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IMPORT COMPETITION AND INDUSTRY LOCATION IN A SMALL-COUNTRY MODEL OF PRODUCTIVITY GROWTH

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Abstract

We study the effects of import competition on industry locations patterns in a small open economy with two regions. Domestic productivity growth converges to the international rate through firm-level investment in process innovation. With firms locating production and innovation in their lowest cost locations, the concentration of industry in the larger region is linked with firm-level innovation through an import competition effect that is increasing in the market share of imported goods and the productivity differential of domestic firms with the rest of the world. We show that increased import competition, through either a larger number of imported goods or a faster international rate of productivity growth, leads to greater industry concentration by reducing domestic market entry and decreasing the relative productivity of domestic firms. We also consider the implications of improved regional and international economic integration.

JEL Classifications: F12; F43; O40; R12

Keywords: Import competition; Industry concentration; Endogenous productivity growth

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1 Introduction

Foreign competition poses a key policy concern for developed and developing countries alike as national governments attempt to resolve regional imbalances in the location patterns of domestic industry while promoting innovation-based economic growth. Indeed, increased trade openness has been found to have important implications for the geographic concentration of industry (Brülhart 2011; Rodríguez-Pose 2012; Ezcurra and Rodríguez-Pose 2013). In addition, empirical evidence suggests that greater competition from an increased range of and lower prices for imported goods has a direct influence on firm-level investment in research and development (R&D) (Bloom et al. 2017; Autor et al. 2019). Although a broad literature has studied the potential effects of industry location patterns on innovation-based economic growth (Baldwin and Martin 2004; Desmet and Rossi-Hansberg 2009, 2014), the effects of innovation activity on domestic industry location patterns are less well-understood. In this paper, we highlight the potential for foreign competition to influence industry location patterns through its effect on firm-level investment in process innovation.

In particular, we extend the theoretical framework of Davis and Hashimoto (2016) to study the implications of increased import competition for industry location patterns in a small open country with two regions. Adopting an endogenous growth and endogenous market structure framework (Aghion and Howitt 1998; Laincz and Peretto 2006; Etro 2009; Peretto 2018), the model focuses on a monopolistically competitive sector in which firms compete with imported goods as they supply the households of each region and invest in process innovation with the aim of lowering future production costs (Smulders and van de Klundert 1995; Peretto 1996). Characterizing long-run equilibrium in terms of the domestic level of market entry and the productivity differential between domestic firms and international firms, we derive sufficient conditions for the convergence of the domestic rate of productivity growth rate with the international productivity growth rate.

Production and innovation are independently located in the regions with the lowest respective costs: firms undertake each activity in a single region and need not locate production and innovation together (Martin and Rogers 1995; Martin and Ottaviano 1999; Davis and Hashimoto 2016). Interregional trade costs and imperfect knowledge diffusion result in the partial concentration of production and the full concentration of innovation in the region with the larger market, as measured by population size. The regional concentration of production is then linked with firm-level innovation through an import competition effect that induces firms to shift production to the larger region to mitigate the negative profit effect associated with imported goods. This import competition effect is magnified by a fall in international trade costs, a rise in the market share of imported goods, or a fall in the productivity of domestic firms relative to the international firms producing the goods imported from the rest of the world.

We use the framework to consider how improved economic integration and increased import competition affect domestic market entry, the productivity differential of domestic firms with international firms, and the regional concentration of industry. First, we show that improvements in regional and international knowledge diffusion both reduce innovation costs, raising profit and inducing domestic firms to enter the market. Domestic productivity growth temporarily rises above the international productivity growth rate over the transition to a new long-run equilibrium, resulting in a smaller productivity differential with international firms. The import competition effect then reduces the concentration of industry in the region with the larger market.

Turning next to trade integration, on the one hand, we find that a fall in interregional trade costs increases firm profitability, causing firms to enter the market, and temporarily accelerating domestic productivity growth as firm-level investment in process innovation rises. As such, the productivity differential of domestic firms with international firms contracts. The home market effect dominates the import competition effect, however, generating an increase in the concentration of industry in the larger region. A fall in international trade costs, on the other hand, reduces firm profitability, inducing domestic firms to exit the market. As the increased market share of imported goods leads to a fall in firm-level investment in process innovation, but potentially raises knowledge spillovers, the regional strength of knowledge diffusion determines whether productivity growth temporarily accelerates or decelerates over the transition to a new equilibrium. Productivity growth temporarily accelerates (decelerates), and the productivity differential with international firms falls (rises) for strong (weak) regional knowledge diffusion. Regardless of the change in the productivity differential, we find that overall the import competition effect always leads to greater industry concentration.

Lastly, addressing the effects of increased import competition, we investigate the implications of either an expansion in the number of imported goods, or an increase in the given productivity growth rate for international firms. In both cases, profits fall, and domestic firms exit the market. In the case of an increase in the number of imported goods, the domestic rate of productivity growth falls over the transition to the new long-run equilibrium. In the case of an increase in the international productivity growth rate, the domestic rate of productivity growth accelerates to match the international rate. In both cases the productivity of domestic firms necessarily falls relative to international firms. Consequently, the import competition effect ensures a rise in the larger region's share of industry.

Our framework builds on the theoretical literature examining the effects of trade integration on the spatial concentration of industry.[1] Krugman and Livas Elizondo (1996) introduce a small open economy framework in which labor is mobile between two regions. Economies of scale, market size, and domestic transport costs pull labor and industry towards a single region, while congestion costs push industry to disperse regionally. Trade liberalization weakens the pull factors, resulting in a dispersed industry location pattern. Paluzie (2000) and Monfort and Nicolini (2000) adapt the framework by removing congestion costs and adding a regionally immobile production factor that is employed in a constant returns to scale sector. Similar to the model developed in this paper, the immobile production factor tends to disperse industry by creating exogenous regional demand. This adaption reverses the result of Krugman and Livas Elizondo (1996) with trade liberalization inducing greater industry

[1]See Brülhart (2011) for a survey of the theoretical and empirical literatures considering the relationship between trade openness and spatial concentration.

concentration. Subsequent research by Brülhart et al. (2004) and Crozet and Koenig (2004) has shown that trade liberalization leads to the spatial concentration of industry in regions with better access to export markets. In addition, Behrens et al. (2007) demonstrate that the relationship between trade openness and industry location patterns depends on the size of domestic transport costs when firms have variable markups. As the studies introduced above do not consider innovation or economic growth, our results extend the literature by demonstrating that import competition and trade liberalization influence industry concentration through their effects on firm-level investment in process innovation.

