

SHOULD TAX POLICY FAVOUR HIGH OR LOW
PRODUCTIVITY FIRMS?

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Should tax policy favor high- or low-productivity firms?*

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Revised Version, September 2013

Abstract

Heterogeneous firm productivity raises the question of whether governments should pursue ‘pick-the-winner’ strategies by subsidizing highly productive firms more, or taxing them less, than their less productive counterparts. We study this issue in a setting where governments can set differentiated effective tax rates in an oligopolistic industry where firms with two productivity levels co-exist. We show that the optimal structure of tax differentiation depends critically on the feasible level of the corporate profit tax, which in turn depends on the degree of international tax competition. When tax competition is weak and optimal profit tax rates are high, favoring high-productivity firms is indeed the optimal policy. When tax competition is aggressive and profit taxes are low, however, the optimal tax policy reverses and favors low-productivity firms.

Keywords: business taxation, firm heterogeneity, tax competition

JEL Classification: H25, H87, F15

*We thank Pol Antràs, Mihir Desai, Ferdinand Mittermaier, Karl Morasch, Paolo Panteghini, Michael Pflüger, Andrea Schneider, Monika Schnitzer and conference participants in Dresden, Glasgow, Göttingen, Munich and Würzburg for valuable comments and discussion.

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1 Introduction

Firms, even those operating in the same market, differ vastly in their productivity. This empirical fact has played a large role in the international trade literature over the last decade.¹ So far, however, very little research has considered how economic policy should take account of these productivity differences. This paper focuses on the corporate tax system and asks whether tax policy should differentiate between high- and low-productivity firms. Should corporate tax systems pursue ‘pick-the-winner’ strategies and favor high-productivity firms, in order to shift production towards the most productive businesses? Or should tax policy support low-productivity firms, in order to align production costs and intensify competition in imperfectly competitive markets?

These questions are relevant because effective corporate tax burdens vary significantly among firms. For example, many countries have programs that selectively reduce the tax burden of small and medium-size enterprises, to induce their market entry or business expansion (see e.g. Mirrlees et al., 2011). However, there is also evidence that larger and more productive firms pay less tax. For instance, these firms exhibit a systematically higher degree of corporate tax noncompliance (Hanlon et al., 2007) and use tax havens more extensively (Desai et al., 2006). These differences may be due to firm characteristics, such as the existence of professional tax planning departments in larger firms. However, it is equally possible that governments do not monitor these large firms as closely as they could, so that granting them a ‘tax break’ is a deliberate, albeit implicit, policy decision.

This paper analyzes how governments should optimally differentiate effective tax rates between firms with different productivity levels. For this purpose, we set up a small open economy model where firms in an oligopolistic sector produce at two different cost or productivity levels. While the government must levy profit taxes at a uniform rate, it may differentiate the tax base according to the different cost levels. Thus, the resulting effective tax rates differ between low-cost and high-cost firms. International tax competition with a tax haven constrains the choice of the profit tax rate. Firms may shift a share of their profits to the tax haven, and do so in the non-cooperative tax equilibrium. In this simple setting we obtain the well-known result that economic

¹Bartelsman and Doms (2000) summarize the empirical literature documenting large productivity differences between firms. For reviews of the literature on firm heterogeneity and international trade, see Bernard et al. (2012) and Melitz and Redding (2012).

integration reduces the equilibrium level of corporate profit taxes. The focus of our analysis is then on the issue of how this reduction in the profit tax rate affects the pattern of optimally differentiated tax base policies.

Our main result is that when economic integration is limited and profit tax rates are relatively high, it is optimal policy to grant tax preferences to large, highly productive firms. In contrast, when economic integration proceeds and tax competition with the haven becomes more aggressive, the pattern of tax discrimination reverses, and it is optimal to tax highly profitable firms at a higher effective rate.

The intuition for these results arises from two conflicting goals pursued by the welfare-maximizing government. First, it aims to raise domestic output in the imperfectly competitive sector. Second, it wants to increase tax revenues from foreign-owned profits via a broader tax base. When international tax competition is weak, the motive to expand domestic output dominates, as the resulting profits can be captured by a high corporate tax rate. To increase aggregate output, the most effective policy is to raise the market share of the low-cost firms, implying a tax advantage for these firms in the policy optimum. In contrast, when tax competition from the tax haven is aggressive, the dominant concern is to raise tax revenue from foreigners. In this case, the higher profitability of low-cost firms makes it attractive to levy a higher effective tax on them, i.e. the optimal policy discriminates against the most profitable firms. These results hold for both quantity and price competition among firms.

In sum, our analysis predicts a fall in the tax advantages of large, productive enterprises as a result of economic integration and more aggressive corporate tax competition. And indeed, recent developments in tax policy point in this direction. Firstly, one well-noted trend is the substantial fall in statutory corporate tax rates: Among the OECD members corporate tax rates averaged around 50% in the early 1980s, but this average has fallen to 30-35% by 2010 (OECD, 2012). A similar trend can also be observed in less-developed parts of the world (Klemm and van Parys, 2012). There is a widespread consensus in the literature that one of the key factors in explaining the reduced ability of countries to directly tax corporate profits is the international competition for mobile capital, firms and profits.²

Secondly, many countries have recently undertaken unilateral measures aimed at limiting the tax advantages of large and highly profitable firms. A first example is the proliferation of thin capitalization rules, which restrict international debt shifting by

²See Devereux et al. (2008) for econometric evidence and Auerbach et al. (2010) for a recent survey.

large multinationals. In the mid-1990s less than one half of all OECD members had adopted thin capitalization rules, but this share has risen to roughly two thirds in 2005 (Buettner et al., 2012, Table 1).³ A second example are state investment subsidies offered to attract, or keep, large multinational firms. The number of large-scale subsidy cases has peaked in the early 2000s, and has dropped significantly since then (Hauffer and Mittermaier, 2011, Table 1). A third example comes from less-developed countries, where tax holidays – periods of reduced or no profit taxation – are a major policy measure to attract highly profitable FDI by large multinational firms. In a broad sample of countries, the average length of tax holidays has fallen from more than four years in the late 1980s to around 2.5 years in 2005 (Klemm and van Parys, 2012, Fig. 1).

Existing paradigms cannot explain these developments. The literature that allows tax burdens for different firms to diverge (see below) has so far focussed on differences in the international mobility of firms. Considering the basic finding from recent trade theory that more productive firms are also the most mobile internationally (Helpman et al., 2004; Baldwin and Okubo, 2006), this literature predicts that the most productive firms should be treated *more* favorably as economic integration proceeds. In contrast, we find that *reduced* tax advantages for highly productive firms are the optimal policy response to economic integration when tax discrimination is based on productivity differences between firms. Simply put, our argument is that governments are less willing to offer special tax breaks to highly profitable firms when they are not able to participate to a sufficient degree in the high profits generated by these firms. Our analysis thus offers a rationale for the above-mentioned recent trends in corporate tax policy.⁴

Our analysis is related to several strands of previous research. A first strand is the literature on preferential tax regimes. Janeba and Peters (1999) and Keen (2001) compare discriminatory and non-discriminatory tax competition in a setting with two tax bases that differ in their degree of international mobility. Peralta et al. (2006) ask un-

³The ‘interest barrier’ introduced as part of the German corporate tax reform of 2008 is a prominent example for a reform that was explicitly aimed at limiting the tax-deductibility of interest payments only for the most productive, multinational firms (Buslei and Simmler, 2012). It only applies to firms with interest expenses of over three million Euro.

