Dividend and Capital Gains Taxation in a Cross-Section of Firms

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Abstract

I reconsider the effect of capital income taxation on firm size and firm growth by embedding the nucleus theory of firm development of Sinn (1991) into a framework of monopolistic competition with new firm creation. In a turnover of firms, firm destruction is counterbalanced by a permanent creation of new firms. Young firms are set up using an initial capital infusion of new equity and undergo an intermediate stage of internal growth until they finally reach a steady payout stage. The cross-section then contains firms of all ages and development stages.

Dividend and capital gains tax have important effects on initial firm size and growth but also on the creation of new firms and thus on diversity in the economy. First, a differential treatment of dividends and capital gains introduces a distortion in the allocation of capital across firms. Second, dividend as well as capital gains tax are anticipated at the start-up stage of firms. While leaving the firm specific capital stock unaffected, the capitalisation is shown to depress firm creation and aggregate capital accumulation.

Keywords: capital income taxation, investment, firm creation, aggregate production.
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1 Introduction

Capital income taxes receive prime attention in popular discussions on capital accumulation and new firm creation. Politicians are highly interested in likely consequences of changes in the dividend and capital gains taxes. Research in public finance however does not give univocal support for some of the most often cited arguments. The discussion in the literature centers around the so called old and new view of dividend taxation where the main difference lies in the marginal source of investment funds. The derivation of the two different views is typically based on a partial, dynamic firm model. Auerbach (2002) summarises the basic setup.

The traditional old view argues that new equity is used as the marginal source of investment finance. The investment calculus is based on an investor comparing an additional capital infusion into the firm with an alternative investment at the market rate of return. If repayments to firm investments are subject to the dividend tax, then the investor will request a higher pre-tax yield from the firm increasing its cost of capital and thus depressing marginal investments. If firms finance additional investments using new equity, then dividend and investment policy are not directly connected. It is typically assumed that dividend policy is then used as a signalling instrument where the effectiveness of the instrument is determined by its costs, the tax disadvantage of dividends versus capital gains. An increase in the dividend tax should allow a smaller dividend to communicate the same signal. The old view predicts that dividend payments decline with an increase in the dividend tax, see the version of the old view presented by Poterba and Summers (1985).

The new view, sometimes referred to as the trapped equity view, in contrast uses retained earnings as the source of marginal investments. According to this approach, investors decide between receiving a taxable dividend payment today or reinvesting profits which postpones the taxable dividend payment into the future. Since dividend taxes are due anyway, they drop out of the investment calculus and will have no effect on marginal investment decisions. Tax changes, however, affect future payments to investors and are fully capitalised into firm values. According to the new view, firms pay dividends if they have no profitable investment opportunities at hand. If the dividend tax changed permanently, then firms would still have the same excess cash flow to distribute so that dividends stay unaffected. Payouts are a residual.

In explaining aggregate behavior of an economy, both views have some intuitive applications in mind. The old view's focus on new equity finance is relevant for new firms with no free cash flow while the use of profit retentions is plausible for large established firms with high free cash flow at hand. None of the two views seems completely convincing as a description of the "representative" firm. Neither do firms regularly issue new equity, see Auerbach and Hassett

(2003), so that the old view would be an adequate description of aggregate behavior, nor does it seem plausible to focus on mature firms only and ignore new firms that depend on external funds as done by the new view. In reality a mixture or combination of both streams seems appropriate.

Despite the distinct differences of the two views, testing for the two views of dividend taxation has turned out to be difficult. The most often cited empirical estimation supporting the old view goes back to Poterba and Summers (1985). Given that old and new view have opposing predictions related to the shadow price of capital q, Poterba and Summers (1985) estimate an aggregate measure of q and find results in favour of the old view. In general however, estimations based on the q theory of firm investment have proven to be hard to estimate and have only recently provided meaningful results, see Hassett and Hubbard (2002). The results can thus be critisized for technical reasons. In addition, Auerbach and Hassett (2003) emphasise that the estimation of Poterba and Summers (1985) would only contradict the tax capitalisation and not the cost of capital prediction of the new view. Auerbach and Hassett (2003) then try to test the new view's neutrality result more closely by looking at the relationship between dividend payments and new investments. They find that, in line with the new views predictions, *mature* firms decrease dividend payments in response to profitable investment opportunities which makes retentions the marginal source of investment funds. Their result applies mostly to mature firms, while in general there seems to be considerable heterogeneity concerning the marginal source of investments. Auerbach and Hassett (2003) conclude that "[t]he discretness of the regimes is really just a useful simplification." Old and new view seem to be relevant for a subsample of firms.

Sinn (1991) provides an important addition to the theoretical literature which can be interpreted in line with these recent empirical findings. His model descibes a tax induced life-cycle of firm evolution. Initially, a new firm is set up using new equity and thus follows the old view of dividend taxation. The firm then starts to grow to a mature state by retaining all internal funds. The mature state is achieved when retaining additional funds is no longer profitable. In the mature state, the firm thus follows the new view. The firm only starts to pay dividends once it has finished growing and there are no profitable investment opportunities at hand. Defending the new view, Sinn (1991, p. 295) argues that the last stage seems to describe real world best but agrees that new firms are better described using the first phase with new equity as the marginal source of finance.

Empirical work has provided some insights into new firm creation and capital income taxation. Rosen (2002) summarises the literature and emphasises that taxation is an important determinant of firm creation and firm growth. While the old view with its focus on new equity finance can be interpreted as looking exactly at newly founded firms, the new view predicts no real effect of dividend taxation on marginal investment decisions but a capitalization of tax payments in firm values. However, taxation has consequences for new firm creation if future tax payments are anticipated by new entrepreneurs faced with the discrete decision of starting a venture. Gompers and Lerner (1998) provide additional support for the influence of taxes on firm creation. They look at the market for venture capital, typically used at the creation stage of firms, and find that demand for venture capital is highly sensitive to changes in the capital gains tax. Taken together, we suppose that an important burden of dividend and capital income taxes falls on new firm creation and incorporating new firm creation seems to add a very relevant margin to the discussion on the real effects of dividend and capital gains taxation.

Given the insights of partial equilibrium models as well as anecdotical evidence, we expect that capital income taxation will influence the growth of established firms as well as the creation of new firms. Consequently, an integrated approach on the economic effects of dividend and capital gains taxation must not stop with the single firm case but rather consider the problem in a macroeconomic environment with firm heterogeneity and new firm creation. Our approach is thus to embed the dynamic firm model of Sinn (1991) into a turnover model of new firm creation and destruction. Given the permanent creation of new firms, the cross section will contain firms of all development stages and show a heterogeneity of firms just as described in the recent empirical literature. This will allow us to capture the different implications that dividend and capital gains tax might have on young and mature firms. While repeating result for single firm case, this approach will allow the calculation of aggregate measures and their movement in response to changes in tax parameters.

Coexistence of new and mature firms in the presence of dividend and capital gains taxes poses some systematical problems. If new and mature firms would produce the same good, then the competitive market price would reflect the low cost of capital of mature firms when using profit retentions. New firms with external equity could only produce at higher tax adjusted opportunity costs of capital and would therefore possibly not be founded at all, see Judd and Petersen (1986). New firms thus have to have some sort of advantage in order to justify their creation. On the other side, we want mature firms to approach some finite firm size, a feature that is also not present in a standard neoclassical model. Both problems are solved by a revenue function with declining returns as in Sinn (1991). While he considers a production function with decreasing returns to scale and a competitive output market, the same revenue function follows from a downward sloping demand curve and a production function with constant rates of return.[1] As stressed by McGee (1998), the market power approach of a monopolistic competition model captures typical arguments raised when discussing new firm creation. New firms are not perfect competititors for established firms but concentrate on new, innovative products.

This paper expands the basic setup of monopolistic competition by describing a single firm along the lines of the nucleus theory of firm evolvement. A firm is set up at a fixed cost and is endowed with an initial capital infusion using new equity. Because of its monopolistic power, the firm then starts generating profits which are, at first, reinvested to increase its capital stock. If the firm finally reaches a mature status, it starts paying out all additional profits as dividends. The growth period of individual firms is solely a tax effect and hence greatly sensitive to tax rates. Firm destruction happens due to adverse shocks with an exogenous hazard rate. In equilibrium, the turnover of firms guaranties a stable distribution of firms of all development stages, see Caves (1998).

