Corporate Tax Policy and Industry Location with Fully Endogenous Productivity Growth

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Abstract

This papers considers how national corporate tax policy affects productivity growth through adjustments in geographic patterns of industry in a two-country model of trade. With trade costs and imperfect knowledge spillovers between countries, production concentrates partially and innovation concentrates fully in the country with the lowest tax rate. When firms have weak (strong) monopoly power, a decrease in the tax rate of the low-tax-rate country depresses (accelerates) productivity growth. The paper also investigates the relationship between relative tax rates and the level of product variety, and analytically characterizes the effects of changes in tax policy on national welfare.

Key Words: National Corporate Tax Policy, Fully Endogenous Productivity Growth, Monopoly Power, Industry Concentration
JEL Classifications: F43; O30; O40; R12

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1 Introduction

The influence of national tax policy on geographic patterns of industry is a key concern for policy makers at local, regional, and national levels, with emphasis often placed on the pro-growth effects of low corporate tax rates as a component of trade policy. Indeed, Kammas (2011) and Brülhart et al. (2012) present empirical evidence indicating that tax policies are an important factor in the location decisions of firms.[1] Moreover, Devereux and Loretz (2013) survey the tax competition literature and conclude that the evidence suggests a pattern of strategic interaction in the corporate tax rates set by national governments, which may provide one possible explanation for the international trend towards lowering effective tax rates on corporate income (IMF, 2014). Given this policy trend, it is important to consider how economic growth is affected by shifts in production between locations, as firms respond to changes in corporate tax policy. In this paper, we attempt to address this question by studying the effects of corporate taxes on industry location in a two-country model of trade and fully endogenous economic growth.

In particular, we extend the framework of Davis and Hashimoto (2015a) to investigate the effects of national tax policy on industry location, productivity growth, and market entry. Monopolistically competitive firms employ labor in process innovation with the objective of reducing unit production costs, and knowledge accumulation within the production technologies of firms lowers the costs of future innovation efforts, potentially generating endogenous productivity growth (Smulders and van de Klundert, 1995; Peretto, 1996). Perfect capital mobility allows firms to locate production and innovation independently in the countries with the lowest costs. As a result, with international trade costs, a standard home market effect causes a greater share of firms to locate production in the country with the lowest corporate tax rate

[1] Feld and Heckemeyer (2011) provide a survey of the empirical literature investigating the effects of fiscal policy on foreign direct investment flows.

and the largest after tax market (Martin and Rogers, 1995). In addition, imperfect international knowledge diffusion leads to greater knowledge spillovers from production to innovation, lower R&D costs, and the full concentration of process innovation in the low-tax-rate country.

The effects of national tax policy on firm-level employment in production and innovation are intrinsically linked to monopoly power through free market entry and exit. Specifically, firms employ a greater share of labor in production when they have weak monopoly power, and a greater share of labor in innovation when they have strong monopoly power. Decreasing the corporate tax rate of the low-tax-rate country raises its share of production, affecting employment in innovation through two channels. The first is a knowledge spillover effect, through which the increased concentration of industry lowers the cost of innovation, causing firm employment in innovation to fall when monopoly power is weak and to rise when monopoly power is strong. The second channel is a profit effect that is positive when the tax rate of the low-tax-rate country is high and the rise in industry-wide profit corresponding with lower trade costs dominates. The profit effect is negative when the initial tax rate is low and the fall in firm-level profit resulting from greater competition in the low-tax-rate country dominates.

The balance of the knowledge spillover and profit effects determines how changes in national tax policy affect product variety and productivity growth. When firms have weak monopoly power, reducing the tax rate of the low-tax-rate country depresses productivity growth, but has a positive effect on product variety if the initial tax rate is high and an ambiguous effect on product variety if the initial tax rate is low. Alternatively, when monopoly power is strong, a reduction in the tax rate accelerates productivity growth, but has an ambiguous effect on product variety if the initial tax rate is high and a negative effect on product variety if the initial tax rate is low.

In general, the empirical literature tends to find evidence supporting a negative relationship between corporate taxes and economic growth (Lee and Gordon, 2005; Arnold et al., 2011; Gemmell at al., 2015), in contrast to the mixed theoretical results of this paper. Although, Angelopoulos et al. (2007) report that corporate taxes have a positive effect on growth, and Ojede and Yamarik (2012) find that tax policy has no significant influence on long-run growth. As such, given the moderately mixed nature of empirical results, the framework presented in this paper emphasizes the importance of considering the firm location decision, when estimating the size of fiscal policy effects on economic growth (Gemmell at al., 2015).