⁴We do not claim, of course, that mobility-based approaches to discriminatory tax competition are unimportant. For example, a recent development in several EU countries, including the United Kingdom and the Benelux countries, is to offer significantly reduced tax rates for knowledge-intensive firms. The high international mobility of intellectual capital clearly causes this preferential tax treatment. For an analysis of these so-called ‘patent boxes’, see Griffith et al. (2012).

der which conditions countries may have an incentive to tax-discriminate in favor of multinational firms by not monitoring international profit shifting. More recently, several papers have analyzed – with diverging conclusions – the role of tax havens, which allow countries to tax-discriminate in favor of internationally mobile firms (Slemrod and Wilson, 2009; Hong and Smart, 2010). In all these papers, equilibrium patterns of tax differentiation arise from differences in the international mobility of tax bases. In contrast, productivity differences between firms are either ruled out, or are not central to the results obtained.⁵

A second related literature strand considers tax and subsidy competition in settings with heterogeneous firm productivity. Some articles in this area model the competition for internationally mobile firms (e.g. Davies and Eckel, 2010; Hauffer and Stähler, 2013), whereas others focus on profit shifting (Krautheim and Schmidt-Eisenlohr, 2011) or entry subsidies (Pflüger and Suedekum, 2013). A still different line of research derives simultaneous tax rate and tax base policies in the presence of firm heterogeneity (Baldwin and Okubo, 2009; Bauer et al., 2011). None of these papers, however, allows for taxes or subsidies that differ between the heterogeneous firms.

Lastly, a few papers analyze government policies that are differentiated according to productivity. Gersovitz (2006) derives the optimal pattern of income and consumption taxes when both have differential effects on firms with varying productivity. Karacaovali (2011) studies both empirically and theoretically the interaction between firm productivity and trade policy. In contrast to our paper, which considers the welfare-maximizing policy, he uses a political economy model to show that more productive firms enjoy more protection by tariffs. Neither analysis links its results to the constraints that countries face in an international environment in which they compete with other countries.

The plan of this paper is as follows. Section 2 lays out our benchmark model and determines the market equilibrium. Section 3 analyzes international competition via profit taxes and relates the optimal structure of tax bases to the degree of economic integration and the equilibrium level of profit taxation. Section 4 analyzes the robustness of our results. Section 5 concludes.

⁵The latter is true, for example, for the analysis of Johannesen (2012). In his model firms with different productivities self-select into either being a multinational or a national firm. The discriminatory tax treatment in this model is, however, based on the differential mobility of firms in equilibrium, not on their exogenous differences in productivity.

2 The Benchmark Model

We study a small open economy that produces and consumes two homogeneous goods, X and Y . Firms in the Y industry (the numeraire sector) are homogeneous and operate under perfect competition. The X sector has an oligopolistic market structure and the firms producing in this sector differ with respect to their unit cost. Consumers in the small economy hold a total endowment of K units of capital, which is the only variable input in the production of both goods. Producing one unit of Y requires $1/r$ units of capital. Capital and the numeraire Y can be freely traded internationally at the fixed world interest rate r .⁶

The focus of our analysis lies on the corporate tax structure that the small country's government applies to the heterogeneous firms in the X sector. To keep the model as simple as possible, we assume that good X is a non-traded good. This assumption ensures that corporate tax policy directly affects the domestic market equilibrium, without incorporating the attenuating effects arising from import and export markets. It is well-known from the literature that the effects of domestic tax policies are qualitatively similar when costly international trade is permitted.⁷

2.1 Private Agents

Consumers. Consumers are homogeneous. A quasilinear utility function represents their preferences over the two private goods X and Y :

$$U = aX - \frac{1}{2}bX^2 + Y^D, \quad (1)$$

where Y^D is the quantity demanded of the numeraire, and $a, b > 0$ are parameters.

Utility maximization is subject to the budget constraint $Y^D + pX \leq I$, where p is the price of good X in the small country. To determine national income I , we need to specify the international allocation of profits. In our benchmark model we assume that

⁶Free trade in both Y and K implies that the model does not specify where the numeraire good is produced. This, however, is immaterial for all our results.

⁷As a result of transport costs, foreign-produced goods remain more expensive than domestically produced goods. Thus a setting with costly international trade maintains the motive for tax policy to expand domestic production in an imperfectly competitive market and to increase domestic consumer surplus (see e.g. Haufler and Wooton, 2010).

all profit income in the X industry accrues to foreigners, as only foreigners own the intellectual property necessary for production.⁸ National income is then

$$I = rK + T, \quad (2)$$

where rK is the representative consumer's exogenous capital income and T is tax revenue, which the government redistributes to the consumer as a lump-sum payment. Utility maximization yields linear demand functions

$$X = \frac{a - p}{b}, \quad Y^D = I - pX, \quad (3)$$

which imply that all income changes affect only the demand for the numeraire good Y .

Producers. In the oligopolistic X sector, there is an exogenously given number of n potential entrants ('firms'). Each of these firms possesses one unit of a specific factor, labelled 'intellectual property' (such as a license or patent), which it can employ profitably in the imperfectly competitive industry. As this factor is indispensable for the production of good X , at most n firms can engage in the production of good X . Since the number of firms is exogenously constrained, the owners of the fixed factor earn pure profits. As explained above, we assume in our benchmark model that this factor is fully owned by foreigners.

Production of good X additionally requires capital as the only variable factor of production. Firms in the industry are heterogeneous, differing in their (exogenous) capital requirement per unit of good X . For reasons of concreteness and tractability, we assume that there are only two possible levels of unit capital requirements, c_L and c_H , where the indices L and H respectively denote a low-cost and a high-cost firm. This simplifying assumption allows us to derive closed-form solutions for all variables. Differing input requirements translate into different unit costs of the two firm types, given by $c_L r$ and $c_H r$, respectively.

Due to the existence of pure profits, firms with different variable costs can co-exist in equilibrium. In total, n_L low-cost firms and n_H high-cost firms are active, with $n_L + n_H = n$. The output of a firm of type i is denoted by x_i , so that industry output X is

$$X = n_L x_L + n_H x_H. \quad (4)$$

⁸Given the small-country setting, this corresponds to a perfect international diversification of portfolios. We relax this assumption in Section 4, where we introduce domestic ownership of profit income.

We assume that firms in the X sector engage in quantity competition.⁹ In equilibrium, a low-cost firm will produce more output than a high-cost firm. We will therefore also refer to the low-cost and the high-cost firms as ‘large firms’ and ‘small firms’, respectively.

To simplify notation, we normalize $c_L \equiv 1$ and define the capital requirement of high-cost firms as $c_H \equiv 1 + \Delta$ (with $\Delta > 0$). Our analysis focuses on the case where the productivity gap Δ is sufficiently small (relative to the firm’s profit opportunities) so that in the absence of taxes, even the high-cost firms make positive profits in equilibrium. This condition is derived in Appendix 1. In the absence of government intervention, all firms will therefore produce.

