Industry Concentration, Knowledge Diffusion, and Economic Growth Without Scale Effects

Colin Davis
Ken-ichi Hashimoto

February 2014
Discussion Paper No.1408

GRADUATE SCHOOL OF ECONOMICS

KOBE UNIVERSITY

ROKKO, KOBE, JAPAN

Industry Concentration, Knowledge Diffusion, and Economic Growth Without Scale Effects

Colin Davis
Doshisha University*

Ken-ichi Hashimoto
Kobe University†

February, 2014

Abstract

This paper develops a two region model of trade to study the relationship between geographic patterns of industry and economic growth without scale effects. With transport costs, imperfect knowledge diffusion, and perfect capital mobility, firms locate production, process innovation, and product development independently in their lowest cost regions, leading to the partial concentration of production and the full agglomeration of innovation in the region with the largest market. A rise in industry concentration increases knowledge spillovers from production to innovation, resulting in a fall or a rise in the level of market entry depending on whether productivity increases more for process innovation or for product development. As a result, the rate of economic growth may rise or fall, depending on the effects of industry concentration on market entry.

Key Words: Industry Concentration, Industry Share, Knowledge Diffusion, Productivity Growth, Scale Effect
JEL Classifications: F43; O30; O40; R12

*The Institute for Liberal Arts, Doshisha University, Karasuma-Higashi-iru, Imadegawa-dori, Kamigyo, Kyoto, Japan, 602-8580, cdavis@mail.doshisha.ac.jp.

†Graduate School of Economics, Kobe University, 2-1 Rokkodai, Nada, Kobe, Japan, 657-8501, hashimoto@econ.kobe-u.ac.jp.

Acknowledgements: We are grateful for helpful comments from T. Iwasako, T. Nakamura, and participants of a seminar held at Kobe University and the spring meeting of the Japanese Society of International Economics. We acknowledge financial support from JSPS though a Grant-in-Aid for Scientific Research (C) and a Grant-in-Aid for Young Scientists (B). We are responsible for all remaining errors.

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 empirical evidence is mixed, however. For example, Bosker (2007) and Gardiner et al. (2011) report a negative relationship between a number of measures of industry concentration and GDP growth for several levels of agglomeration using empirical data. In addition, Abdel-Rahman et al. (2006) find that the growth of urban areas affects economic growth negatively in developing countries. In contrast, investigating cross-country data, Brülhart and Sbergami (2009) conclude that the relationship between industry concentration and GDP growth depends on a country's level of economic development, while Braunerhjelm and Borgman (2004) find that industry concentration has a positive effect on labor productivity growth in Sweden.

One possible source of the discrepancy between these mixed empirical results and the general consensus of the new economic geography literature 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 standard 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.

More specifically, building on Peretto and Connolly (2007), we develop a two region model of trade and endogenous growth that focuses on the production, process innovation, and product development of manufacturing firms. In a world characterized by perfect capital mobility, transport costs, and imperfect knowledge diffusion, firms are free to locate these activities independently across regions with the objective of raising profits on the margin (Martin and Rogers 1995; Martin and Ottaviano 1999, 2001). As a result, geographic patterns of production and R&D are determined endogenously, with a concentration of production and the full agglomeration of process innovation and product development in the larger market of the two regions, as measured by household expenditure.

A key feature of the endogenous market structure and endogenous growth framework (Smulders and van de Klundert 1995; Peretto 1996, Aghion and Howitt 1998; Dinopoulus and Thompson 1998; Peretto and Connolly 2007; Etro 2009) adopted in this paper is a fixed operating cost incurred on individual product lines that drives the rate of market entry down to the rate of growth in market size, or the population growth rate. As such, the level of entry relative to market size is constant, but closely related to the distribution of economic activity. In particular, a rise in industry concentration lowers R&D costs, through greater knowledge spillovers from production to innovation in the larger region, with two effects. The first is a *product development* effect, whereby a fall in the cost of creating a new product design raises the level of market entry. The second is a *process innovation* effect, whereby a fall in labor costs raises firm-level employment in process innovation, decreasing operating profits and lowering the level of market entry. Overall, the relationship between the level of market entry and industry concentration depends on which effect dominates.

The distribution of economic activity also has important implications for the rate of economic growth. While the constant rate of population growth determines the pace of variety expansion, the rate of productivity growth is determined by firm scale, and is therefore intrinsically linked with the level of market entry. Accordingly, an increase in industry concentration has a direct positive effect on productivity growth, through a rise in the labor productivity of process innovation, but may have a negative or a positive indirect effect on productivity growth, depending on whether the level of market entry rises or falls. In general, we find a positive relationship between industry concentration and economic growth when the process innovation effect dominates, and a convex relationship when the product development effect dominates. Our framework therefore produces mixed results with respect to the effects of industry concentration on economic growth.

This paper contributes to the theoretical literature investigating the relationship between geography and economic growth using key elements of the variety-expansion model of 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 lowest cost regions.[2] 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.[3] A key aspect of the variety-expansion models adopted in this literature, however, is the existence of a scale, which is problematic in that the empirical evidence does not support a significant relationship between economic growth and population size (Jones 1995a; Dinopoulos and Thompson 1999; Barro and Sala-i-Martin 2004; Laincz and Peretto 2006).

In a recent paper, Mittini and Parello (2011) extend the model of Martin and Ottaviano (1999) to correct for the scale effect by introducing population growth and diminishing returns to knowledge according to Jones (1995b). With this modification, the model produces semi-endogenous growth, and the rate of variety expansion determined proportionately with the population growth rate. Accordingly, while the distribution of industry is important for the level of product variety, it has no effect

[1] See Baldwin and Martin (2004) and Baldwin et al. (2004) for surveys of this literature.

[2] See Duranton and Puga (2001) for evidence that firms undertake production and innovation activities at independent locations.

[3] Two papers extending the standard model to allow for a negative relationship between industry concentration and the rate of innovation are Acceturo (2010), which adds congestion costs to R&D activity, and Cerina and Mureddu (2012), which considers endogenous expenditure shares for manufacturing goods. However, both papers feature scale effects.

on the long-run rate of economic growth. Moreover, semi-endogenous growth is generally not supported by the empirical evidence (Barro and Sala-i-Martin 2004; Laincz and Peretto 2006; Ha and Howitt 2007). In contrast, the model developed in this paper allows for the endogenous determination of both the geographic distribution of economic activity and the rate of economic growth, with both semi-endogenous and fully endogenous components, while removing the scale effect. Further, the endogenous market structure and endogenous growth framework is now supported by a large body of empirical evidence (Zachariadis 2003, 2004; Laincz and Peretto 2006; Ha and Howitt 2007; Madsen 2008, 2010; Madsen et al. 2010a; Madsen et al. 2010b).

The remainder of the paper is organized as follows. Section 2 introduces a two region model of trade, variety expansion, and productivity growth without scale effects, and examines the equilibrium location patterns of production, process innovation, and product development. Then, in Section 3 we study the effects of changes in industry concentration on the level of product variety and the rate of productivity growth, and investigate the implications of greater regional integration through a decrease in transport costs or an increase in the degree of knowledge diffusion between regions. We also briefly discuss the effects of greater integration on regional welfare levels. Section 4 provides brief concluding remarks.

