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## TAXATION AND ENTREPRENEURSHIP

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**ABSTRACT:** The paper analyses the impacts of occupational choice and entrepreneurial effort on the structure of wage, profit and capital taxation. Entrepreneurial effort is unobservable and therefore not tax-deductible. The optimal profit tax is less than unity even if individual entrepreneurial effort is fixed. It decreases with the sufficiently adverse effects on the number of firms. With the optimal setting of wage and profit taxes entrepreneurial effort has ambiguous effect on the optimal profit tax level. Because of the possible opposite effects of the adjustment in the number of firms and entrepreneurial effort, information on aggregate entrepreneurial effort is not enough in the setting of the optimal tax policy. It is also shown that the optimal setting of wage taxes is different when profit taxation is arbitrarily low. This leads to the setting of wage taxes at too high a level. The reason is that lower entrepreneurial effort owing to severe wage taxes also raises the wage tax base.

**KEY WORDS:** optimal taxation, occupational choice, entrepreneurship, self-employment JEL-code: M13, H21, H25, J62.

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**TIIVISTELMÄ:** Tutkimus tarkastelee ammattivalinnan ja yrittäjäpanoksen vaikutusta palkka-, yritys- ja pääomaverotukseen. Yrittäjäpanos ei ole havaittava tuotantopanos eikä verotuksessa vähennyskelpoinen. Tästä syystä optimaalinen yritysverotus on vähemmän kuin 100 prosenttia vaikka yrittäjäpanos olisi joustamaton verotuksen tasolle. Optimaalinen yritysverotus alenee kun yritysvero vähentää yrittäjien määrää riittävän paljon. Kun sekä palkka- ja yritysverotus asetetaan optimaalisesti, yritysverotus voi sen sijaan eräissä tapauksissa kiristyä, kun yritysvero vähentää yrittäjäpanosta. Optimaaliseen yritysverotukseen vaikuttaa siten olennaisesti sekä yrittäjien määrä että kunkin yrittäjän panostus. Tutkimuksessa osoitetaan myös, että optimaalinen palkkaverotus muuttuu olennaisesti silloin, kun yritysverotus on liian keveätä. Tälloin palkkaverotuksen taso muodostuu korkeaksi. Syynä tähän on se, että myös yrittäjäpanoksen väheneminen kireän palkkaverotuksen myötä nostaa palkkoja ja palkkaveropohjaa. Optimaalisessa verotuksessa palkkaverotus sen sijaan aina alenee mitä negatiivisemmat vaikutukset veroilla on yrittäjäpanokseen.

## 1. Introduction

We present and analyse a model of occupational choice where agents decide whether to become entrepreneurs or workers. The model extends, by occupational choice, the basic model of international taxation used in many applications by for example Giovannini (1989), Razin and Sadka (1991), Huizinga and Nielsen (1997) and Keen and Piekkola (1997), among others. Profits are not "pure" and should not be taxed away completely. This is an important distinction, since in all of the approaches listed above the choice between source-based taxes on production and residence-based taxes on factor suppliers has been relevant only if all profits are pure in Diamond and Mirrlees' (1971) meaning, and not fully taxed for some unexplained reason. Entrepreneurial effort is considered as one factor of production. Constant returns-to-scale are assumed to prevail in respect of all factors of input. If profits from entrepreneurial effort were fully taxed, no one would be willing to become an entrepreneur, since the entrepreneurial effort is not tax-deductible.

Our model also differs from some of the earlier occupational choice models, where a non-marginal decision is made between becoming a laborer or an entrepreneur (risk-taker). As in Kanbur (1979, 1981), but in contrast to Pestieau and

Possen (1991), the labour market must clear, and those who enter upon entrepreneurial activity must demand all the labour for those who decide to become workers. But in Kanbur (1981) individuals differ in their risk aversion to the investment return from risky entrepreneurial income. Here, there is no uncertainty and profit tax also affects entrepreneurial effort. As entrepreneurs, agents differ in terms of the talent they have if they want to act as entrepreneurs. The "talent" refers to the welfare costs of supplying entrepreneurial effort to the firms they run. Blanchflower and Oswald (1998) use a model similar to our approach to empirically evaluate the factors underlying the choice as to whether to become an entrepreneur or not. According to their results, the choice is much affected by how difficult it is to raise (initial) capital for the firm. In our model the cost of providing entrepreneurial effort can also be interpreted as measuring how difficult it is to finance the firm. Our model is also consistent with the Blanchflower-Oswald observation that, on average, entrepreneurs have higher lifetime welfare than workers, because of the costs of supplying entrepreneurial effort.

The main focus of the paper is the impacts of taxation not only on the number of firms (entrepreneurs) but also on the individual entrepreneurial effort when effort costs are not observable to the government, and hence not deductible in taxation. [1] The model differs from Moresi (1997) by not analysing the non-linear optimal tax problem, where the profit tax rate is entrepreneurial effort contingent. [2] The income in the economy is divided into labor income, capital income and entrepreneurial rents or profits. In the general equilibrium of the economy the marginal entrepreneur is indifferent between being an entrepreneur or becoming a worker. The government sets taxes on wage income, investment and savings besides those on profit, and knows the distribution of agents.

Taxes have *a priori* no unambiguous relation to entrepreneurial income. Even with homothetic preferences the number of entrepreneurs (firms) ambiguously depends on profit taxes. Hence, aggregate entrepreneurial effort changes ambiguously although individual entrepreneurial effort decreases in the profit tax rate.

Assuming quadratic (non-individual specific) effort aversion we are able obtain some interesting tax rules. The optimal profit tax is less than unity even if individual entrepreneurial effort is fixed, since entrepreneurial effort is not tax deductible. Profit taxes are decreasing in the sufficiently strong negative effects on the number of entrepreneurs, since with full taxation no one would be willing

[1] Hart (1995) considers the property rights approach and contracting between managers and firm owners to solve this problem.

[2] We also include capital in a dynamic framework. Moresi (1997) is analogous to optimal nonlinear consumption tax problem with the difference that in his paper the number of entrepreneurs is endogenous (see Mirrlees (1971, 1976).

to become entrepreneur. Profit taxes only decrease with the negative effect on entrepreneurial effort if the size of entrepreneurial class or optimal profit taxes are low. In the converse case, induced higher wages increase the optimal tax bases so as to raise the profit tax level. In this case, entrepreneurial effort and the number of firms have opposite implications and information on aggregate entrepreneurial effort is not enough in the setting of the optimal wage policy. The optimal wage taxes are also ambiguous if the size of entrepreneurial class or optimal profit taxes are high.

Although the tax theory that finds no difference between pure economic profits and entreprenerial income favours severe profit taxation, the current trend is rather the opposite with a decrease in profit taxes. Optimal profit tax policy is, however, essential. Arbitrarily low profit taxation leads to the setting of wage taxes at too high a level. The reason is that it becomes desirable to discourage entrepreneurial effort via high wage taxes. Under optimal tax policy, the implied higher wage level and wage tax base never raise the optimal wage taxes, but possibly optimal profit taxes. Lower private utility of income, when entrepreneurial effort costs are high, further raises the wage tax rate. Although not explicitly shown, this may well lead to lower gross national income. National income decreases since all the entrepreneurs' after-profit tax earnings are higher than the workers' earnings because of the costs of supplying entrepreneurial effort.