We also investigate the relationship between corporate tax policy and national welfare levels. A decrease in the tax rate of the low-tax-rate country affects welfare levels through three channels. The first is a fall in the average price of manufacturing goods in the low-tax-rate country and a rise in average price in the high-tax-rate country. The second and third channels are a love of variety effect and a productivity growth effect. We show analytically that the balance between these channels is determined by the degree of monopoly power. As such, national welfare levels may be increasing or decreasing in the corporate tax rate of the low-tax-rate country, depending on the monopoly power of manufacturing firms.

There is a broad theoretical literature studying the relationship between corporate tax rates and economic growth. However, the number of studies considering firm, or capital, mobility is limited. In a closed economy model of fully endogenous productivity growth, Peretto (2007) shows that a budget-neutral increase in corporate taxes has a positive effect on economic growth. Iwamoto and Shibata (2008) and Palomba (2008) develop open economy models using overlapping generations frameworks to study the effects of capital income tax rates on the movement of capital and the economic growth rate, and find that lowering tax rates with the aim of attracting capital may have a negative effect on growth. Both of these models exhibit scale effects, however, with a positive relationship between the size of the labor force and the rate of economic growth. In this paper, we develop an open economy framework that allows for firm mobility, and study the relationship between corporate taxes and economic growth that is not biased by scale effects.[2]

The remainder of the paper proceeds as follows. In Section 2, we introduce our theoretical framework and investigate the effects of national corporate tax rates on the location patterns of production and innovation. Then, we consider the implications of corporate taxes for the rate of productivity growth, level of product variety, and national welfare. The paper concludes in Section 3.

2 The Model

This section extends Davis and Hashimoto (2015a) to consider the implications of national corporate tax policy for patterns of industrial activity, productivity growth, and market entry. The model consists of two countries, home and foreign, that potentially employ labor in three activities: traditional production, manufacturing, and process innovation. The home and foreign labor supplies, L and L^*, are mobile between sectors, but not between countries, with an asterisk denoting variables associated with foreign. We focus on home as we introduce the model setup.

2.1 Households

The demand side of the economy is made up of the dynastic households residing in each country. These households choose optimal saving-expenditure paths over an infinite time horizon with the aim of maximizing lifetime utility,

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

[2]This paper develops an endogenous market structure and endogenous growth framework that is not biased by scale effects (Aghion and Howitt, 1998; Etro, 2009). Empirical support for the framework is found in Laincz and Peretto (2006), Ha and Howitt (2007), and Madsen et al. (2010).

where $C_X(t)$ and $C_Y(t)$ are household consumptions of a manufacturing composite and traditional goods at time t, ρ is the subjective discount rate, and $\alpha \in (0,1)$. Lifetime utility is maximised subject to the following flow budget constraint:

$$\dot{A}(t) = r(t)A(t) + w(t) + T(t) - P_X(t)C_X(t) - P_Y(t)C_Y(t),$$

where $A(t)$ is asset wealth, $r(t)$ is the interest rate, $w(t)$ is the wage rate, $T(t)$ is a lump-sum transfer from government to households, $P_X(t)$ is the price index associated with the manufacturing composite, $P_Y(t)$ is the price of traditional goods, and a dot indicates differentiation with respect to time.

The households of home and foreign have equal access to an international financial market, leading to a common interest rate across countries, and common motions for the evolution of household expenditure:

$$\frac{\dot{E}}{E} = \frac{\dot{E}^*}{E^*} = r - \rho, \tag{2}$$

where $E = P_X C_X + P_Y C_Y$. We suppress time notation for the remainder of the paper, when doing so does not cause confusion.

The per-period demands for the manufacturing composite and traditional good are $C_X = \alpha E / P_X$ and $C_Y = (1-\alpha)E/P_Y$, with the manufacturing composite, and its price index, taking a constant elasticity of substitution (CES) form:

$$C_X = \left(\int_0^N c_i^{\frac{\sigma-1}{\sigma}} di \right)^{\frac{\sigma}{\sigma-1}}, \qquad P_X = \left(\int_0^N p_i^{1-\sigma} di \right)^{\frac{1}{1-\sigma}}, \tag{3}$$

where the mass of product varieties available ($N = n + n^*$) equals the sum of varieties (n) produced in home and varieties (n^*) produced in foreign, c_i and p_i are the household consumption and price of variety i, and the constant elasticity of substitution between any pair of varieties is $\sigma > 1$. Given the constant level of household expenditure allocated to manufacturing goods, the home household demands for a domestically supplied variety i and an imported variety j are

$$c_i = \alpha p_i^{-\sigma} P_X^{\sigma-1} E, \qquad c_j = \alpha(\tau p_j^*)^{-\sigma} P_X^{\sigma-1} E, \tag{4}$$

where $\tau > 1$ is an iceberg trade cost, under which τ additional units must be shipped for every unit sold in an export market (Samuelson, 1954). We also derive analogous demand conditions for foreign households.

