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Optimal Taxation with Imperfect Competition and Aggregate Returns to Specialization.*

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Abstract

In this paper we explore the proposition that in economies with imperfect competitive markets the optimal capital income tax is negative and the optimal tax on firms profits is confiscatory. We show that if the total factor productivity as well as the measure of firms or varieties are endogenous instead of fixed, then the optimal fiscal policy can lead to different results. The government faces a trade-off between the fixed costs that society pays for the introduction of a new firm and the productivity gains associated to the introduction of a new variety. We find that the optimal fiscal policy depends on the relationship between the index of market power, the returns to specialization, and the government's ability to control entry.

Keywords: Optimal taxation, returns to specialization, monopolistic competition.
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1. Introduction

The empirical evidence shows that any source of capital income, profit or rent, is taxed in most of the OECD countries. This fact has generated an important theoretical discussion in order to find the sign and the magnitude of the optimal capital income tax. According to Judd (1985) and Chamley (1986), in an economy with competitive markets and infinitely-lived consumers, the steady-state optimal capital income tax should be zero[1]. More recently Judd (1997, 2002) has challenged the importance of the competitive markets assumption. Using a model with monopolistic competition and a fixed number of firms, he finds that the optimal fiscal policy prescribes a negative capital income tax and a confiscatory tax rate on firms profits[2]. One potential problem of implementing investment subsidies is that in an environment with free entry such subsidies could lead to excessive entry and reduce aggregate efficiency. Consequently, the optimal tax should take into account the possibility that investment subsidies could lead to a socially inefficient number of firms.

In this paper we construct a model with monopolistic competition and free entry where the introduction of new varieties increases the productivity of the economy. We examine the connection between the optimal tax policy and the incentives for new firms to enter the market. The main contribution of the paper is to show that once we consider an endogenous number of firms, the optimal fiscal policy can lead to different results. In contrast to Judd (1997, 2002), the introduction of free entry eliminates pure profits in equilibrium[3]. The government then faces a trade-off between the fixed costs that society pays for the introduction of a new firm and the aggregate gains associated with entry. The resolution of this trade-off and the properties of the optimal fiscal policy hinge on the government capacity to control firms' entry-exit decisions and to induce the optimal number of firms in the market[4]. We identify some additional sources and

[1] Golosov, Kocherlakota and Tsyvinski (2003) have challenged the perfect information assumption. In an environment with private information, they show that the capital income tax can be positive once the informational constraints are considered by the government.

[2] The basic intuition works as follows. Since the market price exceeds the marginal cost, the government uses a capital subsidy to counterbalance the market power and thus the efficient capital-labor ratio is recovered. Moreover, given that profits do not affect any agent's decision at the margin, the government finds it optimal to tax them at a confiscatory rate. According to Judd (1997), the estimates of welfare gains associated to implementing the optimal capital income tax can be misleading since the prescribed policy implies an investment subsidy other than zero.

[3] In a related paper, Schmitt-Grohé and Uribe (2004) show that if the government has no access to a 100% tax rate on monopoly profits, then the Friedman rule is not optimal and the government resorts to a positive nominal interest rate as an indirect way to tax profits. Recently, Mankiw and Weinzierl (2004) show that the presence of market power and monopoly profits are relevant to analyzing the revenue effects of changes in the capital income tax rate. In particular, they show that monopoly profits can raise the ability of a capital income tax cut to be self-financing.

[4] Guo and Lansing (1999) introduce depreciation allowances and endogenous government expenditure in Judd's (1997) imperfect competition model. They show that if the government can fully confiscate profits, then the steady-state capital income tax is negative. However, in the case that the tax authority cannot differentiate between capital income and profits, they find that the optimal corporate tax in steady state can be negative, positive, or zero, depending on the degree of monopoly power, the size of the depreciation allowances, and the magnitude of the government expenditure.

parameters, in particular an index of market power and an index of returns to specialization, that affect the sign of both the capital income tax and the tax on firms' profits[5].

A second contribution of the paper is to show that the modeling of the monopolistic competition framework is not innocuous. Our formulation departs from the seminal work of Dixit and Stiglitz (1977), since we consider the formulation proposed by Ethier (1982) and Benassy (1998) that separates the returns to specialization (or returns to variety, as in Kim, 2004) from the monopolistic mark-up. This formulation has two advantages. First, the set-up embeds the standard monopolistic competition with a fixed number of firms as a special case. Second, it allows us to characterize the optimal tax policy as function of the market power and returns to specialization. We show that separating these two parameters is crucial in order to avoid misleading results.

In this economy the presence of imperfect competition combined with free entry introduces two sources of market inefficiency. The first inefficiency is the price-marginal cost distortion or mark-up distortion: the monopoly power in the intermediate goods sector introduces a wedge between the price and the marginal productivity of each input. The presence of free entry generates a second inefficiency: the market equilibrium can generate an inefficient number of firms. When a firm decides to enter the market, it only considers the private net benefit from entry, but it ignores the social net benefit generated by its entry. Consequently, the private benefit from entry (monopoly profits) can be different than the social benefit. At the aggregate level, the introduction of a new firm is determined by two opposite effects: a complementary effect and a business-stealing effect. The complementary effect tends to generate an inefficiently low number of firms, since firms do not take into account the positive effect on total productivity when they enter the market. The business-stealing effect tends to produce excessive entry of firms, since new firms enter the market attracted by high profits but they do not take into account the negative impact of their entry on the incumbent firms' demand. Consequently, if government does not control entry, market outcomes could generate a number of firms too low (high) relative to the social optimum when monopoly profits are too low (high).

The scope of the paper is to study the optimal distortionary tax policy. However, the analysis of the social optimum is useful to illustrate the different inefficiencies arising from monopolistic competition. A social planner ensures that the private return and the social return coincide allowing for the distortion associated with the monopoly power to be effectively eliminated through the correspondent investment subsidy. An additional instrument is still required to determine the efficient number of firms. We call this instrument profits tax, and its optimal value can be positive, negative or zero.

The optimal tax policy depends on the tax authority's capacity to control entry. We consider three different cases. In the first case, the government has access to a complete set of fiscal

[5] Throughout the paper we assume that the government can commit to the optimal policy ignoring time-inconsistency issues. Clearly this is an important restriction that can change the results. However, the analysis of time-consistent policies goes beyond the scope of this paper.

instruments and, therefore, can directly control entry through the profits tax. We show that this tax is equivalent to have different tax allowances for fixed and variable costs. We find that the optimal capital income tax only depends on the degree of market power or mark-up, and it is always negative, as in Judd (1997, 2002). By implementing a capital subsidy, the government removes mark-up distortion in capital accumulation. In addition, the optimal profits tax/subsidy depends on the relationship between the mark-up and the returns to specialization, and it coincides with the social planner tax/subsidy. Neither the capital subsidy nor the profits tax/subsidy depend on the burden of taxation. Hence, it is labor that bears the tax burden.

In the second case, we assume that the government is restricted to set equal tax allowances for fixed and variable costs. With this tax code restriction, the equilibrium number of firms cannot be affected by the fiscal authority. In this scenario, the number of firms is pinned down by the zero profit condition in the market equilibrium, which is taken as a constraint by the government. Therefore, the profits tax is irrelevant, since firms can expense all their costs and make zero profits. In contrast with the previous case, we find that the optimal capital income tax does not depend on the magnitude of the mark-up, but it does depend on the returns to specialization. Surprisingly, we show that in the absence of aggregate returns to specialization the optimal steady-state capital income tax is zero. The threat of endogenous entry leads to a prescribed capital income tax of zero instead of a subsidy. This finding is consistent with some theoretical results in the industrial organization literature (see Benassy,1998; de Groot and Nahuis ,1998; or Jones and Williams 2000), which show that when returns to specialization are not present, a tax or a subsidy leads to a socially inefficient number of firms[6].

In the third case, we assume that the government cannot differentiate monopoly profits from capital income and, as a result, both are taxed at the same rate. Hence, the government levies a corporate tax on any source of income generated by firms. While Guo and Lansing (1999) consider the optimal corporate tax in an economy without entry and this corporate tax is used by the government as an indirect way to tax the monopoly profits, in our formulation the government can indirectly control firms' entry through corporate taxation. We find that the optimal corporate tax depends not only on the magnitude of the returns to specialization and the mark-up, but also on the curvature degree of the production function.

Finally, as a robustness excercise, we show that the previous findings remain unchanged in a model with differentiated consumption and investment goods. We find that the introduction of different degrees of returns to specialization in the consumption and investment goods does not change the main driving forces. However, capital depreciation affects the optimal fiscal policy since optimal investment decisions have to take into account not only the investment aggregate returns to specialization, but also the steady-state invesment.

[6] Auerbach and Hines (2002) consider a static oligopoly model in order to compare the optimality of ad valorem and specific commodity taxes. They study how the government could use commodity taxation to reduce the market power distortion. But in the case of free entry they show that a government tax aiming to reduce the market power distortion could lead to an inefficient entry of firms .

The remainder of the paper is organized as follows. In the next section we describe the basic framework and derive the market equilibrium. In section 3 we compare the market allocation with the social optimum in order to identify the main inefficiency sources. This comparison is useful to understand the trade-offs that the government faces when choosing the optimal policy. In section 4 we analyze the optimal fiscal policy depending on the tax code or fiscal instruments available to the government. Section 5 concludes.

