0^N q(i)q(j)didj + q_0 \end{aligned} \tag{1}$$

where $q(i)$ is the quantity of variety $i \in [0, N]$ and q_0 the quantity of the numéraire. The parameters in (1) are such that $\alpha > 0$ and $\beta \geq \gamma > 0$, while K is a constant of integration for the utility function to be well-behaved. For a given value of β, the parameter γ expresses the substitutability between varieties: the higher γ, the closer substitutes the varieties.

Any individual is endowed with one unit of labor (of type A or L) and $\overline{q}_0 > 0$ units of the numéraire. His budget constraint can then be written as follows:

$$\int_0^N p(i)q(i)di + q_0 = y + \overline{q}_0$$

[4]So our model is very much in the same spirit as mainstream urban economics where quantities and prices are also expressed by density functions (see, e.g. Fujita, 1989).

where y is the individual's labor income, $p(i)$ is the price of variety i while the price of the agricultural good is normalized to one. The initial endowment $\overline{q}_0$ is supposed to be large enough for the optimal consumption of the numéraire to be strictly positive for each individual regardless of his labor income.

Solving the budget constraint for the numéraire consumption, plugging the corresponding expression into (1) and solving the first order conditions with respect to $q(i)$ yields

$$\alpha - \beta q(i) - \gamma \int_0^N q(j)dj = p(i), \quad i \in [0, N]$$

For these equations to have a solution in the $q(i)$, it must be that $\beta \neq \gamma$. If so, the demands for variety $i \in [0, N]$ is:

$$q(i) = a - bp(i) + c \int_0^N [p(j) - p(i)]dj \tag{2}$$

where $a \equiv \alpha/(\beta + N\gamma)$, $b \equiv 1/(\beta + N\gamma)$ and $c \equiv \gamma/[(\beta - \gamma)(\beta + N\gamma)]$.

Our specification (2) of the linear demand system differs from the standard model and is based on Irmen (1997). As usual, the parameter c represents the degree of product differentiation among varieties: they are independent when $c = 0$ and perfect substitutes when $c \to \infty$. In other words, increasing the degree of product differentiation among a given set of varieties amounts to decreasing c. However, assuming that all prices are identical and equal to p, we see that the aggregate demand for the differentiated product equals $Na - bpN$ which is independent of c. Hence (2) has the desirable property that the market size in the industry does not change when the substitutability parameter c varies. More generally, it is possible to decrease (increase) c through a decrease (increase) in the parameter γ in the utility U while keeping the other structural parameters a and b of the demand system unchanged. Finally, the own price effect is stronger (as measured by $b + cN$) than each cross price effect (as measured by c) as well as the sum of all cross price effects (cN), thus allowing for different elasticities of substitution between pairs of varieties as well as for different own elasticities at different prices.

The indirect utility corresponding to the demand system (2) is as follows:

$$V(y; p(i), i \in [0, N]) = -a \int_0^N p(i)di + \frac{b + cN}{2} \int_0^N [p(i)]^2 di - c \int_0^N \int_0^N p(i)p(j)didj + y + \overline{q}_0 \tag{3}$$

When all varieties are priced at the same level p, the indirect utility level is given by $-apN+bp^2N^2/2-cp^2N^2/2$ which always increases with N provided that varieties are differentiated enough (c is sufficiently small), thus implying that the quadratic subutility expresses a preference for variety as does the CES subutility.

While Krugman (1991a) and others define a Cobb-Douglas preference on the homogeneous and differentiated goods with CES subutility, we assume instead a *quasi-linear preference with a quadratic subutility.*[5] This difference in preferences explains why we make a different assumption about individuals' initial endowments. In Krugman, a positive endowment in a good different from labor would imply an income higher than wage, thus yielding a much more complex framework. By contrast, here a positive endowment is assumed in order for each individual to be able to consume at the maximum of his quadratic subutility. Observe also that both utilities correspond to two rather extreme cases: the former assumes a unit elasticity of substitution, the latter an infinite elasticity between the differentiated product and the numéraire. Finally, since the marginal utility of the numéraire is constant and equal across all consumers, our model can be used in welfare comparisons and is known not to generate any perverse effect when it is cast into a general equilibrium framework. Though this model has considerable merits, we must acknowledge the fact that it has a strong partial equilibrium flavor to the extent that it eliminates income effects.

Technology in agriculture requires one unit of A in order to produce one unit of output. With free trade in agriculture, the choice of this good as the numéraire implies that in equilibrium the wage of the farmers is equal to one in both regions, that is, $w_A^H = w_A^F = 1$. Technology in manufacturing requires ϕ units of L in order to produce any amount of a variety, i.e. the marginal cost of production of a variety is set equal to zero. This simplifying assumption, which is standard in many models of industrial organization, makes sense here unlike in Dixit and Stiglitz (1977) because our preferences imply that firms use an absolute markup instead of a relative one when choosing prices.

In the analysis below, we will encounter several conditions involving the parameters b, c and τ. Throughout the paper, we will assume that the least demanding condition regarding these three parameters, that is,

$$\tau \leq a/b \tag{4}$$

[5] A similar assumption is made by Spence (1976) in studying monopolistic competition.

is always satisfied. This condition must hold for a spatial monopolist producing at zero marginal cost to sell in the foreign market, regardless of whom pays for the transport cost.

Labor market clearing then implies that

$$n_H = \lambda L/\phi \tag{5}$$

and

$$n_F = (1-\lambda)L/\phi. \tag{6}$$

Consequently, the total mass of firms (varieties) in the economy is fixed and equal to $N = L/\phi$. This means that, in equilibrium, ϕ can also be interpreted as an inverse measure of the mass of firms. As $\phi \to 0$ (or $L \to \infty$), the mass of varieties becomes arbitrarily large. In addition, (5) and (6) show that the larger labor market is also the region accommodating the larger mass of firms.

Entry and exit are free so that profits are zero in equilibrium. Hence, (5) and (6) imply that any change in the population of workers located in one region must be accompanied by a corresponding change in the mass of firms. By (5) and (6), the demand and supply of workers in each region are equal. As in Krugman (1991a), the corresponding equilibrium wages are then determined by a bidding process between firms which ends when no firm can earn a strictly positive profit at the equilibrium market prices.

By assumption, firms compete in segmented markets. In the sequel, we focus on region H. Things pertaining to region F can be derived by symmetry. Using the assumption of symmetry between varieties and Roy's identity, demands for a representative firm in H are given by:

$$q^{HH} = a - (b + cN)p^{HH} + cP^H \tag{7}$$

and

$$q^{HF} = a - (b + cN)p^{HF} + cP^F \tag{8}$$

where

$$P^H \equiv n_H p^{HH} + n_F p^{FH}$$

$$P^F \equiv n_H p^{HF} + n_F p^{FF}$$

Clearly, P^H/N and P^F/N can be interpreted as the price index prevailing in region H and F, respectively.