The paper proceeds as follows. In Section 2 we introduce our small open economy model of import competition and industry concentration. Section 3 characterizes the long-run equilibrium and derives the conditions for saddlepath stability. We study the effects of improvements in regional and international economic integration in Section 4, and then consider the implications of increased import competition in Section 5. We conclude in Section 6.

2 The Model

Consider a small open economy with two distinct regions, and three types of economic activity: traditional production, manufacturing, and process innovation. Labor is mobile across activities, but not between regions or with the rest of the world. The traditional sector produces a numeraire good for a competitive international market characterized by free trade. Adopting a unit-coefficient constant-returns-to-scale technology, and assuming that both regions are active in traditional production, we normalize the traditional good price to unity. As such, the wage rate equals one in both regions.

2.1 Households

The demand side of the model consists of dynastic households with symmetric regional preferences. The lifetime utility of the representative household residing in region i is

$$U_i = \int_0^\infty e^{-\rho t} \left(\alpha \log C_{Xi}(t) + (1-\alpha) \log C_{Yi}(t)\right) dt, \tag{1}$$

where C_{Xi} and C_{Yi} are the quantities consumed of a composite of manufacturing goods and the traditional good, ρ is the subjective discount rate, and $\alpha \in (0,1)$. We suppress the time argument (t), where possible, in order to simplify notation.

The manufacturing composite is a constant elasticity of substitution (CES) aggregator across the manufacturing varieties produced in three locations:

$$C_{Xi} = \left(\int_0^{N_i} c_i(m)^{\frac{\sigma-1}{\sigma}} dm + \int_0^{N_j} c_j(m)^{\frac{\sigma-1}{\sigma}} dm + \int_0^{N^*} c^*(m)^{\frac{\sigma-1}{\sigma}} dm\right)^{\frac{\sigma}{\sigma-1}}, \tag{2}$$

with $c(m)$ denoting the household consumption of a representative variety m from the masses of product varieties produced in region i (N_i) and region j (N_j). The total mass of domestically produced varieties is $N \equiv N_1 + N_2$. Consumption of a representative variety m from the mass of imported varieties (N^*) is denoted by $c^*(m)$, where variables associated with the rest of the world are indicated with an asterisk. The elasticity of substitution between any given pair of varieties is $\sigma > 1$.

The household's utility maximization problem is solved in three stages. First, the household sets an optimal expenditure path with the objective of maximizing lifetime utility (1) subject to the flow budget constraint $\dot{V}_i = rV_i + L_i - E_i$, where r is the interest rate, V_i is asset wealth, L_i is the labor force (labor income) in region i, and time differentiation is denoted with a dot over a variable. While households do not have access to international investment assets, a nationally integrated financial market ensures that the interest rate equalizes across regions. As a result, the solution to the household's optimization problem features common expenditure dynamics for the households residing in each region: $\dot{E}_1/E_1 = \dot{E}_2/E_2 = r - \rho$.

Second, at each moment in time, households allocate constant shares of expenditure to the manufacturing composite and traditional goods: $C_{Xi} = \alpha E_i / P_{Xi}$ and $C_{Yi} = (1-\alpha)E_i$. The price index associated with the manufacturing composite is

$$P_{Xi} = \left(\int_0^{N_i} p_i(m)^{1-\sigma} dm + \int_0^{N_j} (\tau p_j(m))^{1-\sigma} dm + \int_0^{N^*} (\tau^* p^*(m))^{1-\sigma} dm \right)^{\frac{1}{1-\sigma}}, \quad (3)$$

where p_i and p_j are the prices of goods produced in regions i and j, and p^* is the price of goods imported from the rest of the world. Iceberg trade costs are incurred on shipments between regions and on imports, but at different rates. Specifically, $\tau > 1$ units must be shipped for each unit sold in regional trade, while $\tau^* > 1$ units must be shipped for each unit imported and sold to households residing in either region 1 or region 2. We assume that trade costs are lower for regional shipments than for international shipments; that is, $\tau < \tau^*$.

Third, given the constant expenditure share allocated to the manufacturing composite, applying Shephard's Lemma to the price index yields the instantaneous demand functions for the household in region i

$$c_i = p_i^{-\sigma} P_{Xi}^{\sigma-1} \alpha E_i, \qquad c_j = (\tau p_j)^{-\sigma} P_{Xi}^{\sigma-1} \alpha E_i, \qquad c^* = (\tau^* p^*)^{-\sigma} P_{Xi}^{\sigma-1} \alpha E_i, \quad (4)$$

for varieties produced in regions i and j, and for varieties imported from the rest of the world.

2.2 Manufacturing

The manufacturing sector produces differentiated product varieties for a domestic market characterized by Dixit and Stiglitz (1977) monopolistic competition. At each moment in time, a representative firm incurs variable labor costs in the production of a distinct product variety (l_{Xi}) and in process innovation (l_{Ri}). In addition, the firm bears fixed labor costs each period in the management of production and innovation activities (l_F). Although the production technologies associated with specific product lines are unique, we assume that labor productivity is symmetric across domestic firms, while allowing for an international productivity differential with international firms located in the rest of the world.

Following the process innovation literature (Smulders and van de Klundert 1995, Peretto 1996), the technology of a firm with production located in region i is

$$x_i = \theta^{\gamma} l_{Xi}, \tag{5}$$

where l_{Xi} is firm-level employment in production, θ is a firm-specific productivity parameter that is symmetric across regions, and $\gamma \in (0, 1)$ is the productivity elasticity of output. The innovation technology of a firm with R&D located in region i is

$$\dot{\theta} = \theta k_i l_{Ri}, \tag{6}$$

where l_{Ri} is firm-level employment in process innovation, and θk_i is labor productivity. Under this specification for R&D activity, technical knowledge is captured by firm-level productivity and accumulates within the production technology of the firm.