2 The Model

This section introduces a two region, North (N) and South (S), model of trade, productivity growth, and variety expansion. There are four type of economic activity: traditional production (Y), manufacturing (X), process innovation (I), and product development (R). The traditional sector produces a homogeneous 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 transport costs on shipments between regions. Productivity growth arises as a result of process innovation undertaken by incumbent manufacturing firms with the objective of lowering production costs. The product development sector creates new product designs for firms entering the manufacturing sector. Production, process innovation, and product development are all footloose in nature, and can therefore be located independently across regions, regardless of the home region of the associated firm.

Labor, the sole factor of production, is supplied inelastically by households. We assume that regional labor endowments are equal and grow at the same rate λ, and accordingly regional labor endowments are $L(t) = L_N(t) = L_S(t) = e^{\lambda t}$ at time t, with initial labor endowments normalized to one and subscripts N and S denoting variables associated with the North and South. There is perfect labor mobility across sectors, but no migration between regions. We allow, however, for differences in asset wealth and assume greater initial asset wealth for the North, $B_N > B_S$.

2.1 Households

The demand side of the economy consists of dynastic households that maximize utility over an infinite time horizon. We adopt a standard formulation for this intertemporal maximization problem (Barro and Sala-i-Martin 2004), and define the lifetime utility of a household in region i as follows:

$$U_i = \int_0^\infty e^{-(\rho-\lambda)t} \left(\alpha \ln C_{Xi}(t) + (1-\alpha) \ln C_{Yi}(t)\right) dt, \qquad i \in \{N, S\}, \tag{1}$$

where $C_{Xi}(t)$ and $C_{Yi}(t)$ denote household consumption of a manufacturing composite and a traditional good, ρ is the subjective discount rate ($\rho > \lambda$), and $\alpha \in (0, 1)$ is the constant share of expenditure allocated to manufacturing goods.

Each household chooses an expenditure-saving path with the objective of maximizing (1) subject to the following flow budget constraint for time t:

$$\dot{B}_i(t) = (r_i(t) - \lambda)B_i(t) + w_i(t) - E_i(t), \tag{2}$$

where $E_i(t)$ is household expenditure, $r_i(t)$ is the interest rate, $w_i(t)$ are the wage rate, $B_i(t)$ is asset wealth, and a dot denotes time differentiation. The solution to the intertemporal optimization problem is the Euler equation:

$$\frac{\dot{E}_i(t)}{E_i(t)} = r_i(t) - \rho. \tag{3}$$

With perfect capital mobility, interest rates equalize across regions ($r_N = r_S = r$) leading to a common motion for household expenditure: $\dot{E}_N/E_N = \dot{E}_S/E_S = r - \rho$.[4] We suppress time notation where possible for the remainder of the paper.

With equal subjective discount rates and population growth rates, the integrated financial market provides equivalent investment opportunities for residents in both regions, $\dot{B}_N/B_N = \dot{B}_S/B_S$, ensuring constant regional shares of asset wealth. As such, the greater initial asset wealth of Northern households results in higher household expenditure in the North. Specifically, summing the flow budget constraints (2) to describe average household expenditure $E \equiv (E_N + E_S)/2$ as a function of average asset household wealth $B \equiv (B_N + B_S)/2$, and using the result to substitute the net return to investment $(r - \lambda - \dot{B}/B)$ out of the regional flow budget constraints gives

$$E_i = w_i + b_i(2E - w_i - w_j), \qquad i, j \in \{N, S\}; i \neq j, \tag{4}$$

where $b_i \equiv B_i/(B_N + B_S)$ is region i's share of asset wealth. In the next section, we show that wage rates are equalized through free trade in the traditional good ($w_N = w_S$). Therefore, the greater asset wealth of the North ($b_N > 1/2$) leads to

[4] We assume that initially there is no borrowing or lending between regions, as Northern and Southern households have the same rate of time preference.

higher expenditure for Northern households ($E_N > E_S$).

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

$$P_{Xi}C_{Xi} = \alpha E_i, \qquad\qquad P_{Yi}C_{Yi} = (1-\alpha)E_i, \tag{5}$$

where P_{Yi} is the traditional good price, and P_{Xi} is the price index associated with the manufacturing composite. In particular, the manufacturing composite and price index take the following forms:

$$C_{Xi} = \left(\int_0^N c_i(\omega)^{\frac{\sigma-1}{\sigma}} d\omega\right)^{\frac{\sigma}{\sigma-1}}, \qquad\qquad P_{Xi} = \left(\int_0^N p_i(\omega)^{1-\sigma} d\omega\right)^{\frac{1}{1-\sigma}}, \tag{6}$$

where $p_i(\omega)$ and $c_i(\omega)$ are the price and household demand in region i for product variety ω, $N = N_N + N_S$ is the total mass of product varieties available, and $\sigma > 1$ is the elasticity of substitution between any two varieties.

Regarding the composite price index (6) as the household's unit expenditure function for manufacturing goods, household demand for a representative variety in region i can be obtained using Shephard's Lemma:

$$c_i(\omega) = \alpha p_i(\omega)^{-\sigma} P_{Xi}^{\sigma-1} E_i. \tag{7}$$

2.2 Traditional Production

Traditional firms employ a constant returns to scale technology, with one unit of labor required for each unit of output, and market competition ensures that the price of a traditional good equals the wage rate. As there are no transport costs associated with trade between regions, prices and wage rates are the same for the North and the South. The traditional good is set as the model numeraire: $P_{YN} = P_{YS} = w_N = w_S = 1$.[5]

[5]Wage rate equalization requires that both regions produce traditional goods in equilibrium.

2.3 Manufacturing

Manufacturing firms produce horizontally differentiated product varieties and compete according to monopolistic competition (Dixit and Stiglitz 1977). In addition to the costs of market entry associated with product development, firms face a fixed per-period labor cost (f) related to product marketing and production management, and incur iceberg costs on the transport of goods between regions, whereby τ units must be shipped for every unit sold in the export market (Samuelson 1954).

A firm ω, with production located in region i, employs labor $l_{Xi}(\omega)$ with the following production technology:

$$x_i(\omega) = \theta_i(\omega)^\gamma l_{Xi}(\omega), \tag{8}$$

where $x_i(\omega)$ is output, $\theta_i(\omega)$ is a firm-specific productivity coefficient, and $\gamma \in (0, 1)$ is the productivity elasticity of output (Peretto and Connolly 2007). While each firm employs a production technique that is unique to its product line, the productivity levels (θ) associated with production techniques are symmetric across all firms regardless of the location of production. As such, we now suppress the firm index ω.

Firms maximize profit on sales using the constant markup over unit cost pricing rule associated with monopolistic competition, and with symmetric productivity levels, similar pricing rules are adopted by all firms, regardless of where production is located. Specifically, the price of goods sold in their region of production is $p = \sigma/((\sigma - 1)\theta^\gamma)$, and the price of goods sold outside their region of production is $p^* = \tau p$, with an asterisk indicating variables associated with units that are consumed outside the region where they were manufactured. Equating household demand (7) with firm supply (8), and substituting the result with the pricing rules into

$\pi_i = px_i - l_{Xi}$, optimal profit on sales for a firm with production located in region i is

$$\pi_i = \frac{p^{1-\sigma}\alpha L}{\sigma}\left(\frac{E_i}{P_{Xi}^{1-\sigma}} + \frac{\varphi E_j}{P_{Xj}^{1-\sigma}}\right), \qquad i,j \in \{N,S\};\ i \neq j, \tag{9}$$

where we have used $x_i = (c_i + \tau c_j^*)L$ and $p^* = \tau p$, and $\varphi \equiv \tau^{1-\sigma}$ describes the *freeness of trade*: $\varphi = 0$ implies prohibitive trade costs and $\varphi = 1$ indicates free trade.