2.2 Production

The traditional good sector employs labor with a unit coefficient technology that exhibits constant returns to scale. We suppose that the share of traditional goods in household expenditure is large enough to ensure both countries produce traditional goods. Thus, with free trade in a competitive international market, the price of traditional goods and the wage rate are common across home and foreign. Setting the traditional good as the model numeraire, we have $P_Y = P_Y^* = w = w^* = 1$.

The manufacturing sector features Dixit and Stiglitz (1977) monopolistic competition, with each firm supplying a single unique product variety. While there are no costs associated with the development of new product designs, every period firms incur labor costs in the management (l_F) and implementation innovation (l_R), which are fixed with respect to production. The production technology of a firm with production located in home is

$$x = \theta l_X, \tag{5}$$

where x and l_X are output and employment in production, and θ is a firm-level productivity coefficient. Although each firm employs a unique production technique, we assume that productivity is symmetric across all firms in all locations ($\theta = \theta^*$).

We define the degree of monopoly power associated with each firm as the ratio of average revenue to marginal revenue (Helpman and Krugman, 1985). Therefore, with CES preferences over product variety, the degree of monopoly power is $\eta \equiv \sigma/(\sigma-1) > 1$, and firms set price equal to a constant markup over unit cost: $p = p^* = \eta/\theta$. Matching supply with the demands from the home and foreign markets, home-based production is $x = c_i L + \tau c_i^* L^*$, where $\tau > 1$ units must be produced for every unit sold in the export market. Together with (4), this condition yields optimal operating profit on sales for a firm with production located in home:

$$\pi = px - l_X = (\eta - 1)l_X = \frac{\alpha(\eta-1)}{\eta}\left(\frac{EL}{n+\varphi n^*} + \frac{\varphi E^* L^*}{\varphi n + n^*}\right), \tag{6}$$

where $\varphi = \tau^{1-\sigma}$ describes the freeness of trade.

2.3 Process Innovation

Manufacturing firms invest in process innovation with the objective of lowering production costs. In particular, each period a representative firm employs l_F units of labor in the management of innovation and l_R units of labor in process innovation, with the evolution of firm productivity governed by

$$\dot{\theta} = k\theta l_R, \tag{7}$$

where $k\theta$ is labor productivity in innovation. Following the in-house innovation literature (Smulders and van de Klundert, 1995; Peretto, 1996), a firm's current state of technical knowledge is captured by θ, and as a result knowledge accumulates within the production technology of the firm, generating an intertemporal knowledge spillover through which current innovation efforts reduces future R&D costs.

Adapting the specification of Baldwin and Forslid (2000), we assume that knowledge spillovers from production to innovation diminish with distance:

$$k = s + \delta s^*, \tag{8}$$

where $s \equiv n/N$ and $s^* \equiv n^*/N$ are the shares of firms with production located in home and foreign, and $\delta \in (0, 1)$ is the degree of knowledge diffusion between countries. Under this specification for knowledge spillovers, labor productivity in process innovation is determined as a weighted average of the productivities of technologies observable by the firm, with a stronger weighting for technologies used in production located in proximity to the R&D department of the firm.[3]

We consider territorial tax systems in which the source of production, rather than the point of sale, is used for taxation (IMF, 2014). As such, firm value equals the present discounted value of net per-period profits:

$$V = \int_0^\infty e^{-\int_0^t r(t')dt'}((1-z)(\pi(t) - l_R(t) - l_F))dt, \tag{9}$$

where $z \in (0, 1)$ is the corporate tax rate set on per-period profit in the home country.[4] Firms employ labor in process innovation with the goal of maximizing (9). We solve this optimization problem using the following current value Hamiltonian function: $H = (1-z)(\pi - l_R - l_F) + \mu k \theta l_R$, where μ is the current shadow value of the firm's stock of technical knowledge. Combining the first order conditions, $\partial H/\partial l_R = 0$ and $\partial H/\partial \theta = r\mu - \dot{\mu}$, leads to the following no-arbitrage condition for a firm's optimal level of investment in process innovation:

$$r \geq \frac{\pi k}{\eta - 1} - \frac{\dot{k}}{k} - \frac{\dot{\theta}}{\theta}. \tag{10}$$

[3]Coe et. al. (2009) and Ang and Madsen (2013) provide empirical support for the positive effects of international knowledge spillovers on total factor productivity growth.

[4]Within our framework, z is an average effective tax rate that may reflect a variety of country-specific tax rates (Bénassy-Quéré et al., 2005).

The internal rate of return to investment in process innovation equals the risk-free interest rate when firms exhibit productivity growth.