Following the process innovation literature (Smulders and van de Klundert 1995, Peretto 1996), current innovation activity improves the labor productivity of future innovation efforts, generating an intertemporal knowledge spillover that potentially leads to endogenous productivity growth (Romer 1990). The strength of the intertemporal knowledge spillover is closely connected with the geography of production through a knowledge spillover from production to innovation (Baldwin and Forslid 2000). In particular, we specify the strength of knowledge spillovers into process innovation located in region i as follows:

$$k_i = s_i + \delta s_j + \delta^* s^* \omega, \tag{7}$$

where $\delta \in (0, 1)$ is the degree of regional knowledge diffusion, $\delta^* \in (0, 1)$ is the degree of international knowledge diffusion, $s_i \equiv N_i/(N + N^*)$, $s_j \equiv N_j/(N + N^*)$, and $s^* \equiv N^*/(N + N^*)$ are the shares of firms with production located in region i, region j, and the rest of the world, and $\omega \equiv \theta^*/\theta$ describes the productivity differential between domestic and international firms.

Under specification (7), knowledge spillovers are determined as a weighted average of the technologies observable by the firm, with the weights decreasing in the distance between the observed technologies and the location of the R&D department of the firm. We capture the geographic nature of knowledge spillovers by assuming that $\delta > \delta^*$, such that domestic spillovers are greater than international spillovers. This assumption matches with evidence from the empirical literature of both the localized nature of knowledge spillovers and the presence of international knowledge diffusion (Bottazi and Peri 2007; Mancusi 2008; Coe et al. 2009; and Ang and Madsen 2013). Importantly, the region with the greatest share of production has the strongest potential for knowledge spillovers from production into innovation.

The total per-period profit of a firm with production located in region i and innovation located in region j is composed of operating profit on sales ($\pi_i = p_i x_i - l_{Xi}$) minus the cost of employing labor in innovation (l_{Rj}) and the per-period fixed cost (l_F):

$$\Pi_i = \pi_i - l_{Rj} - l_F, \tag{8}$$

where the firm may or may not locate production and innovation in the same region, following from the footloose nature of firm organization.

At each moment in time, a representative firm sets its product price (p_i) and employment in process innovation (l_{Rj}) with the objective of maximizing firm value, which is equal to the present value of the future profit stream:

$$v_i = \int_0^\infty \Pi_i(t) e^{-\int_0^t r(t')dt'} dt. \tag{9}$$

This optimization problem is solved using a current value Hamiltonian function $H_i = \pi_i - l_{Rj} - l_F + p_{Rj}\theta k_j l_{Rj}$, where p_{Rj} captures the internal value of the firm's technical knowledge when production is located in region i and innovation is located in region j.

With CES preferences over product variety, the optimal pricing strategy is a constant markup over the unit cost of production, $p = \sigma/((\sigma-1)\theta^{\gamma})$, with symmetric pricing strategies across regions. Each firm sets its output level to meet the combined demands from each region ($x_i = c_i + \tau c_j$) generating operating profit on sales equal to

$$\pi_i = \frac{l_{Xi}}{\sigma - 1} = \frac{\alpha p_i^{1-\sigma}}{\sigma} \left(\frac{E_i}{P_{Xi}^{1-\sigma}} + \frac{\tau^{1-\sigma} E_j}{P_{Xj}^{1-\sigma}} \right), \tag{10}$$

for a firm with production located in region i.

Firms set their optimal levels of employment in process innovation to satisfy the following static and dynamic efficiency conditions:

$$p_{Rj} = \frac{1}{\theta k_j}, \qquad\qquad r = \gamma(\sigma-1)k_j\pi_i - \frac{\dot{k}_j}{k_j} - \frac{\dot{\theta}}{\theta}. \tag{11}$$

Note that firms do not account for changes in either the prices indices (3) or the level of knowledge spillovers (7), when setting optimal employment for process innovation, given the small firm-level market shares that arise under monopolistic competition.

2.3 Market Entry

Per-period profit determines the domestic level of entry into the manufacturing sector ($s \equiv N/(N+N^*)$). In particular, we suppose that firm value responds correctly to market entry and exit through adjustments in profit ($\partial\Pi/\partial s$) in the spirit of Novshek and Sonnenchein (1987).[2] The time derivative of firm value (9) yields a no-arbitrage condition that equates the return to market entry with the risk free interest rate: $rv = \Pi + \dot{v}$. With no costs incurred in the creation of new product designs, new firms enter when firm value is positive ($v > 0$), decreasing profit and reducing firm value. Alternatively, firms exit when firm value is negative ($v < 0$), increasing profit and raising firm value. The adjustment process is immediate ($\dot{v} = 0$), and

[2] See Smulders and van de Klundert (1995), Peretto (1996), and van de Klundert and Smulders (1997) for a full discussion of the dynamics that arise in this class of growth models.

leads to an equilibrium level of market entry that satisfies $v = 0$. As such, we have the following free market entry and exit condition for the manufacturing sector:

$$l_{Xi} = (\sigma - 1)(l_{Rj} + l_F). \tag{12}$$

With firm value driven to zero, domestic asset wealth also falls to zero ($V = Nv = 0$). The household's flow budget constraint then confirms that expenditure equals labor income in each region $E_i = L_i$, and thus $r = \rho$ at all moments in time.

2.4 Location Patterns

Firms shift production and innovation freely and independently between regions, at no cost, with the aim of maximizing firm value by minimizing both production and innovation costs (Martin and Rogers 1995; Martin and Ottaviano 1999; Davis and Hashimoto 2016). In this section, we show that the domestic share of manufacturing firms (s) and the productivity differential (ω) play key roles in the determination of regional location patterns.