2.4 Process Innovation

Incumbent manufacturing firms invest in process innovation with the aim of raising firm value through productivity improvements that lower production costs and raise profit on sales (9). A firm with its R&D department located in region i employs labor l_{Ii} in process innovation, and firm-level productivity evolves according to

$$\dot{\theta} = k_i \theta l_{Ii}, \tag{10}$$

where $k_i\theta$ captures knowledge spillovers from production to R&D. Technical knowledge on production techniques accumulates within the firm as a by-product of process innovation. We adopt the level of productivity as a proxy for the stock of technical knowledge, and increases in θ therefore raise the labor productivity of future process innovation, potentially generating perpetual growth in long-run equilibrium.

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

$$k_i\theta = (s_i + \delta(1 - s_i))\theta, \tag{11}$$

where $s_i \equiv N_i/N$ is the share of firms with production located in region i. Although productivity is symmetric across firms, each firm's production technology is unique and comprises technical knowledge that includes both codifiable aspects which are conveyed easily across large distances and tacit aspects which are only transferred through face-to-face communication (Keller 2004). The *degree of knowledge diffusion* $\delta \in (0,1)$ captures the imperfect nature of knowledge spillovers: $\delta = 0$ indicates that knowledge spillovers are completely local in scope and $\delta = 1$ indicates perfect knowledge spillovers between regions.[6]

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:

$$\Pi_i = \pi_h - l_{Ii} - f, \qquad h \in \{N, S\}. \tag{12}$$

A firm invests l_{Ii} in process innovation with the objective of maximizing firm value, $V_i(t) = \int_t^\infty \Pi_i(t') e^{-\int_t^{t'} r(i)di} dt'$, subject to the technological constraint (10). We solve this optimization problem using the following current value Hamiltonian function: $H_i = \Pi_i + \mu_i k_i \theta l_{Ii}$, where μ_i 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 effects of their R&D investments on the price indices and knowledge spillovers, when maximizing firm value.

The solution to the intertemporal profit maximization problem is captured by a static efficiency condition $\mu_i = 1/(k_i\theta)$ that equates the value of a marginal improvement in technology with the marginal cost of process innovation, and a dynamic efficiency condition $\partial\pi_h/\partial\theta = r\mu_i - \dot{\mu}_i$ that equates the internal rate of return to process innovation with the rate of return on a risk free asset.[7] Combined, these

[6] 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 formulation for imperfect spillovers is adapted from Baldwin and Forslid (2000).

[7] The solution to the intertemporal optimization problem must also satisfy the following tranversality condition $\lim_{t\to\infty} e^{-\int_0^t r(t')dt'} \mu_i(t)\theta(t) = 0$.

conditions yield a no-arbitrage condition for investment in process innovation:

$$r \geq (\sigma - 1)\gamma\pi_h k_i - \frac{\dot{k}_i}{k_i} - \frac{\dot{\theta}}{\theta}. \tag{13}$$

This condition binds when process innovation occurs in region i.

2.5 Product Development

Manufacturing firms purchase product designs, and associated production processes, from the competitive product development sector, and enter the market with the current productivity level of incumbent firms. The overall creation of new product designs follows

$$\dot{N} = \left(\frac{k_N N}{2EL}\right) l_{RN} + \left(\frac{k_S N}{2EL}\right) l_{RS}, \tag{14}$$

where l_{Ri} is regional employment in product development. Setting the stock of knowledge related to product design equal to the number of product varieties that have been invented to date (N), the creation of a new product designed adds to the existing stock of knowledge, improving the labor productivity of future product development (Romer 1990). Again, however, intertemporal knowledge spillovers are imperfect as they diminish with distance ($k_i = s_i + \delta(1 - s_i) < 1$). In addition, product development costs are increasing in the overall market size ($2EL = E_N L + E_S L$), as the costs associated with product role out are higher for larger markets (Peretto and Connolly 2007; Etro 2009; Dinopoulos and Unel 2011).

Free entry into the product development sector drives the value of a product design down to its development cost. Therefore, in region i

$$V_i = \frac{2EL}{k_i N}. \tag{15}$$

when labor is employed in product development in region i. Since the value of a product design equals the value of a manufacturing firm $V_i(t) = \int_t^\infty \Pi_i(t')e^{-\int_t^{t'} r(i)di}dt'$, the time derivative of $V_i(t)$ yields a no-arbitrage condition for investment in product development (Romer 1990; Grossman and Helpman 1991):

$$r \geq \frac{\Pi_i}{V_i} + \frac{\dot{V}_i}{V_i}, \tag{16}$$

which ensures that the rate of return to investment in a product design equals the risk-free interest rate when product development occurs in region i.

2.6 Locations of Production and Innovation

This section characterizes the equilibrium location patterns of production, process innovation, and product development. Following Martin and Rogers (1995) and Martin and Ottaviano (1999, 2001), manufacturing firms shift their production and R&D activities independently between regions at zero cost; the locations of production and product development need not coincide.

As firms relocate production with the aim of increasing profit on the margin, when production occurs in both the North and the South, profit on sales equalizes across regions, $\pi_N = \pi_S$. Therefore, with symmetry, combining (6) and (9) with the pricing rules, we solve for the Northern share of production as

$$s_N(E;\varphi) = \frac{E_N - \varphi E_S}{(1-\varphi)(E_N + E_S)} = \frac{(1-\varphi) + 2(b_N - \varphi b_S)(E-1)}{2(1-\varphi)E}, \tag{17}$$

where we have used (4). Note that with $b_N > 1/2$, we have $E_N/E_S > 1$ and $s_N > 1/2$. The positive relationship between s_N and E in (17) describes a home market effect, whereby a greater share of firms locate production in proximity to the larger Northern market in order to minimize transport costs (Krugman 1980). With its greater share of asset wealth, the North receives a larger share of the investment income generated by total household expenditure, allowing it to maintain a higher level of expenditure. Substituting (17) and the pricing rules into (9) gives

$$\pi_N = \pi_S = \frac{\alpha}{\sigma}\frac{2EL}{N}. \tag{18}$$

With profit on sales equalized across regions, we can now show that all product development activity takes place in the North, as its higher share of production ($s_N > 1/2$) generates larger knowledge spillovers from production to innovation, $k_N > k_S$, which allows for lower innovation costs than the South. In particular, an examination of (15) shows that the cost of product designs is lower in the North ($V_N < V_S$), ensuring that no product development occurs in the South, i.e., $l_{RS} = 0$.