The paper is new in its combination of the typical dynamic firm model used to analyse capital income taxation with a macroeconomic model of monopolistic competition. The concept of monopolistic competition has however been used intensively to analyse related problems. Keuschnigg (2001) considers the trade-off between bigger and smaller production units using a vintage model of firm investment. In his model there are trade-offs between the size and the growth rate of firms. Recently, Klette and Kortum (2002) considered the innovation process of firms and have combined a model of monopolistic competition with firm level evidence on R&D and the size of firms. Firm heterogeneity is obtained by a variable number of goods that a firm produces while the production capacity for each good, which is heterogeneous in our setup, is fixed in their work. Much of the endogenous growth literature following Romer (1990) is based on the microeconomics of monopolistic competition. There exists a variety of papers that consider taxation of labour, physical and human income in this growth context. None of these models considers capital income taxation in greater detail. Judd (1997) is most similar to our model. It is different from the paper here as it does not consider new firm creation and does not distinguish between dividend and capital gains taxation. His focus lies on the optimal trade-off between capital and labour taxation while we are interested in dividend versus capital gains taxation.

The paper proceeds as follows. The subsequent section establishes the equilibrium outcome by introducing the production setup with final and intermediate goods producers as well as consumers together with their dynamic behavior and then calculates macroeconomic aggregates.

[1] Consider a linear homogenous production function with a demand function of constant elasticity $\frac{1}{1-\varepsilon}$, the revenue function can be written as $R = p \cdot K = (const. \cdot K^{1-\varepsilon})K = const. \cdot K^{\varepsilon}$, identical to a decreasing returns to scale technology with exogenous pricing. See McGee (1998, p. 659).

The following part then focuses on the effects of the capital gains and dividend tax. We discuss changes in individual firm behavior and macroeconomic aggregates as well as empirical implications of the model and optimal capital income taxation. The final section summarizes our results.

2 The Model

2.1 Final good producers

We consider a two stage production technology following Ethier (1982) which is based on the formulation of monopolistic competition by Spence (1976) and Dixit and Stiglitz (1977). Production Y_i of a final good producer i makes use of labour L_i and a diversified intermediate capital good x_{ij} produced by different firms $j = 1, .., N$. The production function is such that different capital goods are imperfect substitutes with a substitution elasticity of $\frac{1}{1-\varepsilon}$ between each two of them.

$$Y_i = \left[\int_0^N (x_{ij})^{\varepsilon} \, dj \right]^{\frac{\alpha}{\varepsilon}} L_i^{1-\alpha} \tag{1}$$

We will assume $\alpha < \varepsilon$ for decreasing returns to scale in both productive factors, capital and diversity of intermediate goods.[2] The price of the final output good is taken as a numeraire. Final good producers are faced with a perfectly competitive market which eliminates their profits. Being price-takers in the markets for intermediate goods they minimize production costs by choosing an optimal allocation between different intermediate goods.

$$\max Y_i - w \cdot L_i - \int_0^N p_j x_{ij} dj$$

$$FOC : \alpha \left[\int_0^N (x_{ij})^{\varepsilon} dj \right]^{\frac{\alpha}{\varepsilon}-1} L_i^{1-\alpha} (x_{ij})^{\varepsilon-1} = p_j \tag{2a}$$

$$(1-\alpha) \frac{Y_i}{L_i} = w \tag{2b}$$

We define $Y = \int Y_i di$, $x_j = \int x_{ij} \, di$ and $L = \int L_i di = 1$. Now using the definition of Y_i and the constant labor-output-ratio, we can add up over all L_i and find the demand for intermediate

[2] Notice that a version of the model with symmetric inputs of intermediate goods can be written as $Y = N^{\frac{\alpha}{\varepsilon}-\alpha} \cdot (Nx)^{\alpha}$. The assumption of $\alpha < \varepsilon$ is true for a typical calibration of the model and rules out endogenous growth, see the discussion in Romer (2001, p. 110).

products:

$$x_j = \left[\frac{\alpha}{p_j \, Y^{\frac{\varepsilon-\alpha}{\alpha}}} \right]^{\frac{1}{1-\varepsilon}} \tag{3}$$

The final output good serves as consumption as well as input good for setting up the capital stock of intermediate good producing firms. We will come back to the usage of final goods at a later stage. Because of the competitive nature of the final good producing industry, firms make zero profits and also have zero firm values so that neither dividend nor capital gains taxes are relevant. We can now turn to the intermediate goods producing firms which will be at the centre of the analysis.

2.2 Intermediate goods producing firms

Each diversified good is produced by a single, profit maximising firm. An investor expects to receive the market rate of return from his investments in such a firm. Return to firm value $V_j(t)$ can be made using dividends $D_j(t)$ (upon which a dividend tax τ is levied) or capital gains $\dot{V}_j(t) - VN_j(t)$ (who pay a capital gains tax c). Capital gains are changes in firm value $\dot{V}_j(t)$ that are not due to new equity issues $VN_j(t)$. We will assume that firm destruction takes place with an exogenous hazard rate of δ. Anticipating the final outcome, we take the real rate of return r as constant over time. The capital market equilibrium then requests:

$$(r+\delta)V_j(t) = (1-\tau)\, D_j(t) + (1-c)\left[\dot{V}_j(t) - VN_j(t)\right] \tag{4}$$

The capital gains tax rate c is an *effective* tax rate. As the tax is due only when capital gains are realized, it allows for tax deferral as well as evasion strategies. Both will tend to decrease the effective tax burden below the statutory rate. In applied studies it is therefore common practise to use half of the statutory rate as an approximation for the effective one. We assume that firm destruction is not eligible for (negative) capital gains taxes that is, investors are assumed not to have an offsetting opportunity. We can then see that the market rate of return is augmented by the depreciation rate reflecting the possibility of firm failure. Equation (4) can be evaluated to

$$V_j(t) = \int_t^{\infty} \left[\frac{1-\tau}{1-c} D_j(s) - VN_j(s) \right] \exp\left(-\frac{r+\delta}{1-c}\,(s-t) \right) ds. \tag{5}$$

Firm value is a sum of future net after taxes payouts to investors $\frac{1-\tau}{1-c}D_j(s) - VN_j(s)$ discounted using the factor $\frac{r+\delta}{1-c}$. Firms are assumed to operate at a linear production function that uses capital $K_j(s)$ as the only input good where the capital stock evolves according to the familiar law of motion

$$\dot{K}_j(s) = I_j(s) \tag{6}$$

where $I_j(s)$ are new investments made out of the final good. Production possibilities are limited by the capital stock $x_j(s) \leq K_j(s)$. There are no fixed or variable costs implying that firm profits equal revenues $\pi_j(s) = p_j(s) \cdot x_j(s)$. The firm is then faced with a cash flow constraint

$$p_j(s)\, x_j(s) + VN_j(s) = D_j(s) + I_j(s)\,. \tag{7}$$

Inflows are profits and new equity and outflows are dividends and new investment. As a monopolist the firm can set prices to maximise its profit using the demand function (3). Corporate financial policy is constrained by the two standard assumptions that dividends and new equity are non-negative. The general setup of a firm is not different from well known results, so that we can postpone the formal solution to the appendix and state only the most important results here.

Firms undergo an evolution beginning with their birth followed by a growth stage to a mature status. The three cases describe the nucleus theory as in Sinn (1991):[3]

1. Start-up Firm
   This is only a momentary state of setting up the firm. New equity is the marginal source of investments and the firm thus reflects the "old“ view of dividend taxation so that the shadow price of capital equals one $q(0) = 1$. Because of the cash flow and capital accumulation condition we find $I(0) = VN(0) = K(0)$. The initial capital stock will be set to a fraction $\kappa(\tau, c, \varepsilon)$ of the final one.

$$K(0) = \kappa(\tau, c, \varepsilon)\, K(T) \tag{8}$$

   The choice of κ will reflect an optimal trade-off between tax considerations and the timely usage of the monopoly power. Based on the differential treatment of dividends versus capital gains, firms will prefer to retain profits and grow internally. The possibility to generate supernatural profits due to the monopoly power on the other side, asks for a high capital stock right from the start and an early start of the final payout phase. An in depth analysis is postponed to the general section on taxation.

[3]From now on, we will count time beginning from the start of the firm. It reaches the steady state after time T. Values indexed T are then representative for the steady state of a mature firm. By the symmetry of firms of the same age we will also drop the index j.

