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Abstract

The aim of this paper is to qualify the claim that a more competitive transport sector is always beneficial to consumers. We show indeed that, although transport deregulation is beneficial to consumers in the short run when the location of economic activity is fixed, this need no longer be true in the long run when firms and workers are mobile. A change in the spatial structure of the economy, triggered by an increasing number of carriers or a fall in their marginal cost can, quite surprisingly, increase consumer prices in some regions. The static gains from less monopoly power in the transport sector may then well map into dynamic dead-weight losses as deregulation leads to more inefficient agglomeration, lower aggregate consumer welfare, and more pronounced interregional wage inequalities.

Keywords: transport liberalization; economic geography; imperfect competition; trade
JEL Classification: F12; F16; R12; R48

Dérégulation du secteur transport: la bonne voie à suivre?

Résumé

L'objectif de ce papier est d'analyser si un secteur du transport plus concurrentiel est toujours profitable pour les consommateurs. Nous montrons que, si la dérégulation du secteur transport est profitable pour les consommateurs à court terme, ceci n'est pas forcément vérifié quand les firmes et les travailleurs sont mobiles géographiquement. Une modification de l'organisation spatiale de l'économie, due à un nombre croissant de transporteurs ou une baisse des coûts marginaux du transport, peut accroitre les prix. Les gains de court terme dus à un pouvoir de marché plus faible des transporteurs peut être plus que compensés par une diminution du bien-être à long terme. En effet, on montre que la dérégulation favorise l'agglomération, qui accroit les prix du transport et réduit le bien-être des consommateurs.

Mots clés: Libéralisation du transport; Economie géographique; Concurrence imparfaite; Commerce.

Classification JEL: F12; F16; R12; R48

1 Introduction

In most countries, the transport sector is replete with allocative distortions of various types. Designing policies to correct these distortions and to make this sector more competitive is thus expected to promote a more efficient allocation of resources through fiercer competition between carriers, thus lowering 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 favor a more flexible and competitive environment (see Winston, 1993, for an overview). As pointed out by Boylaud and Nicoletti (2001), the general tendency among OECD countries has been similar in recent years as greater competition between road haulers has been promoted. More competition in the transport sector is also a key objective ranking high on the European Union's agenda, especially for the rail freight industry (European Commission, 2001).

Despite the above economic rationale underlying deregulation, a thorough assessment of the possible welfare and distributional impacts of opening a sector to competition is fundamental. For such an assessment to be as accurate as possible it should, in addition to the direct effects, also take into account most of the indirect effects that such a policy 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)

Given these considerations, it is surprising that no study has yet investigated the efficiency of transport policies by taking into account their *spatial impacts*. Such a neglect might well be a serious issue since the very nature of the transportation activity is spatial, and since the bulk of the empirical evidence suggests that manufacturing firms' locational decisions are still largely based on the accessibility to input and output markets (e.g., Head and Mayer, 2004; Redding and Venables, 2004). This observation has a major implication that has been very much overlooked in the literature until now: *transport policies affect not just consumer prices and the volume of commodity flows across regions, but also the location of industry.*[1] Since the location of economic activity has important distributional and overall welfare implications (Matsuyama and Taka-hashi, 1998; Ottaviano and Thisse, 2002; Charlot *et al.*, 2006), analyses of the potential benefits

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[1]Even though freight rates have dramatically declined since the Industrial Revolution, there are still places where transport costs are lower than in others, thus making these places attractive to consumers and firms. Furthermore, the success of the gravity model in predicting commodity flows across space indeed suggests that the "death of distance" is premature (Leamer and Levinsohn, 1995; Disdier and Head, 2007). This confirms the idea that transport costs still matter for the spatial organization of the economy (Anderson and van Wincoop, 2004).

of transport policies that hold the spatial distribution of activity fixed may be misleading. This is even more so for integrating economic blocks that have committed themselves to a regional cohesion objective, as is the case for the European Union under the Amsterdam Treaty of 1997.

The purpose of this paper is to study how the opening of the transport sector to more competition affects social welfare once it is recognized that firms and mobile agents are free to relocate in the long run in response to 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, a more competitive transport sector reduces static losses arising from market power in both the transport and the manufacturing sectors; but, in the long run, it generates dynamic dead-weight losses because of a sub-optimal redistribution of industrial activity across regions. In order to investigate in depth such short- and long-run consequences of transport policies in a spatial economy, we must account for, 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 manufacturing firms and consumers in response to carriers' pricing policies. By focusing on the interactions 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 different transport policies affect the well-being of economic agents, especially consumers and carriers.

