Do transport costs and tariffs shape the space-economy in the same way?*

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Abstract

We compare the impact of falling transport costs, borne by firms, and decreasing tariffs, borne by either firms or consumers, on the regional distribution of economic activities. Our main result shows that tariffs and transport costs play symmetric roles in that a decrease in either of them favors agglomeration. Yet, tariff rent redistribution has a significant impact on the spatial equilibrium; when tariffs are origin- (resp. destination-based), agglomeration (resp. dispersion) is more likely to emerge in equilibrium.

The market outcome is shown to be possibly inefficient when transport costs are strictly positive. Further, the range of parameter values for which equilibrium and optimum differ increases with the magnitude of tariff barriers.

Keywords: transport costs; tariff barriers; non-tariff barriers; agglomeration; economic geography.

JEL Classification: F12; F15; R12; R13.

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Résumé

Nous comparons les impacts d'une baisse des coûts de transport (payés par les firmes) et d'une diminution des tarifs (payés soit par les firmes, soit par les consommateurs) sur la répartition régionale de l'activité économique. Notre principal résultat montre qu'il y a symétrie entre coûts de transport et tarifs en ce sens qu'une baisse de l'un ou de l'autre favorise l'apparition d'agglomérations. Néanmoins, la redistribution des recettes des tarifs a un impact significatif sur l'équilibre spatial. Lorsque les tarifs sont prélevés sur la production (resp. sur la consommation), l'agglomération (resp. la dispersion) est plus probable d'être un équilibre.

Nous montrons que la solution de marché peut être inefficiente en présence de coûts de transport strictement positifs. De plus, la plage de valeurs des paramètres pour lesquelles l'équilibre et l'optimum diffèrent augmente avec la valeur des barrières tarifaires.

Mots-clés: coûts de transport; tarifs; barrières non-tarifaires; agglomération; économie géographique.

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1 Introduction

It is a well established fact that the costs of trading goods across space have a significant impact on the geographical distribution of economic activities, population, employment and wealth. Economic historians have repeatedly pointed out that the secular decline in transport, trade and communication costs has largely favored the emergence of highly industrialized and urbanized regions, whereas others have been left behind in the economic development process (Bairoch, 1988; Hohenberg and Lees, 1985). Despite some interesting early contributions by Hirschman, Perroux and Myrdal, mainstream economic theory had to wait until the 1990s, and the seminal paper by Krugman (1991), before being able to tackle the question of regional divergence in a general equilibrium framework. Since then, knowledge has progressed rapidly in the expanding field of economic geography and the crucial role played by transport and trade costs in the emergence of regional clusters is better understood (see Fujita *et al.*, 1999; and Fujita and Thisse, 2002, for state-of-the-art surveys).

Yet, because of the difficulties inherent to spatial general equilibrium, many important issues are still in quest for refinement. We believe that one of the most important, yet least discussed ones, is *the way the costs of exchanging goods between distant locations are modeled.* Although increasing international and regional integration, as well as declining costs of communication and transportation, all have decreased the costs of trade, these costs are still far from being negligible (see, e.g., Daly and Kuwahara, 1997; Limão and Venables, 1999; Henderson *et al.*, 2002). While there is hence no possible debate on whether trade is costly or not, there is no general consensus on which costs are the most important ones, neither on the way they enter the economic problem and should be modeled. Although this state of affairs is not specific to economic geography and also plagues new trade and location theory, we believe that economic geography should pay particular attention to it because, as argued by Fujita and Thisse (2002), transport and trade costs are one of the two fundamental characteristics defining this field of research. Stated differently, we believe it is of the utmost importance to know whether the way we model trade costs matters and whether the main results of new economic geography (henceforth NEG), namely the existence of a core-periphery structure once trading goods across locations becomes sufficiently cheap, are robust with respect to different modeling choices.

The lack of variety in trade cost specifications in the existing literature is mostly due to considerations of modeling simplicity. Indeed, there is an important trade-off between the realism of the assumptions and the tractability of the model (Fujita *et al.*, 1999). Yet, we believe there is also another fundamental reason. A casual look at real-world data reveals that there are a myriad of different impediments to trade. Hence, the questions of which are the large groups of impediments, what their defining characteristics are and how they enter the economic specification, all become important ones. Despite their huge number, we believe that impediments to trade can roughly be classified into three large categories: transport costs, tariff barriers and non-tariff barriers (henceforth NTBs).[1]

First, there are *transport costs* which arise due to the sheer existence of space and time. The existing literature on international trade and economic geography has modeled transport costs in several different ways, all of which have their advantages and drawbacks. The most widely used approaches can be classified into either of the following two categories. First, there is the 'iceberg' cost, which is widely used in new trade theory and NEG (Samuelson, 1954; Krugman, 1979; Fujita *et al.*, 1999). When shipping a unit of output between two locations, only a fraction of it arrives at its destination, while the rest 'melts away' en route (hence 'iceberg'). While this approach allows to account for the fact that transportation is resource consuming, without having to resort to a separate transportation sector, its main drawback is that the share of transport costs in delivered prices remains constant.[2] It also implies that any increase in mill prices is accompanied by a proportional increase in transport costs, which often seems both unrealistic and undesirable (Fujita and Thisse, 2002, Ch. 9). It is hence fair to say that the iceberg cost has more the nature of an *ad valorem* tariff than that of a real transport cost, even if it is resource consuming and does not generate tariff rents. Second, transport costs have been modeled as either increases in firms' marginal costs of production or as costs in terms of a numéraire (Venables, 1987; Ottaviano *et al.*, 2002). The underlying idea is that transportation burns up scarce resources, which limits either the amount of resources firms can devote to productive activities or the wages they pay to their workers. The two main advantages of this approach are

[1]For the sake of simplicity, we abstract from more general forms of transaction costs. This voluntary neglect does not signify that those costs are either small or unimportant.

[2]Transport costs are frequently expressed as *freight rates* on either a per-unit, per-weight or, less frequently, an ad valorem basis. As argued by Bryan (2000), including freight rates per se into a pricing model of trade complicates significantly the analysis, because market conditions in the transport sector have to be taken into consideration. Freight rates should indeed be endogenously determined and depend on supply and demand conditions in an imperfectly competitive industry. This state of affairs explains why, as argued by Neary (2001), there are almost no models in which the transportation sector is explicitly modeled.

that transport costs are incurred in resources other than the good shipped (usually labor or some numéraire), while the share of transport costs in delivered prices need no longer be constant.

The second group of impediments to trade are *tariff barriers*, whose primary purpose is to protect domestic industries from foreign competition and to provide governments with tax revenues. Contrary to transport costs, tariffs are 'unreal' (or 'rent-creating') trade costs, in the sense that they do not consume but only redistribute existing resources. Although their average rate has steadily decreased from approximately 30% in 1948 to less than 7% before the 1994 Uruguay round of the World Trade Organization (Daly and Kuwahara, 1997), they still exert a strong influence on trade volumes and location decisions (see, e.g., Limão and Venables, 1999).[3] While tariffs can be beneficial, they also give rise to costs, which are mainly reflected in higher consumer prices and possibly inefficient allocation of resources in the protected economy; welfare considerations become hence an important issue in the presence of tariff barriers.

Third and finally, there is a large group of relatively heterogenous impediments to trade called *non-tariff barriers* (see, e.g., Deardorff and Stern, 1997, for an extensive survey on NTBs). Whereas tariffs have steadily decreased, recent years have witnessed a sharp rise in NTBs. This is essentially because, as argued by Daly and Kuwahara (1997), non-tariff barriers lack transparency and are more easily manipulated than tariffs. Hence, they allow governments to run protectionist policies without essentially violating the WTO agreements (or, at least, making assessment and proof of violations more difficult). NTBs are broadly defined as laws, regulations, policies, conditions, restrictions or specific requirements that protect domestic industries from foreign competition. They comprise, without being exhaustive, import and export quotas, import licensing, advertising restrictions, health and safety regulations, technical standards, exchange rate management policies, multiple exchange rate programs, anti-dumping duties and countervailing actions.[4]

Given the myriad of existing barriers to trade, it is of fundamental impor-

[3]In recent years, several industries have experience a marked rise in tariff barriers. This is essentially due to the 'tariffication' of NTBs as a result of the WTO Uruguay round (especially in the agricultural sector).