A representative firm in H maximizes its profits defined by:

$$\Pi^H = p^{HH}q^{HH}(p^{HH})[A/2+\lambda L] + (p^{HF}-\tau)q^{HF}(p^{HF})[A/2+(1-\lambda)L] - \phi w^H \tag{9}$$

where $A/2$ stands for the farmers' demand in each region.

3 Short-run price equilibria

In this section, we study the process of competition between firms for a given spatial distribution of workers. Prices are obtained by maximizing profits while wages are determined as described above by equating the resulting profits to zero. Since we have a continuum of firms, each one is negligible in the sense that its action has no impact on the market. Hence, when choosing its prices, a firm in H accurately neglects the impact of its decision over the two price indices P^H and P^F. In addition, because firms sell differentiated varieties, each one has some monopoly power in that it faces a demand function with finite elasticity. All of this is in accordance with Chamberlin (1933)'s monopolistic competition theory where the effect of a price change by one firm has a significant impact on its own demand, but only a negligible impact on each competitor's demand.

When Dixit and Stiglitz use the CES, the same assumption implies that each firm is able to determine its price independently of the others because the price index enters the demand function as a multiplicative term. This no longer holds in our model because the price index now enters the demand function as an additive term (see (7) and (8)). Stated differently, a firm must account for the distribution of the firms' prices through some aggregate statistics, given here by the price index, in order to find its equilibrium price. As a consequence, our market solution is given by a Nash equilibrium with a continuum of players in which prices are interdependent: *each firm neglects its impact on the market but is aware that the market as a whole has a non-negligible impact on its behavior*. This reflects well, we believe, Chamberlin's (1933, p.74) pivotal idea when he writes: "Theory may well disregard the interdependence between markets whenever business men do, in fact, ignore it." In our model, this idea is captured by assuming that interaction among firms goes through the regional price index only.

Our model thus provides an alternative way to tackle monopolistic competition, more appealing than Dixit and Stiglitz because some degree of interaction among firms is involved at the market level. As a result, the equilibrium prices will be seen to depend on all the key aspects of the market instead of being given by a simple relative mark-up rule.

Since profit functions are concave in own price, solving the first order conditions for profit maximization with respect to prices yields the equilibrium prices:

$$p_D^{HH} = \frac{1}{2}\frac{2a + \tau cN(1-\lambda)}{2b + cN} \tag{10}$$

$$p_D^{FF} = \frac{1}{2}\frac{2a + \tau cN\lambda}{2b + cN} \tag{11}$$

$$p_D^{HF} = p_D^{FF} + \frac{\tau}{2} \tag{12}$$

$$p_D^{FH} = p_D^{HH} + \frac{\tau}{2} \tag{13}$$

Unlike the (spatialized) Dixit-Stiglitz model, *the equilibrium prices under monopolistic competition depend here on the total mass of firms active in the economy as well as on their distribution between regions.* In particular, using (4) we observe that more firms in the economy leads to lower market prices for the same distribution $(\lambda, 1-\lambda)$ because there is more competition on each regional market. Similarly, both the prices charged by local and foreign firms fall when the mass of local firms increases (because price competition is fiercer) but the impact is weaker when τ is smaller. In the limit, when τ is negligible, the relocation of firms in H, say, has almost no impact on market prices. In this case, prices are 'independent' of the way firms are distributed between the two regions.

Equilibrium prices also rise when the size of the local market, evaluated by a, gets larger or when the degree of product differentiation, inversely measured by c, increases provided that (4) holds. All these results are in accordance with what is known in industrial organization and spatial pricing theory, and are more explicit than in the Dixit-Stiglitz model.

Furthermore, *there is freight absorption since less than one-half of the transportation cost is passed onto the consumers.* Indeed we have:

$$p_D^{HF} - p_D^{HH} = \tau\frac{b + \lambda cN}{2b + cN} \leq \frac{\tau}{2}, \text{ ...which is equal to...} \frac{\tau}{2} \text{ when } \lambda = 1$$

$$p_D^{FH} - p_D^{FF} = \tau \frac{b + (1-\lambda)cN}{2b + cN} \leq \frac{\tau}{2}, \text{...which is equal to...} \frac{\tau}{2} \text{ when } \lambda = 0$$

It is well known that a monopolist facing a linear demand absorbs exactly one-half of the transport cost (Phlips, 1983a). Hence, we see that monopolistic competition leads to more freight absorption than monopoly: competition leads firms to a higher price gap in their attempt to penetrate the distant market. Also by inspection, it is readily verified that p_D^{HH} (p_D^{FF}) is increasing in τ because the local firms in H (F) are more protected against foreign competition while $p_D^{HF} - \tau$ ($p_D^{FH} - \tau$) is decreasing because it is now more difficult for these firms to sell on the foreign market. Finally, our demand side happens to be consistent with identical demand functions at different locations but different price levels, as in standard spatial pricing theory.

Substracting τ from (12) and (13), we see that firms' prices net of transport costs are positive regardless of the workers' distribution if and only if

$$\tau < \tau_{trade}^{D} \equiv \frac{2a}{2b + cN} \tag{14}$$

The same condition must hold for consumers in F (H) to buy from firms in H (F), i.e. for the demand (8) evaluated at the prices (10) and (11) to be positive for all λ. From now on, condition (14) is assumed to hold. Consequently, there is intra-industry trade and reciprocal dumping, as in Anderson *et al.* (1995).

Finally, local sales rise with τ because of the higher protection enjoyed by the local firms but exports fall for the same reason. It is easy to check that the equilibrium profits earned by a firm established in H on each separated market are as follows:

$$\Pi^{HH} = (b + cN)(p_D^{HH})^2(A/2 + \lambda N\phi) \tag{15}$$

where Π^{HH} denotes the profits earned in H while the profits made from selling in F are

$$\Pi^{HF} = (b + cN)(p_D^{HF} - \tau)^2[A/2 + (1-\lambda)N\phi] \tag{16}$$

Increasing λ has two opposite effects on Π^{HH}. First, the equilibrium price (10) falls as well as the quantity of each variety bought by each consumer living in region H. However, the total population of consumers residing in this region is now larger so that the profits made by a firm located in H on local sales may increase. What is at work here is *a global demand effect due to the increase in the local population that may compensate firms for the adverse price effect as well as for the individual demand effect.* This is reminiscent of the results obtained in recent shopping models where more firms in a given location attract more consumers due to the higher expected match, and earn higher profits despite the intensified competition (Schultz and Stahl, 1996; Gehrig, 1998).

