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Transport liberalization and regional imbalances with endogenous freight rates

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Abstract

This paper develops a tractable two-region New Economic Geography model with footloose capital and endogenous freight rates to investigate the welfare implications and long-run industry reallocation patterns triggered by different types of transport liberalization. Two policy scenarios are considered: one where a unique tariff per route is imposed, independently of the direction of shipment, and one of complete deregulation. Carriers in fully deregulated transport markets are shown to charge higher markups in shipments towards the periphery. This pricing behavior counterbalances the welfare-decreasing agglomeration forces associated with lowering trade costs and ensures welfare gains in both regions in the short and long run.*

JEL codes: R12 - R32 - L51 - L91

Keywords: Transport liberalization; endogenous transport costs; regional imbalances; Home Market Effect

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1 Introduction

In the absence of product differentiation, economies of scale and firm location considerations, trade costs can be seen as just a source of price distortion, decreasing the welfare for all market participants by driving prices up and profits down, besides leading to a misallocation of resources. This consideration has led policy makers to develop an attitude towards transport costs that can be epitomized as: the cheaper, the better. Lower transport costs are expected to lead to better integrated markets which in turn trigger improvements in citizens' welfare through price reductions due to stronger competition in the final products' market.

But are early welfare improvements meant to last in the long run? Do they depend on the market structure in the transport sector? And are the resulting gains evenly distributed across regions? This paper tries to answer these questions in the context of a New Economic Geography (NEG) framework in which products are differentiated and firms' interactions are described following the monopolistic-competition tradition (Dixit and Stiglitz, 1977; Krugman, 1991) with the additional feature of an endogenous transport sector where firms are also allowed to price discriminate by direction of shipment. NEG models with footloose capital are typically adopted to draw predictions on the spatial distribution of economic activities, which then map into location-specific market outcomes (Martin and Rogers, 1995). The key underlying idea is that, once firms are allowed to relocate from one region to the other to equalize returns on capital investments, market outcomes are affected in both origin and destination markets because of an alteration in the competitive interactions between firms (Fujita, 1988; Gaigné and Behrens, 2006; Ottaviano and Thisse, 2004).

This paper investigates the spatial agglomeration patterns and welfare implications of a cost-reducing liberalization of the transport sector, with and without the possibility for carriers to price discriminate by the direction of shipment. Following the intuition of Behrens et al. (2009), transport costs are not treated as parameters after liberalization, but they are determined endogenously by profit maximizing carriers providing an undifferentiated transport service subject to capacity constraints. Two scenarios are analyzed: the first one is a regulated liberalization regime in which prices are fixed per route (or, say, distance), independently of the direction of the shipment, which follows the modeling strategy of Behrens et al. (2009). The second is a complete deregulation regime, allowing for price discrimination based on the direction of the shipment, similarly to Behrens and Picard (2011), who analyze the case of a transport industry characterized by carriers committing the same given level of capacity in the two direction of a route and defining a pricing strategy that allows them to avoid "empties" (the so-called back-haul problem). Differently from Behrens and Picard (2011), in this paper the carriers are allowed to set up a different level of capacity in the two directions so as to relax the constraint of an equal amount of quantities shipped in the two directions, as for example in Takahashi (2011).

The empirical relevance of developing a model where prices and quantities shipped may vary by direction of shipment in the absence of ad hoc regulation or constraints is warranted by recent empirical studies. For example, Jonkeren et al. (2011) observe trade imbalances in quantities shipped in the inland waterway transport market in north-west Europe and similar findings are reported by Tanaka and Tsubota (2014) based on micro-level data on carriers connecting different Japanese prefectures. They also find variation in prices based on the direction of shipment within the same route.

Final goods in the model are supplied in horizontally differentiated varieties produced by firms operating in a monopolistic competition framework with variable elasticity of substitution (Di Comite et al., 2014; Melitz and Ottaviano, 2008) characterized by increasing returns to scale and a limited amount of market power granted from the assumption that consumers value variety. Transport costs are assumed linear so as to be able to explicitly model them as resulting from competitive interactions in the transport sector.

Differently from most NEG literature, in the framework explored in this paper there is no reversal of the short-run (static) welfare gains in the long run. Similarly to Behrens and Picard (2011), transport liberalization is shown to increase agglomeration, which affects welfare negatively, but the gains in terms of lower prices and higher profits more than compensate the negative impact of agglomeration. The more so in the case of complete liberalization, which is shown to yield less industrial agglomeration than a symmetric transport cost reduction. The results is driven by the fact that tougher (softer) competition in the core (peripheral) region's goods market forces carriers to charge a lower (higher) price to firms supplying those markets from the periphery (core), luring some firms towards the periphery to enjoy softer competition. One way to interpret this result is to look at the combined problem of the carriers and variable-elasticity-of-substitution final good producers in terms of double marginalization (Tirole, 1988), where the profits that the two types of agents can extract from the final consumers depend on the toughness of competition in the downstream market.

The model presented here has relevant policy implications in terms of the impact of transport liberalization on total welfare and geographical fairness. In terms of total welfare, a reduction in transport costs is always beneficial, but it comes at the cost of higher disparities in industrialization between regions. The latter effect can be mitigated by allowing carriers to price discriminate by direction of shipment, increasing the welfare improvements of liberalization further. Therefore, a clear policy message stems from the model: a full liberalization regime not imposing any restrictions on the market segmentation of carriers seems to be superior to a regulated market with symmetric low tariffs or a liberalization where carriers are required to charge the same price in the two directions of shipment of the same route (or to follow any other direction-invariant pricing strategy, such as a distance-based one).

The paper is organized as follows. In Section 2, the model is developed in the short run. In Section 3 the relocation of firms in the long run is described. In Section 4 the transport sector yielding endogenous freight rates is introduced in the model, under two different regulatory settings: complete deregulation and unique-bilateral-tariff liberalization. The two different regulatory regimes are compared in terms of welfare and geographic distribution of industrial activity in Section 5. Finally, Section 6 concludes.

2 The model

Consider an economy composed of two regions: a more populated core, H, and a less populated periphery, F (for notational purposes, the two regions are called i and j when considered in general terms). Consumers exhibit quadratic preferences and the economy is characterized by two sectors, one displaying constant returns to scale and using one unit of labor to produce the numeraire, the other exhibiting increasing returns to scale and using inter-regionally mobile capital and local labor to produce varieties of a differentiated good. When the differentiated good is produced in i and sold in j, it incurs a linear transport cost t_{ij}, whereas $t_{ii} = 0$. The value of t_{ij} is initially taken as a parameter (under a regulated transport sector) and independent of the direction of the shipment ($t_{ij} = t_{ji} = t$); then, it is determined endogenously in the transport sector following two types of liberalization, one imposing $t_{ij} = t_{ji}$, which is called *unique-bilateral tariff* (or symmetric tariff), and the other allowing carriers to price discriminate by the direction of shipment, $t_{i,j} \neq t_{ji}$, which is called *complete deregulation* (or full liberalization).

Here follows a description of the economy, first in the short run and then taking firm relocation into account (the long run).

2.1 Consumers

The economy is inhabited by M identical consumers which are exogenously distributed in the two regions and are endowed with one unit of labor, L, which is geographically immobile, and one unit of capital, K, which can be invested in either region (so that $M = L = K$). The share of people living in region i is expressed by θ_i, i.e. $\theta_H \in [\frac{1}{2}; 1]$ and $\theta_F = 1 - \theta_H$, so that the absolute number of consumers living in that region is $M_i = \theta_i M$. To simplify the notation, in the rest of the paper whenever a parameter (say, θ, λ) is left without subscript, it refers by convention to the largest region (say, θ_H, λ_H), which can be interpreted as a measure of demand concentration in the economy. The preferences of each consumer are captured by a standard quadratic utility function (Belleflamme et al., 2000; Ottaviano et al., 2002):

$$U_i = \alpha \int_{s\in N_i} q_{s,i} ds - \frac{\beta}{2}\int_{s\in N_i} q_i^2(s) ds - \frac{\gamma}{2}\left[\int_{s\in N_i} q_{s,i} ds\right]^2 + q_0, \tag{1}$$

Where $N_i \equiv N_{ii} + N_{ji}$ is the mass of varieties present in region i, each variety being of negligible size for the market, $q_{s,i}$ is the amount of variety $s \in (0; N]$ consumed by each consumer i, the parameter α defines the intensity of preference accorded to the consumption of the differentiated good, as compared to the homogeneous one, q_0, whose marginal utility is normalized to unity and used as the numeraire of the economy. The parameters $\beta \in (0;\infty)$ and $\gamma \in [0;\infty]$ determine consumer's love for variety by capturing perceived horizontal differentiation of varieties (β) and the degree of substitutability (γ) between varieties (Di Comite et al., 2014). Consumers are subject to the following budget constraint:

$$\int_{s\in N_{ii}} p_{s,ii} q_{s,ii} ds + \int_{s\in N_{ji}} p_{s,ji} q_{s,ji} ds + q_0 = y_i + \bar{q_0}, \tag{2}$$

where $p_{s,ii}$ and $q_{s,ii}$ are the price (in terms of the numeraire) and quantities sold of a variety s of differentiated good bought by a consumer living in the same region as the producing firm; $p_{s,ji}$ and $q_{s,ji}$ are the price and quantities sold of a variety of differentiated good bought by a consumer living in a region different from the one where the producing firm operates; the parameter $\bar{q_0}$ represents the consumer's i initial endowment of homogeneous good (assumed to be large enough to allow the consumer to enjoy any level of consumption of the differentiated good); finally, y_i is consumers' nominal income earned through the provision of factors L in region i and K in either one of the two regions, in addition to the profits redistributed from the transport sector.[2]

Optimizing Eq. (1) subject to Eq. (2) with respect to $q_{s,ii}$ leads to the following linear demand function:

$$q_{s,ji} = \frac{\alpha - p_{s,ji} - \gamma Q_i}{\beta},$$

where $Q_i = \int_{s\in N_i} q_{s,i} ds$. This can be rewritten as

$$q_{s,ji} = \frac{\alpha\beta + \gamma N_i \bar{p}_i}{\beta(\beta+\gamma N_i)} - \frac{p_{s,ji}}{\beta}, \tag{3}$$

where

$$\bar{p}_i = \frac{\int_{s\in N_i} p_{s,i} ds}{N_i}$$

is a price index capturing the average price of all the varieties of the differentiated good sold in region i.