2.2 Government

The government of the small country has two tax instruments at its disposal. First, there is a *profit tax*, levied at a uniform rate t . It corresponds to a statutory corporate tax rate. While some countries levy reduced corporate tax rates, the threshold income up to which this rate is levied is typically very low.¹⁰ A uniform rate is thus a good approximation in the oligopolistic setting studied in this paper.

Second, the government can tax (or subsidize) capital inputs. These *capital taxes*, levied at rate τ , change the tax base to which the profit tax applies and may be differentiated between high-cost and low-cost firms. Thus, the capital taxes capture in a simplified way various real-world policies that affect a firm’s cost of capital. On the one hand, there are policies that increase the cost of capital ($\tau_i > 0$). A first example are taxes on interest and dividend payments that fall on the firm’s owners and creditors, raising the gross return to capital they demand. Another example are policies limiting the deductibility of interest payments from the corporate profit base, as done by many forms of thin capitalization rules. On the other hand, the government can also choose to decrease the cost of capital ($\tau_i < 0$). An example are subsidies that are paid in proportion to the firm’s capital investment in a given country.

⁹In Section 4 we analyze an alternative market structure where goods are differentiated and firms compete over prices. We show there that this setting yields the same qualitative conclusions as the homogeneous goods Cournot model.

¹⁰See OECD (2012). The reason for not introducing a continuously progressive tax schedule is that firms could then simply divide up their operations among independent units, each of which would benefit from lower tax rates.

Such capital taxes often apply selectively to different types of firms. Thin capitalization rules, for example, may include a threshold value up to which interest payments are always tax deductible. In this case they represent a selective tax on the capital costs of large, high-productivity firms.¹¹ Similarly, capital subsidies are often targeted at specific firms. Investment subsidies are often paid to attract, or keep, the largest and most profitable firms, and they are typically granted in relation to the amount of capital investment in a particular country (Hauffer and Mittermaier, 2011, Table 1). On the other hand, there is also a number of programs that target capital subsidies explicitly at small and medium-size firms, to promote their market entry or business expansion.¹² We denote the profit tax base of a firm of type i by π_i . With the capital taxes or subsidies discussed above, and using the normalized marginal costs $c_L = 1$ and $c_H = 1 + \Delta$, profit tax bases of the different firm types can be written as:

$$\begin{aligned}\pi_L &= [p - (1 + \tau_L)r]x_L, \\ \pi_H &= [p - (1 + \tau_H)(1 + \Delta)r]x_H.\end{aligned}\tag{5}$$

Hence, for $\tau_i = 0$, the tax-inclusive marginal cost of production equals the marginal cost of credit r in the world market, multiplied by the firm-specific input requirement. A positive capital tax ($\tau_i > 0$) increases these marginal production costs, whereas a capital subsidy ($\tau_i < 0$) reduces marginal costs. Irrespective of the sign of optimal capital taxes, the tax system favors the low-cost firms if $\tau_L < \tau_H$, whereas it favors the high-cost firms if $\tau_L > \tau_H$.

The home government levies a corporate profit tax at the uniform rate t on the tax bases in (5). We model tax competition by assuming that both types of firms may shift a fraction $\alpha_i \in [0, 1]$ of their profits to a tax haven, whose tax rate is denoted by t^0 . This profit shifting causes costs, which may consist of transaction costs, fees for legal counseling, or the expected costs of being caught and fined. Specifically, we assume these shifting costs as being quadratic in the share of profits shifted. In a simple way, this specification reflects the fact that a given absolute amount of profit shifting is easier to conceal from the tax authorities when the underlying profit tax base is larger. The convexity of the shifting cost function ensures interior solutions for the firms' profit

¹¹This is true for the German thin capitalization rule, for example, where interest expenses up to three million Euro are always tax-deductible.

¹²See, for example, Mirrlees et al. (2011) for a critical account of the tax advantages of small businesses in the United Kingdom.

shifting. This is in accordance with the empirical observation that most firms pay some tax also in high tax countries.

Profits net of tax (π_i^n) are thus given by¹³

$$\pi_L^n \equiv \pi_L \left[(1 - \alpha_L)(1 - t) + \alpha_L(1 - t^0) - \frac{s}{2}\alpha_L^2 \right], \quad (6a)$$

$$\pi_H^n \equiv \pi_H \left[(1 - \alpha_H)(1 - t) + \alpha_H(1 - t^0) - \frac{s}{2}\alpha_H^2 \right], \quad (6b)$$

where profit tax bases are given in (5) and $s > 0$ is a parameter of the shifting cost function that is identical for all firms.

The home government's tax revenue T depends on both the profit tax rate and the rates of capital taxes or subsidies. It is given by

$$T = (1 - \alpha_L)tn_L\pi_L + (1 - \alpha_H)tn_H\pi_H + \tau_L n_L x_L r + \tau_H n_H x_H (1 + \Delta) r. \quad (7)$$

We impose no constraint on the sign of T . As is seen from equation (2), positive tax collections are redistributed to the representative consumer lump sum. Conversely, if total tax revenue from the corporate tax system turns negative, then lump-sum taxes are available to finance effective subsidy payments to firms.¹⁴

2.3 Market Equilibrium

Our following analysis rests upon a two-stage game. In the first stage, the government chooses its tax policy parameters (t, τ_L, τ_H) , taking into account the impact of taxation on production, consumer prices, and profit shifting. In the second stage, both types of firms choose their output levels given the tax system, and choose their optimal levels of profit shifting.

We solve the model by backward induction and first derive the market outcomes in the last stage. Here, we only consider the case when both low-cost and high-cost firms are active in the market. We discuss the alternative – that only the low-cost firms produce as tax policy makes entry unattractive for the high-cost firms – in Appendix 2.

¹³In (6a)–(6b) we assume, for analytical simplicity, that capital taxes are deductible from the corporate profit tax base. As long as $t < 1$, which holds throughout the analysis, this assumption does not affect any of our qualitative results.

¹⁴We will show below, however, that tax revenues are always be positive in the home government's policy optimum.

When all firms compete over quantities in a Cournot oligopoly, maximizing profits in (6a)–(6b), subject to (3) and (4), gives optimal quantities as

$$x_L = \frac{a - (1 + \tau_L)r + n_H[(1 + \tau_H)(1 + \Delta)r - (1 + \tau_L)r]}{b(1 + n)}, \quad (8a)$$

$$x_H = \frac{a - (1 + \tau_H)(1 + \Delta)r + n_L[(1 + \tau_L)r - (1 + \tau_H)(1 + \Delta)r]}{b(1 + n)}. \quad (8b)$$

Comparing (8a) and (8b) immediately shows that $x_L > x_H$ when both firms face the same capital tax ($\tau_L = \tau_H$). This reflects the fact that firms with lower marginal production costs will have a larger market share in equilibrium.

