Productivity Growth and Patterns of Industry Location Without Scale Effects

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Abstract

This paper investigates the relationship between geographic patterns of economic activity and productivity growth in a two region model of trade and endogenous growth without scale effects. At the core of the model is the production and in-house innovation activities of manufacturing firms and, in a world of transport costs, imperfect knowledge dispersion and perfect capital mobility, these activities are located independently in the region that provides the lowest associated cost. In contrast to the existing literature, we remove scale effects by shifting the focus from aggregate research and development activity to innovation at the level of individual product lines and find that although industry concentration raises the level of product variety, it reduces the rate of productivity growth so that the pace of economic growth is highest when industry is equally dispersed across regions. We also study the effects of greater economic integration between regions and find that increases in the freeness of trade and the level of knowledge dispersion both have negative effects on productivity growth while raising the level of product variety. These opposing effects for growth and product variety lead to mixed results for the impacts of economic integration on regional welfare.

Key Words: Industry Concentration, Industry Share, Productivity Growth, Scale Effect
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1 Introduction

In recent years there has been considerable interest in understanding the implications of the geographic distribution of industrial activity for patterns of economic growth at the local, regional, and international levels. Indeed, a general consensus that industry concentration promotes economic growth appears to have developed within the theoretical literature of the "new economic geography" (Baldwin and Martin, 2004). The available empirical evidence is often at odds with this consensus, however, as many empirical studies report a negative relationship between the pace of economic growth and industry concentration (Abdel-Rahman et al. 2006; Bosker, 2007; Gardiner et al. 2010). One possible source of this discrepancy is the close connection between a scale effect, whereby growth is positively linked with the size of the labor force, and the positive relationship between industry concentration and growth derived by existing theoretical models. In this paper we re-examine the relationship between industry concentration and economic growth using a novel approach that shifts the focus from aggregate research and development (R&D) activity to innovation at the level of individual product lines thereby sterilizing the scale effect. Within this framework we find that while industry concentration raises the level of product variety, it reduces the rate of productivity growth so that the pace of economic growth is highest when industry is equally dispersed across regions.

More specifically, we develop a two region model of trade and endogenous productivity growth that focuses on the production and in-house innovation activities of manufacturing firms. In a world characterized by perfect capital mobility, firms are free to locate these activities independently across regions with the objective of minimizing associated costs in order to raise profits on the margin. As a result, aggregate patterns of production and innovation activity are determined endogenously according to the freeness of trade and the level of knowledge dispersion between regions. The equilibrium pattern of economic activity features a concentration of production and the full agglomeration of innovation in the larger of the two regions, as measured by labor endowments. Moreover, the level of product variety and the rate of productivity growth are closely linked with this distribution of industrial activity. In particular, a rise in industry concentration improves knowledge dissemination from production to innovation in the larger region and thus lowers the cost of process innovation. With this cost reduction, however, the total number of manufacturing firms and associated fixed costs increase thereby lowering the firm-level of innovation employment that can be supported by the overall economy. This mechanism leads to a negative relationship between industry concentration and productivity growth. In addition, we find that increased regional integration arising from either a decrease in transport costs or an increase in knowledge dispersion has effects similar to greater industry concentration.

This paper contributes to the theoretical literature investigating the relationship between geography and economic growth using key elements of the variety-expansion model of innovation-based endogenous growth (Grossman and Helpman, 1991).[1] Within this literature, our paper is most closely related to Martin and Ottaviano (1999; 2001) in that they also assume "footloose" production and product development–firms locate these activities independently in the region that provides the lowest cost. These studies find that agglomeration economies promote economic growth by raising the productivity of labor in R&D when knowledge spillovers are local in scope. As discussed above, however, a key aspect of the variety-expansion models adopted in this literature is the existence of a strong scale effect. This is problematic in that empirical evidence does not support a significant relationship between growth and population (Jones, 1995a; Dinopoulos and Thompson, 1999; Barro and Sala-i-Martin, 2004).

In a recent paper, Mittini and Parello (2011) extend the model of Martin and Ottaviano (1999) to correct for the strong scale effect by introducing population growth

[1] See Baldwin and Martin (2004) for a review of this literature.

and diminishing returns to knowledge according to Jones (1995b). Under this modification, the long-run growth rate is proportionate to the exogenous population growth rate and determined independently of the distribution of industry. This positive relationship between economic growth and population growth is referred to as the weak scale effect, however, and is also not supported by empirical evidence (Barro and Sala-i-Martin, 2004; Ha and Howitt, 2007). In contrast, the in-house process innovation framework (Smulders and van de Klundert, 1995; Peretto, 1996) allows for the endogenous determination of both the pattern of economic activity and the growth rate. Further, recent evidence suggests that the method adopted in this paper for removing the scale effect is supported empirically (Lainez and Peretto, 2006).