2.2 Firms

Turning to the production side of the economy, two factors are used in the production processes: regionally mobile capital (K) and immobile labor (L). The perfectly competitive constant-returns-to-scale sector produces the homogeneous numeraire employing only labor. The monopolistically competitive differentiated manufacturing sector, with single-product firms operating under increasing returns to scale, employs both factors, capital in fixed amounts and labor proportionally to production. Manufacturing firms' profit can be expressed as follows:

$$\Pi_{s,i} = (p_{s,ii} - c) q_{s,ii} M_i + (p_{s,ij} - c - t) q_{s,ij} M_j - r_i f, \tag{4}$$

[2] Notice that since wages are determined in the numeraire producing sector and profits are redistributed to consumers in the two regions, no differences arise between the two regions in terms of nominal income. The numeraire is assumed here to be freely traded, as common in NEG models, even if this assumption has been shown from Picard and Zeng (2005) to have stronger implications than generally thought. Indeed, the presence of transport costs in the homogeneous goods' market (which is assumed to be an agricultural good in their case) turns out to be a rather important dispersion force.

where c is the amount of labor needed to produce one unit of the differentiated good, t is the linear transport cost, taken as exogenous, r is the return on capital invested, and f is the amount of capital needed to set up a firm, which can be interpreted as a fixed entry cost. Plugging Eq. (3) into Eq. (4) the profit function can be rewritten as:

$$\Pi_{s,i} = (p_{s,ii} - c)\left[\frac{\alpha\beta - (\beta + \gamma N_i)p_{s,ii} + \gamma N_i \bar{p}_i}{\beta(\beta + \gamma N_i)}\right] M_i +$$

$$+ (p_{s,ij} - c - t)\left[\frac{\alpha\beta - (\beta + \gamma N_j)p_{s,ij} + \gamma N_j \bar{p}_j}{\beta(\beta + \gamma N_j)}\right] M_j - r_i f. \tag{5}$$

Notice that the total number of firms in the economy, $N = N_i + N_j$, is a function of the amount of capital in the economy and the fixed entry cost, $N = K/f$, but it is split between the two regions according to the fraction of capital, λ, allocated to each region, so that:

$$N_i = \frac{\lambda_i K}{f} \quad ; \quad N_j = N - N_i. \tag{6}$$

2.3 Market outcomes in the short run

Manufacturing firms maximize their profits determining prices independently in the domestic and the foreign markets. Since regions are not fully integrated ($t_{ij} > 0$) and the extent of competition varies (captured by price indices), two different prices are likely to emerge for the same good sold in the two markets. Firms are assumed to be of negligible size and thus treat price indices as exogenous. Assuming no other source of heterogeneity except location, four segments can be identified in the markets: *HH* and *HF* for the firms located in the core; *FF* and *FH* for the firms located in the periphery.

The profit-maximizing prices chosen by the firms in region i are:

$$p_{s,ii} = \frac{\alpha\beta + \gamma N_i \bar{p}_i}{2(\beta + \gamma N_i)} + \frac{c}{2} \quad ; \quad p_{s,ji} = p_{s,ii} + \frac{t}{2} = \frac{\alpha\beta + \gamma N_i \bar{p}_i}{2(\beta + \gamma N_i)} + \frac{c}{2} + \frac{t}{2}, \tag{7}$$

Goods' prices rise as consumers' bias toward the consumption of differentiated goods (α), marginal costs (c) or price indices ($\bar{p}$) increase. Product differentiation as well, as captured by the parameter β (the higher, the more variety in consumption is appreciated) plays an important role, as can be better understood by developing equation Eq. (7). Indeed, taking into account that

$$\bar{p}_i = P_i/N_i = \int_{s \in N_i} \frac{p_{s,i}}{N_i} ds = \frac{N_{ii}}{N_i} p_{s,ii} + \frac{N_{ji}}{N_i} p_{s,ji} = p_{s,ii} + \frac{N_{ji}}{N_i}\frac{t}{2} = p_{s,ii} + \lambda_j \frac{t}{2} \tag{8}$$

and expressing p^* only in terms of structural parameters (taking λ as a parameter too, at least in the short run), it can be seen that:

$$p^*_{s,ii}(t) = \frac{\beta(\alpha + c) + \gamma N_i (c + \lambda_j \frac{t}{2})}{2\beta + \gamma N_i} \quad ; \quad p^*_{s,ji}(t) = p^*_{s,ii} + \frac{t}{2}. \tag{9}$$

From Eq. (9) it can be noticed that as $\beta \to 0$ (or similarly as $\gamma \to \infty$) consumers' love for variety disappears and $p^*_{s,ii} \to c + \frac{\lambda_j}{2} t$ and $p^*_{ji} \to c + \frac{\lambda_j}{2} t + \frac{t}{2}$. This is exactly equal to the marginal cost of production plus a markup component deriving from the acknowledgment that a share λ_j of firms in the market is characterized by higher marginal costs of production and delivery, $c + t$, thus affecting the price index and relaxing price competition. In fact, imported varieties pass-through to their consumers half of the transport costs incurred, $\frac{t}{2}$.

Similarly, average prices in market i can be expressed in terms of the structural parameters and transport costs:

$$\bar{p}_i = \frac{P_i}{N_i} = \frac{\alpha\beta + (c + \lambda_j t)(\beta + \gamma N_i)}{2\beta + \gamma N_i}, \tag{10}$$

which confirms that, as $\beta \to 0$ (or $\gamma \to \infty$), then $\bar{p}_i \to c + \lambda_j t$. This result is explained by the fact that a share λ_i of the varieties found in the region has marginal costs equal to c and a share λ_j of varieties has marginal costs equal to $c + t$. The higher marginal costs due to transport thus hurt consumers through the reduction in manufacturing firms' profits and higher prices, which is a common result in the NEG literature. In particular,

$$p^*_{s,ii}(t) = \bar{p}_i - \frac{t}{2}\lambda_j \quad ; \quad p^*_{ji}(t) = \bar{p}_i + (1-\lambda_j)\frac{t}{2} = \bar{p}_i + \frac{t}{2}\lambda_i,$$

from which two considerations derive. The first is that price differentials between domestically produced and imported varieties are directly related to the magnitude of transport costs. The second is that *transport costs affect asymmetrically the optimal pricing of the two varieties*. Since $\lambda_i > \lambda_j$, importers' deviation from the average price in region i (charging a higher price than the average) is higher than domestic firms' (charging a lower price than the average).

Equilibrium prices, as expressed in Eq. (9), could also be plugged into the demand function Eq. (3), so as to obtain the equilibrium quantities only as a function of structural parameters:

$$q^*_{s,ii}(t) = \frac{\beta(\alpha - c) + \gamma N_i \lambda_j \frac{t}{2}}{\beta(2\beta + \gamma N_i)} \quad ; \quad q^*_{s,ji}(t) = q^*_{s,ii}(t) - \frac{t}{2\beta}. \tag{11}$$

As expected, the transport cost, t, enters positively in q^*_{ii} and negatively in q^*_{ji}, but asymmetrically. Indeed,

$$\frac{\partial q^*_{ii}}{\partial t} = \frac{\gamma N_i \frac{\lambda_j}{2}}{\beta(2\beta + \gamma N_i)} \quad ; \quad \frac{\partial q^*_{ji}}{\partial t} = -\frac{\beta + \gamma N_i \frac{\lambda_i}{2}}{\beta(2\beta + \gamma N_i)}. \tag{12}$$

This means that even if transport costs shift demand towards domestically produced goods at the expense of imported ones, they create less demand on the domestic segment than they destroy on the imported one. This implies that the total amount of consumption in the differentiated sector is reduced and this implies that prices in each region rise for both segments, as shown in equations Eq. (9) and Eq. (10).

As for the effects of industrial agglomeration, it can be noted that as long as $\lambda > \frac{1}{2}$, both prices and quantities are always lower in the bigger region than in the smaller one, when t is equal in the two directions, because of the larger presence of firms not incurring transport costs in the local market. Therefore, tougher competition in the bigger region induced by lower transport costs benefits consumers in H by raising their real wage (because the nominal wage is normalized to unity, but goods' prices are declining). However, the same is not true for the firms located in H. Indeed, in the short run the profits of the firms located in the periphery increase in their export segment while the profits and market share of the domestic firms decrease in the local market.