2. Market equilibrium

We consider an infinite-horizon production economy with imperfectly competitive product markets. There is a composite final good Y, which is at the same time a consumption and investment good. Also, the government finances an exogenous stream of purchases of the final good by levying distortionary taxes. The final good is produced by competitive firms using the following technology (as in Ethier, 1982; Benassy, 1996; Kim, 2004)[7]:

$$Y = \left(z^{v(1-\eta)-\eta} \int_0^z x_i^{1-\eta} di \right)^{\frac{1}{1-\eta}}, \quad \eta \in [0,1), \; v \in [0,1), \tag{1}$$

where the inputs are a continuum of intermediate goods x_i, $i \in [0, z]$, and z is the total number of intermediate goods at time t. We assume monopolistic competition in the intermediate goods sector; see Dixit and Stiglitz (1977)[8]. Each intermediate good x_i is produced by a single firm, and since intermediate goods are not perfect substitutes, firms face a downward slopping demand curve, which confers them some degree of market power. Thus, η is the inverse of the elasticity of demand for each intermediate good and measures the degree of market power. Moreover, this technology introduces aggregate returns to specialization in the economy as in Ethier (1982) and Benassy (1996). Since there is free entry in the intermediate goods sector, the number of varieties z is determined by the zero profit condition. In a symmetric equilibrium, all firms in the intermediate goods sector produce the same output level x and, thus, aggregate output is $Y = z^{v+1}x$. Therefore, an expansion in the number of intermediate inputs raises the final production. Thus, the elasticity of output with respect to the number of firms z is given by the "degree of returns to specialization" v. This parameter measures the degree to which society benefits from spreading production among a large number of intermediate goods. As a result, an increase in the variety of inputs improves the total factor productivity of the final good technology. This formulation allows us to separate the consequences of the mark-up from the returns to specialization for the design of the optimal tax policy.

In order to obtain the inverse demand function for each intermediate input, we solve the

[7] The time subscripts on the production side of the economy have been eliminated to keep notation simple.

[8] An exposition of a simple static macromodel with monopolistic competition can be found in Blanchard and Kiyotaki (1987). Also, Rotermberg and Woodford (1995) and Schmitt-Grohé (1997) present different dynamic macromodels with monopolistic competition.

profit maximization problem of the competitive firm producing the final good, which is given by

$$\max_{\{x_i\}} Pz^{\frac{v(1-\eta)-\eta}{1-\eta}} \left(\int_0^z x_i^{1-\eta} di \right)^{\frac{1}{1-\eta}} - \int_0^z p_i x_i di, \tag{2}$$

where p_i is the price of the ith intermediate good and P is the price of the final output, and we obtain

$$x_i = \left(\frac{p_i}{P} \right)^{-\frac{1}{\eta}} z^{v\frac{(1-\eta)}{\eta}-1} Y. \tag{3}$$

In the intermediate sector, each firm produces one intermediate input for which it has market power. In order to operate, firms have to pay a fixed cost $P\phi$ (measured in units of the final good)[9]. Firms produce the intermediate good according to a constant returns to scale production function,

$$x_i = F(k_i, l_i), \tag{4}$$

where k_i and l_i denote capital and labor input, respectively, for firm i. The technology is assumed to be strictly concave, C^2, and satisfies the Inada conditions. The profit function of firm i depends on the tax treatment of corporate profits. We assume that firms pay taxes on variable profits at a rate τ^{vp} and receive tax subsidies or depreciation allowances to their operating costs at a rate τ^{s}[10,11]. Each firm solves[12]

$$\max_{\{k_i, l_i\}} \pi_i = (1-\tau^{vp}) [p_i x_i - rk_i - wl_i] - (1-\tau^s) P\phi, \tag{5}$$

subject to the final goods sector demand and the production function given by Eq. (3) and Eq. (4), respectively. r is the rental price of capital and w is the wage rate. This general formulation assumes that the tax authority can distinguish both variable costs and fixed costs, since different business costs can be expensed at different rates. However, if the tax authority cannot distinguish the two types of cost, then it follows that $\tau^{vp} = \tau^s$. We analyze this case in detail later. Since firms have monopoly power, they fix the price above the marginal cost and the mark-up is determined by the elasticity of demand η. The associated first-order conditions of the firm problem yield

$$r = p_i (1-\eta) F_k(k_i, l_i), \tag{6}$$

[9] The fixed cost is independent of the quantity produced, as in Matsuyama (1995) and Wu and Zhang (2000). Examples are fixed maintenance costs, managerial costs, or operational costs.

[10] There is no reason why the tax authority should choose different tax allowances for variable and fixed costs. However, writing the problem in this general form allows us to study the implications of these different instruments.

[11] Since profits in both the final and the intermediate sector are zero in equilibrium, we have omitted a tax on dividends. Also, we have supressed the profits tax from the final goods firms problem since it has no effect on the firms decisions.

[12] There are two possible ways to formulate the investment decisions in the economy. The first, which we have assumed, is that households own the capital and firms rent the capital to them. Alternatively, we could assume that capital belongs to the firms and individuals own the firms. Given that capital markets are perfect, both frameworks generate the same equilibrium outcome; see McGrattan and Prescott (2000).

$$w = p_i\left(1-\eta\right)F_l\left(k_i,l_i\right). \tag{7}$$

We consider a symmetric equilibrium where all firms produce the same output level $x_i = x$ with the same quantity of inputs, $k_i = k$ and $l_i = l$, set the same price $p_i = p$, and have the same gross profits $\pi_i = \pi$. The aggregate stock of capital is $K = zk$ and the aggregate employment is $L = zl$. Thus, in equilibrium, using Eq.(6) and Eq.(7), we can write the return of capital and the wage rate as a function of total employment and capital[13],

$$r = p\left(1-\eta\right)F_K\left(K,L\right), \tag{8}$$

$$w = p\left(1-\eta\right)F_L\left(K,L\right). \tag{9}$$

It is worth noting that the mark-up introduces a wedge between the price of the factors and the value of the marginal productivity, which implies that capital and labor are paid below the value of their marginal productivity. Moreover, at the symmetric equilibrium, the final output is equal to

$$Y = z^v F\left(K,L\right), \tag{10}$$

and the price, by substituting Eq.(4) and Eq.(10) into Eq.(3), is

$$P = pz^{-v}. \tag{11}$$

In each period, new intermediate good producers may enter and produce a new variety. The free-entry condition on gross profits (each intermediate firm makes zero after-tax profits, i.e. $\pi = 0$) determines the equilibrium number of firms. Formally,

$$\frac{(1-\tau^{vp})p\eta F\left(K,L\right)}{z} = (1-\tau^s)P\phi. \tag{12}$$

Since the final cost is defined in terms of the final output, the entry of any firm reduces the relative price between final output and intermediate goods $P/p = z^{-v}$, and thus it makes entry more profitable. However, individual firms do not internalize this effect. From Eq.(11) and Eq.(12), we obtain the total number of firms as a function of capital stock, employment and tax policy,

$$z = \left[\frac{(1-\tau^{\pi})\eta F\left(K,L\right)}{\phi}\right]^{\frac{1}{1-v}}, \tag{13}$$

where we have replaced τ^{vp} and τ^s by a tax on profits defined as $(1-\tau^{\pi}) = (1-\tau^{vp})/(1-\tau^s)$. This tax allows the government to control entry. Note that with equal tax allowances for variable and fixed costs, $\tau^{vp} = \tau^s$, the profits tax is zero and the government cannot control entry.

[13] Note that the homogeneity of degree one of the production function implies that the partial derivatives are homogenous functions of degree zero. Therefore, $z^{v+1}F\left(k,l\right) = z^v F\left(K,L\right)$ and $F_j(k,l) = F_j(zk,zl) = F_j(K,L)$ for $j = K, L$.

Finally, we consider the final good as the numéraire and normalize its price to one, $P = 1$. Hence, the relative price of the intermediate goods becomes $p = z^v$. Thus, we can express the rate of return of capital and the wages in the following way:

$$r = (1-\eta)\, z^v F_K(K, L), \tag{14}$$

$$w = (1-\eta)\, z^v F_L(K, L). \tag{15}$$

In our model, the entry of new firms can be interpreted as R&D in the production of new inputs which increases the total productivity of the economy as in the endogenous growth literature. An expansion in the number of intermediate inputs increases the production of the final good, see Eq. (10). At the same time, the return of capital and wage rise. However, our specification of the final goods production function, based on Benassy (1996), differs from the conventional formulation established by Dixit and Stiglitz (1977), which is generally assumed in most of the endogenous growth (e.g., Romer, 1996) and international trade literatures. In our model, the Dixit and Stiglitz (1977) formulation corresponds to the case where $v = \eta/(1-\eta) < 1$. Thus, there exists a one-to-one relationship between the market power and the degree of returns to specialization. While Benassy (1996) shows that the market equilibrium can generate too much innovation or entry (the number of intermediate goods z is higher than in the social optimum equilibrium), resources devoted to R&D are inefficiently low in the models based on the conventional formulation, as in Romer (1996). In our formulation, we can have two possible situations: in the first case the government has to subsidize the entry of new firms in order to foster innovation, whereas in the second case the government has to restrict the entry of new firms since this represents a social waste of resources. If the government cannot distinguish between fixed and variable costs, or both costs can be expensed at the same rate, then the tax authority does not have a direct instrument to control the number of firms and its size. Entry can only be indirectly controlled through the optimal capital-labor ratio at the plant level. Thus, the conventional formulation, $v = \eta/(1-\eta)$, offers an useful benchmark to explain our results. Note that the model used by Judd (1997), where aggregate returns to specialization are absent, corresponds to the particular case of $v = 0$, $\phi = 0$, and the total number of firms is fixed and normalized to one, $z = 1$. Then, from Eq. (11), $p = P$.