The remainder of the paper is organized as follows. In the following section we introduce a two region model of trade and endogenous productivity growth without scale effects. Then, Section 3 investigates the effects of changes in relative market size, transport cost, and knowledge dispersion for the level of product variety and the pace of productivity growth. Section 4 provides brief concluding remarks.

2 The Model

This section introduces our two region model of trade and productivity growth. We refer to the regions as the North and South, and within each region labor is employed in three activities: traditional production (Y), manufacturing (X), and process innovation (R). The traditional sector produces a numeraire good for sale in a perfectly competitive market characterized by free trade. The manufacturing sector, on the other hand, consists of monopolistically competitive firms that produce differentiated product varieties for sale in a market that features transaction costs on shipments between regions. Productivity growth arises as a result of in-house process innovation undertaken by manufacturing firms with the objective of raising profits by lowering production costs. Each manufacturing firm can relocate its production and innovation activities independently across regions. The labor endowments of the North and South are respectively L and L^*, where an asterisk denotes variables associated with the Southern region. There is perfect labor mobility across sectors but no migration between regions. In the following subsections we focus on introducing the model setup for the North, but analogous conditions can also be derived for the South.

2.1 Households

The demand side of the market consists of dynastic representative households that maximize utility over an infinite time horizon. The lifetime utility of a representative Northern household is

$$U = \int_0^\infty e^{-\rho t} \left[\alpha \ln C_X(t) + (1-\alpha) \ln C_Y(t)\right] dt, \tag{1}$$

where $C_X(t)$ and $C_Y(t)$ respectively denote the consumptions of a manufacturing composite and a traditional good, ρ is the subjective discount rate, and $\alpha \in (0,1)$ is the share of expenditure allocated to manufacturing goods at each moment of time. The manufacturing composite takes the following form

$$C_X = \left[\int_0^n c_i^{\frac{\sigma-1}{\sigma}} di + \int_0^{n^*} c_j^{\frac{\sigma-1}{\sigma}} dj\right]^{\frac{\sigma}{\sigma-1}}, \tag{2}$$

where c_i is the demand for variety i of the n varieties produced in the North, and c_j is the demand for variety j of the n^* varieties produced in the South. The elasticity of substitution between any two varieties is denoted by $\sigma > 1$.

Households choose an expenditure-saving path with the objective of maximizing (1) subject to the following liquidity constraint:

$$\int_0^\infty e^{-\int_0^t r(s)ds} E(t)dt \leq \int_0^\infty e^{-\int_0^t r(s)ds} w(t)Ldt + W(0),$$

where $E(t)$ is household expenditure, $r(t)$ and $w(t)$ are respectively the interest and wage rates at time t, and $W(0)$ is initial asset wealth.[2] The solution to this intertemporal optimization problem is the following Euler equation:

$$\frac{\dot{E}(t)}{E(t)} = r(t) - \rho, \tag{3}$$

where a dot indicates differentiation with respect to time (time notation is suppressed for the remainder of the paper). Southern households solve a symmetric utility maximization problem and, as we assume perfect capital mobility, interest rates equalize across regions ($r = r^*$) leading to a common motion for expenditure: $\dot{E}/E = \dot{E}^*/E^* = r - \rho$.

At each moment in time households allocate constant shares of expenditure to traditional goods and the manufacturing composite:

$$P_X C_X = \alpha E, \qquad P_Y C_Y = (1 - \alpha)E, \tag{4}$$

where P_Y is the traditional good price. The price index associated with the manufacturing composite is

$$P_X = \left[\int_0^n {p_i}^{1-\sigma} di + \int_0^{n^*} (\tau p_j^*)^{1-\sigma} dj \right]^{\frac{1}{1-\sigma}}, \tag{5}$$

where p_i is the price of variety i produced in the North, p_j^* is the price of variety j produced in the South, and $\tau > 1$ denotes an iceberg transport cost whereby τ units must be shipped for every unit sold in the export market (Samuelson, 1954).