Next, we consider the dynamics associated with household expenditure and the Northern share of production. Using the flow budget constraint for average household expenditure $E = 1 + B(r - \lambda - \dot{B}/B)$, the asset market clearing condition $B = NV_N/(2L) = E/k_N$, and the Euler condition $\dot{E}/E = r - \rho$ together with (17), we derive the motion for North's production share as

$$\dot{s}_N = \frac{k_N}{(1-\delta)}\left(\frac{(E(s_N)-1)k_N}{E(s_N)} - (\rho - \lambda)\right), \tag{19}$$

where average household expenditure is determined as a function of s_N from (17).[8] In Appendix A, we evaluate the dynamics of the Northern production share around $\dot{s}_N = 0$, and find that $\partial \dot{s}_N/\partial s_N > 0$. Therefore, production shares and average household expenditure jump immediately to their steady-state levels, implying from (3) that $r = \rho$. Setting (19) equal to zero, the North's share of production and average household expenditure are determined through the system described by (17) and

$$s_N(E;\delta,\lambda) = \frac{(\rho-\lambda)E}{(1-\delta)(E-1)} - \frac{\delta}{1-\delta}. \tag{20}$$

[8] In particular, rearranging (17) yields $E(s_N) = (1+\varphi)(2b_N - 1)/(2(b_N - \varphi b_S - (1-\varphi)s_N))$.

We use this system to obtain the following results:

Proposition 1 *The North's share of production (s_N) is increasing in the freeness of trade (φ), and decreasing in the degree of knowledge diffusion (δ) and the population growth rate (λ). Average household expenditure (E) is decreasing in φ, δ, and λ.*
Proof: See Appendix A.

An increase in the freeness of trade strengthens the home market effect, raising the share of firms with production located in the North. Average household expenditure falls, however, as increased competition in the larger Northern market leads to lower profit on sales, reducing asset income. An increase in the degree of knowledge diffusion, on the other hand, decreases the cost of market entry, lowering asset value and household incomes. As a result, average household expenditure and the Northern share of production both fall. Similarly, a rise in the population growth rate lowers average household expenditure through a fall in the net return to asset wealth $(r - \lambda)$, and decreases the North's share of production.

Finally, with product development fully concentrated in the North, all firms have the same market value (15) and earn the same per-period profits (12). Therefore, from (18), if process innovation occurs in both regions, employment must be the same for all firms, regardless of location ($l_{IN} = l_{IS}$), as it is determined proportionately with profit on sales. We can use (9), (10), and (11), however, to rewrite the no-arbitrage conditions (13) for Northern and Southern process innovation as

$$\rho = k_N((\sigma - 1)\gamma\pi - l_{IN}), \qquad \rho > k_S((\sigma - 1)\gamma\pi - l_{IN}). \tag{21}$$

Again, with $k_N > k_S$, the larger share of production located in the North attracts all investment in process innovation, as the no-arbitrage condition is not satisfied for the South ($l_{IS} = 0$). With process innovation fully concentrated in the North, firm-level employment in process innovation is

$$l_{IN} = \frac{\alpha(\sigma-1)\gamma}{\sigma}\frac{2EL}{N} - \frac{\rho}{k_N}, \tag{22}$$

where we have substituted (18) into the Northern no-arbitrage condition in (21).

3 Product Variety and Productivity Growth

This section investigates how the geographic concentration of production affects product variety and productivity growth. We also examine the effects of greater economic integration arising from a fall in transport costs or a rise in knowledge diffusion, and discuss the implications for regional welfare.

3.1 Industry Concentration

We begin with product variety. As a positive rate of population growth leads to continuous entry into the manufacturing sector, we study the characteristics of the ratio of incumbent firms to market size as a measure of the *level of product variety*, which we define as the number of firms per unit of expenditure, $n \equiv N/(2EL)$, where total household expenditure ($2EL$) describes the overall market size.

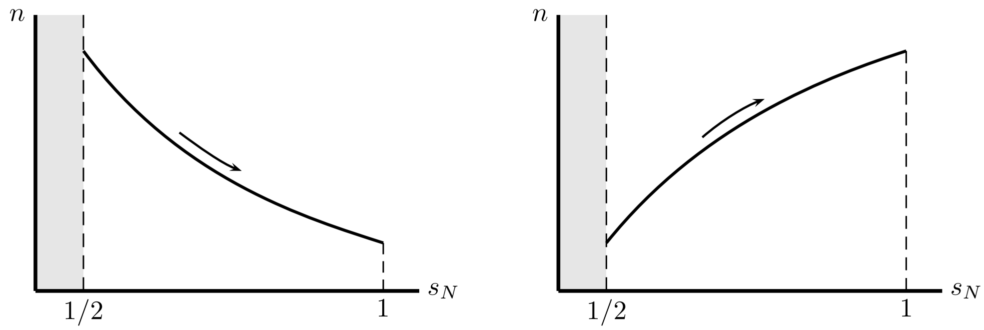
Substituting (12), (15), (18), and (22) into (16), and reorganizing, the evolution of the level of product variety can be obtained as follows:

$$\frac{\dot{n}}{n} = (\nu k_N - \rho) - (f k_N - \rho)n, \tag{23}$$

where $\nu \equiv \alpha(1-(\sigma-1)\gamma)/\sigma \in (0,1)$ is the marginal industry profit associated with an increase in market size.[9] Although population growth generates continuous market entry, and rising product variety, growth in the level of product variety is driven to

[9]From (12), (18), and (22), we have $\partial(N\Pi)/\partial(2EL) = \alpha/\sigma - \alpha(\sigma-1)\gamma/\sigma = \nu$.

Figure 1: The Level of Product Variety



(a) $\nu > f$ (b) $\nu < f$

zero by the existence of per-period fixed costs, with a stable equilibrium arising for $\partial \dot{n}/\partial n = -(fk_N - \rho) < 0$, as n is a state variable.

We solve for the steady-state level of product variety by setting (23) equal to zero:[10]

$$n = \frac{\nu k_N - \rho}{f k_N - \rho}, \tag{24}$$

where with $fk_N > \rho$ as a necessary stability condition, $\nu k_N > \rho$ is also required for a positive level of market entry, with positive productivity growth. Intuitively, a rise in marginal industry profit (ν) increases market entry, while a rise in the per-period fixed cost (f) lowers market entry. Moreover, $n > 1$ if $\nu > f$, and $n < 1$ if $\nu < f$. We use (24) with $k_N = s_N + \delta(1 - s_N)$ to examine how changes in s_N affect n:

Proposition 2 *The level of product variety (n) is decreasing in industry concentration (s_N) for $\nu > f$, and increasing in s_N for $\nu < f$.*

Proof: Partial derivation of (24) yields

$$\frac{\partial n}{\partial s_N} = -\frac{(\nu - f)\rho}{(fk_N - \rho)^2}\frac{\partial k_N}{\partial s_N}, \qquad \frac{\partial^2 n}{\partial s_N^2} = -\frac{2f}{(fk_N - \rho)}\frac{\partial k_N}{\partial s_N}\frac{\partial n}{\partial s_N},$$

[10] While the level of product variety is constant in equilibrium, product variety increases at the rate of population growth ($\dot{N}/N = \lambda$). The dynamics of N are provided in Appendix B.

where $\partial k_N/\partial s_N = 1-\delta > 0$.

An increase in the Northern share of production affects the level of market entry through two mechanisms: a *product development* effect and a *process innovation* effect. The product development effect increases the level of market entry as greater industry concentration raises labor productivity in product development through an increase in knowledge spillovers from production to R&D. The process innovation effect, on the other hand, decreases the level of market entry, as a rise in the labor productivity of R&D induces firms to employ more labor in process innovation, causing per-period profits to fall. The balance of these opposing mechanisms is determined by ν and f, with increased industry concentration lowering the level of product variety for $\nu > f$, as illustrated in Figure 1a, and raising it for $\nu < f$, as shown in Figure 1b.

