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## ABSTRACT

### Is the Regulation of the Transport Sector Always Detrimental to Consumers?\*

The aim of this paper is to qualify the claim that regulating a competitive transport sector is always detrimental to consumers. We show indeed that, although transport deregulation is beneficial to consumers as long as the location of economic activity is fixed, this is no longer true when, in the long run, firms and workers are freely mobile. The reason is that the static gains due to less monopoly power in the transport sector may well map into dynamic dead-weight losses because deregulation of the transport sector leads to more inefficient agglomeration. This latter change may, quite surprisingly, increase consumer prices in some regions, despite a more competitive transport sector. Transport deregulation is shown to map into aggregate consumer welfare losses and more inequality among consumers in the long run.

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# 1 Introduction

In most countries, the transport sector was replete (and still is) with allocative distortions of various types. Transport deregulation is expected to promote a better allocation of resources through fiercer competition between carriers and, therefore, lower freight rates and consumer prices. This is why, in the wake of the Motor Carrier Act and the Stagger Act of 1980, the trucking and the rail industries have been deregulated in the US to promote a more flexible and competitive environment (see Winston, 1993, for an overview). As pointed out by Boylaud and Nicoletti (2001), this has been, in recent years, a general tendency among OECD countries where greater competition between road haulers has been promoted. More competition in the transport sector is also an objective ranking high on the European Union's (henceforth, EU) agenda, especially for the rail freight industry (European Commission, 2001).

Because deregulation is widely met with public scepticism in the EU, a thorough assessment of the possible welfare and distributional impacts of such policies is important. Yet, it is well known that for such an assessment to be halfway accurate, it should take into account most of the indirect effects that regulation might have:

“The central methodological lesson from assessments appears to be that their accuracy is highly dependent on their completeness. That is, a good assessment must take into account all variables that have been influenced by deregulation.” (Winston, 1993, p.1283)

While several studies take into account the effects deregulation may have on market structure, firms' structure, technological change, and organization, it is surprising that, to the best of our knowledge, no study has investigated the efficiency of transport deregulation by taking into account its *spatial impacts*, at least at the interregional level. While such a neglect may not be a serious issue in, for example, the banking and financial sector or the distribution of electricity and gas, it is unlikely to be so in the transport sector. The reason is that transport costs are key determinants of the spatial organization of the economy as manufacturing firms' locational decisions are based on the accessibility to output and input markets (Beckmann and Thisse, 1986; Fujita *et al.*, 1999). This observation has a major implication that has been very much overlooked in the literature until now: *transport pricing and regulatory reforms in the transport sector affect not just consumer prices and the volume of commodity flows across regions, but also the location*

of industry.<sup>1</sup> Since the location of economic activity has important distributional and overall welfare implications (Ottaviano and Thisse, 2002; Charlot *et al.*, 2006), analyses of the potential benefits of transport deregulation that hold the spatial distribution of activity fixed may be misleading. This is even more so for integrating blocks that have committed themselves to a regional cohesion objective, as is the case of the EU under the Amsterdam Treaty of 1997.

The purpose of this paper is to study how the deregulation of the transport sector affects social welfare once it is recognized that firms and mobile agents are free to relocate in the long-run in response to permanent changes in freight rates and consumer prices. Our key result is to show that *there is a trade-off between short run benefits and long run losses*: in the short run, transport deregulation reduces static dead-weight losses arising from market power in both the transport and the manufacturing sector; but, in the long run, it generates dead-weight losses because of a sub-optimal redistribution of industrial activity across regions. In order to investigate in depth these short and long-run consequences of transport deregulation in a spatial economy, we must identify, on the one hand, the microeconomic underpinnings of the pricing of transport services and, on the other hand, the manufacturing firms' reactions to the strategies selected by the carriers. This will be done within a modeling framework combining: (i) an imperfectly competitive transport sector in which freight rates are determined through strategic interactions between carriers, and (ii) a model of location and trade that allows for a detailed description of the pricing and locational choices made by the manufacturing firms in response to carriers' pricing policies. By focussing on the interaction between the transport and the manufacturing sectors, we provide a new and richer description of the corresponding market structure: *the demand for transport services depends on the spatial distribution of the manufacturing sector, which itself varies with the degree of competition between carriers through the level of freight rates*. Such a nested market structure may then be used to study how deregulating the transport sector affects the well-being of economic agents, especially consumers and carriers. It is worth emphasizing that our approach has a broader scope than standard cost-benefit analyses used in transport economics in that

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<sup>1</sup>Even though freight rates have dramatically declined since the Industrial Revolution, they still represent a significant fraction of the costs that firms must bear when shipping goods across regions or countries (Anderson and van Wincoop, 2004; Combes and Lafourcade, 2005). This is why we may safely conclude that the geographical organization of the economy remains, to a large extent, shaped by the transport sector and by infrastructure, especially at the subnational level. Teixeira (2006) has, for example, shown by means of a structural econometric approach that better transport infrastructure in Portugal has indeed resulted in more spatial inequality across regions.

we consider *the impact of transport deregulation not only upon commodity flows but upon wage rates as well*. This point is important because deregulation and antitrust policies tend to focus on consumers' surplus gains, neglecting too often possible losses on labor markets.

Our first result is in line with standard analysis. We show that, even though wages fall, consumers always benefit from deregulation as long as the location of economic activity remains unchanged. The reason is that deregulation reduces freight rates and maps into lower consumer prices. This finding agrees with Morrison and Winston (1999) for whom a conservative estimate of the annual benefit that American consumers have reaped from intercity transport deregulation amounts approximately to \$50 billion. Our remaining results reveal some unsuspected long-run implications of deregulation. Interestingly, they are all related to the spatial organization of the economy. First, we show that the demand for transport services depends on the spatial distribution of the manufacturing sector. Quite surprisingly, *this demand becomes less elastic as the degree of spatial agglomeration rises*, which increases carriers' market power and allows them to charge higher markups. Given constant marginal cost in the transport sector, freight rates unambiguously rise with the degree of spatial concentration of production.<sup>2</sup> Second, and as a direct consequence of the previous result, we show that the economy becomes gradually more agglomerated as the number of carriers increases, as the marginal cost in the transport sector falls, or both. The reason is that market power in the transport sector implies that more agglomeration raises shipping costs for manufactured goods, thereby reducing the agglomeration forces. In other words, *the agglomeration process is self-defeating*. This trade-off between a better allocation of resources in the short run and a growing agglomeration of the manufacturing sector in the long run suggests a role for regulators that has not been often considered so far. Last, we show that the welfare impacts of transport deregulation are opposite, both with respect to consumers' welfare and carriers' aggregate profits. Indeed, once the dependency of the spatial distribution on the competitive environment in the transport sector is taken into account, deregulation leads to (i) aggregate consumer welfare losses<sup>3</sup>

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<sup>2</sup>There is some evidence that the spatial structure of freight rates has been affected by deregulation. For example, Blair *et al.* (1986) show that trucking rates fell more in large markets than in small markets in the wake of complete trucking deregulation in Florida. Levin (1981) and Winston (1993) argue that deregulation led to a reshuffling in prices affecting various consumer groups and markets differently, especially in the presence of initial cross-subsidization.

<sup>3</sup>There is no clear evidence from rigorous econometric studies that deregulation has induced lower freight rates. On the one hand, Rose (1985) concludes that US trucking deregulation has eliminated a fraction of rents earned by carriers under regulation. Blair *et al.* (1986) estimate that the deregulation of

but (ii) higher aggregate profits in the transport sector.<sup>4</sup> Hence, we uncover a new and important trade-off for policy makers and antitrust authorities: *if, in the short run, deregulating the transport sector is beneficial to consumers, the reverse holds true in the long run.*<sup>5</sup> Although our approach differs from Baumol and Willig (1998), we may also conclude that there is a need for defensive regulatory rules in transport markets.

Before proceeding, a final comment is in order. Ever since the pioneering work of Lipsey and Lancaster (1956), we know that when at least one optimality condition is not satisfied, for whatever reason, the other optimality conditions no longer hold. Consequently, implementing a first-best policy on one market may not be socially desirable when the other markets are not competitive. Yet, it is not easy to cook up examples in which a move toward the competitive solution makes the whole economy worse off. Our analysis offers such an example in the sense that a more competitive transport sector appears to be detrimental to consumers in the long run.

The remainder of the paper is organized as follows. In Section 2, we present the model as well as some preliminary results. The market outcome for the transport sector is analyzed in Section 3. In Section 4, we show how the degree of competition in the transport sector affects the location of the manufacturing sector and the volume of trade. Section 5 provides a welfare analysis of the transport deregulation, whereas Section 6 concludes.

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intrastate trucking in Florida has led to an average reduction of 14.62% in carriers' rates. On the other hand, using simulations, Levin (1981) has shown that, for most plausible scenarios, average rail rates would increase under deregulation. Boyer (1987) found that the most likely effect of deregulation has been to increase rail rates by about 2%, while McFarland (1989) suggests that deregulation had no effect on railroad rates. We are not aware of studies estimating the impact of deregulation on consumer prices.

<sup>4</sup>Winston (1993) also provides evidence that suggests that railroad carriers may have actually gained from deregulation. Indeed, deregulation "has also produced some unexpected price differences [...]. In particular, the concentration of airline competition at hub airports and of interexchange telecommunications competition for big users, and the greater freedom of railroads to charge bulk commodity shippers what the traffic will bear has increased genuine price discrimination" (Winston, 1993, p.1276).

<sup>5</sup>This result bears some resemblance with what Norman and Thisse (2000) observe in a very different context: policies that create too though a competitive environment may eventually end up being detrimental to consumers. It should also be noted that Hurley (1994) has shown that forcing a carrier to price a captive shipper at marginal cost would not enhance efficiency when shippers and carriers are in a vertical relationship.