Regarding the composite price index (5) as the household's unit expenditure function on manufacturing goods, the Northern demands for varieties produced respec-

[2] We will find that the value asset wealth (W) is zero in equilibrium as free entry drives the value of manufacturing firms to zero. See Section 2.5 for more details.

tively in the North and South can be obtained using Shephard's Lemma:

$$c_i = \alpha p_i^{-\sigma} P_X^{\sigma-1} E, \qquad c_j = \alpha(\tau p_j^*)^{-\sigma} P_X^{\sigma-1} E. \tag{6}$$

Southern households face a similar utility maximization problem and therefore have symmetric demand conditions.

2.2 Traditional production

Traditional firms employ a constant returns to scale technology whereby one unit of labor is required for each unit of output. The competitive nature of the market thus ensures that the price of a traditional good equals the wage rate and, as there are no transport costs associated with inter-regional transactions, both prices and wage rates are common across regions. The traditional good is set as the model numeraire and hence $P_Y = P_Y^* = w = 1$ at all times.

2.3 Manufacturing

Firms in the manufacturing sector produce horizontally differentiated product varieties and compete according to monopolistic competition (Dixit and Stiglitz, 1977). Although there are no costs associated with product development and market entry, incumbent firms face a fixed per-period labor cost (l_F) related to product marketing and the management of production and innovation activities.

A representative firm employs labor (l_X) with the following production technology:

$$x = \theta l_X, \tag{7}$$

where x is output and θ is a firm-specific productivity coefficient. While each firm employs a production technique that is unique to its product line, we suppose that the productivity levels (θ) associated with production techniques are symmetric across all firms regardless of the location of production.

Firms maximize profit on sales using the well known constant markup over unit cost pricing rule associated with monopolistic competition, and given our assumption of symmetric productivity levels, a similar price is set by firms producing in both regions, $p = p^* = \sigma/(\sigma - 1)\theta$. Profit on sales is calculated as the difference between revenues and labor costs and accordingly the optimal profit on sales for a representative firm is

$$\pi = px - l_X = \frac{l_X}{\sigma - 1}, \tag{8}$$

where we have used the pricing rule and the production function (7).

The firm-level scale of employment in production (l_X) is set to meet the combined demands from local and export markets. For example, the total demand for a product produced in the North is $c_i + \tau c_i^*$, where the iceberg transport cost $\tau > 1$ captures the addition units that must be shipped for every unit sold to Southern households. Equating this demand with firm supply, $x = c_i + \tau c_i^*$, and combining the production function (7) with the demand functions (6), the equilibrium firm-level scale of employment in Northern-based production is

$$l_X = \frac{\alpha(\sigma - 1)p^{1-\sigma}\left(P_X^{\sigma-1}E + \varphi {P_X^*}^{\sigma-1}E^*\right)}{\sigma}, \tag{9}$$

where $\varphi = \tau^{1-\sigma}$ describes the freeness of trade with $\varphi = 0$ implying prohibitively high trade costs and $\varphi = 1$ implying free trade. We assume that the market share of each firm is small enough that it perceives the composite price indexes P_X and P_X^* as constant when evaluating the effects of changes in its price on production scale (9) and thus profit on sales (8).

2.4 Process Innovation

The in-house process innovation of incumbent manufacturing firms drives economic growth. A representative firm employs labor l_R in process innovation with the aim of raising firm value through productivity improvements that lower production costs and raise profit on sales (8). Firm-level productivity evolves according to

$$\dot{\theta} = Kl_R, \tag{10}$$

where K captures knowledge spillovers from production to R&D.

Following the in-house process innovation framework developed by Smulders and van de Klundert (1995) and Peretto (1996), we model knowledge spillovers into in-house innovation as a function of the weighted average productivity of technical knowledge observable by the R&D department of the firm:

$$K = (s + \delta s^*)\theta, \tag{11}$$

where $s \equiv n/(n+n^*)$, and $s^* \equiv n^*/(n+n^*)$ are the respective shares of firms locating production in the North and South. Under this specification, technical knowledge accumulates within the firm as a side product of process innovation and can be proxied for using the productivity coefficient θ. It is this intertemporal externality that generates perpetual growth in long-run equilibrium. Although firm-level productivity is symmetric across firms, each firm's production technology is unique and comprises technical knowledge that includes both codifiable aspects which can be conveyed easily across large distances and tacit aspects which can only be transferred through face-to-face communication (Keller, 2004). The parameter $\delta \in (0, 1)$ describes the imperfect nature of spatial knowledge dissemination: $\delta = 0$ indicates knowledge spillovers that are completely local in scope and $\delta = 1$ indicates perfect inter-regional knowledge dispersion.[3]