Looking first at the location pattern for production, when both regions have positive production shares, location arbitrage leads to the equalization of operating profit across regions: $\pi_1 = \pi_2$. We suppose that imported varieties are also priced using a constant markup over unit production costs: $p^* = \sigma/((\sigma - 1)\theta^{*\gamma})$, where we normalize the common wage rate in the rest of the world to unity. Substituting (10) into the location-arbitrage condition ($\pi_1 = \pi_2$) yields regional shares of domestic production:

$$\frac{s_i}{s} = \frac{(L_i - \varphi L_j)}{(1 - \varphi)L} + \frac{(L_i - L_j)\varphi^* s^* \omega^{\gamma(\sigma-1)}}{(1 - \varphi)Ls}, \tag{13}$$

where $L \equiv L_1 + L_2$ is the national labor force, $s \equiv N/(N + N^*)$ is the share of product varieties produced domestically, and $s^* \equiv N^*/(N + N^*)$ is the share of product varieties imported from the rest of the world. The level of regional trade costs is measured by $\varphi \equiv \tau^{1-\sigma} \in (0, 1)$, with $d\varphi/d\tau < 0$: there is no regional trade for $\varphi = 0$ and regional trade is free for $\varphi = 1$. In a similar manner, $\varphi^* \equiv \tau^{*1-\sigma} \in (0,1)$ indexes the level of trade costs on imports.

We use (s_i/s) as a measure of the domestic level of industry concentration. There are two mechanisms determining industry concentration. The first term on the righthand side of (13) describes a *home market* effect (Krugman 1980) whereby a greater share of firms locate production in proximity to the market of the larger region. The second term captures an *import competition* effect, through which a rise in the share of imported varieties (s^*) induces firms to shift production towards the larger region in order to mitigate the effects of greater import competition. The import competition effect is increasing in the technology gap with the rest of the world $(\omega \equiv \theta^*/\theta)$. Hereafter, we assume without loss of generality that region 1 has the larger population and thus the greater production share; that is, $L_1 > L_2$ and $s_1 > s_2$. In addition, because we are interested in location patterns that feature non-negative production shares for both regions, we focus on equilibria that satisfy $(L_i - \varphi L_j)s + (L_i - L_j)\varphi^* s^* \omega^{\gamma(\sigma-1)} \geq 0$ in order to ensure that $s_i \geq 0$.

Turning next to the location pattern for innovation, given the current state of technology (θ), firms shift their innovation activities to the region with the lowest cost of process innovation (p_{Ri}). Because region 1 has a larger production share $(s_1 > s_2)$, it supports stronger knowledge spillovers from production into innovation. As a result, all firms locate process innovation in region 1 in order to take advantage of lower innovation costs $(p_{R1} < p_{R2})$. With innovation fully concentrated in region 1, the no-arbitrage condition for investment in process innovation becomes

$$\rho = \gamma k l_X - k l_R - \frac{\dot{k}}{k}, \tag{14}$$

where we now drop the subscript on the strength of knowledge spillovers $(k_1 = k)$ with the understanding that while there are positive shares of firms locating production in each region, all firms locate process innovation in region 1.

The equilibrium strength of knowledge spillovers is obtained by substituting regional production shares (13) into (7):

$$k(\omega, s) = \frac{(1-\delta)((L_1 - \varphi L_2)s + (L_1 - L_2)\varphi^* s^* \omega^{\gamma(\sigma-1)})}{(1-\varphi)L} + \delta s + \delta^* s^* \omega. \tag{15}$$

A rise in the domestic share of firms (s) has three opposing effects on the strength of knowledge spillovers. First, as shown by the first term on the righthand side, while an increase in the larger region's share of firms (s_1) improves knowledge spillovers from production to innovation, from (13) the direction of the adjustment in s_1 after an increase in s depends on whether the home market effect or the import competition effect dominates. The second term shows the direct improvement in domestic knowledge spillovers resulting from a rise in s. The third term describes how a fall in the imported share of varieties (s^*) leads to a deterioration in international knowledge spillovers. The overall balance of these effects depends on regional and international knowledge diffusion, regional and international trade costs, and the size of the productivity differential. In contrast, an increase in the productivity differential itself always leads to stronger knowledge spillovers.

Finally, with a common level of operating profit for all domestic firms, regardless of the location of production, the equilibrium scale of production becomes

$$l_X(\omega, s) = \frac{\alpha(\sigma-1)(1+\varphi)Ls^*}{\sigma((1+\varphi)s + 2\varphi^* s^* \omega^{\gamma(\sigma-1)})N^*} \tag{16}$$

for all firms, where we have used regional production shares (13) with (10). An increase in the domestic share of firms (s) reduces the scale of production as the industry becomes more competitive. Similarly, an increase in the productivity differential leads to a smaller production scale as the price of imports falls relative to the price of domestic products.

3 Long-run Equilibrium

This section characterizes the long-run equilibrium and derives the necessary conditions for saddlepath stability. We reduce the model to two implicit expressions for the determination of the steady-state productivity differential (ω) and the domestic share of firms (s). The long-run equilibrium features constant labor allocations across sectors in each region. As discussed above, under our small country assumption, the number of international firms (N^*) and the international rate of productivity growth ($g^* \equiv \dot{\theta}^*/\theta^*$) are exogenous.

Beginning with the dynamics for the productivity differential (ω), we substitute the free market entry and exit condition (12) into the time derivative of $\omega \equiv \theta^*/\theta$ to obtain the following differential equation:

$$\frac{\dot{\omega}}{\omega} = g^* - g = g^* - kl_R = g^* - \frac{kl_X}{\sigma - 1} + kl_F. \tag{17}$$

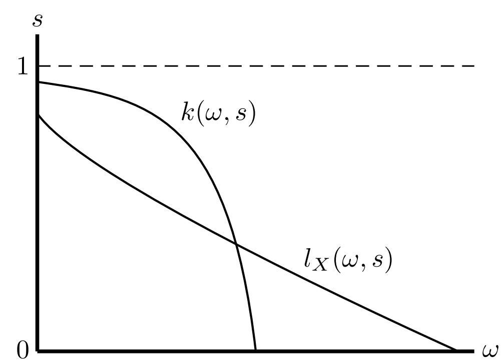
Naturally, a constant productivity differential requires that the domestic rate of productivity growth ($g \equiv \dot{\theta}/\theta$) match the international productivity growth rate (g^*). Thus, in long-run equilibrium we have $l_X = (\sigma - 1)(l_F + g^*/k)$, capturing a negative relationship between the strength of knowledge spillovers and the firm scale of production.