2.4 Factors' remuneration

As for labor remuneration, since it can be used to produce the two types of good, the homogeneous under constant returns to scale and the differentiated under increasing returns to scale, its supply results perfectly elastic at the wage level corresponding to the value of the homogeneous good. Thus, the resulting wage in nominal terms will be equal in the two sectors of the two regions.

As for capital, it is taken as fixed in the short run but it becomes mobile in the long run. This means that, after a shock in transport costs, remuneration can temporarily differ, but will eventually equalize across the two regions. Its remuneration is directly related to the operating profits generated by firms in the two regions. Because capital is the scarce resource in this economy, firms' operating profits are absorbed by its remuneration. This can be interpreted as the result of a bidding process in which any new entrant firm, if incumbents are making profits, has room to offer a slightly higher remuneration to attract capital, thus leading to fierce competition between firms to the advantage of capital holders. As a consequence, as far as there is free entry of enterprises in the differentiated goods' manufacturing market and no heterogeneity across firms, consolidated profits are equal to zero and the remuneration of capital in the two regions equate the operating profits:

$$r_{s,i} = \frac{(p_{s,ii} - c)q_{s,ii}M_i + (p_{s,ij} - c - t)q_{s,ij}M_j}{f},$$

which can be rewritten as

$$r_{s,i} = \frac{M}{f\beta}\left[(p_{s,ii} - c)^2\theta_i + (p_{s,ij} - c - t)^2\theta_j\right].$$

From this expression, it can be understood where the trade-offs concerning capital remuneration stem from. Each variety is in fact extracting profits from two segments, the domestic and the foreign, each having a different number of consumers ($\theta_i M$ and $\theta_j M$), different marginal costs of production and delivery (c and $c + t$) and different local price indices yielding different prices ($p_{s,ii}$ and $p_{s,ij}$). This explains how, even in the absence of any technological difference, subsidy or barrier to trade, the two regions can reach very different levels of industrialization, just on the basis of differences in market size.

3 The long run: industrial agglomeration and regional imbalances

In the long run, capital is free to move between the two regions. Thus, it will flow from one region to the other until capital holders are indifferent between investing in one region or in the other, i.e. when $r_i = r_j$, which can be rewritten as

$$\left[(p^*_{s,ii} - c)^2\theta_i + (p^*_{s,ij} - c - t)^2(1-\theta_i)\right] = \left[(p^*_{s,jj} - c)^2(1-\theta_i) + (p^*_{s,ji} - c - t)^2\theta_i\right].$$

As long as transport costs t are taken as exogenous, it must be noted that this relation holds only if transport costs are not excessive, i.e. if there is trade between the regions. The maximum value consistent with the existence of international trade in the two directions, which can be called t_{trade}, can be computed as the value which ensures q_{ji} in Eq. (11) or, equivalently, p_{ji} in Eq. (9) to be positive. In terms of the structural parameters, it is

$$t_{trade} = \frac{\beta(\alpha - c)}{\beta + \frac{\gamma N}{2}}. \tag{13}$$

Focusing on cases in which $t \leqslant t_{trade}$ and solving the capital rent equalization equation, it can be seen that the following relation holds between the agglomeration of consumption and production:

$$\lambda_i - \frac{1}{2} = \frac{2\beta(\alpha - c - \frac{t}{2})}{\gamma N \frac{t}{2}}\left(\theta_i - \frac{1}{2}\right), \tag{14}$$

which implies that $\lambda_i > \theta_i$ as long as there is trade between the two regions ($t < t_{trade}$) and $\theta_i > 1/2$. This means that *the region displaying a higher share of consumption, $\theta_i > 1/2$, will attract more than proportional quantity of capital and thus firms, $\lambda_i > \theta_i$.* This phenomenon is called the Home Market Effect (HME).

Furthermore, it can be noted that $\frac{\partial \lambda_i}{\partial t} < 0$ when $\theta_i > 1/2$, this meaning that lower transport costs, when t is equal in the two directions, always lead to a higher degree of industrial concentration in the regions with the highest level of consumption.

The magnitude of the effect is inversely related to the level of transport costs in the two directions, so that a decrease in transport costs is bound to result into more industrial concentration in the core ($\theta_i > 1/2$) and intensify the HME.

The interaction between θ_i and t in determining the equilibrium agglomeration of economic activities is illustrated in the simulation in Figure 1, where the lowest possible level of trade costs (interpretable as the marginal cost of providing the transport service), τ has been normalized to unity (which is the prevailing remuneration for labor in the economy) and the other structural parameters have been chosen respecting the restrictions on variable domains.[3] Each line represents a different level of concentration of consumption in the core (H) region, θ_H. It can be observed, for instance, that even low levels of consumption concentration, $\theta_H = 0,53$, associated with very low transport costs, can lead to a complete agglomeration of economic activities in the core.

INSERT FIGURE 1 HERE.

3.1 Industrial concentration and market outcomes

Looking at price, quantity and profit equations Eq. (9), Eq. (11) and Eq. (5) it can be noted that all the relevant market outcomes are affected by the level of industrial concentration, λ. Before turning to the impact of changes in freight rates on the consumers, it can be useful to sum up how industrial concentration, λ affects equilibrium prices and quantities, holding transport costs fixed (as could result for example from an exogenous shock in the relative concentration of consumption, θ), in Table 1.

Table 1: Core and periphery effects of marginal changes in industrial agglomeration (λ) on market outcomes.

Market outcomes	HH variety impact of $\nearrow\lambda$	FH variety impact of $\nearrow\lambda$	HF variety impact of $\nearrow\lambda$	FF variety impact of $\nearrow\lambda$
n	$\nearrow$	$\searrow$	$\nearrow$	$\searrow$
q	$\searrow$	$\searrow$	$\nearrow$	$\nearrow$
p	$\searrow$	$\searrow$	$\nearrow$	$\nearrow$

Summing up, while the number of varieties and the quantity per variety produced in F and sold in H decrease, the number of varieties and the quantity per variety produced in H and sold in F rise. But what will then be the overall effect on international trade? The answer is not *a priori* clear, as it depends on transport costs and structural parameters in a complex way. The two directional flows of total trade flows move asymmetrically in opposite directions, i.e. Q_{FH} monotonically decreases in λ whereas Q_{HF} increases. The total volume of inter-regional trade in the two directions is determined by three elements: the number of people living in the importing region, M_i,the individual consumption of each imported variety $q_{s,ji}$ and the number of firms in the exporting region, N_j. Formally, it is $Q_{ij} = \lambda_i N_{ij} \theta_j M_j q_{ij}$ which, plugging Eq. (11), can be written in terms of specific regional flows as

$$Q_{HF}(t) = \lambda N(1-\theta)Mq_{HF} = \frac{\lambda N(1-\theta)M}{\beta(2\beta+\gamma N)}\left[(\alpha-c)\beta - \frac{t}{2}(2\beta+\gamma(1-\lambda)N)\right]$$

and

$$Q_{FH}(t) = (1-\lambda)N\theta Mq_{FH} = \frac{(1-\lambda)N\theta M}{\beta(2\beta+\gamma N)}\left[(\alpha-c)\beta - \frac{t}{2}(2\beta+\gamma\lambda N)\right].$$

Therefore,

$\frac{\partial Q_{HF}}{\partial\lambda} \geqslant 0$ and $\frac{\partial Q_{FH}}{\partial\lambda} < 0$ $\quad\forall$ feasible t (i.e. $t < t_{trade}$ as defined in equation Eq. (13)).

[3]For example, β should be bigger than γ for the own substitution effect to be larger than the cross substitution effect.

This means that an increase in industrial agglomeration increases the shipments from the core to the peripheral region and decreases them from the periphery towards the core. The overall effect can be seen by combining the trade flows in the two directions, $Q(t) = Q_{HF}(t) + Q_{FH}(t)$, which can be written explicitly as

$$Q(t) = NM \frac{(\alpha - c)\beta(\theta_H\lambda_F + \theta_F\lambda_H) - t\left[\lambda_H\lambda_F\gamma\frac{N}{2}(\theta_H + \theta_F) + \beta(\theta_H\lambda_F + \theta_F\lambda_H)\right]}{\beta(2\beta + \gamma N)}. \tag{15}$$

Notice that the effect is always positive, for every feasible level of inter-regional transport costs. Formally

$$\frac{\partial Q(t)}{\partial \lambda} > 0 \quad \forall t < t_{trade}.$$

4 Introducing the transport sector in the economy

Up to this point, the transport cost t in the model has been treated as an exogenous parameter, shaping market outcomes in the differentiated good sector and the location choice of firms. From now on, a transport sector is introduced in the economy, turning the exogenously given transport costs into endogenously determined freight rates, similarly to Behrens et al. (2009) and Behrens and Picard (2011). This analysis then feeds into the next Section, whose focus is on how freight rates affect market outcomes and shape the economic geography of the regions. Two different regulatory regimes for the transport sector are considered, each one corresponding to a different type of liberalization:

- First, the case is considered of a transport sector in which carriers are allowed only to charge the same price per route or, equivalently, to set the tariff based only on distance and not on the direction of the shipment. This is referred to as the **unique-bilateral-tariff liberalization**, or just symmetric freight rates;
- Second, the case is considered of a transport in which carriers are left free to set their prices freely and possibly segment their market based on the direction of the shipment (which is the only source of heterogeneity among their clients). This is referred to as **complete deregulation**, or full liberalization.