The total per-period profit of a firm equals operating profit on sales less the cost of investment in process innovation and the per-period fixed labor cost:

$$\Pi = \pi - l_R - l_F. \tag{12}$$

A representative firm invests l_R in process innovation with the objective of maximizing firm value, $V = \int_0^\infty \Pi(t) e^{-\int_0^t r(s)ds} dt$, subject to the technological constraint (10). We solve this optimization problem using the following current value Hamiltonian function: $H = \Pi + \mu K l_R$, where μ denotes the current shadow value of an improvement in the technology of the firm. As each firm perceives itself as small relative to the overall market firms ignore the impact of R&D investment on knowledge spillovers when maximizing firm value, that is, $\partial K / \partial \theta = 0$.

The solution to the firm's intertemporal profit maximization problem is captured by a static efficiency condition $\mu = 1/K$ that equates the value of a marginal improvement in technology with the marginal cost of process innovation, and a dynamic efficiency condition $\partial \pi / \partial \theta = r\mu - \dot{\mu}$ that equates the internal rate of return to in-house process innovation with the rate of return that can be earn on a risk free asset.[4] Combining these conditions we derive the following no-arbitrage condition for in-house R&D investment:

$$r \geq \frac{(\sigma - 1)\pi K}{\theta} - \frac{\dot{K}}{K}. \tag{13}$$

This no-arbitrage condition binds whenever there is active process innovation.

[3]The imperfect nature of knowledge spillovers has been well documented by a number of empirical studies, for example, Jaffe et al. (1993), Mancusi (2008), and Coe et al. (2009). Our theoretical formulation for imperfect spillovers is adapted from Baldwin and Forslid (2000).

[4]The solution to the firm's intertemporal optimization problem must also satisfy the following tranversality condition $\lim_{t \to \infty} e^{-\rho t} \mu \theta = 0$, where with free entry $r = \rho$ at all moments in time as discussed in Section 2.5.

2.5 Equilibrium

Equilibrium is characterized by the shares of production taking place in each region. With negligible product development costs, free entry drives total per-period profits (12) to zero, $\Pi = 0$, ensuring that households earn income from wages alone. As a result, given our choice of labor as the model numeraire, $E = L$ and $E^* = L^*$. Therefore, referring to (3) we have $r = \rho$ at all moments in time.[5]

Next, following Martin and Rogers (1995), we assume that manufacturing firms are free to shift their production and innovation activities independently between regions at negligible cost. As firms relocate production with the aim of increasing profit on the margin, profit on sales is equalized between the North and South, $\pi = \pi^*$, whenever there is active production in both regions. Consequently, inspection of (8) indicates that the production scale of all firms will be the same, $l_X = l_X^*$. Combining the conditions introduced above with the pricing rule, $p = \sigma/(\sigma - 1)\theta$, we can solve for the share of firms locating production in the North as

$$s = \frac{L - \varphi L^*}{(1-\varphi)(L + L^*)}. \tag{14}$$

This condition describes a home market effect whereby the region with the larger market, represented here by labor endowment, hosts the larger share of manufacturing activity (Krugman, 1980).[6] In addition, (14) can be substituted with the pricing rules into (9) to obtain the long-run scale of production for all firms as

$$l_X = l_X^* = \frac{\alpha(\sigma - 1)(L + L^*)}{\sigma N}, \tag{15}$$

where $N = n + n^*$ is the total number of incumbent firms.

[5] In particular, total household wealth is zero in equilibrium, $W = 0$, as free entry drives firm value to zero, $V = 0$.

[6] The Northern share of production activity is increasing in φ for $L > L^*$, that is, $ds/d\varphi = (L - L^*)/(1-\varphi)^2(L + L^*) > 0$. A closer examination of (14) shows, however, that increases in φ beyond the threshold L^*/L have no further impact on patterns of production activity as $s = 1$.

Turning next to innovation activity, we can now show that all process innovation takes place in the region with the larger market and thus the greater share of industry. First, we set (12) to zero and use (8) in the result to obtain the following free entry conditions for the manufacturing industry:

$$l_X = (\sigma - 1)(l_R + l_F), \qquad l_X^* = (\sigma - 1)(l_R^* + l_F). \tag{16}$$

These conditions show that if there is active R&D in both regions, firm-level employment in innovation must be the same for all firms regardless of location as it is determined proportionally with the scale of production, $l_R = l_R^*$. Returning to (13), however, we can use $r = \rho$ with (8), (10), (11), and (16) to rewrite the no-arbitrage conditions for process innovation in the North and South respectively as

$$\rho = (s + \delta s^*)(l_X - l_R), \qquad \rho > (s^* + \delta s)(l_X - l_R). \tag{17}$$

With asymmetric market sizes, $L > L^*$, the no-arbitrage condition only binds for the larger Northern region as it hosts the larger share of industry from (14). Accordingly, innovation activity concentrates fully in the larger region.