We consider a representative consumer that each period chooses consumption c_t, the allocation of savings between investment in capital K_t or government bonds D_t, and the allocation of their one unit of time endowment between work L_t, and leisure $(1 - L_t)$. We assume there is no population growth. Formally, the consumers solve

$$V(K_0, D_0) = \max_{\{c_t, L_t, K_{t+1}, D_{t+1}\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta^t U(c_t, L_t) \tag{16}$$

$$s.to \quad c_t + K_{t+1} + D_{t+1} = w_t(1-\tau_t^l)L_t + (K_t + D_t)\left[1 - \delta + r_t(1-\tau_t^k)\right] + \Pi_t + T_t^c, \tag{17}$$

$$c_t \geq 0,\ L_t \in [0,1],\ K_{t+1}, D_{t+1} \geq -B,$$

where τ_t^k and τ_t^l are the taxes on capital income and labor, respectively, T_t^c is a lump-sum tax/transfer and Π_t denotes aggregate profits net of taxes. However, we know that in equilibrium $\Pi_t = 0$. Note that the government debt and capital have to offer the same rate of return, $1 - \delta + r_t(1 - \tau_t^k)$, where δ is the depreciation rate. The utility function U is strictly concave, C^2, and satisfies the usual Inada conditions. We assume that B is a large positive constant that prevents Ponzi schemes. The solution to the consumer problem yields the standard first-order conditions,

$$\frac{U_{c_t}}{\beta U_{c_{t+1}}} = 1 - \delta + r_{t+1}(1 - \tau_{t+1}^k), \tag{18}$$

$$-\frac{U_{L_t}}{U_{c_t}} = w_t(1 - \tau_t^l), \tag{19}$$

together with a transversality condition for capital and government debt. The goods market clearing condition is

$$c_t + K_{t+1} - (1-\delta) K_t + G_t = z_t^v F(K_t, L_t) - \phi z_t, \tag{20}$$

where G_t denotes the period government expenditure. Combining the consumer budget constraint with the aggregate resource constraint and the free- entry condition, we can derive the government budget constraint. Next, we define the notion of market equilibrium of the described economy.

Definition 1 (Market equilibrium): *Given a fiscal policy* $\{\tau_t^\pi, \tau_t^l, \tau_{t+1}^k, T_t^c\}_{t=0}^\infty$, *government expenditure* $\{G_t\}_{t=0}^\infty$, *and the initial conditions* K_0 *and* D_0, *a market equilibrium is a set of plans* $y = \{c_t, L_t, K_{t+1}, z_t\}_{t=0}^\infty$ *satisfying 1) the household problem, 2) the firm problem in both sectors, 3) the market clearing conditions, and 4) the government budget constraint.*

The following conditions are satisfied in the market equilibrium:

$$-\frac{U_{L_t}}{U_{c_t}} = (1 - \tau_t^l) z_t^v (1-\eta) F_L(K_t, L_t), \tag{21}$$

$$\frac{U_{c_t}}{\beta U_{c_{t+1}}} = 1 - \delta + (1 - \tau_{t+1}^k) z_{t+1}^v (1-\eta) F_K(K_{t+1}, L_{t+1}), \tag{22}$$

together with the free-entry condition Eq.(13) and the resource constraint Eq.(20). In the presence of lump-sum taxes and transfers, it is well-known that the government can achieve Pareto efficient allocations. The scope of this paper is to study the optimal fiscal policy when these transfers are not available. However, the analysis of the social optimum is useful to illustrate the trade-offs that the government faces when the optimal tax policy is designed, and it shows the different inefficiencies introduced by the monopolistic competition sector.

3. Social optimum

Next, we show that the market allocation is not Pareto efficient. We can asses Pareto optimality by comparing the market allocation and the social or unconstrained optimum. The social planner can control the number of firms in the intermediate goods sector. Thus, the planner faces a trade-off between the fixed costs that society pays for the introduction of a new firm and the productivity gains associated with the introduction of a new variety. We assume that the social planner takes as given the sequence of public expenditure $\{G_t\}_{t=0}^{\infty}$ and the initial level of the capital stock K_0. For a symmetric allocation across intermediate goods, the social planner solves:

$$V(K_0) = \max_{\{c_t, L_t, K_{t+1}, z_t\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta^t U(c_t, L_t)$$

$$s.to \quad c_t + K_{t+1} - (1-\delta) K_t + G_t = z_t^v F(K_t, L_t) - \phi z_t, \qquad \forall t,$$

and the usual non-negativity constraints $c_t \geq 0$ and $L_t \in [0,1]$. The associated first-order conditions yield

$$-\frac{U_{L_t}}{U_{c_t}} = z_t^v F_L(K_t, L_t), \tag{23}$$

$$\frac{U_{c_t}}{\beta U_{c_{t+1}}} = 1 - \delta + z_{t+1}^v F_K(K_{t+1}, L_{t+1}), \tag{24}$$

$$U_{c_t}\left[v z_t^{v-1} F(K_t, L_t) - \phi\right] = 0, \tag{25}$$

together with a transversality condition for the capital, and the resource constraint. Eq.(25) reveals that an increase in total production $v z_t^{v-1} F(K_t, L_t)$ resulting from a unit increase in z_t must be equal to the entry cost ϕ. This simply states that at the social optimum the marginal social benefit of a new intermediate input must equal its marginal social cost. Note that the assumption $v \in [0,1)$ implies that the marginal benefit of a new input declines with the number of inputs, therefore, the social optimum is well-defined[14]. Rearranging Eq.(25), we express the socially efficient number of firms as a function of the aggregate returns to specialization parameter, fixed cost, capital stock and employment,

$$z_t = \left[\frac{vF(K_t, L_t)}{\phi}\right]^{\frac{1}{1-v}}, \quad v \in [0,1). \tag{26}$$

Note that when $v = 0$ we have a corner solution, since the entry of a new firm does not increase the productivity of the final goods sector but duplicates the fixed cost. Therefore, it is socially efficient to only allow one (normalized) firm, $z_t = 1$.

Next, we use the social planner's solution to asses the efficiency of the market allocation.

[14] Alternatively, we can compute the total output, $z_t^v F(K_t, L_t) - \phi z_t$. Re-writing Eq.(25) as $v z_t^v F(K_t, L_t) = z_t \phi$, the total output is equal to $(1-v) z_t^v F(K_t, L_t)$. Then the condition $v \in [0,1)$ ensures that we have an interior solution.

First, we analyze the mark-up or price-marginal cost distortion. Inspection of Eq.(21) and Eq.(23) reveals that the monopoly power in the intermediate goods sector reduces the wage below the marginal productivity of labor. The market power introduces a distortion in the household labor/consumption decision, such that the marginal rate of substitution between consumption and labor is lower than the marginal productivity of labor. We have the same distortion in the intertemporal household decision, as Eq.(22) and Eq.(24) show. The marginal rate of substitution between present and future consumption, $U_{c_t}/\beta U_{c_{t+1}}$, is lower than the intertemporal marginal rate of transformation $1-\delta+z_{t+1}^{v}F_K\left(K_{t+1},L_{t+1}\right)$. However, this mark-up distortion does not depend on the number of firms in the market. The social planner can attain Pareto efficient allocations by implementing

$$\tau_t^k=\tau_t^l=-\eta/(1-\eta), \qquad \forall t. \tag{27}$$

These two subsidies only depend on the mark-up magnitude, and they ensure that the private and the social returns coincide. Then, and as in Judd (1997), the distortion on capital accumulation generated by the monopoly power is effectively eliminated.

There exists a second distortion, since the market equilibrium can generate an inefficient level of firms. When a firm has to decide to enter the market it only considers if monopoly profits are higher than the fixed cost, but it ignores the productivity gains generated by the introduction of a new intermediate good. Hence, the private benefits from entry (monopoly profits) can be different from the social benefits (productivity increase). In contrast with the social planner's choice in Eq.(26), the market allocation for z_t in Eq.(13) depends on η instead of v. The entry of a new firm in the market is determined by two opposite effects, a complementary effect and a business-stealing effect. The complementary effect arises from the fact that a new firm in the market raises the demand by increasing the productivity in the final goods sector. Then, since profits increase relative to the fixed cost, entry becomes more profitable. This effect tends to generate an inefficiently low number of firms, given that firms do not take into account the positive effect of entry on aggregate productivity. The business-stealing effect results from the fact that the existing firms in the market have to share the demand with the new firm, although this new firm produces a differentiated product and it does not compete directly with the incumbent firms. Therefore, individual profits decline with the number of firms. This effect tends to produce excessive entry of firms, since new firms enter the market attracted by high profits but they do not take into account the negative effect on the incumbent firms. Overall, the market can generate a number of firms too low (high) relative to the social optimum when monopoly profits are too low (high). Therefore, by comparing Eq.(13) and Eq.(26), the Pareto efficient allocation implies setting[15,16]

$$\tau_t^{\pi} = (\eta - v)/\eta, \qquad \forall t. \tag{28}$$

The profits tax can be positive, negative or zero, depending on the relationship between the mark-up and the returns to specialization. When these returns are strong enough, entry is insufficient and it is better to subsidize profits, since the increase in the aggregate productivity due to a new firm offsets the social cost. When the returns to specialization are low enough, there is excessive entry and a positive profits tax is optimal. Note that the market equilibrium number of firms is only efficient when the complementary effect and the business-stealing effect coincide, $v = \eta$.