## 2 The model

It should be clear from the foregoing that we need a setting in which the impact of freight rates on the location of economic activity may be analyzed. This is precisely what economic geography aims at achieving (Fujita *et al.*, 1999; Ottaviano and Thisse, 2004). Ever since the pioneering contribution of Krugman (1991), the typical thought experiment of economic geography is to figure out how changing transport costs affects the location of firms and workers. It seems, therefore, natural to include an economic geography model within our framework. Specifically, we will use the linear model proposed by Ottaviano *et al.* (2002) because it captures directly the impact that the level of freight rates has on manufacturing firms' pricing strategies. It is also analytically solvable, which makes it especially well suited as a building-block of a broader model such as ours.

The economy consists of two regions, labeled  $r$  or  $s = H, F$ . Variables associated with each region will be subscripted accordingly. There are two production factors, skilled and unskilled labor. We denote by  $L$  the total mass of skilled and by  $A$  the total mass of unskilled workers in the economy. Each individual works and consumes in the region she lives in. While the unskilled are immobile and their interregional distribution is exogenously given, skilled workers are mobile and their spatial distribution is endogenously determined. In order to control for any exogenous size advantage, we assume that the unskilled are evenly spread across the two regions, each of which hosts a mass  $A/2$  of them. Let  $0 \leq \lambda \leq 1$  stand for the share of skilled workers living in region  $H$ . Without loss of generality, we may then restrict ourselves to the domain  $\lambda \geq 1/2$ , i.e., agglomeration takes place in region  $H$ .

In order to disentangle the various effects at work, it is both relevant and convenient to distinguish between what we call a *short-run equilibrium*, in which skilled workers are supposed to be immobile, i.e.  $\lambda$  is exogenous; and a *long-run equilibrium* when they are mobile, i.e.  $\lambda$  is endogenous.

### 2.1 Preferences

All workers have the same quasi-linear utility with respect to a homogeneous good and a continuum of horizontally differentiated varieties of mass  $n \equiv n_H + n_F$ . For reasons that will be made clear below, the homogeneous good is chosen as the numéraire. The utility is quasi-linear and the subutility over the varieties is quadratic. All workers are endowed with one unit of their labor type (skilled or unskilled) and  $\bar{q}_0 > 0$  units of the

numéraire. The initial endowment  $\bar{q}_0$  is supposed to be large enough for the consumption of the numéraire to be strictly positive at the market outcome, which eliminates the income effects in our quasi-linear setting. A consumer residing in region  $r$  then solves the following problem:

$$\begin{aligned} \max_{q_{ir}(v)} \quad U = & \sum_{i=r,s} \left[ \alpha \int_0^{n_i} q_{ir}(v) dv - \frac{\beta - \gamma}{2} \int_0^{n_i} [q_{ir}(v)]^2 dv \right] - \frac{\gamma}{2} \left[ \sum_{i=r,s} \int_0^{n_i} q_{ir}(v) dv \right]^2 + q_0 \\ \text{s.t.} \quad & \sum_{i=r,s} \int_0^{n_i} p_{ir}(v) q_{ir}(v) dv + q_0 = y_r + \bar{q}_0 \end{aligned}$$

where  $\alpha > 0$ ,  $\beta > \gamma > 0$  are parameters (the condition  $\beta > \gamma$  implies that consumers have a preference for variety);  $q_{ir}(v)$  and  $p_{ir}(v)$  are the quantity and the consumer price of variety  $v$  in region  $r$  when it is produced in region  $i$ ; and  $y_r$  is the resident's income, which depends on her skilled or unskilled status.

Solving the consumption problem yields the following demand functions:

$$q_{sr}(v) = a - (b + cn)p_{sr}(v) + cP_r \quad s, r = H, F \quad (1)$$

where  $a \equiv \alpha b$ ,  $b \equiv 1/[\beta + (n-1)\gamma]$  and  $c \equiv \gamma b/(\beta - \gamma)$  are positive bundles of parameters, and where

$$P_r \equiv \int_0^{n_r} p_{rr}(v) dv + \int_0^{n_s} p_{sr}(v) dv \quad (2)$$

is the price index (i.e., the average price) of all varieties sold in region  $r = H, F$ .

## 2.2 The consumption goods sectors

There are two sectors producing consumption goods. The *traditional sector* supplies the homogeneous good under perfect competition using unskilled labor as the only input of a constant-returns technology. The unit input requirement is set to one by choice of units. In the *manufacturing sector*, monopolistically competitive firms offer a continuum of varieties of a horizontally differentiated good employing both factors under increasing returns to scale. Specifically, we assume that firms face a fixed requirement of  $\phi > 0$  units of skilled labor, whereas their marginal unskilled labor requirement is constant and set equal to zero without loss of generality.<sup>6</sup> Given the foregoing assumptions, skilled labor market clearing in each region implies:

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

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<sup>6</sup>When the marginal requirement  $m$  is strictly positive, what follows continues to hold true provided that  $\alpha$  is replaced by  $\alpha - m$  in the demand functions (Ottaviano *et al.*, 2002).

Shipping the homogeneous good is assumed to be costless, thus implying that its price is equalized across regions. This explains why that good is the natural choice for the numéraire. Consequently, in equilibrium the unskilled wage is equal to one in each region. By contrast, shipping the differentiated varieties is costly. Specifically, firms have to pay a *freight rate* of  $t > 0$  units of the numéraire per unit of any variety transported between the two regions. Because there is a continuum of firms, each one is negligible to the economy. It may thus accurately treat  $t$  as a parameter. Note, however, that *this rate will be endogenously determined in a game involving imperfectly competitive carriers*, whereas it is considered as exogenous in standard economic geography and location models. Furthermore, the existence of transport costs in the manufacturing sector implies that trade no longer leads to the equalization of skilled wages between regions; they are also endogenous in our setting.

We also assume that product markets are *segmented* and that labor markets are *local*. The first assumption means that each firm is free to price discriminate and to set a price specific to the region in which it sells its output (Engel and Rogers, 1996; Wolf, 2000; Haskel and Wolf, 2001). The second assumption means that no interregional commuting takes place so that workers are employed only in their region of residence. For skilled workers this implies that their wages may differ across regions; we denote by  $w_r$  the skilled wage rate prevailing in region  $r$ . As markets are segmented, a firm located in region  $r$  maximizes profits given by:

$$\Pi_r = p_{rr}q_{rr} \left( \frac{A}{2} + \phi n_r \right) + (p_{rs} - t)q_{rs} \left( \frac{A}{2} + \phi n_s \right) - \phi w_r$$

where  $p_{rs}$  is the producer price of a variety produced in region  $r$  and sold in  $s \neq r$ . Because skilled workers are geographically mobile, aggregate regional incomes depend on their spatial distribution. Throughout the paper, we focus on the meaningful case in which the freight rate  $t$  is sufficiently low for interregional trade to be bilateral, regardless of the firm distribution  $\lambda$ .

### 2.3 The transport sector

There are  $m$  carriers that supply non-cooperatively a homogeneous transport service. They all have access to the same constant returns technology, which requires only unskilled labor as input. In other words, the unskilled can work either in the traditional sector or in the transport sector, and their wage is equal to one in each sector. Shipping one unit of the differentiated product between  $H$  and  $F$  requires  $\tau > 0$  units of unskilled labor,

thus implying that  $\tau$  is also the marginal production cost of a carrier with respect to the volume of hauling. The transport sector being a priori competitive, deregulation should be especially efficient because of the well-known ‘inefficiencies of regulating a competitive industry’.<sup>7</sup> Finally, we assume that the number  $m$  of carriers prior to deregulation is small due to entry regulations.<sup>8</sup>

Let  $q_k$  stand for the supply of transport service by carrier  $k = 1, 2, \dots, m$ . The profit of carrier  $k$  is then given by

$$\Pi_k^T = (t - \tau)q_k. \quad (3)$$

### 3 Prices, wages, and freight rates

Formally, the short-run equilibrium is described by a sequential game, the carriers being the leaders and the manufacturing firms the followers. Such a division of roles reflects the structuring power that the transport sector has on the spatial distribution of the manufacturing sector. In the first stage, carriers choose the quantities of transport service they supply, whereas manufacturing firms choose their prices in the second stage of the game, taking the freight rate as given. In other words, when choosing how much service to supply, carriers anticipate the consequences of their strategies on the volume of trade between the two regions. However, carriers do not account for the impact that they have on the spatial distribution of the manufacturing sector. Handling such an effect is formally involved and not necessarily empirically meaningful. Indeed, if firms are likely to be able to anticipate what happens in their own market, they probably do not realize that changing their freight rates may have an influence on the spatial structure of the economy or, if they do, they do not have the ability to tackle that problem.

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<sup>7</sup>Yet, deregulation *per se* is not necessarily beneficial in industries that involves a small number of producers (see, e.g., Levin, 1981, who argues that deregulation in rail transportation may not be beneficial). The reason is that market power may be large enough to trigger structural changes, which generates pure profits, high prices, and static dead-weight losses after deregulation.

<sup>8</sup>This assumption describes fairly well the trucking industry before deregulation, in which scale economies appear to be relatively small (Ying, 1990). For example, Blair *et al.* (1986, p.160) summarize the regulations in Florida’s trucking industry prior to deregulation as follows: “First, prices (or price schedules) were determined by the intrastate bureaus with review and approval of the resulting rate submissions by the Public Service Commission. Second, entry into the regulated sector of the trucking industry was strictly controlled by the Public Service Commission. Third, various operating restrictions were imposed that limited geographic areas served, backhauls, types of vehicles used, types of commodities carried, and so on. Finally, the common carrier obligation required a trucker to provide service to all customers willing to pay the approved rate even if this required serving unprofitable small markets.”