The central difference between the two regimes is, thus, the possibility of segmenting the transport market into *HF* and *FH* sub-markets, shipping different amounts of goods for different rates.

Regulators are also allowed to determine the intensity of competition in the transport sector by choosing the number of carriers in the market. It is important to notice that differences between the two regulatory regimes hold as long as the number of carriers is small. When the number of competitors increases in the transport sector and competition intensifies, prices converge to the marginal costs of production in the two regimes.

4.1 Market structure in the transport sector

There are several dimensions over which carriers can differentiate their service, both vertically (speed, punctuality, traceability and so on) or horizontally (specializing in particular sector of the economy or geographical areas). Yet, none of this would be conceivable in an economy characterized by identical consumers and identical firms producing a continuum of horizontally differentiated varieties of the same good in four segments, whose only distinctive features are the regions of production and sale. Following this consideration, the transport sector is modeled in a more classical way, treating the transport service as homogeneous in a standard oligopoly framework, in which a fixed number of firms, k, compete in quantities or, equivalently, compete in prices after having committed to a certain capacity (Vives, 1999) per destination of shipment. This market structure is convenient in terms of analytical tractability, as the only decision available to regulators to shape the market outcomes is to decide the numbers of competitors to allow in the transport sector.[4]

[4] For simplicity, without loss of generality, the number of firms in the transport sector is chosen by the regulator. In alternative, the amount of fixed entry costs could be decided by the regulator and indirectly determines the number of carriers associated with a sufficient level of profits to cover the fixed costs.

Behrens and Picard (2011) as well model the transport service as homogeneous and produced under constant returns to scale, but they model the market interactions as perfectly competitive with freight rates equal to the costs of a round-trip. In contrast, the oligopolistic structure suggested here allows firms to retain some market power and charge a markup which can be used to repay the fixed costs of entry into the transport sector if the regulator sets the number of competitors by issuing licenses (or simply redistributed to consumers if no fixed cost is involved and the number of carriers is chosen exogenously). The advantage of the approach followed here is that, while it can also generate a perfectly competitive framework by setting the number of competitors arbitrarily high, it still leaves one degree of freedom to regulators (the number of competitors to allow in the market or equivalently the fixed entry costs) to compare different policy options.

The other difference with respect to Behrens and Picard (2011) concerns the constraint on carriers' capacity, which is not assumed here to be the same in the two directions of shipment, thus relaxing the back-haul problem. Even though the cargo space may be the same in the two directions, indeed, additional fixed costs have to be incurred to ship the goods from and to a specific destination (as for example the personnel devoted to deal with import procedures, or the stocking facilities, or any kind of regulatory asymmetries in the exporting and importing region).[5] As for the marginal costs associated with the shipment, it may be argued that the route-specific part (such as fuel consumption), when considered per unit of good transported, may be much less relevant than direction-specific marginal costs such as insurance, so that the cost of returning half-empty or not completely full in the return trip can be assumed negligible. This assumption can be found also in the spatial competition model of Anderson and Wilson (2008).

It has been remarked that the relevance of route-specific costs depends on the goods shipped. As noted by Hummels (2007), shipping the same volumes of coal or computer microchips would result in a different relative importance of insurance over other types of costs. Hence, depending on the types of goods that are shipped over a given route, different sets of assumptions may be more appropriate. The set of assumptions used in this paper are notably consistent with the shipment of goods with high value added per unit of weight. In addition the assumptions on direction-specific capacity and a finite number of carriers allow the model to be consistent with the observed shipment patterns of asymemtric volumes and prices. In fact, as noted by Behrens and Picard (2011) "about 60% of the containers shipped from Asia to North America in 2005 came back empty, and those that did come back full were often transported at a steep discount for lack of demand".

4.2 Endogenization of the transport costs under a unique tariff

Assuming that all the carriers have the same marginal costs of shipment, after having committed to a given direction-specific capacity, the operating profit function determining the k^{th} carrier's behavior resulting from the market structure adopted for the transport sector can be written as

$$\Pi_{k,ij} = (t_{ij} - \tau) q_{k,ij}, \tag{16}$$

where t is the freight rate, τ is the marginal cost of transport and $q_{k,ij}$ represents the quantity of goods delivered by each carrier, $q_{k,ij} = Q_{ij}/k$. Notice that the expression capturing the total amount of international trade, as computed in equation Eq. (15), can now be seen as the demand function associated with the transport sector. It is well behaved in the sense that it linearly decreases in the parameter of interest, the freight rate t, so that the carriers' problem is well defined and yields an interior solution: as the price of the transport service rises, the imported goods become more expensive and the inter-regional trade flows decline. The elasticity of international trade to transport costs is positive and

[5]Notice that a preliminary commitment plays also in their own interest, as it allows carriers to compete in quantities, ï¿½ la Cournot, rather than in prices, ï¿½ la Bertrand, as discussed by Vives (1999). For an analysis of how carriers can investments in different technologies to adapt their cost structure to demand see Kleinert and Spies (2011).

increasing in t:[6]

$$\epsilon_{Qt} = -\frac{\partial Q}{Q} \cdot \frac{t}{\partial t} \equiv -\frac{\partial Q}{\partial t} \cdot \frac{t}{Q}$$

$$\Rightarrow \quad \epsilon_{Qt} = \frac{t[\theta_i\lambda_j(2\beta + \gamma N\lambda_i) + \theta_j\lambda_i(2\beta + \gamma N\lambda_j)]}{2(\alpha - c)\beta(\theta_i\lambda_j + \theta_j\lambda_i) - t[\theta_i\lambda_j(2\beta + \gamma N\lambda_i) + \theta_j\lambda_i(2\beta + \gamma N\lambda_j)]},$$

where $\epsilon_{Qt} \in [0; +\infty]\ \forall\ t \in [0; t_{trade}]$. A visual representation of the carrier's problem is provided in Figure 2, where it can be observed that the problem of the carriers closely resembles the problem of suppliers of an intermediate input in the context of a double marginalization setting (Tirole, 1988).

INSERT FIGURE 2 HERE.

In order to solve analytically the carrier's problem, it is convenient to express the freight rate, t , in terms of the inter-regional flow of goods, given by Eq. (15), and then maximize profit function Eq. (16) with respect to total quantities shipped. The inverse demand for inter-regional transport is then

$$t(Q) = \frac{(\alpha - c)\beta(\theta_i\lambda_j + \theta_j\lambda_i) - Q\frac{\beta(2\beta+\gamma N)}{NM}}{\lambda_i\lambda_j\gamma\frac{N}{2}(\theta_i + \theta_j) + \beta(\theta_i\lambda_j + \theta_j\lambda_i)}$$

and the resulting optimization problem of each carrier results in the pricing function

$$t^* = \frac{k}{k+1}\tau + \frac{2(\alpha - c)\beta}{(k+1)}\left[\frac{\theta_i\lambda_j}{(\theta_i\lambda_j + \theta_j\lambda_i)}(2\beta + \gamma N\lambda_i) + \frac{\theta_j\lambda_i}{(\theta_i\lambda_j + \theta_j\lambda_i)}(2\beta + \gamma N\lambda_j)\right]^{-1}. \qquad (17)$$

This expression has the advantage of being fairly flexible in terms of market outcomes. In fact, t^* declines as the number of competitors, k, increases. Ranging from $k = 1$ to $k \to \infty$, freight rates can be as high as standard monopoly pricing or as low as perfect competition pricing ($t^* \to \tau$). Regulators can thus indirectly determine the resulting price in the transport sector by just setting the number of competitors. The impact of consumption concentration and competition on equilibrium freight rates is illustrated with a simulation Figure 3.[7]

INSERT FIGURE 3 HERE.

4.3 Endogenization of the transport costs under segmentation

In a completely deregulated regime, profit-maximizing carriers are expected to segment their markets because all the conditions for segmenting are satisfied: their revenues will be higher, consumer screening is costless and arbitrage between consumers (firms involved in inter-regional trade, in this case) is not profitable.

The first condition can be inferred by the analysis of the elasticities of trade flow to the freight rate in the two segments. Since the elasticity in the segment from F to H can be shown to be higher than the one from H to F, applying the same price to both segments would imply too high prices in the former segment and too low price in the latter, which would not be profit-maximizing in the short run.[8]

[6] The analysis of the elasticity is rather convenient too in the study of monopolies and oligopolies. Indeed, the multiplicative inverse of the price elasticity equals exactly the relative mark-up that a pure monopolist will charge in the market. This result is easily generalizable to oligopolists by simply dividing this value by the number of competitors. For example, in the case here analyzed, it would hold the following relationship:

$$\frac{t^* - \tau}{t^*} = \frac{1}{k} \cdot \frac{1}{\epsilon_{Qt}}$$

[7] The equilibrium outcomes are shown in terms of simulation because the explicit analytical solution for the freight rates would be analytically intractable.

[8] An interesting result is that in the long run, after firms relocate due to the carriers pricing strategy, the profits of the carriers turn out to be lower when they segment the transport markets as compared to imposing a symmetric tariff, but it would probably not be reasonable to expect that each carrier takes into account the aggregate relocation patterns of manufacturing firms when setting its freight rate on an individual shipment.