The relationship between industry concentration and the level of product variety has interesting implications for productivity growth. Combining (10), (22), and (24), the long-run rate of productivity growth is

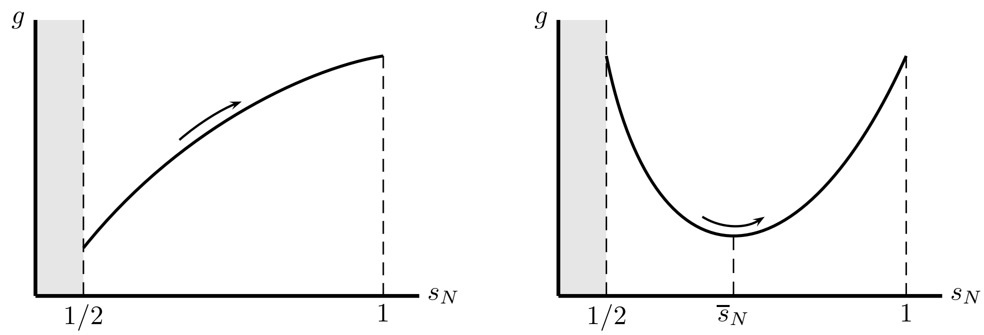
$$g \equiv \frac{\dot{\theta}}{\theta} = \frac{\alpha\gamma(\sigma-1)k_N}{\sigma n} - \rho = \frac{\alpha\gamma(\sigma-1)(fk_N-\rho)k_N}{\sigma(\nu k_N-\rho)} - \rho. \tag{25}$$

We assume that $n < \gamma\alpha(\sigma-1)k_N/(\sigma\rho)$, in order to ensure active investment in process innovation, with a positive rate of productivity growth (Peretto and Connolly 2007), and use (25) to consider the effects of changes in s_N on g:

Proposition 3 *The rate of productivity growth (g) is increasing in industry concentration (s_N) for $\nu > f$, and convex in s_N for $\nu < f$, with a minimum at*

$$\overline{s}_N = \frac{(1+\sqrt{(f-\nu)/f})\rho}{(1-\delta)\nu} - \frac{\delta}{1-\delta}.$$

Figure 2: Productivity Growth



(a) $\nu > f$ (b) $\nu < f$

Proof: Partial derivation of (25) gives

$$\frac{\partial g}{\partial s_N} = \left(\frac{g+\rho}{k_N} + \frac{(g+\rho)(\nu - f)\rho}{(\nu k_N - \rho)(f k_N - \rho)} \right) \frac{\partial k_N}{\partial s_N}, \quad \frac{\partial^2 g}{\partial s_N^2} = -\frac{2(g+\rho)(\nu - f)\rho^2 (\partial k_N / \partial s_N)^2}{(\nu k_N - \rho)(f k_N - \rho)^2 k_N},$$

where $\partial k_N / \partial s_N = 1 - \delta > 0$.

Once again, a rise in industry concentration increases the level of knowledge spillovers from production to innovation, with two resulting effects on productivity growth. The first is the direct effect of improved labor productivity in process innovation, which leads to an increase in the rate of productivity growth. The second is the effect of adjustments in the level of market entry. Recalling Proposition 2, when $\nu > f$, the level of product variety falls, and the effect of lower market entry matches with the direct effect of improved labor productivity in process innovation, causing the rate of productivity growth to increase, as depicted in Figure 2a. Alternatively, when $\nu < f$ the level of market entry increases. Then, as illustrated in Figure 2b, the overall impact on productivity growth is negative for low levels of industry concentration ($s_N < \overline{s}_N$), where the negative effect of greater market entry is stronger than the direct positive effect of improved labor productivity. For high levels of industry concentration ($s_N > \overline{s}_N$), however, the overall impact is positive, as the positive labor productivity effect dominates.

Before completing this section, we consider how changes in the population size and the population growth rate affect productivity growth. Returning to (25), we see that productivity growth is not biased by a scale effect since increases in the overall labor endowment ($2L$) are fully absorbed by a rise in product variety (N) that leaves the number of firms per unit of household expenditure (n) unchanged. Productivity growth is also not directly affected by changes in the population growth rate (λ). Reviewing Proposition 1, however, an increase in the population growth rate reduces industry concentration, and thus may raise or lower productivity growth depending on the relationship between industry concentration and the level of product variety.

Proposition 4 *An increase in the population growth rate (λ) raises the level of product variety (n) and decreases the rate of productivity growth (g) for $\nu > f$, and lowers n but may raise or lower g for $\nu < f$.*

Proof: From (24) and (25),

$$\frac{dn}{d\lambda} = -\frac{(\nu - f)\rho}{(fk_N - \rho)^2}\frac{\partial k_N}{\partial s_N}\frac{ds_N}{d\lambda}, \quad \frac{dg}{d\lambda} = \left(\frac{g+\rho}{k_N} + \frac{(g+\rho)(\nu - f)\rho}{(\nu k_N - \rho)(fk_N - \rho)}\right)\frac{\partial k_N}{\partial s_N}\frac{ds_N}{d\lambda},$$

where $\partial k_N/\partial s_N = 1 - \delta > 0$, and $ds_N/d\lambda < 0$ from Proposition 1.

Consider a decrease in the population growth rate that raises the net return on asset wealth, increasing household income. With a larger share of asset wealth, the income effect is stronger for the North and its share of production increases. The consequent impacts on market entry and productivity growth then depend on the process innovation and product development effects. If the process innovation effect dominates, the level of market entry falls and the rate of productivity growth rises, as indicated by the arrows in Figures 1a and 2a. Therefore, when $\nu > f$ the economy features a negative relationship between productivity growth and population growth, through adjustments the level of in industry concentration. In contrast, when $\nu < f$

and the product development effect dominates, the increase in industry concentration raises the level of market entry, as shown by the arrow in Figure 1b. In this case, the productivity growth rate falls for $s_N < \overline{s}_N$, but rises for $s_N > \overline{s}_N$, as depicted in Figure 2b, indicating that the economy may exhibit a positive or a negative relationship between productivity growth and population growth, given the current level of industry concentration.[11]

3.2 Regional Integration

We now briefly consider the effects of greater regional integration resulting from either a decrease in transport costs or an increase in the degree of knowledge diffusion. Beginning with trade liberalization, we obtain the following results:

Proposition 5 *An increase in the freeness of trade (φ) lowers the level of product variety (n) and increases the rate of productivity growth (g) for $\nu > f$, and raises n but may raise or lower g for $\nu < f$.*

Proof: From (24) and (25),

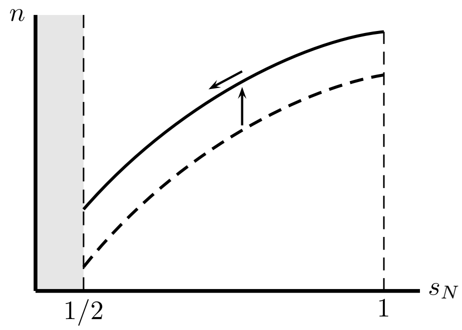
$$\frac{dn}{d\varphi} = -\frac{(\nu - f)\rho}{(fk_N - \rho)^2}\frac{\partial k_N}{\partial s_N}\frac{ds_N}{d\varphi}, \quad \frac{dg}{d\varphi} = \left(\frac{g+\rho}{k_N} + \frac{(g+\rho)(\nu - f)\rho}{(\nu k_N - \rho)(fk_N - \rho)}\right)\frac{\partial k_N}{\partial s_N}\frac{ds_N}{d\varphi},$$

where $\partial k_N/\partial s_N = 1 - \delta > 0$, and $ds_N/d\varphi > 0$ from Proposition 1.