2. Growing Firm

   Given its initial capital stock, the firm starts generating profits and retaining them in order to built up the remaining share $1-\kappa(\tau,c,\varepsilon)$ of its capital stock. Marginal source of new investments are now retained earnings. There are no payouts so that all free cash flow is invested in increasing the capital stock.

$$I(s) = p(s)\,K(s) = \frac{\alpha}{Y^{\frac{\varepsilon-\alpha}{\alpha}}} \cdot K(s)^{\varepsilon}$$

   This is in an intermediate growth stage during which the capital stock increases permanently. The evolvement of the capital stock follows the closed form:

$$K(t) = \left[\frac{\alpha}{Y^{\frac{\varepsilon-\alpha}{\alpha}}}\left(\varepsilon\frac{1-c}{r+\delta} - (1-\varepsilon)(T-t)\right)\right]^{\frac{1}{1-\varepsilon}} \tag{9}$$

   The length of the growth period depends again on the initial share of the capital stock $\kappa(\tau,c,\epsilon)$ as well as the monopolistic power and the cost of capital.

$$T = \frac{\varepsilon}{1-\varepsilon}\frac{1-c}{r+\delta}\left(1-\kappa(\tau,c,\varepsilon)^{1-\varepsilon}\right) \tag{10}$$

   The growth period depends on on the financial share of retentions κ in a nonlinear way reflecting the accelerating growth of firms following the dynamic monopolistic price setting.

3. Mature Firm

   Once the final capital stock is reached, the firm finds itself in a steady payout state with no new investments $I(T) = 0$ (remember that we assumed no depreciation of capital at the firm level, only the firm as a whole can decease). The firm has retained profits until the point when this was no longer profitable. Now, firm profits will be fully paid out to investors as dividends. The mature status thus follows the "new“ view so that the shadow price of capital reflects the differential between dividend and capital gains tax rates $q(T) = \frac{1-\tau}{1-c}$.

   The firm will use a typical markup price-setting rule over the marginal costs using its monopolistic power. Marginal costs related to an increase in the capital stock are given by the opportunity costs of renting a unit of capital at the discount rate $\frac{r+\delta}{1-c}$.

$$p(T) = \frac{1}{\varepsilon} \cdot \frac{r+\delta}{1-c} \tag{11}$$

$$K(T) = \left[\varepsilon\frac{1-c}{r+\delta}\frac{\alpha}{Y^{\frac{\varepsilon-\alpha}{\alpha}}}\right]^{\frac{1}{1-\varepsilon}} \tag{12}$$

$$D(T) = \left(\frac{\alpha}{Y^{\frac{\varepsilon-\alpha}{\alpha}}}\right)^{\frac{1}{1-\varepsilon}}\left[\varepsilon\frac{1-c}{r+\delta}\right]^{\frac{\varepsilon}{1-\varepsilon}} \tag{13}$$

Figure 1 gives the graphical intuition of firm growth. Capital stock $K(t)$ and shadow price $q(t)$ follow the differential equations (A.6a) and (A.6b) and thereby provide a smooth transition between the start phase and the mature state. While the start phase is only valid momentarily, the final state is valid until the firm depreciates.

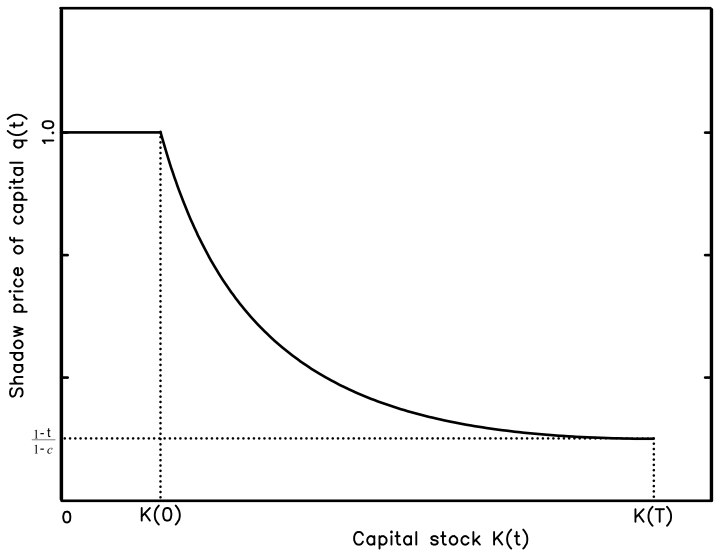

Figure 1: Growth path of a single firm

Having determined firm behavior, we can now calculate initial firm value using (5). We have already seen that there is a capital infusion $VN(0)$ at the beginning of the firm life-cycle followed by a period of length T with internal growth and neither new equity nor dividend payments until the firm reaches a steady payout phase with dividends $D(T)$. We can then give two useful measures of firm value at time 0:

$$\begin{aligned} V(0) &= \frac{1-\tau}{1-c} D(T) \int_T^\infty \exp\left(-\frac{r+\delta}{1-c} s\right) ds - VN(0) \\ &= \frac{(1-\tau)\cdot D(T)}{r+\delta} \exp\left(-\frac{r+\delta}{1-c} T\right) - VN(0) \end{aligned} \tag{14}$$

Firm value equals the present value of a discounted stream of dividend payments starting after the growth period.

2.3 Equilibrium

We will assume that developing a new product causes a fixed cost of a. These costs refer to a nonproductive start-up investment made out of the final good. Free entry of new intermediate goods producing firms will ultimately eliminate excess profits in the sector. In general, setting up a new firm is profitable if $V(0) \geq a$ and firm profits $V(0)$ are decreasing in the firm variety N. If we would have $V(0) > a$ so that there are too few firms then firm creation NN would take place until profits are finally eliminated.

Firms of all age depreciate at a constant rate of δ. Once a firm dies, its capital stock as well as the fixed costs are lost. In an aggregated version, a fraction δ of all firms and thus of overall capital will depreciate and resemble economic depreciation. If the economy would start with a firm number that is too high so that $V(0) < a$, then no new firm creation would take place and depreciation of firms would reduce firm diversity. The only stable long-run equilibrium then is characterised by the equilibrium conditions

$$V(0) = a \tag{15}$$

$$\dot{N} = NN - \delta N = 0 \tag{16}$$

New firm creation will balance depreciation of firms so that the total number of firms stays constant. By the constant rate of new firm creation $NN = \delta N$, we also see that there will be a stable distribution of firms over their life-cycle. Given the hazard rate of firm depreciation, the unconditional survival probability of a single firm declines exponentially with its age, that is, after time t only a fraction of $\exp(-\delta t)$ from an intial firm creation of δN is still alive. By the end of the growth phase T all firms reach their steady mature state. Given that growing firms form a fraction $\int_0^T \delta N \exp(-\delta t) dt = N\,(1 - \exp(-\delta T))$, mature firms will amount to $N \exp(-\delta T)$.

Consumer are assumed to maximize a standard intertemporal utility function given an intertemporal budget constraint with wealth accumulation A:

$$U = \int_0^\infty \frac{C^{1-\sigma}}{1-\sigma} \exp(-\rho t) dt \tag{17}$$

$$\dot{A} = r \cdot A + w \cdot L - C \tag{18}$$

All taxes are reimbursed to consumers so that they do not appear in this expression.