The equilibrium wage prevailing in region H may be obtained by evaluating Π^H/ϕ at the equilibrium prices but, unfortunately, the corresponding expression turns out to be especially cumbersome. For the analysis developed in section 7, it is sufficient to study their behavior in the vicinity of $\lambda = 1/2$. Differentiating (15) and (16) with respect to λ yields

$$\frac{d\Pi^{HH}}{d\lambda}\Big|_{\lambda=1/2} = \frac{(b+cN)N}{8(2b+cN)^2}(4a+cN\tau)(2a\phi - cA\tau) \tag{17}$$

and

$$\frac{d\Pi^{HF}}{d\lambda}\Big|_{\lambda=1/2} = -\frac{(b+cN)N}{8(2b+cN)^2}(4a-cN\tau-4b\tau)(2a\phi-cA\tau-c\phi N\tau-2b\phi\tau) \tag{18}$$

The inspection of (17) and (18) reveals that w^H is not necessarily monotonic with respect to λ because $dw^H/d\lambda$ evaluated at $\lambda = 1/2$, obtained from the sum of (17) and (18), changes sign and is $\cap$-shaped with respect to τ. This is so because more workers in H also means more firms located in this region, thus making the final impact on the local wage ambiguous. Standard analysis shows that both (17) and (18) are $\cap$-shaped; (17) is positive for low τ and negative for large τ while (18) is negative for low and high values of τ and positive for intermediate values. As a result, four domains of τ are to be considered as τ rises from zero: (i) (17) is positive and (18) negative; (ii) (17) and (18) are both positive; (iii) (17) is negative but (18) is still positive; and (iv) both (17) and (18) are negative. Since (17) and (18) describe two concave parabolas, the locus describing $dw^H/d\lambda$ evaluated at $\lambda = 1/2$ is also a concave parabola with a positive intercept, a single maximizer arising at

$$\tau_{\max} = \frac{a}{4b+cN+cA/\phi}$$

and a positive zero, corresponding to the highest wage prevailing at a dispersed equilibrium, given by

$$\tau_0 = \frac{a}{2b + cN + cA/\phi} > \tau_{\max}$$

Hence the relocation of some workers (and firms) in region H depresses the local wage when τ exceeds τ_0, the more so the higher τ. On the other hand, for τ lower than τ_0, more workers in H increases the local wage. However, the marginal impact of an increase of λ above 1/2 upon the equilibrium wage reaches its peak at $\tau_{\max}$. This implies that such a positive impact becomes weaker and weaker as τ gets closer to zero.

4 When do we observe agglomeration?

We now ask whether for a given spatial distribution of mobile workers, $(\lambda, 1 - \lambda)$, there is an incentive for them to migrate and, if so, what direction the flow of migrants will take. Following the tradition of economic geography, we assume that workers care only about their current utility levels. Accordingly, if they observe that a location offers a higher indirect utility than the other, they want to move to that location.[6] When moving, workers anticipate that 'some' firms will follow. More precisely, the mass of firms that relocate must be such that (5) and (6) remain valid for the new distribution of workers; wages are adjusted in each region for each firm to earn zero profits everywhere. In other words, the driving force in the migration process is workers' indirect utility differential between H and F, denoted ΔV:

$$\dot{\lambda} \equiv d\lambda/dt = \delta \Delta V \tag{19}$$

where δ is a positive constant standing for the speed of adjustment. If ΔV is positive, workers will move from F to H; if it is negative, they will go in opposite direction.

Then a *spatial equilibrium* arises when $\dot{\lambda} = 0$. This happens at $\lambda = n_H/N \in (0,1)$ when $\Delta V(\lambda) = 0$ in which case we have a *dispersed configuration*. Motion also stops at endpoints $\lambda = 0$ when $\Delta V(0) \leq 0$ or at $\lambda = 1$ when $\Delta V(1) \geq 0$ in which case we have an *agglomerated configuration*. Therefore, the agglomerated configuration is always stable when it is

[6] Note that comparing real wages is equivalent to comparing indirect utility levels in Krugman's model.

an equilibrium while the dispersed configuration is stable when the slope of $\Delta V(\lambda)$ is negative.

The forces at work are similar to those found in the core-periphery model. First, the immobility of the farmers is a centrifugal force, at least as long as there is trade between the two regions. The centripetal force finds its origin in a demand effect generated by the preference for variety. If a larger number of firms are located in region H, there are two effects at work. First, less varieties are imported. Second, (10) and (13) imply that the equilibrium prices of all varieties sold in H are lower. Both effects generate a higher indirect utility. (Observe that the latter effect does not appear in Krugman's model). This, in turn, induces some consumers to migrate toward this region. The resulting increase in the number of consumers creates a larger demand for the industrial good in the corresponding region, which therefore leads more firms to locate there. In other words, both backward and forward linkages are present in our model, though the constitutive effects are somewhat richer than those uncovered by Krugman.

The indirect utility differential is obtained by plugging the equilibrium prices (10)-(13) and, using (5) and (6), the equilibrium wages for the workers into (3):

$$\begin{aligned}\Delta V &\equiv V^H - V^F = \frac{\tau(b+cN)(2\lambda-1)N}{4(2b+cN)^2}\{12a(b+cN) \\ &-\tau[2b(3b+2cN+cA/\phi)+c^2N(A/\phi-N)]\}\end{aligned} \quad (20)$$

It follows immediately from this expression that $\lambda = 1/2$ is always an equilibrium. The stability analysis of this equilibrium is especially easy to perform here. Since (20) is linear in λ, the critical value of τ below which symmetry is no longer stable (the break point) and the value below which agglomeration is stable (the sustain point) are identical. For $\lambda \neq 1/2$, the indirect utility differential has always the same sign as $2\lambda - 1$ if and only if the curly bracketed term is positive, a condition which holds if and only if:

$$\tau < \tau^D \equiv \frac{12a(b+cN)}{2b(3b+2cN+cA/\phi)+c^2N(A/\phi-N)} \quad (21)$$

Observe that $\tau^D > 0$ is positive if and only if

$$A/\phi > \frac{c^2N^2 - 2b(3b+2cN)}{c(2b+cN)} \quad (22)$$

which always holds when varieties are differentiated enough or the population of farmers is sufficiently large. We will often use these two restrictions on c and A, and assume throughout the rest of the paper that (22) is verified.

When $\tau < \tau^D$, the symmetric equilibrium is therefore unstable and workers agglomerate in region H (F) provided that the initial fraction of workers residing in this region exceeds 1/2. In other words, *agglomeration arises when the transportation rate is low enough*, as in Krugman (1991a) and for similar reasons. Also, when increasing returns are stronger, as expressed by higher values of ϕ, (21) implies that τ^D rises. This means that *the agglomeration of the manufactured sector is more likely, the stronger are the increasing returns at the firm's level.*

When τ is given, (21) is more likely to be satisfied when the market size, as expressed by a, is sufficiently high and when $N + A/\phi = (L + A)/\phi$ does not exceed some critical value depending on τ. In other words, both agglomeration and trade occur when the size of the population is not too large compared to the fixed cost. Consequently, when the demand side is replicated many times, τ^D becomes arbitrarily small (or even negative) so that the economy exhibits regional symmetry. Stated differently, *a large economy in terms of population is more likely to involve dispersion of economic activities.* Such an effect cannot appear in Krugman's model because, unlike us, he assumes homothetic preferences. More fundamentally, maybe, is the fact that the sequence of Nash price equilibria converges toward the common marginal cost when the number of firms is finite but tends to infinity; indeed, in this case, our model provides a good approximation of a competitive economy in which dispersion is the natural outcome. This is not true with the Dixit-Stiglitz model (Anderson *et al.*, 1992).