### 3.1 Prices and wages

For any given value of  $t$ , the first-order conditions for manufacturing firms yield the following profit-maximizing prices:

(i) intraregional prices:

$$p_{rr}(P_r) = \frac{a + cP_r}{2(b + cn)} \quad (4)$$

(ii) interregional prices:

$$p_{sr}(P_r) = p_{rr}(P_r) + \frac{t}{2} \quad s \neq r. \quad (5)$$

Expressions (4)–(5) show that the price a firm sets in region  $r$  depends on the price index  $P_r$  of this region, which depends itself on the prices set by all other firms. Because each firm is negligible to the market, it chooses its optimal price by taking aggregate market conditions and wages as given. At the same time, aggregate market conditions must be consistent with firms' optimal pricing decisions. Hence, the (Nash) equilibrium price index  $P_r^*$  must satisfy the following fixed point condition:

$$P_r^* = n_r p_{rr}(P_r^*) + n_s p_{sr}(P_r^*). \quad (6)$$

Under the assumption of bilateral trade between regions, the equilibrium price indices can be found by solving (6) for  $P_r^*$  and using expressions (4)–(5). This yields:

$$p_{rr}^* = \frac{2a + ct n_s}{2(2b + cn)} \quad \text{and} \quad p_{sr}^* = p_{rr}^* + \frac{t}{2}. \quad (7)$$

Substituting the equilibrium prices (4) and the price index (2) into the demands (1), the equilibrium consumption levels can be expressed as follows:

(i) intraregional demands:

$$q_{rr}^* = a - b p_{rr}^* + c n_s \frac{t}{2} = (b + cn) p_{rr}^* \quad (8)$$

(ii) interregional demands:

$$q_{sr}^* = q_{rr}^* - \frac{(b + cn)t}{2} = (b + cn)(p_{sr}^* - t). \quad (9)$$

Thus, a higher freight rate raises the demand for each local variety at the expense of imported varieties. In other words, carriers' pricing decisions have a direct impact on trade patterns, yet this substitution effect decreases when varieties becomes more differentiated (i.e., when  $c$  decreases).

We are now equipped to determine the conditions on  $t$  for trade to occur between the two regions at the equilibrium prices ( $q_{sr}^* > 0$  or, equivalently,  $p_{sr}^* > t$ ). It can be readily verified that

$$t \leq \min \left\{ \frac{2a}{2b + cn_r}, \frac{2a}{2b + cn_s} \right\}$$

must hold for both interregional demands to be positive. Because equilibrium prices depend on the firm distribution, the occurrence of interregional trade also depends on the spatial distribution of the industry. The most stringent condition on  $t$  is obtained when  $\lambda = 1$ , since when all firms are agglomerated the larger market is more competitive and, therefore, harder to penetrate from the outside. This then yields the condition

$$t < t_{trade} \equiv \frac{2a}{2b + cn} \quad (C1)$$

which we assume to hold throughout the paper.<sup>9</sup>

Turning to the labor market, the equilibrium wages of the skilled are such that all operating profits are absorbed by the wage bill, i.e.  $\Pi_r(w_r^*) = 0$ . Stated differently, firms bid up wages for workers until no firm can profitably enter in or exit from the market. Substituting the equilibrium prices, as well as the equilibrium quantities (8)–(9) into the profits, and solving for the wages gives

$$w_r^* = \frac{b + cn}{\phi} \left[ \left( \frac{A}{2} + \phi n_r \right) (p_{rr}^*)^2 + \left( \frac{A}{2} + \phi n_s \right) \left( p_{ss}^* - \frac{t}{2} \right)^2 \right]. \quad (10)$$

### 3.2 Freight rates

The demand for transport services is given by the aggregate volume of trade between the two regions evaluated at the equilibrium prices (7).<sup>10</sup> Some straightforward calculations show that the total volume of trade is as follows:

$$\begin{aligned} Q(\lambda, t) &= n_H \left( \frac{A}{2} + n_F \phi \right) q_{HF}^* + n_F \left( \frac{A}{2} + n_H \phi \right) q_{FH}^* \\ &= \rho_0 + \rho_2 \lambda (1 - \lambda) \eta - [\rho_1 + \rho_2 \lambda (1 - \lambda)] t. \end{aligned} \quad (11)$$

The price-elasticity of transport demand is then given by

$$\varepsilon(\lambda, t) \equiv - \frac{\partial Q}{\partial t} \frac{t}{Q} = \frac{[\rho_1 + \rho_2 \lambda (1 - \lambda)] t}{\rho_0 - \rho_1 t + \rho_2 \lambda (1 - \lambda) (\eta - t)} \quad (12)$$

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<sup>9</sup>To improve readability, we single out some conditions involving structural parameters by indexing the equation numbers with ‘C’.

<sup>10</sup>In the literature on general equilibrium with oligopolistic competition (Bonanno, 1990), this means that we consider a Cournot-Chamberlin equilibrium instead of the standard Cournot-Walras equilibrium in which the outcome of the second stage is described by a Walrasian equilibrium. When locations are exogenous, the function  $Q$  is then the so-called ‘objective’ demand of the carriers.

where  $\rho_0, \rho_1, \rho_2$  and  $\eta$  are strictly positive bundles of parameters defined in Appendix A.1. and satisfying the inequality

$$\rho_0 - \eta\rho_1 > 0.$$

Hence, for a given firm distribution, the demand for transport services is a linear and downward sloping function of the freight rate. A sufficient condition for  $Q > 0$  for all  $\lambda$  is that all interregional demands are positive, which holds true as long as (C1) is satisfied. Note furthermore that  $\eta < t_{trade}$  when  $A > L$ .<sup>11</sup>

**Insert Figure 1 about here**

It is worth noting that both the intercept and the absolute value of the slope decrease with  $\lambda$  over the interval  $[1/2, 1]$  (see Figure 1). Put differently, the transport demand varies in complex ways with the spatial distribution of firms. In particular,  $Q$  is *not* monotone in the degree of spatial concentration. Indeed, for a given value of  $t$ , it increases in  $\lambda$  when  $t > \eta$  and decreases otherwise. This is because two opposite effects are at work. First, when region  $H$  hosts an increasing share of firms and skilled workers, the quantities imported of each variety produced in the other region ( $q_{FH}^*$ ) and the number of imported varieties ( $n_F$ ) both shrink, which tends to reduce the volume of trade. Second, more agglomeration in region  $H$  increases the quantities exported of each variety produced in region  $H$  ( $q_{HF}^*$ ) as well as the number of exported varieties ( $n_H$ ), which tends to increase trade.

Yet, the transport demand function displays an important property with respect to  $\lambda$ . Using (12) and (C2), it is readily verified that

$$\frac{\partial \varepsilon(\lambda, t)}{\partial \lambda} = \frac{-(2\lambda - 1)(\rho_0 - \eta\rho_1)t\rho_2}{Q^2} < 0 \quad (13)$$

which implies that *the price-elasticity  $\varepsilon$  of transport demand falls as the degree of spatial concentration of the manufacturing sector rises*. This turns out to be the unambiguous outcome of two opposite effects. On the one hand, more agglomeration decreases the intercept of the demand for transport services, thus raising the price-elasticity; on the other hand, the demand gets less steep, thereby lowering the price-elasticity. As the latter effect always dominates the former, the price elasticity falls when  $\lambda$  increases.

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<sup>11</sup>In Section 4, we will impose some further restrictions that require  $A$  to be sufficiently large. In particular,  $\tau < \eta$  is required for the equilibrium freight rates to fall with the number of carriers  $m$ , which is the case when  $A$  exceeds some threshold. The choice of this parameter being free, we will assume that  $A$  exceeds the largest threshold. Such a condition reflects the idea that immobile activity represent the larger share of the economy.

We may now describe the game played by the carriers. First, the *inverse demand* for transport services is readily obtained as follows:

$$t(Q) = \frac{\rho_0 + \rho_2\lambda(1-\lambda)\eta}{\rho_1 + \rho_2\lambda(1-\lambda)} - \frac{Q}{\rho_1 + \rho_2\lambda(1-\lambda)}. \quad (14)$$

The market clearing condition in the transport sector being  $\sum_k q_k = Q$ , the profit of carrier  $k$  is given by

$$\Pi_k^T(q_k, \mathbf{q}_{-k}) = [t(Q) - \tau] q_k$$

where  $\mathbf{q}_{-k}$  is the vector of strategies chosen by the carriers other than  $k$ . As the inverse demand (14) is linear, this game has a single Nash equilibrium in pure strategies. For any given  $\lambda$ , the equilibrium price  $t^*$  of the Cournot game satisfies the following well-known necessary and sufficient first-order condition:

$$\frac{t^* - \tau}{t^*} = \frac{1}{m\varepsilon(\lambda, t^*)}.$$

Using (12), this yields a unique and symmetric solution given by

$$t^*(\lambda) = \tau + \frac{\rho_0 + \rho_2\lambda(1-\lambda)\eta - [\rho_1 + \rho_2\lambda(1-\lambda)]\tau}{(m+1)[\rho_1 + \rho_2\lambda(1-\lambda)]}. \quad (15)$$

The first term in (15) is the carrier's marginal cost, and the second the carrier's markup. In Appendix B, we show that a sufficient conditions for the markup to be positive and the trade condition (C1) to jointly hold, regardless of the spatial distribution  $\lambda$ , is given by

$$\tau \leq \tau_{trade}(m) \equiv \frac{a(2bm - cn)}{bm(2b + cn)}$$

which we assume to hold in what follows.

Note, finally, that since

$$\frac{\partial(1 - \tau/t^*)}{\partial\lambda} = -\frac{\partial\varepsilon(\lambda, t^*)}{\partial\lambda} \frac{1}{m[\varepsilon(\lambda, t^*)]^2} > 0$$

by condition (13), the equilibrium freight rate increases in  $\lambda$  over  $[1/2, 1]$ . The reason is that more concentration of firms in region  $H$  makes the transport demand more inelastic, thus endowing the carriers with more market power, which in turn allows them to charge higher freight rates. Consequently, given the number of carriers, the equilibrium freight rate is maximum when the manufacturing sector is agglomerated in region  $H$  ( $\lambda = 1$ ), and minimum when this sector is evenly dispersed between the two regions ( $\lambda = 1/2$ ).