We also present weighted average rules for the optimal investment and savings taxes that are generalizations of Keen and Piekkola (1997) and Huizinga and Nielsen (1997). Investment tax is, in general, non-zero since it is one form of taxing endogenous profits. It is lowered by the adverse effect on individual entrepreneurial effort and on the number of entrepreneurs. While the investment tax decreases, the optimal tax incidence shifts taxation away from residence to source taxation. This is different from the tax literature, where profit taxes do not affect entrepreneurial effort, and *both* the optimal investment tax and the tax incidence on production should be set at zero.

Section 2 introduces the model and the equilibrium relationships between the taxes, the entrepreneurial effort and the size of the entrepreneurial class. Section 3 examines the optimal profit, wage and capital taxation and the weighted average rules for the optimal tax incidence between these alternative taxes. The results are summarized in the concluding section 4.

## 2. A small open economy

Consider a small open economy for which the world interest rate $r$ is given. Agents, indexed by $i$, are uniformly distributed on (0,1) and differ with respect to human capital endowment. The cost of entrepreneurial effort is increasing in $i$. Agents can be either workers or entrepreneurs. Those above equilibrium value $i^*$ choose to supply labor. Firms use labor as input. Each entrepreneur owns one firm and the entrepreneurial effort put into the firm is unobservable for the government. The government knows, however, the distribution of agents on (0,1). The world lasts for two periods. In the first period, each agent receives an endowment $I$ of a single good. This endowment is allocated between first-period consumption $C_1$ and savings $S$ if the agent decides to be a worker and between first-period consumption $C_1$ , investment $K$ and savings $S$ if the agent decides to be an entrepreneur. Invested capital is only productive in the second period and all the capital depreciates fully. Agents spend all their income and also enjoy a public good $G$ in the second period. Public consumption is financed by imposing a tax, $u$, on savings, a tax, $\nu$, on investment, a tax, $t$, on labor supply, $L$, and a tax, $\tau$, on the profits of entrepreneurs to be earned in the second period.

The order of decisions is as follows: 1) the government decides upon taxes, 2) agents decide upon whether to establish a firm or enter the labor force and upon the effort devoted to entrepreneurship, 3) agents make intertemporal allocation decisions upon consumption and firms (entrepreneurs) decide upon capital and labor demands. Let us consider each decision in converse order.

## 2.1. Firms

Firms produce an output $F(K_i, L_i, e_i)$ in the second period, where the production function $F$ is constant returns-to-scale with respect to capital $K_i$, labor $L_i$ and entrepreneurial effort $e_i$. All the firms produce an identical good. A profit tax $\tau$ is imposed on profits

$$\pi_i = F(K_i, L_i, e_i) - wL_i - (1 + r + v)K_i \tag{2.1}$$

where $r$ is the exogenously given interest rate and investment tax $v$ is deductible from the profit tax base. Given the constant returns-to-scale technology, profits net of taxes can be written as

$$(1 - \tau)\pi_i = (1 - \tau)\, e_i\pi \ , \tag{2.2}$$

$$where \quad \pi \equiv F(K, L) - wL - (1 + r + v)K \ ,$$

where $\partial\pi_i/\partial e = \pi$ and $\partial^2\pi_i/\partial e^2 = 0$. Normalized capital $K = K_i/e_i$ and labor $L = L_i/e_i$ are determined independently of the level of entrepreneurship. Letting subscripts, when obvious, hereby refer to partial derivatives, the optimal capital

$K$ and labor demands $L$ that maximize profits are given by

$$F_K = 1 + r + v \tag{2.3}$$

$$F_L = w \tag{2.4}$$

The choices (2.3) and (2.4) give the profit function[3]

$$\pi = \pi(w, v) \tag{2.5}$$

### 2.2. Consumption

The lifetime wealth $A$ is for workers and an entrepreneur $i$ respectively

$$A^w(R, t) \equiv I + R(1 - t)w \tag{2.6}$$

$$A^e(i, R, v, \tau) \equiv I + R(1 - \tau)\pi_i \tag{2.7}$$

where $(1 - \tau)\pi_i$ is given by (2.2), $w$ by (2.4), $t$ is the tax on wages and $R = 1/(1+r-u)$ is the discount rate of second-period consumption so that $r-u$ is the net return on savings $S$ and $u$ is a tax on savings. Private welfare maximization

[3] The derivates of input prices $w$ and $v$ give the respective factor demands $L$ and $K$.

yields an indirect utility function

$$V^x(i, R, A_i) - h(i)H(e_i) \tag{2.8}$$

$$= \max_{C_1, C_2} \{ U^x(C_{1i}, C_{2i}) - h(i)H(e_i) \mid C_{1i} + RC_{2i} = A^x \} ,$$

where $C_{ji}$ is consumption in period $j, j = 1, 2$ for entrepreneurs (superscript $x = e$) or workers (superscript $x = w$). $h(i)$ describes an agent-specific effort cost, where $h(0) > 0$, $h\,(1) < \infty, h' > 0$, $h'' \geq 0$, and $H(e_i)$ describes non-agent-specific effort cost, where $H(0) = 0, H' > 0$, $H'' > 0$ [more specific assumptions are given later, see section 2.5]. $h(i)$ shows differences in individual productivity, while effort cost $H(e_i)$ is the same for all agents for a given amount of effort $e_i$. If an agent is a worker he supplies 1 unit of labor. In that case, $e_i = 0$. If an agent is an entrepreneur he supplies not labor but entrepreneurial input. It is intuitive to assume that these excess costs are positive so that the expected wealth of an entrepreneur must be higher than that of workers.

Preferences over private consumption are characterized by a homothetic utility function, where individuals consume in the first period a fixed proportion of wealth:[4]

$$V^w = V_A(R)A^w,\ V^e(i) = V_A(R)A^e(i) \tag{2.9}$$

where $V_A(R)$ is the marginal utility of wealth, which is higher when the price of future income $R$ goes up.

## 2.3. Entrepreneurial effort

If an agent chooses to become an entrepreneur he must make the choice in the first period. In making the decision, the agent anticipates that he is going to choose his effort optimally. The first order condition for an entrepreneur $i$ is from (2.7) and (2.9), using the envelope theorem, given by

$$\Omega(i) \equiv \tilde{V}_A \pi(1-\tau) - h(i)\, H'(e_i) = 0 \tag{2.10}$$

where $\pi_i = e_i \pi$ and $\tilde{V}_A \equiv V_A(R)R$ is the discounted constant marginal utility of second-period private consumption. It is required by the second-order-condition, and is indeed intuitive, that higher non-agent specific effort costs $H(e_i) \uparrow$ discourage individual efforts $h(i) \downarrow$. From (2.5) and (2.10) the homotheticity of the utility

[4]The simplifying implication is that the marginal utility of wealth is independent of the wealth level, as is also the case with a quasilinear utility function.

function implies

$$\begin{array}{rcccccc} & & - & - & - & - & + \\ e(i) = & e\,( & i, & \tau, & w, & 1+r+v, & R\,) \end{array} \tag{2.11}$$

The lower net profits owing to profit $\tau$ or investment taxes $v$ on production discourage entrepreneurial effort, since the effort costs are not tax deductible. Labor taxes can later be seen to increase the wages, which has the same effect. Finally, the higher price of future consumption $R$ and the marginal utility of second-period private consumption $\tilde{V}_A$ increases entrepreneurial effort.