For later use, we derive the effects of capital taxes on firm-specific output levels:

$$\begin{aligned} \frac{\partial x_L}{\partial \tau_L} &= \frac{-(1 + n_H)r}{b(1 + n)} < 0, & \frac{\partial x_L}{\partial \tau_H} &= \frac{n_H(1 + \Delta)r}{b(1 + n)} > 0, \\ \frac{\partial x_H}{\partial \tau_H} &= \frac{-(1 + n_L)(1 + \Delta)r}{b(1 + n)} < 0, & \frac{\partial x_H}{\partial \tau_L} &= \frac{n_L r}{b(1 + n)} > 0. \end{aligned} \quad (9)$$

The capital tax τ_i raises the marginal costs of production for firms of type i and thus lowers the output of these firms. Since quantity competition between firms involves downward-sloping best response function, the falling output of firms of type i implies a rising output for all firms $j \neq i$, as firms of type j are not affected by the type-specific capital tax τ_i .

Combining the market demand for good X in (3) with aggregate output from (4) and equilibrium quantities in (8a)–(8b) gives the equilibrium price as an increasing function of both types' unit costs and capital taxes:

$$p = \frac{a + n_L(1 + \tau_L)r + n_H(1 + \tau_H)(1 + \Delta)r}{1 + n}. \quad (10)$$

Maximized profits before deduction of the corporate profit tax t are then

$$\pi_L = bx_L^2, \quad \pi_H = bx_H^2. \quad (11)$$

In a separate decision, firms determine their optimal degree of profit shifting. Maximizing (6a) and (6b) with respect to α yields

$$\alpha_L = \alpha_H = \frac{t - t^0}{s}. \quad (12)$$

The share of profits shifted abroad thus depends only on the tax differential to the haven, $t - t^0$, and on the cost of profit shifting, s . As the costs of profit shifting

are a function of the share (not the amount) of profits shifted to the tax haven, the equilibrium level of α is identical for all firms. This ensures that solely differences in productivity drive the differential tax treatment of the two firm types, not differences in the mobility of tax bases.¹⁵

Evaluating the utility function (1) with the optimal demands for X and Y using (2), (7), (10), and (11), indirect utility is

$$V = \frac{b}{2} (n_L x_L + n_H x_H)^2 + rK + (1 - \alpha)tb(n_L x_L^2 + n_H x_H^2) + \tau_L n_L x_L r + \tau_H n_H x_H (1 + \Delta) r, \quad (13)$$

where equilibrium quantities are given by (8a)–(8b) and α is given in (12). In equation (13), the first term represents the consumer surplus for good X . The remaining terms give the income of the representative individual in the home country, and thus the consumption of the numeraire good Y . This consists of exogenous capital income (the second term) and total tax revenues (the remaining terms; see eq. 7).

3 Optimal Policy

We now derive the optimal tax policy chosen by the small country's government, which correctly anticipates the optimal behavior of firms and consumers. The government faces a central trade-off in our model: On the one hand, it has a motive to levy positive taxes, as these raise tax revenues at the expense of foreigners' profit incomes. On the other hand, the oligopolistic market structure offers a reason for the government to increase output by means of subsidies. The central question we address is whether, in the presence of firm heterogeneity, the resulting optimal taxes or subsidies are differentiated between the low-cost and the high-cost firms. As we will see, this decision is critically affected by the statutory corporate profit tax rate that the government is able to levy.

Since the capital taxes τ_i do not affect firms' profit shifting decisions in our simple setup (eq. 12), we can solve the government's problem sequentially. First, the tax authorities choose the optimal profit tax rate t , taking into account that firms can shift profits to the tax haven. Second, the government imposes – possibly differentiated – taxes or subsidies τ_i on the capital inputs each firm uses.

¹⁵Different tax elasticities of profits would introduce an additional incentive to differentiate tax rates between firms, i.e. to tax the less mobile firms more. The previous literature has extensively discussed this source of tax differentiation (see the introduction).

3.1 Tax Competition and the Profit Tax Rate

When deciding about the profit tax rate, the home government maximizes indirect utility as given by (13), knowing that firms will engage in profit shifting according to (12). This yields a best response function of

$$t(t^0) = \frac{t^0 + s}{2}. \quad (14)$$

We assume that the tax haven has no tax base of its own and receives tax revenue only by attracting profits from firms based in the home country (see e.g. Krautheim and Schmidt-Eisenlohr, 2011). Taking the tax rate of the home country as given, the tax haven maximizes its tax revenues $T^0 = t^0 \alpha (n_L \pi_L + n_H \pi_H)$. Thus its best response function is given by

$$t^0(t) = \frac{t}{2}. \quad (15)$$

As the tax haven can only attract some profits if it offers a lower tax rate, it will always undercut.

Solving the equation system (14)-(15) shows that, in equilibrium, the two countries will set their tax rates to

$$t^* = \frac{2}{3}s \quad \text{and} \quad t^{0*} = \frac{1}{3}s. \quad (16)$$

Finally, using (16) in the firm's optimal profit shifting decision (12) yields the equilibrium share of profit shifting:

$$\alpha^* = \frac{1}{3}. \quad (17)$$

Thus, the profit tax rates depend solely on the firms' common profit shifting parameter s . A fall in s , which we interpret as economic integration in the following, continuously reduces the home country's profit tax rate. Note that non-confiscatory profit tax levels $t < 1$ result only if $s < s^{max} = 3/2$. In the following, we assume that this restriction on s is met. At the other extreme, when shifting costs disappear altogether ($s = 0$), tax competition leads to zero taxes in both countries in the non-cooperative Nash equilibrium.

It should be emphasized that our objective in this section is not to provide a detailed model of profit shifting into a tax haven. Rather, the purpose is to link the corporate tax rate in the small country to exogenous changes in its economic environment, as measured by the parameter s . At the core of our analysis are the effects of a reduction in s (i.e. closer economic integration) on the optimal pattern of differentiated capital taxes τ_i . This is the issue to which we turn now.

3.2 Optimally Differentiated Capital Taxes

Having chosen the profit tax rate t , the small country's government determines its corporate tax bases by setting type-specific capital taxes (or subsidies) τ_i . Since both the profit tax rate and the equilibrium share of profits shifted abroad are the same for both firm types, differences in the effective tax burden on capital can arise only from the differentiated setting of capital taxes. The capital tax choices τ_i affect the entrants' participation constraints. We focus here on the setting in which all firms remain active in equilibrium. The case in which the optimal tax policy prevents entry by the high-cost firms is analyzed in Appendix 2.