[4]Several hybrid tools like anti-dumping duties, countervailing actions and tariff-rate quotas exhibit both features of tariffs and NTBs. Note that anti-dumping duties and countervailing actions are not prohibited by WTO agreements. Neither is the 'precautionary principle' and several other quantity restrictions. Yet, there is some presumption that those mechanisms are widely employed as unjustified non-tariff barriers to trade.

tance to isolate several key characteristics in order not to get bogged down in untractable and sterile specifications. In the present paper, we develop a model that allows for a simple, yet more 'realistic' specification of barriers to trade than the ones used in the literature thus far. Most NEG and new trade models assume that all costs to exchanging goods across distant locations can be jointly represented by a single parameter and hence implicitly enter the problem in a symmetric way (Krugman, 1991; Fujita *et al.*, 1999; Fujita and Thisse, 2002). Yet, until now this *symmetry assumption* has neither been justified theoretically nor empirically. Stated differently, collapsing all the impediments to trade into a single parameter affecting prices in the same way might lead to somewhat misleading results.[5]

Our approach in the present paper partly avoids this difficulty by clearly separating the different large groups of impediments to trade. Indeed, we use a *composite trade cost specification* that encapsulates both resource consuming *transport costs*, modeled additively, and rent creating *tariffs*, modeled multiplicatively. Such an approach captures, we believe, the main characteristics of the 'real costs of doing business' in a simple way. Although empirically pertinent and theoretically important, such an approach has, to the best of our knowledge, not been applied to models of NEG until now (see, however, Schröder, 2002, for a more trade theory oriented approach). This neglect might be crucial, because the distinction between transport costs and tariffs allows for a finer analysis of the spatial distribution of economic activities in the presence of economic integration, which can consist in either the improvement of infrastructure or the removal of tariff barriers or the removal of NTBs. It also allows us to investigate how transport costs and tariffs interact in shaping the spatial economy when (i) tariffs are levied according to different principles, (ii) tariff rents are not redistributed within the economy and (iii) tariff rents are uniformly redistributed in the region in which they accrue. The third case allows for clearer results because tariff rents are spent within the model, which allows to account for general equilibrium feedbacks.[6]

The remainder of the paper is organized as follows. In Section 3, we show that both transport costs and tariffs have a *qualitatively similar im-*

[5]Anderson *et al.* (2001) have shown that the market outcome can be very different under ad valorem tariffs and per unit commodity taxes. Further, Behrens *et al.* (2003) have shown in a two-country four-region setting that the distinction between international and interregional trade costs becomes fundamental. These results suggest that the precise nature of trade costs plays a major role.

[6]See, e.g. Picard *et al.* (2002) for a model that analyzes the impact of the redistribution of profits on the spatial configuration of the economy.

pact in a two region model. More precisely, we confirm the main result of NEG, namely the existence of a core-periphery structure once transport costs and/or tariffs become *sufficiently low*, hence providing a partial justification for the symmetry assumption. We further show that dispersion of economic activity can be sustained as a spatial equilibrium for a larger range of parameter values once we allow for the redistribution of *destination-based tariff* rents, while the redistribution of *origin-based tariff* rents might have the opposite effect.

In Section 4, we analyze the impacts of transport costs and tariffs on welfare. Using a first-best setting, we show that the equilibrium and the optimum usually differ and that this is more likely to happen the higher the tariff barriers. Further, we show that if rents are redistributed, agglomeration is more likely to be an optimal spatial configuration under both origin- and destination-based tariffs.

Section 2 presents the model whereas Section 5 concludes.

2 The model

Consider an economy with two regions, labeled H and F. Variables associated with each region will be subscripted accordingly. We suppose that there are two production factors in the economy: mobile skilled workers, who are employed in the modern sector and produce a differentiated good under monopolistic competition and increasing returns to scale; and immobile unskilled workers, who are employed in the traditional sector and produce a homogenous good (chosen as the numéraire) under constant returns to scale and perfect competition. Let L be the mass of skilled and A be the mass of unskilled workers in the economy. Denote by $\lambda \in [0, 1]$ the share of skilled workers located in region H. Unskilled workers are assumed to be evenly split between the two regions, each of which hosts a mass $A/2$ of them. Products in the modern sector can be costlessly differentiated and we assume there are no economies of scope. Therefore, each firm in the modern sector produces one and only one differentiated variety. Denote by $N = n_H + n_F$ the mass of firms, respectively of varieties, in the economy, where n_r is the mass of firms located in region $r = H, F$. We assume, for simplicity, that trading the homogenous good is costless. The differentiated good can be traded at no cost within each region, whereas trading varieties of the differentiated good across regions is costly. As argued previously, trade costs are a composite of additive transport cost and multiplicative tariffs. We will be more precise concerning the particular forms of these costs later.

Each worker in the economy is endowed with one unit of labor and $\overline{q}_0 > 0$ units of the numéraire. The initial endowment $\overline{q}_0$ is supposed to be large enough for her consumption of the numéraire to be strictly positive at the market outcome. All workers have the same quadratic utility and solve the following consumption problem:

$$(\mathcal{P}_Q)\left\{\begin{array}{c} \max\limits_{q(i),\, i\in[0,N]} \quad \alpha\int_0^N q(i)di - \dfrac{\beta-\gamma}{2}\int_0^N q(i)^2 di - \dfrac{\gamma}{2}\left[\int_0^N q(i)di\right]^2 + q_0 \\ \text{s.t.} \int_0^N p(i)q(i)di + q_0 = y + \overline{q}_0 \end{array}\right.$$

where $p(i)$ is the consumer price of variety i and y is the nominal income of a worker, depending on her skilled or unskilled status. The parameters $\alpha > 0$, $\beta > \gamma > 0$ are exogenously given. In what follows, we assume that trade costs are such that trade always occurs between the two regions. The precise conditions for this to hold will be given below. Solving the consumption problem $(\mathcal{P}_Q)$, under the assumption that trade always occurs, yields the demand functions

$$q^{\star}(i) = a - (b + cN)p(i) + cP(i), \tag{1}$$

where a, b and c are given by

$$a \equiv \frac{\alpha}{\beta + (N-1)\gamma}, \quad b \equiv \frac{1}{\beta + (N-1)\gamma} \quad \text{and} \quad c \equiv \frac{\gamma}{(\beta-\gamma)[\beta + (N-1)\gamma]}$$

and

$$P(i) \equiv \int_0^N p(j)dj.$$

Clearly, $P(i)/N$ can be interpreted as the price index of the differentiated industry.

Each firm in the modern sector has a fixed input requirement of $\phi > 0$ units of skilled and $mq(i)$ units of unskilled labor to produce the quantity $q(i)$. Because firms are symmetric and only differ by their location and by the particular variety they produce, we drop the firm index i in what follows. Without loss of generality, we may set $m = 0$ because this amounts to rescaling firms' demand intercepts (Ottaviano *et al.*, 2002). Under these assumptions, labor market clearing in each region implies that

$$n_H = \frac{\lambda L}{\phi} \quad \text{and} \quad n_F = \frac{(1-\lambda)L}{\phi}. \tag{2}$$

As already mentioned, trading the differentiated good between the two regions is costly. In what follows, we consider two different settings.

(i) there is a multiplicative tariff on imports, levied on a *destination basis* (i.e. paid by the consumers in the region in which the good is consumed) as well as an additive transport cost, paid by the exporting firms;

(ii) there is a multiplicative tariff on exports, levied on an *origin basis* (i.e. paid by the firm in the region in which the good is produced) as well as an additive transport cost, paid also by the exporter.

The multiplicative component can be thought of as being an ad valorem tariff or a sales tax, whereas the additive component stands for transport costs and non-tariff barriers.[7] Because consumers and/or firms incur costs, our approach captures both demand- and supply-driven impediments to trade. The main difference between the two components is that, as mentioned previously, the multiplicative tariff is a rent creating barrier whereas the additive transport cost is a cost creating barrier. In what follows we refer, for simplicity, to the additive component as *transport costs* and to the multiplicative componenent as *tariffs.* Both are incurred in the economy's numéraire so that everything works as if there was an *exogenous* transport sector.

Under a destination-based tariff, the profit of a firm located in region $r = H, F$ is given by

$$\pi_r = \left(\frac{A}{2} + \phi n_r\right) p_{rr} q^{\star}_{rr}(p_{rr}) + \left(\frac{A}{2} + \phi n_s\right) [p_{rs} - \tau] q^{\star}_{rs}(p_{rs}/t) - \phi w_r, \tag{3}$$

where $\tau > 0$ is the transport cost incurred in shipping one unit of the differentiated product between the two regions, $t \in (0, 1]$ is a parameter inversely related to the tariff barrier and w_r is the skilled labor wage in region r. That same profit under an origin-based tariff is given by

$$\pi_r = \left(\frac{A}{2} + \phi n_r\right) p_{rr} q^{\star}_{rr}(p_{rr}) + \left(\frac{A}{2} + \phi n_s\right) [t p_{rs} - \tau] q^{\star}_{rs}(p_{rs}) - \phi w_r. \tag{4}$$

[7] Strictly speaking, the additive component could also capture specific tariffs and per unit commodity taxes. Yet, because we assume that the additive component creates no rent, we solely focus on the transport cost interpretation.