Note that our approach has a broader scope than standard cost-benefit analyses used in transport economics in that we consider the impact of transport policies not only upon commodity flows but upon wage rates as well. This point is worth emphasizing because deregulation and antitrust policies typically focus on consumers' surplus gains, neglecting far 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 when 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 transport deregulation

policies. Interestingly, they are all related to the spatial organization of the economy, thereby highlighting how crucial this factor is for evaluating such policies. First, we show that the demand for transport services depends on the spatial distribution of the manufacturing sector. Rather unexpectedly, *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.[2] 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, or 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 freight rates for manufactured goods, thus dampening 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 policy makers and governments that has not been considered so far. Last, we show that the long-run welfare impacts of transport deregulation are opposite to the short-run ones, both with respect to consumer welfare and carriers' aggregate profits. More precisely, once the dependence of the spatial distribution on the competitive environment in the transport sector is taken into account, deregulation leads to aggregate consumer welfare losses, higher aggregate profits in the transport sector, and more inequality among consumers in different regions.[3] We thus uncover a new trade-off for regulators and antitrust authorities: *if, in the short run, liberalizing the transport sector is beneficial to consumers, the reverse holds true in the long run*. Although most readers would probably expect the long-run losses of transport deregulation to be of second order magnitude when compared to the short-run gains, our analysis reveals that the opposite might well be true.

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[2]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.

[3]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 elimated a fraction of rents earned by carriers under regulation. Blair *et al.* (1986) estimate that the deregulation of 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 transport deregulation on consumer prices. Turning to carriers' profits, Winston (1993) provides evidence that suggests that railroad carriers may have actually gained from deregulation.

It is worth stressing that this result is more than a mere theoretical curiosum, since the spatial distribution of economic activity is indeed sensitive to changes in transport and trade costs. In this respect, Teixeira (2006) shows in an econometric model of the Portuguese economy that better transport infrastructure has resulted in more spatial inequality across regions. The resulting welfare consequences need, therefore, to be taken into account when assessing the desirability of this evolution, especially in the light of the regional cohesion objective.

Despite the foregoing observations, we would be the last to claim that the transport sector should remain regulated. Instead, our hope is that our analysis will draw the attention of public decision makers on a far too neglected issue when designing transport policies.

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 detailed welfare analysis of transport deregulation and discusses our main findings. Finally, Section 6 concludes.

2 The model

To investigate the interdependencies between transport deregulation and the spatial distribution of economic activity requires a setting in which the reciprocal impacts of freight rates on firms' and consumers' location choices may be analyzed. This is precisely the framework that economic geography provides (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 tractable and useful for welfare analysis, which makes it especially well suited as a building-block for 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 of mobile workers 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. λ is exogenous; and a *long-run equilibrium* when they are mobile, i.e. λ is endogenous.

2.1 Preferences

All workers have the same quasi-linear utility over a homogeneous good and a continuum of horizontally differentiated varieties.[4] 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 set $\mathcal{V}$ (with measure n) of 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. Let $\mathcal{V}_H$ (with measure n_H) and $\mathcal{V}_F$ (with measure n_F) denote the sets of varieties produced in regions H and F, respectively. A consumer residing in region $r = H, F$ then solves the following problem:

$$
\max_{q_{sr}(v)} \quad U_r = \sum_{s=H,F} \left[\alpha \int_{\mathcal{V}_s} q_{sr}(v) \mathrm{d}v - \frac{\beta - \gamma}{2} \int_{\mathcal{V}_s} [q_{sr}(v)]^2 \mathrm{d}v \right] - \frac{\gamma}{2} \left[\sum_{s=H,F} \int_{\mathcal{V}_s} q_{sr}(v) \mathrm{d}v \right]^2 + q_0
$$

$$
\text{s.t.} \quad \sum_{s=H,F} \int_{\mathcal{V}_s} p_{sr}(v) q_{sr}(v) \mathrm{d}v + q_0 = y_r + \bar{q}_0
$$

where $\alpha > 0$, $\beta > \gamma > 0$ are parameters (the condition $\beta > \gamma$ implies that consumers have a preference for variety); $q_{sr}(v)$ and $p_{sr}(v)$ are the quantity and the consumer price of variety v in region r when it is produced in region s; 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:

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

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

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[4]Although quasi-linear preferences rank far behind homothetic preferences in general equilibrium models of trade, Dinopoulos *et al.* (2006, p.22) show that "quasi-linear preferences behave reasonably well in general-equilibrium settings".

where

$$P_r \equiv \int_{\mathcal{V}_r} p_{rr}(v)\mathrm{d}v + \int_{\mathcal{V}_s} p_{sr}(v)\mathrm{d}v \qquad (2)$$

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 a 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.[5] Given the foregoing assumptions, skilled labor market clearing in each region implies that

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

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. 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 λ. 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 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

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[5]When the marginal unit input requirement m is strictly positive, what follows continues to hold true provided that α is replaced by $\alpha - m$ in the demand functions (Ottaviano *et al.*, 2002).

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, firm v located in region r maximizes profits given by:

$$\Pi_r(v) = p_{rr}(v)q_{rr}(v)\left(\frac{A}{2} + \phi n_r\right) + \left(p_{rs}(v) - t\right)q_{rs}(v)\left(\frac{A}{2} + \phi n_s\right) - \phi w_r \tag{3}$$

where $p_{rs}(v)$ is the producer price of variety v produced in region r and sold in $s \neq r$. Because skilled workers are geographically mobile, aggregate regional incomes and demands depend on their spatial distribution.