Before concluding this section we discuss the requirements necessary for a positive level of innovation activity. Combining the free-entry condition (16) and the Northern no-arbitrage condition (17), firm-level employment in innovation can be solved for as

$$l_R = \frac{\rho - (\sigma - 1)(s + \delta s^*) l_F}{(\sigma - 2)(s + \delta s^*)}. \tag{18}$$

Active innovation requires that the return to in-house process innovation ($r = \rho$) exceed the fixed per-period labor cost by a sufficient margin. Since we are interested in equilibria with positive growth rates, we assume that $\rho > (\sigma - 1)(s + \delta s^*) l_F$.[7]

[7]Note that we also require $\sigma > 2$ for both positive market entry and productivity growth. The average elasticity of substitution estimates reported by Broda and Weinstein (2006) for various levels

3 Equilibrium Product Variety and Productivity Growth

The proceeding section introduced a simple model in which geographic patterns of production and innovation are determined endogenously according to regional labor endowments, and the level of transport costs. In this section, we investigate the implications of these patterns for the overall level of product variety and the pace of productivity growth. In addition, we consider the growth effects of greater economic integration through lower transport costs and greater inter-regional knowledge spillovers. To simplify our discussion, we focus on the case where the Northern share of labor is larger than that of the South ($L > L^*$), and all innovation activity occurs in the North.

3.1 Industry Concentration

Beginning with the overall level of product variety, (15), the first equation of (16), and (18) can be combined to yield the total number of manufacturing firms as

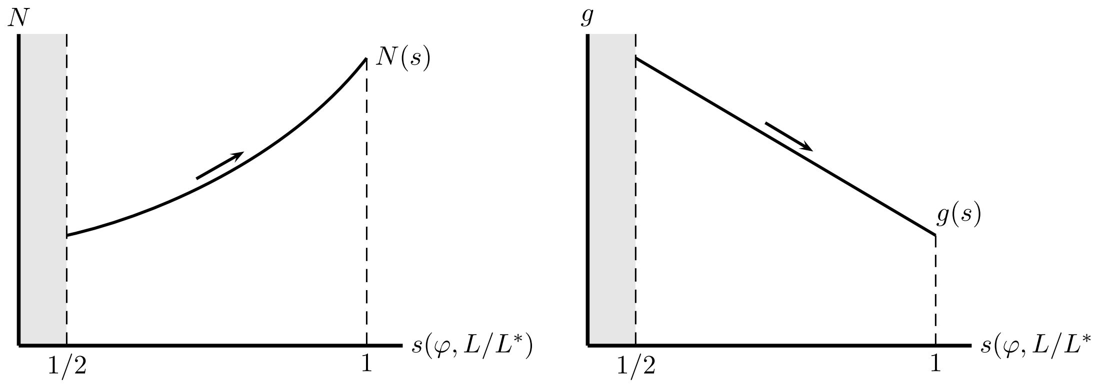
$$N = \frac{\alpha(\sigma - 2)(L + L^*)}{\sigma} \left[\frac{\rho}{\delta + (1 - \delta)s} - l_F \right]^{-1}. \tag{19}$$

A comparison of (19) with (18) indicates that active process innovation ensures a positive level of market entry. Moreover, the total number of firms is determined as a negative function of the discount rate and a positive function of the fixed per-period labor cost. For example, an increase in l_F causes a larger decrease in the cost of innovation, $dl_R/dl_F = -(\sigma - 1)/(\sigma - 2) < -1$, and total per-period fixed costs fall. As a result, positive per-period profits induce market entry until firm value is driven back to zero: $\Pi = 0$.

Figure 1a provides an illustration of $N(s)$ for $s > 1/2$. With the long-run level of product variety determined as an increasing function of the relative level of knowledge

of industry disaggregation suggest that this assumption is reasonable within the context of our simple model.