As can be seen from expressions (3) and (4), firms take their optimal pricing decisions by accounting for the existence of both transport costs and tariffs.

In what follows, we superscript equilibrium values of variables under a destination-based (resp. an origin-based) tariff with a $\star$ (resp. with a $\circ$). In accord with empirical evidence, labor and product markets are assumed to be segmented (Greenhut, 1981; Head and Mayer, 2000). Denote by p_{rs} the price a firm located in region r sets in market s. Because markets are segmented, firms are free to set their optimal prices on each market independently. Under the assumption of bilateral interregional trade, the prices maximizing profits (3) are given by

$$p_{rr} = \frac{a + cP_r}{2(b + cN)} \quad \text{and} \quad p_{rs} = \frac{t(a + cP_s) + \tau(b + cN)}{2(b + cN)} = tp_{ss} + \frac{\tau}{2} \tag{5}$$

whereas those maximizing profits (4) are given by

$$p_{rr} = \frac{a + cP_r}{2(b + cN)} \quad \text{and} \quad p_{rs} = \frac{t(a + cP_s) + \tau(b + cN)}{2t(b + cN)} = p_{ss} + \frac{\tau}{2t}.$$

Clearly, expression (5) reveals the multiplicative nature of t and the additive nature of τ.

Because of the monopolistically competitive market structure with a continuum of firms, each firm accurately neglects its impact upon, and hence reactions from, other firms. Yet, individual pricing decisions must be consistent with aggregate market conditions, so that firm behavior remains *weakly strategical* in this model. The (Nash) equilibrium price index in each region under destination-based tariffs is a solution to the equation

$$P_r = n_r p_{rr}(P_r) + n_s \frac{p_{sr}(P_r)}{t},$$

which, using expression (5), yields

$$P_r^\star = \frac{aNt + n_s\tau(b + cN)}{t(2b + cN)}. \tag{6}$$

Plugging (6) into the optimal prices (5) finally yields

$$p_{rr}^\star = \frac{2at + cn_s\tau}{2t(2b + cN)} \quad \text{and} \quad p_{rs}^\star = tp_{ss}^\star + \frac{\tau}{2}. \tag{7}$$

In what follows, we derive analytical expressions for destination-based tariffs only. This is because $p_{rr}^\circ = p_{rr}^\star$ and $P_r^\circ = P_r^\star$, whereas $p_{rs}^\circ = p_{rs}^\star/t$. Hence, tariff inclusive equilibrium prices, quantities and wages are the same in both cases. Stated differently, *in the absence of tariff rent redistribution, it is immaterial whether firms or consumers initially bear the tariff.* That such a result no longer holds once tariff rents are redistributed will be shown in sections 3.2 and 3.3.

The equilibrium prices (7) encapsulate some interesting competition effects. It is indeed easy to check that

$$\frac{\partial p_{rr}^{\star}}{\partial t} \leq 0, \quad \frac{\partial p_{rs}^{\star}}{\partial t} \geq 0 \quad \text{and} \quad \frac{\partial (p_{rs}^{\star}/t)}{\partial t} \leq 0.$$

Hence, as tariffs increase (i.e. as t decreases), so do local prices while pre-tariff export prices decrease. Nevertheless, post-tariff import prices $p_{rs}^{\star}/t$ increase, which shows that there is incomplete *tariff pass-through.* Foreign firms decrease their prices less than proportionally to the increase in tariffs. These results are in line with what is known in international trade theory (see, e.g., Winters and Chang, 2000; Chang and Winters, 2002, for recent estimates). We further have

$$\frac{\partial p_{rr}^{\star}}{\partial \tau} > 0 \quad \text{and} \quad \frac{\partial p_{rs}^{\star}}{\partial \tau} > 0,$$

which shows that both local and import prices increase with the value of transport costs. Yet, since $\partial p_{rs}^{\star}/\partial \tau < 1$ there is *freight absorption* because firms do not pass the full variation of transport costs to the consumers (see, e.g., Bryan, 2000, for some empirical results). As we show later in this paper, the 'symmetry pass-through result' highlighted by Feenstra (1989), namely that variations in tariffs and exchange rates have equivalent effects on import prices, does not generalize to tariffs and transport costs, which have different effects on the rates of pass-through.[8] We believe this point highlights the importance of clearly separating transport costs and tariffs in spatial models of trade, because the firm's pricing decisions with respect to changes in these parameters are not the same.

Some calculations show that individual equilibrium demands are given by

$$q_{rr}^{\star} = (b + cN)p_{rr}^{\star} \quad \text{and} \quad q_{rs}^{\star} = (b + cN)\left(p_{ss}^{\star} - \frac{\tau}{2t}\right). \tag{8}$$

[8] One possible explanation for the symmetry result is that tariffs and exchange rates both have a multiplicative impact, whereas transport costs have an additive impact. Note also that changes in the elasticity of demand are crucial in explaining the pass-through effects, which shows that our model is probably more suited to this kind of exercise than the CES specification.

Clearly, interregional equilibrium demands $q^{\star}_{rs}$ are positive for all spatial distributions λ of mobile workers if and only if

$$\rho \leq \rho_{\text{trade}} \equiv \frac{2a}{2b+cN}, \quad \text{where} \quad \rho \equiv \frac{\tau}{t}. \tag{9}$$

The parameter $\rho \in [0, +\infty)$ can be interpreted as a measure of the *freeness of trade*. The larger (resp. the smaller) ρ, the more costly (resp. the cheaper) is interregional trade.[9] In the remainder of this paper, we assume that condition (9) always holds. It states that, taken together, transport costs and tariffs must be sufficiently low for interregional trade to occur.

Whereas perfect competition implies that wages in the unskilled sector are equal to 1, the assumption of free entry and exit of firms in each region implies that skilled wages are determined by the zero-profit condition. More precisely, the equilibrium wages of the skilled are determined by a bidding process in which firms compete for workers by offering higher wages until no firm can profitably enter or exit the market. Evaluating expression (3) at the market equilibrium, the zero-profit wages are given by

$$w^{\star}_r = \frac{b+cN}{\phi}\left[\left(\frac{A}{2}+\phi n_r\right)(p^{\star}_{rr})^2 + t\left(\frac{A}{2}+\phi n_s\right)\left(p^{\star}_{ss}-\frac{\tau}{2t}\right)^2\right]. \tag{10}$$

Using the results established by Ottaviano *et al.* (2002), the indirect utility in region r can be expressed as

$$V^{\star}_r(\lambda) = \frac{a^2N}{2b} - aN\left[\lambda p^{\star}_{rr} + (1-\lambda)\frac{p^{\star}_{sr}}{t}\right] + \frac{(b+cN)N}{2}\left[\lambda (p^{\star}_{rr})^2 + (1-\lambda)\left(\frac{p^{\star}_{sr}}{t}\right)^2\right]$$
$$-\frac{cN^2}{2}\left[\lambda p^{\star}_{rr} + (1-\lambda)\frac{p^{\star}_{sr}}{t}\right]^2 + y^{\star}_r + \bar{q}_0,$$

where $y^{\star}_r = w^{\star}_r + R^{\star}_r$ is the nominal equilibrium income and $R^{\star}_r \geq 0$ is the per capita share in tariff rents when those rents are redistributed. In what follows, we will focus on two special but meaningful cases. First, there is the case in which tariff rents are spent outside the model and hence do not accrue to agents. Second, there is the case in which tariff rents are uniformely redistributed to agents residing in the region *in which the rents are generated.*

[9]Note that, because ρ encapsulates two different trade barriers, an unambiguous interpretation is unfortunately not possible. For example, $\rho = 0$ does not signify that trade is necessarily costless. Nevertheless, small values of ρ are usually associated with a rather low overall level of trade costs.

Although our quasi-linear utility function does not capture income effects per se, we will see that tariff rents nevertheless have a significant impact on the spatial distribution of economic activities via the consumption of the numéraire.

3 Spatial equilibrium

The indirect utility differential between regions H and F is defined by

$$\Delta V^\star(\lambda) \equiv V_H^\star(\lambda) - V_F^\star(\lambda). \tag{11}$$

A *spatial equilibrium* is such that product and labor markets clear at the equilibrium prices (7) and wages (10), while no skilled worker has an incentive to change his current location. Formally, a spatial equilibrium arises at $\lambda \in (0,1)$ when $\Delta V^\star(\lambda) = 0$, or at $\lambda = 0$ if $\Delta V^\star(0) \leq 0$, or at $\lambda = 1$ if $\Delta V^\star(1) \geq 0$. Such an equilibrium always exists because $V^\star$ is a continuous function of λ (Ginsburgh *et al.*, 1985, Proposition 1). An interior equilibrium is stable if and only if the slope of the indirect utility differential (11) is negative in a neighborhood of the equilibrium, whereas the two agglomerated equilibria are always stable whenever they exist.