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 τ is also the marginal production cost of a carrier with respect to the volume of hauling. Finally, we assume that the number m of carriers prior to deregulation is small due to entry regulations, and that there are no fixed costs.[6]

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

$$\Pi_k^T = (t - \tau)q_k. \tag{4}$$

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. In the first stage, carriers choose the quantities

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[6]These assumptions describe fairly well the trucking industry before deregulation, in which scale economies appear to be relatively small and in which there were many regulations (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."

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. Though peculiar, two reasons motivate our choice. First, taking this effect into account makes the formal analysis much more involved without adding any further insights. Indeed, as shown Section 5.2.2, if carriers take into account how their supply of transport services affects the spatial distribution of economic activity would make our main results only stronger. Second, handling such an effect is probably not 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 and hence on demand for transport services.

3.1   Prices and wages

All manufacturing firms maximize their profits (3) with respect to the prices $p_{rr}(v)$ and $p_{rs}(v)$ on each market separately. For any given value of t, the first-order conditions yield the following profit-maximizing prices:

(i) intraregional prices:

$$p_{rr}(P_r) = \frac{a + cP_r}{2(b + cn)} \tag{5}$$

(ii) interregional prices:

$$p_{sr}(P_r) = p_{rr}(P_r) + \frac{t}{2} \qquad s \neq r. \tag{6}$$

Since all firms in a region face the same price index, (5) and (6) show that they will set identical prices. We can hence alleviate notation by dropping the variety index v in what follows. Expressions (5) and (6) further 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:

$$P_r^* = n_r p_{rr}(P_r^*) + n_s p_{sr}(P_r^*). \tag{7}$$

Under the assumption of bilateral trade between regions, the equilibrium price indices can be found by solving (7) for P_r^* and using expressions (5) and (6). This yields:

$$p_{rr}^* = \frac{2a + ctn_s}{2(2b + cn)} \qquad \text{and} \qquad p_{sr}^* = p_{rr}^* + \frac{t}{2}. \tag{8}$$

9

Substituting the equilibrium prices (5) and the price index (2) into the demands (1), the equilibrium consumption levels can be expressed as follows:

(i) intraregional demands:

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

(ii) interregional demands:

$$q_{sr}^* = q_{rr}^* - \frac{(b+cn)t}{2} = (b+cn)(p_{sr}^* - t). \tag{10}$$

Thus, a higher freight rate t 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 and the 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

$$t \leq \min\left\{\frac{2a}{2b+cn_H}, \frac{2a}{2b+cn_F}\right\}$$

must hold for both interregional demands to be positive. Because the equilibrium prices depend on the firm distribution, the occurrence of interregional trade also depends on the spatial distribution of the industry (via n_H and n_F). 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

$$t < t_{\text{trade}} \equiv \frac{2a}{2b+cn} \tag{C1}$$

which we assume to hold throughout the paper.[7]

Turning finally 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 (9) and (10) into the profits (3), and solving for the wages gives

$$w_r^* = \frac{b+cn}{\phi}\left[\left(\frac{A}{2} + \phi n_r\right)(p_{rr}^*)^2 + \left(\frac{A}{2} + \phi n_s\right)\left(p_{ss}^* - \frac{t}{2}\right)^2\right] \tag{11}$$

for $r = H, F$.

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[7]To improve readability, we single out some frequently cited conditions involving structural parameters by indexing the equation numbers with 'C'.

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 (8).[8] Some straightforward calculations show that the total volume of trade is as follows:

$$
\begin{aligned}
Q(\lambda, t) &= n_H \left(\frac{A}{2} + n_F \phi \right) q^*_{HF} + n_F \left(\frac{A}{2} + n_H \phi \right) q^*_{FH} \\
&= \rho_0 + \rho_2 \lambda (1 - \lambda) \eta - [\rho_1 + \rho_2 \lambda (1 - \lambda)] t.
\end{aligned}
\tag{12}
$$

The price-elasticity of transport demand is then given by

$$
\varepsilon(\lambda, t) \equiv -\frac{\partial Q}{\partial t} \frac{t}{Q} = \frac{[\rho_1 + \rho_2 \lambda (1 - \lambda)] t}{\rho_0 - \rho_1 t + \rho_2 \lambda (1 - \lambda)(\eta - t)}
\tag{13}
$$

where ρ_0, ρ_1, ρ_2 and η are strictly positive bundles of parameters defined in Appendix A.1. They satisfy the inequality

$$
\rho_0 - \eta \rho_1 > 0.
\tag{C2}
$$

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 λ is that all interregional demands are positive, which holds true as long as condition (C1) is satisfied. Note furthermore that $\eta < t_{trade}$ when $A > L$.[9]

It is worth noting that both the intercept and the absolute value of the slope decrease with λ over the interval $[1/2, 1]$. 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 λ 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

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[8]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.

[9]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 represents the larger share of the economy.

to increase trade. Despite that, we can show that the transport demand function displays an important property with respect to λ. Using (13) and (C2), it is readily verified that

$$\frac{\partial \varepsilon(\lambda, t)}{\partial \lambda} = \frac{-(2\lambda - 1)(\rho_0 - \eta \rho_1)t\rho_2}{Q^2} < 0 \tag{14}$$

which implies that *the price-elasticity ε 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 flatter, thereby lowering the price-elasticity. As the latter effect always dominates the former, the price elasticity falls when λ increases.