2.4 Market Entry

With zero costs incurred in the design of new product varieties, net per-period profits determine the level of market entry.[5] When firm value is positive ($V > 0$), new firms enter the market causing a fall in firm-level market shares and lowering firm value through a fall in operating profit on sales. Alternatively, when firm value is negative ($V < 0$), firms exit the market and firm value rises. This process is immediate, and leads to the following free entry conditions for production located in home and foreign:

$$\pi = l_R + l_F, \qquad\qquad \pi^* = l_R^* + l_F. \tag{11}$$

With all firms earning zero profits, corporate tax revenues are zero in both countries ($T = 0$), and household expenditure equals wage income ($E = 1$ and $E^* = 1$). Then, from (2), $r = \rho$ at all moments in time. For the remainder of the paper, we assume that the populations of home and foreign are equal ($L = L^*$), and focus on cross-country differences in corporate tax rates.

2.5 Corporate Taxes and Location Patterns

Free to shift production between countries, at zero cost, manufacturing firms locate production in the country that offers the highest level of operating profit, net of corporate taxes, with the aim of maximizing firm value. Accordingly, when manufacturing occurs in both countries, net operating profit on sales equalizes between home and foreign based production: $(1 - z)\pi = (1 - z^*)\pi^*$. Substituting (6) into this condition

[5] See Davis and Hashimoto (2015b) for a similar framework with positive entry costs.

yields the equilibrium share of firms with production located in home:

$$s(\varphi, Z) = \frac{(Z - \varphi) - \varphi(1 - \varphi Z)}{(1 - \varphi)^2(1 + Z)}, \tag{12}$$

where $Z \equiv (1-z)/(1-z^*)$ describes the corporate tax gap between home and foreign. An rise in Z indicates a fall in the home tax rate relative to foreign. In addition, $Z \in (\underline{Z}, \overline{Z})$, with $\underline{Z} = 2\varphi/(1+\varphi^2)$ and $\overline{Z} = (1+\varphi^2)/(2\varphi)$, is required for $s \in (0, 1)$. The home share of production features a standard home market effect (Krugman, 1980), with a greater share of firms locating production in the country with the larger after-tax market.

The effect of a change in the corporate tax gap on the location of production is summarized in the following lemma.

Lemma 1 *An increase in the tax gap (Z) raises the home share of production (s).*

Proof: The derivative of (12) with respect to Z yields

$$\frac{ds}{dZ} = \frac{(1+\varphi)^2}{(1-\varphi)^2(1+Z)^2} > 0.$$

This is a standard result in the New Economic Geography literature (Baldwin et al., 2003). Intuitively, an increase in the corporate tax gap (a decrease in home's relative tax rate) makes home more attractive as a location for production, as the relative size of its after-tax market increases. In order to simplify the analysis, we consider long-run equilibria for which home has a lower corporate tax rate and a larger share of manufacturing activity; that is, $Z \in (1, \overline{Z})$ and $s \in (1/2, 1)$. Accordingly, we focus on cases for which $k \in ((1+\delta)/2, 1)$ is satisfied.

The concentration of manufacturing activity leads to the full agglomeration of process innovation in home. To see this, we rewrite the no-arbitrage conditions (10) associated with investment in innovation in home and foreign as

$$\frac{\rho}{k} \geq \frac{(2-\eta)\pi}{\eta-1} + l_f, \qquad\qquad \frac{\rho}{k^*} \geq \frac{(2-\eta)\pi}{\eta-1} + l_f, \tag{13}$$

where we have used (11), equalized net operating profits $(1-z)\pi = (1-z^*)\pi^*$, and the fact that $\dot{s} = \dot{k} = 0$ in equilibrium. With manufacturing concentrated in home, greater knowledge spillovers from production to innovation ($k > k^*$) ensure that all process innovation occurs in home.

Combining the home no-arbitrage condition with (11), we solve for equilibrium firm-level employment in production and innovation:

$$l_X = \frac{kl_F - \rho}{(\eta-2)k}, \qquad\qquad l_R = \frac{kl_F - (\eta-1)\rho}{(\eta-2)k}. \tag{14}$$

As discussed in Davis and Hashimoto (2015a), these conditions dictate the range of knowledge spillovers consistent with both market entry and productivity growth.

Lemma 2 *Positive employment in both production and innovation requires (i)* $k \in ((1+\delta)/2, (\eta-1)\rho/l_F)$ *when monopoly power is weak* ($\eta < 2$)*, and (ii)* $k \in ((\eta-1)\rho/l_F, 1)$ *when monopoly power is strong* ($\eta > 2$)*.*

The degree of monopoly power dictates the ratio of labor employment in production to labor employment in process innovation that is consistent with positive productivity growth and free market entry and exit. When monopoly power is weak ($\eta < 2$), a low range of knowledge spillovers ensures that firms employ a greater share of labor in production ($l_X/(l_R + l_F) > 1$). On the other hand, a high range of knowledge spillovers is necessary with strong monopoly power ($\eta > 2$) in order to ensure that firms employ a higher share of labor in innovation ($l_X/(l_R + l_F) < 1$).