On the other hand, for large transport costs, that is, when (21) does not hold, it is straightforward to see that the symmetric configuration is the only stable equilibrium.

Proposition 1 *Assume that discriminatory pricing prevails and that $\tau < \tau^D_{trade}$. Then, if $\tau > \tau^D$ the symmetric configuration is the only stable equilibrium with trade; if $\tau < \tau^D$ there are two stable equilibria corresponding to the agglomerated configurations with trade; if $\tau = \tau^D$ there is a continuum of equilibria.*

In the discriminatory pricing case, our results differ from Krugman's in that both the break point and sustain point coincide here. The reason for this difference lies in the fact that Krugman does not really deal with spatial discrimination. Though the equilibrium prices are determined independently in Krugman's model, his framework implies that spatial price discrimination is equivalent to mill pricing so that his results are better compared to those we derive below under mill pricing.

The assumption that the condition (14) allowing for trade is less stringent than the condition for agglomeration (21) is equivalent to

$$A/\phi > \frac{7c^2N^2 + 14bcN + 6b^2}{c(2b + cN)} \tag{23}$$

when (22) holds. When $\tau^D_{trade} > \tau^D$, trade occurs regardless of the type of equilibrium that is stable. However the nature of trade varies with the type of configuration emerging in equilibrium. In the dispersed configuration, there is only intra-industry trade in the differentiated product; in the agglomerated equilibrium, the urban region accommodating the manufacturing sector also imports the homogeneous good from the rural region.

Observe that, in the discriminatory pricing case, c very small implies that $\tau^D_{trade} < \tau^D$ so that agglomeration always arises under trade. This is confirmed by the special case where varieties are independent in consumers' preferences. Indeed, (14) becomes $\tau < a/b$ while (21) reduces to $\tau < 2a/b$. This says that the gradient of the indirect utility is positive for all admissible values of τ. In this case, there is always agglomeration in equilibrium (unless the initial value of λ is 1/2).

5 Agglomeration under alternative pricing policies

So far, we have focussed on a particular price policy called *spatial discriminatory pricing*. This is only one of the many possibilities open to firms once they operate in the economic space (Phlips, 1983a). Given their practical relevance, we also assume that firms follow one of the following two policies: *mill pricing*, i.e. any firm charges the same price p_M at the firm's door regardless of the destination of its product (in which case markets are integrated), and *uniform delivered pricing*, i.e. any firm selects the same delivered price p_U regardless of the consumers' location (which corresponds to a special form of price discrimination since the mill price varies with the destination). For example, Greenhut (1981) found that a third of the firms he surveyed in the US used the former policy, whereas a fifth of them followed the latter. It is well known in location theory that the choice of a price policy may have a substantial impact on the spatial distribution of production. Consequently, it is worth studying how a change in the price policy followed by firms may affect the agglomeration process studied in Section 4.

5.1 Mill pricing

In this case, there is no freight absorption so that the domestic and foreign prices are related as follows:

$$p^{HH} \equiv p_M \text{ and } p^{HF} \equiv p_M + \tau$$

while the profit of a firm in H is:

$$\Pi_M^H = p_M q^{HH}(p_M)[A/2 + \lambda L] + p_M q^{HF}(p_M + \tau)[A/2 + (1-\lambda)L] - \phi w^H$$

It is then immediate that the equilibrium mill price common to all firms located in H is

$$p_M^{H*} = p_D^{HH} - \frac{\tau}{2}\frac{[A/\phi + 2(1-\lambda)N][b + c(1-\lambda)N]}{(2b + cN)(A/\phi + N)} \tag{24}$$

while the equilibrium mill price of the firms established in F is

$$p_M^{F*} = p_D^{FF} - \frac{\tau}{2}\frac{(A/\phi + 2\lambda N)(b + c\lambda N)}{(2b + cN)(A/\phi + N)} \tag{25}$$

These two prices depend on the distribution of workers and are equal in the special case where $\lambda = 1/2$. More generally

$$p_M^{H*} - p_M^{F*} = \frac{\tau}{2}\frac{(2\lambda - 1)N}{A/\phi + N} \tag{26}$$

Using (24), it is readily verified that the equilibrium mill price may fall when c decreases. This is the case when τ is small and A large. Hence it is not necessarily true that more product differentiation leads to higher prices. Though not standard, such a result already appeared in some models of spatial competition (see, e.g. Anderson *et al.*, 1992). In addition, it follows from (26) that the larger mill price is set by firms located in the region with the larger home market. This is because it is the main outlet for their outputs.

Both prices are positive regardless of λ if and only if

$$\tau < \tau_1^M \equiv \frac{2a(A/\phi + N)}{b(A/\phi + 2N) + cN^2} \tag{27}$$

while imports are always positive in both regions if and only if

$$\tau < \tau_2^M \equiv \frac{2a(A/\phi + N)(b + cN)}{b^2(3A/\phi + 2N) + cN(2A/\phi + N)(3b + cN)} < \tau_1^M \tag{28}$$

Clearly, the latter condition must be fulfilled for two-way trade to occur for all λ.

Let us now describe how the agglomeration process works when firms are mill pricers. Evaluating the indirect utility differential at the market equilibrium yields

$$\Delta V_M = \frac{\tau(2\lambda - 1)N}{4(A/\phi + N)(2b + cN)}[16bcN^2\tau\lambda^2 - 16bcN^2\tau\lambda - k_1\tau + k_2]$$

where

$$k_1 = 2b^2(2A/\phi + 3N) + cN(2A/\phi + N)(b - cN)$$

which is always positive when varieties are very differentiated, and

$$k_2 = 4a(A/\phi + N)(2b + 3cN) > 0$$

As usual, the dispersed outcome ($\lambda = 1/2$) is an equilibrium. However ΔV_M involves a second factor which is a quadratic function of λ, thus allowing for the possibility of other interior equilibria. Consider the equation

$$16bcN^2\tau\lambda^2 - 16bcN^2\tau\lambda - k_1\tau + k_2 = 0 \tag{29}$$

The coefficients of λ^2 and λ in (29) being identical, the two roots (when they are real) can be shown to be symmetric about 1/2 because

$$\lambda_{1,2} = \frac{1}{2} \pm \frac{1}{2}\left(1 + \frac{k_1}{4bcN^2} - \frac{k_2}{4bcN^2\tau}\right)^{1/2}$$

Between these two roots, the left hand side of (29) is negative since the coefficient of λ^2 is positive. The break point is then obtained when the two roots of (29) are both equal to 1/2, that is, for the value of τ where the derivative of ΔV_M evaluated at $\lambda = 1/2$ is just equal to zero. Some calculations show that

$$\tau_{break}^M \equiv \frac{k_2}{k_1 + 4bcN^2} = \frac{4a(A/\phi + N)(2b + 3cN)}{2b^2(2A/\phi + 3N) + cN(2A/\phi + N)(5b - cN)} \quad (30)$$

In turn, the sustain point is determined when the two roots of (29) are given by 0 and 1, that is, for the value of τ where $\Delta V_M = 0$ at these two values. It can be shown that

$$\tau_{sustain}^M \equiv \frac{k_2}{k_1} = \frac{4a(A/\phi + N)(2b + 3cN)}{2b^2(2A/\phi + 3N) + cN(2A/\phi + N)(b - cN)} \quad (31)$$

Clearly, $\tau_{break}^M < \tau_{sustain}^M$ so that the two roots fall inside of the unit interval provided that $\tau \in \left[\tau_{break}^M, \tau_{sustain}^M\right]$.