Maximizing (13) with respect to τ_L and τ_H and using (9), (16) and (17) results in two interdependent first-order conditions for τ_L and τ_H . Solving this set of equations yields reduced-form expressions for the optimal capital taxes:

$$\tau_L^* = \left(1 - \frac{8s}{9}\right) \frac{bx_L^*}{r}, \quad \tau_H^* = \left(1 - \frac{8s}{9}\right) \frac{bx_H^*}{(1 + \Delta)r}, \quad (18)$$

where the reduced-form output levels of each firm type are

$$x_L^* = \frac{(a - r)(1 - 4s/9) + \Delta rn_H/2}{b(1 - 4s/9)(2 + n - 8s/9)}, \quad x_H^* = \frac{[a - (1 + \Delta)r](1 - 4s/9) - \Delta rn_L/2}{b(1 - 4s/9)(2 + n - 8s/9)}. \quad (19)$$

The optimal capital taxes in (18) represent the central result of our analysis, and deserve detailed discussion. The round bracket, which is identical for both firm types, captures the trade-off between the conflicting motives of increasing output (and thus consumption) in the imperfectly competitive sector X , and taxing the profits of foreign firm owners. In our benchmark model the latter motive, labelled a *tax exportation effect*, is maximized because all firms are entirely owned by foreigners.¹⁶

In the limit case of $s = 0$, i.e. when no direct profit taxation is possible, this tax exportation effect dominates and capital taxes are positive. Capital taxes then serve as a second-best instrument to tax foreign-owned profits. When the profit tax rate is positive, however (i.e., when $s > 0$), the role of capital taxes as an indirect way of taxing foreign-owned profits diminishes. When the shifting cost parameter exceeds a critical level of $s^c = 9/8$, and hence the rate of profit taxation feasible in competition with the tax haven is sufficiently high, then the *output expansion* motive dominates the

¹⁶For analyses of this effect see, for example, Huizinga and Nielsen (1997) and Fuest (2005). In Section 4 we analyze how partial domestic ownership of firms changes the tax exportation motive.

tax exportation effect. Therefore, capital taxes will turn negative at this point. In sum, then, positive capital taxes are an indirect and distortive way of taxing foreign profits in the X -industry, and will be used only when international tax competition strongly constrains the more efficient profit tax instrument.

The core question asked in this paper is whether capital taxes should be lower or higher for low-cost firms, as compared to their high-cost competitors. We are now able to provide an answer to this question by analyzing eqs. (18) and (19). Note first from (19) that the equilibrium output of a low-cost firm is always higher than the output of a high-cost firm, irrespective of any differences in capital taxes.¹⁷ This implies that the positive second terms in (18) are unambiguously larger for τ_L . Thus $\tau_L < \tau_H$ holds, and low-cost firms are tax-favored, if and only if profit shifting costs exceed the critical level s^c and profit taxation is accordingly high. In this case the government subsidizes capital inputs for all firms, but the subsidy level is higher for the low-cost firms. In contrast, when economic integration reduces the cost of profit shifting to $s < s^c$, then the government taxes all firms' capital inputs, but the tax is higher for the low-cost firms.¹⁸

The intuition for this reversal in the tax pattern comes from the changing relative importance of the conflicting *tax exportation* and *output expansion* motives. When the small country's profit tax can capture a large share of the profits in the X -industry, then increasing aggregate production is the optimal policy. For a given level of capital subsidies – and thus a given revenue cost to taxpayers – a subsidy produces more additional output when granted to the low-cost firms. Therefore, the optimal tax policy discriminates *in favor of* low-cost firms, to increase their market share. At the same time, however, high-cost firms are also subsidized, despite their less effective use of the subsidy. This reflects the fact that the government is also concerned about the competitive conditions in the market for good X , and the effective competition between a given number of competitors is stronger when their total unit costs (including capital taxes and subsidies) are not too dissimilar. Only for very high levels of profit shifting costs ($s > \bar{s}$) – and correspondingly high profit tax rates – it may become optimal to have only the low-cost firms in the market. Then the government subsidizes only the

¹⁷Note that we assume $s < s^{max} = 3/2$. Hence all terms in (19) are positive.

¹⁸In more general settings, the critical level of shifting costs at which optimal tax rates are zero need not coincide for the two firm types, and they need not coincide with the level of shifting costs at which $\tau_L = \tau_H$. As we discuss in the next section, this will be true, in particular, when the foreign ownership shares differ for the two firm types.

inputs of the low-cost firms, and the subsidy is such that the market price falls under the marginal production cost of the high-cost firms. This case is discussed in detail in Appendix 2.

In contrast, when tax competition with the haven is aggressive and the small country's government is only able to levy a low direct tax rate on corporate profits, then the tax exportation motive dominates in the setting of capital taxes. In this case, taxing the low-cost firms is more efficient, as these firms have the higher profit tax base in comparison to their higher-cost competitors.¹⁹ This is why the optimal pattern of capital taxes now discriminates *against* the low-cost firms. At the same time, applying a positive, albeit lower, capital tax also on the high-cost firms reduces the aggregate output loss for any given level of profits captured from foreign firm owners.

In sum, the dominating motive – either tax exportation or output expansion – determines both whether there is a capital tax or a capital subsidy, and whether it favors low-cost or high-cost firms. When tax exportation is more important ($s < s^c$), then all firms' capital is taxed, but tax revenues are maximized by taxing the low-cost firms more. When output expansion is the dominant motive ($s > s^c$), capital is subsidized for all firms, but more so for the low-cost firms, as they use the subsidy more efficiently.

We obtain total tax revenues, resulting from the combined impact of profit taxes and taxes on capital, from using (11), (16), (17) and (18) in (7). This yields

$$T^* = \left(1 - \frac{4}{9}s\right) (n_L\pi_L + n_H\pi_H) > 0, \quad (20)$$

which is positive for any level of $s < s^{max}$. Therefore, even though consumer surplus is included in the objective function (eq. 13), leaving foreign-owned profits in the X -industry completely untaxed it is never optimal for the small country.²⁰

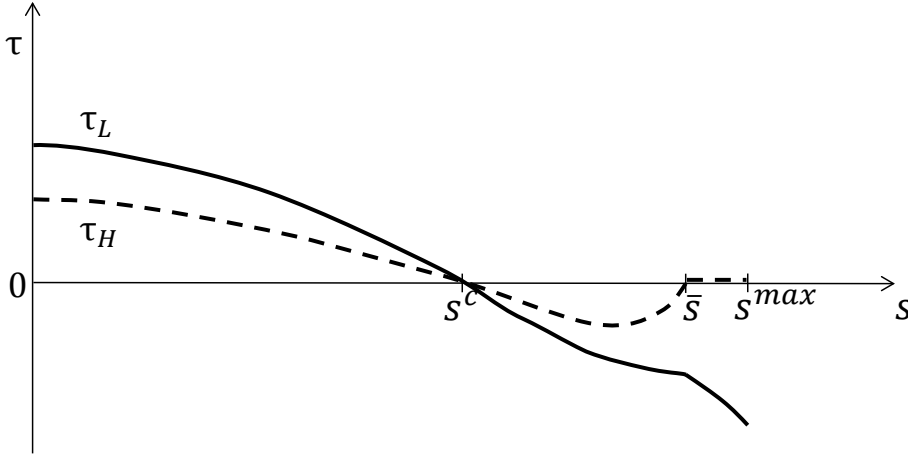
We are now in the position to state our main result:

Proposition 1 *The pattern of optimally differentiated taxation is a function of the degree of international tax competition.*

¹⁹At the same time, the elasticity of the two tax bases is the same from our assumption that both firm types have equal profit-shifting costs.

²⁰At first sight, it might seem surprising that total equilibrium tax revenues are falling in the level of profit shifting costs. This is because the incentive to subsidize output for higher levels of shifting costs dominates the positive effect of an increase in s on isolated profit tax revenue.