Before ending this section, we derive the level of operating profit on sales associated with the free movement of production between countries by substituting (12) into (6):

$$\pi = \frac{\pi^*}{Z} = \frac{\alpha(\eta-1)(1-\varphi)^2(1+Z)L}{\eta(1-\varphi Z)(Z-\varphi)N}, \tag{15}$$

where $Z \in (1, \overline{Z})$ ensures positive operating profit since $Z \in (\varphi, 1/\varphi)$.

2.6 Product Variety and Productivity Growth

We now consider the effects of changes in the corporate tax gap on productivity growth and product variety. Beginning with the rate of productivity growth, we combine (12) with firm-level employment in process innovation (14) to obtain

$$g \equiv \frac{\dot{\theta}}{\theta} = \frac{kl_F - (\eta-1)\rho}{\eta-2}. \tag{16}$$

From this expression, we can see that productivity growth is not biased by a scale effect, as proportionate increases in the population sizes of home and foreign do not affect national shares of production.

We use (16) to examine how corporate taxes rates affect productivity growth.

Proposition 1 *A rise in the corporate tax gap (Z) depresses productivity growth when monopoly power is weak ($\eta < 2$) and $k \in ((1+\delta)/2, (\eta-1)\rho/l_F)$, but accelerates productivity growth when monopoly power is strong ($\eta > 2$) and $k \in ((\eta-1)\rho/l_F, 1)$.*
Proof: Taking the derivative of (16) with respect to Z gives

$$\frac{dg}{dZ} = \frac{l_F}{(\eta-2)}\frac{dk}{ds}\frac{ds}{dZ}, \tag{17}$$

where $dk/ds = 1 - \delta > 0$ and $ds/dZ > 0$ from Lemma 1.

Changes in the corporate tax gap influence productivity growth through a knowledge spillover effect. In particular, a decrease in the home tax rate (a rise in Z) raises the home share of production, resulting in a greater level of knowledge spillovers from production to innovation. The increase in knowledge spillovers causes adjustments in firm-level employment in process innovation (14), the direction of which are determined by the degree of monopoly power. When monopoly power is weak ($\eta < 2$), employment in process innovation falls, dampening the rate of productivity growth. In contrast, when monopoly power is strong ($\eta > 2$), innovation employment rises, accelerating productivity growth.

Next, we use firm-level employment in production (14) with $\pi = (\eta - 1)l_X$ and operating profit on sales (15) to derive the equilibrium level of market entry as

$$N = \frac{\alpha(1-\varphi)^2(1+Z)L}{\eta(1-\varphi Z)(Z-\varphi)l_X}. \tag{18}$$

From this expression, we find that product variety is determined proportionally with population size.[6]

We investigate how changes in the corporate tax gap affect product variety (18) and obtain the following proposition.

Proposition 2 *With weak monopoly power ($\eta < 2$) and $k \in ((1+\delta)/2, (\eta-1)\rho/l_F)$, a rise in the corporate tax gap has an ambiguous effect on product variety for $Z \in (1, \tilde{Z})$, and a positive effect for $Z \in (\tilde{Z}, \overline{Z})$, where $\tilde{Z} = -1 + (1+\varphi)/\sqrt{\varphi}$. In contrast, with strong monopoly power ($\eta > 2$) and $k \in ((\eta-1)\rho/l_F, 1)$, a rise in Z has a negative effect on product variety for $Z \in (1, \tilde{Z})$, and an ambiguous effect for $Z \in (\tilde{Z}, \overline{Z})$.*

Proof: See the Appendix.

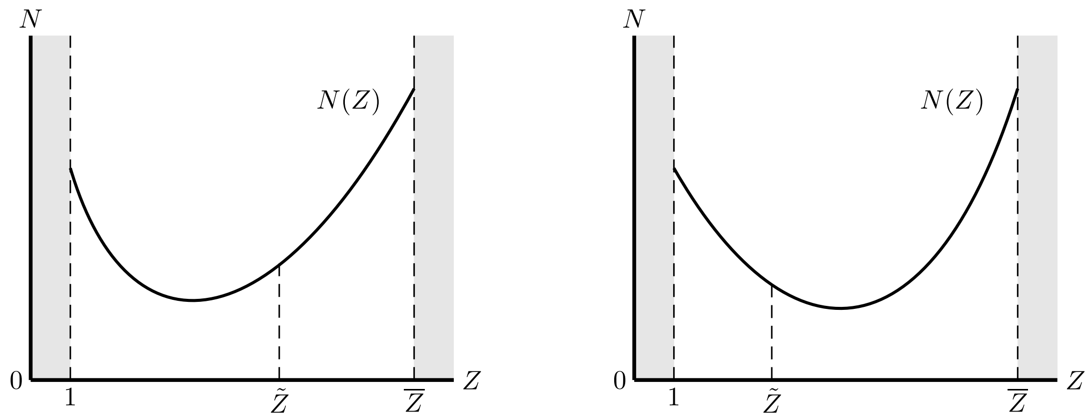
Taking the derivative of product variety (18) with respect to Z, we have