3.1 Spatial equilibrium without redistribution

In this section, we assume that $R_r^\star(\lambda) \equiv 0$. Hence, tariff rents are spent outside the model.[10] Substituting expressions (7) and (10) into $V_r^\star$, some longer calculations show that

$$\Delta V^\star(\lambda) = \frac{-(b+cN)N}{4\phi t^2(2b+cN)^2}\left(\lambda - \frac{1}{2}\right)[C_3 t^3 + C_2(\tau)t^2 + C_1(\lambda,\tau)t + C_0(\lambda,\tau)], \tag{12}$$

where

$C_3 \equiv 8\phi a^2 > 0$
$C_2(\tau) \equiv -4a[2\phi a + 4\phi\tau b + 2\phi N c\tau + Ac\tau] < 0$

[10] Note that, because we focus on a single industry, an alternative interpretation is to consider that rents are redistributed but spent on other goods. This does not seem implausible to us, especially because the share of each individual industry in consumers' budgets is usually quite small. This is further exacerbated by the fact that, in a model with more than two regions, rents generated by imports from one region can be spent on imports from another different region.

$$C_1(\lambda,\tau) \equiv -\tau[-8\tau\phi b(b+cN) - 4bAc\tau + 8a\phi(b+cN)$$
$$+2\phi N^2c^2\tau\lambda(1-\lambda) - \tau Nc^2A - 2\phi N^2c^2\tau - 4Aca]$$
$$C_0(\lambda,\tau) \equiv \tau^2[4\phi b^2 + 4cN\phi b + 2\phi N^2c^2\lambda(1-\lambda) + Ac^2N] > 0.$$

Let

$$K(\lambda,t,\tau) = C_3t^3 + C_2(\tau)t^2 + C_1(\lambda,\tau)t + C_0(\lambda,\tau), \tag{13}$$

which is continuous and differentiable with respect to all its arguments. From expression (12), we see that full agglomeration with $\lambda = 1$ (resp. with $\lambda = 0$) is a spatial equilibrium if and only if $K(1,t,\tau) < 0$ (resp. if $K(0,t,\tau) > 0$), while dispersion is a stable spatial equilibrium if and only if

$$\frac{\partial(\Delta V^\star)}{\partial\lambda}\Big|_{\lambda=1/2} \leq 0 \quad\Leftrightarrow\quad K(1/2,t,\tau) \geq 0. \tag{14}$$

Note that, because K is a function of λ, there might exist interior equilibria, which is not the case in the original model by Ottaviano *et al.* (2002). Let us begin by investigating the special case in which $\tau = 0$. Clearly, if there are no transport costs, $C_1(\lambda,0) = C_0(\lambda,0) = 0$. Albeit particular, this setting yields some interesting results. Evaluating the indirect utility differential (12) at $\tau = 0$, we get

$$\Delta V^\star(\lambda)\Big|_{\tau=0} = \frac{2a^2N(b+cN)(1-t)}{(2b+cN)^2}\left(\lambda - \frac{1}{2}\right).$$

This leads to the following result.

Proposition 1 *Assume that transport costs are zero ($\tau = 0$), tariffs are strictly positive ($t < 1$) and tariff rents are not redistributed. Then agglomeration of all mobile workers in the same region is the only stable spatial equilibrium.*

Proof. Because $t \in (0,1)$, the slope of the indirect utility differential is always positive, which implies that full agglomeration is the only stable spatial equilibrium. ■

Stated differently, when there are no cost creating barriers to trade, the existence of rent creating barriers implies that economic activity always agglomerates into one of the two regions. What are the forces driving this surprising result? As one can see from expression (7), if $\tau = 0$ prices of all varieties are the same across all regions. Firms hence absorb all tariffs, which implies that there is no more pass-through.[11] This allows to explain the result as follows. If $p^\star_{rs}/t = p^\star_{ss}$, post-tariff import prices in region s are just equal to local prices. Hence, equilibrium prices no longer depend on the spatial distribution of economic activities, which implies that differences in the indirect utility $V^\star_r$ are simply driven by differences in (nominal) wages. In case $\tau = 0$, equilibrium wages (10) can be rewritten as

$$w^\star_r = \frac{b + cN}{\phi}\bar{p}^2\big[A + \phi\big((1-t)n_r + tN\big)\big], \tag{15}$$

where $\bar{p}$ denotes the unique consumer price in the spatial economy. Because $t \in (0,1)$, the equilibrium wage is increasing in the mass n_r of local firms (recall that the total mass of firms N is fixed). Firms and workers therefore agglomerate into one of the two regions in order to maximize profits and wages (which is equivalent to minimizing tariff rents). Of course, this particular result is partly driven by the fact that tariff rents do not accrue to consumers. Once rents are redistributed, minimizing expenditures on tariffs might no longer be profitable. It is of interest to note that everything works as if firms were using a *uniform delivered pricing policy.* As shown by Ottaviano (1998), in that case there is no dispersed equilibrium with interregional trade, a result that further confirms our findings.

The particular case without tariffs (i.e. with $t = 1$) but with strictly positive transport costs, is covered by Ottaviano *et al.* (2002). They show that if the mass of immobile factor is sufficiently large ($A > \bar{A} > 3L$), there exists a threshold value

$$\tau^\star \equiv \frac{4a\phi(3b + 2cN)}{2b(3b\phi + 3c\phi N + cA) + c^2N(A + \phi N)} \tag{16}$$

such that the spatial equilibrium involves dispersion for all $\tau \geq \tau^\star$, while agglomeration is the outcome when $\tau < \tau^\star$. Hence, *decreasing transport costs* favor the emergence of a core-periphery structure, a result that is in line with that established by Krugman (1991).

We show now that decreasing tariffs have a similar impact on the spatial structure of the economy. As in Ottaviano *et al.* (2002), we assume that the mass of immobile factor A is sufficiently large so that $\tau^\star \leq 2a/(2b + cN)$.[12]

[11] Note that if $\tau = 0$, firms must sell at the same price in both regions. Indeed, if a firm located in region r sets a price $p_{rs} > p_{rr}$, arbitrage becomes possible so that consumers in s can buy the variety in region r. In that case, firm's demand drops to zero in region s, which cannot be a profit maximizing strategy.

[12] This is reminiscent of, yet different from, what Krugman (1991) calls the 'no black hole' condition.

Hence, if $\tau < \tau^\star$, the spatial configuration involves full agglomeration when there are no tariffs. Evaluating $K(1,t,\tau)$, we can show that $K(1,t,\tau) < 0$ if and only if $SM(t,\tau) < 0$, where

$$SM(t,\tau) = A_2(t)\tau^2 + A_1(t)\tau + A_0(t) \tag{17}$$

is the *sustain mapping* of the spatial economy and where

$$A_2(t) \equiv t[8\phi b(b+cN) + Ac(4b+cN) + 2N^2\phi c^2] + Ac^2N + 4\phi b(b+cN) > 0$$
$$A_1(t) \equiv -4at[t(Ac + 4b\phi + 2c\phi N) + 2\phi(b+cN) - Ac]$$
$$A_0(t) \equiv 8a^2t^2\phi(t-1) \leq 0.$$

As one can see, if there are no transport costs ($\tau = 0$), full agglomeration is always a spatial equilibrium for all values of t. This case has been discussed previously. Clearly, for a given and fixed value of t, the sustain mapping SM is a convex parabola of τ. Because $SM(t,0) \leq 0$, there is always a unique value $\tau_s(t) \geq 0$, which we will refer to as the *break point* of the spatial economy, such that full agglomeration is a spatial equilibrium for all $\tau \leq \tau_s(t)$, while agglomeration cannot be sustained for all $\tau > \tau_s(t)$.

Proving that decreasing tariffs lead to more agglomeration (resp. that increasing tariffs lead to more dispersion) is equivalent to showing that SM (resp. τ_s) is decreasing (resp. increasing) with respect to t. This task is complicated by the fact that the derivative of SM with respect to t is difficult to evaluate. Yet, several results can be established. Evaluating the derivative of K with respect to t at $t = 1$ and $\tau = \tau^\star$, one can show that

$$\frac{\partial K}{\partial t}(\lambda, \tau^\star, 1) < 0, \quad \forall \lambda \in [0,1]. \tag{18}$$

Hence, a decrease in t (i.e. an increase in tariffs) leads to an increase in K, which gets strictly positive (recall that, by definition, $K(\lambda,\tau^\star,1) = 0$). It follows then from the continuity of $\Delta V^\star$ that full agglomeration is no longer a stable spatial equilibrium, hence confirming that *decreasing tariffs usually foster the agglomeration of economic activities, just as decreasing transport costs do.* Provided that tariffs t are sufficiently low whereas the mass of immobile factor A is sufficiently large, we can prove a stronger result.