Turning next to the domestic share of product variety (s), we combine (8) and (14) to rewrite per-period profit as follows:

$$\Pi = \frac{(1 - \gamma(\sigma - 1))l_X}{\sigma - 1} + \frac{\rho}{k} + \frac{\partial k}{\partial \omega}\frac{\dot{\omega}}{k^2} - l_F = 0, \tag{18}$$

where we have used the time derivative of (15). With free market entry and exit, the share of domestic firms adjusts immediately ($\dot{s} = 0$) to drive per-period profit and firm value to zero, given both the current level and the evolution of the productivity differential. This adjustment process requires that firm profit respond correctly to market entry and exit ($\partial \Pi/\partial s < 0$), as discussed in Section 2.3. To ensure that per-period profit (Π) is an increasing function of

Figure 1: Market Entry and the productivity differential



This stylized figure can be produced using the following parameter values: $\alpha = 0.75$, $\sigma = 5$, $\rho = 0.03$, $\gamma = 0.15$, $l_F = 0.15$, $\delta = 0.5$, $\delta^* = 0.35$, $\varphi = 0.15$, $\varphi^* = 0.1$, $g^* = 0.03$, $L_1 = 300$, $L_2 = 200$, and $N^* = 500$. This parameter set yields $\omega = 0.75$, $s = 0.36$, $s_1/s = 0.67$, $(ds/d\omega)|_{l_X} - (ds/d\omega)|_k = 0.57$, and $d\Pi/ds = -0.12$.

operating profit on sales ($\pi = l_X/(\sigma - 1)$), we focus on the case for which $1 > \gamma(\sigma - 1)$.

The first implicit expression for the steady-state determination of ω and s is obtained by setting $\dot{\omega} = 0$ in (17) and (18), solving for k, and then equating the result with (15):

$$k(s, \omega) = \overline{k} \equiv \frac{\rho + (1 - \gamma(\sigma - 1))g^*}{\gamma(\sigma - 1)l_F}. \tag{19}$$

This expression is illustrated by the k-curve in Figure 1, and indicates the combinations of ω and s for which knowledge spillovers (k) satisfy the conditions for firm-level optimal investment in process innovation and free market entry and exit. An increase in the productivity differential improves knowledge spillovers, necessitating an adjustment in the domestic level of market entry. Given the opposing effects of changes in s on knowledge spillovers, as described by (15), however, market entry may rise or fall depending on regional trade costs and the regional degree of knowledge diffusion. Figure 1 depicts the case for which an increase in the productivity differential causes domestic firms to exit the market. Pairs of ω and s to the left (right) of the k-curve describe levels of knowledge spillovers below (above) the steady-state level.

The second implicit expression is obtained by once again setting $\dot{\omega} = 0$ in (17) and (18), but now solving for l_X, and combining the results with (16) to derive the firm-level scale of production as a function of the ω and s combinations that are consistent with optimal investment in process innovation and free market entry and exit:

$$l_X(s,\omega) = \bar{l}_X \equiv \frac{(\sigma-1)(\rho+g^*)l_F}{\rho+(1-\gamma(\sigma-1))g^*}. \tag{20}$$

This condition is depicted by the l_X-curve in Figure 1. An increase in the productivity differential intensifies import competition, forcing a share of domestic firms to exit the market and returning the firm-level scale of production to its long-run level. The firm-level scale of production rises above (falls below) its steady-state level for combinations of ω and s that lie to the left (the right) of the l_X-curve.

The long-run equilibrium is found at the intersection of the k-curve (19) and the l_X-curve (20). Importantly, the long-run strength of knowledge spillovers and firm-level scale of production are determined independently of trade costs and knowledge diffusion, depending solely on the exogenous rate of productivity growth, firm-level fixed costs, and demand parameters. Together (17) and (18) describe a dynamic system for ω and s with one differential equation and one side condition. In the Appendix A we evaluate the local dynamics around the steady state using a Taylor expansion of (17), and obtain the following proposition outlining the necessary conditions for the saddlepath stability of long-run equilibrium described by the k-curve and the l_X-curve:

Proposition 1 *A long-run equilibrium with constant values for the productivity differential ($\dot{\omega}=0$) and the domestic level of market entry ($\dot{s}=0$) is saddlepath stable for*

$$\left.\frac{ds}{d\omega}\right|_{l_X} - \left.\frac{ds}{d\omega}\right|_{k} = \left(\frac{(1+\varphi)\delta^*\omega+\gamma(\sigma-1)(2k-1-\delta)\varphi^*\omega^{\gamma(\sigma-1)}}{(1+\varphi)s+2\varphi^*s^*\omega^{\gamma(\sigma-1)}}\right)\frac{\bar{l}_X}{\omega} > 0,$$

under $\partial\Pi/\partial s < 0$.

Proof: See Appendix A.

Consider the effects of a small increase in the productivity differential (ω), starting from the long-run equilibrium. The balance of two mechanisms determine whether the productivity differential will return to its steady-state level: a *knowledge spillover* effect (15) and an *innovation scale* effect (16). First, the direct effects of a rise in ω are an improvement in knowledge spillovers ($\partial k/\partial\omega > 0$) and a reduction in the firm-level scale of process innovation ($\partial l_R/\partial\omega = 1/(\sigma-1)\partial l_X/\partial\omega < 0$). As a result, per-period profit falls under our assumption that per-period profit is increasing in operating profit $(1 > \gamma(\sigma-1))$. Next, the indirect effect of the rise in ω is the market exit of a share of domestic firms in response to the fall in profit ($\partial\Pi/\partial s < 0$). The decrease in s allows the remaining firms to increase the scale of innovation ($\partial l_R/\partial s = 1/(\sigma-1)\partial l_X/\partial s < 0$), while causing knowledge spillovers to either improve or deteriorate, depending on whether the home market effect, the import competition effect, or the direct knowledge spillover effect dominates in (15). These mechanisms lead to saddlepath stability if the slope of the l_X-curve is greater than the slope of the k-curve, $(ds/d\omega)|_{l_X} > (ds/d\omega)|_k$, with an increase in ω temporarily raising the domestic productivity growth rate above the international growth rate ($g > g^*$), causing the productivity differential to return to its steady state level. The conditions outlined in Proposition 1 ensure this slope ranking, as depicted in Figure 1.