$$\frac{1}{N}\frac{dN}{dZ} = -\frac{1}{l_X}\frac{dl_X}{dk}\frac{dk}{ds}\frac{ds}{dZ} + \frac{(1+\varphi)(Z-\varphi)-(1+Z)(1-\varphi Z)}{(1+Z)(Z-\varphi)(1-\varphi Z)}, \tag{19}$$

where $dk/ds = 1 - \delta > 0$ and $ds/dZ > 0$ from Lemma 1. Changes in the corporate

[6] See Davis and Hashimoto (2015a) for a discussion of the effects of improved regional integration through lower trade costs or greater knowledge diffusion.

Figure 1: Corporate Taxes and Product Variety



(a) $\eta < 2$ (b) $\eta > 2$

In Panel (a) we use $\alpha = 0.5$, $\rho = 0.15$, $l_F = 0.07$, $\eta = 1.65$, $L = 1$, $\varphi = 0.35$, and $\delta = 0.9$. In Panel (b) we use $\alpha = 0.5$, $\rho = 0.1$, $l_F = 0.65$, $\eta = 5.6$, $L = 1$, $\varphi = 0.35$, and $\delta = 0.5$.

tax gap affect the level of market entry through two channels. The first channel is the indirect knowledge spillover effect described by the first term on the righthand side of (19). A decrease in the relative tax rate of home (a rise in Z) increases the home share of production, raising the level of knowledge spillovers from production to innovation. The result is a tendency for firm-level employment in production to fall and market entry to rise when monopoly power is weak ($\eta < 2$). On the other hand, when monopoly power is strong ($\eta > 2$), the knowledge spillover effect is negative and market entry tends to fall with a decrease in the relative tax rate of home.

The second channel is the direct profit effect captured by the second term on the righthand side of (19). The sign of the profit effect depends on the relative strengths of two mechanisms. First, a decrease in the relative tax rate of home causes a shift in production from foreign to home, improving profitability as the industry-level cost of transporting goods from the smaller foreign country to the larger home country falls. Second, the increased concentration of production in the home market raises the level of competition, thereby reducing profitability. The negative competition effect dominates, and the profit effect is negative, for $Z \in (1, \tilde{Z})$, while the benefit of lower transport costs dominates, and the profit effect is positive, for $Z \in (\tilde{Z}, \overline{Z})$.

The overall balance between the knowledge spillover effect and the profit effect determines the level of market entry. Figure 1a illustrates the case where firm's have weak monopoly power ($\eta < 2$). While the knowledge spillover effect associated with a rise in the corporate tax gap is positive, the profit effect is negative for $Z < \tilde{Z}$. As either effect may dominate, the overall impact on product variety is ambiguous. For $Z > \tilde{Z}$, however, both the knowledge spillover effect and the profit effect are positive, and an increase in the corporate tax gap raises product variety. Similarly, a numerical example for the case of strong monopoly power ($\eta > 2$) is provided in Figure 1b. In this case, the corporate tax gap and product variety have a negative relationship for $Z < \tilde{Z}$, and an ambiguous relationship for $Z > \tilde{Z}$.

2.7 National Welfare and Corporate Tax Rates

Finally, we consider the relationship between the corporate tax gap and national welfare levels. With the governments of both countries earning zero tax revenues ($T = 0$), steady-state welfare levels can be derived using (1), (3), (7), and (12):

$$U_0 = \ln A_1 + \frac{\alpha}{\rho}\left((\eta - 1)\ln\frac{(Z-\varphi)N}{(1+Z)} + \frac{g}{\rho}\right), \tag{20}$$

$$U_0^* = \ln A_1 + \frac{\alpha}{\rho}\left((\eta - 1)\ln\frac{(1-\varphi Z)N}{(1+Z)} + \frac{g}{\rho}\right), \tag{21}$$

where $A_1 \equiv (\alpha\theta(0)/\eta)^{\alpha/\rho}(1-\alpha)^{(1-\alpha)/\rho}((1+\varphi)/(1-\varphi))^{\alpha(\eta-1)/\rho} > 0$ is a constant.