The second condition holds because the key characteristic for segmentation is impossible to hide, since the very purchase of the transport service in one region rather than the other gives information about the segment which is being served.[9]

Finally arbitrage can be excluded, as the third condition states, because it is never profitable to carry it out as can be argued from the following relationship, based on equations Eq. (9) defining equilibrium prices:

$$p^*_{FF} - p^*_{HH} = \frac{t}{2} \cdot \frac{\gamma N(\lambda_H - \lambda_F)}{(2\beta + \gamma N)} < t.$$

This means that no third agent could make profits out of buying a good in one region and reselling it in the other one, as long as some transport service has to be purchased.

4.3.1 Redefining economic variables under a segmented transport sector

Under transport market segmentation, equilibrium price and quantity equation have to be rewritten to take into account the direction of shipment:

$$p_{s,ii}(t_{ji}) = \frac{\alpha\beta + c(\beta + \gamma N) + \gamma N \lambda_j \frac{t_{ji}}{2}}{2\beta + \gamma N} \quad ; \quad p_{s,ji}(t_{ji}) = p_{s,ii} + \frac{t_{ji}}{2}, \tag{18}$$

$$q_{s,ii}(t_{ji}) = \frac{(\alpha - c)\beta + \gamma N \lambda_j \frac{t_{ji}}{2}}{\beta(2\beta + \gamma N)} \;\; ; \;\; q_{s,ji}(t_{ji}) = q_{s,ii}(t_{ji}) - \frac{t_{ji}}{2\beta} \tag{19}$$

Carriers' maximize their profits in each segment of shipment, i.e. each $Q_{ij}(t_{ij})$ is considered individually. The sum of these two regional components determines the aggregate inter-regional trade flow:

$$Q = Q_{HF}(t_{HF}) + Q_{FH}(t_{FH}),$$

where, for each region, exports to the other can be expressed as

$$Q_{ij}(t_{ij}) = \lambda_i N \theta_j M q_{ij} = \frac{\lambda_i N \theta_j M}{\beta(2\beta + \gamma N)} \left[(\alpha - c)\beta - \frac{t_{ij}}{2}(2\beta + \gamma \lambda_j N) \right] \tag{20}$$

This means that the transport services offered in the two segments are now traded in different markets, each one characterized by a specific elasticity of inter-regional trade flows to transport cost:

$$\epsilon_{Q_{ij}t_{ij}} = t_{ij} \frac{(2\beta + \gamma \lambda_j N)}{2(\alpha - c)\beta - t_{ij}(2\beta + \gamma \lambda_j N)} \tag{21}$$

which are both increasing in the freight rate and in λ, but since $\lambda_i = 1 - \lambda_j$ the trade elasticity in the two regions move in opposite directions as industrial concentration increases. Indeed it can be verified that

$$\frac{\partial \epsilon_{Q_{ij}t_{ij}}}{\partial \lambda_i} > 0 \quad ; \quad \frac{\partial \epsilon_{Q_{ij}t_{ij}}}{\partial \lambda_j} < 0.$$

From Eq. (20) it is then possible to derive the inverse demand function in each region:

$$t_{ij} = \frac{1}{2\beta + \gamma \lambda_j N} \left[2(\alpha - c)\beta - \frac{\beta(2\beta + \gamma N)}{\lambda_i N \theta_j M} Q_{ij} \right]$$

Then, plugging them into equation Eq. (16) and optimizing with respect to quantities, the prevailing freight rates on the two segments become

$$t_{ij} = \frac{k}{k+1}\tau + \frac{2(\alpha - c)\beta}{(k+1)(2\beta + \gamma \lambda_j N)} \tag{22}$$

[9] It can also be noted that the assumption of identical firms (or, at least, technologies of production) rules out the possibility of alternative, cheaper ways of getting from one region to the other: if even one firm were able to deliver its products to the other region in a cheaper way, indeed, all the other firms would be also able to, leaving no room for the existence of a specific transport sector.

This direction-specific differentiated freight rate can be compared with the equation in Eq. (17), which describes the freight rate carriers would choose for the transport service if not allowed to price discriminate. It can be noticed that their second term displays the same numerator, but the denominator, which is the part in square brackets in Eq. (17), is the weighted average sum of the value of the denominator in Eq. (22) in the two directions of shipment. Given the higher elasticity of demand in the core region because of the price pressure imposed by the presence of a higher number of varieties in the market not being subject to transport costs, transport from the smaller to the bigger region will be cheaper than under the unique tariff, but transport from the bigger to the smaller would be more expensive in the short run:

$$t_{FH} < t^* < t_{HF}. \tag{23}$$

A long-run simulation of equilibrium freight rates in the two directions of shipment is presented in Figure 4, showing that this short-run relation need not hold after capital relocation in taken into account. Even if $t_{FH} < t_{HF}$ is always true, the different levels of λ associated with different liberalization regimes, for a given level of competition in the transport sector (as approximated by the number of carriers), imply that it is possible that $t_{FH} < t_{HF} < t$ if the agglomeration patterns induced by the symmetric tariffs are much stronger than those induced by asymmetric tariffs. This is shown in Figure 5, where equilibrium freight rates in the long run are simulated for a monopolist carrier ($k = 1$) and for an oligopoly of ten carriers ($k = 10$).

INSERT FIGURES 4 AND 5 HERE.

Further simulations are shown in the next Section to study the impact on welfare and spatial agglomeration patterns of transport regime's changes.

5 Comparing regulatory regimes

In this section, the two types of liberalization are considered. The starting point is an economy with high, symmetric transport costs before regulatory intervention. The two policy options are compared in a sequential way. First, the transition from an expensive and heavily regulated framework to a unique-bilateral-tariff liberalization is considered, as captured by an increase in the number of carriers. Then, the additional effect of allowing carriers to price discriminate by the direction of shipment is explored. The two regimes yield different results as long as the number of carriers is finite, but converge to the same outcomes (pricing to marginal costs) as the number of carriers increase.

5.1 Transport liberalization under symmetric tariffs

The focus of the welfare analysis is on the effects of transport liberalization on prices, quantities and industrial agglomeration in the differentiated good sector.

Prices and quantities

As for prices, equation Eq. (9) implies that prices of the differentiated goods decrease together with transport costs in the short run, but with different intensities in the different segments. Looking at the first derivatives of Eq. (9) (or, equivalently, Eq. (18)) with respect to t, it suffices to remind that $\lambda_H > \lambda_F$ to see that

$$\frac{\partial p_{HF}}{\partial t} > \frac{\partial p_{FH}}{\partial t} > \frac{\partial p_{FF}}{\partial t} > \frac{\partial p_{HH}}{\partial t} > 0. \tag{24}$$

A reduction in transport costs thus affects all manufacturing firms in the economy, but while in the domestic segment firms located in the peripheral region (F) are more affected than those in the core region (H), the opposite is true in the export segments. From a consumers' standpoint this means also that prices in F will decrease more than prices in H: this is a consequence of the higher share of imported varieties in the smaller market:

$$\frac{\partial \bar{p}_F}{\partial t} > \frac{\partial \bar{p}_H}{\partial t},$$

which implies higher consumer surplus gains in the periphery than in the core in the short run, with the overall impact in the long run depending on the extent of agglomeration after the liberalization.

As for the quantities, Eq. (12) ensures that in the short run

$$\frac{\partial q_{HH}}{\partial t} > 0 \quad ; \quad \frac{\partial q_{FH}}{\partial t} < 0$$

and

$$\frac{\partial q_{FF}}{\partial t} > 0 \quad ; \quad \frac{\partial q_{HF}}{\partial t} < 0.$$

Note that, interestingly, movements in opposite directions have been found also as a consequence of changes λ. However there is an important difference between the effects of variations in the parameters t and λ: the latter, in fact, implies a zero-sum transfer of quantities sold, i.e. a perfectly balanced and symmetric variation. However, this is not the case for transport costs, whose variation yields

$$\left|\frac{\partial q_{ii}}{\partial t}\right| < \left|\frac{\partial q_{ji}}{\partial t}\right|. \tag{25}$$

Since there are no attribute or technological differences between varieties produced in region i and j and the marginal rate of substitution between all the varieties is the same, the price and quantity wedges between otherwise equivalent varieties for the consumer can be interpreted as a distortion if they result from transport market regulation or the exertion of market power from carriers. Therefore, equations Eq. (25) and Eq. (24) show how a reduction of transport costs is expected to unambiguously improve welfare in the short run.

Agglomeration and Manufacturing firms' Operating Profits

As for the agglomeration of economic activities, it can be seen from equation Eq. (14) that a reduction in transport costs implies a magnification of the disparities in the long run,

$$\frac{\partial \lambda_H}{\partial t} < 0,$$

This reallocation of resources is triggered by a disproportionate impact of changes in t on the firms based in the smaller region. It may appear counterintuitive, as firms in the peripheral region have to incur lower transport costs to serve customers in the other region. However, this effect has to be traded off against tougher competition coming from the firms located in the core region, which now have easier access to the peripheral markets. Equation Eq. (14) is derived from the equalization of capital remuneration across the two regions and it signals that profits of firms located in the smaller region are affected more severely than those in the bigger region from the intensification of competition due to lower transport costs, so as to lead a higher share of region F's capital to flow toward H and a higher relative number of varieties produced there.

For ease of comparison with the effect changes in agglomeration, shown in Table 1, a summary of the short-run impacts of an increase in transport costs on the number of firms producing each variety and their equilibrium prices and quantities are displayed in Table 2 for the four segments.

Table 2: Core and periphery effects of marginal changes in transport costs.