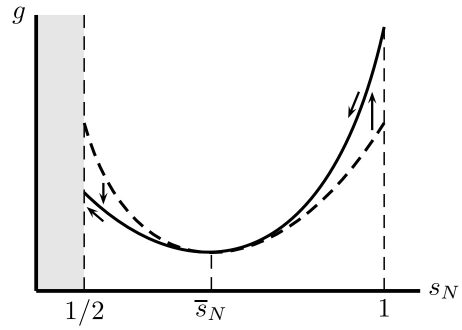
The effects of an increase in the freeness of trade are the same as those for a decrease in the population growth rate. Invoking Proposition 1, a fall in transport costs raises the share of production located in the North. The resulting rise in knowledge spillovers from production to innovation then leads to a decrease in the level of market entry and an increase in the productivity growth rate for $\nu > f$. Alternatively, for $\nu < f$ the level of product variety rises, while the rate of productivity growth falls as the Northern production share increases, until a threshold level of industry concentration

[11]Many empirical studies support a negative relationship between population growth and productivity growth (Ahitur 2001; Headey and Hodge 2009; Herzer et al. 2012; Strulik et al. 2013).

Figure 3: An Increase in the Degree of Knowledge Diffusion



(a) Level of Product Variety



(b) Productivity Growth

has been surpassed, after which the rate of productivity growth rises. These cases are illustrated by the arrows shown in Figures 1 and 2.

Next, we investigate the effects of greater economic integration arising from an increase in the degree of knowledge diffusion between regions:

Proposition 6 *An increase in the degree of knowledge diffusion (δ) lowers the level of product variety (n) and raises the rate of productivity growth (g) for $\nu > f$, and raises n but may raise or lower g for $\nu < f$.*

Proof: From (24) and (25),

$$\frac{dn}{d\delta} = -\frac{(\nu - f)\rho}{(fk_N - \rho)^2}\frac{dk_N}{d\delta}, \qquad \frac{dg}{d\delta} = \left(\frac{g+\rho}{k_N} + \frac{(g+\rho)(\nu - f)\rho}{(\nu k_N - \rho)(fk_N - \rho)}\right)\frac{dk_N}{d\delta},$$

where $dk_N/d\delta = \partial k_N/\partial\delta + (\partial k_N/\partial s_N)(ds_N/d\delta) > 0$, $\partial k_N/\partial\delta = 1 - s_N > 0$, $\partial k_N/\partial s_N = 1 - \delta > 0$, and $ds_N/d\delta < 0$ from Proposition 1.

An increase in the degree of knowledge diffusion has two opposing effects on knowledge spillovers from production to innovation. From (11), the first is a direct effect ($\partial k_N/\partial\delta$) that increases knowledge spillovers. The second is an indirect effect that decreases knowledge spillovers through reduced industry concentration $(\partial k_N/\partial s_N)(ds_N/d\delta)$. As shown in Appendix C, however, the direct effect always dominates the indirect effect, and knowledge spillovers increase with a rise in the degree of knowledge diffusion. Once again, the subsequent results for market entry and productivity growth depend on the process innovation and product development effects. When $\nu > f$, the level of market entry decreases, and the rate of productivity growth increases. When $\nu < f$, the level of market entry increases, and the productivity growth rate decreases for $s_N < \overline{s}_N$, but increases for $s_N > \overline{s}_N$. The second case is illustrated in Figure 3, where the direct effect of a greater degree of knowledge diffusion is captured by shifts in the n and g curves, and the indirect effect of greater industry concentration is illustrated by movements along the curves.

3.3 Regional Welfare

In this section, we briefly discuss the welfare implications of greater regional integration through reduced transport costs and improved knowledge spillovers. Steady-state regional welfare levels are obtained by substituting (5), (6), (10), (24), and (25) into lifetime utility (1):[12]

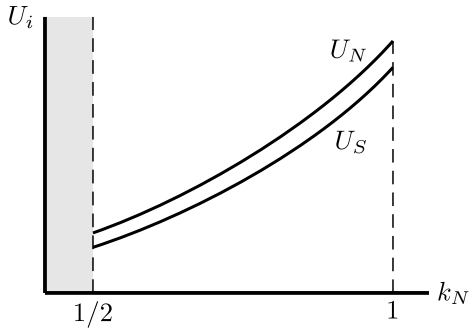
$$(\rho - \lambda)U_i = \ln A + \left(1 + \frac{\alpha}{\sigma - 1}\right) \ln E_i + \frac{\alpha \ln((1+\varphi)n)}{\sigma - 1} + \frac{\alpha}{\rho - \lambda}\left(\frac{\lambda}{\sigma - 1} + \gamma g\right),$$

where $A = (\alpha(\sigma - 1)\theta(0)^{\gamma}/\sigma)^{\alpha}(1-\alpha)^{1-\alpha}$ is a constant. The second and third terms on the RHS are the level contributions of current expenditure and the level of product variety. The fourth term captures the contribution of total factor productivity growth, which derives from semi-endogenous growth in product variety ($\lambda = \dot{N}/N$) and fully endogenous productivity growth ($g = \dot{\theta}/\theta$).

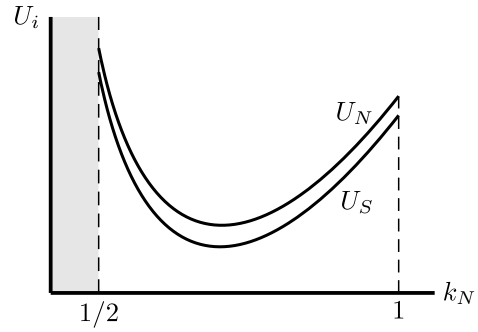
The opposing level and growth components of regional welfare make a general analytical analysis intractable. As an alternative, we use simple numerical examples to discuss the implications of improved regional integration. Figure 4 plots regional welfare levels against the level of knowledge spillovers, and with equal population

[12]Using (17), we find that $s_i + \varphi(1 - s_i) = (1 + \varphi)E_i/(2E)$.

Figure 4: Knowledge Spillovers and Welfare



(a) $\nu > f$



(b) $\nu < f$

For both panels, $\rho = 0.05$, $\lambda = 0.02$, $\gamma = 0.3$, $\sigma = 2.1$, $f = 0.2$, $\varphi = 0.8$, and $b_N = 0.6$. Noting that $\nu \equiv \alpha(1 - (\sigma - 1)\gamma)/\sigma$, in Panel (a) $\alpha = 0.75$ and $\nu = 0.24$, and in Panel (b) $\alpha = 0.35$ and $\nu = 0.11$.

levels, the greater asset wealth of the North naturally leads to a higher level of utility for all levels of knowledge spillovers. Figure 4 suggests that regional welfare levels are generally increasing in the level of knowledge spillovers when the process innovation effect dominates $\nu > f$, and are generally convex in knowledge spillovers when the product development effect dominates $\nu < f$.