Proposition 3 *The welfare effects of an increase in the corporate tax gap (Z) are summarized in the following table, where $1 < \eta_1 < \eta_2 < 2 < \eta_3$.*

Monopoly Power	$\eta \in (1, \eta_1)$	$\eta \in (\eta_1, \eta_2)$	$\eta \in (\eta_2, 2)$	$\eta \in (2, \eta_3)$	$\eta > \eta_3$
Home Welfare (dU_0/dZ)	$+$	$+$	$-$	$+$	$+$
Foreign Welfare (dU_0^*/dZ)	$+$	$-$	$-$	$+$	$-$

Proof: See the Appendix.

The effects of a change in the tax gap on national welfare levels (20) and (21) are

$$\frac{\rho}{\alpha}\frac{dU_0}{dZ} = \frac{(\eta-1)(1+\varphi)}{(1+Z)(Z-\varphi)} + \frac{(\eta-1)}{N}\frac{dN}{dZ} + \frac{1}{\rho}\frac{dg}{dZ}, \tag{22}$$

$$\frac{\rho}{\alpha}\frac{dU_0^*}{dZ} = -\frac{(\eta-1)(1+\varphi)}{(1+Z)(1-\varphi Z)} + \frac{(\eta-1)}{N}\frac{dN}{dZ} + \frac{1}{\rho}\frac{dg}{dZ}. \tag{23}$$

Changes in the corporate tax gap affect national welfare levels through adjustments in production shares (s). A decrease in the tax rate of home raises its share of production causing the average price of manufacturing goods to fall for home residents, but to rise for foreign residents. This price effect is captured by the first terms on the righthand sides of (22) and (23). The second term is the love of variety affect associated with changes in the level of market entry, and may be positive, negative, or ambiguous depending on the degree of monopoly power. Finally, the third term is the growth effect, and is negative for $\eta \in (1, 2)$ and positive for $\eta > 2$. The balance of these effects is determined by the degree of monopoly power (η).

3 Conclusion

In this paper we consider how changes in national tax rates on corporate incomes affect the geographic location of industry, the level of product variety, and fully endogenous productivity growth without scale effects in a two-country model of trade. Economic growth is driven by monopolistically competitive firms that invest in process innovation with the aim of lowering production costs. Faced with imperfect knowledge diffusion and trade costs, firms shift production and innovation between countries to the lowest cost location, leading to a greater share of firms locating production and all firms locating innovation in the country with the lower corporate tax rate and thus the larger after tax market.

Investigating the relationships between national tax policy, productivity growth and market entry, we find that the effects of changes in corporate tax rates depend on the monopoly power of firms and the initial levels of relative tax rates. Focusing on the policy of the country with the relatively low tax rate, when firms have weak monopoly power, reducing the tax rate depresses productivity growth, but has a positive effect on product variety if the initial tax rate is high and an ambiguous effect on product variety if the initial tax rate is low. In contrast, when monopoly power is strong, a reduction in the tax rate accelerates productivity growth, but has an ambiguous effect on product variety if the initial tax rate is high and a negative effect on product variety if the initial tax rate is low.

Appendix

Beginning with Proposition 1, the derivative of (18) with respect to Z yields

$$\frac{1}{N}\frac{dN}{dZ} = \frac{\rho/k}{(\rho - kl_F)}\frac{dk}{dZ} + \frac{(1+\varphi)(Z-\varphi) - (1+Z)(1-\varphi Z)}{(1+Z)(Z-\varphi)(1-\varphi Z)},$$

where $dk/dZ > 0$. The first term on the righthand side is positive for $\eta < 2$ and negative for $\eta > 2$. The second term is negative for $Z < \tilde{Z} = -1 + (1+\varphi)/\sqrt{\varphi}$ and positive for $Z > \tilde{Z}$.

Turning next to Proposition 3, using (14), the marginal utilities associated with the corporate tax gap are

$$\frac{1}{A_2}\frac{dU}{dZ} = \frac{\varphi(1-\varphi)^2(1+Z)^2}{(1-\delta)(1+\varphi)^2(1-\varphi Z)} + \Phi, \tag{A1}$$
$$\frac{1}{A_2}\frac{dU^*}{dZ} = -\frac{(1-\varphi)^2(1+Z)^2}{(1-\delta)(1+\varphi)^2(Z-\varphi)} + \Phi, \tag{A2}$$