Finally, $\tau_{break}^M < \tau_2^M$ if and only if

$$A/\phi > \frac{(6b - cN)N}{2cN - 4b} \quad (32)$$

and $\tau_{sustain}^M < \tau_2^M$ if and only if

$$A/\phi > \frac{(2b + cN)(3b - cN)N}{(2cN - 4b)(b + cN)} \quad (33)$$

where (32) is more stringent than (33). It is readily verified that (32) is satisfied when varieties are differentiated enough, when the population of farmers is large, or when the level of fixed cost is sufficiently low.

The stability analysis is then standard. First, if $\tau > \tau_{sustain}^M$ the only equilibrium is given by the dispersed solution which is also globally stable. Second, if $\tau < \tau_{break}^M$ there are two equilibria given by the polarized outcomes which are also stable. Last, when $\tau \in \left[\tau_{break}^M, \tau_{sustain}^M\right]$ there are five equilibria. The two additional equilibria given by the two roots of (29) are unstable while the other three equilibria are stable.

We can summarize our results as follows.

Proposition 2 *Consider mill pricing and assume that (32) holds. Then, the symmetric configuration remains a stable equilibrium as long as* τ *is larger* *than or equal to τ^M_{break}, while the agglomerated configurations are stable equilibria once τ is smaller than or equal to $\tau^M_{sustain}$. When (32) does not hold, there is always agglomeration under trade.*

As τ decreases from some value larger than $\tau^M_{sustain}$ but smaller than τ_2^M, we first move from a stable dispersed equilibrium to a market situation characterized by the existence of three stable equilibria and, then, reach a state where any stable equilibrium involves full agglomeration in the manufacturing sector. This set of configurations is very similar to that uncovered by Krugman (1991a) (see also Fujita *et al.*, 1998, ch.5) who used a very different framework in terms of equilibrium concept, preferences and transportation. Since his framework implies that spatial price discrimination is equivalent to mill pricing, our results are compatible with his and, therefore, robust against several changes in the specification of the model.

5.2 Uniform delivered pricing

We now have:

$$p^{HH} \equiv p_U \text{ and } p^{HF} = p_U$$

so that

$$\Pi_U^H = p_U q^{HH}(p_U)[A/2 + \lambda L] + (p_U - \tau)q^{HF}(p_U)[A/2 + (1-\lambda)L] - \phi w^H$$

A straightforward calculation shows that the equilibrium uniform prices set by firms located in H and F are respectively:

$$p_U^{H*} = p_D^{HH} + \frac{\tau}{2}\frac{[A/\phi + 2(1-\lambda)N](b + c\lambda N)}{(2b + cN)(A/\phi + N)} \tag{34}$$

and

$$p_U^{F*} = p_D^{FF} + \frac{\tau}{2}\frac{(A/\phi + 2\lambda N)[b + c(1-\lambda)N]}{(2b + cN)(A/\phi + N)} \tag{35}$$

It can be shown that the equilibrium prices posted by firms fall when c rises in the case where τ is small and A large, as under mill pricing (it can be checked that the sensitivity of prices to changes in c is the same in the two price regimes).

Firms's prices net of transport costs are positive regardless of the workers' distribution if and only if

$$\tau < \tau_1^U \equiv \frac{2a(A/\phi + N)}{b(3A/\phi + 4N) + cN(A/\phi + 2N)} \tag{36}$$

Imports in both regions are positive for all λ if and only if

$$\tau < \tau_2^U \equiv \frac{2a(A/\phi + N)}{b(A/\phi + 2N) + cN^2}$$

which is less stringent than (36). Hence we have two-way trade if and only if (36) is satisfied.

Evaluating the indirect utility differential at the market equilibrium now yields

$$\Delta V_U = \frac{\tau(b + cN)(2\lambda - 1)N}{4(2b + cN)(A/\phi + N)}[4cN^2\tau\lambda^2 - 4cN^2\tau\lambda - k_3\tau + k_4] \tag{37}$$

where

$$k_3 = 2b(A/\phi + N) + cN^2 > 0$$

and

$$k_4 = 4a(A/\phi + N) > 0$$

Using the same argument as in the above, we see that the break point arises for the value of τ where the derivative of ΔV_U evaluated at $\lambda = 1/2$ is just equal to zero. Again, standard calculations show that

$$\tau_{break}^U \equiv \frac{k_4}{k_3 - bcN^2} = \frac{2a}{b}$$

so that any value of τ allowing for two-way trade is always smaller than τ_{break}^U; otherwise (36) is violated. This means that the symmetric configuration cannot emerge as a stable equilibrium with trade. Similarly, it can be verified that

$$\tau_{sustain}^U \equiv \frac{k_4}{k_3} = \frac{4a(A/\phi + N)}{2b(A/\phi + N) + cN^2}$$

By inspection, $\tau_1^U < \tau_{sustain}^U < \tau_{break}^U$. The only stable equilibria are therefore given by the configurations involving full agglomeration in the manufacturing sector. Hence we have:

Proposition 3 *Consider uniform delivered pricing and assume that (36) holds. Then, the only stable equilibria with trade are the agglomerated configurations.*

In other words, uniform delivered pricing always leads to agglomeration of the industrial sector, at least when the transport cost are low enough to permit trade. In turn, trade is likely to occur, that is, (36) holds when varieties are sufficiently differentiated, when the population of farmers is high, when fixed costs get larger and larger, or when the market size for the differentiated product is large enough. Furthermore, under uniform delivered pricing, there is no two-way trade: the differentiated good is exported from the urban region and the homogeneous good from the rural region.

The market outcome is here very different from what is observed in the above cases in that there is no room for a dispersed configuration with trade. Hence our result may come as a surprise since one would expect this kind of pricing policy to foster a more balanced distribution of activities across regions. This is not so because competition under uniform delivered pricing competition is very fierce and yields fairly low prices. Accordingly, trade requires very low transport costs which are below the break point, thus showing why the dispersed configuration does not emerge under this pricing regime.