Two cases deserve special attention. First, in the absence of aggregate returns to specialization, $v = 0$, then $\tau_t^{\pi} = 1 - \phi/\eta F(K_t, L_t)$. In this case firms will try to enter the market to capture monopoly profits, but from a social point of view, the entry of new firms is a waste of resources. Therefore, the social planner confiscates all the monopoly profits to prevent entry of new firms. Second, in the conventional formulation, $v = \eta/(1-\eta)$, the market always generates an insufficient number of firms. Hence the social planner needs to introduce a subsidy $\tau_t^{\pi} = -\eta/(1-\eta)$, which is identical to the capital and labor subsidies, Eq.(27). However, this result could be misleading since the subsidy to entry is not only determined by the mark-up, since in this case η measures both market power and returns to specialization.

By comparing the social optimum with the market allocation, we clearly identify two market failures or distortions. First, the mark-up or price-marginal cost distortion implies that capital and labor are paid below their marginal productivity. Therefore, we have a distortion in both the household labor/consumption and intertemporal decisions. If lump-sum taxes were available, it would be possible to eliminate this distortion with the capital and labor subsidies described in Eq.(27). The second market failure or distortion is the inefficient entry. In the market equilibrium, the number of firms is determined by monopoly profits. However, the social optimum is determined by the productivity growth generated by the introduction of a new intermediate input. As we can see in Eq.(28), if $\eta > v$, the monopoly profits are higher than the social benefits of entry and the social planner introduces a tax on profits in order to avoid a problem of excess entry. In the opposite case $\eta < v$, the market does not generate enough intermediate inputs and

[15] Clearly, any pairwise $\{\tau_t^{vp}, \tau_t^{s}\}$ satisfying the condition $1 - \tau_t^{\pi} = (1-\tau_t^{vp})/(1-\tau_t^{s}) = v/\eta$ would be Pareto efficient, as for instance $\tau_t^{\pi} = \tau_t^{vp} = (\eta - v)/\eta$ and $\tau_t^{s} = 0$, or $\tau_t^{vp} = 0$ and $\tau_t^{s} = (v-\eta)/v$. We use the first case to compare the results with other papers.

[16] In fact, it is not so important that the government can differentiate tax allowances between fixed and variable costs. As an example, the government could also implement the optimal level of varieties by introducing a lump-sum tax/subsidy for the firm (measured in units of the final good) $P_t T_t^x$. In this case, the optimal tax is

$$T_t^x = \phi\left(\frac{\eta}{v} - 1\right), \qquad v > 0,$$

and $\tau_t^{\pi} = 0\ \forall t$. The sign of this instrument also depends on the relation between η and v. Note that when $v = 0$, then $T_t^x = \eta F(K, L) - \phi$.

the social planner introduces an entry subsidy to increase the productivity of the economy. In this case, τ_t^π can be interpreted as a subsidy to R&D of new varieties. If the government does not have access to lump-sum taxes, it needs to take into account these two market failures in the design of the optimal tax policy.

4. Optimal taxation

In this section, we characterize the optimal fiscal policy or constrained optimum. In order to solve the government problem, we use the primal approach of optimal taxation proposed by Atkinson and Stiglitz (1980). This approach is based on characterizing the set of allocations that the government can implement for a given fiscal policy. The market equilibrium or set of implementable allocations is described by the period resource constraints, the equilibrium entry condition and the so-called implementability constraint. The implementability constraint is the household's present value budget constraint after the substitution of the first-order conditions of the consumer's and firms' problems. This constraint captures the effect that changes in the tax policy have on agents decisions and market prices. Thus, the government problem is to maximize its objective function over the set of implementable allocations. This is called the Ramsey allocation problem. We present the tax policy as "optimal wedges" rather than a particular tax system. We can implement optimal allocations as a market equilibrium with distortionary taxes. In the Appendix, we present the derivation of the implementability constraint and, following Chari and Kehoe (1999), we show that an implementable allocation can be supported as a market equilibrium with taxes.

It is well-known that the government has an incentive to heavily tax the initial wealth of the consumer. This policy amounts to a nondistortionary lump-sum tax. As a result, the Lagrange multiplier of the implementability constraint would be zero. Given that we already have characterized the unconstrained optimum, we assume that the initial capital income tax τ_0^k is taken as given.

In our framework, the optimal tax policy depends on the government's ability to differentiate tax allowances and, hence, to control entry. We consider three different cases:

- Effective control on entry-decisions: the government has a complete set of fiscal instruments and can directly control entry. This formulation is equivalent to a tax code with different tax allowances for fixed and variable cost, or a tax code where fixed cost cannot be expensed, i.e., $\tau^{vp} \neq \tau^s$ and the government can introduce a profits tax τ^π.

- Ineffective control on entry-decisions: the government cannot directly choose the number of firms. The tax code does not distinguish between variable and fixed costs and, thus, it is restricted to use the same tax rate, i.e., $\tau^{vp} = \tau^s$ and the profits tax is not available $\tau^\pi = 0$.

- In the third case, suggested by Stiglitz and Dasgupta (1971), we assume that the government has to apply the same marginal tax to both capital income and profits. In this case, the government can indirectly control entry through a corporate tax.

4.1. Effective control on entry-decisions

Next, we define the government problem for the case where entry-exit decisions are controlled by the government. This formulation is consistent with a profits tax that differentiates tax allowances between fixed and variable costs, or a tax code where fixed costs cannot be expensed, i.e. $\tau_t^{\pi} \neq 0$. Thus, the tax authority uses the profits tax to control the number of firms (aggregate level of productivity) in the intermediate goods sector. The government will set a subsidy in case of an insufficient entry or a tax in case of an excessive entry. This case is used as a benchmark to compare the results with those arising from a limited set of tax instruments.

Definition 2 (Ramsey allocation problem): *Given the government expenditure* $\{G_t\}_{t=0}^{\infty}$*, and the initial conditions* $\{\tau_0^k, K_0, D_0\}$*, the allocations associated to the optimal fiscal policy* $\{\tau_t^{\pi}, \tau_t^l, \tau_{t+1}^k\}_{t=0}^{\infty}$ *are derived by solving*

$$V(K_0, D_0, \tau_0^k) = \max_{\{c_t, L_t, K_{t+1}, z_t\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta^t U(c_t, L_t),$$

$$s.to \qquad \sum_{t=0}^{\infty} \beta^t (c_t U_{c_t} + L_t U_{L_t}) = U_{c_0}(K_0 + D_0)\left[1 - \delta + z_0^v (1-\eta) F_K(K_0, L_0)(1 - \tau_0^k)\right], \quad (29)$$

$$c_t + K_{t+1} - (1-\delta) K_t + G_t = z_t^v F(K_t, L_t) - \phi z_t, \qquad \forall t,$$

where $c_t \geq 0$ *and* $L_t \in [0, 1]$.

Let λ and α_t be the Lagrange multiplier of the implementability constraint and the resource constraint, respectively. The first-order conditions of the government problem with respect to $\{c_t, L_t, K_{t+1}, z_t\}$ are[17]

$$\beta^t \left[U_{c_t} + \lambda (U_{c_t} + c_t U_{c_t c_t} + L_t U_{L_t c_t})\right] - \alpha_t = 0, \quad (30)$$

$$\beta^t \left[U_{L_t} + \lambda (U_{L_t} + L_t U_{L_t L_t} + c_t U_{c_t L_t})\right] + \alpha_t z_t^v F_L(K_t, L_t) = 0, \quad (31)$$

$$-\alpha_t + \alpha_{t+1}[1 - \delta + z_{t+1}^v F_K(K_{t+1}, L_{t+1})] = 0, \quad (32)$$

[17] Throughout the paper we assume that the solution of the Ramsey allocation problem exists and converges to a unique steady state. Neither of these assumptions are innocuous. The sufficient conditions for an optimum involve third derivatives of the utility function. Therefore, the solution might not represent a maximum, or the system might not have a solution because it does not exist a feasible policy that satisfies the intertemporal government budget constraint. However, if the solution to the government problem exists and is interior, it satisfies the above first-order conditions. Hence, the optimal fiscal analysis applies only to these cases.

$$vz_t^{v-1}F\left(K_t,L_t\right)-\phi=0, \tag{33}$$

together with a transversality condition for the capital, the period resource constraint and the implementability constraint. Note that the Lagrange multiplier λ measures the effect of the distortionary taxes on the utility function, i.e., the burden of taxation or the social cost of tax revenue. In particular, it can be interpreted as the amount that the households would be willing to pay in order to replace one unit of distortionary tax revenue by one unit of lump-sum revenue, measured in terms of the consumption good at time zero.