Considering now the effects of a reduction in transport costs, we obtain the following result for the impact of greater integration on Northern households:

$$\frac{(\rho - \lambda)(\sigma - 1)}{\alpha} \frac{dU_i}{d\varphi} = \frac{1}{(1 + \varphi)} + \left(\frac{(\alpha + \sigma - 1)}{\alpha E_i} \frac{dE_i}{dk_N} + \frac{1}{n} \frac{dn}{dk_N} + \frac{\gamma(\sigma - 1)}{(\rho - \lambda)} \frac{dg}{dk_N} \right) \frac{dk_N}{d\varphi},$$

where $dk_N/d\varphi > 0$. The first term on the RHS captures the direct positive effect of lower prices as a result of reduced transports costs between regions. The second effect captures the overall negative impact of freer trade on regional household expenditure. The third and fourth terms describe the effects of changes in the level of product variety and the rate of productivity growth, and may be positive or negative. While the general effect of a fall in transport costs is ambiguous, returning to the numerical examples presented in Figure 4, regional utility shifts upward and the regions move rightward along their utility curves, suggesting that an increase in the freeness of trade benefits welfare for $\nu > f$, and may hurt or benefit welfare for $\nu < f$.

Next, we examine the effects of greater economic integration stemming from an improvement in the degree of knowledge diffusion:

$$\frac{(\rho-\lambda)(\sigma-1)}{\alpha}\frac{dU_i}{d\delta} = \left(\frac{(\alpha+\sigma-1)}{\alpha E_i}\frac{dE_i}{dk_N} + \frac{1}{n}\frac{dn}{dk_N} + \frac{\gamma(\sigma-1)}{(\rho-\lambda)}\frac{dg}{dk_N}\right)\frac{dk_N}{d\delta},$$

where $dk_N/d\delta > 0$. The first term on the RHS captures the overall negative impact of greater knowledge dispersion on regional household expenditure. The second and third terms describe the effects of changes in the level of product variety and the rate of productivity growth, and may be positive or negative. Again, the overall effect is ambiguous. The numerical examples in Figure 4, however, suggest that an increase in the degree of knowledge dispersion benefits welfare for $\nu > f$, and may hurt or benefit welfare for $\nu < f$, as the regions move rightward along their utility curves.

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 growth that corrects for scale effects. The production, process innovation, and product development of monopolistically competitive manufacturing firms assume a central role in the model and, faced with transport costs, imperfect knowledge diffusion and perfect capital mobility, firms locate these activities independently across regions with the objective of minimizing costs. These location decisions lead to the partial concentration of production and the full agglomeration of innovation in the region with the larger market, as measured by household expenditure.

Within this framework, we find that the level of market entry is closely related with the distribution of economic activity. In particular, an increase in the concentration of industry raises knowledge spillovers from production to R&D, leading to lower costs for process innovation and product development. As a result, the level of market entry decreases if costs fall more for process innovation, and increases if costs fall more for product development. As firm-level employment in process innovation is closely linked with firm scale, adjustments in the level of market entry have important implications for economic growth. Specifically, an increase in industry concentration has a positive direct effect on productivity growth, through a rise in the labor productivity of process innovation, but may have a negative or a positive indirect effect on productivity growth, depending on whether the level of market entry rises or falls. As such, in general we find a positive relationship between industry concentration and economic growth when improved knowledge spillovers lead to a greater fall in costs for process innovation, and a convex relationship when greater knowledge spillovers lead to a greater fall in costs for product development.

Appendix A

We first evaluate the partial derivative of (19) at $\dot{s}_N = 0$ to confirm that s_N and E jump immediately and permanently to their steady-state levels:

$$\frac{\partial \dot{s}_N}{\partial s_N} = \frac{(E-1)k_N}{E} + \frac{(1-\varphi)k_N^2}{(1-\delta)(b_N - \varphi b_S - 2(1-\varphi)s_N)E} > 0,$$

where $(b_N - \varphi b_S) - (1-\varphi)s_N > 0$ is required for $E > 0$, from (17). The steady-state comparative statics presented in Proposition 1 are then derived from (17) and (20):

$$\begin{bmatrix} 1 & -\frac{(b_N-\varphi B_S)-(1-\varphi)s_N}{(1-\varphi)E} \\ 1 & \frac{\rho-\lambda}{(1-\delta)(E-1)^2} \end{bmatrix} \begin{bmatrix} ds_N \\ dE \end{bmatrix} = \begin{bmatrix} 0 & \frac{(b_N-\varphi b_S)(E-1)}{(1-\varphi)^2 E} & 0 \\ -\frac{E}{(1-\delta)(E-1)} & 0 & -\frac{1+s_N}{1-\delta} \end{bmatrix} \begin{bmatrix} d\lambda \\ d\varphi \\ d\delta \end{bmatrix}.$$

The determinant of the Jacobian matrix given above is strictly positive: $|J| > 0$. The results of Proposition 1 are found using Cramer's rule:

$$\begin{aligned}
\frac{ds_N}{d\lambda} &= -\frac{(b_N - \varphi b_S) - (1-\varphi)s_N}{(1-\delta)(1-\varphi)(E-1)|J|} < 0, & \frac{dE}{d\lambda} &= -\frac{E}{(1-\delta)(E-1)|J|} < 0,\\
\frac{ds_N}{d\varphi} &= \frac{(\rho-\lambda)(b_N - \varphi b_S)}{(1-\delta)(1-\varphi)^2 E(E-1)|J|} > 0, & \frac{dE}{d\varphi} &= -\frac{(b_N - \varphi b_S)(E-1)}{(1-\varphi)^2 E|J|} < 0,\\
\frac{ds_N}{d\delta} &= -\frac{(1+s_N)((b_N - \varphi b_S) - (1-\varphi)s_N)}{(1-\delta)(1-\varphi)E|J|} < 0, & \frac{dE}{d\delta} &= -\frac{1+s_N}{(1-\delta)|J|} < 0.
\end{aligned}$$

Appendix B

With positive productivity growth, the aggregate labor market clearing condition is

$$2L = (1-\alpha)2EL + \frac{\alpha(\sigma-1)2EL}{\sigma} + \left(\frac{\alpha\gamma(\sigma-1)2EL}{\sigma N} - \frac{\rho}{k_N}\right)N + fN + \frac{2EL}{k_N}\frac{\dot{N}}{N},$$

where the RHS captures labor demands from traditional production, manufacturing production, process innovation, the per-period fixed cost, and product development. Using $k_N = (\rho-\lambda)E/(E-1)$ from (20), we obtain the following differential equation for market entry:

$$\frac{\dot{N}}{N} = \nu k_N - \rho - \frac{(fk_N - \rho)N}{2EL} + \lambda,$$

where $\nu = \alpha(1-(\sigma-1)\gamma)/\sigma \in (0,1)$. Then, using $n \equiv N/(2EL)$ and (24), the rate of entry reduces to the rate of population growth in steady-state equilibrium: $\dot{N}/N = \lambda$.