6 The political economy of spatial price policies

We are now equipped to try to gain insight on the reasons why in reality firms are sometimes forced by the public authorities to restrain from spatial discrimination in favor of either mill or uniform delivered pricing. In particular, we are going to discuss the two justifications that are most frequently brought forward. One justification is more 'aggressive' and it is based on the need to promote an even spatial distribution of economic activities (as in France or Italy): lower trade costs and labor mobility lead to regional imbalances which are bad and restrictions on spatial discrimination could help to prevent them. The other justification is more 'defensive': even if little can be done (if they are bad) or has to be done (if they are good) about regional imbalances, it is important to take care of those who cannot move and are therefore left behind in abandoned areas (as in China or India).

Let us consider the *aggressive argument* first by comparing the different configurations that emerge under those various pricing policies. First, using (21) and (36), it can be checked that τ_1^U exceeds τ^D when the industrial product is very differentiated. A similar result holds provided that A/ϕ is large enough. Hence, in a country where the rural population is still substantial, uniform delivered pricing induces agglomeration before discriminatory pricing, but the reverse relationship holds when the population of workers is predominant. Considering now mill versus discriminatory pricing, one can show from (21), (30) and (31) that A/ϕ large enough implies $\tau^D < \tau^M_{break} < \tau^M_{sustain}$, while τ^D jumps on the right hand side of these inequalities for A/ϕ low enough. So, in a rural country, one should expect the manufacturing sector to show a stronger tendency towards concentration for higher transport under mill pricing than under discriminatory pricing. It remains to compare uniform delivered pricing and mill pricing. It is readily verified that $\tau_1^U < \tau^M_{break}$ is always satisfied. In other words, mill pricing always favors agglomeration when compared to uniform delivered pricing.

Proposition 4 *When A/ϕ is sufficiently high, we have:* $\tau^D < \tau_1^U < \tau^M_{break} < \tau^M_{sustain}$.

Accordingly, a 'rural' country endowed with a low-scaled industrial sector would experience urbanization, first when mill pricing is used, then uniform delivered pricing, and finally discriminatory pricing. This suggests that a developing country that tries to avoid regional imbalances should deter the use of mill pricing and promote discriminatory pricing.

Thus, in general, the aggressive argument against spatial discrimination needs to be qualified under two respects. First, to hinder spatial price discrimination is not necessarily a good idea in order to promote a more even spatial distribution of economic activities. Second, even if it is, sooner or later ongoing reduction in trade costs will make any price policy useless. So, pricing policies are not enough.

More robust is the *defensive argument* that stresses the need to protect those who are left behind by spatial agglomeration. In our model they are the farmers in the location which is abandoned by the industrial sector. In order to assess which policy is the most suited to their needs, we have to evaluate their indirect utility in an agglomerated equilibrium under the three different price policies. This is readily done: since farmers' income is always equal to one due to free trade in the numéraire and the indirect utility is decreasing in prices, all we need to check is under which price policy industrial exports are cheapest in an agglomerated equilibrium.

Without loss of generality, assume that agglomeration has taken place in region H so that $\lambda = 1$. Then, delivered prices to region F can be obtained from (12), (24) plus τ, and (34). It is readily verified that, for $\lambda = 1$, $p_M^{H*} + \tau > p_D^{HF} > p_U^{F*}$.

Proposition 5 *Consider an agglomerated equilibrium. Then, (i) spatial discriminatory pricing is a better policy than mill pricing and (ii) uniform delivered pricing is a better policy than spatial discriminatory pricing for the farmers in the region that has no industry.*

The intuition is simple. Uniform pricers absorb a larger fraction of trade costs on distant sales than spatially-discriminating firms, which anyway, as opposed to mill pricers, absorb at least some freight. Accordingly, as it can also be checked, the volume of industrial imports in the 'abandoned region' is the largest under uniform delivered pricing and the smallest under mill pricing, though the lagging population is the same. Therefore, *if the aim is not to prevent agglomeration, but rather to take care of those people who are left behind, uniform delivered pricing is better than discriminatory pricing which in turn is better than mill pricing.* In a sense, such a recommendation is very much in the same spirit as the constraint of 'universal service' that the European Commission wants to impose to the private firms supplying public services within the European common space. To the extent that spatial equity is a main concern in regional planning, it is therefore no real surprise that uniform delivered pricing is the best pricing policy allowing to reach this goal.

7 The impact of workers' expectations on the agglomeration process

The adjustment process (19) is often used in economic geography models. Yet, the underlying dynamics is myopic because workers care only about their current utility level, thus implying that only history matters. This strikes us as a pretty naive assumption to the extent that *migration decisions are typically made on the grounds of current and future utility flows.* In addition, this approach has been criticized because it is not consistent with fully rational forward-looking behavior (Matsuyama, 1991). In this section, we want to see how the model presented in Section 2 can be used to shed more light on the interplay between history and expectations in the formation of the economic space when migrants maximize the intertemporal value of their utility flows.

The easiest way to do so is to assume that workers face a costly intertemporal migration decision. When moving from one region to the other, migrants incur a utility loss which depends on the rate of migration $\dot{\lambda}$ because a migrant imposes a negative externality on the others by congesting the migration process (Mussa, 1978). In order to capture the hardships linked to large migration flows, we follow Krugman (1991b) and assume that the utility loss for a migrant is equal to $\left|\dot{\lambda}\right|/\delta$, where $\delta \in (0, +\infty)$ has the same meaning as in (19).

Following Fukao and Bénabou (1993) as well as Ottaviano (1998), we now define the utility of a worker residing in region H as

$$v_H(t) = \int_t^T e^{-\rho(s-t)} V_H(s) ds + e^{-\rho(T-t)} v_H(T) \tag{38}$$

where T is the first time when all workers are established into a single region and ρ the discount rate, while a similar expression holds for $v_F(t)$. Since each worker is free to choose where to reside, for a worker having selected H it must be that

$$v_H(t) \geq v_F(t) - \left|\dot{\lambda}(t)\right|/\delta \quad \text{where the equality is obtained when } \dot{\lambda}(t) < 0 \tag{39}$$

while a similar expression can be written for someone living in region F. Then, $v_H(t) - v_F(t)$ stands for the private value for a worker to be in H instead of F. In the sequel, we consider the case of segmented markets only, but other pricing rules could be similarly analyzed.

Assuming an interior solution for (39), we easily get

$$\dot{\lambda} = \delta v \tag{40}$$

while differentiating (38) yields

$$\dot{v} = \rho v - \Delta V \tag{41}$$

where $\Delta V \equiv V_H - V_F$ stands for the instantaneous indirect utility differential flow given by (20). Hence we obtain a system of two linear differential equations instead of the first order differential equation (19). Since ΔV is linear in λ, we can simplify notation by defining two constants η_0 and η_1 such that $(\eta_0 + \eta_1\lambda) \equiv \Delta V$.