Figure 1: Product Variety and Productivity Growth



(a) Product Variety (b) Productivity Growth Rate

observable by innovation workers employed in the Northern region, $K/\theta = \delta + (1-\delta)s$, a rise in the Northern share of production activity raises the labor productivity of in-house innovation thereby reducing per-period costs (l_R) and raising the number of firms that the overall market can support. Consequently, the level of product variety is positively related to the level of industry concentration.[8]

The relationship between industry concentration and product variety has interesting implications for the pace of productivity growth. Substituting $r = \rho$, (8), (11), and (15) into (13) and using (19) in the result, the productivity growth rate is

$$g \equiv \frac{\dot{\theta}}{\theta} = \frac{\alpha(\sigma-1)\left(\delta+(1-\delta)s\right)(L+L^*)}{\sigma N} - \rho = \frac{\rho - (\sigma-1)(\delta+(1-\delta)s)l_F}{\sigma - 2}. \quad (20)$$

From (20) we can see that productivity growth is not biased by a scale effect as an increase in the overall labor endowment ($L + L^*$) is fully absorbed by a rise in the number of manufacturing firms (N). As discussed above, an increase in the fixed per-period labor cost (l_F) causes a greater decrease in firm-level R&D employment (l_R),

[8]The second-order derivative of (19) with respect to s is

$$\frac{d^2N}{ds^2} = \frac{2\rho(1-\delta)^2 l_F N}{(\delta+(1-\delta)s)\left(\rho - (\delta+(1-\delta)s)l_F\right)^2} > 0.$$

Thus, N is a convex function of s as depicted in Figure 1a.

and therefore depresses the rate of productivity growth. In contrast, an increase in the subjective discount rate (ρ) accelerates productivity growth. This result stems from the balance between a negative direct effect whereby a rise in the market rate of return to investment raises the opportunity cost of in-house R&D, and a positive indirect effect whereby a fall in the number of incumbent firms shifts aggregate employment away from the fixed per-period labor requirement (l_F) into production and innovation. The positive indirect effect always dominates the negative direct effect and hence an increase in ρ has a positive impact on productivity growth. These results accentuate the tension between market concentration and productivity growth that arise in this type of endogenous growth model and can also be found in the close economy model of Smulders and van de Klundert (1995).

We are particularly interested in the negative relationship that arises between the level of industry concentration (s) and the productivity growth rate. As shown in Figure 1b, the rise in the total number of firms that coincides with an increase in the relative level of knowledge available in the North, $K/\theta = \delta + (1-\delta)s$, leads to lower profit on sales thereby reducing the firm-level of employment in innovation that can be supported by the overall economy. On this account, the rate of productivity growth falls. We summarize the relationships between industry concentration, product variety, and productivity growth in the following proposition:

Proposition 1 *(Industry concentration, product variety, and productivity growth): An increase in the concentration of industry in the larger region raises the level product variety (N) and lowers the rate of productivity growth (g).*

Proof: From (19) and (20),

$$\frac{dN}{ds} = \frac{(1-\delta)\rho N}{(\delta+(1-\delta)s)(\rho-(\delta+(1-\delta)s)l_F)} > 0,$$
$$\frac{dg}{ds} = -\frac{(\sigma-1)(1-\delta)l_F}{\sigma-2} < 0,$$

for $s > 1/2$ with $L > L^*$ as assumed. $\square$

While at first glance a negative relationship between industry concentration and economic growth appears to contradict the positive relationship generally derived using variety expansion models of innovation-based growth (Martin and Ottaviano, 1999; 2001), in fact our results complement the existing literature in that an increase in industry concentration coincides with a rise in the *level* of product variety. In addition, Proposition 1 is supported by empirical studies such as Bosker (2010) and Gardiner et al. (2010) which find a negative relationship between various measures of agglomeration and the rate of GDP growth for several levels of aggregation using European regional data.

3.2 Regional Integration

We now briefly discuss the effects of greater regional integration stemming from a decrease in transport costs or an increase in the level of knowledge dispersion. Given that the impact of a change in relative market size on productivity growth reflects the home market effect (see (14)), trade liberalization has an effect similar to that for a change in relative market size:

