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

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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.

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1 Introduction

Firms, even those operating in the same market, exhibit large and persistent differences in their productivity. This empirical fact has played an important 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 on average. 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 optimally differentiate effective tax rates between firms with different levels of productivity. For this purpose, we set up an open economy model where firms in an oligopolistic sector produce at two different cost or productivity levels. The government has two policy instruments, namely the statutory tax rate and a tax base parameter. While it must levy the nominal profit tax 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 (nominal) profit tax

[1] Syverson (2011) summarizes 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 (2014).

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

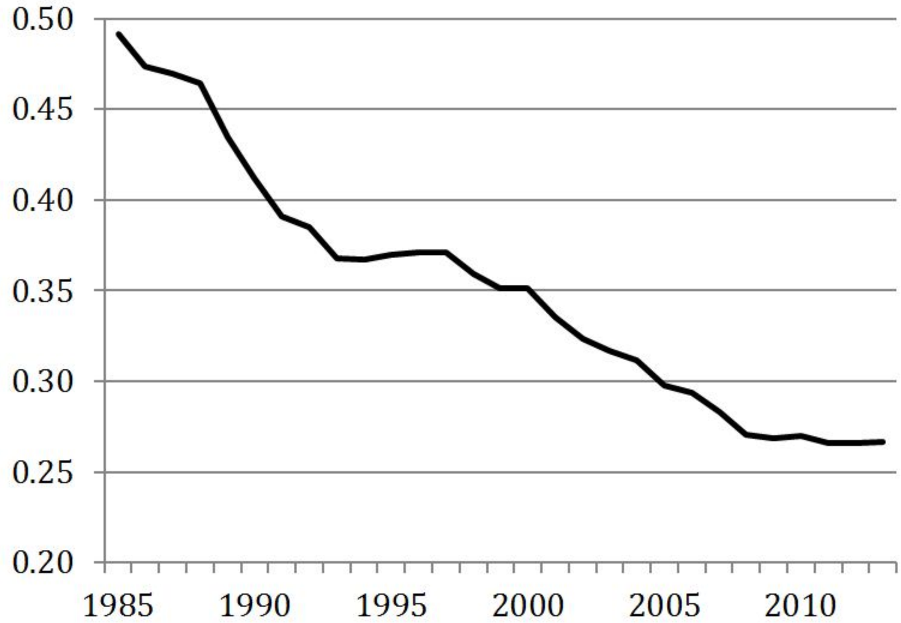
Our main result is that when economic integration is limited and profit tax rates are relatively high, the optimal policy grants tax preferences to large, highly productive firms. In contrast, when economic integration proceeds and tax competition with the haven becomes more aggressive, the pattern of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

The intuition for these results arises from two conflicting goals pursued by the welfare-maximizing government. On the one hand, the government aims to raise domestic output in the imperfectly competitive sector, but on the other hand it seeks to increase tax revenues from foreign-owned profits via a broader tax base.[2] As long as international tax competition is weak, the motive to expand domestic output dominates, because the government can capture the resulting profits by a high profit tax rate. To achieve this aim, the government raises the market share of the low-cost firms by giving these firms a tax advantage. However, as tax competition from the tax haven becomes more aggressive, the dominant concern switches to raising 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.

Recent developments in tax policy offer empirical support for our results. First, one well-noted trend is the substantial fall in statutory corporate tax rates. Figure 1 shows that statutory corporate tax rates in the EU-15 countries have fallen by almost one half over the last three decades, from close to 50% in the mid-1980s to less than 27% at present. Similar trends, although somewhat less pronounced, can be observed among the OECD countries (OECD, 2012), and also in less-developed parts of the world

[2]See Huizinga and Nicodème (2006) for an analysis documenting the empirical importance of the latter effect for corporate income taxation in Europe. Theoretical analyses focusing on this effect are Huizinga and Nielsen (1997) and Fuest (2005).

Figure 1: Corporate Tax Rates in EU-15



Average corporate tax rate for EU-15 countries, unweighted sum of central and sub-central rates. Source: OECD tax database.

(Klemm and van Parys, 2012). There is a widespread consensus in the literature that one of the key explanations of the reduced ability of countries to directly tax corporate profits is the international competition for mobile capital, firms and profits.[3]

Second, many countries have recently undertaken unilateral measures aimed at limiting the tax advantages of large and highly profitable firms, often in the context of base-broadening reforms that have accompanied the reduction in statutory tax rates.[4] A typical example is the proliferation of thin capitalization rules, which limit the deductibility of interest payments from the corporate tax base. In the mid-1990s less than one half of all OECD members had adopted such rules, but this share has risen to over two thirds in 2005 (Buettner et al., 2012, Table A.1).

Table 1 documents the changes in this policy area that have taken place in the EU-15 countries during the last years. After the last round of reforms, thin capitalization rules in most countries apply only to firms with interest payments above a certain, often

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

[4]See Devereux et al. (2002) for an overview of corporate tax reforms since the mid-1980s and Kawano and Slemrod (2012) for a recent analysis.