Since $\lambda = 1/2$ implies $\Delta V = 0$, this system has a steady state at $(\lambda, v) = (1/2, 0)$ which corresponds to the dispersed configuration. Consider now its stability. The eigenvalues of the Jacobian matrix of this system evaluated at $(1/2, 0)$ are given by

$$\frac{\rho \pm \sqrt{\rho^2 - 4\delta\eta_1}}{2} \tag{42}$$

When $\eta_1 < 0$, the two eigenvalues are real and have opposite signs. Then, the steady state is a saddle point so that one always converges towards the dispersed configuration, thus implying that neither history nor expectations matter for the final outcome.

Assume now that $\eta_1 > 0$. Two cases may arise. In the first one, $0 < \eta_1 < \rho^2/4\delta$ so that the two eigenvalues are positive. The steady state $(1/2, 0)$ is an unstable node and there are two trajectories that steadily go to the endpoints $(0, 0)$ and $(1, 0)$, depending on the initial conditions. In this case, *only history matters*: from any initial $\lambda \neq 1/2$, there is a single trajectory that goes towards the closer endpoint, as in the case where the dynamics is given by (19).

Things turn out to be quite different when $\eta_1 > \rho^2/4\delta$. The two eigenvalues are complex and have a positive part so that the steady state is an unstable focus. The two trajectories now spiral out from $(1/2, 0)$. Therefore, for any initial λ close enough to, but different from, $1/2$, there are two alternative trajectories going in opposite directions. It is in such a case that expectations decide along which trajectory the system is going to move. In other words, *expectations matter for λ close enough to $1/2$, while history matters otherwise.* The corresponding domains are now described.

The range of values for which both history and expectations matter, called the *overlap* by Krugman (1991b), can be obtained as follows. As observed by Fukao and Bénabou (1993), the system must be solved backwards in time starting from the terminal points $(0, 0)$ and $(1, 0)$. The first time the backward trajectories intersect the locus $v = 0$ allows for the identifications of the endpoints of the overlap:

$$\lambda_L \equiv \frac{1}{2}\left[1 - \exp\left(-\frac{\rho\pi}{\sqrt{4\delta\eta_1 - \rho^2}}\right)\right]$$

$$\lambda_H \equiv \frac{1}{2}\left[1 + \exp\left(-\frac{\rho\pi}{\sqrt{4\delta\eta_1 - \rho^2}}\right)\right]$$

Clearly, the overlap is an interval centered around $\lambda = 0.5$ whose width is:

$$\Lambda \equiv \exp\left(-\frac{\rho\pi}{\sqrt{4\delta\eta_1 - \rho^2}}\right)$$

It exists as long as $\eta_1 > \rho^2/4\delta$. Thus, the width of the overlap is increasing in η_1 and δ, while it decreases with ρ. Since the parameter $\eta_1 > 0$ is the slope of ΔV, it expresses the strength of the forward and backward linkages pushing towards agglomeration. Since Λ rises with η_1, we see that expectations matter more when the forward and backward linkages are stronger. Given that

$$\eta_1 \equiv \frac{\tau(b + cN)N}{2(2b + cN)^2}\{12a(b + cN) - \tau[2b(3b + 2cN + cA/\phi) + c^2N(A/\phi - N)]\}$$

it follows from (21) that $\eta_1 > 0$ if and only if $\tau < \tau^D$ so that agglomeration occurs as long as $\eta_1 > 0$. We know that expectations matter for values of τ such that $\eta_1 > \rho^2/4\delta$. Since $\eta_1 = 0$ when $\tau = 0$ and $\tau = \tau^D$, the equation $\eta_1 - \rho^2/4\delta = 0$ has two positive roots in τ, denoted τ_1^e and τ_2^e, smaller than τ^D. Furthermore, since η_1 is concave in τ, the role of expectations matter when τ falls in between these two roots. Consequently, we have shown the following result:

Proposition 6 *Workers' expectations about their future earnings influence the process of agglomeration if and only if* $\tau \in [\tau_1^e, \tau_2^e]$.

Hence, history alone matters when τ is large enough or small enough. In other words, the agglomeration process evolves as if workers were short-sighted for high and low values of τ. The relative importance of expectations and history is therefore ∪-shaped in the transport rate. Moreover, the domain of values of τ for which expectations matter shrinks when the discount rate ρ gets larger or when the speed of adjustment δ decreases.

The existence of range $[\tau_1^e, \tau_2^e]$ for intermediate values of τ can be explained in terms of the issues discussed at the end of Section 3. There we showed that the positive effect of workers' immigration on local wages reaches a maximum at $\tau_{\max} > 0$. In other words, the 'complementarity' of workers' migration decisions reaches its maximum strength for a positive level of transport costs below which it becomes weaker and weaker as one gets closer to free trade ($\tau = 0$). This is crucial to understand the circumstances under which a whirling trajectory is viable.

Suppose, indeed, that the economy is such that $\lambda(0) > 1/2$ and ask what is needed to reverse the agglomeration process towards $\lambda = 0$. If the evolution of the economy were to change direction, workers would experience falling instantaneous indirect utility flows for some time period as long as $\lambda > 1/2$. The instantaneous indirect utility flows would start growing only after that period. Accordingly, workers would first experience utility losses followed by utility gains. Since the losses would come before the gains, they would be less discounted. This provides the root for the intuition behind Proposition 6. When complementarity of workers locations leads to substantial wage rises (that is, for intermediate values of τ), the benefits of agglomerating at $\lambda = 0$ can compensate workers for the losses they incur during the transition phase, thus making the reversal of migration possible. On the contrary, when complementarity of workers locational decisions gets weaker (that is, for low or high values of τ), the benefits of agglomerating at $\lambda = 0$ do not compensate workers for the losses.

As a consequence, the reversal in the migration process may occur only for intermediate values of τ. Clearly, proximity to the endpoint increases the time period over which workers bear losses because it takes more time to reach $\lambda = 1/2$. As observed before, a large rate of time preference gives more weight to the losses, while a slow speed of adjustment extends the time period over which workers bear losses.

8 Concluding remarks

Recent years have seen the proliferation of applications of the Dixit-Stiglitz model of monopolistic competition for studying the impact of trade costs on the spatial distribution of economic activities. While these applications have produced valuable insights in several fields, especially in trade and development theory, they have often been criticized because they rely on a very specific implementation of Chamberlin's monopolistic competition theory.

We have shown that *a more flexible model is able not only to confirm those insights but also to produce new results that could barely be obtained within the standard model.* In particular, we have proposed a more realistic description of the process of spatial competition in which, as opposed to the standard model, the pricing decisions of firms are affected by the spatial location of their competitors as well as by the distribution of demand. This has allowed us to come up with a richer set of results regarding the impact of the fundamentals of the economy on the equilibrium prices. This model has then been used to investigate the implications of the most-frequently-observed pricing policies in terms of both the existence and stability of spatial equilibria as well as in terms of their policy implications. The model has also proved to be useful to address the intrinsically dynamic issue of the lock-in effect of historical events on the spatial distribution of activities. While this issue is at the core of the policy debate, it has never been properly addressed from a theoretical point of view.