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

$$t(Q) = \frac{\rho_0 + \rho_2 \lambda(1 - \lambda)\eta}{\rho_1 + \rho_2 \lambda(1 - \lambda)} - \frac{Q}{\rho_1 + \rho_2 \lambda(1 - \lambda)}. \tag{15}$$

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 (15) is linear, this game has a single Nash equilibrium in pure strategies. For any given λ, 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 (13), this yields a unique and symmetric solution given by

$$t^*(\lambda) = \tau + \frac{\rho_0 + \rho_2 \lambda(1 - \lambda)\eta - [\rho_1 + \rho_2 \lambda(1 - \lambda)]\tau}{(m + 1)[\rho_1 + \rho_2 \lambda(1 - \lambda)]}. \tag{16}$$

The first term in (16) is the carrier's marginal cost, and the second the carrier's markup. In Appendix A.7, we show that a sufficient condition for the markup to be positive and the trade condition (C1) to jointly hold, regardless of the spatial distribution λ, is given by

$$\tau \leq \tau_{\text{trade}}(m) \equiv \frac{a(2bm - cn)}{bm(2b + cn)} \tag{C3}$$

which we assume to hold in what follows.

Note, finally, that since

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

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by condition (14), the equilibrium freight rate increases in λ 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.[10] We will show below that neglecting the interdependencies between freight rates and industry location has indeed important consequences when studying the impact of transport deregulation on industry location and welfare.

Second, as can be seen from (C3), $\tau_{\text{trade}}(m)$ is increasing in m which shows that the restrictions on carriers' marginal cost for bilateral trade to occur get 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 λ, the equilibrium markup rate decreases with the number of carriers because competition gets fiercer. Furthermore, $t^*(\lambda) \to \tau$ as $m \to \infty$, thus showing that marginal cost pricing prevails when the number of carriers gets arbitrarily large. Because $\tau_{\text{trade}}(m) \to t_{\text{trade}}$ when $m \to \infty$, economic geography models 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 (or fully deregulated) sector.

Last, when τ is large, the trade condition (C3) 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

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[10]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.

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impossible for exporters because local competition is too fierce.[11] At the same time, carriers must set a non-negative markup to break even. When τ 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: 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 become 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.[12]

For a given firm distribution, the *short-run market equilibrium* is defined by (8), (11) and (16). As discussed above, it may be viewed as an equilibrium in which agents' locations are exogenously 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 via the selection of the most efficient firms), 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 τ.[13] When the distribution of activity is fixed, in a setting *à la* Cournot such as ours, increasing m or decreasing τ leads to lower freight rates, which is precisely the effect we want to apprehend. Hence, since both have the same qualitative impact on the manufacturing sector, we can restrict ourselves to changes in m only to investigate the impact on λ.

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[11]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."

[12]See Behrens (2005) for a more detailed analysis of asymmetric trade patterns in a similar framework.

[13]Empirical evidence regarding those two objectives may be found in Morrison and Winston (1999) who study the deregulation of US 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 τ. 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, 1986, pp.3-4). A third objective in the US 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).

As in most economic geography models (Krugman, 1991; Fujita *et al.*, 1999), 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 highest utility level evaluated at the equilibrium prices (5) and at the equilibrium wages (11). As shown by Ottaviano *et al.* (2002), the welfare of a consumer/worker living in region $r = H, F$ 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:

$$V_r^* = S_r^* + w_r^* + \bar{q}_0 \tag{17}$$

where

$$S_r^* = \frac{a^2 n}{2b} - a(n_r p_{rr}^* + n_s p_{sr}^*) + \frac{b+cn}{2} \left[n_r (p_{rr}^*)^2 + n_s (p_{sr}^*)^2 \right] - \frac{c}{2}(n_r p_{rr}^* + n_s p_{sr}^*)^2 \tag{18}$$

is the consumer surplus evaluated at the equilibrium prices. Because (17) 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.[14]

The utility differential driving the location choices of the skilled is given by

$$\Delta V^*(\lambda) \equiv V_H^*(\lambda) - V_F^*(\lambda). \tag{19}$$

Thus, a *spatial equilibrium* arises at: (i) $\lambda^* \in [1/2, 1]$ when $\Delta V^*(\lambda^*) = 0$; or (ii) $\lambda^* = 1$ if $\Delta V^*(1) \geq 0$. Such an equilibrium always exists because V_r^* is a continuous function of λ. An interior equilibrium is stable if and only if the slope of the indirect utility differential (19) 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 ΔV^* at (5), (6), and (11), the indirect utility differential becomes

$$\Delta V^*(\lambda) = \frac{n(b+cn)}{2\phi(2b+cn)^2} \left(\lambda - \frac{1}{2} \right) t^*(\lambda) \left[-\varepsilon_1 t^*(\lambda) + \varepsilon_2 \right] \tag{20}$$

where ε_1 and ε_2 are strictly positive bundles of parameters whose expressions are given in Appendix A.1. It is easy to check that

$$\varepsilon_2 - \eta\varepsilon_1 > 0, \tag{C4}$$

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

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[14]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.