### 2.4. Public Sector

The public sector budget constraint is given by

$$G = \int_0^{i^*} \left( ve_iK + u\,S_i + \tau e_i \pi \right) d\,i \, + (1-i^*) \, \left( u\,S^w + tw \right) \, , \tag{2.12}$$

where $S^w$ is the aggregate savings of workers. We assume that agents receive the same level of public consumption and welfare irrespective of their individual characteristics. Utility from public spending is given by $\mu(G)$ satisfying $\mu'(G) > 0$ and $\mu''(G) < 0$. Indirect utility can be written for the worker as

$$W\left(R, A(R,t,u,w), G\right) = V^w(R, A^w(R,t,u,w)) + \mu(G) \, , \tag{2.13}$$

noting $e_i, H(e_i) = 0$, and for the entrepreneur i as

$$\begin{aligned} E\left(i, R, A_i^e(i, R, u, v, \tau, w), \tau, \nu, w, G\right) &= V^e(i, R, A_i^e(i, R, u, v, \tau, w)) \\ &\quad - h(i)H(e_i) + \mu(G). \end{aligned} \tag{2.14}$$

**2.5. Formation of the Entrepreneurial Class**

Ruling out corner solutions, the marginal entrepreneur is indifferent to establishing a firm or entering the labor force. The number of firms, i.e. the size of entrepreneurial class, $i^*$, is from (2.13) and (2.14) determined by

$$V^w\left(R, A^w(R, u, t, w), \right) = V^e(i^*, R, A_i^e(i^*, R, u, v, \tau, w)) - h(i^*)H(e_i^*) \tag{2.15}$$

Since effort costs $h(i)$ and $H(e_i)$ are increasing in $i$, people above $i^*$ choose to become workers. The decision is independent of the amount of public spending since public good and private consumption are taken to be separable. Normalizing one unit of labor per worker, the equilibrium in the labor market requires that the wages adjust so that:

$$\Gamma \equiv \int_0^{i^*} L_i \, di = L \int_0^{i^*} e_i \, di = 1 - i^* \ , \tag{2.16}$$

where $L = -\pi_w$ from (2.2) using the envelope theorem. (2.15) and (2.16) characterize the equilibrium conditions, and the system is stable. An increase in $t$, for example, lower the indirect utility of workers, leading to an increase in the number of entrepreneurs so that $\Gamma_t$ from (2.14). Define $e_x \equiv \partial \left( \int_0^{i^*} e_i \, di \right) / \partial x$ to denote partial derivatives with respect to a variable $x$. The number of firms and wages from (2.10) and (2.16) are affected by taxes and by the price of future consumption as follows

$$\frac{\partial i^*}{\partial \tau} = \frac{\tilde{V}_A \pi \Gamma_w + e_\tau L \Omega_w}{D} \ ; \tag{2.17}$$

$$\frac{\partial w}{\partial \tau} = \frac{-e_\tau L \Omega_i - \tilde{V}_A \pi \Gamma_i}{D} \ ; \tag{2.18}$$

$$\frac{\partial i^*}{\partial t} = \frac{\Gamma_t \Omega_w}{D} \ ; \tag{2.19}$$

$$\frac{\partial w}{\partial t} = \frac{-\Gamma_t \Omega_i}{D} \ ; \tag{2.20}$$

$$\frac{\partial i^*}{\partial R} = \frac{-\Omega_R \Gamma_w + L e_R \Omega_w}{D} \ ; \tag{2.21}$$

$$\frac{\partial w}{\partial R} = \frac{-L e_R \Omega_i + \Omega_R \Gamma_i}{D} \ , \tag{2.22}$$

where

$$\begin{aligned}
\Omega_i &= -h'(i^*)H'(e_i^*) < 0\,;\Omega_w = -\tilde{V}_A(1-\tau)L < 0\,;\\
\Gamma_t &> 0\,;\, \Omega_R = \pi(1-\tau)\partial\tilde{V}_A/\partial R \, < 0\,;\\
\Gamma_i &= e_{i^*}L + 1 > 0\,;\, \Gamma_w = L_w \int_o^{i^*} e_i di < 0\,;\\
D &= \Omega_i\Gamma_w - \Omega_w\Gamma_i > 0\,.
\end{aligned}$$

These, also including the non-reported investment tax $v$ implications, can be summarized as follows:

$$i^* = i(\overset{?}{\tau},\ \overset{-}{t},\ \overset{?}{1+r+v},\ \overset{?}{R}) \tag{2.23}$$

$$w = w(\overset{-}{\tau},\ \overset{+}{t},\ \overset{?}{1+r+v},\ \overset{?}{R}) \tag{2.24}$$

It is seen that wage taxes raise and profit taxes lower the level of wages. For example, a higher wage tax, $t$, raises wages and this will decrease the number of entrepreneurs, which has the same effect. Wage taxes also lower the number of entrepreneurs. It is not clear into which direction the profit taxes affect the number of firms. A higher profit tax lowers the marginal utility of entrepreneurial effort and this, through lower wages, increases the number of firms. Investment taxes have unclear effects since the higher demand for labour is accompanied by a decrease in entrepreneurial effort that lowers the wage level. Finally, a higher price of future consumption, $R$, encourages entrepreneurial effort but the increase in efforts costs makes the change in the number of firms unclear.

Assume quadratic non-specific effort aversion $H = e_i^2/2$ so that $e_i = \tilde{V}_A \pi(1-\tau)/h$ from (2.10). Assume further that agent-specific effort costs $h(i) = \theta i + a$ are linear (where $\theta,\, a > 0$). We can, hence, approximate the various elasticities to be constant, i.e. independent of the individual characteristics of entrepreneurs. For quadratic non-agent specific effort aversion, the partial derivative $e_x$ for a variable $x$ equals $\int_0^{i^*} -\, \partial\Omega/\partial x\, e_i/\tilde{V}_A \pi(1-\tau)\, di$, from (2.10). The elasticities from (2.17) to (2.20), using (2.10), reduce to:

$$\begin{aligned} \frac{\partial i^*}{\partial \tau} &= D^{-1}\tilde{V}_A \pi(1-i^*)\left[1/(1-\tau) - \varepsilon_w^L\right] ?\,; && (2.25) \\ \frac{\partial w}{\partial \tau} &= -D^{-1}\tilde{V}_A \pi\left(e_{i^*}\theta + e_{i^*}L + 1\right) < 0\ ; && (2.26) \\ \frac{\partial i^*}{\partial t} &= D^{-1}\tilde{V}_A \Gamma_t (1-\tau) L\ < 0\,; && (2.27) \\ \frac{\partial w}{\partial t} &= -D^{-1}\Gamma_t e_{i^*}\theta\ > 0. && (2.28) \end{aligned}$$

where $D = e_{i^*}\theta(1-i^*)\varepsilon_w^L + \tilde{V}_A(1-\tau)L\left(e_{i^*}L + 1\right)$ and $\varepsilon_w^L \equiv -L_w/L$. In what follows, it is assumed that labour demand semi-elasticity $\varepsilon_w^L$ exceeds $1/(1-\tau)$ and profit taxes decrease the number of entrepreneurs. In the opposite case, high profit taxes lead to such a decrease in the entrepreneurial effort that the number of entrepreneurs has to increase to compensate this.