We can now calculate macroeconomic aggregates. Combining (14) and (15) with $D(T) = p(T) \cdot K(T)$ and $VN(0) = \kappa \cdot K(T)$ determines the optimal size of mature firms $K(T)$ as a function of exogenous parameters alone. We can then calculate overall production by solving (12) for Y and finally use the definition of production in (1) to find the equilibrium number of firms.

$$K(T) = \frac{a}{\kappa(\tau, c, \varepsilon)} \left[\frac{1}{\varepsilon \cdot \kappa(\tau, c, \varepsilon)^{1-\varepsilon}} - 1 \right]^{-1} \tag{19}$$

$$Y = \left(\alpha K(T)^{\varepsilon - 1} \varepsilon \frac{1-c}{r+\delta} \right)^{\frac{\alpha}{\varepsilon - \alpha}} \tag{20}$$

$$Y = \left[\int_0^T \delta N \exp(-\delta t) \cdot K(t)^{\varepsilon} dt + N \exp(-\delta T) \cdot K(T)^{\varepsilon} \right]^{\frac{\alpha}{\varepsilon}} L^{1-\alpha} \tag{21}$$

We define the aggregate capital stock K as the sum of individual firm's capital stocks

$$K = \int_0^N K_j dj = \int_0^T \delta N \exp(-\delta t) K(t) + \delta N \exp(-\delta T) K(T). \tag{22}$$

Taking a cash-flow perspective, consumers receive dividend payments from mature firms and invest funds in new firm creation. Taxes are reimbursed and we can evaluate capital income of consumers as:

$$r \cdot A = \delta N (1 - \exp(-\delta T)) D(T) - \delta N (a + K(0)) = \alpha Y - \delta \cdot K - \delta N a \tag{23}$$

Because of decreasing returns in the sum of the variable production factors diversity and capital, the economy ultimately approaches a steady state without growth. In the long-run equilibrium, the rate of return equals the consumers time preference $r = \rho$ implying $\dot{A} = 0$ und we determine usage of the final good from (18) and (23) as

$$Y = C + \delta(K + Na) \tag{24}$$

In order to emphasize the symmetry of this model with a typical neoclassical model, we can rearrange equation (21) to:

$$\begin{aligned} Y &= N^{\alpha\left(\frac{1}{\varepsilon}-1\right)} (\Gamma \cdot K)^{\alpha} L^{1-\alpha} \\ \Gamma^{\varepsilon} &= \frac{\int_0^T \delta \exp(-\delta t) K(t)^{\varepsilon} dt + \exp(-\delta T) K(T)^{\varepsilon}}{\left[\int_0^T \delta \exp(-\delta t) K(t) dt + \exp(-\delta T) K(T) \right]^{\varepsilon}} \end{aligned} \tag{25}$$

The variable Γ measures a tax induced distortion in capital allocation across firms. For now it seems sufficient to notice that without taxation, so that $\kappa = 1$ and $T = 0$, we have $\Gamma = 1$ and $Y = N^{\alpha\left(\frac{1}{\varepsilon}-1\right)} K^{\alpha} L^{1-\alpha}$ so that production is identical to a typical textbook case. Tax parameter affect aggregate production at various margins. The next sections will then analyse this problem step by step and we will come back to the allocation of capital across firms measured by Γ at a later stage.

3 Taxation

We will now turn to an analysis of taxation in the framework developed above. We have already argued that mature firms finance additional marginal investments using retained earnings. Firm behavior should then follow the new view of dividend taxation saying that the dividend tax has no effect on marginal investment decisions but that it will change the valuation of the capital stock, see the shadow price $q(T) = \frac{1-\tau}{1-c}$. Changes in the tax parameter will then be capitalised into firm values. The new view predicts that taxing dividends has no allocative effects and only changes the distribution of wealth as the tax is paid by firm owners through a reduction in firm value. While there is no *direct* effect of the dividend tax, the capital gains tax effects the capital stock by changing the firm's discount factor, see (12). In the general equilibrium approach used in this model, effects of dividend and capital gains tax turn out to be quite different from the stylized view just presented.

The analysis is structured as follows: We will first show how tax capitalisation depresses firm creation in general equilibrium and depresses aggregate capital accumulation and production. We then move on to the distorting impact of a *differential* taxation of capital gains and dividends which is shown to disturb the allocation of capital across firms. Having laid out the consequences of capital income taxes in the general equilibrium, we will compare our results with predictions of old and new view of dividend taxation. We conclude the analysis with a brief consideration of optimal taxation.

3.1 Tax capitalisation and new firm creation

Both taxes are felt at the founding stage of the firm, see (14). Increasing the dividend tax reduces net payments to investors. A higher capital gains tax increases the discount rate $\frac{r+\delta}{1-c}$ and reduces firm value as well. Without any endogenous changes in the model, initial firm value will thus fall below the opportunity costs of firm creation a. This is a common argument when considering the impact of capital income taxation on new firm creation. Typically, the impact of the capital gains tax is then emphasized by arguing that is due much earlier in the life cycle of a firm and should thus be more harmful.

We expect two types of endogenous reaction to a change in tax parameters. First, firms might adjust their corporate financial policy in order to cope with changed tax incentives. Second, a decline in firm values will depress aggregate firm creation and initiate macroeconomic changes. We will first concentrate the analysis on the pure capitalisation effect of capital income taxes and thus abstract from endogenous reactions in the firm's financial policy. Arguably such a change in corporate finance will only be able to weaken but not to remove the effect of capitalisation. By equating the tax parameter $\tau = c$, we eliminate the growth process completely so that $\kappa = 1$ and $T = 0$. Firms are thus endowed with their mature capital stock right from the start.

Evaluating (19) at $\kappa = 1$, we find $K(0) = K(T) = a \cdot \frac{\varepsilon}{1-\varepsilon}$ so that single firm size is independent of the level of taxes. However, observing (20) we see that total production Y declines in the level of taxes $\tau = c$ and (21) solved for the firm number $N = \frac{Y^{\frac{\varepsilon}{\alpha}}}{L^{1-\alpha} K(T)^{\varepsilon}}$ proves that the tax burden falls on the creation of new firms and depresses diversity in the economy. By the definition of the aggregate capital stock $K = N \cdot K(T)$, capital usage of the economy falls as well.

An increase in the tax parameter depresses net payments to investors, initial firm values fall and new firm creation ceases. As firm depreciation reduces capital and diversity and thus aggregate production of the economy, the monopolistic power of an individual firm increases and expected profits from new firm creation increase. Firm creation will finally restart, however at a lower level of production, diversity and aggregate capital usage.

3.2 Differential taxation and the allocation of capital across firms

3.2.1 Firm financial behavior

As the model of individual firms is based on the nucleus theory of Sinn (1991), individual firm behavior will share many of his results.[4] Since we succeeded in solving out the difference equations related to single firm growth, see the appendix, we are able to provide analytical derivatives of the firm's endogenous behavior.

Internal versus external finance We have already found that the capital stock will initially be set to a fraction $\kappa(\tau, c, \varepsilon)$ of the final capital stock using new equity. The remaining part $1 - \kappa(\tau, c, \varepsilon)$ will then be financed using internal capital accumulation. This partition will play an important part in the following analysis. From the viewpoint of a single firm, it represents the optimal trade off between usage of monopolistic power and tax incentives. In an aggregate view and corrected for firm depreciation during the growth phase, it will describe the financing shares of the total capital stock as well asgross investments out of new equity and profit retentions. It is thus interesting to start the analysis by determining the behavior of κ in response to changes in the tax variables.

[4] Weichenrieder (1995) provides several simulations of the nucleus model. McGee (1998) extends the basic setup by allowing for debt finance and agency costs. Many remarks in his paper relate to general equilibrium effects which can however not be made rigorous in his partial equilibrium setup.

When deciding upon the optimal financial mix, firms are faced with a trade-off to explore the monopoly power as soon as possible on the one side, and using the lightly taxed capital gains as a possibility to finance the building up of the capital stock on the other side. Changing the tax parameter will change the tax incentives for capital gains versus dividends and will shift the optimal mix of financial instruments. Increasing the dividend tax increases the relative advantage of capital gains while increasing the capital gains tax decreases the tax wedge. The formal results are thus easily anticipated. Using a total differential in the definition of κ, see (A.11) in the appendix, we determine:

$$\frac{d\kappa}{d\tau} = -\frac{1}{\varepsilon}\frac{1}{1-\tau}\frac{\kappa}{1-\kappa^{1-\varepsilon}} < 0 \tag{26}$$

$$\frac{d\kappa}{dc} = \frac{1}{\varepsilon}\frac{1}{1-c}\frac{\kappa}{1-\kappa^{1-\varepsilon}} > 0 \tag{27}$$

The dividend tax induces the firm to increase profit retention while the capital gains tax shifts the financial mix towards the use of external new equity.