Table 1: Tax Rates and Limitations on Interest Deductibility (EU-15 Countries)

			Before reform		After reform		Tighter
Country	CTR[1]	Reform	Scheme	Threshold	Scheme	Threshold	rule?
Austria	25.0%	n/a	*No thin capitalization rule*				n/a
Belgium	34.0%	2012	Thin capitalization rule, debt-to-equity ratio 7:1	–	Thin capitalization rule, debt-to-equity ratio 5:1	–	yes
Denmark	25.0%	2007	Thin capitalization rule, debt-to-equity ratio 4:1	Debt > kr. 10m	Additional interest cap, 80% of profits	Interest > kr. 21.3m	yes
Finland	24.5%	2014	*No thin capitalization rule*	–	Interest cap, 30% of EBITDA	Interest > € 0.5m	yes
France	34.4%	2007	Thin capitalization rule,[3] int. debt-to-equity ratio 1.5:1	–	Thin capitalization rule, int. debt-to-equity ratio 1.5:1	Interest > € 0.15m	yes
Germany	30.2%	2008	Thin capitalization rule, debt-to-equity ratio 1.5:1	–	Interest cap, 30% EBITDA	Interest > € 3m	?[2]
Greece	26.0%	2014	Thin capitalization rule, debt-to-asset ratio 3:1	–	Interest cap, 25% EBITDA	Interest > € 1m	?[2]
Ireland	12.5%	n/a	*No thin capitalization rule*				n/a
Italy	27.5%	2008	Thin capitalization rule, int. debt-to-equity ratio 4:1	–[4]	Interest cap, 30% EBITDA	–	?[2]
Luxemb.	29.2%	n/a	*No thin capitalization rule*				n/a
Nether-lands	25.0%	2013	Thin capitalization rule, debt-to-equity ratio 3:1	Debt > € 0.5m	Restriction of interest deduction on some loans	Interest > € 0.75m	?[2]
Portugal	31.5%	2013	Thin capitalization rule,[3] debt-to-net worth 2:1	–	Interest cap, 30% EBITDA	Interest > € 3m	yes
Spain	30.0%	2012	Thin capitalization rule,[3] debt-to-net worth 3:1	–	Interest cap, 30% EBITDA	Interest > € 1m	yes
Sweden	22.0%	n/a	*No thin capitalization rule, some rules on deductibility of internal debt*				n/a
United Kingdom	23.0%	2010	–	–	Worldwide debt cap[5]	Large groups[6]	yes

[1] CTR: overall corporate tax rate in 2013; source: OECD tax database.
[2] Not directly comparable due to change in system of interest deductibility.
[3] Applies only to non-EU firms.
[4] All holdings, other companies only if turnover > € 7.5m.
[5] UK companies in a worldwide group can only deduct interest of up to the gross finance expense of the whole group.
[6] Large groups as defined by EU commission recommendation 2003/361.
All information on limitations on interest deductibility from IBFD European Tax Handbooks.

relatively high, threshold. They thus apply only to the largest and most productive firms.[5] Moreover, for those firms, thin capitalization rules have generally been tightened during the last decade. This increases the productive firms' cost of debt financing, as additional debt is no longer tax deductible. Thin capitalization rules thus act as a tax on capital that is specifically aimed at the largest and most productive firms, increasing the tax burden of these firms relative to smaller, less productive firms in exactly the way our model predicts.

Governments have further ways in which they can influence the effective tax burden of some groups of firms, for example by selectively enforcing tax laws. In the past, such measures have favored large firms: Using data from 1983 to 1998, Hanlon et al. (2007) show that among the largest firms in the U.S., 74% had some tax deficiency, i.e. auditors found that these firms had paid too little tax. This tax underpayment amounted on average to 14.6% of the overall tax burden. In contrast, only less than half of the smallest firms had some tax deficiency, and this deficiency was on average less than ten percent. It likely contributed that only about 30% of firms with assets above US-$ 100 million were audited in the U.S. in the early 1990s (U.S. Government Accountability Office, 1995). More recently, in contrast, there is much less room for tax noncompliance of large firms. In 2007, the U.S. introduced accounting rules requiring firms to disclose tax positions that would likely not hold up if audited (FIN 48). These rules have significantly decreased tax avoidance activities at the sub-national level (Gupta et al., 2014), as they also provide auditors with additional information. At the same time, audit rates for large firms are now quite high. Evidence from Germany suggests that currently any tax year of a large firm is audited with a probability of 80% (Bundesfinanzhof, 2012). These developments again suggest, in accordance with our model, that the effective base broadening arising from tighter enforcement standards has primarily fallen on large, productive firms, reducing the previous tax advantages of these firms in a period where corporate tax rates have fallen.

Existing paradigms cannot explain these trends. 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.,

[5] The interest cap introduced as part of the German corporate tax reform of 2008, for example, was explicitly targeted at increasing the tax base only for the most productive, multinational firms. See Buslei and Simmler (2012) for a detailed analysis.