Figure 1: Optimal Capital Taxes and Economic Integration



- (i) *With aggressive tax competition ($s < s^c$), the government taxes capital in both firms and the optimal policy favors the high-cost firms ($\tau_L > \tau_H$).*
- (ii) *With weak tax competition ($s > s^c$), the government subsidizes capital in both firms and the optimal policy favors the low-cost firms ($\tau_L < \tau_H$).*

Figure 1 illustrates this proposition. We start on the left side of the graph, where profit shifting costs are low. In the regime of *aggressive tax competition* ($s < s^c$) both capital taxes are positive and the tax on low-cost firms (solid line) exceeds the tax on high-cost firms (dashed line). This pattern of discrimination is maintained as s rises until at $s = s^c$, capital taxes for both firm types are zero and the graphs for τ_L and τ_H intersect. At higher values of s , we reach the regime of *weak tax competition* where capital taxes on both firm types are negative, i.e. a subsidy. Moreover, capital tax rates on low-cost firms are lower than those for their higher-cost competitors. Further to the right, when the profit shifting cost parameter s exceeds a critical threshold \bar{s} , the optimal capital tax policy will be such that only the low-cost firms are active in equilibrium. As is shown in Appendix 2, this is achieved by choosing a strongly negative level of τ_L , whereas τ_H is set to zero (or any positive level) to keep the high-cost firms from entering the market.

To summarize, the tax pattern we have analyzed in this section has a clear and intuitive interpretation. As economic integration proceeds and corporate profit tax rates fall due to more aggressive competition with tax havens, the role of capital taxes as an indirect and distortive way of taxing corporate profits becomes more important. This

conforms with the observation that tax bases have been broadened in many countries, in combination with – and as a consequence of – falling corporate tax rates.²¹ Our analysis has gone beyond this general pattern, however, by showing that the increase in capital taxes should be particularly strong for low-cost firms, which are more profitable than their higher-cost competitors. This is consistent with recent observations, mentioned in the introduction, that point to capital tax increases (or reductions in capital subsidies) that are aimed specifically at the most productive firms.

4 Discussion and Extensions

This section discusses the robustness of our results when some of the assumptions made in the benchmark model are relaxed.

Home ownership of firms. In our benchmark model we have assumed that all profits accrue to foreigners. We now analyze the implications when domestic residents partly own the rent-generating production factor (‘intellectual property’). Specifically, we assume that a share $0 < \beta \leq 1$ of all *after-tax* profits goes to domestic consumers.

The change in ownership does not affect firms’ production and profit shifting choices. The government’s optimal tax policy, however, takes into account that profits now partially accrue to domestic consumers. The indirect utility function of the representative consumer is in this case

$$\tilde{V} = \frac{b}{2}X^2 + rK + \beta [(1 - \alpha)(1 - t) + \alpha(1 - t^0) - s\alpha^2] (n_L\pi_L + n_H\pi_H) + T, \quad (21)$$

where T is given in (7). Consider first the tax competition game. From the point of view of the tax haven, nothing changes, so that the tax haven’s best response function is again given by (15). The home country, in contrast, has an incentive to set a lower tax rate, as profits now partially remain in the country even without a tax. Thus, the best response function that follows from maximizing (21) is $t(t^0) = (s + t^0)(1 - \beta)/(2 - \beta)$. This yields Nash equilibrium tax rates equal to

$$\tilde{t} = \frac{2(1 - \beta)}{3 - \beta}s, \quad \tilde{t}^0 = \frac{1 - \beta}{3 - \beta}s. \quad (22)$$

²¹See Devereux et al. (2002) for a survey of the empirical evidence and Bauer et al. (2011) for a recent theoretical analysis in a heterogeneous firms setting.

Optimal capital taxes are

$$\begin{aligned}\tilde{\tau}_L &= \left[(1 - 2\beta) - \frac{(1 - \beta)^2(8 - 3\beta)}{(3 - \beta)^2} s \right] \frac{b\tilde{x}_L}{r}, \\ \tilde{\tau}_H &= \left[(1 - 2\beta) - \frac{(1 - \beta)^2(8 - 3\beta)}{(3 - \beta)^2} s \right] \frac{b\tilde{x}_H}{(1 + \Delta)r},\end{aligned}\quad (23)$$

with the equilibrium output levels of each firm type given by

$$\begin{aligned}\tilde{x}_L &= \frac{(1 - \beta)(a - r) \left[1 - \frac{(1 - \beta)(8 - 3\beta)}{2(3 - \beta)^2} s \right] + \Delta r n_H / 2}{b(1 - \beta) \left[1 - \frac{(1 - \beta)(8 - 3\beta)}{2(3 - \beta)^2} s \right] \left\{ n_H + n_L + 2(1 - \beta) \left[1 - \frac{(1 - \beta)(8 - 3\beta)}{2(3 - \beta)^2} s \right] \right\}}, \\ \tilde{x}_H &= \frac{(1 - \beta) [a - (1 + \Delta)r] \left[1 - \frac{(1 - \beta)(8 - 3\beta)}{2(3 - \beta)^2} s \right] - \Delta r n_L / 2}{b(1 - \beta) \left[1 - \frac{(1 - \beta)(8 - 3\beta)}{2(3 - \beta)^2} s \right] \left\{ n_H + n_L + 2(1 - \beta) \left[1 - \frac{(1 - \beta)(8 - 3\beta)}{2(3 - \beta)^2} s \right] \right\}}.\end{aligned}$$

Comparing the optimal tax expressions in (23) with those of our benchmark case in (18) shows that domestic ownership of firms generally reduces the level of capital taxes, as it diminishes the incentive to tax foreign-owned profits. Even when $s = 0$ and tax competition with the haven results in a zero level of corporate profit taxes (see eq. 22), positive levels of capital taxation will only be set when $\beta < 0.5$ and hence the majority of firms' profits is foreign-owned. For $\beta > 0.5$ the policy motive to expand domestic output dominates and capital is subsidized, irrespective of the degree of international tax competition.

As long as $\beta < 0.5$ however, the basic pattern of tax differentiation remains unchanged from our benchmark model. In particular, at any given level of β , a fall in the profit shifting costs s will tend to increase capital taxes (or reduce capital subsidies) for both firm types. Moreover, the tax increase will still be more pronounced for the low-cost firms, due to the stronger incentive to tax the remaining share of foreign-earned income by means of a higher capital tax.

Note, finally, that introducing different home ownership shares for the two firm types would yield an additional reason for differentiated capital taxes. For example, if home ownership is larger in the high-cost firms ($\beta_H > \beta_L$), optimal capital taxes and the critical threshold s^c will both be lower for the high-cost firms, other things being equal. For a simplified tax competition setting with no profit shifting in equilibrium, this is demonstrated in our working paper version, Langenmayr et al. (2012). However, in the more complex tax competition setting studied here, introducing type-specific ownership shares β_i will make the profit tax t dependent on the capital taxes τ_i , rendering explicit analytical solutions impossible.

Bertrand competition with heterogeneous goods. In the model presented so far, firms compete over quantities and produce a homogeneous good. An alternative model of an imperfectly competitive industry considers firms that compete over prices while producing heterogeneous, but substitutable, goods.²² Here, we will briefly summarize the results of this alternative market structure. For clarity we look at only two firms, which differ in both their productivity and in the good they produce. We assume that a firm with input cost c_i produces good x_i . Again, we normalize the input cost levels so that $c_L = 1$ and $c_H = 1 + \Delta$.