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

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

The threshold $\tau^s(m)$ is called the *sustain point* by analogy with the terminology used in standard economic geography models (Fujita *et al.*, 1999). Observe that for both the agglomerated and the dispersed configurations to arise as a spatial equilibrium when transport and/or trade costs vary, it must be that $\tau^s(m) < \tau_{\text{trade}}(m)$. Indeed, when $\tau^s(m) > \tau_{\text{trade}}(m)$, there is always agglomeration under bilateral trade, a case that arises when A is sufficiently small. By contrast, $\tau^s(m) < \tau_{\text{trade}}(m)$ when the mass A of unskilled workers exceeds some threshold value $\overline{A}$, 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 $\partial(\Delta V^*)/\partial\lambda < 0$ when evaluated at $\lambda^* = 1/2$, which yields the condition

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

The threshold $\tau^b(m)$ is called the *break point*. As in the foregoing, $\tau^b(m) < \tau_{\text{trade}}(m)$ 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 τ-values for which stable partially agglomerated equilibria arise. The intuition is that *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 of τ-values for which interior equilibria arise 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 ($m \to \infty$). 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 shown in the foregoing, the economy may involve partial agglomeration of the manufacturing sector ($1/2 < \lambda^* < 1$), which occurs when $\tau^b(m) > \tau >$

$\tau^s(m)$. The equilibrium distribution λ satisfies the equation $-\varepsilon_1 t^*(\lambda) + \varepsilon_2 = 0$, which is quadratic in λ with two solutions symmetric about $1/2$. The equilibrium value of $\lambda > 1/2$ is then given by

$$\lambda^*(\tau, m) = \frac{1}{2} + \frac{1}{2}\sqrt{\frac{\Lambda_1}{\Lambda_2}} \tag{21}$$

where Λ_1 and Λ_2 are bundles of parameters defined in Appendix A.1. It is readily verified that $\lambda^* < 1$ when $\tau > \tau^s(m)$ and that $\lambda^* > 1/2$ when $\tau < \tau^b(m)$.[15] Therefore, $1/2 < \lambda^*(\tau, m) < 1$ if and only if $\tau^b(m) > \tau > \tau^s(m)$. Furthermore, we have

$$\frac{\partial(\Delta V^*)}{\partial \lambda}\Big|_{\lambda=\lambda^*} = \frac{-\varepsilon_2 \Lambda_1 (\Lambda_2/\rho_2)}{2(m+1)\varepsilon_1^2(\rho_0 - \eta\rho_1)}$$

which, under condition (C2), implies that the foregoing equilibrium is stable whenever $\tau^b(m) > \tau > \tau^s(m)$. Finally, we obtain

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

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

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

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 larger local demands since foreign firms face higher costs of exporting. Consequently, *changes in the spatial organization of the economy are no longer catastrophic* as agglomeration forces are now partially balanced by additional dispersion forces arising from the price-setting behavior 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 usually never arise in standard economic geography models with exogenous freight rates (Krugman, 1991; Ottaviano *et al.*, 2002). Furthermore, when the transportation technology 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.

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[15] Note that $\Lambda_2(\tau) > 0$ if and only if $\tau > \tau^s(m)$, while $\Lambda_1(\tau) > 0$ if and only if $\tau < \tau^b(m)$.
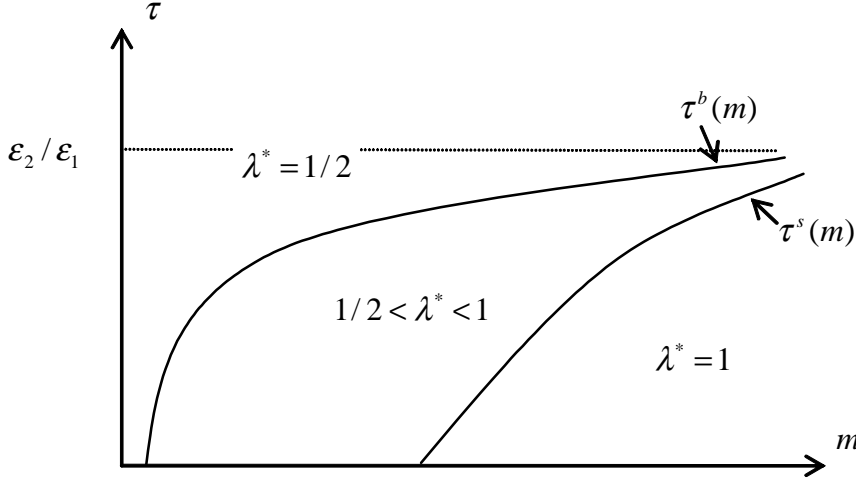
Figure 1. Spatial equilibria in (m, τ)-space

Accordingly, our findings, illustrated in Figure 1, can be summarized as follows.