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 among 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.[6]

Our analysis relates to several lines of previous research. A first line 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 under which conditions countries 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 among firms are either ruled out, or are not central to the results obtained.[7]

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 (Davies and Eckel, 2010), 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., 2014). None of these papers, however, allows for taxes or subsidies that

[6]We 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. (2014).

[7]The 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.

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 several extensions of our benchmark model. Section 5 concludes.

2 The Benchmark Model

We study tax policy in a home country that is integrated with the rest of the world through capital mobility and international ownership of assets. The home country is one of m symmetric countries comprising the world economy. In our benchmark model the number of countries is large ($m \to \infty$) so that the home country is in fact a small open economy. In our first model extension (Section 4.1) we will, however, consider the case where the number of countries m is finite, and the home country is 'large'.

The home country produces and consumes two homogeneous goods, X and Y. Capital and the numeraire good Y can be freely traded internationally. Firms in the Y industry (the numeraire sector) are homogeneous and operate under perfect competition. This sector uses capital as the only input, requiring $1/r$ units of capital per unit of output. This fixes the interest rate in the home country at r. The X sector has an oligopolistic market structure with an exogenously given number of firms. This sector combines capital with a specific factor that is in limited supply, giving rise to pure profits in this industry. Importantly, the firms producing in the X sector differ with respect to their unit cost.[8]

The focus of our analysis lies on the corporate tax structure that the home 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.[9]

2.1 Private Agents

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

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

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 home country. National income I is composed of factor earnings and tax revenues. The representative consumer in the home country owns K units of internationally mobile capital, yielding capital income of rK. Moreover, she owns a share of the specific factor in all countries and therefore receives residual profit income. In our benchmark model we assume that the number of countries in the world is large. With a perfect international diversification of portfolios, the profit income of the representative home consumer is affected only in a negligible way by the profits of domestic firms and we can treat the home consumer's (net) profit income

[8]By treating the number of firms of each type as exogenous, and therefore restricting entry to the profitable industry, our analysis effectively focuses on tax policy in the short and medium run only. For a recent analysis of the optimal entry policy towards oligopoly in a globalized economy in a model with identical firms, see Miyagiwa and Sato (2014).

[9]As 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 as a way to increase domestic consumer surplus (see e.g. Haufler and Wooton, 2010). One issue that would arise when good X is tradeable is that the tax policy of a large country can be used to affect the domestic terms of trade. This incentive disappears, however, when countries are symmetric, as we assume in the present analysis (in Section 4.1).

as being fixed exogenously at π^F.[10] We relax this assumption in Section 4.1, where the share of domestically earned profit income accruing to the home consumer is non-negligible. Finally, we denote total tax revenues by T and assume that the government redistributes these to the consumer as a lump-sum payment. National income in the home country is then

$$I = rK + \pi^F + T. \tag{2}$$

Utility maximization yields linear demand functions

$$X = \frac{a-p}{b}, \qquad Y^D = I - pX, \tag{3}$$

which imply that all income changes affect only the demand for the numeraire good Y. We assume that the exogenous income components rK and π^F in Eq. (2) are always large enough to sustain a positive consumption of the numeraire good by the home country's consumers.[11]

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 (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 the domestic ownership share in this profit income is negligible.

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, our benchmark model assumes 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. These input requirements translate into different unit costs of the two firm types, given by $c_L r$ and $c_H r$, respectively. Having only two cost levels is sufficient to capture the fundamental effects of productivity differences for tax policy, and it allows us to

[10] As we will see below, the home country can neither affect the gross profits that the home consumer earns abroad, nor the taxes paid on this profit income.

[11] A sufficient condition for this to be true is given in Section 2.3 (Footnote 20).

derive closed-form solutions for all variables. Section 4.2 relaxes this assumption and considers the implications of allowing for three different firm types.

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

$$X = n_L x_L + n_H x_H. \tag{4}$$

In our baseline model, firms in the X sector engage in quantity competition.[12] As we will see below, a low-cost firm produces more output than a high-cost firm. We 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. Appendix 1 derives the precise condition underlying this case. In the absence of government intervention, all firms therefore produce.

2.2 Government

The home country's government has two tax instruments at its disposal. The first policy variable is a *profit tax*, levied at a uniform rate t on all profits accruing in the X-sector. This instrument corresponds to a nominal, statutory corporate tax rate. While some countries levy reduced corporate tax rates on very small firms, the threshold income up to which this rate applies is typically very low.[13] Therefore, a uniform profit tax rate is a good approximation in the setting of oligopolistic interaction studied in this paper.

[12] In Section 4.3 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.

[13] In most of the eleven OECD countries that have a progressive corporate tax schedule, the maximum tax rate applies when taxable income exceeds about 300,000 € (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.

Second, the government can tax (or subsidize) capital inputs. We assume that only capital inputs in the X-sector are taxed (or subsidized), whereas capital in the numeraire sector Y remains tax free.[14] 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, which we presented in the introduction. 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.