Growth period The growth period measures the time of retaining profits and thus behaves very much in line with the importance of internal finance $1-\kappa$, see also (10). The growth period increases with the dividend tax and decreases with the capital gains tax.

$$\frac{dT}{d\tau} = -\varepsilon\frac{1-c}{r+\delta}\,\kappa^{-\varepsilon}\,\frac{d\kappa}{d\tau} > 0 \tag{28}$$

$$\frac{dT}{dc} = -\varepsilon\frac{1-c}{r+\delta}\,\kappa^{-\varepsilon}\,\frac{d\kappa}{dc} - \frac{T}{1-c} < 0 \tag{29}$$

$$\frac{dT}{d\varepsilon} = \frac{1-c}{r+\delta}\frac{1}{1-\varepsilon}\left[\frac{1-\kappa^{1-\varepsilon}}{1-\varepsilon} - \frac{1}{\varepsilon}\frac{\kappa^{1-\varepsilon}}{1-\kappa^{1-\varepsilon}}\ln\frac{1-\tau}{1-c}\right] > 0 \tag{30}$$

A decrease in market power, that is a higher value of ε, will increase the growth period. We can check the intuition using both limiting cases. Consider first the competitive case $\varepsilon \longrightarrow 1$ where different intermediate goods are substitutes. Existing mature firms can then use lightly taxed internal funds to increase their capacity and compete with new firms that would have to use new equity. New firms can only use a minimal external capital infusion and then have to rely on internal funds to increase their capital stock. From an investor perspective, he will prefer lightly taxed capital gains and not be eager to use the rather limited potential of monopoly power. Moving to the opposite case of $\varepsilon \longrightarrow 0$ we find that given the enormous profit opportunity due to their monopolistic market power, firms will prefer not to grow at all in order to use market power as soon as possible and start the pay out phase immediately.

3.2.2 Size of mature firms

Although mature firms follow the new view by using retentions as their marginal source of finance, a differential treatment of dividends and capital gains has an effect on the final capital stock, see (19). This turns out to be a general equilibrium effect which shifts the demand function of firms while leaving its elasticity unchanged. Enfant firms in their growth phase will demand a higher price for their intermediate goods given a limit pricing strategy, see (A.3). This implies that final good producers will substitute some higher priced products with lower priced ones made by mature firms.[5] Established firms thus feel increased demand for their products and choose to grow to a bigger size by increasing their final capital stock $K(T)$. The small size of enfant firms has a counterbalancing effect of increasing mature firm size.

Formally, we take a derivative of mature firm size given by (19) and determine

$$\frac{dK(T)}{d\tau} = -K(T)\frac{\varepsilon}{\kappa}\frac{1-\kappa^{1-\varepsilon}}{1-\varepsilon\kappa^{1-\varepsilon}}\frac{d\kappa}{d\tau} > 0 \tag{31}$$

$$\frac{dK(T)}{dc} = -K(T)\frac{\varepsilon}{\kappa}\frac{1-\kappa^{1-\varepsilon}}{1-\varepsilon\kappa^{1-\varepsilon}}\frac{d\kappa}{dc} < 0 \tag{32}$$

Notice that the effect is only a result of the *differential treatment* of dividends and capital gains. A joint variation of both tax parameters which keeps the growth phase constant will have no effect on mature firm size. If both tax parameters are equally high and potentially non-zero so that $\kappa = 1$ and $T = 0$, then the mature capital stock is identical to the no-tax case.

3.2.3 The size distribution of firms

By the constant rate of new firm creation in equilibrium, the steady state will experience a stable distribution of firms of all development stages. Thus, the capital stock of firms ranges from the initial $\kappa \cdot K(T)$ for start-ups to a final $K(T)$ for mature firms. The heterogeneity of firm size is solely a tax effect and disappears if tax rates are equated.

Figure 2 is a graphical interpretation of the total capital stock $K = \int_0^N K_j \, dj$, see (22) and provides a useful, graphical interpretation of the steady state distribution of firms. The figure is based on a stylized calibration of the model. This involves a capital share of production of $\alpha = .3$, a coefficient for diversity of $\varepsilon = \frac{10}{11}$ implying a typical price markup in the mature state of 10%, an interest rate of $\rho = r = .05$ and depreciation of $\delta = .1$. The fixed costs of setting up a firm are only a scale parameter and are set to $a = .01$. The capital gains tax is set to

[5] Notice that mature prices are unaffected by an increase in the dividend tax.

$c = 10.0\%$ and simulated dividend taxes are $\tau \in 20.0\%, 22.5\%, 25.0\%$. The figure interpretes the firm number as a continuous variable. Firms are sorted by firm age where new firms are added on the right and firm size can be read from the vertical axis. Mature firms on the left opperate at the mature capital stock, growing firms of all growth stages join to the right and new firms are added on the very right.

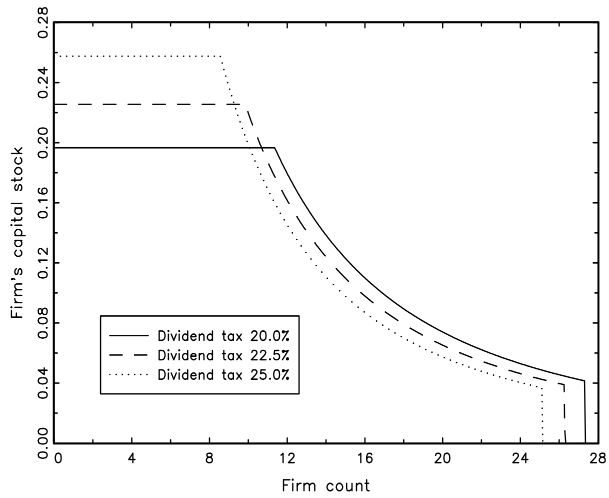

Figure 2: Heterogeneity of firm size (Simulated)

We can now see the distortion in capital allocation described above. Notice first that the higher the dividend tax, and thus the higher the differential treatment of dividends and capital gains, the higher the heterogeneity of firm size. Firm creation takes place at a lower initial capital stock on the very right and firms grow to a higher mature capital stock, see mature firms on the left. While the average lifetime of a firm $\frac{1}{\delta}$ stays constant, the growth period increases with the differential taxation, see (28) and (29). Thus, an increasing part of firms will operate at a capital stock below $K(T)$. Finally, we see that the firm number declines with the dividend tax representing the tax capitalisation effect discussed before.

3.2.4 A macroeconomic perspective

The heterogeneity of firm size translates into the aggregate production function. Moving on to the analysis of macroeconomic variables, we repeat the production function,see (25), for convenience:

$$
\begin{aligned}
Y &= N^{\alpha\left(\frac{1}{\varepsilon}-1\right)} \left(\Gamma \cdot K\right)^{\alpha} L^{1-\alpha} \\
\Gamma^{\varepsilon} &= \frac{\int_0^T \delta \exp(-\delta t) K(t)^{\varepsilon} dt + \exp(-\delta T) K(T)^{\varepsilon}}{\left[\int_0^T \delta \exp(-\delta t) K(t) dt + \exp(-\delta T) K(T)\right]^{\varepsilon}}
\end{aligned}
$$

The term Γ takes account of the firm heterogeneity with respect to the size of the capital stock and formalizes the *distortion in capital allocation* across firms. Notice the similarities between nominator and denominator. Especially, terms $\int_0^T \delta \exp(-\delta t) dt$ and $\exp(-\delta T)$ are weights and add up to 1. A fraction of $\exp(-\delta T)$ already works at the full capital stock, the remaining firms opperate at a fraction between κ and 1 of the final capital stock. The denominator of Γ^{ε} thus calculates the *average* capital stock and then applies the concave power function. The nominator on the other hand considers the actual, heterogeneous distribution of capital and applies the power function on every instance separately. By Jensen's inequality we can thus conclude $\Gamma^{\varepsilon} \leq 1$. Obviously, the impact of the distortion disappears if both taxes are identical implying $\kappa = 1$ and $T = 0$. It will also disappear if $\varepsilon \to 1$ so that there are no gains from diversity.

It is well known from inital work of Dixit and Stiglitz (1977) that all production units in a monopolistic competition framework should produce the same amount of intermediate goods. By the symmetry of products, all producers should be faced the same size decision and thus produce the same amount of intermediate goods. Here, all products are identical but as the decision structure of producers is distorted by the tax induced growth period of firms, the equal outcome is not achieved. In order to escape the capital income tax, firms move away from the efficient capital structure and thus depress aggregate production. Taking a social planner's viewpoint, a redistribution of capital from mature to enfant firms such that all firms opperate at the average size would increase overall production.

Coming back to our tax parameter, we have already shown that both of them will depress capital accumulation by their capitalization into firm values and the following decline in firm creation. We have now analysed a different effect based on the differential treatment of dividends and capital gains and related to the *efficiency of capital allocation.* The dividend tax increases the growth phase of individual firms and will then increase the distortion. The capital gains tax on the other hand reduces the growth phase and improves the efficiency of allocation.