## 3. Optimal tax policy

The government sets its tax policy in order to maximize overall welfare:

$$\begin{aligned}
&\int_0^{i^*} \{V^e(i, R, A_i^e(i, R, u, v, \tau, w)) - h(i)H(e_i)\}\, di \qquad (3.1)\\
&\quad +(1-i^*)V^w(R, u, t, w)\\
&\quad +\mu \left\{ \int_0^{i^*} (\, ve_iK + u\,S_i + \tau e_i\pi)\; d\,i\; + (1-i^*)\; (\,u\,S^w + tw\,) \right\}.
\end{aligned}$$

When setting taxes, all the indirect effects on private welfare from changes in the labor force can be ignored, given that the entrepreneurial class is at the private optimum level.[5] The elasticity between entrepreneurial effort $e$ and wages $w$ is given by

$$\varepsilon_w^{e_i} \equiv -\frac{\partial e_i}{\partial w}\frac{w}{e_i} = \frac{wL}{\pi}\,, \qquad (3.2)$$

[5] This differs from Kanbur's (1981) uncertainty model, where the government would like to encourage individuals to become risk takers (entrepreneurs), since the expected marginal utility from this is higher on aggregate than for any single individual since the risk is idiosyncratic.

In the analysis that follows it is cruxial that (3.2) is constant at the optimal level of firms. The various elasticities used later can be held as constant (see equations from (A. 6) onwards in Appendix A). The optimality conditions associated with (3.1) for $\tau, t, v, u$ are shown in Appendix A, as well as the definitions for tax and wage elasticity terms.

### 3.1. Profit and Wage Taxation

Consider first a constrained tax system with a single optimal taxation of profit $\tau$ or wage taxes $t$ when the other tax is exogenous. The semi-elasticity $\varepsilon_y^x = (\partial x/\partial y)/x$ of a variable $x = i^*, w$ with respect to $y = \tau, t$ is defined positive so as to follow an expected sign, i.e. $-\partial i^*/\partial \tau, \partial i^*/\partial t, \partial w/\partial t, -\partial w/\partial \tau > 0$, where there is ambiguity only in the sign of $\partial i^*/\partial \tau$. We can see from Appendix A that

**Proposition 3.1.** *A constrained tax system implies that (i) the optimal tax on profits $\tau$ for an arbitrary wage tax $\hat{t}$ decreases if the semi-elasticities $\varepsilon_\tau^{i^*}$ or $\varepsilon_\tau^w$ increase, and (ii) the optimal tax on wages $t$ for arbitrary profit tax $\hat{\tau}$ decreases if the semi-elasticity $\varepsilon_t^{i^*}$ increases or the semi-elasticity $\varepsilon_t^w$ decreases and $(t - \hat{\tau})\gamma -$*

$\frac{\hat{\tau}}{1-\hat{\tau}} > 0$, *for* $v = u = 0$ *requiring that*

$$\tau \quad = \quad \gamma \frac{1 - \hat{t}\varepsilon_{\tau}^{w} / \frac{\pi}{wL}}{\Delta^{\tau}} ; \tag{3.3}$$

$$t \quad = \quad \frac{\gamma - \hat{\tau}\Delta^{t}}{i^{*}\varepsilon_{t}^{i^{*}} - \gamma\varepsilon_{t}^{w}} \tag{3.4}$$

$$\begin{aligned} \textit{where } \Delta^{\tau} &= i^{*}e_{i^{*}}\varepsilon_{\tau}^{i^{*}} + (\gamma + \frac{1}{1-\tau})\varepsilon_{\tau}^{w} / \frac{\pi}{wL} \\ \Delta^{t} &= i^{*}e_{i^{*}}(\pi/wL)\varepsilon_{t}^{i^{*}} + (\gamma + \frac{1}{1-\tau})\varepsilon_{t}^{w} \ , \end{aligned} \tag{3.5}$$

where $\gamma = (\mu' - \tilde{V}_A)/\mu'$ is the marginal social cost of public funds and $e_{i^*}$ is evaluated at the optimal level of entrepreneurs $i^*$. The semi-elasticity $\varepsilon_{\tau}^{i^*}$ approaches infinity as $\tau$ approaches unity and the semi-elasticity $\varepsilon_{t}^{i^*}$approaches infinity as $t$ approaches unity so that unconstrained tax rates are below unity. This completes the proof.

It is seen that tax-induced larger job/entrepreneur reallocation (the positive semi-elasticity $\varepsilon_{\tau}^{i^*}$increases) and lower aggregate entrepreneurial effort (the semi-elasticity $\varepsilon_{\tau}^{w}$ increases) lowers the single optimal profit tax. Owing to occupational mobility the profit tax is below unity even if the entrepreneurial effort is fixed. The single optimal tax on wages $t$ changes ambiguously since lower entrepreneurial effort (the semi-elasticity $\varepsilon_t^w$ increases) has a positive effect on the optimal wage tax rate. The reason is that lower entrepreneurial effort raises the wage level and, hence, the wage tax base. Only if the arbitrary profit tax rate is sufficiently high, the negative effect on the profit tax base ensures that the wage tax rate goes down.

The non-deductibility of the entrepreneurial effort is also behind the terms $\frac{1}{1-\tau}$. The non-agent specific effort aversion lowers the relative value of private income. The relative marginal utility of raising public revenues is $\gamma + \frac{1}{1-\tau}$ instead of $\gamma$, having a positive effect on optimal taxes. On the other hand, the non-agent specific effort aversion also lowers the effort $e_{i^*}$ and affects the sensitivity of wages and the number of firms to the taxes in (2.25) through (2.28). Higher agent-specific effort aversion (high $\theta$) further raises the sensitivity of wages to taxes and mitigates occupational choice effects.

We can see that the inverse elasticity rule for the optimal wage tax is ambiguous for two reasons. To begin with, discouragement of entrepreneurial effort and higher wages increase the wage tax base. Second, non-agent entrepreneurial effort aversion has no unambiguous relation to optimal wage taxation.