Such capital taxes often apply selectively to different types of firms. As Table 1 shows, for example, thin capitalization rules often 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. On the other hand, large firms have been empirically shown to reduce their tax base more aggressively through corporate tax noncompliance (Hanlon et al., 2007). For the low auditing rates that have prevailed in the past, this leads to a lower effective tax rate for these firms, relative to smaller and less productive firms. With respect to subsidies, there are a number of selective programs that target capital subsidies explicitly at small and medium-size firms, to promote their market entry or business expansion (Mirrlees et al., 2011).

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 are

$$\pi_L = [p - (1+\tau_L)r]x_L, \tag{5a}$$

$$\pi_H = [p - (1+\tau_H)(1+\Delta)r]x_H. \tag{5b}$$

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

[14]This implies that we effectively focus on the additional taxation of capital in the X sector, relative to the taxation of capital in the Y sector. For further discussion, see Section 3.2.

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 (5a)–(5b). 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. It is common to assume that these shifting costs exhibit some sort of convexity to ensure interior solutions for the firms' profit shifting. More specifically, we assume here that shifting costs are convex in the *share* of profits shifted to the tax haven, i.e. shifting a larger share of profits is more costly at the margin. This assumption captures that a given absolute amount of profit shifting is easier to conceal from the tax authorities when the underlying profit tax base is larger. As we will see below, this assumption (together with the assumption of equal shifting cost parameters) has the important implication that both firm types shift the same *share* of profits abroad in equilibrium, even though larger firms shift more profits in absolute terms than smaller firms.[15] Finally, to ensure closed-form solutions, we assume that the shifting costs are quadratic in the share of profits shifted.

We assume that capital taxes are deductible from the corporate profit tax base.[16] Together with the above specifications, profits net of tax (π_i^n) are then

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

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

where profit tax bases are given in (5a)–(5b) 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

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

We impose no constraint on the sign of T. As Eq. (2) shows, positive tax collections are redistributed to the representative consumer lump sum. Conversely, if total tax revenue

[15] This feature of our model ensures that only differences in productivity, and not in profit shifting behavior, drive the differential tax treatments of the two firm types.

[16] Our results are qualitatively the same when capital taxes cannot be deducted.

from the corporate tax system turns negative, then lump-sum taxes are available to finance effective subsidy payments to firms.[17]

2.3 Market Equilibrium

Our 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 where all 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. Intermediate cases, where only some of the high-cost firms enter the market, cannot occur in our model. To see this, note first that all high-cost firms have the same incentive to enter the market, as they have identical production costs and face the same capital tax. Moreover, firms have no fixed costs of market entry, since they are already in possession of the specific factor that is necessary to produce. In this situation, it is profitable for any high-cost firm to enter the market if the price of good X exceeds its marginal cost, and if it can sell a positive quantity with the price remaining above its marginal cost. If market entry is profitable for one high-cost firm, then it must also be profitable for all high-cost firms.[18]

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

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

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

[17]We will show below, however, that tax revenues are always positive in the government's policy optimum.

[18]Entry is profitable for all high-cost firms at once as quantities are perfectly divisible. Thus, the additional output can be divided among all high-cost firms (and will be in equilibrium). Moreover, the low-cost firms will strategically reduce their own output in response to the high-cost firms' entry, further increasing the market supply of the high-cost firms in equilibrium.

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 that firms with lower marginal production costs have a larger market share in equilibrium.

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

$$\frac{\partial x_L}{\partial \tau_L} = \frac{-(1+n_H)r}{b(1+n)} < 0, \qquad \frac{\partial x_L}{\partial \tau_H} = \frac{n_H(1+\Delta)r}{b(1+n)} > 0, \tag{9a}$$

$$\frac{\partial x_H}{\partial \tau_H} = \frac{-(1+n_L)(1+\Delta)r}{b(1+n)} < 0, \qquad \frac{\partial x_H}{\partial \tau_L} = \frac{n_L r}{b(1+n)} > 0\,. \tag{9b}$$

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 among firms involves downward-sloping best response functions, the falling output of firms of type i implies a rising output for all firms $j \neq i$, as the type-specific capital tax τ_j does not affect firms of type 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:

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

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

$$\pi_L = b x_L^2, \qquad \pi_H = b x_H^2. \tag{11}$$

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

$$\alpha_L = \alpha_H = \frac{t - t^0}{s}. \tag{12}$$

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 (see Footnote 15).[19]

[19] Different 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).

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

$$\begin{aligned} V &= \frac{b}{2}\left(n_L x_L + n_H x_H\right)^2 + rK + \pi^F \\ &+ (1-\alpha)tb(n_L x_L^2 + n_H x_H^2) + \tau_L n_L x_L r + \tau_H n_H x_H \left(1+\Delta\right) r, \end{aligned} \tag{13}$$

where equilibrium quantities are given by (8a)–(8b) and α is given in (12). In Eq. (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, which consists of exogenous capital and profit income (the second and third terms), and total tax revenues (the remaining terms; see Eq. 7). Deducting expenditures for the X-goods from total income (see Eq. 3) then gives the consumption of the numeraire good Y.[20]

3 Optimal Policy

We now derive the optimal tax policy chosen by the home 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 setup (Eq. 12), we can solve the government's problem sequentially. First, the tax authorities

[20] Anticipating the optimal tax results from the following Section 3 and evaluating at the level of profit shifting costs where consumption of good Y is at its minimum (s_{max}), a sufficient condition for a positive consumption level of the numeraire good Y is:

$$rK + \pi^F > \frac{n(a-r)(a-r+3rn) + n_H \Delta r[3(a-2r)n + 2r]}{b(3n+2)}.$$

The right-hand side of this inequality condition gives a measure for the expenditures on good X: the first term in the numerator is a measure of the consumer surplus in the X-sector, whereas the second term is a measure of the average production costs. The value of exogenous endowments must thus be sufficiently high to (more than) cover these optimized expenditures on good X.