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

5 Should the transport sector be more competitive?

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 is given by the sum of consumer surpluses and wages across individuals:

$$
\begin{aligned}
W(\lambda) &= \lambda L[S_1^*(\lambda, t^*(\lambda)) + w_1^*(\lambda, t^*(\lambda))] + (1 - \lambda)L[S_2^*(\lambda, t^*(\lambda)) + w_2^*(\lambda, t^*(\lambda))] \\
&\quad + \frac{A}{2}[S_1^*(\lambda, t^*(\lambda)) + S_2^*(\lambda, t^*(\lambda)) + 2] + (A + L)\overline{q}_0.
\end{aligned}
\tag{22}
$$

As mentioned 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 one, 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.

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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 is obtained in our framework because

$$\frac{\mathrm{d}P_r^*}{\mathrm{d}m} = \left(n\underset{+}{\frac{\partial p_{rr}^*}{\partial t^*}} + \frac{n_s}{2} \right) \underset{-}{\frac{\partial t^*}{\partial m}} < 0$$

by using (2) and (8). 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 λ, 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 tedious, calculations show that $\partial W/\partial t < 0$ over the domain $t < t_{\mathrm{trade}}$. In words, for any given firm distribution, aggregate consumer welfare rises when freight rates decline even though wages decrease. As a result, we have

$$\frac{\mathrm{d}W}{\mathrm{d}m} = \underset{-}{\frac{\partial W}{\partial t}} \underset{-}{\frac{\partial t^*}{\partial m}} > 0, \tag{23}$$

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 section with a fixed distribution. However, neither full agglomeration nor dispersion seems to adequately describe the space-economy in the real world, hence we focus on partial agglomeration.

5.2.1   Commodity prices

When the location of firms and skilled workers can 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 (12) vary with λ. In particular, as shown in Appendix A.2, price indices vary according to regions and in opposite directions:

$$\frac{\mathrm{d}P_H}{\mathrm{d}m} = -\frac{\mathrm{d}P_F}{\mathrm{d}m} < 0.$$

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) the 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, as shown in Appendix A.3:

$$\frac{\mathrm{d}p^*_{HH}}{\mathrm{d}m} < 0 \qquad \text{and} \qquad \frac{\mathrm{d}p^*_{FF}}{\mathrm{d}m} > 0.$$

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

Proposition 4 *When the spatial equilibrium involves partial agglomeration, fiercer competition in the transport sector reduces commodity 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

We now study how the aggregate consumer welfare changes with the number of carriers m. Differentiating W with respect to m yields

$$\frac{\mathrm{d}W}{\mathrm{d}m} = \underbrace{\frac{\partial W}{\partial t}}_{-}\underbrace{\frac{\partial t^*}{\partial m}}_{-} + \underbrace{\frac{\partial W}{\partial t}}_{-}\underbrace{\frac{\partial t^*}{\partial \lambda}}_{+}\underbrace{\frac{\partial \lambda^*}{\partial m}}_{+} + \underbrace{\frac{\partial W}{\partial \lambda}}_{-}\underbrace{\frac{\partial \lambda^*}{\partial m}}_{+} \tag{24}$$

in which two additional terms appear when compared with (23). The first one captures the indirect effect that an increase in m has on the equilibrium freight rate, via a change in the spatial equilibrium ($\partial \lambda^*/\partial m$). Given what we have seen in the previous section, the signs are as indicated in (24) 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. We show in Appendix A.4 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 yields too much agglomeration.*

Although the sign of (24) is a priori ambiguous, due to positive short-run gains and negative long-run losses, we show in Appendix A.5 that it may be clearly signed: $\mathrm{d}W/\mathrm{d}m < 0$. 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.*[16] We may thus conclude as follows:

Proposition 5 (harmful deregulation) *When the spatial equilibrium involves partial agglomeration, transport deregulation lowers aggregate consumer welfare.*

Thus, contrary to a general belief, liberalizing the transport sector at the interregional level is detrimental to consumers when changing this sector's market structure induces a redistribution of activities across space. The spatial effects of transport deregulation are at the heart of the explanation: a more competitive transport sector induces more agglomeration, hence raising freight rates and, thereby, reducing aggregate consumer welfare.

Some comments are in order. First, 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

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[16] The entry of a larger number of carriers may lead to a higher welfare level at the fully agglomerated outcome than what it was in the case of 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 in the real world.

consumer.[17]

Second, it is worth noting that our result also holds in the setting where carriers take into account how their supply of transport services affects the spatial distribution of industry. To see this, note that

$$\frac{\mathrm{d}\pi_k^T(q_k, \lambda^*(Q))}{\mathrm{d}q_k} = \frac{\partial \pi_k^T}{\partial q_k} + \frac{\partial \pi_k^T}{\partial \lambda^*}\frac{\partial \lambda^*}{\partial q_k}.$$

The first term is nil at the Nash equilibrium in the transport sector when firms disregard their impact on the spatial distribution of economic activity. As shown in Appendix A.8, in the second term, $\partial \pi_k^T/\partial \lambda^*$ is always positive at the quantity equilibrium when $1/2 < \lambda^* < 1$. This is because the demand for transport services becomes more inelastic as the degree of agglomeration rises. Furthermore, $\partial \lambda^*/\partial q_k$ is also positive since an increase in q_k decreases t^* which, as established before, increases λ^*. Hence, when firms account for their impact on industry location, they further increase their supply of transport services, thereby sparking more agglomeration and reducing consumer welfare.