**Proposition 1** *The equilibrium freight rate increases with the degree of spatial concentration of the manufacturing sector.*



The following comments are in order. First, Proposition 1 suggests that it may be important to explicitly account for the transport sector in economic geography and location models. These models typically assume that transport costs are exogenously given and they study the impact of decreases in these costs on the agglomeration process.<sup>12</sup> We will show in the following sections that such a neglect has indeed important consequences when studying the impact of transport deregulation on industry location and welfare.

Second, as can be seen from (C3),  $\tau_{trade}(m)$  is increasing in  $m$  which shows that the restrictions on carriers' marginal cost gets less stringent as the number of carriers increases. The reason is that more competition in the transport sector leads to lower freight rates (provided the location of manufacturing firms is fixed), which hence favors the occurrence of interregional trade by increasing manufacturing firms' ability to penetrate the foreign market.

Third, as expected, for any given firm distribution  $\lambda$ , the equilibrium markup rate decreases with the number of carriers because competition is fiercer. Furthermore,  $t^*(\lambda) \rightarrow \tau$  as  $m \rightarrow \infty$ , thus showing that marginal cost pricing prevails when the number of carriers gets arbitrarily large. Because  $\tau_{trade}(m) \rightarrow t_{trade}$  when  $m \rightarrow \infty$ , the economic geography model with an exogenous freight rate, such as Ottaviano *et al.* (2002), may then be viewed as a limit case in which transportation is undertaken by a perfectly competitive (and fully deregulated) sector.

Last, when  $\tau$  is large, the trade condition may be violated since the freight rates charged by the carriers are prohibitive. This is more likely to occur when the number of carriers is small, when goods are little differentiated, or both. In particular, it follows from (C3) that  $m > cn/(2b)$  must hold for interregional trade to occur. The interpretation of this condition is straightforward. When the manufacturing sector is very competitive ( $c$  or  $n$  is large) whereas the transport sector is not ( $m$  is small), an increase in freight rates makes the penetration of foreign markets almost impossible for exporters because local competition is too fierce.<sup>13</sup> At the same time, carriers must set a non-negative markup to break even. When  $\tau$  is large compared to the preference for the differentiated good (captured by  $a$ ), or when the differentiated goods market is very competitive, the demand for transportation services is small. In that case, carriers do not succeed to break even:

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<sup>12</sup>Behrens and Gaigné (2006) analyze the agglomeration process when trade costs vary with the volume of haul (density economies). However, they do not explicitly model the formation of freight rates.

<sup>13</sup>Levin (1981, p 3) points out that “product market or “source” competition among shippers may constrain [them] from raising the rates of [their] “captive shippers” for fear of pricing them out of the product market.”

on the one hand, they must set a freight rate larger than or equal to their marginal cost; on the other hand, there is no interregional trade at such a freight rate. In this case, the carriers set the lowest possible freight rate compatible with zero interregional trade, which is their profit-maximizing (loss-minimizing) strategy. Note that, in that case, transportation and trade between regions becomes asymmetric in the sense that only firms located in one of the two regions may export their variety at the prevailing freight rate, whereas those located in the other serve only their local market.<sup>14</sup>

For a given firm distribution, the *short-run market equilibrium* is defined by (7), (10) and (15). As discussed above, it may be viewed as an equilibrium in which agents' locations are fixed.

## 4 Transport deregulation and industry location

Deregulating a sector is expected to yield lower prices through either a large number of competitors (e.g., by removing legal entry barriers), or lower costs (e.g., by using more efficient technologies), or both. In what follows, to study the impact of transport deregulation, we choose a simple approach that involves a comparative static analysis on the parameters  $m$  and  $\tau$ .<sup>15</sup> When the distribution of activity is fixed, in a setting *à la* Cournot such as ours increasing  $m$  or decreasing  $\tau$  leads to lower freight rates, which is precisely the effect we want to apprehend. Hence, both have the same qualitative impact on the manufacturing sector, so that we may restrict ourselves to changes in  $m$  only.<sup>16</sup>

In this section, we study the location of firms and workers, i.e. the equilibrium value of  $\lambda$ . As in most economic geography models (Krugman, 1991; Fujita *et al.*, 1999),

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<sup>14</sup>See, for example, Behrens (2005) for a more detailed analysis of asymmetric trade patterns in a similar modeling framework.

<sup>15</sup>Empirical evidence regarding those two objectives may be found in Morrison and Winston (1999) who study the deregulation of U.S. intercity transportation. The deregulation of the transport sector has mainly consisted in (i) fostering entry into that industry, i.e., to increase  $m$ ; and (ii) technological innovations, which lower production costs, i.e., decrease  $\tau$ . Transport deregulation, in particular, has “made entry much easier, as the burden of proof was shifted to opponents of entry to show that entry was harmful to consumers” (Bailey, 1985, pp.3-4). A third objective in the U.S. was also to lower wages because they significantly exceeded the competitive level, especially since “the Teamster Union seemed to exploit [...] monopoly power from truck regulation to extract some monopoly rents for organized labor” (Ying and Keeler, 1991, pp.264-265).

<sup>16</sup>Note that cost reductions due to technological innovations always generate a welfare gain. However, it has been argued both in the U.S. and the EU that much of the cost saving that has led to reduced rates is due to lower pays to labor (Gómez-Ibáñez and Meyer, 1998; Combes and Lafourcade, 2005).

firms move together with their workers. Thus, to determine the long-run equilibrium of the manufacturing sector, it is sufficient to study the migration of skilled workers. These workers migrate to the region offering them the higher utility level evaluated at the equilibrium prices (4) and at the equilibrium wages (10).

As shown by Ottaviano *et al.* (2002), the welfare of a consumer/worker living in region  $r$  is given by the sum of her consumer surplus, generated by the consumption of the differentiated good, her wage, and her consumption of the homogenous good, each evaluated at the short-run market equilibrium:

$$V_r^* = S_r^* + w_r^* + \bar{q}_0 \quad (16)$$

where

$$S_r^* = \frac{a^2 n}{2b} - a(n_r p_{rr}^* + n_s p_{sr}^*) + \frac{b + cn}{2} [n_r (p_r^*)^2 + n_s (p_{sr}^*)^2] - \frac{c}{2} (n_r p_{rr}^* + n_s p_{sr}^*)^2 \quad (17)$$

is the consumer surplus evaluated at the equilibrium prices. Because (16) holds whatever the value of  $t$ , any change in the structural parameters of the transport sector is channeled through  $S_r^*$  and  $w_r^*$  only.<sup>17</sup>

The utility differential driving the mobility of the skilled is given by

$$\Delta V^*(\lambda) \equiv V_H^*(\lambda) - V_F^*(\lambda). \quad (18)$$

Thus, a *spatial equilibrium* arises at: (i)  $\lambda^* \in [1/2, 1]$  when  $\Delta V^*(\lambda^*) = 0$ ; or (ii) at  $\lambda^* = 1$  if  $\Delta V^*(1) \geq 0$ . Such an equilibrium always exists because  $V_r^*$  is a continuous function of  $\lambda$ . An interior equilibrium is stable if and only if the slope of the indirect utility differential (18) is negative in a neighborhood of the equilibrium, i.e.,  $\partial(\Delta V^*)/\partial\lambda < 0$  at  $\lambda = \lambda^*$ , whereas an agglomerated equilibrium is stable whenever it exists.

Evaluating  $\Delta V^*(\lambda)$  at (4), (5), and (10), the indirect utility differential becomes

$$\Delta V^*(\lambda) = \frac{n(b + cn)}{2\phi(2b + cn)^2} \left( \lambda - \frac{1}{2} \right) t^*(\lambda) [-\varepsilon_1 t^*(\lambda) + \varepsilon_2] \quad (19)$$

where

$$\begin{aligned} \varepsilon_1 &\equiv Ac(2b + cn) + (6b^2 + 6cnb + c^2n^2)\phi > 0 \\ \varepsilon_2 &\equiv 4a(3b + 2cn)\phi > 0 \end{aligned}$$

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<sup>17</sup>Note that the initial endowment is fully reflected in the indirect utility, since its consumption yields at least a utility of  $\bar{q}_0$ . Yet, changes in  $t$  change the consumption of the numéraire good, which is given by  $1 + \bar{q}_0 - n_r q_{rr}^* p_{rr}^* - n_s q_{sr}^* p_{sr}^*$  for the unskilled and by  $w_r^* + \bar{q}_0 - n_r q_{rr}^* p_{rr}^* - n_s q_{sr}^* p_{sr}^*$  for the skilled, respectively.

are strictly positive bundles of parameters. It is easy to check that

$$\varepsilon_2 - \eta\varepsilon_1 > 0 \quad (\text{C4})$$

a condition that will be useful in the subsequent welfare analysis of Section 5. We now discuss the different types of spatial equilibria that may arise in our model.

**(i) Agglomeration**  $\lambda^* = 1$  is a stable equilibrium if and only if  $-\varepsilon_1 t^*(1) + \varepsilon_2 > 0$  or, equivalently,

$$t^*(1) = \frac{\rho_0 - \tau\rho_1}{(m+1)\rho_1} + \tau < \frac{\varepsilon_2}{\varepsilon_1} \quad \Longleftrightarrow \quad \tau < \tau^s(m) \equiv \frac{m+1}{m} \frac{\varepsilon_2}{\varepsilon_1} - \frac{a}{bm}.$$

The threshold  $\tau^s(m)$  is called the sustain point by analogy with the terminology used in standard economic geography models. Observe that, for both the agglomerated and dispersed configurations to arise as a spatial equilibrium when transport and/or trade costs vary, it must be that  $\tau^s(m) < \tau_{trade}(m)$ . Indeed, when  $\tau^s(m) > \tau_{trade}(m)$ , there is always agglomeration under bilateral trade, which arises when  $A$  is sufficiently small. By contrast,  $\tau^s(m) < \tau_{trade}(m)$  when the mass  $A$  of unskilled workers exceeds some threshold value, which itself exceeds  $L$ . Under this condition, it can be shown that  $\partial\tau^s(m)/\partial m > 0$ . Hence, *agglomeration is more likely to be a spatial equilibrium when the transport sector is very competitive* ( $m$  is large).