Comparing Eq.(33) with Eq.(13), we obtain the optimal profits tax

$$\widehat{\tau}_t^{\pi}=(\eta-v)/\eta. \tag{34}$$

Note that from now onwards, we use a hat to denote optimality. When the government can control entry-decisions, it implements a tax/subsidy in the intermediate goods production which is identical to the social planner tax/subsidy, Eq.(28). As we have seen in Section 3, as long as $v>\eta$, the tax authority subsidizes entry because of the positive effect of the returns to specialization. However, when $v<\eta$, it is optimal to tax profits, since the social cost of introducing a new firm offsets the productivity gain. Since private firms do not internalize this effect, the tax authority has to reduce market entry. Therefore, the government optimally sets the number of firms by taking into account only the productivity gains associated with the introduction of a new variety, regardless of the social cost of tax revenue. This result could be considered as an application of the Diamond and Mirrlees (1971) principle of aggregate production efficiency[18]. The fiscal system should allow the economy to be on the production frontier and then individual decisions among the possible combinations in the frontier are distorted. Diamond and Mirrlees (1971) show that if the government has a complete set of tax instruments, so that a 100% tax can be levied on pure profits, the tax system should not distort the allocation of intermediate inputs. However, as we will see, if the government does not have enough tax instruments to control entry or to remove the mark-up distortion, this result does not apply and the government cannot implement the social planner tax/subsidy on entry.

It is straightforward to find the long-run optimal capital income tax. From the first-order conditions of the government problem, Eq.(30) and Eq.(32), evaluated in steady state we have

$$\frac{1}{\beta}=1-\delta+z^{v}F_K(K,L). \tag{35}$$

Comparing this condition with Eq.(22) evaluated in steady state, we obtain the optimal capital income tax , $\widehat{\tau}^k=-\eta/\left(1-\eta\right)$, which is the subsidy proposed by Judd (1997, 2002) to remove the

[18] Chari and Kehoe (1999) present a simple derivation of this result. In an economy with two sectors, one producing the consumption good and the other the intermediate inputs, the tax system should equate marginal rates of transformation across technologies, and the government should not tax intermediate inputs.

mark-up distortion on capital accumulation[19]. As we have seen in the social planner problem, we need to introduce a capital subsidy to eliminate the wedge between the intertemporal marginal rate of substitution and transformation. The following proposition summarizes all these findings.

Proposition 1: *When the government can control entry-decisions:*
1) The optimal steady-state capital income tax is negative and it coincides with the social planner subsidy, as in Judd (1997, 2002). Therefore, it does not depend on the returns to specialization.
2) The optimal profits tax/subsidy coincides with the social planner tax/subsidy. Therefore, it is always constant and its sign depends on the relationship between the mark-up and the returns to specialization.

The optimal capital income tax in steady state is negative regardless of the relative magnitude of the returns to specialization with respect to the mark-up. The government faces a trade-off between the business-stealing effect and the complementary effect, i.e., the fixed cost that society pays for the introduction of a new firm and the productivity gains associated to the introduction of this new variety. Since the government can control the entry of firms without distorting any individual or firm decision, the degree of returns to specialization does not have any impact on the capital income tax[20]. Note that both the optimal profits tax and the optimal capital subsidy coincide with the social planner's solution. This implies that when the government decides to subsidize/tax R&D, it ignores the social cost of the labor tax. Besides, the magnitude of the capital subsidy does not depend on the labor tax distortion. Again, the conventional formulation, $v = \eta/(1-\eta)$, is an interesting case, since the optimal profits tax is equal to the capital subsidy $\widehat{\tau}^{\pi} = \widehat{\tau}^{k} = -\eta/(1-\eta) < 0$. This result will later help us to understand the corporate tax.

Except for the endogenous entry of firms, the first-order conditions for the government problem in the economy with imperfectly competitive markets are similar to the conditions for an economy with competitive markets. As a consequence, we can extend some of the results of the uniform commodity tax literature to the transition path (see Atkinson and Stiglitz, 1980). An

[19] Judd (1997) obtains this capital tax in the case of a 100% profits tax. He also presents the case of a fixed profits tax. In this case, the capital subsidy depends on the profits tax and the social cost of taxation. The reason is that in his model profits are a "pure rent", hence, a profits tax becomes a lump-sum tax, which helps to reduce the social cost of taxation.

[20] In fact, it is not so important that the government can differentiate tax allowances between fixed and variable costs, since the Ramsey allocation can be implemented in several ways. For instance, the intermediate goods sector can be directly controled by the government through a tax τ_t^x on intermediate production x. In this case, the steady-state optimal fiscal policy implies

$$\widehat{\tau}^{x} = \frac{\eta - v}{\eta}, \qquad v > 0,$$

$$\widehat{\tau}^{k} = \left[(1-\eta)\, v - \eta\right] / \left(1-\eta\right) v, \qquad v > 0,$$

and when $v = 0$ then $\widehat{\tau}^{x} = 1 - \phi/\eta F\left(K, L\right)$ and $\widehat{\tau}^{k} = 1 - \eta F(K, L)/\left(1-\eta\right)\phi$. In fact, the government uses the tax on the intermediate output to efficiently set the number of varieties, and after it uses the capital income tax to efficiently set the capital-labor ratio by correcting the distortion due to the tax on output, so that $(1-\widehat{\tau}^{k})(1-\widehat{\tau}^{x}) = 1/\left(1-\eta\right)$.

inspection of the first-order conditions gives some insight about the requirements that the utility function needs to satisfy in order to have constant taxes from $t > 1$. The proof is in the Appendix.

Corollary 1: *For the class of utility functions that are additively separable (across time and goods) and homothetic with respect to consumption and hours worked, the optimal policy from* $t > 1$ *prescribes constant taxes.*

An example of utility function that satisfies this property is

$$U(c_t, L_t) = \frac{c_t^{1-\sigma}}{1-\sigma} - \frac{L_t^{1+\varphi}}{1+\varphi}. \tag{36}$$

4.2. Ineffective control on entry-decisions

The previous results critically hinge on the assumption that the government has a separate instrument to control entry. To illustrate this point, we consider the case where the government sets equal tax allowances for fixed and variable costs. Therefore, the equilibrium number of firms or varieties cannot be affected by the fiscal authority and production efficiency is not longer attainable. Thus, $\tau_t^\pi = 0$ and z_t is treated by the government as a variable beyond its direct control. However, the government knows that it can affect the number of firms by changing capital accumulation, but it has to bear a utility cost associated to the change in the consumption and leisure paths.

Since $\tau_t^\pi = 0$, the zero profit condition without taxes becomes a constraint for an allocation to be implementable. Combining the free-entry condition Eq.(13) with the resource constraint, Eq.(20), gives

$$c_t + K_{t+1} - (1-\delta)K_t + G_t = (1-\eta)F(K_t, L_t)^{\frac{1}{1-v}} \left(\frac{\eta}{\phi}\right)^{\frac{v}{1-v}}. \tag{37}$$

Let λ and α_t be the Lagrange multiplier associated with the implementability constraint and the new resource constraint Eq.(37), respectively. Then, the associated first-order conditions with respect to $\{c_t, L_t, K_{t+1}\}$ are

$$\beta^t \{U_{c_t} + \lambda[U_{c_t} + c_t U_{c_t c_t} + L_t U_{L_t c_t}]\} - \alpha_t = 0, \tag{38}$$

$$\beta^t \{U_{L_t} + \lambda[U_{L_t} + L_t U_{L_t L_t} + c_t U_{c_t L_t}]\} + \alpha_t \frac{(1-\eta)}{(1-v)} z_t^v F_L(K_t, L_t) = 0, \tag{39}$$

$$-\alpha_t + \alpha_{t+1}[1 - \delta + \frac{(1-\eta)}{(1-v)} z_{t+1}^v F_K(K_{t+1}, L_{t+1})] = 0. \tag{40}$$

Using Eq.(38) and Eq.(40) evaluated in steady state, we have

$$\frac{1}{\beta} = 1 - \delta + \frac{(1-\eta)}{(1-v)} z^v F_K(K, L). \tag{41}$$

Comparing this condition with Eq.(22) evaluated in steady state, we obtain a negative capital income tax, $\widehat{\tau}^k = -v/(1-v) < 0$, that only depends on the returns to specialization. Given that $v \in [0, 1)$, the capital income tax is negative. The next proposition summarizes this result.

Proposition 2: *When the government cannot control entry-decisions, $\tau_t^\pi = 0$, then the sign of the optimal capital income tax in the steady state is negative, regardless of the magnitude of the mark-up, $\widehat{\tau}^k = -v/(1-v) < 0$. Nevertheless, in the absence of aggregate returns to specialization, $v = 0$, the optimal capital income tax in the steady state is zero.*

In contrast with the previous case, the optimal capital income tax does not depend on the magnitude of the mark-up. Since the government cannot control the firms' entry, it uses the capital income tax to partially correct the effects of the returns to specialization. Consequently, the magnitude of the mark-up does not have any impact on the capital income tax. To explain the intuition of this result, one particular case deserves special attention. In the absence of aggregate returns to specialization, $v = 0$, we should not subsidize capital to eliminate the mark-up distortion, $\widehat{\tau}^k = 0$. In this case, the introduction of a new firm only has a negative consequence: a business-stealing effect that translates into a social waste of resources by means of the fixed cost. As a result, the marginal rate of transformation between present and future consumption is equal to $1-\delta+(1-\eta)F_K(K, L)$. This means that the return of a unit investment in terms of future consumption is the marginal productivity of capital F_K, minus the resources wasted by the fixed cost of new firms, ηF_K. The accumulation of capital raises profits by ηF_K, which is used by new firms entering the market to pay the fixed cost. Since the fixed cost is a waste of resources, the net increase in future consumption is equal to $(1-\eta)F_K(K, L)$. By comparing Eq.(22) and Eq.(41), in the case of $v = 0$, we can see that the existence of the mark-up implies that the return of capital in the market coincides with the optimal return of capital from the government point of view. Therefore, the government should not subsidize capital to remove the mark-up distortion. If the government decided to implement the capital subsidy proposed by Judd (1997), given that the number of firms cannot be controlled, the capital subsidy would lead to an inefficient number of firms. Thus, the threat of entry makes the prescribed capital income tax to be zero instead of negative. Therefore, in order to implement the Judd (1997) capital subsidy, the government has to be able to control the number of firms.