3.3 Aggregate production

We will now turn to the influence of tax parameters on aggregate production. Given the arguments developed before, the impact of the dividend tax is clearly anticipated: The tax is capitalised into firm values and thus felt at the start-up phase of a firm where it distorts firm creation and thus puts an additional burden on capital accumulation. Second, it increases the distortion in the allocation of capital by inducing firms to start at a lower capital stock, grow longer and approach a higher final capital stock. Both effects tend to depress overall production. The capital gains tax on the other side has two opposing predictions. First, it increases the tax burden on new firm creation which decreases capital accumulation and production. Second, it reduces the distortion in capital allocation which will increase the efficiency of production. However, it would be quite surprising to find that a tax on capital *increases* the capital stock or total production, so that we suppose that the first effect should dominate. This can be made rigorous using a derivative:

$$\frac{dY}{d\tau} = -\frac{Y}{1-\tau}\frac{\alpha}{\varepsilon-\alpha}\frac{1-\varepsilon}{1-\varepsilon\kappa^{1-\varepsilon}} < 0 \tag{33}$$

$$\frac{dY}{dc} = -\frac{Y}{1-c}\frac{\alpha}{\varepsilon-\alpha}\frac{\varepsilon\left(1-\kappa^{1-\varepsilon}\right)}{1-\varepsilon\kappa^{1-\varepsilon}} < 0 \tag{34}$$

Efficiency gains induced by an increase in the efficiency of capital allocation by a higher capital gains tax turn out to be only of secondary importance.

3.4 A discussion in the light of the existing literature

The source of marginal investment funds Capital accumulation is financed by a mixture of new equity and retained earnings reflecting initial start-up infusion and the following internal growth. While *marginal* investments of most firms are financed using profit retentions, the *crucial* start-up investments of new entrepreneurs are financed using new equity. This influence of taxes on new firm creation is clearly accepted even by staunch supporters of the new view, see Sinn (1991). It is important to notice that changes in the total capital stock mainly come from changes in the firm number, see part 3.1. While owners of mature firms using retentions cannot react on tax changes, potential new entrants facing a descrete decision choice can. A forward looking entrepreneur anticipates any forthcoming tax liabilities resulting in a depression of new firm creation and capital accumulation. The possibility to partially substitute new equity finance by the introduction of a phase of internal growth will not be able to eliminate the general result that the firm has to start with a new equity infusion. That is, although the tax neutrality result of the new view holds for mature and growing firms, both taxes will have "real" consequences through the creation of firms so that new equity is the *macroeconomic important source of finance.*

Average and marginal tax burden When discussing capital income taxation, researchers have typically relied on partial equilibrium models of firms' financial policy to derive theoretical findings. Typical applied studies use the concept of *effective marginal tax rates (EMTR)* developed by King and Fullerton (1984). Recently, the importance of discrete investment choices has been recognised and has led to the development of an *effective average tax rate (EATR)* following Devereux and Griffith (1998). This important distinction is also present in this paper. While marginal investment decisions follow the new view and thus do not react on the level of the dividend tax, there are also discrete investment decisions in the form of the start investment of new entrepreneurs. Since forthcoming tax liabilities are fully taken account of at this stage, the concept of an average tax burden becomes relevant and taxes influence the outcome.

Dividend policy Poterba and Summers (1985) estimate the impact of tax changes on an aggregate measure of payout behavior. They find that dividends as a share of profits decline in response to higher dividend tax rates. This finding is consistent with an explicit dividend policy as described by the old view and violates the new view's prediction that dividends are residual. In our model, firms follow the new view of dividend taxation and there is no signalling through the payout ratio. While payout policy of a single firm is trivial as it either pays out no dividends or keeps no retentions, the aggregate version of the model will respond to tax incentives in accordance with the empirical evidence.

We define an (average) dividend ratio $\theta = \frac{\int_0^N D_j dj}{\int_0^N \pi_j dj}$ as the percentage of overall firm profits that is paid out as dividends. A mass of $\delta N(1 - \exp(-\delta T))$ of firms are still in their growth phase and pay no dividends. The remaining firms $\delta N \exp(-\delta T)$ have constant profits that they pay out as dividends $D(T) = P(T) \cdot K(T)$. For growing firms, profits increase over time by the growing capital stock. Individual firm profits are given as $p(s)\,K(s)$ where price setting follows (A.3) and the capital stock is given in (9). We thus have

$$\begin{aligned}
\theta &= \frac{N \exp(-\delta T) \cdot p(T)\,K(T)}{N \int_0^T \delta \exp(-\delta t) \cdot p(t)\,K(t)\,ds + \exp(-\delta T) \cdot p(T)\,K(T)} \\
&= \frac{1}{\int_0^T \delta \exp(\delta(T-t)) \left(1 - \frac{r+\delta}{1-c}\frac{1-\varepsilon}{\varepsilon}(T-t)\right)^{\frac{\varepsilon}{1-\varepsilon}} dt + 1}
\end{aligned}$$

Notice that absent of taxation or with identical and thus non-distortionary taxes, there would emerge full payout of dividends $[T = 0]$. Firms would start with their optimal capital stock right from the beginning and there would be no intermediate growth phase with capital gains as an alternative usage of profits.

It is now interesting to check the behavior of the payout ratio in response to changes in the two tax parameter:

$$\frac{d\theta}{d\tau} = -\theta^2 \delta \exp(\delta T) \kappa^{\varepsilon} \frac{dT}{d\tau} < 0$$

$$\frac{d\theta}{dc} = -\theta^2 \left[\delta \exp(\delta T) \kappa^{\varepsilon} \frac{dT}{dc} - \int_0^T \delta \exp(\delta x) \left(1 - \frac{r+\delta}{(1-c)} \frac{1-\varepsilon}{\varepsilon} x \right)^{\frac{\varepsilon}{1-\varepsilon}-1} \frac{r+\delta}{(1-c)^2} x \, dx \right] > 0$$

The payout ratio declines with the dividend tax and increases with the capital gains tax. Notice that this is not a single-firm effect but a result of the aggregation of growing and mature firms. Mature firms pay out all there profits independent of the increase in the dividend tax, growing firms retain all profits to reach the mature capital stock. The payout ratio then depends on the *fraction* of firms that are in the growth or payout phase respectively. Taxation can set incentives to use internal funds instead of new equity and thus to increase the time of internal growth. Given that firms have a fixed average lifetime of $\frac{1}{\delta}$ this implies that the payout phase has to decline. The results can then be derived from the behavior of firm's financial policy in part 3.2.1: We expect the payout ratio to decline if firms want to grow longer because of a higher dividend tax, and we expect the payout ratio to increase if the relative advantage of retentions declines because of an increase in the capital gains tax. The derivatives prove this view.

Tax capitalisation Both views have opposing predictions about the capitalisation of taxes. While the old view predicts a shadow price of capital $q = 1$ implying no capitalisation, the new view in its basic formulation predicts full capitalisation of dividend taxes $q = \frac{1-\tau}{1-c}$. The formal results are also present in our model, see stage 1 and 3 of the nucleus, respectively. Using a sample of British companies, Poterba and Summers (1985) test the two opposing predictions and rule out the capitalisation of the new view. A variety of critics can be raised against this approach.[6] In the light of this paper, we can add an additional argument:

Unfortunately, marginal q is hard to measure in empirical studies. The estimation of Poterba and Summers (1985) is thus based on Hayashi (1982)'s result that marginal and average Q are identical for a *competitive firm with a linear revenue function.* Marginal and average Q are then determined as the ratio of firm value over its capital stock. The identity of marginal and average q is however not true for a model of monopolistic competition like the one used here. In this framework, average Q will, absent taxes, exceed 1 while marginal q is 1. We will illustrate this

[6] See the discussion in Auerbach and Hassett (2003).

point by only looking at mature firms which will have the lowest value of marginal q. Following the new view of dividend taxation they have a *marginal* $q = \frac{1-\tau}{1-c}$. From (5) we determine firm value of mature firms as

$$V(T) = \frac{1-\tau}{r+\delta} D(T) = \frac{1-\tau}{1-c} \frac{1}{\varepsilon} \cdot K(T). \tag{35}$$

We see that *average* $Q = \frac{1-\tau}{1-c} \frac{1}{\varepsilon}$ is higher than marginal q and potentially even higher than 1. Measuring average q instead of marginal q, Poterba and Summers (1985) bias their results towards an exceptance of the old view's prediction. Obviously, this bias effect is a result of our assumption of a decreasing returns to scale production function and our argument might therefore appear artificial.[7] However, as we have emphasized in the introduction, a model with constant returns to scale does not seem to be compatible with a diversity of firms using different sources of marginal investments. Especially, such a model would not allow the creation of new firms in the presence of established firms as competitive market prices would reflect the low cost of capital of mature firms.