**(ii) Dispersion**  $\lambda^* = 1/2$  is a stable equilibrium if and only if  $\partial\Delta V^*(\lambda)/\partial\lambda < 0$  evaluated at  $\lambda^* = 1/2$ , which yields the condition

$$t^*(1/2) = \frac{4(\rho_0 - \tau\rho_1) + \rho_2(\eta - \tau)}{(m+1)(4\rho_1 + \rho_2)} + \tau > \frac{\varepsilon_2}{\varepsilon_1} \quad \Longleftrightarrow \quad \tau > \tau^b(m) \equiv \frac{m+1}{m} \frac{\varepsilon_2}{\varepsilon_1} - \frac{4a}{(4b+cn)m}.$$

The threshold  $\tau^b(m)$  is called the break point. As in the foregoing,  $\tau^b(m) < \tau_{trade}(m)$  implies that  $\partial\tau^b(m)/\partial m > 0$ , which again holds when  $A$  is sufficiently large. Consequently, *dispersion is more likely to occur when the transport sector is little competitive* ( $m$  is small).

It follows from condition (C2) that

$$\tau^b(m) - \tau^s(m) = \frac{\rho_0 - \eta\rho_1}{m(4\rho_1 + \rho_2)\rho_1} > 0$$

which implies that (i) the spatial equilibrium is always unique and (ii) there exists a range of  $\tau$ -values for which stable partially agglomerated equilibria arise. This is because *the gradual concentration of the manufacturing sector in one region leads to an increase of the equilibrium freight rate by making the transport demand more inelastic, thus slowing down*

*the agglomeration process.* The range shrinks with the number of carriers. It is worth stressing that the sustain point and the break point are identical when the transport sector is perfectly competitive ( $m \rightarrow \infty$ ). In addition,  $\tau^b(\infty) = \tau^s(\infty)$  is equivalent to the limit value of transport costs above which dispersion is a spatial equilibrium and below which agglomeration prevails, as in Ottaviano *et al.* (2002).

**(iii) Partial agglomeration** As seen in the foregoing, the economy may also involve partial agglomeration of the manufacturing sector ( $1/2 < \lambda^* < 1$ ). We show that this occurs when  $\tau^b(m) > \tau > \tau^s(m)$ . It is obtained by solving the equation  $-\varepsilon_1 t^*(\lambda) + \varepsilon_2 = 0$ , which is quadratic in  $\lambda$  with two solutions symmetric about  $1/2$ . The equilibrium value of  $\lambda > 1/2$  is then

$$\lambda^*(\tau, m) = \frac{1}{2} + \frac{1}{2} \sqrt{\frac{\Lambda_A}{\Lambda_B}} \quad (20)$$

where  $\Lambda_A$  and  $\Lambda_B$  are bundles of parameters defined in Appendix A.2.

It is readily verified that  $\lambda^* < 1$  when  $\tau > \tau^s(m)$  and that  $\lambda^* > 1/2$  when  $\tau < \tau^b(m)$ .<sup>18</sup> Therefore,  $1/2 < \lambda^*(\tau, m) < 1$  if and only if  $\tau^b(m) > \tau > \tau^s(m)$ . Furthermore, we have

$$\frac{\partial(\Delta V^*)}{\partial \lambda} \Big|_{\lambda=\lambda^*} = \frac{-\varepsilon_2 \Lambda_A (\Lambda_B / \rho_2)}{2(m+1)\varepsilon_1^2(\rho_0 - \eta\rho_1)}$$

which, under condition (C2), implies that the foregoing equilibrium is stable as long as  $\tau^b(m) > \tau > \tau^s(m)$ .

Finally, we obtain

$$\text{sgn} \left[ \frac{\partial \lambda^*}{\partial m} \right] = \text{sgn} \left[ \frac{\partial(\Lambda_A / \Lambda_B)}{\partial m} \right] = \frac{4\varepsilon_1(\rho_0 - \eta\rho_1)(\varepsilon_2 - \varepsilon_1\tau)}{\rho_2[(m+1)\varepsilon_2 - \varepsilon_1(\eta + m\tau)]^2} > 0$$

where the inequality comes from (C2). It follows from the fact that firms price above marginal cost, under (C3), that the following condition holds at any interior equilibrium:

$$\tau < \frac{\varepsilon_2}{\varepsilon_1} = t^*(\lambda^*). \quad (C5)$$

Hence, as the number of carriers rises, *the economy moves gradually from dispersion to agglomeration.* Indeed, when some firms leave region  $F$ , say, toward region  $H$ , the equilibrium freight rate increases so that firms located in region  $F$  have an incentive to stay put because this allows them to relax price competition and to benefit from high demand levels in this region. Consequently, *changes in the spatial organization of the economy are no longer catastrophic* because agglomeration forces now are partially

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<sup>18</sup>Note that  $\Lambda_B(\tau) > 0$  if and only if  $\tau > \tau^s(m)$ , while  $\Lambda_A(\tau) > 0$  if and only if  $\tau < \tau^b(m)$ .

balanced by additional dispersion forces arising from the price setting in the transport sector. In other words, agglomeration becomes self-defeating, which stabilizes the spatial distribution of firms. It is worth pointing out that such equilibria never arise in economic geography models with exogenous freight rates (Krugman, 1991; Ottaviano *et al.*, 2002). Furthermore, when the technology in transportation allows for very low marginal costs, we fall back on the standard result involving full agglomeration. Likewise, an increase in the number of carriers implies more agglomeration because competition in the transport sector is fiercer, hence facilitating the penetration of the smaller region from the larger one.

Accordingly, we have:

**Proposition 2** *When the number of carriers increases, the spatial equilibrium gradually moves from dispersion to agglomeration of the manufacturing sector.*

Figure 2 depicts the spatial distribution of the manufacturing sector as the number of carriers  $m$  rises.

**Insert Figure 2 about here**

## 5 Should the transport sector be deregulated?

In what follows, we ask whether or not a larger number of carriers is desirable from the consumers' and the carriers' point of view.

As individual utilities are quasi-linear and firms' profits are zero, aggregate consumer welfare (gross of carriers' profits) is given by the sum of consumer surpluses and wages across individuals:

$$\begin{aligned}
 W(\lambda) &= \lambda L[S_1^*(\lambda, t^*(\lambda)) + w_1^*(\lambda, t^*(\lambda))] + (1 - \lambda)L[S_2^*(\lambda, t^*(\lambda)) + w_2^*(\lambda, t^*(\lambda))] \\
 &\quad + \frac{A}{2}[S_1^*(\lambda, t^*(\lambda)) + S_2^*(\lambda, t^*(\lambda)) + 2] + (A + L)\bar{q}_0.
 \end{aligned} \tag{21}$$

As discussed in the introduction, two cases must be distinguished when assessing the welfare impacts of transport deregulation. In the first one, agents' locations are considered as fixed. In the second case, firms and workers are mobile and free to adjust location in response to changes in the level of freight rates. Those cases are considered in the next two subsections. In a third subsection, we also analyze the changes in carriers' profits in response to transport deregulation.

## 5.1 Exogenous industry distribution

Most economists and policy makers expect that transport deregulation will decrease commodities prices because firms' pay lower freight rates and because spatial price competition gets fiercer. When the location of firms is fixed, such a result obtains in our framework because

$$\frac{dP_r^*}{dm} = \left( n \frac{\partial p_{rr}^*}{\partial t^*} + \frac{n_s}{2} \right) \frac{\partial t^*}{\partial m} < 0$$

by using (2) and (7). Hence, when mobile factors do not relocate in response to changing freight rates, more competition in the transport sector unambiguously lowers the price indices of manufactured goods in both regions. Yet, this change does not directly map into a clear welfare assessment. Indeed, for a given value of  $\lambda$ , the impact of a lower freight rate on aggregate consumer welfare is a priori unclear. This is because of the interdependence between factor and product markets, even when the location of firms is held fixed. Indeed, a decrease in  $t$  has two opposing effects: (i) it directly raises consumer surplus via lower prices, but (ii) it also indirectly lowers consumer welfare by triggering more competition on the products markets, thus leading firms to make lower operating profits and skilled workers to earn lower wages.

Some standard, but cumbersome, calculations show that  $\partial W/\partial t < 0$  over the domain  $t < t_{trade}$ . In other words, for any given firm distribution, aggregate consumer welfare raises when freight rates decline even though wages decrease. As a result, we have

$$\frac{dW}{dm} = \frac{\partial W}{\partial t} \frac{\partial t^*}{\partial m} > 0 \quad (22)$$

which may be summarized as follows:

**Proposition 3** *For any given firm distribution, aggregate consumer welfare rises when the number of carriers increases, even though skilled wages decrease.*

This result is in accordance with what transport analysts and policy-makers expect: *transport deregulation makes consumers better off*. However, they often omit to recognize that such a conclusion might not be robust in a world where agents' have incentives to relocate because of lower freight rates. This aspect has been repeatedly emphasized in economic geography and is the focus of the next section.

## 5.2 Endogenous industry distribution

In what follows, we focus mainly on interior equilibria  $\lambda^* \in (1/2, 1)$ . Indeed, in the case of corner solutions (agglomeration or dispersion), the spatial distribution of firms does not change due to marginal changes in  $m$ . In that case, everything works as in the foregoing. However, neither full agglomeration nor dispersion seem to adequately describe the space-economy in the real world.