Market outcomes	HH variety impact of $\nearrow t$	FH variety impact of $\nearrow t$	HF variety impact of $\nearrow t$	FF variety impact of $\nearrow t$
n	$\searrow$	$\nearrow$	$\searrow$	$\nearrow$
q	$\nearrow$	$\searrow$	$\searrow$	$\nearrow$
p	$\nearrow$	$\nearrow$	$\nearrow$	$\nearrow$

Global welfare

The analysis above shows how, at least in the short run, transport liberalization (as any other shock or policy whose result is to reduce the transport costs) is welfare improving for the entire economy. The result is mainly driven by the evolution of prices, which fall in all the four segments of the differentiated goods' sector, as the transport costs fall.

The indirect utility function stemming from Eq. (1) can be expressed as a function of prices and income,

$$W_i = \frac{\alpha^2 N_i}{2(\beta+\gamma N_i)} - \frac{\alpha}{\beta+\gamma N_i}\int_{s\in N_i} p_{s,i}ds + \frac{\int_{s\in N_i} p_{s,i}^2 ds}{2\beta} - \frac{\gamma}{2\beta(\beta+\gamma N_i)}\left[\int_{s\in N_i} p_{s,i}ds\right]^2 + y_i + \overline{q}_0, \tag{26}$$

which shows that, ceteris paribus, the more a variety is consumed, the higher the welfare gained from a reduction in its price:

$$\frac{\partial W_i}{\partial p_{s,i}} = -\frac{\alpha\beta-(\beta+\gamma N_i)p_{s,i}+\gamma N_i \bar{p}_i}{\beta(\beta+\gamma N_i)} = -q_{s,ji} < 0.$$

An important remark is that *the distribution of economic activities gets more unbalanced while global welfare rises*, which creates a clear trade-off for policy makers. Nonetheless, *welfare improvements in the de-industrializing region, F, are stronger than in the bigger region*, because price reductions are more intense. However, from Eq. (8) it can be seen that, when t is identical in the two directions of trade, F dwellers could never catch up entirely with the welfare level of consumers living in H, in the absence of proper redistribution mechanisms.

Simulations show that in the long run the welfare gains realized in the short run are not reversed under a wide range of parameter combinations.[10] The increase in agglomeration does affect welfare negatively in itself and lower the level of redistributed profits form carriers, but these are second-order effect as compared to the first-order effect of lower prices (price indices decrease in both regions) and higher profits in the manufacturing sector (because of higher markups in the inter-regional shipments) caused by the decrease in transport costs.

[10] Welfare losses can be observed in the long run only when the number of firms approaches the number of consumers, i.e. when the fixed costs of setting up a firm are very low. However, the effect is entirely driven by the redistribution of profits to consumers and not by the consumer surplus as captured by prices, but the quadratic utility framework is not the best suited to capture income effects because of the assumption of a large enough endowment of numeraire to satisfy any level of consumption, so it would be fair to say that the most robust results in this framework are the ones related to consumer surplus.

5.2 Complete deregulation

The analysis of full deregulation leads to qualitatively similar but quantitatively different conclusions. The departure from the symmetric transport cost towards a direction-specific pricing implies that unique-bilateral-tariff liberalization and full deregulation have different impacts on regional prices. In particular, the symmetric outcome shown in equation Eq. (17) is the weighted average for the two regions of equation Eq. (22), where weights are represented by the relative number of firms and consumers. Therefore, moving from a unique-bilateral-tariff liberalization to full deregulation, transport prices in the two directions move in opposite directions, counteracting the agglomeration effect due to lower freight rates.

Prices and quantities

The regional differentials on prices in the short run can be easily deducted by using equation Eq. (18), keeping in mind the impact on prices in the two directions shown in Eq. (23):

$$p^S_{HH} < p_{HH} \quad ; \quad p^S_{FH} < p_{FH}$$

and

$$p^S_{FF} > p_{FF} \quad ; \quad p^S_{HF} > p_{HF},$$

where ^{S} stands for market outcomes after carriers are allowed to segment the transport market. What is worth noting is that prices increase for consumers in the smaller region for both domestic and imported goods. The opposite holds for consumers in the bigger region. This results in price indices diverging further:

$$\bar{p}^S_H(t_{FH}) < \bar{p}_H(t) \quad ; \quad \bar{p}^S_F(t_{HF}) > \bar{p}_F(t).$$

This effect reinforces the relation noted in Eq. (8) and yields

$$\bar{p}^S_H(t_{FH}) < \bar{p}_H(t) < \bar{p}_F(t) < \bar{p}^S_F(t_{HF}) \ .$$

Therefore, in the short run, segmentation is expected to increase the gap in prices between the two regions as compared to a unique tariff in the two directions. Interestingly, this result is reverted in the long run, due to the restraint in agglomeration due to asymmetric tariff, which keeps more firms in the peripheral region (for the same level of competition in the transport sector) and thus reduces the share of varieties in the periphery that have to incur transport costs to be consumed.

As for quantities, the impact of segmentation in the short run can be seen from equation Eq. (19), taking into account the effect on prices shown in Eq. (23):

$$q^S_{HH} < q_{HH} \quad ; \quad q^S_{FH} > q_{FH}$$

and

$$q^S_{FF} > q_{FF} \quad ; \quad q^S_{HF} < q_{HF}.$$

Hence, once carriers are allowed to segment the transport market, each variety produced by the firms located in region F would sell more than under symmetric tariffs in the short run, both in the local (because freight rates from the core are higher) and the export segments (because shipping goods from the periphery to the core is cheaper). The opposite is true of the firms located in H. Hence, compared to a unique-bilateral tariff, in the short run complete deregulation implies higher levels of production in F and higher employment in the manufacturing sector. In addition, given the higher level of domestic prices, complete deregulation engender higher profits in the short run to the firms located in F, as compared to a unique-bilateral tariff. This latter effect plays against agglomeration and yields the following result. This result holds only partly in the long run. After also relocation of firms is taken into account, indeed, simulations show that quantities on the inter-regional export segment are higher under asymmetric tariffs than under symmetric tariffs, but the opposite is true for the domestic segment in the periphery, whose sales are lower.

Agglomeration and Manufacturing Firms' Operating Profits

In terms of agglomeration, due to the analytical intractability resulting from the feedback loop of transport costs and agglomeration, the most suitable way to compare a unique-bilateral-tariff liberalization regime with complete deregulation is through simulations. Once carriers are allowed to price discriminate by the direction of shipment, equation Eq. (14) must be generalized to allow for the possibility of segmentation. The agglomeration patterns as a function of transport costs and structural parameters can thus be computed as

$$\lambda_i - \frac{1}{2} = \frac{2\beta(\alpha - c)}{\gamma N}\left(\frac{\theta_i t_{ji} - \theta_j t_{ij}}{\theta_i t_{ji}^2 + \theta_j t_{ij}^2}\right) + \frac{\beta}{\gamma N}\left(\frac{\theta_j t_{ij}^2 - \theta_i t_{ji}^2}{\theta_i t_{ji}^2 + \theta_j t_{ij}^2}\right), \tag{27}$$

where capital remuneration in the two regions is now expressed in terms of two different freight rates and the changes in profitability of firms in the two regions depend on structural parameters and levels of concentration of consumption, θ, in a highly non-linear way. It should be noted that replacing t_{ij} and t_{ij} with t, equation Eq. (27) turns into Eq. (14). Thus, intuitively, it can be argued that, since the only difference between Eq. (27) and Eq. (14) is transport segmentation and transport costs in the two directions follow the ranking shown in equation Eq. (23) for a given level of λ, then agglomeration should be restrained by the possibility of transport market segmentation. Simulations show that this intuition is correct, as shown in Figure 7, which should be compared to 6, where exactly the same structural parameters, levels of consumption concentration and number of carriers are used as inputs of the simulation, the only difference being the transport liberalization regime.

INSERT FIGURES 6 AND 7 HERE.

The simulation confirms the intuition that transport market segmentation, as opposed to a symmetric tariff, makes the core region less attractive for firms because it increases the costs of shipping their products to the periphery and, at the same time, makes it cheaper to produce goods in the periphery and ship them to the core. This result is robust to different structural parameters and number of competitors in the transport sector.

5.2.1 Global welfare comparisons

As in the case of symmetric tariffs, transport liberalization increases welfare under a complete deregulation regime because of the impact on prices in the two regions. In order to compare the two liberalization regimes in terms of welfare, a simulation has been performed, whose results are shown in Figure 8 for a given level of consumption concentration, θ. The simulation is based on equation Eq. (26), where y_i includes the profits redistributed from manufaturing firms and carriers (assuming they are evenly distributed across all the consumers in the economy). Welfare levels under a complete deregulation are plotted in black for the two regions and for the overall economy (weighing the welfare level of each region by its share of consumers); they are plotted in gray for the unique-bilateral-tariff regime.

INSERT FIGURE 8.