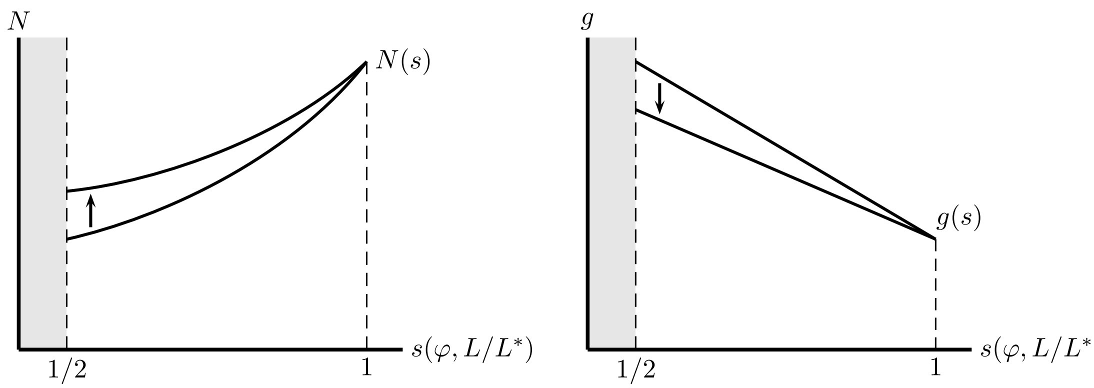
Proposition 2 *(Transport costs, product variety, and productivity growth): A decrease in transport costs (an increase in φ) raises product variety (N) and lowers the rate of productivity growth (g).*

Proof: From (14), (19), and (20),

$$\frac{dN}{d\varphi} = \frac{(1-\delta)(L-L^*)\rho N}{(\delta+(1-\delta)s)(\rho-(\delta+(1-\delta)s)l_F)(1-\varphi)^2(L+L^*)} > 0,$$
$$\frac{dg}{d\varphi} = -\frac{(\sigma-1)(1-\delta)(L-L^*)l_F}{(\sigma-2)(1-\varphi)^2(L+L^*)} < 0,$$

for $1 > s > 1/2$, where $L > L^*$ by assumption. $\square$

Figure 2: An increase in the degree of knowledge dispersion (δ)



(a) Product Variety (b) Productivity Growth Rate

An increase in the freeness of trade makes the larger market more attractive as a production base since firms gain better access to the larger market and incur lower transport costs on exports to the smaller market. Hence, under the assumption $L > L^*$, the Northern share of production rises causing an increase in the level of product variety and a decrease in the rate of productivity growth as indicated by the arrows provided in Figure 1.

Finally, we investigate the effects of greater economic integration through an increase in the degree of inter-regional knowledge dispersion. The result is provided in the following proposition.

Proposition 3 *(Knowledge spillovers, product variety, and productivity growth): An increase in the degree of inter-regional knowledge dispersion (δ) raises product variety (N) and lowers the rate of productivity growth (g).*

Proof: From (19) and (20),

$$\frac{dN}{d\delta} = \frac{(1-s)\rho N}{(\delta + (1-\delta)s)(\rho - (\delta + (1-\delta)s)l_F)} > 0,$$
$$\frac{dg}{d\delta} = -\frac{(\sigma - 1)(1-s)l_F}{(\sigma - 2)(1-\varphi)^2} < 0,$$

for $s > 1/2$ which is the case when $L > L^*$ as assumed. $\square$

Proposition 3 is illustrated in Figure 2 where an increase in the degree of inter-regional knowledge dispersion δ raises the level of product variety and lowers the rate of productivity growth for all levels of industry concentration. An increase in the degree of knowledge dispersion raises knowledge spillovers into innovation (K) causing a reduction in firm-level R&D employment (l_R). This in turn lowers fixed costs and new firms are attracted into the market by positive profits (N rises). As a consequence, aggregate labor employment shifts away from production and innovation to cover the increase in fixed per-period labor costs (l_F) and the rate of productivity growth falls. Once again, this outcome appears to be at variance with the standard result for variety expansion models where an increase in the level of knowledge dispersion always accelerates the rate of growth (Baldwin and Martin, 2004), but actually supports the existing literature in that greater knowledge spillovers are associated with a higher *level* of product variety.

3.3 Regional Welfare

Finally, we discuss the welfare implications of greater regional integration. Recalling that both traditional and manufacturing firms earn zero profits, regional welfare levels can be obtained by substituting (2), (5), (10), and (14) into lifetime utility (1):

$$U_0 = \frac{\ln\left[\theta(0)AL\right]}{\rho} + \frac{\alpha \ln L}{\rho(\sigma-1)} + \frac{\alpha}{\rho}\left[\frac{\ln\left[(1+\varphi)N\right]}{\sigma-1} + \frac{g}{\rho}\right], \tag{21}$$

$$U_0^* = \frac{\ln\left[\theta(0)AL^*\right]}{\rho} + \frac{\alpha \ln L^*}{\rho(\sigma-1)} + \frac{\alpha}{\rho}\left[\frac{\ln\left[(1+\varphi)N\right]}{\sigma-1} + \frac{g}{\rho}\right], \tag{22}$$

where $A = \left[(\alpha(\sigma-1)/\sigma)^{\alpha}(1-\alpha)^{1-\alpha}\right]$ is a constant. As we are interested in the effects of improved regional integration arising from an increase in φ or δ, the third term on the right-hand side of each of these conditions will be our main focus. Moreover, given the symmetric nature of the marginal impacts of greater integration for households residing in both regions, we focus on Northern households in what follows.