Proposition 2 *Assume that $t > 1/2$ and that $A \geq \tilde{A} > \bar{A}$. Then the sustain point τ_s is an increasing function of t.*

Proof. The proof is relegated to Appendix A. ■

Proposition 2 shows that the main result of NEG, namely the existence of a core-periphery pattern once trading becomes sufficiently cheap, does not seem to depend on whether trade costs are additive transport costs (borne by the firms) or multiplicative tariffs (borne by the consumers or the firms). The main prediction of new economic geography seems hence to be highly robust with respect to alternative modeling choices.[13]

Consider now the conditions for a stable equilibrium with dispersion. It is easily shown that

$$\frac{\partial(\Delta V^\star)}{\partial\lambda}\Big|_{\lambda=1/2} < 0 \quad \Leftrightarrow \quad BM(t,\tau) > 0, \tag{19}$$

where

$$BM(t,\tau) = B_2(t)\tau^2 + B_1(t)\tau + B_0(t) \tag{20}$$

is the *break mapping* of the spatial economy and where

$$\begin{aligned}
B_2(t) &\equiv t[16\phi b(b+cN) + 2Ac(4b+cN) + 3\phi N^2c^2] \\
&\qquad +8b\phi(b+cN) + c^2N(2A+\phi N) \geq 2A_2(t) > 0 \\
B_1(t) &\equiv -8at[t(Ac+4b\phi+2c\phi N) + 2\phi(b+cN) - Ac] = 2A_1(t) \\
B_0(t) &\equiv 16a^2t^2\phi(t-1) = 2A_0(t) \leq 0.
\end{aligned}$$

As one can see, when there are no transport costs (i.e. $\tau = 0$), dispersion is never a spatial equilibrium no matter the value of t. Clearly, for a given and fixed value of t the break mapping BM is a convex parabola of τ. Because $SM(t,0) \leq 0$, there is a unique value $\tau_b(t) \geq 0$, which we will refer to as the *break point* of the spatial economy, such that dispersion is a spatial equilibrium for all $\tau \geq \tau_b(t)$, while dispersion cannot be sustained for all $\tau < \tau_b(t)$.

As shown in Appendix B, $\tau_b(t) \leq \tau_s(t)$ for all parameter values of the model, whereas the inequality is strict when there are tariff barriers (i.e. when $t < 1$). Hence, there can be multiple stable equilibria once transport costs and tariffs are jointly accounted for. Note also that the inequality $\tau_b(t) \leq \tau_s(t)$ rules out the existence of stable interior equilibria other than $\lambda = 1/2$. We hence fall back on results that are qualitatively similar to the ones obtained in the CES core-periphery model (see, e.g., Krugman, 1991; Fujita *et al.*, 1999; Puga, 1999).

[13] At least in a two region setting. That these results may not hold when there are more than two regions is shown by Behrens *et al.* (2003) and Tabuchi *et al.* (2003).

Let us summarize the results established in this section as follows. For a given value of tariffs, agglomeration can be sustained when transport costs are sufficiently low, whereas dispersion can be sustained when transport costs are sufficiently high. Further, for a given value of transport costs, decreasing tariffs increase the range of parameter values for which full agglomeration can be sustained, whereas increasing tariffs decrease that same range. Therefore, *both decreasing transport costs and decreasing tariffs favor the emergence of a core-periphery structure*, hence suggesting that *both impediments to trade have a symmetric impact on the space-economy.*

3.2 The impact of destination-based tariff redistribution

In this section, we assume that $R_r^\star(\lambda) \geq 0$ and that tariff rents are equally redistributed to the economic agents residing in the region in which they are generated (in this case, the *region of consumption*). Although our model abstracts from direct income effects, increasing revenues are spent on the numéraire, which has an impact on indirect utilities. Formally, the aggregate rent AR generated in region r at the market equilibrium is given by

$$AR_r^\star(\lambda) = n_s\left(\frac{A}{2} + \phi n_r\right)\left[\frac{1}{t} - 1\right]p_{sr}^\star q_{sr}^\star, \tag{21}$$

which implies that *per capita tariff rent* can be expressed as

$$R_r^\star(\lambda) = n_s(b + cN)(1 - t)\left[(p_{rr}^\star)^2 - \left(\frac{\tau}{2t}\right)^2\right]. \tag{22}$$

Expression (22) clearly highlights the presence of two opposite effects. On the one hand, if there are no tariff barriers (i.e. $t = 1$), there are no rents and hence no impact on wages. On the other hand, if tariff barriers are large, $1 - t$ increases but at the same time demand decreases. Hence, the net effect is not obvious because there is a trade-off between higher consumption of the numéraire and lower consumption of the differentiated good. The regional *per capita rent differential*, evaluated at the market equilibrium, is given by

$$\Delta R^\star(\lambda) \equiv R_H^\star(\lambda) - R_F^\star(\lambda) = \frac{(b + cN)N(t-1)F(\lambda, t, \tau)}{2t^2(2b + cN)^2}\left(\lambda - \frac{1}{2}\right),$$

where

$$F(\lambda, t, \tau) = c^2N^2\tau^2\lambda(\lambda - 1) + 4cN\tau(at - b\tau) + 4(a^2t^2 - b^2\tau^2).$$

The last two terms of F are always positive when condition (9) holds, whereas the first term is clearly negative. As one can see, once the economy becomes very agglomerated, i.e. when $\lambda \to 1$ (resp. when $\lambda \to 0$), the tariff rent differential becomes negative (resp. positive). Further, it is easy to check that

$$\frac{\partial(\Delta R^{\star})}{\partial \lambda}\bigg|_{\lambda=1/2} \leq 0 \tag{23}$$

when condition (9) holds. Taken together, these two conditions show that dispersion can be sustained for a larger range of parameter values when destination-based tariff rents are redistributed. This result can be summarized as follows.

Proposition 3 *Assume that tariffs are destination-based. Then dispersion of firms between the two regions can be sustained as an equilibrium for a larger range of parameter values when rents are uniformely redistributed than when they are not.*

Stated differently, when destination-based tariff rents are redistributed, consumers (and hence firms) have an incentive to remain dispersed for values of transport costs and tariffs that would otherwise lead to agglomeration. Indeed, when transport costs and tariffs are not too low, being dispersed generates rents that compensate partly, by an additional consumption of the numéraire, for the higher costs incurred in shipping goods to and importing goods from the other region.[14] As we argue in the Section 4, rent redistribution might also mitigate the inefficiency one usually observes at the market outcome.

3.3 The impact of origin-based tariff redistribution

In this section, we assume that $R^{\star}_r(\lambda) \geq 0$, so that tariff rents are equally redistributed to the economic agents residing in the region in which they are generated (in this case, the *region of production*). Formally, the aggregate rent AR generated in region r at the market equilibrium is given by:[15]

$$AR^{\circ}_r(\lambda) = n_r\left(\frac{A}{2} + \phi n_s\right)(1-t)p^{\circ}_{rs}q^{\circ}_{rs}, \tag{24}$$

[14] Assuming that shipping the numéraire is costly does not reverse this result, even if it reduces the centrifugal effect of rent redistribution.