3.5 Optimal capital income taxation

We will omit a formal analysis of optimal taxation since results are easily anticipated by comparision with previous work by e.g. Jones (1995). A first and maybe most obvious inefficiency introduced by taxes is the distortion in capital allocation across firms. We have already noted that a redistribution of capital across firms would raise aggregate production. We thus follow that optimal taxation in a decentralised setup must not allow for a growth phase and therefore equate the taxation of dividends and capital gains. Such a rule is however not easily implemented in practise. The capital gains tax that we use in the model is assumed to be an *effective* tax rate which will diverge form the statutory one. As the tax is only due when assetes are sold, investors receive a tax-free deferral of payment. In practise there is a quite long list of other startegies to reduce the effective tax burden. For all positive tax parameter, a typical capital gains tax will then fall short of the dividend tax and introduce the distortion resulting in a welfare loss. Auerbach (1991) proposes a different system of capital gains taxation that eliminates the problems mentioned above. At the moment this "retrospective capital gains taxation" is only an academic proposal and not yet used in practise.

[7] Only recently, Abel and Eberly (2002) have reinterpreted the typical estimations of the Q-theory in the presence of a deceasing returns to scale revenue function. They show that *average* Q, typically above one in value, is correlated with the investment ratio.

The second inefficiency results from using a model of monopolistic competition. In the decentralized outcome, monopolistic firms produce at a too low scale resulting in a reduced output. We have seen that total production declines with both tax rates so that first best capital income taxes are negative implying a subsidy on capital accumulation and repeating a result of Judd (1997).

4 Conclusions

The paper has set up a general equilibrium model of firm creation and destruction that allows for an in depth analysis of dividend and capital gains taxes in general equilibrium. The previous literature using stylised partial equilibrium models has found it hard to yield plausible policy implications as the analysis had to omit several important behavioral margins. The model presented here then allows for a broader view on the problem by including a heterogeneous distribution of firms. Arguments of both the new and the old view of dividend taxation are incorporated so that the aggregate version shares some of the predictions of both approaches. In contrast to other work that tried to describe likely consequences of dividend and capital gains taxes on the macroeconomic level, the paper has a strong microstructural foundation based on profit maximising firms and does not rely on arguments other than capital income taxes in determining the capital structure and payout behavior.

Implications of the model seem to be consistent with typical empirical findings. The microeconomic structure of the model is compatible with recent empirical research by Auerbach and Hassett (2003) who emphasize the heterogeneity of marginal sources of investment across firms. While there exist firms that use new equity issues, there are other mostly mature firms that reduce their dividend payments in order to finance new investments. The payout ratio declines in response to an increase in the dividend tax and increases with the capital gains tax. Firm creation responds to changes in personal tax rates.

It turns out that both the dividend and the capital gains tax are harmful for the economic outcome. We have determined two main channels: First, capital income taxes depress aggregate capital accumulation. Taxes are discounted in firm values and are anticipated at the firms birth stage. Second, a differential treatment of dividends and capital gains creates a distortion in the capital allocation between firms thus depressing aggregate production by inducing firms to use an intermediate growth stage. While both taxes depress production by the capitalisation effect, the dividend tax increases the distortion of capital allocation while the capital gains tax tends to counterbalance it. An optimal tax system should equate both tax rates.

Appendix: Firm financial and investment decisions

Firms are assumed to maximise firm value (5) subject to the capital accumulation (6) [using a Lagrange multiplier of $q_j(s)$], the dividend $D_j(s) \geq 0$ and new equity constraints $VN_j(s) \geq 0$ [with multipliers $\mu_D(s)$ and $\mu_V(s)$ respectively] as well as a market clearing or no excess supply condition for the market of its consumption good [$\lambda(s)$], see (3). We use the cash flow constraint (7) to substitute for $D_j(s)$ and form a Hamiltonian:

$$\begin{aligned}\mathcal{H} = \frac{1-\tau}{1-c}\left[p_j(s)\,K_j(s) - I_j(s)\right] - \frac{\tau-c}{1-c}VN_j(s) + q_j(s)\,I(s) + \mu_V VN_j(s) \\ + \mu_D\left[p_j(s)\,K_j(s) + VN_j(s) - I(s)\right] + \lambda(s)\left[\left[\frac{\alpha}{p_j\,Y^{\frac{\varepsilon-\alpha}{\alpha}}}\right]^{\frac{1}{1-\varepsilon}} - K_j(s)\right]\end{aligned} \tag{A.1}$$

$$\frac{d\mathcal{H}}{dVN_j(s)} = \mu_D + \mu_V - \frac{\tau-c}{1-c} = 0 \tag{A.2a}$$

$$\frac{d\mathcal{H}}{dI_j(s)} = q(s) - \frac{1-\tau}{1-c} + \mu_D = 0 \tag{A.2b}$$

$$\frac{d\mathcal{H}}{dp_j(s)} = \left(\frac{1-\tau}{1-c} + \mu_D\right)K_j(s) - \lambda(s)\left[\frac{\alpha}{p_j\,Y^{\frac{\varepsilon-\alpha}{\alpha}}}\right]^{\frac{1}{1-\varepsilon}}\frac{1}{1-\varepsilon}\frac{1}{p_j(s)} = 0 \tag{A.2c}$$

$$\dot{q}_j(s) - q_j(s)\;\frac{r+\delta}{1-c} = -\left(\frac{1-\tau}{1-c} + \mu_D\right)p_j(s) + \lambda(s) \tag{A.2d}$$

$$\mu_D \geq 0; \mu_V \geq 0; \lambda(s) \geq 0; \lim_{t\to\infty}\exp\left(-\frac{r+\delta}{1-c}(t-s)\right)q_j(t)\,K_j(t) = 0 \tag{A.2e}$$

We can combine (A.2a) and (A.2b) resulting in $q_j(s) = 1 - \mu_V$. Observing (A.2c) and ruling out trivial solutions with $K_j(s) = 0$, we request $\lambda(s) > 0$. This implies a price setting rule such that demand equals maximum production capacity

$$p_j(s) = \frac{\alpha}{Y^{\frac{\varepsilon-\alpha}{\alpha}}} \cdot \frac{1}{K_j(s)^{1-\varepsilon}} \tag{A.3}$$

Given that $K_j(s)$ is positive we can now simplify (A.2c) and (A.2d)

$$\frac{d\mathcal{H}}{dp_j(s)} = K_j(s)\left[q_j(s) - \lambda(s)\frac{1}{1-\varepsilon}\frac{1}{p_j(s)}\right] = 0 \tag{A.4}$$

$$\dot{q}_j(s) = q_j(s)\left[\frac{r+\delta}{1-c} - \varepsilon \cdot p_j(s)\right] \tag{A.5}$$

We can easily see by (A.2a) that dividend payment and new equity issues can never happen together (we restrict ourselves to cases where there is a differential tax treatment of dividends and capital gains so that at least one of μ_D and μ_V has to be positive) and can then distinguish three distinct cases. They describe the nucleus theory as in Sinn (1991). For a more in depth analysis, see the original paper.

1. Start-up Firm $\mu_V = 0$, $\mu_D \geq 0$ and thus $q_j(0) = 1$
   This is only a momentary state of setting up the firm. Because of the cash flow and capital accumulation condition we have $I_j(0) = VN_j(0) = K_j(0)$.