Table 1: Welfare Effects

	$\varphi = 0.4$ $\delta = 0.4$	$\varphi = 0.5$ $\delta = 0.4$	$\varphi = 0.6$ $\delta = 0.4$	$\varphi = 0.5$ $\delta = 0.5$	$\varphi = 0.5$ $\delta = 0.6$	$\varphi = 0.5$ $\delta = 0.7$
s	0.73	0.8	0.9	0.8	0.8	0.8
$dU_0/d\varphi$	2.535	2.681	3.014	2.507	2.304	2.131
$dU_0/d\delta$	0.126	-0.177	-0.330	-0.189	-0.201	-0.213

Parameter values: $L = 0.6$, $L^* = 0.4$, $\alpha = 0.5$, $\sigma = 3$, $l_F = 0.01$, and $\rho = 0.1$.

Beginning with the effects of greater economic integration that arise through a reduction in transport costs we have

$$\frac{1}{B}\frac{dU_0}{d\varphi} = \frac{(1-\varphi)^2(L+L^*)}{(L-L^*)(1+\varphi)} + \frac{\rho(1-\delta)}{(\delta+(1-\delta)s)(\rho-(\delta+(1-\delta)s)l_F)} - \frac{(\sigma-1)^2(1-\delta)l_F}{\rho(\sigma-2)},$$

where $B = \alpha(L-L^*)/\rho(\sigma-1)(1-\varphi)^2(L+L^*)$. The first term on the right-hand side captures the positive impact of lower prices on transported goods arising from freer trade between regions. The second term describes a positive love of variety effect whereby households benefit from a greater level of product variety in consumption. The third term denotes the negative effect associated with a slower decline in the price of goods as productivity growth is retarded by the fall in transport costs. As freer trade coincides with an increase in the concentration of industry, the opposing love of variety and productivity growth effects suggest a trade-off between welfare level and welfare growth. The simple numerical examples provided in Table 1 show, however, that the negative growth effect is always dominated by positive effects suggesting that the greater concentration of industry that occurs with a fall in transport costs is beneficial to the residents of both regions even it depresses the rate of growth.

Next, we examine the effects of greater economic integration stemming from an improvement in the level of knowledge dispersion between regions:

$$\frac{dU_0}{d\delta} = \frac{\alpha(1-s)}{(\sigma-1)(\delta+(1-\delta)s)(\rho-(\delta+(1-\delta)s)l_F)} - \frac{\alpha(\sigma-1)(1-s)l_F}{(\sigma-2)(1-\varphi)^2\rho^2}.$$

The first term on the right-hand side captures the positive love of variety effect and the second term describes the negative productivity growth effect. In this case, either effect may dominate depending on parameter values as shown in numerical examples of Table 1 where an increase in the level of knowledge dispersion actually has a negative impact on regional welfare in a number of cases.

4 Concluding Remarks

In this paper we have investigated the relationship between geographic patterns of industrial activity and economic growth in a two region model of trade and endogenous productivity growth that corrects for scale effects. The production and innovation activities of monopolistically competitive manufacturing firms assume a central role in the model and, faced with transport costs, imperfect knowledge dispersion and perfect capital mobility, firms locate these activities independently across regions with the objective of minimizing cost. This framework produces several interesting results. First, we find that although an increase in the concentration of industry raises the overall level of product variety, it has a negative impact on the rate of productivity growth. This result contrasts with the positive relationship derived by existing theoretical models in the "new economic geography" literature but is supported by recent empirical evidence. Second, investigating the implications of greater economic integration between regions, we find that a decrease in inter-regional transport costs or an increase in inter-regional knowledge spillovers both raise the level of product variety but lower the overall rate of economic growth.

Although our framework provides several novel results, a key simplification is the assumption of free entry into the manufacturing sector. One possible extension is therefore the inclusion of product development costs. This extension would allow for an examination of the dynamics of entry and exit and provide a richer description of the link between economic growth and the evolution of inter-regional inequality.

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