4 Economic Integration

This section investigates the implications of improved economic integration at the national and international levels. Beginning with the effects of improvements in regional and international knowledge diffusion, we have the following proposition.

Proposition 2 *An improvement in either the regional (δ) or the international (δ^*) degree of knowledge diffusion induces domestic market entry (s), lowers the productivity differential (ω), and reduces industry concentration (s_1/s).*

Proof: See Appendix B.

Improvements in regional and international knowledge diffusion directly increase the strength of knowledge spillovers, thereby improving labor productivity in process innovation, as described by a leftward shift in the k-curve in Figure 1. Accordingly, the per-period innovation cost falls and profit rises, inducing new firms to enter the market and increasing the domestic share of firms (s). Improvements in knowledge diffusion temporarily accelerate domestic productivity growth, causing the productivity differential (ω) to fall until firm-level employment and knowledge spillovers return to their steady-state levels, and domestic productivity growth once again matches the international rate. The rise in market entry and the fall in the productivity differential reduce the strength of the import competition effect in (13), leading to a lower level of industry concentration in the larger region (s_1/s).

Turning next to increased trade integration both domestically and with the rest of the world, we obtain the following proposition:

Proposition 3 *A reduction in regional trade costs (a rise in φ) induces market entry (s), lowers the productivity differential (ω), and raises industry concentration (s_1/s). Reducing international trade costs (a rise in φ^*) lowers s, but decreases ω when $\bar{k} < (1+\delta)/2$ and increases ω when $\bar{k} > (1+\delta)/2$. A rise in φ^* increases s_1/s.*

Proof: See Appendix C.

A decrease in regional trade costs raises the firm-level scale of production (16), shifting the l_X-curve to the right in Figure 1. Similarly, for a given productivity differential (ω) and level of market entry (s), the home market effect allows the larger region to increase its share of domestic production, improving knowledge spillovers (15) and shifting the k-curve to the left. As such, greater firm-level investment in process innovation combines with greater labor productivity to temporarily accelerate domestic productivity growth above the international productivity growth rate. The productivity differential falls as the level of market entry rises over the transition to a new steady state. Adjustments in the regional pattern of industry location (s_1/s) depend on the balance of the home market effect, which encourages increased industry concentration toward the larger region, and the import competition effect, through which a smaller productivity differential and a larger level of market entry tend to disperse industry across regions. We find that the home market effect always dominates, however, confirming that a reduction in regional trade costs leads to greater industry concentration.

A decrease in international trade costs reduces the firm-level scale of production (16), as the relative price of imported products falls. The negative effect of increased imported competition is illustrated by a leftward shift in the l_X-curve in Figure 1. At the same time, however, the import competition effect in (13) leads to greater industry concentration, raising the strength of knowledge spillovers (15) and shifting the k-curve to the left. As a result, profit (18) deteriorates and domestic firms exit the market. The direction of the adjustment in the productivity differential then depends on the regional degree of knowledge diffusion (δ) and the steady-state strength of knowledge spillovers ($\bar{k}$): the positive knowledge spillover effect dominates and ω increases for $k < (1 + \delta)/2$, but the negative production scale effect dominates and ω decreases for $k > (1 + \delta)/2$. Finally, the fall in international trade costs and the lower level of market entry combine to strengthen the import competition effect and increase the level of industry concentration in the larger region (s_1/s), regardless of whether the productivity differential rises or falls.

5 Import Competition

In this section, we consider the effects of increased import competition arising from either a greater variety of imports or a faster international rate of productivity growth. Looking first at an increase in the number of imported products, we derive the following result:

Proposition 4 *An increase in the number of imported products (N^*) lowers market entry (s), increases the productivity differential (ω), and raises industry concentration (s_1/s).*

Proof: See Appendix D.

Increased import competition through a rise in N^* leads to a lower production scale (16) for domestic firms, shifting the l_X-curve to the left in Figure 1. Consequently, firms exit as profit falls, reducing the level of market entry (s). With a smaller firm size, employment in process innovation declines, and the domestic rate of productivity growth temporarily falls below the international rate of productivity growth over the transition to a new steady state. Thus, greater import competition expands the technology gap. Together the fall in s and the rise in ω strengthen the import competition effect in (13), generating a higher level of industry concentration (s_1/s) in the larger region.

Lastly, we study the effects of an acceleration in the international rate of productivity growth. The results are summarized in the following proposition.

Proposition 5 *An increase in the international rate of productivity growth (g^*) lowers market entry (s), increases the productivity differential (ω), and raises industry concentration* (s_1/s).
Proof: See Appendix E.

A rise in the international productivity growth rate (g^*) expands the firm-level scale of production (16) causing a leftward shift in the l_X-curve in Figure 1. In addition, knowledge spillovers (15) strengthen and the k-curve shifts to the right. The domestic rate of productivity growth accelerates to match the international rate of productivity growth as the economy transitions to a new steady state with a larger productivity differential (ω). Profit falls, reducing the level of market entry (s). Together the fall in s and the rise in ω strengthen the import competition effect in (13), increasing the concentration of industry in the larger region (s_1/s).

6 Conclusion

In this paper we introduce a model of import competition and industry location for a small open economy with two distinct regions that are symmetric with the exception of market size. In a monopolistically competitive industry, firms compete with imported products from the rest of the world as they produce goods for supply to domestic households. Productivity growth converges to the international rate through firm-level investment in process innovation. With firms free to locate production and innovation independently in the regions with the lowest respective costs, the concentration of industry is linked with firm-level innovation through an import competition effect that is increasing in the market share of imported goods and the productivity differential of domestic firms with the rest of the world.

We use the framework to study the effects of improved regional and international economic integration. First, improvements in regional and international knowledge diffusion lead to a greater domestic level of market entry, a reduced productivity differential between domestic firms and the rest of the world, and a lower level of industry concentration across regions. Second, decreases in regional and international trade costs expand the domestic level of market entry. While lower regional trade costs reduce the productivity differential, however, lower trade costs for imported goods may increase or decrease the productivity differential, depending on the strength of regional knowledge diffusion. Decreases in regional and international trade costs both increase the level of industry concentration.