In the more general case, as we can see in equation Eq.(41), there is a complementary effect, and, then, the entry of new firms increases the return of investment. Since this externality is not internalized by the firms, the government needs to introduce a capital subsidy to promote entry, $\widehat{\tau}^k = -v/(1-v)$. Note that the price-marginal cost distortion is not relevant to design of optimal capital income tax, thus the government should only target the inefficient entry distortion. However, since the government can only encourage entry through a capital subsidy, the production efficiency condition should not be implemented, since it would lead to a large distortion in the capital stock. In particular, in the case of the conventional formulation, $v = \eta/(1-\eta) < 1$, the optimal capital subsidy is $\tau_k = -\eta/(1-2\eta) < 0$. Clearly, this result is a "mirage", in the sense that we cannot know if the government should target the price-marginal cost or the inefficient entry distortion.

This finding is consistent with some theoretical findings in the industrial organization literature. When the government cannot control the entry decisions on a market and there are no returns to specialization, a tax or a subsidy leads to a socially inefficient number of firms, since it increases the fixed costs; this is called inefficient economies of scale. For instance, Auerbach and Hines (2002) show that in a static Cournot model with free entry, an output subsidy to equate the price to the marginal cost encourages inefficient entry of new firms. Our result proves to be more general because we are considering a dynamic general equilibrium analysis instead of a partial equilibrium. Finally, using the same arguments as in the Proof of Corollary 1, it is straightforward to extend the results of Proposition 2 to the transition path.

4.3. Corporate taxation.

In this section, we consider the case where the government cannot distinguish between capital income and profits. Therefore, both taxes have to be the same in all periods, $\tau_t^k = \tau_t^\pi$. We call them corporate taxes, τ_t^c. This tax implies that the government taxes at the same rate all the income generated by the firm after paying the labor cost, and the firm cannot deduct the fixed cost[21]. In this tax structure, suggested by Stiglitz and Dasgupta (1971), the government uses the corporate tax as an indirect way to tax the economic rents or monopoly profits. Judd (1997), Guo and Lansing (1999) and Schmitt-Grohé and Uribe (2005) consider the optimal corporate tax in a dynamic model when the number of firms is fixed. They show that monopoly profits can yield a positive corporate tax. In our economy, the government uses the corporate tax to indirectly set the number of firms z_t. We find that the optimal corporate tax depends on the returns to specialization, the mark-up and the curvature degree of the production function. The assumption that the firm cannot deduct the fixed cost could be considered unappealing from the empirical point of view, since the R&D could be considered part of the fixed cost. However, since the optimal corporate tax does not depend on the fixed cost, the fiscal treatment of the fixed cost is irrelevant to determine the optimal tax. For instance, we could assume that the government allows to deduct a fraction of the fixed cost, like a R&D allowance, and the outcome would be the same. The exception occurs when there is a 100% deduction, since we obtain the tax code of the previous case.

[21] Note that $pF(K,L) - wL = rk + p\eta F(K,L)$. If the government allows the firm to fully deduct the fixed cost, we have the same tax structure as in the previous case.

The tax restriction takes the form of an additional constraint on the Ramsey allocation problem. In this case, by substituting the tax from Eq.(22) into the zero profit condition, we obtain an additional constraint needed to characterize the set of implementable allocations,

$$\left(\frac{U_{c_{t-1}}}{\beta U_{c_t}}-1+\delta\right)\left(\frac{\eta}{\phi(1-\eta)}\right)F\left(K_t,L_t\right)=z_tF_K\left(K_t,L_t\right). \tag{42}$$

This restriction shows that, from the government's perspective, the tax distortion due to either the returns on savings or the introduction of a new firm has to be the same. In the Appendix we show that the following steady-state condition is satisfied:

$$\frac{1}{\beta}-1+\delta=z^{v}F_K\left[v+1-v\varepsilon-(1-\varepsilon)\left(1-\tau^{c}\right)\eta\right], \tag{43}$$

where $\varepsilon=\varepsilon_{F_K,K}/\varepsilon_{F,K}=\left(F_{KK}K/F_K\right)/\left(F_KK/F\right)<0$ is the inverse ratio between the elasticities of the production function and of the marginal productivity of capital with respect to the capital, and it can be interpreted as the curvature degree of the production function. Combining this equation with Eq.(22) evaluated in steady state, we find the optimal corporate tax, $\widehat{\tau}^{c}=\left[(v-\eta)\,\varepsilon-v\right]/\left(1-\eta\varepsilon\right)$. Note that $\widehat{\tau}^{c}$ is bounded above by one. The next Proposition summarizes this result.

Proposition 3: *When the government cannot differentiate between capital income and profits, then the sign of the optimal steady-state corporate tax is positive whenever $v/\eta<-\varepsilon/(1-\varepsilon)$ and negative whenever $v/\eta>-\varepsilon/(1-\varepsilon)$.*

When profits and capital income taxes cannot be differentiated, the government faces a trade-off between eliminating distortions associated to the market power and determining the efficient level of entry. In general, we find that the optimal corporate tax can be positive, negative or zero. It depends on the relative magnitude of the returns to specialization with respect to the mark-up and the curvature degree of the production function. If the returns to specialization relative to the mark-up are big enough, then the government lowers the corporate tax in order to promote the entry of new firms. The curvature degree of the production function shows how the return of capital changes with the capital stock. In the absence of returns to specialization, $v=0$, then the optimal corporate tax is positive, in order to prevent the excessive entry of firms. In the conventional formulation, $v=\eta/(1-\eta)$, we obtain that the corporate tax is equal to the capital subsidy proposed by Judd (1997, 2002), $\widehat{\tau}^{c}=-\eta/(1-\eta)$. As we have seen in the case when the government can control entry, capital and profits tax are identical, $\widehat{\tau}^{k}=\widehat{\tau}^{\pi}=-\eta/(1-\eta)$. Then, in this case we do not have any conflict between the price-marginal cost and the inefficient entry distortion. Since we can use the corporate tax to remove the price-marginal cost distortion in capital accumulation and to achieve the optimal number of firms, the production efficiency condition applies to this case. Unfortunately, there is no a prior a reason to believe in this particular combination of parameters. Therefore, we cannot rely on a corporate subsidy to remove both distortions at the same time. We illustrate this trade-off through the case of a Cobb-Douglas production function.

Corollary 2: *If the production function is* $F(K,L) = K^u L^{1-u}$*, where* u *is the production elasticity with respect to the capital, then* $\varepsilon/(1-\varepsilon) = (u-1)$ *and therefore the steady-state corporate tax is positive if* $v/\eta < (1-u)$.

4.4. Differentiated consumption and investment goods

We analyze the robustness of the previous results by considering a formulation with differentiated consumption and investment goods. In particular, we assume that the individual buys several differentiated consumption goods and derives utility from the following mix:

$$c = \left(z^{v_c(1-\eta)-\eta} \int_0^z x_{ci}^{1-\eta} di \right)^{\frac{1}{1-\eta}}, \quad \eta \in [0,1), \ v_c \in [0,1), \tag{44}$$

where x_{ci} is the consumption good produced by firm i, and v_c is the degree of returns to specialization or love of variety for the consumption mix. Investment goods, I_t, are produced by competitive firms through the following technology:

$$I = \left(z^{v_I(1-\eta)-\eta} \int_0^z x_{Ii}^{1-\eta} di \right)^{\frac{1}{1-\eta}}, \quad \eta \in [0,1), \ v_I \in [0,1), \tag{45}$$

where x_{Ii} is the intermediate good i used to produce investment goods, and v_I is the degree of returns to specialization for the investment. Note that the same varieties are used to consume and to produce investment goods.

In the Appendix, we show that the social optimum implies the same taxes on labor and capital income as in the model with one final goods sector, but now the steady-state profits tax is

$$\tau^\pi = \frac{\eta(1-v_I) - v_c(1-\eta) - (v_I - v_c)\left[\frac{\beta\delta}{1-\beta(1-\delta)}\right]\varepsilon_{F,K}}{\eta(1-v_I+v_c)}. \tag{46}$$

Since the main forces driving the economy do not change, the social planner allocation does not change either. Thus, social planner subsidies are determined only by the mark-up, $\tau_t^k = \tau_t^l = -\eta/(1-\eta)$. Obviously, when $v_c = v_I$ we recover our previous profits tax, Eq.(28).

The socially efficient profits tax depends on the capital depreciation and the elasticity of the production function with respect to the capital $\varepsilon_{F,K}$. Since there exist different degrees of returns to specialization, the social planner has to take into account steady-state investment. However, when depreciation is zero, the optimal tax is

$$\tau^\pi = \frac{\eta(1-v_I) - v_c(1-\eta)}{\eta(1-v_I+v_c)}. \tag{47}$$

Note that $sign\left(\partial\tau^{\pi}/\partial v_I\right) = sign\left(\partial\tau^{\pi}/\partial v_c\right) < 0$, so we have the same effects as when there is only one final goods sector.