So, on the one hand, we have shown that several of the main results in the literature do not depend on the specific modeling choices made, as often argued by their critics. Note, especially, that the robustness of the results obtained in the core-periphery model against alternative formulations of preferences and transportation modeling (see Proposition 2) suggests there is a whole class of models for which similar results would hold. On the other hand, we have also shown that these modeling choices are to be reconsidered once the aim is to shed light on other relevant issues and one such alternative model has been proposed here.

The model used in this paper still displays some undesirable features such as a fixed mass of firms regardless of the consumer distribution. In particular, as said above, by ignoring income effects, our setting has a strong partial equilibrium flavor to which it should be remedied in future research.

References

[1] Anderson, S.P., A. de Palma and J.-F. Thisse (1992) *Discrete Choice Theory of Product Differentiation* (Cambridge (Mass.): MIT Press).

[2] Anderson, S.P., N. Schmitt and J.-F. Thisse (1995) Who Benefits from Antidumping Legislation ? *Journal of International Economics* 38, 321-337.

[3] Bottazzi, L. and G. Ottaviano (1996) Modelling Transport Costs in International Trade: A Comparison among Alternative Approaches, IGIER, Milano, Discussion Paper.

[4] Carlton, D.W. (1983) A Re-examination of Delivered Pricing Systems, *Journal of Law and Economics* 26, 51-70.

[5] Chamberlin E. (1933) *The Theory of Monopolistic Competition* (Cambridge (Mass.): Harvard University Press).

[6] d'Aspremont, C., R. Dos Santos Ferreira and L.-A. Gérard-Varet (1996) On the Dixit-Stiglitz Model of Monopolistic Competition, *American Economic Review* 86, 623-629.

[7] Dixit, A.K. (1979) A Model of Duopoly Suggesting a Theory of Entry Barriers, *Bell Journal of Economics* 10, 20-32.

[8] Dixit, A.K. and J.E. Stiglitz (1977) Monopolistic Competition and Optimum Product Diversity, *American Economic Review* 67, 297-308.

[9] Fujita, M. (1989) *Urban Economic Theory. Land Use and City Size* (Cambridge: Cambridge University Press).

[10] Fujita, M., P. Krugman and A. Venables (1998) *The Spatial Economy. Cities, Regions and International trade* (Cambridge (Mass.): MIT Press), forthcoming.

[11] Fujita, M. and J.-F. Thisse (1996) Economics of Agglomeration, *Journal of the Japanese and International Economies* 10, 339-378.

[12] Fukao, K. and R. Bénabou (1993) History versus Expectations: A Comment, *Quarterly Journal of Economics* 108, 535-542.

[13] Gehrig, T. (1998) Competing Exchanges, *European Economic Review*, forthcoming.

[14] Ginsburgh, V. (1994) Price Discrimination in the EC Car Market, *Cahiers du CERO* 36, 153-180.

[15] Greenhut, M.L. (1981) Spatial Pricing in the USA, West Germany, and Japan, *Economica* 48, 79-86.

[16] Hart O. (1985) Monopolistic Competition in the Spirit of Chamberlin: Special Results, *Economic Journal* 95, 889-908.

[17] Helpman E. and P. Krugman (1985) *Market Structure and Foreign Trade* (Cambridge (Mass.): MIT Press).

[18] Hotelling, H. (1929) Stability in Competition, *Economic Journal* 39, 41-57.

[19] Hwang, H. and C.-c. Mai (1990) Effects of Spatial Price Discrimination on Output, Welfare, and Location, *American Economic Review* 80, 567-575.

[20] Irmen, A. (1997) Note on Duopolistic Vertical Restraints, *European Economic Review* 41, 1559-1567.

[21] Koopmans, T.C. (1957) *Three Essays on the State of Economic Science* (New York: McGraw-Hill).

[22] Krugman, P. (1991a) Increasing Returns and Economic Geography, *Journal of Political Economy* 99, 483-499.

[23] Krugman, P. (1991b) History versus Expectations, *Quarterly Journal of Economics* 106, 651-667.

[24] Krugman, P. (1995) *Development, Geography, and Economic Theory* (Cambridge (Mass.): MIT Press).

[25] Krugman, P. and A.J. Venables (1990) Integration and the Competitiveness of Peripheral Industry, in: C.Bliss and J. Braga de Macedo, eds., *Unity with Diversity in the European Community* (Cambridge: Cambridge University Press).

[26] Lösch, A. (1940) *Die Räumliche Ordnung der Wirtschaft* (Jena: Gustav Fischer Verlag). English translation: *The Economics of Location* (New Haven (Conn.): Yale University Press, 1954).

[27] Matsuyama, K. (1991) Increasing Returns, Industrialization, and Indeterminacy of Equilibrium, *Quarterly Journal of Economics* 106, 617-650.

[28] Matsuyama, K. (1995) Complementarities and Cumulative Process in Models of Monopolistic Competition, *Journal of Economic Literature* 33, 701-729.

[29] Mussa, M. (1978) Dynamic Adjustment in the Heckscher-Ohlin-Samuelson Model, *Journal of Political Economy* 86, 775-791.

[30] Norman, G. and J.-F. Thisse (1996) Product Variety and Welfare under Soft and Tough Pricing Regimes, *Economic Journal* 106, 76-91

[31] Ottaviano, G. (1998) Integration, Geography and the Burden of History, Universita degli Studi di Bologna, mimeo.

[32] Phlips, L. (1983a) *The Economics of Price Discrimination* (Cambridge: Cambridge University Press).

[33] Phlips, L. (1983b) *Applied Consumption Analysis* (Amsterdam: North-Holland).

[34] Rauch, J. (1996) Networks versus Markets in International Trade, NBER Working Paper 5617.

[35] Scherer, M. (1980) *Industrial Market Structure and Economic Performance* (Chicago: Rand McNally).

[36] Schulz, N. and K. Stahl (1996) Do Consumers Search for the Highest Price ? Equilibrium and Monopolistic Optimum in Differentiated Products Markets, *Rand Journal of Economics* *27*, 542-562.

[37] Smith, A. and A.J. Venables (1988) Completing the Internal Market in the European Community, *European Economic Review* 32, 1501-1525.

[38] Spence, A.M. (1976) Product Selection, Fixed Costs and Monopolistic Competition, *Review of Economic Studies* 43, 217-236.

[39] Sraffa, P. (1926) The Laws of Return under Competitive Conditions, *Economic Journal* 36, 535-550.

[40] Tharakan, P.K.M. (1991) The Political Economy of Anti-dumping Undertakings in the European Community, *European Economic Review* 35, 1341-1359.

[41] Vives, X. (1990) Trade Association Disclosure Rules, Incentives to Share Information, and Welfare, *Rand Journal of Economics* 21, 409-430.