Turning to the effects of import competition, we find that an increase in the number of imported products, or an acceleration in the international rate of productivity growth, causes a contraction in the domestic level of market entry, an increase in the productivity differential, and an expansion in the concentration of industry in the larger region.

Appendix A (Proposition 1): With the zero profit condition determining the level of market entry associated with a given productivity differential at each moment in time, the total derivative of (18) evaluated around $\dot{\omega} = 0$ dictates how s adjusts in response to changes in ω: $ds/d\omega = -(\partial\Pi/\partial\omega)/(\partial\Pi/\partial s)$, with

$$\frac{\partial \Pi}{\partial \omega} = \left(\frac{1-\gamma(\sigma-1)}{\sigma-1} - \frac{\omega}{(\sigma-1)\overline{k}}\frac{\partial k}{\partial \omega}\right)\frac{\partial l_X}{\partial \omega} - \left(\frac{\rho}{\overline{k}^2} + \frac{\omega \bar{l}_R}{\overline{k}^2}\frac{\partial k}{\partial \omega}\right)\frac{\partial k}{\partial \omega},$$
$$\frac{\partial \Pi}{\partial s} = \left(\frac{1-\gamma(\sigma-1)}{\sigma-1} - \frac{\omega}{(\sigma-1)\overline{k}}\frac{\partial k}{\partial \omega}\right)\frac{\partial l_X}{\partial s} - \left(\frac{\rho}{\overline{k}^2} + \frac{\omega \bar{l}_R}{\overline{k}^2}\frac{\partial k}{\partial \omega}\right)\frac{\partial k}{\partial s},$$

where firm-level employment is constant in the steady state according to (20), $\bar{l}_R = \gamma(\sigma -$

$1)g^* l_F/(\rho + (1-\gamma(\sigma-1))g^*)$, and from (15) and (16), we have

$$\begin{aligned}
\frac{\partial k}{\partial \omega} &= \frac{(1-\delta)(L_1-L_2)\varphi^* s^* \gamma(\sigma-1)\omega^{\gamma(\sigma-1)-1}}{(1-\varphi)L} + \delta^* s^* > 0,\\
\frac{\partial k}{\partial s} &= \frac{(1-\delta)(L_1-\varphi L_2) + \delta(1-\varphi)(\delta-\overline{k})L}{(1-\varphi)Ls^*} \gtreqless 0,\\
\frac{\partial l_X}{\partial \omega} &= -\frac{2\gamma(\sigma-1)\varphi^* s^* \omega^{\gamma(\sigma-1)-1}\overline{l}_X}{(1+\varphi)s + 2\varphi^* s^* \omega^{\gamma(\sigma-1)}} < 0,\\
\frac{\partial l_X}{\partial s} &= -\frac{(1+\varphi)\overline{l}_X}{s^*((1+\varphi)s + 2\varphi^* s^* \omega^{\gamma(\sigma-1)})} < 0.
\end{aligned}$$

Setting the domestic share of production (s) as a control variable and the productivity differential (ω) as a state variable, the long-run equilibrium is saddlepath stable when the linearized system has one positive and one negative eigenvalue. Therefore, a first-order Taylor expansion of (17) around the steady state described by (19) and (20) yields a saddlepath stable steady state for $d\dot{\omega}/d\omega = \partial\dot{\omega}/\partial\omega + (\partial\dot{\omega}/\partial s)(ds/d\omega) = \gamma l_F \Omega/(\partial\Pi/\partial s) < 0$, where

$$\Omega = \left.\frac{ds}{d\omega}\right|_{l_X} - \left.\frac{ds}{d\omega}\right|_{k} = \left(\frac{(1+\varphi)\delta^*\omega + \gamma(\sigma-1)(2\bar{k}-1-\delta)\varphi^*\omega^{\gamma(\sigma-1)}}{(1+\varphi)s + 2\varphi^* s^* \omega^{\gamma(\sigma-1)}}\right)\frac{\overline{l}_X}{\omega} > 0.$$

Thus, $(1+\varphi)\delta^*\omega + \gamma(\sigma-1)(2\bar{k}-1-\delta)\varphi^*\omega^{\gamma(\sigma-1)} > 0$ becomes a necessary condition for saddlepath stability, with $\partial\Pi/\partial s < 0$ required to ensure that firm value responds correctly to market entry and exit, as described in Section 2.3.

Appendix B (Proposition 2): Using (15), (16), (19) and (20), we obtain

$$\begin{aligned}
\frac{d\omega}{d\delta} &= \frac{\partial k}{\partial \delta}\frac{\partial l_X}{\partial s}\frac{1}{\Omega} < 0, & \frac{ds}{d\delta} &= -\frac{\partial k}{\partial \delta}\frac{\partial l_X}{\partial \omega}\frac{1}{\Omega} > 0,\\
\frac{d\omega}{d\delta^*} &= \frac{\partial k}{\partial \delta^*}\frac{\partial l_X}{\partial s}\frac{1}{\Omega} < 0, & \frac{ds}{d\delta^*} &= -\frac{\partial k}{\partial \delta^*}\frac{\partial l_X}{\partial \omega}\frac{1}{\Omega} > 0,
\end{aligned}$$

where we have used $\partial k/\partial\delta = s_2 > 0$ and $\partial k/\partial\delta^* = s^*\omega > 0$. Substituting these results into the total derivative of (13) provides the following:

$$\frac{d(s_1/s)}{d\delta} = \frac{(L_1 - L_2)\varphi^* s^* \omega^{\gamma(\sigma-1)}}{L(1-\varphi)s} \left(\frac{\gamma(\sigma-1)}{\omega} \frac{d\omega}{d\delta} - \frac{1}{ss^*} \frac{ds}{d\delta} \right) < 0,$$
$$\frac{d(s_1/s)}{d\delta^*} = \frac{(L_1 - L_2)\varphi^* s^* \omega^{\gamma(\sigma-1)}}{L(1-\varphi)s} \left(\frac{\gamma(\sigma-1)}{\omega} \frac{d\omega}{d\delta^*} - \frac{1}{ss^*} \frac{ds}{d\delta^*} \right) < 0.$$