### 5.2.1 Commodities prices

When the location of firms and skilled workers may change due to a fall in freight rates, our previous results no longer hold because both the slope and the intercept of the demand function (11) vary with  $\lambda$ . In particular, as shown in Appendix A.3, price indexes vary according to regions and in opposite directions:

$$\frac{dP_H}{dm} = -\frac{dP_F}{dm} < 0.$$

Observe that a marginal increase in  $m$  favors: (i) a fall in freight rates which, all else equal, reduces the prices of varieties consumed in both regions, as previously; and (ii) relocation of firms towards the large region. This gives rise to two opposite effects. On the one hand, for given freight rates, product prices decrease in the large region at the expense of the small one. On the other hand, more agglomeration implies higher freight rates ( $\partial t^*/\partial \lambda^* > 0$ ), as shown in Section 3, thereby raising product prices in both regions. It is hence not surprising that (see Appendix A.4):

$$\frac{dp_{HH}^*}{dm} < 0 \quad \text{and} \quad \frac{dp_{FF}^*}{dm} > 0.$$

In words, prices fall in the agglomerating region, whereas they rise in the region that loses firms despite the more competitive transport sector. Our results may be summarized as follows.

**Proposition 4** *When there is partial agglomeration, transport deregulation reduces prices in the large region but raises them in the small one.*

Hence, once we take into account the equilibrium relationship between agglomeration and freight rates, an increase in competition among carriers maps into lower consumer prices in the large region and higher consumer prices in the small one. Such a result suggests that the impact of transport deregulation could well be welfare-worsening, at least in one of the regions. This point is the focus of the next section.



### 5.2.2 Aggregate consumer welfare

In the same model as this one but in which the freight rate is exogenously given, Ottaviano and Thisse (2002) show that aggregate consumer welfare evaluated at the market prices and wages is maximized when dispersion prevails if and only if the freight rate exceeds the following threshold:

$$t^o \equiv \frac{16a\phi(3b\phi + cL)}{8b\phi(3b\phi + 2cL + cA) + 3c^2L(A + L)}$$

whereas  $t < t^o$  implies that agglomeration is welfare-maximizing. By contrast, the spatial equilibrium shifts from dispersion to agglomeration once the competitive freight rate  $t^*(\infty) = \tau$  falls below  $\varepsilon_2/\varepsilon_1$ , which is strictly larger than  $t^o$  (Ottaviano and Thisse, 2002). In other words, *the market outcome may be inefficient in the sense that there is too much agglomeration*. Because transport deregulation favors agglomeration, such a policy may affect welfare negatively by amplifying the unequal spatial distribution of firms.

The novelty here is that partial agglomeration may be an equilibrium. Therefore, it is worth asking how the aggregate consumer welfare changes with  $\lambda$ . We show in Appendix A.5 that more agglomeration is welfare-decreasing. This result suggests that increasing the number of carriers could be welfare-worsening as the entry of new carriers leads both to more agglomeration and lower wages.

Differentiating  $W$  with respect to  $m$  now yields

$$\frac{dW}{dm} = \frac{\partial W}{\partial t} \frac{\partial t^*}{\partial m} + \frac{\partial W}{\partial t} \frac{\partial t^*}{\partial \lambda} \frac{\partial \lambda^*}{\partial m} + \frac{\partial W}{\partial \lambda} \frac{\partial \lambda^*}{\partial m} \quad (23)$$

in which two additional terms appear when compared with (22). The first one captures the indirect effect that an increase in  $m$  has on the equilibrium freight rate, which impacts itself on the spatial equilibrium. Given what we have seen in the previous section, the signs are as indicated in (23) so that this term is always negative. The second term accounts for the direct impact that an increase of  $m$  has on the spatial equilibrium. Again, this term is negative.

Although the sign of (23) is a priori ambiguous, due to positive short-run gains and negative long-run losses, it may be clearly signed as follows (see Appendix A.6):

$$\frac{dW}{dm} < 0.$$

Hence, once it is recognized that firms and workers may change location in response to long run changes in competition between carriers, *more competition in the transport*

sector can make consumers worse off because of excessive agglomeration.<sup>19</sup> We may thus conclude as follows.

**Proposition 5 (harmful deregulation)** *When there is partial agglomeration, transport deregulation leads to a lower aggregate consumer welfare.*

Thus, contrary to a general belief, deregulating a competitive transport sector at the interregional level is detrimental to consumers when changing this sector's market structure induces a redistribution of activities across regions. The spatial effects of transport deregulation are at the heart of the explanation: a more competitive transport sector induces more agglomeration which is, by itself, detrimental to welfare and, in addition, raises freight rates, thereby reducing consumers' surplus.

It is worth noting that introducing carriers' fixed costs strengthens the foregoing results when fixed costs are incurred in terms of unskilled labor. Indeed, although the location of skilled workers and the consumption of the differentiated good are not affected, the consumption of the homogenous good decreases, thus reducing the welfare of each consumer.<sup>20</sup>

### 5.2.3 Individual consumer welfare and spatial equity

Until now, we have focused only upon the impact of transport deregulation on aggregate consumer welfare. Yet, assessing more finely the individual changes across consumer groups is important because "regardless of economists' explanations, the public is very sensitive to perceived changes in interpersonal equity" (Winston, 1993, p.1276). In our model, individuals living in different regions are affected differently by transport deregulation and experience different effects. We have seen that it is only under extreme spatial configurations (agglomeration or dispersion) that the welfare of a consumer increases when transport is deregulated. This shows, a contrario, that such patterns of production are needed to justify the implicit assumption that transport deregulation does not affect firms' locations.

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<sup>19</sup>The entry of a larger number of carriers may lead to a higher welfare level at the fully agglomerated outcome than what it was under dispersion under regulation. However, as argued in the foregoing, full agglomeration does not strike us as a reasonable benchmark case against which to judge the welfare impacts of transport deregulation.

<sup>20</sup>When fixed costs are incurred in terms of skilled labor, the analysis is more involved. This is because both the manufacturing and transport sector compete for skilled labor, while the entry of a new carrier leads to a decrease in the total mass of varieties.

There are four types of consumers in our economy: skilled and unskilled workers, living in either region  $H$  or region  $F$ . Because unskilled workers are geographically immobile, and because their wage is fixed, all welfare changes materialize solely through consumer prices. Using (7) and (17), it is straightforward to check that:

$$\frac{dS_H^*}{dm} = \frac{\partial S_H^*}{\partial p_{HH}} \left( \frac{\partial p_{HH}^*}{\partial m} + \frac{1}{2} \frac{\partial t^*}{\partial m} \right) > 0.$$

Because  $d(S_H^* + S_F^*)/dm < 0$  as shown in Appendix A.7, it must be that

$$\frac{dS_F^*}{dm} < 0.$$

Their wage does not vary with respect to their location, which implies that the unskilled workers residing in the large region are better off, whereas those living in the small region are worse off.

Let us study how the welfare of a skilled worker changes with the number of carriers. Because  $w_H^* + S_H^* = w_F^* + S_F^*$  holds due to location arbitrage at any partially agglomerated equilibrium, the welfare of a skilled worker varies in the same direction regardless of her location. It is then shown in Appendix A.7 that

$$\frac{d(w_H^* + S_H^*)}{dm} = \frac{d(w_F^* + S_F^*)}{dm} < 0.$$

Thus, *every skilled worker is hurt by the entry of new carriers*. To sum-up:

**Proposition 6** *When there is partial agglomeration, transport deregulation hurts all workers except the immobile residing in the large region.*

Two remarks are in order. First, because  $dS_H^*/dm - dS_F^*/dm > 0$ , at any interior spatial equilibrium it must be that  $dw_F^*/dm - dw_H^*/dm > 0$ . Stated differently, *interregional wage differentials are magnified by the deregulation of the transport sector*. Second, whereas the welfare gap between skilled remains equal to zero during the whole agglomeration process, things are different regarding the unskilled. Any unskilled in the large region is better off but any unskilled in the small region is worse off. Consequently, transport deregulation exacerbates economic inequality between immobile unskilled workers, thus affecting negatively spatial equity.

### 5.3 Carriers' profits

Let us now turn to the impacts of deregulation on carriers' profits. Aggregate profits in the transport sector are given by

$$\Pi^T(\lambda^*) = \sum_k \Pi_k^T(\lambda^*) = [t^*(\lambda^*) - \tau]Q(\lambda^*).$$

When locations are fixed, differentiating  $\Pi^T$  with respect to  $m$  is equal to  $\partial\Pi^T/\partial m$ , which is always negative. Thus, more competition in the transport sector is harmful to the carriers in the short run as it decreases each carrier's profits. The same holds true when full agglomeration or dispersion prevails, since in this case the spatial distribution of economic activity does not change with  $m$ . More interesting is the case of partial agglomeration. We now have:

$$\frac{d\Pi^T}{dm} = \frac{\partial\Pi^T}{\partial m} + \frac{\partial\Pi^T}{\partial\lambda} \frac{\partial\lambda^*}{\partial m}$$

because  $\partial\Pi_k^T/\partial t_k = 0$  at  $t_k = t^*$ , where

$$\frac{\partial\Pi^T}{\partial\lambda} = \frac{\partial(t^* - \tau)}{\partial\lambda} Q(\lambda^*) + (t^* - \tau) \frac{\partial Q}{\partial\lambda}$$

with  $\partial Q/\partial\lambda \gtrless 0$  if and only if  $t^*(m) \gtrless \eta$ . As expected, the direct effect is negative. However, the indirect effect is positive when  $t^*(m) > \eta$ . Accordingly, the global impact is a priori ambiguous. When more carriers operate, it could well be that they earn more profits. The reason is that, as shown before, the demand for transport services becomes less elastic when agglomeration increases. Because a larger number of competitors leads to more agglomeration, carriers increase their freight rates and markups, which in turn may lead to higher profits.