Consider next the optimal setting of both wage and profit taxes from (3.3) and (3.4) using $\left(i^*\varepsilon_t^{i^*} - \gamma\varepsilon_t^w\right)\Delta^\tau - \gamma\varepsilon_\tau^w\Delta^t/\frac{\pi}{wL} = i^* e_{i^*}\varepsilon_t^{i^*}\varepsilon_\tau^{i^*}\Delta$ as the joint denominator and definitions $\varepsilon_t \equiv \varepsilon_t^w/\varepsilon_t^{i^*}$ and $\varepsilon_\tau \equiv \varepsilon_\tau^w/\frac{\pi}{wL}\ /\varepsilon_\tau^{i^*}$ yielding the following:

**Proposition 3.2.** *Unconstrained optimal taxation for $v = u = 0$ requires that*

$$\tau \;=\; \gamma \frac{i^* \varepsilon_t^{i^*} - \gamma(\varepsilon_t^w + \varepsilon_\tau^w / \frac{\pi}{wL})}{i^* e_{i^*} \varepsilon_t^{i^*} \varepsilon_\tau^{i^*} \Delta}\, ; \tag{3.6}$$

$$t \;=\; \gamma \frac{\Delta^\tau - \Delta^t}{i^* e_{i^*} \varepsilon_t^{i^*} \varepsilon_\tau^{i^*} \Delta}, \tag{3.7}$$

where

$$\Delta \equiv i^* - \gamma \varepsilon_t - \left( \gamma - \left( \gamma + \frac{1}{1-\tau} \right) \frac{1}{e_{i^*}} \right) \varepsilon_\tau \; . \tag{3.8}$$

For optimal individual setting of taxes, (3.6) and (3.7) yield

**Proposition 3.3.** *(i) Optimal profit taxes decrease (increase) with occupational mobility effects ($\varepsilon_\tau^{i^*} \uparrow$) if $i^* > (<) \, \gamma \varepsilon_t$ and a wage tax ($\varepsilon_t^{i^*} \uparrow$) has a negative (positive) effect if $i^* \varepsilon_t^{i^*} \gamma / \Delta \varepsilon_t^w \gamma > (<) \, (\varepsilon_t^w + \varepsilon_\tau^w / \frac{\pi}{wL}) \, (1 + \gamma / \Delta \varepsilon_t^w)$ and optimal wage taxes decrease with the occupational mobility effects and profit tax has a negative (positive) effect if $i^* - \gamma \left( \frac{1}{t \varepsilon_t^{i^*}} + \varepsilon_t \right) > (<) \, 0$, (ii) the wage adjustments ($\varepsilon_\tau^w \uparrow$, $\varepsilon_t^w \uparrow$) lower profit taxes for low enough entrepreneurial sector and profit taxes change ambiguously, for $v = u = 0$ the elasticity $\varepsilon_y^x = (\partial x / \partial y) y / x$ of a variable $x = i^*, w$ with respect to $y = \varepsilon_\tau^{i^*}, \varepsilon_t^{i^*}, \varepsilon_\tau^w, \varepsilon_t^w$ are given by*

$$
\begin{aligned}
\varepsilon^{\tau}_{\varepsilon^{i^*}_{\tau}} &= -\Delta^{-1}\left[i^* - \gamma\varepsilon_t\right] \; ; && (3.9)\\
\varepsilon^{\tau}_{\varepsilon^{i^*}_{t}} &= -\gamma\frac{i^*\varepsilon^{i^*}_t/\Delta\varepsilon^w_t - \left(\varepsilon^w_t + \varepsilon^w_\tau/\frac{\pi}{wL}\right)\left(1+\gamma/\Delta\varepsilon^w_t\right)}{i^*\varepsilon^{i^*}_t - \gamma(\varepsilon^w_t + \varepsilon^w_\tau/\frac{\pi}{wL})} \; ; && (3.10)\\
\varepsilon^{\tau}_{\varepsilon^{w}_{\tau}} &= -\varepsilon^{\Delta}_{\varepsilon^{i^*}_{\tau}}\left[1 - \frac{\gamma}{\gamma - \left(\gamma + \frac{1}{1-\tau}\right)/e_{i^*}}\frac{wL}{\tau i^* e_{i^*}\varepsilon^{i^*}_t \pi}\right] \; ; && (3.11)\\
\varepsilon^{\tau}_{\varepsilon^{w}_{t}} &= -\varepsilon^{\Delta}_{\varepsilon^{w}_{t}} - \frac{\gamma\varepsilon_t}{\tau i^* e_{i^*}\varepsilon^{i^*}_\tau \Delta} \; ; && (3.12)\\
\varepsilon^{t}_{\varepsilon^{i^*}_{\tau}} &= -\Delta^{-1}\left[i^* - \gamma\left(\frac{1}{t\varepsilon^{i^*}_t} + \varepsilon_t\right)\right] \; ; && (3.13)\\
\varepsilon^{t}_{\varepsilon^{i^*}_{t}} &= -1 - \frac{\gamma}{\varepsilon^{i^*}_\tau\Delta}\left(\frac{\pi}{twL} + \varepsilon^w_t\right) < 0 \; ; && (3.14)\\
\varepsilon^{t}_{\varepsilon^{w}_{\tau}} &= \varepsilon^{\Delta}_{\varepsilon^{w}_{\tau}}\left[1 + \frac{\gamma}{\gamma - \left(\gamma + \frac{1}{1-\tau}\right)/e_{i^*}}\frac{\left(\gamma + \frac{1}{1-\tau}\right)wL}{t i^* e_{i^*}\varepsilon^{i^*}_t \pi}\right] < 0 \; ; && (3.15)\\
\varepsilon^{t}_{\varepsilon^{w}_{t}} &= \varepsilon^{\Delta}_{\varepsilon^{w}_{t}}\left[1 + \frac{\gamma + \frac{1}{1-\tau}}{t i^* e_{i^*}\varepsilon^{i^*}_\tau}\right] < 0 \, , && (3.16)
\end{aligned}
$$

where $\varepsilon^{\Delta}_{\varepsilon^{w}_{\tau}} \equiv (\partial\Delta/\partial\varepsilon^w_\tau)\varepsilon^w_\tau/\Delta = -\Delta^{-1}\left(\gamma - \left(\gamma + \frac{1}{1-\tau}\right)/e_{i^*}\right)\varepsilon_\tau < 0$, $\varepsilon^{\Delta}_{\varepsilon^{w}_{t}} \equiv (\partial\Delta/\partial\varepsilon^w_t)$ $\varepsilon^w_t/\Delta = -\gamma\Delta^{-1}\varepsilon_t < 0$ from (3.8). It is seen that profit taxes decrease with sufficient tax induced occupational mobility so that $i^* > (<)\,\gamma\varepsilon_t$. However, wage adjustment via entrepreneurial effort may work in the direction of raising the optimal profit tax rate from (3.11). The optimal tax level (through lower denominator $\Delta$) is higher in a way that outweighs in importance the decrease in entrepreneurial effort and production. It can be concluded that with large occupational mobility effects (highly elastic labour demand $\varepsilon_w^L$ and high $\varepsilon_t^{i^*}$and low $\varepsilon_t = \varepsilon_t^w/\varepsilon_t^{i^*}$) and with relatively low size of entrepreneurial class ($\varepsilon^{\tau}_{\varepsilon_{\tau}^{i*}}$ stays negative and $\varepsilon^{\tau}_{\varepsilon_{\tau}^{w}}$ is negative) both occupational mobility and entrepreneurial effort effects lower the optimal profit tax rate. The situation is different in an economy, where large number of entrepreneurs bear the burden of entrepreneurial effort costs and also pay high taxes from profits. In this case, the economy can afford to raise profit taxes when individual entrepreneurial effort decreases.

It is seen that wage taxes decrease due to occupational mobility, unless the optimal profit taxes alter the result from (3.13). From (3.15) and (3.16), an adjustment in entrepreneurial effort unambiguously works in the direction of lowering the optimal wage taxes. This differs from single optimal wage taxation, where the implied higher tax base raises the optimal wage tax level.