where $A_2 = \alpha(\eta-1)/\rho(dk/ds)(ds/dZ) > 0$, and

$$\Phi = \frac{((\eta-2)\rho + kl_F)l_R}{(\eta-1)(\eta-2)\rho k l_X}.$$

The thresholds presented in Proposition 3 are derived through a comparison of the first terms on the righthand sides of (A1) and (A2) with the sign of Φ. First, while the numerator of Φ is negative for $\eta < \tilde{\eta} = 1 + (\rho - kl_F)/\rho < 2$ and positive for $\eta > \tilde{\eta}$, the denominator is negative for $\eta \in (1, 2)$ and positive of $\eta > 2$. Therefore, $\Phi > 0$ for $\eta \in (1, \tilde{\eta})$, $\Phi < 0$ for $\eta \in (2, \tilde{\eta})$, and $\Phi > 0$ for $\eta > 2$. Then, since Φ takes large values as η approaches values of 1 or 2 and the absolute value of the first term of (A1) is larger than that of (A2), a comparison of the sign of Φ with the signs of the first terms in (A1) and (A2) yields the following: $dU/dZ > 0$ and $dU/dZ^* > 0$ for $\eta \in (1, \eta_1)$; $dU/dZ > 0$ and $dU/dZ^* < 0$ for $\eta \in (\eta_1, \eta_2)$; $dU/dZ < 0$ and $dU/dZ^* < 0$ for $\eta \in (\eta_2, 2)$; $dU/dZ > 0$ and $dU/dZ^* > 0$ for $\eta \in (2, \eta_3)$; and $dU/dZ > 0$ and $dU/dZ^* < 0$ for $\eta > \eta_3$. Note that the thresholds η_1, η_2, and η_3 are within the ranges described in Lemma 2, when l_F/ρ takes sufficiently large values in the weak monopoly power case and sufficiently small values in the strong monopoly power case.

References

[1] Aghion, P., Howitt, P. (1998). *Endogenous Growth Theory*. Cambridge: MIT Press.

[2] Angelopoulos, K., Economides, G., Kammas, P. (2007). Tax-spending policies and economic growth: Theoretical predictions and evidence from the OECD. *European Journal of Political Economy* 23, 885-902.

[3] Arnold, J., Brys, B., Heady, C., Johansson, Å., Schwellnus, C., Vartia, L. (2011). Tax policy for economic recovery and growth. *The Economic Journal* 121, F59-F80.

[4] Ang, J., Madsen, J. (2013). International R&D spillovers and productivity trends in the Asian miracle economies. *Economic Inquiry* 51, 1523-1541.

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

[6] Baldwin, R., Forslid, R., Martin, P., Ottaviano, G., Robert-Nicoud, F. (2003). *Economic Geography and Public Policy*. Princeton University Press.

[7] Bénassy-Quéré, A., Fontagne, L., Lahreche-Révil, A. (2005). How does FDI react to corporate taxation? *International Tax and Public Finance* 12, 583-603.

[8] Brülhart, M., Jametti, M., Schmidheiny, K. (2012). Do agglomeration economies reduce the sensitivity of firm location to tax differentials? *The Economic Journal* 122, 1069 -1093.

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

[10] Davis, C., Hashimoto, K. (2015a). Economic integration, monopoly power and productivity growth without scale effects. *Review of Development Economics*, forthcoming.

[11] Davis, C., Hashimoto, K. (2015b). Industry Concentration, Knowledge Diffusion, and Economic Growth Without Scale Effects. *Economica*, forthcoming.

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

[13] Devereux, M., Loretz, S. (2013). What do we know about corporate tax competition? *National Tax Journal* 66, 745-773.

[14] Etro, F. (2009). *Endogenous Market Structures and the Macroeconomy*. Springer.

[15] Feld, L. Heckemeyer, J. (2011). FDI and taxation: A meta-study. *Journal of Economic Surveys* 25, 233-272.

[16] Gemmell, N. Kneller, R., Sanz, I. (2015). The growth effects of tax rates in the OECD. *Canadian Journal of Economics*, forthcoming.

[17] 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.

[18] Helpman, E., Krugman, P. (1985). *Market Structure and Foreign Trade: Increasing Returns, Imperfect Competition, and the International Economy*. London, England: The MIT Press.

[19] IMF (2014). Spillovers in international corporate taxation. *IMF Policy Paper*.

[20] Iwamoto, Y. Shibata, A. (2008). International and Interegenerational Aspects of Capital Income Taxation in an Endogenously Growing World Economy. *Review of International Economics* 16, 383-399.

[21] Kammas, P. (2011). Strategic fiscal interaction among OECD countries. *Public Choice* 147: 459-480.

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

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

[24] Lee, Y., Gordon, R. (2005). Tax structure and economic growth. *Journal of Public Economics* 89, 1027-1043.

[25] Madsen, J., Ang, J. and Banerjee, R. (2010). Four centuries of British economic growth: The roles of technology and population. *Journal of Economic Growth* 15, 263-290.

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

[27] Ojede, A., Yamarik, S. (2012). Tax policy and state economic growth: The long-run and short-run of it. *Economic Letters* 116, 161-165.

[28] Palomba, G. (2008). Capital income taxation and economic growth in open economies. *International Tax and Public Finance* 15, 668-692.

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

[30] Peretto, P. (2007). Corporate taxes, growth and welfare in a Schumpeterian economy. *Journal of Economic Theory* 137, 353-382.

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

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