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.

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

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

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

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

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 set their tax rates to

$$t^* = \frac{2}{3}s \qquad \text{and} \qquad t^{0*} = \frac{1}{3}s. \tag{16}$$

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

$$\alpha^* = \frac{1}{3}. \tag{17}$$

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 home 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 home 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 (9a)–(9b), (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:

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

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

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

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 the home country is small.

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 tax exportation effect. Therefore, capital taxes 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 they 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.[21] 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.[22]

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 home 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

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

[22]In more general settings, the critical level of shifting costs at which optimal tax rates are zero does not necessarily coincide for the two firm types, and may also differ from the level of shifting costs at which $\tau_L = \tau_H$. This is true, in particular, when the foreign ownership shares vary between the two firm types.

taxes and subsidies) are not too dissimilar.[23]

In contrast, when tax competition with the haven is aggressive and the home 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.[24] 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

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

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 is never optimal for the home country.[25]

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.*

[23]For very high levels of profit shifting costs ($s > \bar{s}$) – and correspondingly high profit tax rates – it becomes optimal to have only the low-cost firms in the market. Then the government subsidizes only the 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. In this situation, it would be inefficient to have the high-cost firms produce. This case is discussed in Appendix 2.

[24]At 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.

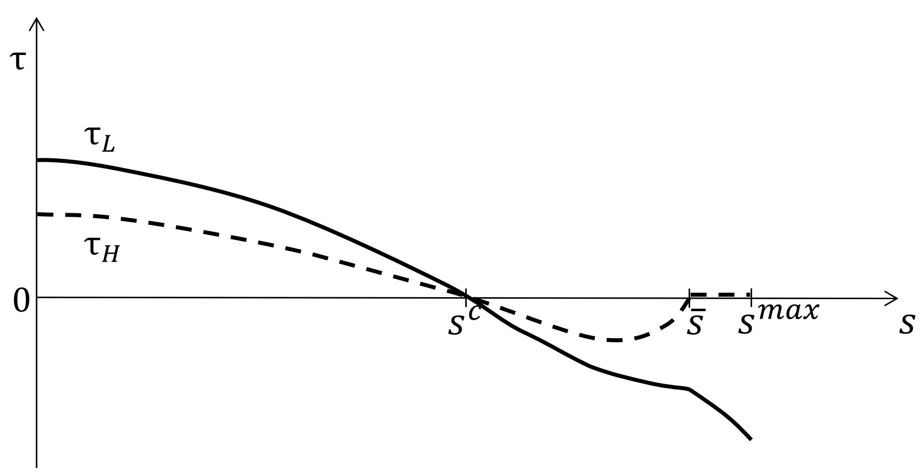
[25]At first sight, it might seem surprising that total equilibrium tax revenues are falling in the level of profit shifting costs. This is because the incentive to subsidize output for higher levels of shifting costs dominates the positive effect of an increase in s on isolated profit tax revenue.

(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 2 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 is 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.

Figure 2: Optimal Capital Taxes and Economic Integration



It should be emphasized that the optimal *level* of capital taxes in sector X depends on our assumption that capital use in the numeraire sector Y is untaxed (see Footnote 14). Appendix 3 considers the case where capital in the numeraire sector is taxed and shows that this introduces one degree of freedom in setting the optimal capital tax structure. Therefore capital taxes in our benchmark model should be interpreted as taxes in the imperfectly competitive sector X, *relative* to the taxation of capital in the numeraire sector Y (see Eq. A.10). For example, the output expansion motive that gives rise to capital subsidies in our benchmark model, other things being equal, can equivalently be addressed by taxing capital in the numeraire sector. In Figure 2, this implies that a positive tax on capital in the numeraire sector leads to an upward shift of both curves $\tau_L(s)$ and $\tau_H(s)$. The optimal *structure* of capital taxation in the X sector, however (i.e., the difference between τ_L and τ_H) is unaffected by our assumption that capital in the numeraire sector is untaxed (see Eq. A.11 in the appendix).

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.[26] Our analysis has gone beyond this general pattern, however, by showing that the increase in capital taxes is 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.