Third, transport policy also aims at enhancing technological efficiency by selecting the most efficient carriers, as well as by promoting a more flexible labor market and the adoption of new technologies. This should translate into lower costs and, in turn, lower freight rates and consumer prices. We can evaluate the impact of such a policy by studying the effect of a fall in marginal cost τ on consumer welfare. Standard calculations reveal that

$$\frac{\mathrm{d}W}{\mathrm{d}\tau} = \frac{\mathrm{d}W}{\mathrm{d}m}\frac{m}{(\varepsilon_2 - \varepsilon_1\tau)\varepsilon_1} > 0. \tag{25}$$

For reasons similar to the ones mentioned above, a fall in carriers' marginal cost favors the agglomeration of manufacturing firms, thus inducing higher freight rates and lower welfare.

Finally, as shown by (25), the harmful long run effects of deregulation may be offset by levying a tax on transportation that increases carriers' marginal cost. Such a policy mix dominates pure deregulation because it can reduce welfare losses sparked by the redistribution of activities without having the baggage of limiting exit of inefficient firms and entry of efficient firms that regulation usually has.

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

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[17]When fixed costs are incurred in terms of skilled labor, the analysis becomes more involved. This is because both the manufacturing and the transport sectors compete for skilled labor, so that the entry of a new carrier leads to a decrease in the total mass of varieties. The welfare effects are then ambiguous and depend on the trade-off between transportation resource savings and consumers' preference for variety.

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 via changes in consumer prices and wages. We have seen that it is only under extreme spatial configurations (full 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' location.

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 (8) and (18), it is straightforward to check that:

$$\frac{\mathrm{d}S_H^*}{\mathrm{d}m} = \frac{\partial S_H^*}{\partial p_{HH}} \underbrace{\left(\underbrace{\frac{\partial p_{HH}^*}{\partial m}}_{-} + \frac{1}{2} \underbrace{\frac{\partial t^*}{\partial m}}_{-} \right)} > 0.$$

Because, as shown in Appendix A.6, $\mathrm{d}(S_H^* + S_F^*)/\mathrm{d}m < 0$ it must be that $\mathrm{d}S_F^*/\mathrm{d}m < 0$. Since their wage does not vary with respect to their location, 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.6 that

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

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

Proposition 6 *When the spatial equilibrium involves partial agglomeration, transport deregulation harms all workers except the immobile residing in the large region.*

Two remarks are in order. First, because $\mathrm{d}S_H^*/\mathrm{d}m - \mathrm{d}S_F^*/\mathrm{d}m > 0$, at any interior spatial equilibrium it must be that $\mathrm{d}w_F^*/\mathrm{d}m - \mathrm{d}w_H^*/\mathrm{d}m > 0$. 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 finally 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 λ are fixed, differentiating Π^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:

$$\frac{\mathrm{d}\Pi^T}{\mathrm{d}m} = \underbrace{\frac{\partial\Pi^T}{\partial m}}_{-} + \frac{\partial\Pi^T}{\partial\lambda}\underbrace{\frac{\partial\lambda^*}{\partial m}}_{+}$$

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

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

with $\partial Q/\partial\lambda \gtreqless 0$ if and only if $t^*(m) \gtreqless \eta$. 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:

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

where the inequality is due to (C2) and (C4). Note that such an effect is unexpected, because the direct effect is shown to be always negative. Nevertheless, as expected, individual profits decrease with the number of operating carriers:

$$\frac{\mathrm{d}(\Pi^T/m)}{\mathrm{d}m} = -\frac{\varepsilon_1\tau - \varepsilon_2}{\varepsilon_2 - \varepsilon_1\eta}\frac{\mathrm{d}\Pi^T}{\mathrm{d}m} < 0$$

because of (C2) and (C4). We may thus conclude as follows.

Proposition 7 *When the spatial equilibrium involves partial agglomeration, transport deregulation raises aggregate 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 liberalization crucially hinge upon the mobility of firms and workers, as well as on changes in factor prices.* Whereas liberalizing transport policies are unambiguously consumer welfare-enhancing in the short run, when the spatial distribution of economic activity is fixed, transport deregulation policies 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, *liberalization 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.

Two final comments are in order. First, 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 find plausible 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 is detrimental to all consumers in the long run. Second, one may wonder to what extent our results are driven by our modeling 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 modeling choices only. It further suggests that our main results are still likely to hold in settings that are weakly 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 strongly suggest that transport deregulation affects the distribution of economic activity across regions and countries, a variable neglected so far even in "good" assessments of such policies.