It is interesting to compare the results with the constrained equilibrium. In general, the optimal wage tax in an unconstrained system remains different. Arbitrarily low profit taxation leads to the setting of wage taxes at too high a level compared with an unconstrained tax policy. There are many reasons why wage taxes are moderated when profit taxes are optimally set. Firstly, with optimal total taxation higher wages work in the direction of raising profit rather than wage taxes, if any. Second, entrepreneurial effort costs lower the private utility of income that lowers the wage tax rate. If profit taxes are arbitrary, this instead raises the single optimal wage tax. In addition, from (3.15) and (3.16) a high optimal profit tax owing to low $\varepsilon_t^{i^*}$, $\varepsilon_\tau^{i^*}$ reinforces the negative effects of $\varepsilon_t^w$, $\varepsilon_\tau^w$ on wage taxes. Hence, insensitive occupational choice may lead to higher profit taxes rather than wage taxes.

### 3.2. Capital Income Taxation

We can see from Appendix A that

**Proposition 3.4.** *The optimal taxation of savings $u$ and investment $v$ for $t = \tau = 0$ requires that*

$$u = \frac{\gamma\, r}{\varepsilon_r^s}\ ; \tag{3.17}$$

$$v = \frac{\gamma - uc - uA^v - \tau B^v}{(1-uc)K_v L/K(1-i^*) + K^* \varepsilon_v^{i^*}}\ , \tag{3.18}$$

*where*

$$\begin{aligned}
\varepsilon_r^s &\equiv \left( \int_o^{i^*} \frac{\partial\, S(i)}{\partial\, r} di + (1-i^*) \frac{\partial\, S^w}{\partial\, r} \right) \frac{r}{S^{e+w}} \left( 1 - \frac{\partial V_A/\partial R}{R^2} \right)^{-1} \\
A^v &= \left[ c\,(K_v + \pi_v)\, L/(1-i^*) + (S^* - S^w) L \varepsilon_v^{i^*} \right] / K \\
B^v &= \left[ (1-uc)\pi_v L/(1-i^*) + (\pi^* - w) L \varepsilon_v^{i^*} \right] / K\,.
\end{aligned}$$

and where $K_v = \varepsilon_v^w \frac{K(1-i^*)}{L}\left(E\frac{\pi^* L}{\pi(1-i^*)} - \frac{\partial K}{\partial w}\frac{w}{K}\right)$ from (A. 8) and $\pi_v = \varepsilon_v^w \frac{\pi(1-i^*)}{wL}\left(E\frac{\pi^* L}{\pi(1-i^*)} - \frac{\partial \pi}{\partial w}\frac{w}{\pi}\right)$from (A. 10), $\varepsilon_v^w = -(\partial w/\partial v)/w, \varepsilon_v^{i^*} = -(\partial i^*/\partial v)/(1-i^*)$. Savings tax $u$ is negatively related to aggregate savings elasticity $\varepsilon_r^s$, which is positive under homothetic preferences (including the change in the marginal utility of wealth when $R$ goes up). Investment tax $v$ is negatively related to a decrease in the number of entrepreneurs, entrepreneurial effort and physical investment. In the numerator, the second term shows the change in savings tax revenues $u$ from a wealth-induced change in savings and from the change in the number of entrepreneurs. It is seen that profit tax $\tau$ works in the direction of lowering investment tax.

It is seen that the optimal simultaneous taxation of both savings and investment is straightforward, and does not alter the basic insights. It is relatively straightforward to derive weighted average rules for capital continuing with the assumption that $t = \tau = 0$ (or harmonized). The tax rates can be reformulated as $v = rt_s/(1-t_s)$ and $u = rt_r$ where $t_s$ is a tax on investment and $t_r$ is a tax on savings. [See also Keen and Piekkola (1997), Huizinga and Nielsen (1997).] Using now $\rho = r(1-t_r)$ and $F' = r/(1-t_s)$, (3.17) and (3.18) yield after some manipulation

**Proposition 3.5.** *The weighted average rule of capital taxes is for* $t = \tau = 0$

*given by*

$$z\rho + (1-z)F' = r\,, \tag{3.19}$$

*where*

$$z \equiv \frac{\varepsilon_r^s K - \varepsilon_v^{i^*} r[S_i^* - S^w]\frac{L}{K}}{\varepsilon_r^s - \varepsilon_v^{i^*} r[S^* - S^w]\frac{L}{K} + r(K_v L/(1-i^*) + K^* \varepsilon_v^{i^*})}\,. \tag{3.20}$$

The shadow price of capital imports, the interest rate, can be written as a weighted average of the net return on savings $\rho$ and the marginal product of capital $F'$, where the weight is given by $z$. The left shows the optimal relative tax levels. $(1-z)F'$ is the shadow price effects of taxing investment and $z\rho$ is the shadow price of taxing savers. Notice that similarly to Keen and Piekkola (1997), the weight $z$ differs from Horst (1980), where domestic capital income taxes are arbitrary and only the residence and source criteria are optimally determined. It also differs from Keen and Piekkola (1997) and Huizinga and Nielsen (1997) in three respects. To begin with, an 'aggregate investment elasticity' can be thought of as depending on three additional factors. Besides physical capital demand, entrepreneurial effort is subject to changes. Additionally, a possible decrease in the number of entrepreneurs lowers $z$ and increases the shadow price of capital (the left-hand side), since workers save less and savings tax revenues are decreased. This also lowers the optimal tax incidence on savers. Finally, a decrease in the number of firms leads to reduced tax revenues because workers save less than entrepreneurs, $S_i^* - S^w > 0$. This shifts tax criteria towards residence criteria.

We can see that entrepreneurial effects lower the level of investment taxes but raise the optimal incidence on production when $K_v > 0$. Similarly to the comparison of wage and profit taxation, lower optimal taxes on investment are accompanied by a higher incidence of the lower tax on the taxed investment. This is different from the earlier tax literature starting from Diamond and Mirrlees (1971), where profit taxes do not affect entrepreneurial effort and both the optimal investment tax and the tax incidence on production should be set at zero.

## 4. Conclusions

The paper characterizes optimal capital, wage and profit taxes, also placing an emphasis on entrepreneurial effort and occupational mobility. These are important issues, given the higher value accorded in current debate to human capital and a lower emphasis on the non-neutral tax treatment of physical capital. The current trend is to eliminate source-based taxes on production due to tax competitive pressures or tax policy recommendations [see e.g. OECD, 1991]. A separate profit tax is not often considered even though the burden of profit taxes can be very different.

It is shown that the optimal profit tax is likely to be positive but less than unity. With occupational mobility very sensitive to profit tax rate profits should be lightly taxed. However, an arbitrary low level of profit taxes is also harmful. Induced high taxes on wages and lower entrepreneurial effort may lower national income and affordable taxes. All this is in sharp contrast to the conventional pure profit taxation following Diamond Mirrless (1971), where all profits should be fully taxed. There rather exists a similar trade-off in taxing profit and wage incomes as is already perceived to exist in the taxation of savings and investment. The paper, hence, suggests a splitting of tax incidence between entrepreneurs and wage-earners when human capital inherit in entrepreneurship is essential. In this setting, occupational mobility effects are rather intuitive, while an increase in entrepreneurial effort costs may increase the optimal profit tax rate.