4.1 Large Home Country

In our benchmark model we have assumed that the home country is small in the world economy and we have therefore treated all profit income as being exogenous to tax policy. We now analyze the implications when the home country is one of m symmetric countries in the world economy, where m is finite. The home country's ownership of the specific production factors remains perfectly diversified across the m countries,

[26] See Devereux et al. (2002) for a survey of the empirical evidence and Bauer et al. (2014) for a recent theoretical analysis in a heterogeneous firms setting.

implying that the home consumer now owns a share $1/m$ of the domestic profit income in sector X. Therefore

$$\tilde{I} = rK + \frac{1}{m}\left(n_H \pi_H^n + n_L \pi_L^n\right) + \frac{(m-1)}{m}\,\pi^F + T,$$

where a tilde symbol denotes variables in the large country case, π_H^n and π_L^n refers to after-tax profits as given in (6a)–(6b), and π^F are the net profits in each of the (symmetric) foreign countries. Importantly, this last income term continues to be exogenous, as the home country's tax policy can neither affect the gross profits of X firms in a foreign country, nor the tax paid on these profits.[27]

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 now

$$\tilde{V} = \frac{b}{2}X^2 + rK + \frac{1}{m}\left[(1-\alpha)(1-t) + \alpha(1-t^0) - s\alpha^2\right]\left(n_L \pi_L + n_H \pi_H\right) + \frac{(m-1)}{m}\,\pi^F + T, \tag{21}$$

where we have substituted in net profits from (6a)–(6b) and 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 $t(t^0) = (s + t^0)(m-1)/(2m-1)$. This yields Nash equilibrium tax rates equal to

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

Optimal capital taxes are

$$\tilde{\tau}_L = \left[\frac{(m-2)}{m} - \beta s\right]\frac{b\tilde{x}_L}{r}, \qquad \tilde{\tau}_H = \left[\frac{(m-2)}{m} - \beta s\right]\frac{b\tilde{x}_H}{(1+\Delta)\,r}\,, \tag{23}$$

where

$$\beta = \frac{(m-1)^2(8m-3)}{m(3m-1)^2} > 0,$$

[27] This is because good X is not tradable and taxes are set in the host country of the investment. Finally, tax savings through profit shifting depend on the tax policy of the tax haven, but not on the tax policy in the residence country of the investor. Cf. Footnotes 9 and 10.

and the equilibrium output levels of each firm type are

$$\tilde{x}_L = \frac{(a-r)\left[\frac{(m-1)}{m} - \frac{\beta s}{2}\right] + \Delta r n_H/2}{b\left[\frac{(m-1)}{m} - \frac{\beta s}{2}\right]\left[n_H + n_L + \frac{2(m-1)}{m} - \beta s\right]},$$

$$\tilde{x}_H = \frac{[a-(1+\Delta)r]\left[\frac{(m-1)}{m} - \frac{\beta s}{2}\right] - \Delta r n_L/2}{b\left[\frac{(m-1)}{m} - \frac{\beta s}{2}\right]\left[n_H + n_L + \frac{2(m-1)}{m} - \beta s\right]}.$$

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 $m > 2$ and hence the majority of the domestic firms' profits is owned by foreigners. For $m = 2$, and thus for a symmetric two-country model, the policy motive to expand domestic output dominates and capital is subsidized whenever profit-shifting costs s are strictly positive.[28]

In the context of the OECD or the European Union, however, we can realistically assume that $m > 2$. In this case the basic pattern of tax differentiation remains unchanged from our benchmark model. In particular, for any given number of countries m, a fall in the profit shifting costs s tends to increase capital taxes (or reduce capital subsidies) for both firm types. Moreover, the tax increase is still 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.

4.2 Three Firm Types

So far we have assumed that there are only two different productivity levels. To gauge how our results change when more firm types exist, we now extend the benchmark model to an economy with firms operating at three different productivity levels. Specifically, we assume that there are low-cost firms with a marginal production cost of $c_l = r$, medium-cost firms with a marginal production cost of $c_m = (1 + \Delta_m)r$, and high-cost firms with a marginal production cost of $c_h = (1 + \Delta_h)r$, with $\Delta_h > \Delta_m$, and lower-case indices denoting variables in this model variant. To keep the analysis tractable, we assume that there is an equal number of firms in each group, with a total of n firms

[28] Of course, this holds only when capital in the numeraire sector Y remains untaxed. See Appendix 3.

in the market. As in the benchmark model, we again assume that the home economy is small relative to the rest of the world.

The government has the tax policy parameters t, τ_l, τ_m and τ_h at its disposal. International tax competition again constrains the setting of the profit tax rate, so that the government sets t according to (16). The government chooses the three capital tax rates to maximize welfare. The optimal capital tax rates are derived in Appendix 4 and are given by:

$$\tau_l = \left(1 - \frac{8s}{9}\right)\frac{bx_l^*}{r}, \quad \tau_m = \left(1 - \frac{8s}{9}\right)\frac{bx_m^*}{(1+\Delta_m)r}, \quad \tau_h = \left(1 - \frac{8s}{9}\right)\frac{bx_h^*}{(1+\Delta_h)r}, \tag{24}$$