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Appendix

A.1. Parameter-bundle definitions:

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

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

$$\varepsilon_1 \equiv Ac(2b+cn) + \left(6b^2 + 6cnb + c^2n^2\right)\phi > 0$$

$$\varepsilon_2 \equiv 4a(3b+2cn)\phi > 0$$

$$\Lambda_1 \equiv (4\rho_1 + \rho_2)[(m+1)\varepsilon_2 - m\varepsilon_1\tau] - (4\rho_0 + \rho_2\eta)\varepsilon_1$$

$$\Lambda_2 \equiv -\rho_2[\varepsilon_1(m\tau + \eta) - (m+1)\varepsilon_2]$$

A.2. Price aggregates as a function of m: One can check that

$$\frac{\mathrm{d}P_H}{\mathrm{d}m} = -\frac{\mathrm{d}P_F}{\mathrm{d}m} = \frac{-(\varepsilon_2 - \varepsilon_1\tau)(\rho_0 - \eta\rho_1)\varepsilon_2 n(b+cn)}{\rho_2[m(\varepsilon_2 - \varepsilon_1\tau) + \varepsilon_2 - \varepsilon_1\eta]^2(2b+cn)\sqrt{\Lambda_1/\Lambda_2}} < 0$$

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

A.3. Prices as a function of m: We have

$$\frac{\mathrm{d}p_{HH}^*}{\mathrm{d}m} = \underbrace{\frac{\partial p_{HH}^*}{\partial \lambda^*}}_{-} \underbrace{\frac{\partial \lambda^*}{\partial m}}_{+} + \underbrace{\frac{\partial p_{HH}^*}{\partial t^*}}_{+} \underbrace{\frac{\partial t^*}{\partial m}}_{-} + \underbrace{\frac{\partial p_{HH}^*}{\partial t^*}}_{+} \underbrace{\frac{\partial t^*}{\partial \lambda^*}}_{+} \underbrace{\frac{\partial \lambda^*}{\partial m}}_{+}.$$

It is then readily verified that

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

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

$$\frac{\mathrm{d}p_{HH}^*}{\mathrm{d}m} < 0 \quad \Rightarrow \quad \frac{\mathrm{d}p_{FF}^*}{\mathrm{d}m} > 0.$$

A.4. Welfare as a function of λ: It is easy to see that

$$\frac{\partial W}{\partial \lambda} = -\frac{n^2(b+cn)t(2\lambda-1)\left[Ac(8b+3cn)t + \left((24b^2+16cnb+3c^2n^2)\,t - 16a(3b+cn)\right)\phi\right]}{8(2b+cn)^2}.$$

The sign of this expression depends on the sign of

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

which is positive (resp., negative) if $t > t^o$ (resp., $t < t^o$), with

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

Because $t^o < t^*(\lambda^*) = \varepsilon_2/\varepsilon_1$, it must be that $\partial W/\partial \lambda < 0$ at any partially agglomerated equilibrium.

A.5. Welfare as a function of m:

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

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

A.6. Consumer surplus and welfare: It is readily verified that

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

and

$$\frac{\mathrm{d}(w_H^*+S_H^*)}{\mathrm{d}m} = -\frac{(\varepsilon_2-\varepsilon_1\tau)(\rho_0-\eta\rho_1)\varepsilon_2c^2n^2a\phi\Lambda_1(2n^2c\phi+5bn\phi+2bA)(b+cn)}{2\rho_2\varepsilon_1\phi[m(\varepsilon_2-\varepsilon_1\tau)+\varepsilon_2-\varepsilon_1\eta]^2(2b+cn)^2\Lambda_1} < 0.$$

A.7. Markups and the trade condition: 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 ρ_i and η, 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 λ on $[1/2, 1]$. Evaluating the threshold $\bar{\tau}$ at $\lambda = 1/2$ then yields the sufficient condition

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

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

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

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

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

Finally, one can check that $\tau_{\text{trade}}(m) < \bar{\tau}(1/2)$ 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 $\lambda \in [1/2, 1]$.

A.8. Sign of $\partial \pi_k^T / \partial \lambda^*$: In this appendix, we show that at any interior equilibrium, the carriers' profits are non-decreasing in λ for any given value of m.

To establish our claim, we need to evaluate $\partial \Pi_k^T / \partial \lambda$ at $m = \overline{m}$, taking into account the inverse demand schedule $t = t(Q)$. Since all firms are symmetric, and since a change in λ affects all carriers identically, we can evaluate this expression at $q_k = Q/\overline{m}$. Using expressions (12) and (16), the derivative of the carrier's profit with respect to λ is evaluated as follows:

$$\frac{\partial \Pi_k^T}{\partial \lambda} = -\frac{Q(2\lambda - 1)(Q - \rho_0 + \eta\rho_1)\rho_2}{\overline{m}[\rho_1 + \lambda(1-\lambda)\rho_2]}.$$

Since $Q > 0$, $\lambda \geq 1/2$ and $\rho_2 > 0$, and because the denominator is positive, we just have to check the sign of $Q - \rho_0 + \eta\rho_1$ when evaluated at $Q^* = Q(t^*)$. Some straightforward calculations show that

$$Q^* - \rho_0 + \eta\rho_1 = (\eta - t^*)[\rho_1 + \lambda(1-\lambda)\rho_2].$$

Since we know from condition (C4) that $\eta < \varepsilon_2/\varepsilon_1 = t^*$ at an interior equilibrium, it follows that $Q^* - \rho_0 + \eta\rho_1 < 0$. Consequently $\partial \Pi_k^T / \partial \lambda > 0$ when $Q = Q^*$ which establishes the result.

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