We have the same qualitative results and effects in the optimal tax policy. In particular, when the government can control entry, $\tau_t^{\pi} \neq 0$, we obtain in steady state that the optimal profits and capital income tax are equal to the socially efficient values. Besides, when the government cannot control entry $\tau_t^{\pi} = 0$, the optimal capital subsidy is equal to

$$\widehat{\tau}^k = \frac{\beta\delta\left(v_c - v_I\right)\varepsilon_{F,K} - v_c\left[1 - \beta\left(1-\delta\right)\right]}{\beta\delta\left(v_c - v_I\right)\varepsilon_{F,K} + \left(1 - v_I\right)\left[1 - \beta\left(1-\delta\right)\right]}. \tag{48}$$

Again, given that the government cannot control entry, the capital subsidy should not be used to eliminate the mark-up distortion, but it should be used to encourage entry. The corporate tax, in the case of no depreciation $\delta = 0$, is (the general case is in the Appendix)

$$\widehat{\tau}^c = \frac{\left(v_I - v_c\right)\eta + \left[-\eta\varepsilon + \left(v_c - v_I\right)\eta\left(1-\varepsilon\right) - v_c\left(1-\varepsilon\right)\right]}{\left(1 + v_c - v_I\right)\left(1 - \eta\varepsilon\right)}. \tag{49}$$

Note that when $v_c = v_I$, the tax policy coincides with the one final goods sector model. Hence, we can conclude that the introduction of differentiated consumption and investment goods does not change the qualitative results of the paper, but it can affect the optimal magnitude.

5. Conclusions

In recent papers, Judd (1997, 2002) has presented evidence in favor of a negative capital income tax. Using a representative-agent model with a fixed number of goods produced by monopolistic firms, he finds that the optimal fiscal policy implies a negative capital income tax and a 100% tax rate on firms' profits.

The main contribution of our paper is to show that once we consider an endogenous number of firms or varieties, the optimal fiscal policy can lead to different results. We show that the optimal fiscal policy is conditioned by the existence of two market failures: market power and inefficient entry. In particular, the capital income tax depends on the government's ability to control entry through a tax on variable profits. We follow the formulation of Ethier (1982) and Benassy (1996) to separate the mark-up from the index of returns to specialization, which measures the trade-off between the fixed costs that society pays for the introduction of a new firm and the productivity gains associated to this new firm.

We consider three different cases. In the first case, we assume that the government can levy a tax on profits, so that the government can control entry. The government implements a capital subsidy to remove the price-marginal cost distortion on capital accumulation, as in Judd (1997, 2002). Besides, the optimal profits tax coincides with the tax that a social planner would implement if lump-sum taxes were available. We show that both the capital subsidy and the profits tax do not depend on the tax burden. One important implication of these results is that if the government has available a complete set of taxes, the subsidies to promote the entry of new firms or R&D should not be constrained by the tax burden.

In the second case, we assume that the government cannot tax profits, so the equilibrium number of firms cannot be directly controlled by the fiscal authority. With this tax code restriction, we find that the government should not implement a capital subsidy to remove the price-marginal cost distortion, but that the capital subsidy should be used to encourage the entry of firms, then it does depend on the returns to specialization. In contrast with Judd (1997, 2002), we show that in the absence of aggregate returns to specialization the optimal steady-state capital income tax is zero.

In the third case, suggested by Stiglitz and Dasgupta (1971), the government has to apply the same marginal tax to both capital income and profits. In this case the government can indirectly control entry through a corporate tax. We find that the optimal corporate tax depends not only on the magnitude of the returns to specialization and the mark-up, but also on the curvature degree of the production function. Also, we show that the results remain unchanged if we consider differentiated consumption and investment goods.

Finally, our results highlight the idea that the optimal tax system would depend on the information available about the structure of the economy: market power, productivity of the R&D, etc. Since this information could be considered as firms' private information, future research could consider the introduction of informational or enforcement constraints, following the Mirrlees's (1971) approach. Recently, Golosov, Kocherlakota and Tsyvinski (2003) have developed the Mirrlees approach in a dynamic setting. Their work could be extended to analyze the issues considered in this paper.

Appendix

Derivation of the implementability constraint: The implementability constraint can be derived as follows. Multiplying Eq.(19) by L_t we have

$$-L_t U_{L_t} = U_{c_t} w_t (1-\tau_t^l) L_t. \tag{A.1}$$

Multiplying Eq.(17) by U_{c_t} and using Eq.(A.1) gives

$$c_t U_{c_t} + L_t U_{L_t} = (K_t + D_t) U_{c_t} \left[1-\delta + r_t(1-\tau_t^k)\right] - (K_{t+1} + D_{t+1}) U_{c_t}. \tag{A.2}$$

Multiplying Eq.(A.2) by β^t and adding up from $t=0$ to $t=\infty$ yields

$$\sum_{t=0}^{\infty} \beta^t \left(c_t U_{c_t} + L_t U_{L_t}\right) = (K_0 + D_0) U_{c_0} \left[1-\delta + r_0(1-\tau_0^k)\right]$$

$$+\sum_{t=0}^{\infty} \beta^t \left(\beta(K_{t+1} + D_{t+1}) U_{c_{t+1}} \left[1-\delta + r_{t+1}(1-\tau_{t+1}^k)\right] - (K_{t+1} + D_{t+1}) U_{c_t}\right). \tag{A.3}$$

Using Eq.(A.3), Eq.(8) and Eq.(18) we obtain the implementability constraint, Eq.(29).

Equivalence between an implementable and a market allocation: An allocation in the market equilibrium $y = \{c_t, L_t, K_{t+1}, z_t\}_{t=0}^{\infty}$ satisfies the set of implementable allocations. Moreover, if an allocation y is implementable, then we can construct a tax policy $\{\tau_t^\pi, \tau_t^l, \tau_{t+1}^k\}_{t=0}^{\infty}$ and prices $\{r_t, p_t, w_t\}_{t=0}^{\infty}$, such that the allocation together with prices and the policy constitute a market equilibrium.

Proof: The first part of the claim is always satisfied, since any market equilibrium allocation has to satisfy the resource constraint, the zero profit condition and the implementability constraint. Now we prove the second part of the claim. Given an implementable allocation y, the market prices can be backed out using Eq.(8), Eq.(9) and Eq.(11). The tax policy is recovered from Eq.(13), Eq.(18) and Eq.(19). Substituting U_{c_t} and U_{L_t} in the implementability constraint we obtain the consumer budget constraints, from where we recover the level of debt. If the resource constraint and the consumers budget constraints are satisfied, then the government budget constraint is also satisfied.

Proof of Corollary 1: The class of utility functions that are additively separable (across time and goods) and homothetic with respect to consumption and hours worked satisfy

$$L_t U_{L_t L_t} + c_t U_{c_t L_t} = D U_{L_t}, \tag{A.4}$$

$$c_t U_{c_t c_t} + L_t U_{L_t c_t} = E U_{c_t}, \tag{A.5}$$

where D and E are different constants, and separability between consumption and hours worked implies $U_{c_t L_t} = U_{L_t c_t} = 0$. In this case, the first-order conditions of the government problem can be written as

$$\frac{U_{c_t}}{\beta U_{c_{t+1}}} = 1 - \delta + z_{t+1}^v F_K (K_{t+1}, L_{t+1}), \tag{A.6}$$

$$-\frac{[1 + \lambda(1 + D)] U_{L_t}}{[1 + \lambda(1 + E)] U_{c_t}} = z_t^v F_L (K_t, L_t), \tag{A.7}$$

where λ is constant. Clearly, from the market equilibrium Eq.(22), we derive the optimal capital income tax

$$\hat{\tau}_{t+1}^k = -\frac{\eta}{(1 - \eta)}. \tag{A.8}$$

From the consumption-labor decisions Eq.(21), we can derive the optimal labor tax

$$1 - \hat{\tau}_t^l = \frac{[1 + \lambda(1 + E)]}{[1 + \lambda(1 + D)]} \frac{1}{(1 - \eta)}. \tag{A.9}$$

For the example stated in Eq.(36), we have $E = -\sigma$ and $D = \varphi$, and clearly $E < D$. Note that λ, and therefore $\hat{\tau}_t^l$, depends on the initial conditions K_0 and D_0. Both taxes are constant for $t > 1$. At $t = 1$, the first-order conditions contain additional terms.