As in our benchmark model (see eq. 1), preferences over the imperfectly substitutable goods are represented by a quadratic, quasi-linear utility function (Singh and Vives, 1984)

$$U = a(x_L + x_H) - \frac{b}{2}(x_L^2 + x_H^2) - dx_Lx_H + Y^D, \quad 0 < d < b, \quad (24)$$

where (b/d) measures the degree of heterogeneity between the two goods. Given these preferences, firm i faces an inverse demand curve $p_i = a - bx_i - dx_j$ and sets its profit-maximizing prices accordingly. The profit shifting decision is not affected by the market structure, so that the share of profits shifted abroad follows from (12).

Anticipating firm behavior, the government determines its tax policy. The feasible profit tax rate is again limited by international tax competition and is set according to (16). Optimal capital taxes are equal to²³

$$\hat{\tau}_L = \left(1 - \frac{8}{9}s\right) \frac{(b^2 - d^2)\hat{x}_L}{br}, \quad \hat{\tau}_H = \left(1 - \frac{8}{9}s\right) \frac{(b^2 - d^2)\hat{x}_H}{b(1 + \Delta)r}, \quad (25)$$

with equilibrium output levels of each firm given by

$$\hat{x}_L = \frac{(a - r)(b - d) \left[3b + 2d - \frac{8}{9}(b + d)s\right] + db\Delta r}{(b^2 - d^2) \left[3b + 2d - \frac{8}{9}(b + d)s\right] \left[3b - 2d - \frac{8}{9}(b - d)s\right]} b,$$

$$\hat{x}_H = \frac{[a - (1 + \Delta)r](b - d) \left[3b + 2d - \frac{8}{9}(b + d)s\right] - db\Delta r}{(b^2 - d^2) \left[3b + 2d - \frac{8}{9}(b + d)s\right] \left[3b - 2d - \frac{8}{9}(b - d)s\right]} b.$$

Comparing (25) with (18) shows that the pattern of capital taxation is unchanged from our benchmark model, and optimal tax rates depend again on the degree of international tax competition. If tax competition is weak and profit taxation at relatively

²²In a Bertrand model with homogeneous goods, only the low-cost firms would produce. Price competition among them would bring prices down to their marginal cost r , whenever $n_L \geq 2$. Bertrand competition in homogeneous goods thus eliminates the policy issue that is at the heart of our analysis by ruling out the – empirically observed – concurrent production of firms with different cost levels.

²³For a complete derivation see Appendix 3.

high rates is feasible ($s > s^c$), the motive to expand output dominates in the setting of optimal capital taxes and the low-cost firm receives the higher subsidy. In contrast, when tax competition is aggressive and feasible profit tax rates are low ($s < s^c$), the low-cost firm's higher profits leads to it being taxed more heavily by the capital tax. The basic trade-off for tax policy that determines the optimal differentiation of capital taxes is thus the same under quantity and under price competition of the heterogeneous firms.²⁴

Additional policy instruments. Another extension arises when the small country's government has an additional policy instrument at its disposal to influence the profit shifting costs s . Maximized utility is unambiguously rising in s . Therefore, the small country has an incentive to engage in costly measures that increase s and thus reduce tax avoidance via profit shifting. If measures to control profit shifting impose convex costs, the small country will only invest in this activity until the marginal gains from reduced profit shifting equal the marginal cost of the avoidance measure (Cremer and Gahvari, 2000; Johannesen, 2012).²⁵ Therefore, a fall in s induced by economic integration will not be fully offset in the small country's policy optimum and the equilibrium level of the profit tax rate will still decline. Consequently, we expect that the basic effects of economic integration on the choice of optimally differentiated input taxes τ_i will remain intact in such an extended framework. The difficulty that arises from this model extension is, however, that all policy choices (including t) become interdependent when profit shifting can be limited by an independent policy instrument.

5 Conclusion

The recent international trade literature has produced conclusive evidence of large productivity differences among firms operating in the same market. In this paper we

²⁴Note that the *level* of capital taxes and subsidies falls in (25) when the substitutability of goods is increased (i.e., d rises, but remains below b). This is because a higher substitutability of goods under price competition leads to higher output and lower profits for both firms; hence the motives to expand output and to tax foreign-owned profits simultaneously decline.

²⁵In Cremer and Gahvari (2000) the costs are resources that have to be spent in order to limit tax avoidance. In Johannesen (2012) the costs are instead given by lost advantages of economic integration which arise when the home country taxes all cross-border interest income as a means to reduce profit shifting into tax havens.

have asked an obvious policy question that follows from this heterogeneity: Should countries tax firms with different productivity levels at different effective capital tax rates?

Our analysis has shown that the motivation to tax discriminate according to productivity levels depends critically on the corporate profit tax rate that is feasible in the presence of competition from an outside tax haven. When tax competition from the haven is weak, introducing capital tax preferences for the most productive firms is indeed optimal for the small country. This measure increases aggregate production and thus efficiency, whereas foreign-owned profits can be taxed to a sufficient degree by the non-distortive profit tax. When competition from the tax haven becomes more aggressive, however, then the tax preferences for large firms are gradually reduced and eventually turned around. It then becomes profitable for the small country to impose the heavier capital tax on the low-cost firms, as a means to indirectly capture the rents accruing to foreign owners of the firm.

The previous literature on discriminatory tax competition has focused on the role of isolated differences in the international mobility of firms, while largely ignoring differences in firm productivity. In this paper, we have adopted the opposite set of assumptions, deliberately assuming that more and less productive firms exhibit the same international mobility of their tax bases. Interestingly, the implications of economic integration turn out to be exactly opposed in the two different settings. While economic integration will lead to more tax advantages for the most productive, multinational firms when the latter are characterized primarily by their international mobility, the tax advantages for these firms are instead reduced in the tax optimum when the distinguishing feature of these firms is their high profitability. This finding may offer an explanation for existing trends to reduce the tax advantages for highly productive, multinational firms in a period where profit taxes have significantly fallen due to increasingly aggressive tax competition. In sum, therefore, we have argued in this paper that differences in productivity and profitability across firms may be a complementary, and perhaps equally important, determinant of corporate tax policy as the traditional, mobility-based approaches.

Our analysis has been held deliberately simple, and it can be extended in several directions. It is conceptually straightforward (but computationally non-trivial) to add a foreign investment opportunity for the low-cost firms, thus combining firm heterogeneity with respect to both mobility and productivity in a single, unified setting. Another

interesting extension would be to incorporate an additional labor market, where workers can participate in the higher profits earned by highly productive firms through a bargaining process over the firm's rents (e.g. Egger and Kreickemeier, 2009). An even more ambitious extension would be to endogenize the cost differentials between different firms, for example by incorporating *R&D* choices in a heterogeneous firms' framework (Long et al., 2011). Finally, from an empirical perspective, it would be highly desirable to subject our main hypothesis to a rigorous econometric test, linking quantifiable indicators of tax advantages for the most productive firms to the development of statutory corporate profit tax rates.

Appendix 1: The Critical Cost Gap Δ

This appendix derives an upper bound on the cost gap Δ , which ensures that high-cost firms will find it profitable to enter the market for good X in the absence of government intervention. For market entry by high-cost firms to occur, a necessary condition is that the market price that results from the supply of the low-cost firms alone exceeds the unit production costs of high-cost suppliers.