[15] Note that $AR^{\circ}_r = AR^{\star}_s$ for $r \neq s$. Hence, total aggregate rent $AR = AR_r + AR_s$ generated in the two regions is the same under both origin- and destination-based tariffs. What changes is the way rents are redistributed and hence impact on individual utilities.

which implies that per capita tariff rents in region $r = H, F$ are given by

$$R_r^\circ(\lambda) = n_r(b + cN)\frac{A/2 + \phi n_s}{A/2 + \phi n_r}(1 - t)\left[(p_{ss}^\circ)^2 - \left(\frac{\tau}{2t}\right)^2\right]. \tag{25}$$

As one can see from (25), under an origin-based tariff the relative size of the two regions has a direct impact on per capita rent, which was not the case under a destination-based tariff. The regional *per capita tariff rent differential*, evaluated at the market equilibrium, is given by

$$\Delta R^\circ(\lambda) = \frac{N(b + cN)(t - 1)F^\circ(\lambda, t, \tau)}{2t^2(A + 2\phi\lambda N)(2b + cN)^2[A + 2\phi(1 - \lambda)N]}\left(\lambda - \frac{1}{2}\right), \tag{26}$$

where F° is a complex function of λ, t and τ, whose expression is given by

$$\begin{aligned} F^\circ(\lambda, t, \tau) = {} & 4\lambda^4 N^4 \phi^2 \tau^2 c^2 - 8N^4 \phi^2 \lambda^3 \tau^2 c^2 - 16\lambda^2 N^2 \phi^2 \tau^2 b^2 - 4A\lambda^2 N^3 \phi \tau^2 c^2 \\ & +16\lambda^2 N^2 \phi^2 a^2 t^2 - 16A\lambda^2 N^2 \phi a t \tau c - 16N^3 \phi^2 \lambda^2 \tau^2 cb + A^2 \tau^2 c^2 N^2 \lambda^2 \\ & +4N^4 \phi^2 \tau^2 c^2 \lambda - A^2 \tau^2 c^2 N^2 \lambda - 16N^2 \phi^2 \lambda a^2 t^2 + 16N^3 \phi^2 \tau^2 cb\lambda + 4AN^3 \phi \tau^2 c^2 \lambda \\ & +16N^2 \phi^2 \lambda \tau^2 b + 16AN^2 \phi a t \tau c\lambda + 4A^2 a t \tau c N - 4A^2 \tau^2 bcN + 4A^2 a^2 t^2 - 4A^2 \tau^2 b^2. \end{aligned}$$

Although F° cannot be unambiguously signed, casual inspection reveals that $F^\circ > 0$ for low values of transport costs and tariffs (recall that we assume that $A > L$), whereas $F^\circ < 0$ for intermediate to large values. Hence, the per capita rent differential acts as an additional agglomeration force when transport and trade costs are not sufficiently low, whereas it acts as an additional dispersion force otherwise. The economic intuition behind this result is the following. The larger region has fiercer local price competition than the smaller region. This implies that equilibrium prices all firms charge in the larger region are lower than in the smaller region, which increases rent revenues in the larger region and decreases rent revenues in the smaller region (recall that those rents are levied on export prices). This *price effect* is, unlike in the case of destination-based tariffs, now counterbalanced by a *size effect*: demand in the smaller region is lower than in the larger region, whereas consumers are more numerous in the larger region which implies that per capita rent is lower. From F° we see that the price effect dominates the size effect for high values of transport and trade costs, whereas once economic integration has sufficiently proceeded, this relationship is reversed.[16] Note further that larger values of A also favor the price effect.

[16] Recall that in Krugman (1991) the size effect also dominates the price effect once transport costs become sufficiently low.

It is easy to construct numerical examples for which dispersion is the only stable spatial equilibrium when rents are not redistributed, whereas agglomeration is the only stable spatial equilibrium once origin-based tariff rents are uniformly redistributed. It therefore seems that origin-based tariffs could favor the agglomeration of economic activities when integration has not sufficiently proceeded, which shows that a possible future change from destination- to origin-based value added taxation in the European Union (see, e.g., Keen *et al.*, 2002) might have some serious spatial repercussions.

4 Welfare

The modeling framework developed by Ottaviano *et al.* (2002) allows for a neat welfare analysis. In this section, we investigate how transport costs and tariffs alter the level of welfare in the economy when compared with the *first-best* outcome. Assume that a welfare maximizing planner controls both prices and firm distribution and that he can use lump-sum transfers as compensation mechanisms. Equating all prices to marginal costs, we have

$$p_{rr}^{\star} = 0 \quad \text{and} \quad p_{rs}^{\star} = \tau, \tag{27}$$

which implies that transfers must be such that $w_r^{\star} = 0$ in order for firms to make zero profits.[17] Note that the new condition for bilateral interregional trade is given by $\rho < a/(b + cN)$, which implies that there is *wasteful trade* in equilibrium for all values of transport costs

$$\rho \in \left[\frac{a}{b + cN} \, , \, \frac{2a}{2b + cN} \right]. \tag{28}$$

Stated differently, when trade costs are *neither too large nor too small*, the market outcome involves bilateral trade between the two regions, whereas a welfare maximizing planner would favor regional autarky. This is because, as in Brander and Krugman (1983), the resource waste due to 'dumping' offsets the gains due to fiercer price competition. Using expression (27), the indirect utility in region r is given by

$$V_r^{\star} = \frac{a^2 N}{2b} - a n_s \frac{\tau}{t} + \frac{b + cN}{2} n_s \left(\frac{\tau}{t} \right)^2 - \frac{cN}{2} \left(n_s \frac{\tau}{t} \right)^2 + \bar{q}_0 + y_r^{\star}(\lambda). \tag{29}$$

[17]In case of origin-based tariffs, marginal cost pricing implies that $p_{rs}^{\circ} = \tau/t = p_{rs}^{\star}/t$ still holds. Hence, in the absence of redistribution, welfare results are the same whether tariffs are origin- or destination-based.

Because utilities are quasi-linear and hence transferable, we can define aggregate welfare as the sum of individual welfares. Hence

$$W(\lambda) = \frac{A}{2}\big[S_H(\lambda) + 1 + R_H^\star(\lambda)\big] + \lambda\phi N\big[S_H(\lambda) + R_H^\star(\lambda)\big]$$
$$+\frac{A}{2}\big[S_F(\lambda) + 1 + R_F^\star(\lambda)\big] + (1-\lambda)\phi N\big[S_F(\lambda) + R_F^\star(\lambda)\big],$$

where 1 is the wage in the perfectly competitive traditional sector.

4.1 Welfare without redistribution

Assume that tariff rents are not redistributed so that $R_r^\star(\lambda) \equiv 0$. In that case, welfare is given by

$$W(\lambda) = \frac{W_2 t^2 + W_1(\lambda,\tau)t + W_0(\lambda,\tau)}{4bt^2}, \tag{30}$$

where

$$W_2 \equiv 4Ab + 2a^2N(A+\phi N) > 0$$
$$W_1(\lambda,\tau) \equiv 2abN\tau[4N\phi\lambda(\lambda-1) - A] < 0$$
$$W_0(\lambda,\tau) \equiv bN\tau^2[2N\lambda(1-\lambda)(N\phi c + 2\phi b + Ac) + Ab] > 0.$$

One can easily check that in case $t = 1$, the welfare function W reduces to that derived by Ottaviano *et al.* (2002). The derivative of (30) with respect to λ is given by

$$\frac{\partial W}{\partial \lambda}(\lambda) = \frac{N^2\tau\big[4\phi a t - 2\phi\tau b - \tau c(A+\phi N)\big]}{t^2}\left(\lambda - \frac{1}{2}\right), \tag{31}$$

which, because W is either convex or concave, shows that only full agglomeration or dispersion can be a socially optimal spatial pattern. This leads to the following result.

Proposition 4 *The welfare maximizing planner will chose dispersion as an optimal spatial pattern if and only if*

$$\tau > \tau_w(t) \equiv \frac{4\phi a}{2b\phi + c(A+\phi N)}t, \tag{32}$$

while he will chose full agglomeration in either of the two regions otherwise.

As shown by Ottaviano *et al.* (2002), $\tau_w(1) < \tau^\star$. Hence, equilibrium and optimum coincide for either high or low values of transport costs, while there is a divergence for intermediate values. Since τ_w obviously decreases as tariffs increase (i.e. as t decreases), we have the following result.

Proposition 5 *The larger the tariff barriers in the economy, the more likely that the market outcome is inefficient.*

Proposition 5 shows that there exist values of τ for which equilibrium and optimum coincide when there are no tariff barriers, whereas they differ in the presence of tariff barriers. We therefore have *two different kinds of inefficiency in the spatial economy.* When tariffs take low or intermediate values, whereas trade costs are large, there can be wasteful trade. When tariffs are large whereas transport costs take high or intermediate values, there can be a divergence between the optimum and the equilibrium spatial structure. Both inefficiencies reduce welfare in the space-economy. One can finally check that

$$\frac{\partial W}{\partial t} = -\frac{N}{2t^2}E(\lambda,\tau,t)\rho \quad \text{and} \quad \frac{\partial W}{\partial \tau} = \frac{N}{2t^2}E(\lambda,\tau,t), \tag{33}$$

where E is given by

$$E(\lambda,\tau,t) = 2\lambda(\lambda-1)N[2\phi(at-b\tau) - c(A+\phi N)\tau] + A(b\tau - at). \tag{34}$$

Evaluating E at $\lambda = 1/2$ and at $\lambda = 1$ (resp. at $\lambda = 0$), one can check that $E(\lambda,\tau,t) < 0$ at any optimum. Hence, welfare increases monotonically with decreasing transport costs and tariffs at any optimum. Note, however, that *transport costs and tariffs can have a quantitatively different impact on welfare.* Indeed, if impediments to trade are 'large' (i.e. if $\rho > 1$), decreases in tariffs have a larger impact on welfare than decreases in transport costs. On the other hand, when impediments to trade are 'small' (i.e. if $\rho < 1$), this relationship is reversed and decreases in transport costs have a larger impact on welfare. Let us summarize this result as follows.