Derivation of the optimal corporate tax Eq.(43): Substituting Eq.(42) into the aggregate resource constraint, we obtain a new resource constraint,

$$c_t + K_{t+1} - (1 - \delta) K_t + G_t =$$

$$\left[\frac{\left(\frac{U_{c_{t-1}}}{\beta U_{c_t}} - 1 + \delta \right) \eta}{\phi (1 - \eta) F_K (K_t, L_t)} \right]^v F (K_t, L_t)^{v+1} - \frac{\left(\frac{U_{c_{t-1}}}{\beta U_{c_t}} - 1 + \delta \right) \eta F (K_t, L_t)}{(1 - \eta) F_K (K_t, L_t)}. \tag{A.10}$$

Let λ and α_t be the Lagrange multiplier of the implementability constraint and the new resource constraint, respectively. The first-order conditions of the government problem with respect to $\{c_t, L_t, K_{t+1}\}$, after substituting for Eq.(42), are

$$\beta^t [U_{c_t} + \lambda (U_{c_t} + c_t U_{c_t c_t} + L_t U_{L_t c_t})] - \alpha_t \left(1 + \left[\frac{U_{c_{t-1}} U_{c_t c_t}}{\beta U_{c_t}^2 \left(\frac{U_{c_{t-1}}}{\beta U_{c_t}} - 1 + \delta \right)} \right] [v z_t^v F (K_t, L_t) - z_t \phi] \right)$$

$$+\alpha_{t+1} \left[\frac{U_{c_t c_t}}{\beta U_{c_{t+1}} \left(\frac{U_{c_t}}{\beta U_{c_{t+1}}} - 1 + \delta \right)} \right] \left[v z_{t+1}^v F (K_{t+1}, L_{t+1}) - z_{t+1} \phi \right] = 0, \tag{A.11}$$

$$\beta^t \left[U_{L_t} + \lambda \left(U_{L_t} + L_t U_{L_t L_t} + c_t U_{c_t L_t}\right)\right] + \alpha_t z_t^v \left[(v+1) F_L\left(K_t, L_t\right) - v \frac{F\left(K_t, L_t\right) F_{KL}\left(K_t, L_t\right)}{F_K\left(K_t, L_t\right)}\right]$$

$$-\alpha_t z_t \phi \left[\frac{F_L\left(K_t, L_t\right)}{F\left(K_t, L_t\right)} - \frac{F_{KL}\left(K_t, L_t\right)}{F_K\left(K_t, L_t\right)}\right] - \alpha_t \frac{U_{c_{t-1}} U_{c_t L_t}}{\beta U_{c_t}^2 \left(\frac{U_{c_{t-1}}}{\beta U_{c_t}} - 1 + \delta\right)} \left[v z_t^v F\left(K_t, L_t\right) - z_t \phi\right]$$

$$+\alpha_{t+1} \left[\frac{U_{c_t L_t}}{\beta U_{c_{t+1}} \left(\frac{U_{c_t}}{\beta U_{c_{t+1}}} - 1 + \delta\right)}\right] \left[v z_{t+1}^v F\left(K_{t+1}, L_{t+1}\right) - z_{t+1} \phi\right] = 0, \tag{A.12}$$

$$-\alpha_t + \alpha_{t+1} \left\{1 - \delta + \left[z_{t+1}^v F_K\left(K_{t+1}, L_{t+1}\right)\right]\right.$$
$$\left.\left(v + 1 + \left[\frac{F\left(K_{t+1}, L_{t+1}\right) F_{KK}\left(K_{t+1}, L_{t+1}\right)}{F_K\left(K_{t+1}, L_{t+1}\right) F_K\left(K_{t+1}, L_{t+1}\right)}\right] \left[\frac{z_{t+1}^{1-v} \phi}{F\left(K_{t+1}, L_{t+1}\right)} - v\right] - \frac{z_{t+1}^{1-v} \phi}{F\left(K_{t+1}, L_{t+1}\right)}\right)\right\} = 0. \tag{A.13}$$

Substituting α_{t+1} from Eq.(A.11) into Eq.(A.12), evaluating the resulting equation in steady state and dividing it by the same equation one period forward, we obtain that

$$\beta \alpha_t = \alpha_{t+1}. \tag{A.14}$$

Noting that $\varepsilon = \varepsilon_{F_K,K} / \varepsilon_{F,K} = \left(F_{KK} K / F_K\right) / \left(F_K K / F\right) < 0$ and using Eq.(13) and Eq.(A.14), in steady state Eq.(A.13) becomes Eq.(43).

Differentiated consumption and investment goods: Next, we consider the market equilibrium. The inverse demand function for each consumption good and intermediate good used to produce investment goods is

$$x_{ji} = \left(\frac{p_i}{P_j}\right)^{-\frac{1}{\eta}} z^{v_j \frac{(1-\eta)}{\eta} - 1} j, \quad j = c, I, \tag{A.15}$$

where P_j is the price of good j[22]. Each goods firm solves

$$\max_{\{k_i, l_i\}} \pi_i = \left(1 - \tau^\pi\right) \left[p_i \left(x_{ci} + x_{Ii}\right) - r k_i - w l_i\right] - P_I \phi, \tag{A.16}$$

subject to the demands, Eq.(A.15), and the production function. The prices at the symmetric equilibrium are

$$P_j = z^{-v_j} p, \quad j = c, I. \tag{A.17}$$

We normalize the price of intermediate inputs, $p = 1$. The first-order conditions of the monopolistic firm combined with Eq.(A.17) show that we have a mark-up distortion. Moreover, the

[22] P_j is an index associated to the composite good, $P_j = z^{-v_j + \eta/(1-\eta)} \left(\int_0^z p_i^{(\eta-1)/\eta} di\right)^{\eta/(\eta-1)}$, $j = c, I$.

entry of firms increases the return of capital r/P_I and the purchasing power of wages w/P_c,

$$\frac{r}{P_I} = z^{v_I}(1-\eta)F_K(K,L), \tag{A.18}$$

$$\frac{w}{P_c} = z^{v_c}(1-\eta)F_L(K,L). \tag{A.19}$$

The free-entry condition indicates that the number of firms depends on v_I, since the fixed cost is defined in terms of the investment good,

$$z = \left[\frac{(1-\tau^{\pi})\eta F(K,L)}{\phi}\right]^{\frac{1}{1-v_I}}. \tag{A.20}$$

The individual budget constraint is

$$P_{c_t}c_t + P_{I_t}(K_{t+1}-(1-\delta)K_t) + D_{t+1} = w_t(1-\tau_t^l)L_t + R_tD_t + K_tr_t(1-\tau_t^k) + \Pi_t + T_t^c, \tag{A.21}$$

whereR_t is retrun of government debt. Maximizing Eq.(16) subject to Eq.(A.21) yields

$$-\frac{U_{L_t}}{U_{c_t}} = \frac{w_t(1-\tau_t^l)}{P_{c_t}}, \tag{A.22}$$

$$\frac{U_{c_t}}{\beta U_{c_{t+1}}} = \frac{P_{c_t}}{P_{c_{t+1}}}\frac{P_{I_{t+1}}}{P_{I_t}}\left[1-\delta+\frac{r_{t+1}}{P_{I_{t+1}}}(1-\tau_{t+1}^k)\right]. \tag{A.23}$$

The equilibrium condition in the output markets is

$$z_t^{-v_c}(c_t+G_t) + z_t^{-v_I}\left[K_{t+1}-(1-\delta)K_t\right] = F(K_t,L_t) - \left(z_t^{-v_I}\phi\right)z_t. \tag{A.25}$$

The social planner maximizes Eq.(16) subject to Eq.(A.25). From the first-order conditions with respect to c_t, L_t and K_{t+1}, we have

$$-\frac{U_{L_t}}{U_{c_t}} = z_t^{v_c}F_{L_t}, \tag{A.26}$$

$$\frac{U_{c_t}}{\beta U_{c_{t+1}}} = \frac{z_{t+1}^{v_c}}{z_t^{v_c}}\frac{z_t^{v_I}}{z_{t+1}^{v_I}}\left[1-\delta+z_{t+1}^{v_I}F_{K_{t+1}}\right]. \tag{A.27}$$

Combining these last two equations with those of the market equilibrium, we derive the same steady-state labor and capital income taxes as when there is only one final goods sector. The first-order condition with respect to z_t is

$$-v_cz_t^{-v_c-1}(c_t+G_t) - v_Iz_t^{-v_I-1}\left[K_{t+1}-(1-\delta)K_t\right] + (1-v_I)z_t^{-v_I}\phi = 0. \tag{A.28}$$

Substituting G_t and ϕ from Eq.(A.25) and Eq.(A.20), respectively, into Eq.(A.28), and evaluating the resulting equation in steady state, we obtain that

$$(1 - v_I + v_c)(1 - \tau^{\pi})\eta = v_c + (v_I - v_c)\,\delta \frac{z^{-v_I} K}{F}. \tag{A.29}$$

Multiplying Eq.(A.27) by K_{t+1}, and evaluating it in steady state, we have

$$z^{-v_I} K = \frac{F_K K}{\frac{1}{\beta} - 1 + \delta}. \tag{A.30}$$

Combining the last two equations gives Eq.(46).

For the tax policy, the implementability constraint is

$$\sum_{t=0}^{\infty} \beta^t (c_t U_{c_t} + L_t U_{L_t}) = U_{c_0} \left[1 - \delta + z_0^{v_I}(1-\eta) F_K(K_0, L_0)(1 - \tau_0^k)\right] \frac{P_{I_0}}{P_{c_0}} (K_0 + D_0). \tag{A.31}$$

Repeating the same process of the paper, we obtain Eq(48) and the following corporate tax:

$$\widehat{\tau}^c = \frac{(v_I - v_c)\left[\eta(1-\beta) + \beta\delta\left(\varepsilon_{F_K,K} - \varepsilon_{F,K}\right)(1-\eta)\right] + \left[1 - \beta(1-\delta)\right]\left[(1 + v_c - v_I)\,\eta\,(1-\varepsilon) - \eta - v_c(1-\varepsilon)\right]}{(1-\eta)\left(1 - \beta(1-\delta) + (v_c - v_I)\left[1 - \beta - \beta\delta\left(\varepsilon_{F_K,K} - \varepsilon_{F,K}\right)\right]\right) + \left[1 - \beta(1-\delta)\right](1 + v_c - v_I)\,\eta\,(1-\varepsilon)}. \tag{A.32}$$

In the case $\delta = 0$, we obtain Eq.(49).

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