Standard calculations reveal that carriers' aggregate profits increase when their number rises:

$$\frac{d\Pi^T}{dm} = \frac{(\varepsilon_1\tau - \varepsilon_2)^2(\rho_0 - \eta\rho_1)(\varepsilon_2 - \varepsilon_1\eta)}{\varepsilon_1 [((m+1)\varepsilon_2 - \varepsilon_1(\eta + m\tau))]^2} > 0$$

where the inequality is due to (C2) and (C4). Note that such an effect does not suggest itself, because the direct effect is shown to be always negative. Nevertheless, as expected, individual profits decrease with the number of operating carriers:

$$\frac{d(\Pi^T/m)}{dm} = -\frac{(\varepsilon_2 - \varepsilon_1\tau)^3(\rho_0 - \eta\rho_1)}{\varepsilon_1 [(m+1)\varepsilon_2 - \varepsilon_1(\eta + m\tau)]^2} < 0$$

because of (C2) and (C4).

We may thus conclude as follows.

**Proposition 7** *When there is partial agglomeration, transport deregulation raises global profits in the transport sector but reduces individual carriers' profits.*

## 6 Conclusion

In modern market economies, freight rates are largely determined by the interactions between imperfectly competitive carriers and imperfectly competitive manufacturing firms. We have presented a model incorporating such an enriched market structure to show that *the welfare implications of transport deregulation crucially hinge upon the mobility of firms and workers, as well as on changes in factor prices*. Whereas deregulating transport policies are unambiguously consumer welfare-enhancing in the short run, when the spatial distribution of activity is taken as given, they are consumer welfare-worsening in the long run when the spatial distribution of firms adjusts to those changes. Three main reasons underlie this unsuspected result. First, as agglomeration increases, the elasticity of demand for transport services decreases. This in turn confers more market power to the carriers, despite the deregulation, which dampens the magnitude of price responses to the initial policies. Consequently, *deregulation of the transport sector makes that sector as a whole more profitable, at the expense of consumers*. Second, as often emphasized in the literature, deregulation and antitrust policies tend to focus predominantly on consumer gains, neglecting too often possible losses on labor markets. We have shown that transport deregulation exacerbates competition in the manufacturing sector, thereby reducing prices but decreasing the wage bill. Last, it is often overlooked that the spatial distribution of economic activity has, by itself, important implications for both welfare and equity. Since the market outcome already yields usually too much agglomeration, additional agglomeration due to transport deregulation clearly further reduces welfare.

One final comment is in order. Indeed, one may wonder to what extent our results are driven by our modelling strategy. In that respect, it is worth emphasizing that our model is of the linear type and has, as such, been widely used in industrial organization, imperfect competition, and competition policy (see, e.g., Vives, 1999; Motta, 2004). This suggests that our results can hardly be dismissed out of hand on the grounds of modelling choices only. It further suggests that our main results are still likely to hold in settings that are not too nonlinear, thus implying that deregulation might well have more welfare costs than usually claimed by transport analysts, policy makers, and antitrust authorities. At the very least, our results show that transport deregulation affects the distribution of economic activity across regions and countries, a variable neglected so far in “good”

assessments of this policy.

## References

- [1] Anderson, J. and E. van Wincoop. 2004. Trade costs. *Journal of Economic Literature* XLII, 691-751.
- [2] Bailey, E.E. 1986. Price and productivity change following deregulation: The US experience. *Economic Journal* 96, 1-17.
- [3] Baumol W. and R. Willig. 1998. Competitive rail regulation rules. *Journal of Transport Economics and Policy* 33, 43-54.
- [4] Beckmann, M.J. and J.-F. Thisse. 1986. The location of production activities. In *Handbook of Regional and Urban Economics*. Volume 1, ed. P. Nijkamp. Amsterdam, North-Holland, 21-95.
- [5] Behrens, K. 2005. How endogenous asymmetries in interregional market access trigger regional divergence. *Regional Science and Urban Economics* 35, 471-492.
- [6] Behrens, K and C. Gaigné. 2006. Density economies in transportation: revisiting the core-periphery model. *Economics Bulletin* 18, 1-7.
- [7] Blair, R.D., D.L. Kaserman and J.T. MacClave. 1986. Motor carrier deregulation: The Florida experiment. *Review of Economics and Statistics* 68, 159-164.
- [8] Bonanno, G. 1990. General equilibrium theory with imperfect competition. *Journal of Economic Surveys* 4, 297-328.
- [9] Boyer K. 1987. The costs of price regulation: Lessons from railroad deregulation. *RAND Journal of Economics* 18, 408-416.
- [10] Boylaud, O. and G. Nicoletti. 2001. Regulatory reform in road freight. *OECD Economic Studies* 32, 229-251.
- [11] Charlot S., C. Gaigné, F. Robert-Nicoud and J.F. Thisse. 2006. Agglomeration and welfare in the light of Bentham, Kaldor and Rawls. *Journal of Public Economics* 90, 325-347.

- [12] Combes, P.-P. and M. Lafourcade. 2005. Transport costs: measures, determinants, and regional policy. Implications for France. *Journal of Economic Geography* 5, 319-349.
- [13] Engel, C. and J. Rogers. 1996. How wide is the border? *American Economic Review* 86, 1112-1125.
- [14] European Commission. 2001. White Paper – European transport policy for 2010: time to decide.
- [15] Fujita, M., P. Krugman and A.J. Venables. 1999. *The Spatial Economy. Cities, Regions and International Trade*. Cambridge MA, The MIT Press.
- [16] Gómez-Ibáñez, J.A. and J.R. Meyer. 1993. *Going Private: The International Experience with Transport Privatization*. Washington D.C., Brookings Institution Press.
- [17] Haskel, J. and H. Wolf. 2001. The law of one price - A case study. *Scandinavian Journal of Economics* 103, 545-558.
- [18] Hurley, W. 1994. Is it necessary to regulate prices in freight transport markets? *Journal of Transportation Economics and Policy* 29, 169-178.
- [19] Krugman, P.R. 1991. Increasing returns and economic geography. *Journal of Political Economy* 99, 483-499.
- [20] Levin, R.C. 1981. Railroad rates, profitability, and welfare under deregulation. *RAND Journal of Economics* 12, 1-26.
- [21] Lipsey, R. and K. Lancaster. 1956. The general theory of second best. *The Review of Economic Studies* 24, 11-32.
- [22] McFarland, H. 1989. The effects of United States railroad deregulation on shippers, labor, and capital. *Journal of Regulatory Economics* 1, 259-270.
- [23] Morrison, S.A. and C. Winston. 1999. Regulatory reforms in U.S. intercity transportation. In *Essays in Transportation Economics and Policy: A Handbook in Honor of John R. Meyer*, ed. J.A. Gómez-Ibáñez, W.B. Tye and C. Winston. Washington D.C., Brookings Institution Press.
- [24] Motta, M. 2004. *Competition Policy: Theory and Practice*. Cambridge, Cambridge University Press.

- [25] Norman, G. and J.-F. Thisse. 2000. Market Structure and Competition Policy. Game-theoretic Approaches. Cambridge, Cambridge University Press.
- [26] Ottaviano, G.I.P., T. Tabuchi and J.-F. Thisse. 2002. Agglomeration and trade revisited. *International Economic Review* 43, 409-436.
- [27] Ottaviano, G.I.P. and J.-F. Thisse. 2002. Integration, agglomeration and the political economics of factor mobility. *Journal of Public Economics* 83, 429-456.
- [28] Ottaviano, G.I.P. and J.-F. Thisse. 2004. Agglomeration and economic geography. In *Handbook of Regional and Urban Economics*. Volume 4, ed. J.V. Henderson and J.-F. Thisse. Amsterdam: North-Holland, 2564-2608.
- [29] Rose, N. 1985. The incidence of regulatory rents in the motor carrier industry. *RAND Journal of Economics* 16, 299-318.
- [30] Teixeira, A.C. 2006. Transport policies in the light of new economic geography: The Portuguese experience. *Regional Science and Urban Economics* 36, 450-466.
- [31] Vives, X. 1999. *Oligopoly Pricing: Old Ideas and New Tools*. MIT Press, Cambridge, MA.
- [32] Winston, C. 1993. Economic deregulation: Days of reckoning for microeconomists. *Journal of Economic Literature* 31, 1263-1289.
- [33] Wolf, H. 2000. Intranational home bias in trade. *Review of Economics and Statistics* 82, 555-563.
- [34] Ying, J.S. 1990. The inefficiency of regulating a competitive industry: productivity gains in trucking following reform. *Review of Economics and Statistics* 72, 191-201.
- [35] Ying, J.S. and T.E. Keeler. 1991. Pricing in a deregulated environment: The motor carrier experience. *RAND Journal of Economics* 22, 264-273.

## Appendix A

### (A.1) Parameter definitions:

$$\rho_0 \equiv \frac{A(b+cn)na}{2(2b+cn)} > 0 \quad \rho_1 \equiv \frac{A(b+cn)nb}{2(2b+cn)} > 0$$

$$\rho_2 \equiv \frac{n^2[4b\phi + c(n\phi + A)](b+cn)}{2(2b+cn)} > 0 \quad \eta \equiv \frac{4a\phi}{4b\phi + c(n\phi + A)} > 0$$



**(A.2) Parameter definitions:**

$$\begin{aligned}\Lambda_A &= (4\rho_1 + \rho_2)[(m+1)\varepsilon_2 - m\varepsilon_1\tau] - (4\rho_0 + \rho_2\eta)\varepsilon_1 \\ \Lambda_B &= -\rho_2[\varepsilon_1(m\tau + \eta) - (m+1)\varepsilon_2]\end{aligned}$$

**(A.3) Price aggregates as a function of  $m$ :** One can check that

$$\frac{dP_H}{dm} = -\frac{dP_F}{dm} = \frac{-(\varepsilon_2 - \varepsilon_1\tau)(\rho_0 - \eta\rho_1)\varepsilon_2 n(b+cn)}{\rho_2[m(\varepsilon_2 - \varepsilon_1\tau) + \varepsilon_2 - \varepsilon_1\eta]^2(2b+cn)\sqrt{\Lambda_A/\Lambda_B}} < 0,$$

where the inequality is due to (C2) and (C5).