Appendix C (Proposition 3): Using (15), (16), (19) and (20), we obtain the following:

$$\frac{d\omega}{d\varphi} = \left(\frac{\partial k}{\partial \varphi} \frac{\partial l_X}{\partial s} - \frac{\partial l_X}{\partial \varphi} \frac{\partial k}{\partial s} \right) \frac{1}{\Omega} < 0, \qquad \frac{ds}{d\varphi} = \left(\frac{\partial l_X}{\partial \varphi} \frac{\partial k}{\partial \omega} - \frac{\partial k}{\partial \varphi} \frac{\partial l_X}{\partial \omega} \right) \frac{1}{\Omega} > 0,$$
$$\frac{d\omega}{d\varphi^*} = \frac{(1+\delta-2\bar{k})\omega^{\gamma(\sigma-1)}\bar{l}_X}{((1+\varphi)s + 2\varphi^* s^* \omega^{\gamma(\sigma-1)})\Omega}, \qquad \frac{ds}{d\varphi^*} = -\frac{2\delta^* s^{*2} \omega^{\gamma(\sigma-1)}\bar{l}_X}{((1+\varphi)s + 2\varphi^* s^* \omega^{\gamma(\sigma-1)})\Omega} < 0,$$

with $\Omega > 0$ from Proposition 1 and $\partial k/\partial s > 0$ by assumption. In addition,

$$\frac{\partial k}{\partial \varphi} = \frac{(1-\delta)(L_1 - L_2)(s + \varphi^* s^* \omega^{\gamma(\sigma-1)})}{(1-\varphi)^2 L} > 0,$$
$$\frac{\partial l_X}{\partial \varphi} = \frac{2\varphi^* s^* \omega^{\gamma(\sigma-1)}\bar{l}_X}{(1+\varphi)((1+\varphi)s + 2\varphi^* s^* \omega^{\gamma(\sigma-1)})} > 0,$$
$$\frac{\partial k}{\partial \varphi^*} = \frac{(1-\delta)(L_1 - L_2)s^* \omega^{\gamma(\sigma-1)}}{(1-\varphi)L} > 0,$$
$$\frac{\partial l_X}{\partial \varphi^*} = -\frac{2s^* \omega^{\gamma(\sigma-1)}\bar{l}_X}{(1+\varphi)s + 2\varphi^* s^* \omega^{\gamma(\sigma-1)}} < 0.$$

Then, from (7) we have $s_1/s = \overline{k}/((1-\delta)s) - \delta/(1-\delta) - \delta^* s^* \omega/((1-\delta)s)$, and

$$\begin{aligned} \frac{d(s_1/s)}{d\varphi} = {} & \frac{s^* \bar{l}_X}{(1-\delta)(1-\varphi)^2 sL\Omega} \times \\ & \Bigg(\frac{(1-\delta)(L_1 - L_2)\left((1+\varphi)s + 2\gamma(\sigma-1)\varphi^* s^* \omega^{\gamma(\sigma-1)}\right)}{(1+\varphi)ss^*} + \\ & \frac{(1-\varphi)\varphi^* s^* \omega^{\gamma(\sigma-1)}\left((1-\delta)(L_1 - L_2)s + 2(\delta - \bar{k})sL + 2\delta(1-\varphi)s^* L\right)}{(1+\varphi)((1+\varphi)s + 2\varphi^* s^* \omega^{\gamma(\sigma-1)})s} \Bigg) > 0, \\ \frac{d(s_1/s)}{d\varphi^*} = {} & \frac{(s_1 - s_2)\delta^* s^* \omega^{\gamma(\sigma-1)}\bar{l}_X}{((1+\varphi)s + 2\varphi^* s^* \omega^{\gamma(\sigma-1)})s^2\Omega} > 0. \end{aligned}$$

Appendix D (Proposition 4): From (15), (16), (19) and (20), we have

$$\frac{d\omega}{dN^*} = -\frac{\partial l_X}{\partial N^*}\frac{\partial k}{\partial s}\frac{1}{\Omega} > 0, \qquad \frac{ds}{dN^*} = \frac{\partial l_X}{\partial N^*}\frac{\partial k}{\partial \omega}\frac{1}{\Omega} < 0,$$

where $\partial l_X/\partial N^* = -l_X/N^* < 0$. Thus, (13) yields the following:

$$\frac{d(s_1/s)}{dN^*} = \frac{(L_1 - L_2)\varphi^* s^* \omega^{\gamma(\sigma-1)}}{L(1-\varphi)s}\left(\frac{\gamma(\sigma-1)}{\omega}\frac{d\omega}{dN^*} - \frac{1}{ss^*}\frac{ds}{dN^*}\right) > 0.$$

Appendix E (Proposition 5): Using (15), (16), (19) and (20), we obtain

$$\frac{d\omega}{dg^*} = \left(\frac{\partial l_X}{\partial g^*}\frac{\partial k}{\partial s} - \frac{\partial k}{\partial g^*}\frac{\partial l_X}{\partial s}\right)\frac{1}{\Omega}, \qquad \frac{ds}{dg^*} = \left(\frac{\partial k}{\partial g^*}\frac{\partial l_X}{\partial \omega} - \frac{\partial l_X}{\partial g^*}\frac{\partial k}{\partial \omega}\right)\frac{1}{\Omega},$$

where

$$\frac{\partial k}{\partial g^*} = \frac{(1-\gamma(\sigma-1))\overline{k}}{\rho + (1-\gamma(\sigma-1))g^*} > 0, \qquad \frac{\partial l_X}{\partial g^*} = \frac{\gamma(\sigma-1)\rho\bar{l}_X}{(\rho+g^*)(\rho + (1-\gamma(\sigma-1))g^*)} > 0.$$

Combining these results with (13) yields

$$\frac{d(s_1/s)}{dg^*} = \frac{(L_1 - L_2)\varphi^*\gamma(\sigma-1)\omega^{\gamma(\sigma-1)-1}\bar{l}_X}{L(1-\varphi)s^2(\rho+g^*)\Omega}\left(\bar{k} + \frac{(1-\gamma(\sigma-1))\rho\delta^* s^*\omega}{\rho + (1-\gamma(\sigma-1))g^*}\right) > 0.$$

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