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

$$x_l^* = \frac{(a-r)(1-4s/9) + (n/3)(\Delta_m + \Delta_h)r/2}{b(1-4s/9)(2+n-8s/9)},$$
$$x_m^* = \frac{[a-(1+\Delta_m)r](1-4s/9) - (n/3)(\Delta_m - \Delta_h/2)r}{b(1-4s/9)(2+n-8s/9)},$$
$$x_h^* = \frac{[a-(1+\Delta_h)r](1-4s/9) - (n/3)(\Delta_h - \Delta_m/2)r}{b(1-4s/9)(2+n-8s/9)}.$$

This tax pattern is very similar to the one derived in the benchmark model. In fact, it becomes clear that even with more productivity levels, the optimal capital tax continues to be a function of the profit shifting cost s, the marginal cost of the firm, and its equilibrium quantity. Again, when tax competition is weak and profit tax rates are relatively high ($s > s^c$), the motive to expand output dominates and capital in all firms is subsidized. In this case, the most productive firms obtain the highest subsidy, and the least productive firms receive the lowest subsidy, so that $\tau_l < \tau_m < \tau_h < 0$. In contrast, when tax competition is aggressive, capital in all firms is taxed. The tax is higher the lower the marginal cost of the firm: $\tau_l > \tau_m > \tau_h > 0$.

Thus, the government optimally taxes a firm with an intermediate cost level also at an intermediate capital tax rate, i.e. a capital tax rate between those of the high-cost and the low-cost firms. We expect that this line of argumentation carries over to still more firms, or even to a continuum of firms with heterogeneous productivity levels, but the computations become increasingly involved.

4.3 Bertrand Competition with Heterogeneous Goods

In the models 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.[29] Here, we 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)

$$U = a(x_L + x_H) - \frac{b}{2}(x_L^2 + x_H^2) - dx_L x_H + Y^D, \qquad 0 < d < b, \tag{25}$$

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 to[30]

$$\hat{\tau}_L = \left(1 - \frac{8}{9}s\right)\frac{(b^2 - d^2)\hat{x}_L}{br}, \qquad \hat{\tau}_H = \left(1 - \frac{8}{9}s\right)\frac{(b^2 - d^2)\hat{x}_H}{b(1+\Delta)r}, \tag{26}$$

with equilibrium output levels of each firm given by

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

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

Comparing (26) with (18) shows that the pattern of optimally differentiated capital taxes 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 high rates is feasible ($s > s^c$), the motive to expand output dominates the incentive to tax foreigners, and the low-cost firm receives the higher

[29] In 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.

[30] For a complete derivation see Appendix 5.

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.[31]

4.4 Additional policy instruments

Another extension arises when the home 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 home 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 home country will only invest in this activity until the marginal gains from reduced profit shifting equal the marginal cost of the avoidance measure.[32] Therefore, a fall in s induced by economic integration will not be fully offset in the home 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 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 have asked an immediate policy question that follows from this heterogeneity: Should countries tax firms with different productivity levels at different effective capital tax rates?

[31] Note that the *level* of capital taxes and subsidies falls in (26) 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; thus the motives to expand output and to tax foreign-owned profits simultaneously decline.

[32] See Cremer and Gahvari (2000), or Johannesen (2012). In 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.

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 and nominal profit tax rates can be high, then capital inputs are subsidized and capital tax preferences are introduced for the most productive firms, who respond to these incentives with the largest output increase. As economic integration proceeds and tax competition from the haven becomes more aggressive, however, the optimal tax pattern changes. Capital inputs are now taxed, rather than subsidized, and this broadening of the tax base is strongest for highly productive firms. It thus becomes profitable to impose the heavier capital tax on the low-cost firms, as a means to indirectly capture the high profits generated by them. These predictions of our model can explain why many countries have recently tightened tax laws as well as tax enforcement for the largest and most productive firms (often multinationals), which operate within their jurisdictions.

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 leads 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, 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 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. In such a setting we would expect that the motives for tax policy on which the present analysis has focused will be the more important, the higher are the mobility costs of firms. 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 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 $p = a - bn_L x_L$. 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 $p = (a + n_L r)/(n_L + 1)$. This price exceeds the unit production costs $(1+\Delta)r$ of high-cost firms if and only if

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

The condition derived in Eq. (A.1) is thus a necessary condition for high-cost firms to enter the market.[33]

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.[34] When only the low-cost firms remain in the market, output per firm in (8a) and the market price in (10) reduce to

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

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

$$\bar{V} = \frac{b}{2}\ (n_L\bar{x}_L)^2 + rK + \pi^F + tb(1-\alpha)n_L\bar{x}_L^2 + \bar{\tau}_L n_L \bar{x}_L r, \tag{A.3}$$

[33]Our 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 produce in equilibrium.