Proposition 6 *Consider a first-best optimum. In the early stages of economic integration, decreases in tariffs lead to larger increases in welfare, while in later stages of economic integration decreases in transport costs lead to larger welfare gains.*

Proposition 6 suggests that policy makers should focus on the removal of tariff barriers in the early stages of economic integration, whereas their attention should shift to improvements in infrastructure and the removal of non-tariff barriers in the later stages.[18] Note that our results are opposed to those derived by Schröder (2002) in a CES trade model without factor mobility, which suggests that either demand elasticities, pricing policies and/or factor mobility have a significant impact on welfare issues when there are multiple barriers to trade.

4.2 Welfare with redistribution

In this section, we assume that $R_r^\star(\lambda) \geq 0$, so that tariff rents are equally redistributed to the economic agents residing in the region in which they are generated. Because only aggregate rent matters for welfare and because aggregate rent is the same under both origin- and destination-based tariffs, we cover both cases simultaneously. Stated otherwise, *in the first-best it does not matter whether tariffs are levied in the region of production or in the region of consumption.* Note that under marginal cost pricing the equilibrium quantities are given by $q_{rr}^\star = a + cn_s\tau/t$ and $q_{rs}^\star = a - (b + cn_s)\tau/t$ respectively. Denote by W_d the welfare with redistribution of tariff rents. In that case, welfare is given by

$$W_d(\lambda) = W(\lambda) + AR^\star(\lambda), \tag{35}$$

where the the *total aggregate rent* $AR^\star = AR^\circ$ is given by

$$\begin{aligned} AR^\star(\lambda) = (1-\lambda)N\left(\frac{A}{2} + \phi\lambda N\right)\left(\frac{1}{t} - 1\right)\tau\left[a - (b + c\lambda N)\frac{\tau}{t}\right] \\ +\lambda N\left(\frac{A}{2} + \phi(1-\lambda)N\right)\left(\frac{1}{t} - 1\right)\tau\left[a - (b + c(1-\lambda)N)\frac{\tau}{t}\right]. \end{aligned}$$

Evaluating its derivative with respect to λ, we have

$$\frac{\partial AR^\star}{\partial \lambda}(\lambda) = \frac{2N^2(t-1)\tau\left[2\phi(at - b\tau) - c\tau(A + \phi N)\right]}{t^2}\left(\lambda - \frac{1}{2}\right), \tag{36}$$

which shows that aggregate tariff rent is either maximal for the dispersed or for the agglomerated configuration. The dispersed configuration yields the highest aggregate rent if and only if

[18] Note that the European economic integration actually proceeded in exactly this way. At first, the Treaty of Rome in 1958 abolished most tariff barriers, while afterwards, the Maastricht treaty in 1992 and the common transport policy of the EU abolished most non-tariff barriers.

$$\tau \leq \frac{2a\phi}{2b\phi + c(A + \phi N)} t < \tau_w(t). \tag{37}$$

Because, as shown by Proposition 4, dispersion is a global consumer surplus maximizing configuration if and only if $\tau > \tau_w(t)$, condition (37) highlights the fundamental trade-off between global consumer surplus and aggregate tariff rent. Clearly, we have

$$\frac{\partial W_d}{\partial \lambda}(\lambda) = \frac{\partial W}{\partial \lambda}(\lambda) + \frac{\partial AR^\star}{\partial \lambda}(\lambda), \tag{38}$$

which yields

$$\frac{\partial W_d}{\partial \lambda}(\lambda) = \frac{N^2 \tau \left[4\phi a t^2 - \tau(2t-1)(2\phi b + c(A + \phi N))\right]}{t^2}\left(\lambda - \frac{1}{2}\right). \tag{39}$$

This allows to establish the following result.

Proposition 7 *Assume that $t > 1/2$. The welfare maximizing planner will chose dispersion as an optimal spatial pattern when tariff rents are redistributed if and only if*

$$\tau > \tau_d(t) \equiv \tau_w(t)\frac{t}{2t-1}, \tag{40}$$

while he will chose full agglomeration in either of the two regions otherwise. When $t \leq 1/2$, only full agglomeration is an optimal spatial structure when tariff rents are redistributed.

It is easy to check that for t sufficiently large we have

$$\tau^\star \geq \tau_d \geq \tau_w, \tag{41}$$

which shows that *full agglomeration is more likely to be an optimal spatial structure once tariff rents are redistributed.* Note also that when tariff rents are redistributed, the range of transport costs τ for which the market outcome differs from the optimum shrinks. Because

$$\frac{\partial \tau_d}{\partial t} \leq 0,$$

we see that $\tau_d \to \tau_w$ as tariff barriers vanish (i.e. as $t \to 1$). Some cumbersome calculations reveal that

$$\frac{\partial W_d}{\partial t} \geq 0, \tag{42}$$

which shows that welfare is monotonically increasing as tariff barriers are progressively removed *in case tariff rents are redistributed.*

As shown in this section, tariff barriers increase the range of parameter values for which optimum and equilibrium differ. Yet, when tariff rents are redistributed, the increase is smaller than in case tariff rents are spent outside the model. We can therefore unambigously conclude that (i) the lower the tariff barriers, the higher the welfare and the smaller the range of parameter values for which the market outcome is inefficient; (ii) when tariffs barriers are present in the economy, welfare is larger and the range of parameter values for which the market outcome is inefficient is smaller when tariff rents are redistributed to consumers. In either case, the social costs of tariff barriers dominate their benefits.

5 Concluding remarks

Even in so-called modern integrated economies, barriers to trade remain numerous and play an important role in influencing both trade flows and spatial structures. We have developed an approach that concisely accounts for the main impediments to trade in a spatial economy. More precisely, we have modeled composite trade costs in terms of additive transport costs and multiplicative tariffs. Such a modeling strategy is more consistent with 'real' trade costs and allows to investigate the question on how tariff rent redistribution might influence the spatial outcome.

We have shown that transport costs and tariffs play a *symmetric role* in a two region context. Roughly speaking, agglomeration can be sustained once tariffs and/or transport costs are sufficiently low, a result that concurs with the main findings of NEG. Yet, we have also shown that the endogenous redistribution of tariffs might significantly impact upon the spatial equilibrium, depending crucially on whether tariffs are levied on production or consumption (i.e. according to an origin or a destination principle). Whereas origin-based tariffs favor the emergence of a core-periphery structure when regional integration is not sufficiently advanced, destination-based tariffs have the opposite impact of promoting a more even spatial distribution of economic activities. As further shown, high tariffs are likely to make the market outcome inefficient by either leading to wasteful trade or too much agglomeration. Yet, this inefficiency is reduced once tariff rents are redistributed in the economy.

Our results confirm the fact that economic integration is susceptible to lead to stronger regional inequalities when production factors are mobile. Yet, as shown by Behrens *et al.* (2003) in a two-country four-region context, this result might no longer hold once factors are internationally immobile. What is hence needed for a more complete understanding of the issues at hand is an approach in which factors move at some geographical scale but do not move at another, whereas trade costs are a composite of both additive and multiplicative components. This task is left for future works.

References

[1] Anderson S.P., A. de Palma and B. Kreider (2001) Tax incidence in differentiated product oligopolies, *Journal of Public Economics* 81, 173-192.

[2] Bairoch P. (1988) *Cities and Economic Development: From the Dawn of History to the Present.* Chicago, University of Chicago Press.

[3] Behrens K., C. Gaigné, G.I.P. Ottaviano and J.-F. Thisse (2003) Interregional and international trade: Seventy years after Ohlin. CEPR Discussion Paper N° 4065.

[4] Brander J. and P. Krugman (1983) A 'reciprocal dumping' model of international trade, *Journal of International Economics* 15, 313-321.

[5] Bryan I. (2000) The cost of the border effect: Freight rates, exchange rates and export prices, *Canadian Buisness Economics*, February, 1-10.

[6] Chang W. and L.A. Winters (2002) How regional blocs affect excluded countries: The price effects of MERCOSUR, *American Economic Review* 92, 889-904.

[7] Daly M. and H. Kuwahara (1997) Examining restraints on trade, *The OECD Observer* 203, 27-31.

[8] Deardorff A. and R. Stern (1997) Measurement of non-tariff barriers, OECD Economics Department Working Paper OECD/GD(97)129.

[9] Feenstra R.C. (1989) Symmetric pass-through of tariffs and exchange rates under imperfect competition: an empirical test, *Journal of International Economics* 27, 25-45.