Complete liberalization is shown to yield higher levels of welfare in the two regions as compared to a liberalization regime imposing a unique tariff per route. A welfare analysis based on consumer surplus alone shows that the ranking of liberalization regimes is robust to changes in the structural parameters.[11]

[11] A caveat is due on the welfare impact of the extent of competition in the transport sector when also profit redistribution is taken into account. In fact, when the number of manufacturing firms increase as compared to the number of consumers (for example, by altering the fixed amount of capital needed to set up a firm, f) unreported simulations show that intermediate levels of competition in the transport sector may be welfare superior to high levels of competition. This result is driven by the income effect of higher levels of competition in the final goods sector (causing reduction in returns on capital in the economy) that generate welfare losses in the peripheral region only partly compensated by the gains from lower prices. At the limit, when there are as many firms as consumers ($f = 1$), any reduction in transport costs decreases welfare instead of increasing it. However, when the analysis of welfare is restricted to consumer surplus because income effects are not easily captured in a standard quadratic utility setting and cannot properly take into account of general equilibrium feedback effects.

There is an important implication stemming from the welfare comparison of transport liberalization regimes. Since asymmetric tariffs are shown to be welfare superior to symmetric tariffs, any policy aimed at reducing transport costs should keep in mind that a decentralized market-driven reduction in transport costs (which can be obtained by regulating only the number of entrants in the market) is to be preferred to an exogenous reduction in transport costs, as can be obtained for example by keeping the transport sector highly regulated and decreasing the tariffs. In order to be optimal, a reduction in transport costs that does not result from a complete liberalization should indeed apply different prices in the two directions of the same route depending on the elasticities of inter-regional export demand to transport costs, but that means that the regulated sector should mimic the decentralized market behavior. So it may be arguably more efficient to allow carriers to set the prices maximizing their profits per segment of shipment, subject to an entry fee. This solution ensures that, while in equilibrium the carriers' profits are redistributed to the public, their pricing strategies result in direction-specific freight rates that increase welfare and restrain agglomeration in the core region.

One final remark on the impact of agglomeration on total welfare of the economy is due. As often discussed in NEG models, agglomeration may be inefficient in terms of welfare and turn static welfare gains into dynamic welfare losses. In the particular framework studied in this paper, this has been shown not to be the case, even if the negative impact of agglomeration on welfare is confirmed. In Figure 9 is shown how the exogenous distribution of consumption affects the level of welfare that can be attained in the two regions. On the left pane is shown the case of a monopolist carrier and on the right pane a more competitive transport sector. On the one hand, it can be noticed that when carriers can segment the transport sector (black lines) the overall negative impact of consumption concentration on welfare is the result of an improvement in the core region more than compensated by a loss in the periphery, even if the weight of the welfare level in the core increases with θ. On the other hand, when a symmetric tariff is imposed (gray lines), high levels of concentration in consumption cause losses in both the core and the periphery, which signals a very inefficient level of agglomeration.

INSERT FIGURE 9.

6 Concluding remarks

In this paper, a New Economic Geography model has been presented where the only source of heterogeneity across varieties is the location of producers and consumers. Goods produced in one region and shipped to another have to incur transport costs, which are first assumed exogenous and treated as a parameter and then endogenized and obtained as the market outcome of a decentralized transport sector. Through the endogenization of freight rates in the model, it has been possible to study the welfare impacts of different transport liberalization regimes and the corresponding location patterns of the economic activity. Two liberalization policies have been analyzed, the first one imposing symmetric tariffs the two directions of a route, the second one leaving carriers free to price discriminate. Notably, the former type of liberalization is equivalent to an exogenous reduction in transport costs, whereas the latter describes a competitive behavior, under given market conditions.

The model shows that transport liberalization is indeed expected to yield static and dynamic welfare gains for consumers of the entire economy under rather general conditions, with complete deregulation being superior to a symmetric reduction in transport costs in terms of both welfare and geographical dispersion of economic activities. The result is not trivial because, whereas gains are clear in the short run due to cheaper inter-regional connections inducing tougher competition in the manufacturing sector, in the long run the relocation of economic activities due to the liberalization may be inefficient in terms of welfare, making the overall impact in the two regions' welfare not a priori clear. In fact, in the long run the concentration of economic activities in the larger region compounds welfare gains in the core and partially offsets them in the periphery. However, also the peripheral region has been shown to experience net welfare gains in the long run.

Finally, two remarks in terms of policy relevance are in order. First of all, in the present model only interactions between manufacturing and transport sectors have been analyzed, thus nothing can be easily inferred about transport liberalization processes affecting commuters or travelers. Second, the implicit simplifying assumption on which this work has relied is that the most direct effect of liberalizations is to reduce prices. This is not always true, but this does not invalidate the underlying analysis, which can be extended to different types of shocks affecting trade costs. The framework presented here can indeed be applied to other sources of change in trade costs, such as the efficiency gains in transport derived from technological improvement or, conversely, the inefficiencies generated by higher marginal costs of delivery (for example, trade tariffs, port fees, fuel price and so on). Of course, when extending this framework to other contexts it should be verified that the main modeling assumptions be relevant, such as the oligopolistic market structure or the possibility of committing capacity (or setting prices) in specific directions of shipment. When these assumptions do not hold, the results presented here on welfare in the long run may not hold anymore, as shown for example by Behrens and Picard (2011), who stress the back-haul problem faced by carriers by modeling an equal level of capacity in the two directions of a given trade route and analyze the market and agglomeration outcomes in such a perfectly competitive setting.

In this paper, a purely theoretical model has been presented. A natural next step is to test empirically some of the implications of the model, especially the ones concerning the determination of the freight rate in the transport sector. In addition, the model has been developed in a two-country setting, excluding labor mobility and vertical linkages. In can be possible to extend the model to introduce these features but the resulting complexity would harm the analytical tractability of the model.

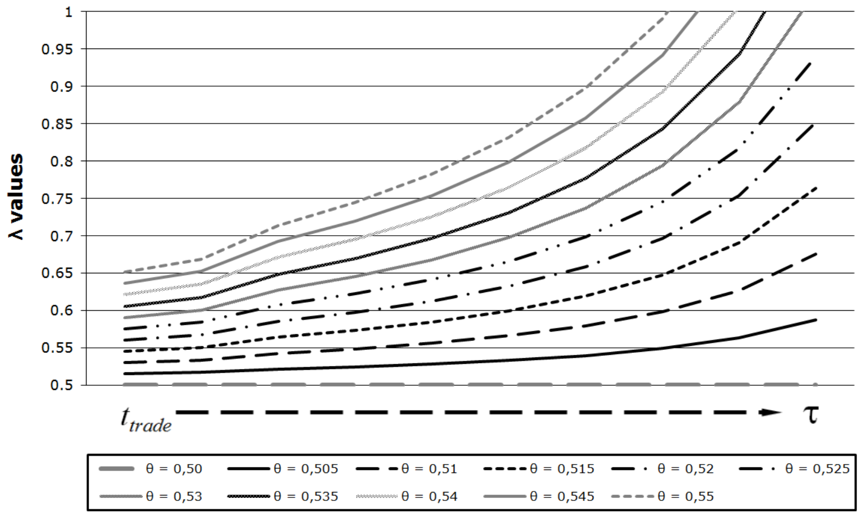

Figure 1: Simulation of changes in the agglomeration of industrial activities, λ_H, as a function of transport costs (ranging from t_{trade} to τ) and agglomeration of consumption, θ_H. The values of the structural parameters used in this simulation are the following: $\alpha = 10$; $\beta = 6.2$; $\gamma = 1.2$; $c = 1$; $\tau = 1$; $M = 100$; $K = 100$; $f = 10$.

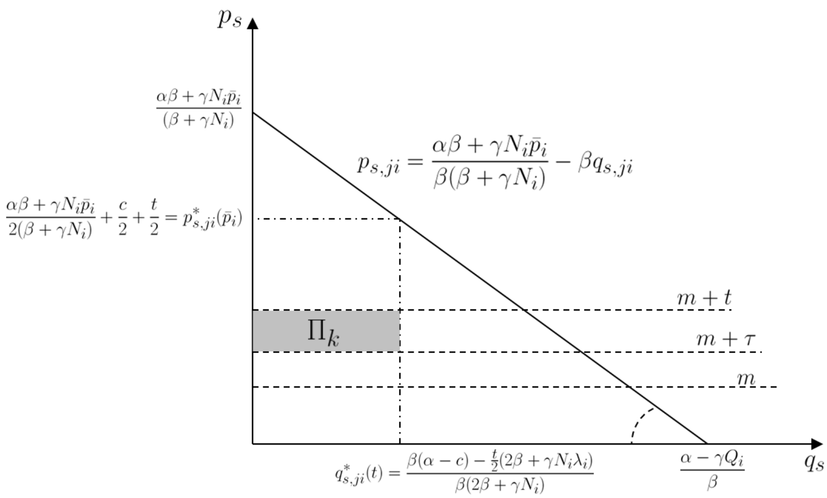

Figure 2: Visual illustration of how final good's demand structure affects the carriers' problem.