2. Growing Firm $\mu_V \geq 0$ and $\mu_D \geq 0$
   Marginal source of new investments are retained earnings. There are no payouts. All free cash flow is invested in increasing the capital stock.

$$I_j(s) = p_j(s)\, K_j(s) = \frac{\alpha}{Y^{\frac{\varepsilon-\alpha}{\alpha}}} \cdot K_j(s)^{\varepsilon}$$

   This is in an intermediate growth stage whose transitional behavior is given by the two difference equations

$$\dot{K}_j(s) = \frac{\alpha}{Y^{\frac{\varepsilon-\alpha}{\alpha}}} \cdot K_j(s)^{\varepsilon} \tag{A.6a}$$

$$\dot{q}(s) = q(s)\left[\frac{r+\delta}{1-c} - \varepsilon\, \frac{\alpha}{Y^{\frac{\varepsilon-\alpha}{\alpha}}}\, \frac{1}{K_j(s)^{1-\varepsilon}}\right] \tag{A.6b}$$

3. Mature Firm $\mu_V \geq 0$, $\mu_D = 0$ and thus $q_j(T) = \frac{1-\tau}{1-c}$
   The capital stock has reached its final stage so that there are no new investments $I_j(T) = 0$. As q is constant, equations (A.5), (A.3) and (7) imply respectively:

$$p_j(T) = \frac{1}{\varepsilon} \cdot \frac{r+\delta}{1-c} \tag{A.7}$$

$$K_j(T) = \left[\varepsilon \frac{1-c}{r+\delta} \frac{\alpha}{Y^{\frac{\varepsilon-\alpha}{\alpha}}}\right]^{\frac{1}{1-\varepsilon}} \tag{A.8}$$

$$D_j(T) = \left[\frac{\alpha}{Y^{\frac{\varepsilon-\alpha}{\alpha}}}\right]^{\frac{1}{1-\varepsilon}} \left[\varepsilon \frac{1-c}{r+\delta}\right]^{\frac{\varepsilon}{1-\varepsilon}} \tag{A.9}$$

Knowing that the capital stock and the shadow price q evolve constantly without jumps, we can then solve the difference equations backwards, starting from the final points of a mature firm $q_j(T) = \frac{1-\tau}{1-c}$ and $K_j(T)$ back to the setting up with $q_j(0) = 1$. The transitional behavior follows (A.6a) and (A.6b) and the two important unknowns are T and $K_j(0)$.

Using the boundary conditions $q(0) = 1$ and $K_j(T) = \left[\varepsilon\frac{1-c}{r+\delta}\frac{\alpha}{Y^{\frac{\varepsilon-\alpha}{\alpha}}}\right]^{\frac{1}{1-\varepsilon}}$, the closed form solution of the two difference equations are given as:

$$K_j(t) = \left[\frac{\alpha}{Y^{\frac{\varepsilon-\alpha}{\alpha}}}\left(\varepsilon\frac{1-c}{r+\delta} - (1-\varepsilon)(T-t)\right)\right]^{\frac{1}{1-\varepsilon}} \tag{A.10}$$

$$q_j(t) = \exp\left[\int_0^t \left(\frac{r+\delta}{1-c} - \varepsilon\,\frac{\alpha}{Y^{\frac{\varepsilon-\alpha}{\alpha}}}\,\frac{1}{K_j(s)^{1-\varepsilon}}\right)ds\right]$$

The shadow price declines until the firm reaches it mature status. That is $\exp\left[-\int_0^T(...)\,ds\right] = \frac{1-\tau}{1-c}$ where T is the time of internal growth of the firm. We can now evaluate the integral plugging in (9) and reach, after a series of tedious but straightforward calculations, the following expression:

$$\exp\left[1-\kappa^{1-\varepsilon}\right]\cdot\kappa^{1-\varepsilon} = \left(\frac{1-\tau}{1-c}\right)^{\frac{1-\varepsilon}{\varepsilon}} \tag{A.11}$$

with $\kappa = \left(1 - \frac{1-\varepsilon}{\varepsilon}\frac{r+\delta}{1-c}T\right)^{\frac{1}{1-\varepsilon}}$.

$\kappa(\tau, c, \varepsilon)$ is thus implicitly defined and can be evaluated numerically. For economic reasons, we know $\kappa(\tau, c, \varepsilon) \in [0; 1]$.[8] We can then determine T and the initial capital stock using (A.10):

$$T = \frac{\varepsilon}{1-\varepsilon}\frac{1-c}{r+\delta}\left(1-\kappa(\tau,c,\varepsilon)^{1-\varepsilon}\right) \tag{A.12}$$

$$K_j(0) = \kappa(\tau,c,\varepsilon)\cdot K_j(T) \tag{A.13}$$

References

Abel, A. B., and J. C. Eberly (2002): "Q Theory Without Adjustment Costs & Cash Flow Effects Without Financing Constraints," *Working Paper*, pp. 1–31.

Auerbach, A. J. (1991): "Retrospective Capital Gains Taxation," *American Economic Review*, 81(1), 167–178.

——— (2002): "Taxation and Corporate Financial Policy," in *Handbook of Public Economics III*, ed. by A. Auerbach, and M. Feldstein, vol. 3, chap. 19, pp. 1251–1292. North-Holland.

Auerbach, A. J., and K. A. Hassett (2003): "On the Marginal Source of Investment Funds," *Journal of Public Economics*, 87(1), 205–232.

[8] It is $\kappa = 1$ if $\tau = c$ and $\kappa = 0$ at the limit if $\tau \to 1$ and $c = 0$ which are the two economically relevant limiting cases as we request $\tau \geq c$.

Caves, R. E. (1998): "Industrial Organization and New Findings on the Turnover and Mobility of Firms," *Journal of Economic Literature*, 36(4), 1947–1982.

Devereux, M. P., and R. Griffith (1998): "The Taxation of Discrete Investment Choices," *IFS Working Paper*, 98/16(Rev. 2), 1–57.

Dixit, A. K., and J. E. Stiglitz (1977): "Monopolistic Competition and Optimum Product Diversity," *American Economic Review*, 67(3), 297–308.

Ethier, W. J. (1982): "National and International Returns to Scale in the Modern Theory of International Trade," *American Economic Review*, 72(3), 389–405.

Gompers, P. A., and J. Lerner (1998): "What Drives Venture Capital Fundraising?," *Brooking Papers on Economic Activity: Microeconomics*, pp. 149–192.

Hassett, K. A., and R. G. Hubbard (2002): "Tax Policy and Business Investment," in *Handbook of Public Economics III*, ed. by A. J. Auerbach, and M. Feldstein, chap. 20, pp. 1293–1343. North-Holland, Amsterdam.

Hayashi, F. (1982): "Tobin's Marginal Q and Average Q: A Neoclassical Interpretation," *Econometrica*, 50(1), 213–224.

Jones, C. I. (1995): "R&D-Based Models of Economic Growth," *Journal of Political Economy*, 103(4), 759–784.

Judd, K. L. (1997): "The Optimal Tax Rate for Capital Income is Negative," *NBER Working Paper*, 6004, 1–47.

Judd, K. L., and B. C. Petersen (1986): "Dynamic Limit Pricing and Internal Finance," *Journal of Economic Theory*, 39, 368–399.

Keuschnigg, C. (2001): "Business Formation and Aggregate Investment," *German Economic Review*, 2(1), 31–55.

King, M. A., and D. Fullerton (1984): *The Taxation of Income from Capital*. University of Chicago Press, Chicago and London.

Klette, T. J., and S. S. Kortum (2002): "Innovating Firms and Aggregate Innovation," *CEPR Discussion Paper*, 3248.

McGee, M. K. (1998): "Capital Gains Taxation and New Firm Investment," *National Tax Journal*, 51(4), 653–673.

Poterba, J. M., and L. H. Summers (1985): "The Economic Effects of Dividend Taxation," in *Recent Advances in Corporate Finance*, ed. by E. I. Altman, and M. G. Subrahmanyam, pp. 227–284. Richard D. Irwin, Homewood, Ill.

Romer, D. (2001): *Advanced Macroeconomics*. McGraw-Hill, Irwin, 2nd edn.

Romer, P. M. (1990): "Endogenous Technological Change," *Journal of Political Economy*, 98(5, Part 2), S71–S102.

Rosen, H. S. (2002): "Entrepreneurship and Taxation: Empirical Evidence," *Working Paper*.

Sinn, H.-W. (1991): "The Vanishing Harberger Triangle," *Journal of Public Economics*, 45, 271–300.

Spence, M. (1976): "Product Selection, Fixed Costs, and Monopolistic Competition," *Review of Economic Studies*, 43(2), 217–235.

Weichenrieder, A. J. (1995): *Besteuerung und Direktinvestition*, Schriften zur angewandten Wirtschaftsforschung. Mohr, Tübingen, [Taxation and Foreign Investment].