[34]Keeping 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

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

Therefore, 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 becomes 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:

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

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

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

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 $\Delta > 2(a-r)/[(2+3n_L)r]$. 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: Taxing Capital in the Numeraire Sector

Let us assume that the home country taxes capital in the numeraire sector Y by means of a source-based tax at rate τ_Y. Since good Y is tradeable, the producer price in the home country, and hence the domestic price of capital, must then fall below the international capital return r. International arbitrage implies:

$$r^{num}(1+\tau_Y) = r, \tag{A.7}$$

where the superscript 'num' denotes variables in the home country when capital in the numeraire sector is taxed. The tax on the numeraire sector reduces the net return to the home consumer's capital endowment but simultaneously increases tax revenue. From the full employment condition for the home country's capital endowment, and the fact that producing one unit of Y requires $1/r$ units of capital, output of the numeraire good equals

$$Y^S = \frac{K}{r} - n_L x_L - n_H x_H(1+\Delta). \tag{A.8}$$

National income in the home country is now given by

$$I^{num} = \frac{r^F K}{(1+\tau_Y)} + \pi^F + T^{num},$$

where tax revenue T^{num} includes the taxation of the numeraire

$$T^{num} = (1-\alpha)t(n_L\pi_L + n_H\pi_H) + \tau_L^{num} n_L x_L r + \tau_H^{num} n_H x_H (1+\Delta) r + \tau_Y Y^S \frac{r}{(1+\tau_Y)}.$$

Using (A.8), proceeding as in the main text (see the derivation of Eq. 13) and cancelling terms gives indirect utility

$$\begin{aligned} V^{num} &= \frac{b}{2}(n_L x_L + n_H x_H)^2 + rK + \pi^F + (1-\alpha)tb(n_L x_L^2 + n_H x_H^2) \\ &+ \frac{(\tau_L^{num} - \tau_Y)}{(1+\tau_Y)} n_L x_L r + \frac{(\tau_H^{num} - \tau_Y)}{(1+\tau_Y)} n_H x_H r \end{aligned} \tag{A.9}$$

Equation (A.9) is equivalent to Eq. (13) in the main text when we set

$$\tau_L = \frac{(\tau_L^{num} - \tau_Y)}{(1+\tau_Y)} \quad \text{and} \quad \tau_H = \frac{(\tau_H^{num} - \tau_Y)}{(1+\tau_Y)}. \tag{A.10}$$

This implies that the capital tax rates derived in our benchmark model must be interpreted as capital tax rates in the X-sector, *relative* to those in the Y-sector. With this re-interpretation, all results from our analysis carry over without changes to a setting where capital in the numeraire sector can also be taxed. Finally, it immediately follows from (A.10) that

$$\tau_L - \tau_H = \frac{\tau_L^{num} - \tau_H^{num}}{(1+\tau_Y)}\ , \tag{A.11}$$

and hence the *difference* in the capital tax rates on low-cost and high-cost firms is unaffected by the taxation of the numeraire.

Appendix 4: Three Firm Types

Consider a total of n firms that are divided equally to produce with the three exogenous cost levels $c_l = r$, $c_m = (1+\Delta_m)r$, and $c_h = (1+\Delta_h)r$. The firms compete under quantity competition, facing demand as given by (3). Optimal quantities are

$$\begin{aligned}
x_l &= \frac{a-(1+\tau_l)r+(n/3)[(1+\tau_h)(1+\Delta_h)r+(1+\tau_m)(1+\Delta_m)r-2(1+\tau_l)r]}{b(1+n)},\\
x_m &= \frac{a-(1+\tau_m)(1+\Delta_m)r+(n/3)[(1+\tau_l)r+(1+\tau_h)(1+\Delta_h)r-2(1+\tau_m)(1+\Delta_m)r]}{b(1+n)},\\
x_h &= \frac{a-(1+\tau_h)(1+\Delta_h)r+(n/3)[(1+\tau_l)r+(1+\tau_m)(1+\Delta_m)r-2(1+\tau_h)(1+\Delta_h)r]}{b(1+n)}.
\end{aligned}$$

The government maximizes the representative consumer's indirect utility, which is

$$\begin{aligned}
V =& \frac{b}{2}\left(\frac{n(x_l+x_m+x_h)}{3}\right)^2 + rK + \pi^F + (n/3)\left[(1-\alpha)tb(x_l^2+x_m^2+x_h^2)+\right.\\
&\left.\tau_l x_l r + \tau_m x_m (1+\Delta_m) r + \tau_h x_h (1+\Delta_h) r\right].
\end{aligned} \tag{A.12}$$

Maximizing this function with respect to τ_l, τ_m and τ_h, and solving for the optimal capital taxes yields (24). The profit shifting decisions and thus the tax competition equilibrium are as in the main model.

Appendix 5: 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. 25) 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

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

The corresponding equilibrium quantities are

$$
x_L = \frac{a(b-d)(2b+d) - (2b^2-d^2)(1+\tau_L)r + bd(1+\tau_H)(1+\Delta)r}{(2b^2-d^2)^2 - b^2d^2} b, \quad \text{(A.13)}
$$

$$
x_H = \frac{a(b-d)(2b+d) - (2b^2-d^2)(1+\tau_H)(1+\Delta)r + bd(1+\tau_L)r}{(2b^2-d^2)^2 - b^2d^2} b. \quad \text{(A.14)}
$$

Maximizing the utility function (25) after inserting (A.13)-(A.14) yields the welfare maximizing capital taxes given in (26).

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