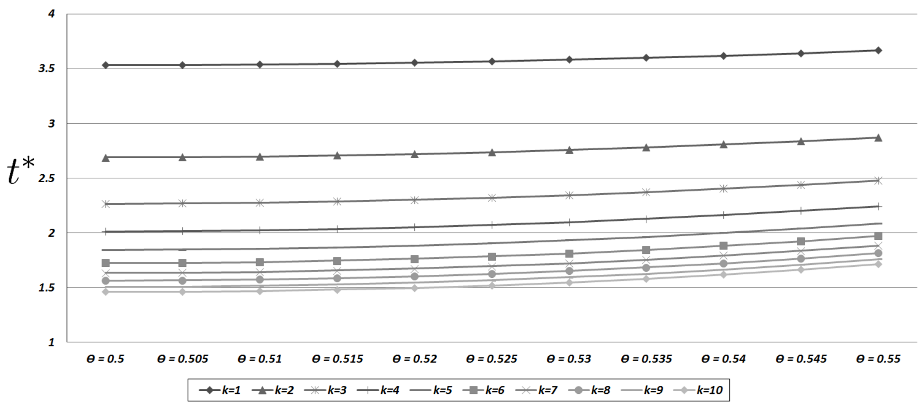

Figure 3: Simulation of equilibrium freight rates in the long run as a function of agglomeration of consumption, θ_H and competition in the transport sector (ranging from $k = 1$ to $k = 10$) when tariffs are symmetric. The values of the structural parameters used in this simulation are the following: $\alpha = 10$; $\beta = 6.2$; $\gamma = 1.2$; $c = 1$; $\tau = 1$; $M = 100$; $K = 100$; $f = 10$.

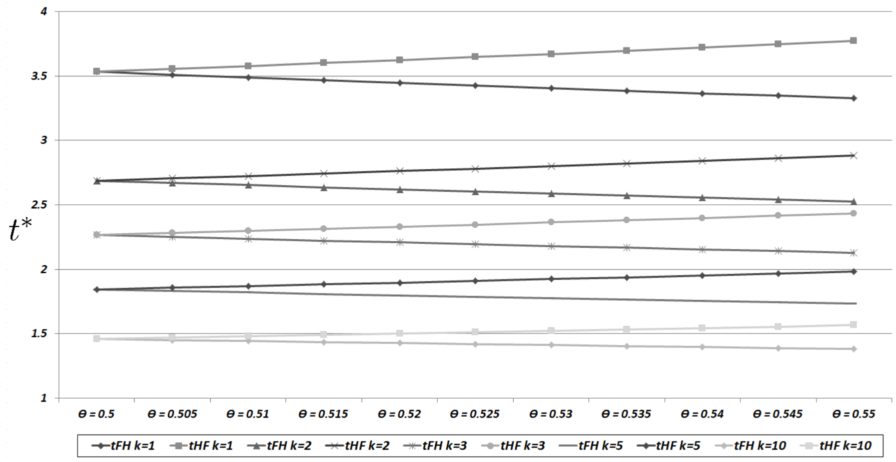

Figure 4: Simulation of equilibrium freight rates in the long run as a function of agglomeration of consumption, θ_H and competition in the transport sector (ranging from $k = 1$ to $k = 10$) when tariffs are asymmetric. The values of the structural parameters used in this simulation are the following: $\alpha = 10$; $\beta = 6.2$; $\gamma = 1.2$; $c = 1$; $\tau = 1$; $M = 100$; $K = 100$; $f = 10$.

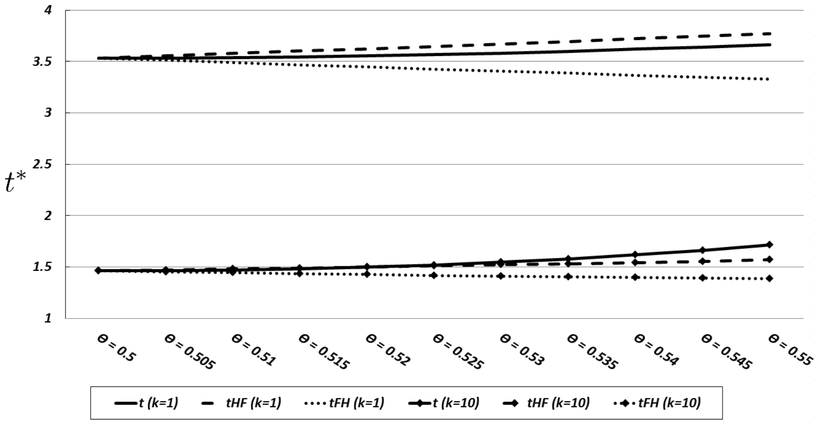

Figure 5: Equilibrium freight rates in the long run, as a function of agglomeration of consumption, θ and the number of carriers ($k = 1$ and $k = 10$). The values of the structural parameters used in this simulation are the following: $\alpha = 10$; $\beta = 6.2$; $\gamma = 1.2$; $c = 1$; $\tau = 1$; $M = 100$; $K = 100$; $f = 10$.

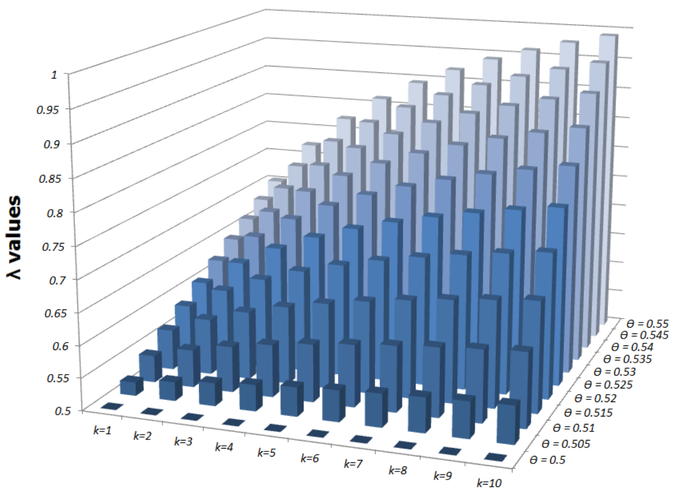

Figure 6: Simulation of agglomeration of industrial activities, λ_H, as a function of agglomeration of consumption, θ_H and competition in the transport sector (ranging from $k = 1$ to $k = 10$) when tariffs are symmetric. The values of the structural parameters used in this simulation are the following: $\alpha = 10$; $\beta = 6.2$; $\gamma = 1.2$; $c = 1$; $\tau = 1$; $M = 100$; $K = 100$; $f = 10$.

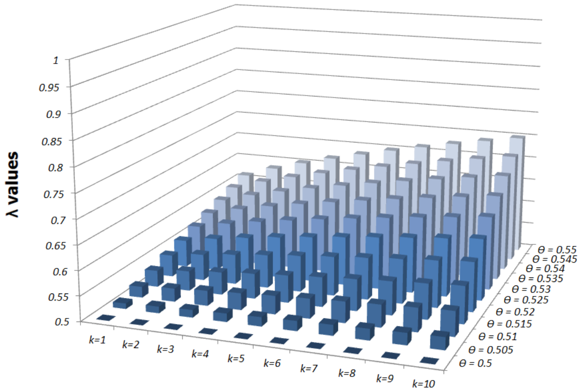

Figure 7: Simulation of agglomeration of industrial activities, λ_H, as a function of agglomeration of consumption, θ_H and competition in the transport sector (ranging from $k = 1$ to $k = 10$) when tariffs are asymmetric. The values of the structural parameters used in this simulation are the following: $\alpha = 10$; $\beta = 6.2$; $\gamma = 1.2$; $c = 1$; $\tau = 1$; $M = 100$; $K = 100$; $f = 10$.

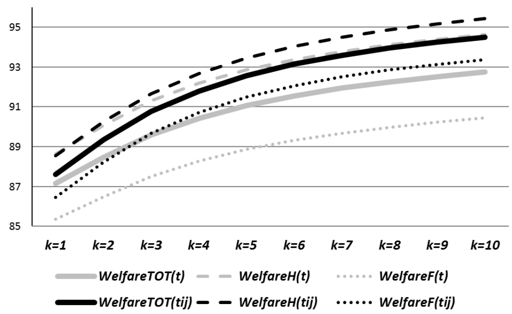

Figure 8: Simulation level of welfare in the two regions, and in the entire economy, as a function of the level of competition in the transport sector (ranging from $k = 1$ to $k = 10$) and liberalization regime. The values of the structural parameters used in this simulation are the following: $\alpha = 10$; $\beta = 6.2$; $\gamma = 1.2$; $c = 1$; $\tau = 1$; $M = 100$; $K = 100$; $f = 10$; $\theta = 0.55$.

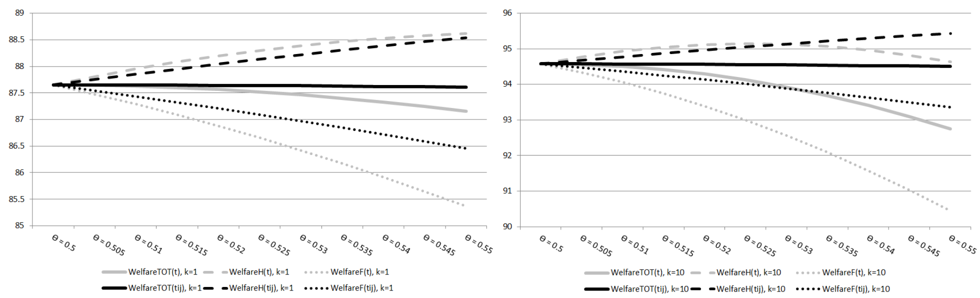

Figure 9: Simulation level of welfare in the two regions, and in the entire economy, as a function of concentration of consumption and liberalization regime. On the left pane with a monopolist carrier, $k = 1$, and on the right pane with $k = 10$. The values of the structural parameters used in this simulation are the following: $\alpha = 10$; $\beta = 6.2$; $\gamma = 1.2$; $c = 1$; $\tau = 1$; $M = 100$; $K = 100$; $f = 10$.

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