The optimal setting of capital taxes has been considered in many previous papers and the implications for the optimal tax criteria are apparent. What is the consequence of the considerations above on the international setting of profit and wage taxes? It is precisely the international mobility of labor (or perhaps the international allocation of firms) that would crucially affect the tax incidence so that the weighted average rules are directly applicable. The general rule is that higher optimal tax revenue should be accompanied by lower tax incides. We have allowed only capital to be internationally mobile, where the weighted average rule is then directly applicable. The effects of entrepreneurial effort and the choice of occupation both raise the optimal incidence of taxes on physical capital, but with lower level of the taxes. We have also considered an optimal tax policy for a small open economy. One would expect the analysis to apply also for a single large open economy fully tax cooperating with its neighboring countries so that the terms-of-trade manipulation can be ignored, indeed the case in the consideration of the optimal intergenerational capital taxation in Piekkola (1995).

# A. Proof of Propositions

The first-order-conditions with respect to profit tax $\tau$, wage tax $t$, investment tax $v$ and savings tax $u$ are from (2.2), (2.6), (2.7), (2.9) and (3.1) given by:

$$\begin{aligned} 0 = \; & \tilde{V}_A \left\{ (1-\tau) \int_0^{i^*} e_i \frac{\partial \pi}{\partial \tau} \, di \right. \\ & \left. + (1-t)(1-i^*) \frac{\partial w}{\partial \tau} - \int_0^{i^*} e_i \pi \, di \right\} \\ & + \mu' \left\{ (1-uc) \int_0^{i^*} e_i \pi \, di + [\tau + (1-\tau)uc] \int_0^{i^*} \frac{\partial (e_i \pi)}{\partial w} \frac{\partial w}{\partial \tau} \, di \right. \\ & + [t + (1-t)uc](1-i^*) \frac{\partial w}{\partial \tau} \\ & \left. + [v + (1-v)uc] \int_0^{i^*} \frac{\partial (e_i K)}{\partial w} \frac{\partial w}{\partial \tau} \, di + \frac{\partial B^*}{\partial i^*} \frac{\partial i^*}{\partial \tau} \right\} \end{aligned} \tag{A. 1}$$

$$\begin{aligned} 0 = \; & \tilde{V}_A \left\{ (1-\tau) \int_0^{i^*} e_i \frac{\partial \pi}{\partial t} \, di \right. \\ & \left. + (1-i^*) \left( (1-t) \frac{\partial w}{\partial t} - w \right) \right\} \\ & \mu' \left\{ (1-i^*) \left( [t + (1-t)uc] \frac{\partial w}{\partial t} + w(1-uc) \right) + [\tau + (1-\tau)uc] \right. \\ & \left. \int_0^{i^*} \frac{\partial (e_i \pi)}{\partial w} \frac{\partial w}{\partial t} di + (v + (1-v)uc) \int_0^{i^*} \frac{\partial (e_i K)}{\partial w} \frac{\partial w}{\partial t} \, di + \frac{\partial B^*}{\partial i^*} \frac{\partial i^*}{\partial t} \right\} \end{aligned} \tag{A. 2}$$

$$
\begin{aligned}
0 \;=\; & \tilde{V}_A \left\{ (1-\tau)\int\limits_0^{i^*} e_i \frac{\partial \pi}{\partial w} di - \int\limits_0^{i^*} e_i K di \right. \\
& \left. +(1-t)(1-i^*)\frac{\partial w}{\partial v} \right\} \\
& +\mu' \left\{ (1-uc)\int\limits_0^{i^*} e_i K di + [v+(1-v)uc]\int\limits_0^{i^*} \frac{\partial(e_i K)}{\partial v} di \right. \\
& +[\tau+(1-\tau)u\,c]\int\limits_0^{i^*} \frac{\partial(e_i \pi)}{\partial v} \\
& \left. +(1-i^*)[t+(1-t)uc]\frac{\partial w}{\partial v} + \frac{\partial B^*}{\partial i^*}\frac{\partial i^*}{\partial v} \right\}
\end{aligned}
\tag{A. 3}
$$

$$
0 = \frac{\partial \tilde{V}_A}{\partial R}\frac{\partial R}{\partial u} A^{e+w} - \tilde{V}_A S^{e+v} + \mu' \left[ S^{e+v} + \frac{\partial S^{e+v}}{\partial u} \right], \tag{A. 4}
$$

where $B^* \equiv \int\limits_0^{i^*} (\,v e_i K + u\,S_i + \tau e_i \pi)\; d\,i \,+ (1-i^*)\;(\,u\,S^w + tw\,)$, $c = (\partial C_1/\partial I)R$ is the propensity to consume, $A^{e+w} \equiv \int\limits_0^{i^*} A_i di + (1-i^*)A^w$ is the aggregate wealth and $S^{e+w}$ is the analogous aggregate savings. Using (2.16), implying $\int\limits_0^{i^*} e_i \frac{\partial \pi}{\partial w} di$

$= -L\int_0^{i^*} e_i di = -(1-i^*)$ and $\varepsilon_w^{e_i}$ from (3.2) it appears for $y = w, \tau, t, v$ that

$$\int_0^{i^*} e_i \frac{\partial \pi}{\partial y}\, di = \int_0^{i^*} e_i \pi_w \frac{\partial w}{\partial y} = -(1-i^*)\frac{\partial w}{\partial y}, \tag{A. 5}$$

$$\int_0^{i^*} \frac{\partial e_i}{\partial y}\pi\, di = -\varepsilon_w^{e_i}\int_0^{i^*} \frac{e_i \pi}{w}\frac{\partial w}{\partial y} di = -\frac{1-i^*}{1-\tau}\frac{\partial w}{\partial y}, \tag{A. 6}$$

$$\int_0^{i^*} \frac{\partial (e_i K)}{\partial v} di = K_v, \tag{A. 7}$$

$$\begin{aligned} \textit{where } K_v &\equiv \left(-\frac{\partial w}{\partial v}\right) - \int_0^{i^*} e_i K \left(\frac{\partial e_i}{\partial w}\frac{1}{e_i} + \frac{\partial K}{\partial w}\frac{1}{K}\right) \\ &= \varepsilon_v^w \frac{K(1-i^*)}{wL}\left(E - \frac{\partial K}{\partial w}\frac{w}{K}\right); \end{aligned} \tag{A. 8}$$

$$\int_0^{i^*} \frac{\partial (e_i \pi)}{\partial v} di = \pi_v \tag{A. 9}$$

$$\begin{aligned} \textit{where } \pi_v &\equiv \left(-\frac{\partial w}{\partial v}\right) - \int_0^{i^*} e_i \pi \left(\frac{\partial e_i}{\partial w}\frac{1}{e_i} + \frac{\partial \pi}{\partial w}\frac{1}{\pi}\right) \\ &= \varepsilon_v^w \frac{\pi(1-i^*)}{wL}\left(1 - \frac{\partial \pi}{\partial w}\frac{w}{\pi}\right) \end{aligned} \tag{A. 10}$$