**(A.4) Prices as a function of  $m$ :** We have

$$\frac{dp_{HH}^*}{dm} = \frac{\partial p_{HH}^*}{\partial \lambda^*} \frac{\partial \lambda^*}{\partial m} + \frac{\partial p_{HH}^*}{\partial t^*} \frac{\partial t^*}{\partial m} + \frac{\partial p_{HH}^*}{\partial t^*} \frac{\partial t^*}{\partial \lambda^*} \frac{\partial \lambda^*}{\partial m}. \quad (24)$$

It is then readily verified that

$$\text{sgn} \left[ \frac{dp_{HH}^*}{dm} \right] = \text{sgn} \left[ -\frac{(\rho_0 - \eta\rho_1)(\varepsilon_2 - \varepsilon_1\tau)}{[\varepsilon_2 - \varepsilon_1\eta + m(\varepsilon_2 - \tau\varepsilon_1)]^{3/2}} \right] < 0$$

where the inequality is due to (C2), (C3) and (C5). Because prices in the two regions move in opposite directions with respect to  $\lambda$ , we then have

$$\frac{dp_{HH}^*}{dm} < 0 \quad \Rightarrow \quad \frac{dp_{FF}^*}{dm} > 0.$$

**(A.5) Welfare as a function of  $\lambda$ :** It is easy to see that

$$\frac{dW}{d\lambda} = -\frac{n^2(b+cn)t(2\lambda-1)[Ac(8b+3cn)t + ((24b^2 + 16cnb + 3c^2n^2)t - 16a(3b+cn))\phi]}{8(2b+cn)^2}$$

the sign of which depends on the sign of

$$Ac(8b+3cn)t + [(24b^2 + 16cnb + 3c^2n^2)t - 16a(3b+cn)]\phi.$$

This expression is positive (resp., negative) if  $t > t^o$  (resp.,  $t < t^o$ ). Because  $t^o < t^*(\lambda^*) = \varepsilon_2/\varepsilon_1$ , it must be that  $dW/d\lambda < 0$  at any partially agglomerated equilibrium.

**(A.6) Welfare as a function of  $m$ :**

$$\frac{dW}{dm} = -\frac{ac^2n^3(b+cn)(5b+2cn)\varepsilon_2(\rho_0 - \eta\rho_1)(\varepsilon_2 - \varepsilon_1\tau)\phi(A+n\phi)}{2(2b+cn)^2\varepsilon_1\rho_2[(m+1)\varepsilon_2 - \varepsilon_1(\eta+m\tau)]^2} < 0.$$

where the sign is due to (C2) and (C5).

**(A.7) Consumer surplus and welfare:** It is readily verified that

$$\frac{d(S_H^* + S_F^*)}{dm} = -\frac{(\rho_0 - \eta\rho_1)(\varepsilon_2 - \varepsilon_1\tau)(b + cn)n^3c^2\varepsilon_2^2}{\rho_2\varepsilon_1[m(\varepsilon_2 - \varepsilon_1\tau) + \varepsilon_2 - \varepsilon_1\eta]^2(2b + cn)^2} < 0$$

and

$$\frac{d(w_H^* + S_H^*)}{dm} = -\frac{(\varepsilon_2 - \varepsilon_1\tau)(\rho_0 - \eta\rho_1)\varepsilon_2c^2n^2a\phi\Lambda_A(2n^2c\phi + 5bn\phi + 2bA)(b + cn)}{2\rho_2\varepsilon_1\phi[m(\varepsilon_2 - \varepsilon_1\tau) + \varepsilon_2 - \varepsilon_1\eta]^2(2b + cn)^2\Lambda_A} < 0.$$

## Appendix B

Let  $K \equiv \rho_0 + \lambda(1 - \lambda)\rho_2\eta - [\rho_1 + \lambda(1 - \lambda)\rho_2]\tau$  stand for the numerator of the markup. Using the definitions of the coefficients  $\rho_i$  and  $\eta$ , as given in Appendix A.1, it is readily verified that  $K > 0$  if and only if

$$\tau < \bar{\tau}(\lambda) \equiv \frac{a[A + 4L\lambda(1 - \lambda)]}{A[b + cn\lambda(1 - \lambda)] + L(4b + cn)\lambda(1 - \lambda)}$$

which is strictly increasing in  $\lambda$  on  $[1/2, 1]$ . Evaluating the threshold  $\bar{\tau}$  at  $\lambda = 1/2$  then yields the sufficient condition

$$\tau < \bar{\tau}(1/2) = \frac{4a}{4b + cn} \quad (25)$$

for markups to be positive regardless of the industry distribution  $\lambda$ . Furthermore, imposing  $t^*(\lambda) < t_{trade}$  as required by (C1) for interregional trade to occur regardless of the value of  $\lambda$ , yields the condition

$$\tau < \frac{1}{m} \left[ \frac{2a(m + 1)}{2b + cn} - \eta - \frac{\rho_0 - \eta\rho_1}{(1 - \lambda)\lambda\rho_2 + \rho_1} \right]. \quad (26)$$

Since the right-hand side of (26) is strictly decreasing in  $\lambda$  under (C2), a sufficient condition for it to hold regardless of the spatial distribution of the industry is given by

$$\tau \leq \tau_{trade}(m) \equiv \frac{a(2bm - cn)}{bm(2b + cn)}.$$

Finally, one can check that  $\tau_{trade}(m) < \bar{\tau}(1/2)$  for all  $m \geq 1$ . Hence, condition (C3) is sufficient for (i) trade to occur and (ii) carriers' equilibrium markups to be strictly positive, regardless of the value of  $\lambda \in [1/2, 1]$ .

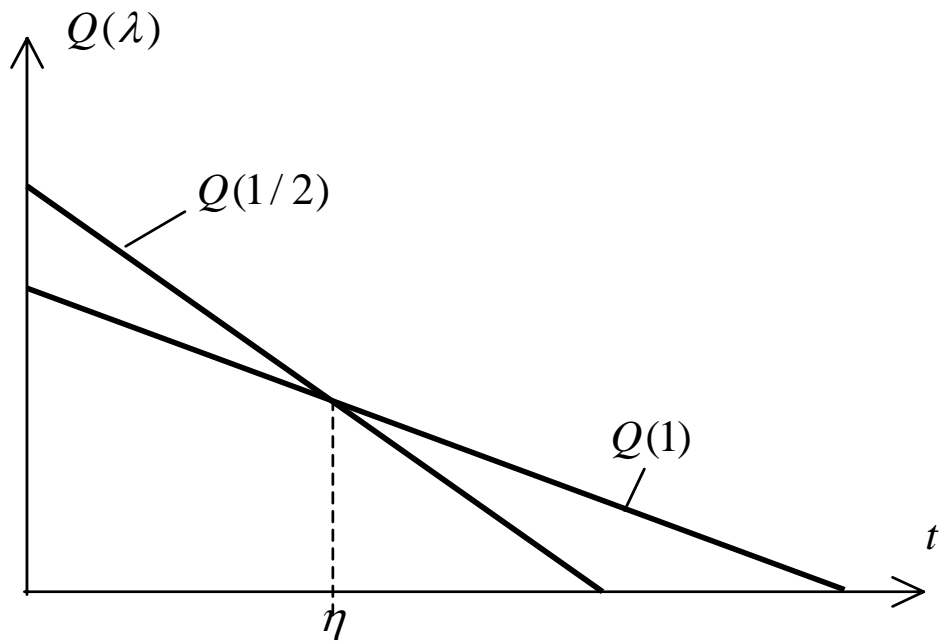


Figure 1. Demand for transport services

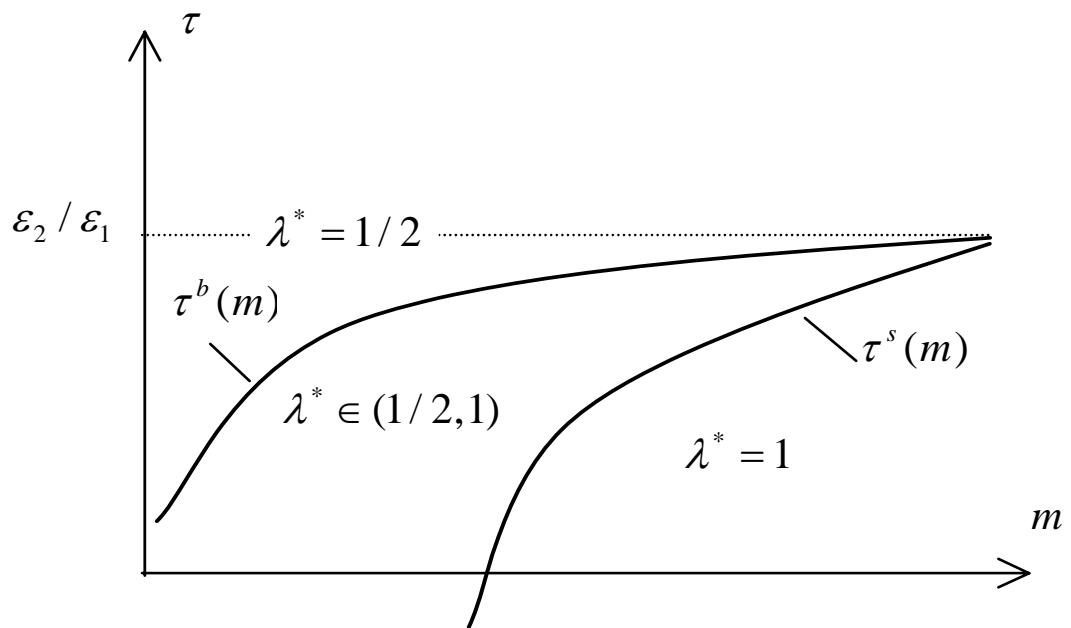


Figure 2. Spatial equilibria in  $(m, \tau)$ -space