[10] Fujita M., P. Krugman and A.J. Venables (1999) *The Spatial Economy. Cities, Regions and International Trade.* Cambridge, MA: MIT Press.

[11] Fujita M. and J.-F. Thisse (2002) *Economics of Agglomeration: Cities, Industrial Location and Regional Growth.* Cambridge, MA: Cambridge University Press.

[12] Ginsburgh V., Papageorgiou Y. and J.-F. Thisse (1985) On existence and stability of spatial equilibria and steady-states, *Regional Science and Urban Economics* 15, 149-158.

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

[14] Head K. and T. Mayer (2000) Non-Europe: The Magnitude and causes of market fragmentation in the EU, *Weltwirtschaftliches Archiev* 136(2), 285-314.

[15] Henderson V., Z. Shalizi and A.J. Venables (2001) Geography and development, *Journal of Economic Geography* 1, 81-105.

[16] Hohenberg P. and L.H. Lees (1985) *The Making of Urban Europe (1000-1950).* Cambridge, MA: Harvard University Press.

[17] Keen M., S. Lahiri and P. Raimondos-Møller (2002) Tax principles and tax harmonization under imperfect competition: a cautionary example, *European Economic Review* 46, 1559-1568.

[18] Krugman P. (1979) Increasing returns, monopolistic competition, and international trade, *Journal of International Economics* 9, 469-479.

[19] Krugman P. (1991) Increasing returns and economic geography, *Journal of Political Economy* 99, 483-499.

[20] Limão N. and A.J. Venables (1999) Infrastructure, geographical disadvantage and transport costs, World Bank Papers N° 2257.

[21] Neary P. (2001) Of hype and hyperbolas: Introducing the New Economic Geography, *Journal of Economic Literature* 39, 536-561.

[22] Ottaviano G.I.P. (1998) *Dynamic and strategic considerations in international and interregional trade.* CORE PhD Dissertation, Université Catholique de Louvain.

[23] Ottaviano G.I.P., T. Tabuchi and J.-F. Thisse (2002) Agglomeration and trade revisited, *International Economic Review* 43, 409-436.

[24] Picard P., J.-F. Thisse and E. Toulemonde (2002) Economic Geography and Firms' Ownership, CORE Discussion Paper N° 2002/27.

[25] Puga D. (1999) The rise and fall of regional inequalities, *European Economic Review* 43, 303-334.

[26] Samuelson P. (1954) The transfer problem and transport costs, II: analysis of effects of trade impediments, *Economic Journal* 64, 264-289.

[27] Schröder P. (2002) Real trade costs, tariffs and welfare. Mimeographed.

[28] Tabuchi T., J.-F. Thisse and D.-Z. Zheng (2003) On the number and size of cities, CEPR Discussion Paper N° 3386.

[29] Venables A.J. (1987) Trade and trade policy with differentiated products: a Chamberlinian-Ricardian model, *The Economic Journal* 97, 700-717.

[30] Winters L.A. and W. Chang (2000) Regional integration and import prices: an empirical investigation, *Journal of International Economics* 51, 363-377.

Appendix A: Tariffs and agglomeration

Full agglomeration with $\lambda = 1$ (resp. with $\lambda = 0$) is a stable spatial equilibrium for a given couple (t, τ) of tariffs and transport costs if and only if $SM(t, \tau) < 0$. Hence, the sustain point $\tau_s(t)$ of the spatial economy satisfies the equation $SM(t, \tau_s(t)) = 0$, which allows us to apply the inverse function theorem. We have

$$\frac{\partial \tau_s}{\partial t}\Big|_{SM(t,\tau_s(t))=0} = -\frac{\partial SM/\partial t}{\partial SM/\partial \tau}$$

provided that $\partial SM/\partial \tau \neq 0$. Some straightforward calculations show that

$$\frac{\partial SM}{\partial t}(t, \tau) = \left[8\phi b(b + cN) + cA(4b + cN) + 2N^2\phi c^2\right]\tau^2$$
$$-4a\big(2tcA + 8t\phi b + 4tc\phi N + 2\phi b + 2c\phi N - cA\big)\tau + 8a^2 t\phi(3t - 2)$$

and

$$\frac{\partial SM}{\partial \tau}(t,\tau) = 2\big[[8\phi b(b+cN)+cA(4b+cN)+2N^2\phi c^2]t+Ac^2N+4\phi b(b+cN)\big]\tau$$
$$-4at\big[(cA+4\phi b+2c\phi N)t+2\phi(b+cN)-cA\big].$$

It is easy to check that for A sufficiently large, say $A > A_\tau$, $\partial SM/\partial\tau > 0$ for all couples (t,τ). Further, when $t > 1/2$ which, when combined with condition (9) implies that

$$\frac{\tau}{2t-1} < \frac{4a}{4b+cN},$$

we see that for A sufficiently large, say $A > A_t$, $\partial SM/\partial t < 0$ for all couples (t,τ). Hence, for $A \geq \max\{A_\tau, A_t\} > \bar{A}$ (we can choose both A_τ and A_t greater than $\bar{A}$), we have

$$\frac{\partial \tau_s}{\partial t}\Big|_{SM(t,\tau_s(t))=0} > 0$$

which shows that agglomeration can be sustained for a larger range of parameter values as tariffs t decrease.

Appendix B: Break and sustain point rankings

We show in this appendix that $\tau_b(t)$ and $\tau_s(t)$ can be unambiguously ranked. Let $B_2(t) = 2A_2(t) + \epsilon(t)$, where $\epsilon(t) = c^2N^2\phi(1-t) \geq 0$. Using the equalities $B_1(t) = 2A_1(t)$ and $B_0(t) = 2A_0(t)$, the break mapping BM can be rewritten as

$$BM(t,\tau) = 2\Big[A_2(t)\tau^2 + A_1(t)\tau + A_0(t)\Big] + \epsilon(t)\tau^2 = 2SM(t,\tau) + \epsilon(t)\tau^2.$$

Clearly, because $A_2(t) > 0$ (and hence $A_2(t)+\epsilon(t) > 0$), for any given value of t the mapping SM (resp. BM) is a convex parabola with respect to τ and has a single root $\tau_s(t)$ (resp. $\tau_b(t)$) for $\tau > 0$.

Insert Figure 1 about here

By definition, we have $SM(\bar{t},\tau_s(\bar{t})) = 0$ for all values of $\bar{t} \in (0,1]$. Hence

$$BM(\bar{t},\tau_s(\bar{t})) = 2SM(\bar{t},\tau_s(\bar{t})) + \epsilon(\bar{t})(\tau_s(\bar{t}))^2 = \epsilon(\bar{t})\big[\tau_s(\bar{t})\big]^2 \geq 0.$$

Because BM is increasing at $\tau_s(\bar{t})$, this implies that

$$\tau_b(\bar{t}) \leq \tau_s(\bar{t}). \tag{43}$$

Note that if $t \in (0, 1)$, the inequality (43) is strict, whereas we fall back on the result $\tau_b(\bar{t}) = \tau_s(\bar{t})$ by Ottaviano *et al.* (2002) in case $t = 1$.

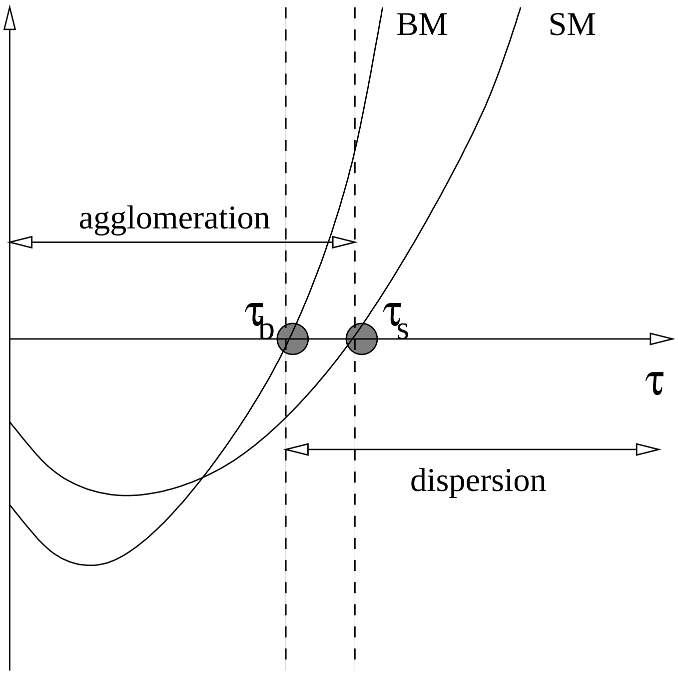

Figure 1: Break- and sustain-mappings