Using (A. 5) through (A. 8) and the definitions $\varepsilon_t^w \equiv \frac{\partial w}{\partial t}\frac{1}{w}$, $\varepsilon_\tau^w \equiv -\frac{\partial w}{\partial \tau}\frac{1}{w}$, $\varepsilon_v^w \equiv -\frac{\partial w}{\partial v}\frac{1}{w}$ and $\pi^* \equiv \partial\int_0^{i^*}\pi_i di^*/\partial i^* = e_{i^*}\pi$, $K^* \equiv \partial\int_0^{i^*} K_i di^*/\partial i^* = e_{i^*}K$, $S^* \equiv \partial\int_0^{i^*} S_i di^*/\partial i^* =$

$e_{i^*}S$ the FOCs reduce to

$$\begin{aligned}
0 &= \tilde{V}_A \left\{ w(1-i^*)(1-\tau)\varepsilon_\tau^w - (1-t)w\left(1-i^*\right)\varepsilon_\tau^w - \pi(1-i^*)/L \right\} \\
&+ \mu' \left\{ (1-uc)\pi(1-i^*)/L \right. \\
&+ [\tau + (1-\tau)uc](1-i^*)w(1+\frac{1}{1-\tau})\varepsilon_\tau^w \\
&- [t + (1-t)uc]w(1-i^*)\varepsilon_\tau^w - [v + (1-v)uc]K_\tau \\
&\left. + \left[\tau e_{i^*}\pi + vK^* - tw + u(S^* - S^w)\right] \frac{\partial i^*}{\partial \tau} \right\}
\end{aligned} \tag{A. 11}$$

$$\begin{aligned}
0 &= \tilde{V}_A \left\{ w(1-i^*)(1-t)\varepsilon_t^w - (1-\tau)w(1-i^*)\varepsilon_t^w - w(1-i^*) \right\} \\
&+ \mu' \left\{ w(1-i^*)\left( [t + (1-t)uc]\varepsilon_t^w + 1 - uc \right) \right. \\
&- (\tau + (1-\tau)uc)w(1-i^*)(1+\frac{1}{1-\tau})\varepsilon_t^w \\
&\left. - (v + (1-v)uc)\, K_t + \left[\tau e_{i^*}\pi + vK^* - tw + u(S^* - S^w)\right] \frac{\partial i^*}{\partial t} \right\}
\end{aligned} \tag{A. 12}$$

$$
\begin{aligned}
0 &= \tilde{V}_A \left\{ -K(1-i^*)/L + (1-\tau)w(1-i^*)\varepsilon_v^w - (1-t)w(1-i^*)\varepsilon_v^w \right\} \quad \text{(A. 13)} \\
& \mu' \left\{ (1-uc)K(1-i^*)/L - [v+(1-v)u\,c]K_v \right. \\
& \quad -[\tau+(1-\tau)uc][\pi_v - w(1-i^*)\varepsilon_v^w] - [t+(1-t)uc]w(1-i^*)\varepsilon_v^w \\
& \quad \left. + [\tau\pi^* + vK^* - tw + u(S^* - S^w)] \frac{\partial i^*}{\partial v} \right\}
\end{aligned}
$$

$$
0 = \frac{\partial \tilde{V}_A}{\partial R} \frac{\partial R}{\partial u} A^{e+w} - \tilde{V}_A S^{e+v} + \mu' \left[ S^{e+v} - \frac{\partial S^{e+v}}{\partial r} \right] \qquad \text{(A. 14)}
$$

Solving for tax parameters gives

Profit tax:

$$
\tau = \frac{\gamma \left[ 1 - t\varepsilon_\tau^w / \frac{\pi}{wL} \right] + uc \left[ 1 - (\frac{1}{1-\tau} + t)\varepsilon_\tau^w / \frac{\pi}{wL} \right] - uA^\tau - vB^\tau}{\left[ \gamma + \frac{E}{1-\tau} - uc(1 + \frac{E}{1-\tau}) \right] \varepsilon_\tau^w / \frac{\pi}{wL} + i^* e_{i^*} \varepsilon_\tau^{i^*}} \qquad \text{(A. 15)}
$$

where

$$
\begin{aligned}
\varepsilon_\tau^{i^*} &= -\frac{\partial i^*}{\partial \tau} \frac{1}{i^*}, \\
A^\tau &= c[\pi_\tau + (1-v)K_\tau]/\pi + ((S^* - S^w)(1-i^*)/\pi)\varepsilon_\tau^{i^*} \\
B^\tau &= \left( K_\tau / L + K^* \varepsilon_\tau^{i^*} \right)(1-i^*)/w
\end{aligned}
$$

and

$$\gamma \equiv \frac{\mu' - \tilde{V}_A}{\mu'} \tag{A. 16}$$

is the marginal social cost of public funds and $M \equiv h' i^*/h$ measures agent-specific effort aversion. Wage tax is equally given by

$$\begin{aligned} t\left[(\gamma - uc)\,\varepsilon_t^w - i^* \varepsilon_t^{i^*}\right] \quad = \quad & -\gamma + \tau\varepsilon_t^w \left[\gamma + \frac{1}{1-\tau} \right. \\ & \left. -uc(1 + \frac{1}{1-\tau})\right] \\ & -uc(1 + (\frac{1}{1-\tau} + t)\varepsilon_t^w) \\ & +[v + uc(1-v)]K_t \\ & + \left[\tau i^* e_{i^*}\pi/wL + vK^*/wL + u(S^* - S^w)/wL\right]\varepsilon_t^{i^*} \end{aligned} \tag{A. 17}$$

where

$$\begin{aligned} \varepsilon_t^{i^*} \quad &= \quad \frac{\partial i^*}{\partial t}\frac{1}{i^*} \\ B^t \quad &= \quad ; \end{aligned}$$

Investment tax:

$$
\begin{aligned}
& v[(1-uc)K_w L/(1-i^*)\varepsilon_v^w + K^* \varepsilon_v^{i^*} L] && \text{(A. 18)} \\
= \quad & (\gamma - uc)K(1-i^*)/L - (1-uc)\tau\pi_v L/(1-i^*)\varepsilon_v^w \\
& -(1-uc-\tilde{V}_A/\mu')(t-\tau)wL\varepsilon_v^w \ , \\
& -(\tau\pi^* L - twL)\varepsilon_v^{i^*} \\
& -u\left(c(K_w+\pi_w)\,\varepsilon_v^w L/(1-i^*) + (S^*-S^w)L\varepsilon_v^{i^*}\right.,
\end{aligned}
$$

where

$$\varepsilon_v^{i^*} = -\frac{\partial i^*}{\partial v}\frac{1}{1-i^*}$$

Savings tax:

$$u = \frac{\gamma\, r}{\varepsilon_r^s} \ , \qquad \text{(A. 19)}$$

where $\varepsilon_r^s \equiv \left(\int_o^{i^*} \frac{\partial\, S_i}{\partial\, r}di + (1-i^*)\frac{\partial\, S^w}{\partial\, r}\right)\frac{r}{S^{e+w}}\ \left(1 - \frac{\partial V_A/\partial R}{R^2}\right)^{-1}$ is the aggregate savings elasticity. The tax formulas for investment and savings taxes in the text are straightforward. (A. 15) and(A. 17) yield, after some manipulation, the reduced form of profit and wage tax rates given in the text.

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