The inverse demand function when only low-cost firms produce is given by $p = a - bn_Lx_L$. Standard profit maximization by oligopolists with the low cost level r results in an output per low-cost firm of $x_L = (a - r)/[b(n_L + 1)]$ and a resulting market price of $p = (a + n_Lr)/(n_L + 1)$. This price exceeds the unit production costs $(1 + \Delta)r$ of high-cost firms if and only if

$$\Delta < \bar{\Delta} = \frac{a - r}{(1 + n_L)r}. \quad (\text{A.1})$$

The condition derived in eq. (A.1) is thus a necessary condition for high-cost firms to enter the market.²⁶

Appendix 2: Only Low Cost Firms Active in Equilibrium

For high levels of feasible profit taxation it may be optimal for tax policy to drive the high-cost firms from the market, so that all production takes place at the lower marginal cost c_L .²⁷ When only the low-cost firms remain in the market, output per firm in (8a) and the market price in (10) reduce to

$$\bar{x}_L = \frac{a - (1 + \bar{\tau}_L)r}{b(1 + n_L)}, \quad \bar{p} = \frac{a + n_L(1 + \bar{\tau}_L)r}{1 + n_L}, \quad (\text{A.2})$$

where the bar refers to variables in the equilibrium with low-cost firms only. Gross profits for each low-cost firm are then $\bar{\pi}_L = b(\bar{x}_L)^2$. The representative consumer's indirect utility in this case is

$$\bar{V} = \frac{b}{2} (n_L\bar{x}_L)^2 + rK + tb(1 - \alpha)n_L\bar{x}_L^2 + \bar{\tau}_Ln_L\bar{x}_Lr, \quad (\text{A.3})$$

²⁶Our treatment leaves out the possibility that low-cost firms collude and engage in predatory pricing to keep the high-cost firms out of the market. If this possibility is incorporated, the cost differential must be smaller than in (A.1) to ensure that high-cost firms will produce in equilibrium.

²⁷Keeping the low-cost firms out of the market is never optimal, as they are more productive and profits of both firms accrue to foreigners.

with the equilibrium quantity \bar{x}_L given in (A.2).

The government sets the tax parameters \bar{t} and $\bar{\tau}_L$ to maximize this indirect utility function. The firms' optimal profit shifting choice is unchanged and given by (12). Therefore, the tax competition game yields the same equilibrium as in the benchmark and tax rates are as in (16).

Maximizing (A.3) with respect to $\bar{\tau}_L$ yields the optimal capital tax and the resulting output per low-cost firm

$$\bar{\tau}_L^* = \left(1 - \frac{8}{9}s\right) \frac{b\bar{x}_L^*}{r}, \quad \bar{x}_L^* = \frac{a-r}{b\left(2+n_L - \frac{8}{9}s\right)}. \quad (\text{A.4})$$

Hence, if only the low-cost firms are active in the market, the optimal capital tax is again negative when $s > s^c = 9/8$, but positive when $s < s^c$. This pattern is thus the same as in the case where all firms are active, and the intuition is also analogous. In the extreme case where the cost of shifting profits become prohibitive ($s = s^{max} = 3/2$), so that the government can tax profits completely, the capital subsidy will become so high that it induces the first-best level of output in the market.

Using (A.4) in (A.3) yields the maximized indirect utility when only the low-cost firms produce:

$$\bar{V}^* = \frac{n_L(a-r)^2}{2b\left(2+n_L - \frac{8}{9}s\right)} + rK. \quad (\text{A.5})$$

In the last step, we determine the critical level of s above which the government wants to eliminate the high-cost firms from the market. Using (18) and (19) in (13) and comparing the result with (A.5) shows that deterring entry by the high-cost firms is optimal if

$$s > \bar{s} = \frac{9[a - (1 + \Delta)r - n_L\Delta r/2]}{4[a - (1 + \Delta)r]}. \quad (\text{A.6})$$

How do optimal capital taxes change at $s > \bar{s}$? Since $\bar{s} > s^c$, we know from (A.4) that the remaining L -firms will surely be subsidized. Also, substituting (A.6) into the low-cost firms' optimal output choice in (A.4) confirms that the resulting market price in good X is just equal to $(1 + \Delta)r$ at \bar{s} . Therefore, any weakly positive capital tax on high-cost firms suffices to keep these firms from entering the market.

It is straightforward to show that (A.6) implies a critical cost of profit shifting of $\bar{s} > s^c$ iff the condition $\Delta < (a-r)/[(1+n_L)r]$ is fulfilled. We have already shown in Appendix 1 that this condition must be fulfilled when high-cost firms enter the market in the absence of government intervention. Thus we can infer that it can only

be optimal for the government to keep the high-cost firms from entering the market when $s > s^c$, i.e. in a regime where it is already discriminating against these firms.

It is however only optimal to keep the high-cost firms from entering if they are not too similar to the low-cost firms, i.e. when the cost gap Δ is sufficiently large. Comparing \bar{s} from (A.6) with s^{max} shows that this is the case if $\Delta > 2(a - r)/[3(1 + n_L)r]$. Otherwise, low-cost and high-cost firms are so similar that it is not worthwhile to forego the additional competition from having the latter firms in the market. If all firms are in the market, the optimal policy is as described in Section 3.

Appendix 3: Bertrand Competition With Heterogeneous Goods

This appendix derives optimal capital taxes when two firms compete over prices and goods are heterogeneous. Preferences are given by a quadratic, quasi-linear utility function (eq. 24) in which two goods (x_L, x_H) enter as imperfect substitutes. Consumer optimization leads to the following demand functions for the goods produced by the low-cost and the high-cost firm:

$$\begin{aligned} x_L &= \frac{a}{(b+d)} - \frac{b}{(b^2-d^2)} p_L + \frac{d}{(b^2-d^2)} p_H, \\ x_H &= \frac{a}{(b+d)} - \frac{b}{(b^2-d^2)} p_H + \frac{d}{(b^2-d^2)} p_L. \end{aligned}$$

Taking these demand functions into account, each firm sets its price to maximize profits, which are given by (6a)-(6b). Optimal prices thus are

$$\begin{aligned} p_L &= \frac{a(b-d)}{(2b-d)} - \frac{b}{(4b^2-d^2)} [2b(1+\tau_L)r + (1+\tau_H)(1+\Delta)rd], \\ p_H &= \frac{a(b-d)}{(2b-d)} - \frac{b}{(4b^2-d^2)} [2b(1+\tau_H)(1+\Delta)r + (1+\tau_L)rd]. \end{aligned}$$

The corresponding equilibrium quantities are

$$x_L = \frac{a(b-d)(2b+d) - (2b^2-d^2)(1+\tau_L)r + bd(1+\tau_H)(1+\Delta)r}{(2b^2-d^2)^2 - b^2d^2} b, \quad (\text{A.7})$$

$$x_H = \frac{a(b-d)(2b+d) - (2b^2-d^2)(1+\tau_H)(1+\Delta)r + bd(1+\tau_L)r}{(2b^2-d^2)^2 - b^2d^2} b. \quad (\text{A.8})$$

Maximizing the utility function (24) after inserting (A.7)-(A.8) yields the welfare maximizing capital taxes given in (25).

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