Appendix C

Using the result for $ds_N/d\delta$ from Appendix A, we can show that an increase in the degree of knowledge diffusion raises knowledge spillovers:

$$\frac{dk_N}{d\delta} = (1 - s_N) + (1 - \delta)\frac{ds_N}{d\delta} = \frac{4(1 - s_N)(1 - \varphi)E^2}{(1 + \varphi)(2b_N - 1)|J|} > 0.$$

References

[1] Abdel-Rahman, A., Safarzadeh, M., Bottomley, M., 2006. Economic growth and urbanization: A cross-section and time-series analysis of thirty-five developing countries. International Review of Economics 53, 334-348.

[2] Acceturo, A., 2010. Agglomeration and growth: The effects of commuting costs. Papers in Regional Science 89, 173-190.

[3] Aghion, P., Howitt, P., 1998. Endogenous growth. Cambridge: MIT Press.

[4] Ahituv, A., 2001. Be fruitful or multiply: On the interplay between fertility and economic development. Journal of Population Economics 14, 51-71.

[5] Baldwin, R., Forslid R., 2000. The core-periphery model and endogenous growth: Stabilizing and destabilizing integration. Economica 67, 307-324.

[6] Baldwin, R., Martin, P., 2004. Agglomeration and regional growth. Handbook of Regional and Urban Economics 4, 2671-2711.

[7] Baldwin, R., Forslid, R., Martin, P., Ottaviano, G., Robert-Nicoud, F., 2004. Economic Geography and Public Policy. Princeton: Princeton University Press.

[8] Barro, R., Sala-i-Martin, X., 2004. Economic growth 2nd edition. Cambridge: MIT Press.

[9] Bosker, M., 2007. Growth, agglomeration and convergence: A space-time analysis for European regions. Spatial Economic Analysis 2, 2007.

[10] Braunerhjelm, P., Borgman, B., 2004. Geographical concentration, entrepreneurship and regional growth: Evidence from regional data in Sweden, 1975-99. Regional Studies 38, 929-947.

[11] Brülhart, M., Sbergami, F., 2009. Agglomeration and growth: Cross-country evidence. Journal of Urban Economics 65, 48-63.

[12] Cerina, F., Mureddu, F., 2012. Agglomeration and growth with endogenous expenditure shares. Journal of Regional Science 52, 324-360.

[13] Coe, D., Helpman, E., Hoffmaister, A., 2009. International R&D spillovers and institutions. European Economic Review 53, 723-741.

[14] Dinopoulos, E., Thompson, P., 1998. Schumpeterian growth without scale effects. Journal of Economic Growth 3, 313-335.

[15] Dinopoulos E., Thompson, P., 1999. Scale effects in schumpeterian models of economic. Journal of Evolutionary Economics 9, 157-185.

[16] Dinopoulos, E., Unel, B., 2011. Quality heterogeneity and global economic growth. European Economic Review 55, 595-612.

[17] Dixit, A., Stiglitz, J. E., 1977. Monopolistic competition and optimum product diversity. American Economic Review 67, 297-308.

[18] Duranton, G., Puga, D., 2001. Nursery cities: Urban diversity, process innovation, and the life cycle of products. American Economic Review 91, 1454-1477.

[19] Etro, F., 2009. Endogenous Market Structures and the Macroeconomy. Springer.

[20] Gardiner, B., Martin, R., Tyler, P., 2011. Does spatial agglomeration increase national growth? Some evidence from Europe. Journal of Economic Geography 11, 979-1006.

[21] Grossman, G., Helpman, E., 1991. Innovation and growth in the global economy. Cambridge: MIT Press.

[22] Ha, J., Howitt, P., 2007. Accounting for trends in productivity and R&D: A shumpeterian critique of semi-endogenous growth theory. Journal of Money, Credit, and Banking 39, 733-774.

[23] Headey, D., Hodge, A., 2009. The effect of population growth on economic growth: A meta-regression analysis of the macroeconomic literature. Population and Development Review 35, 221-248.

[24] Herzer, D., Vollmer, S., Strulik, H., 2012. The long-run determinants of fertility: One century of demographic change 1900-1999. Journal of Economic Growth 17, 357-385.

[25] Jaffe, A. B., Trajtenberg, M., Henderson, R., 1993. Geographical localization of knowledge spillovers as evidenced by patent citations. The Quarterly Journal of Economics 108, 577-598.

[26] Jones, C., 1995a. Times series of endogenous growth models. Quarterly Journal of Economics, 110, 495-525.

[27] Jones, C., 1995b. R&D-based models of endogenous growth. Journal of Political Economy, 103, 759-784.

[28] Keller, W., 2004. International technology diffusion. Journal of Economic Literature 42, 752-782.

[29] Krugman, P., 1980. Scale economies, product differentiation, and the pattern of trade. American Economic Review 70, 950-959.

[30] Laincz C., Peretto, P., 2006. Scale effects in endogenous growth theory: An error of aggregation not specification. Journal of Economic Growth 11, 263-288.

[31] Madsen, J., 2008. Semi-endogenous versus Schumpeterian growth models: testing the knowledge production function using international data. Journal of Economic Growth 13, 1-26.

[32] Madsen, J., 2010. The anatomy of growth in the OECD since 1870. Journal of Monetary Economics 57, 753-767.

[33] Madsen, J., Saxena, S., Ang, J., 2010a. The Indian growth miracle and endogenous growth. Journal of Development Economics 93, 37-48.

[34] Madsen, J., Ang, J., Banerjee, R., 2010b. Four centuries of British economic growth: the roles of technology and population. Journal of Economic Growth 15, 263-290.

[35] Mancusi, M. L., 2008. International spillovers and absorptive capacity: A cross-country cross-sector analysis based on patents and citations. Journal of International Economics 76, 155-165.

[36] Martin, P., Ottaviano, G. I., 1999. Growing locations: Industry location in a model of endogenous growth. European Economic Review 43, 281-302.

[37] Martin, P., Ottaviano, G. I., 2001. Growth and agglomeration. International Economic Review 42, 947-968.

[38] Martin, P., Rogers, C., 1995. Industrial location and public infrastructure. Journal of International Economics 39, 335-351.

[39] Minniti, A., Parello, C., 2011. Trade integration and regional disparity in a model of scale-invariant growth. Regional Science and Urban Economics 41, 20-31.

[40] Romer, P., 1990. Endogenous Technical Change. Journal of Political Economy 98, S71-S102.

[41] Peretto, P., 1996. Sunk costs, market structure, and growth. International Economic Review 37, 895-923.

[42] Peretto, P., Connolly, M., 2007. The manhattan metaphor. Journal of Economic Growth 12, 329-250.

[43] Samuelson, P., 1954. The transfer problem and transport costs, II. Economic Journal 64, 264-289.

[44] Smulders, S., van de Klundert, T., 1995. Imperfect competition, concentration, and growth with firm-specific R&D. European Economic Review 39, 139-160.

[45] Strulik, H., Prettner, K., Prskawetz, A., 2013. The past and future of knowledge-based growth. Journal of Economic Growth 18, 411-437.

[46] Zachariadis, M., 2003. R&D, innovation, and technological progress: a test of the Shumpeterian framework without scale effects. Canadian Journal of Economics 36, 566-586.

[47] Zachariadis, M., 2004. R&D-induced growth in the OECD? Review of Development Economics 8, 423-439.