THE EQUITY TRAP, THE COST OF CAPITAL AND THE FIRM'S GROWTH PATH

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Abstract

This paper reconsiders Sinn's (1991) nucleus theory of the corporation by comparing two different regimes for the equity trap. In the first of these, all cash paid to the shareholders is taxed as dividends, in the second, shareholders are allowed a tax-free return of capital contributed through new issues. A substantial difference is found between the regimes in the size of initial equity injections, although in both regimes, no dividends are paid until a new long-run equilibrium is reached. Contrary to Sinn, we find that with optimal behavior, the cost of new equity is lower than suggested by conventional formulae.

JEL Code: H24, H25, H32.

Keywords: dividend taxation, equity trap, cost of capital, nucleus theory, growth path.

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1. Introduction

The economic consequences of dividend taxation have been the subject of a continuing debate among public finance researchers for more than a quarter of a century. Much of this discussion has been concerned with whether the "new" or "old" view of dividend taxation best describes its effects.[1] A crucial difference between the two views is in the source of equity finance used at the margin by the corporate firm. Under the new view, the marginal source of equity is retained earnings. As the dividend tax reduces the opportunity cost to the shareholders of an additional unit of profits retained for investment in the same proportion as it reduces future dividends, the dividend tax has no impact on investment incentives. Under the old view, the dividend tax falls also on marginal investment projects. Though the exact interpretation of the old view varies between different researchers, a common assumption is that the firm is unable to cut dividends to finance new investment projects or finds it costly to do so.[2] With new issues of shares rather than retained profits as the marginal source of equity, the shareholders' opportunity cost of investment is not mitigated by the dividend tax, and as a result, the tax reduces the rate of return to investment.

That the dividend tax falls on marginal investments financed by new issues of equity is, however, accepted also by holders of the "new" view. "New" view- models typically state that the cost of new share issues equals the shareholders' after-tax rate of return requirement adjusted for the total tax – at the corporate and personal levels – levied on distributed profits. A useful reference here is the study by King and Fullerton (1984) whose formulae for the cost of capital have been put to a widespread use in international comparisons and for policy oriented research.[3]

Some time ago, however, Sinn (1991) argued that the distortion from dividend taxation is larger than the conventional formulae such as those derived in King and Fullerton (*ibid.*) suggest. Sinn's point is that earlier research underestimated the true cost of equity because it invariably assumed that profits from marginal investment projects were distributed as dividends.

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[1] The new view of equity was developed by Auerbach (1979), Bradford (1981) and King (1977). For a survey of the debate, see Auerbach (2002) and Auerbach and Hassett (2002, 2005).

[2] See Auerbach (2002).

[3] See for example OECD (1991) and EU (2001).

To derive the cost of equity in a consistent manner, Sinn sets up a model of an all-equity firm, with a personal tax on dividends as the only tax parameter. Share repurchases are ruled out, leaving dividends and internal investment as the only possible uses of profits. The outcome of this model is a "nucleus" theory of the corporation. A firm faced by an initial shortage of retainable profits following a disturbance to the marginal productivity of capital, will let the shareholders inject less than the total amount of funds needed to reach a new long-run equilibrium. Once the "nucleus" of new equity has been obtained, the firm embarks upon a growth path using less expensive retained earnings. The firm then continues to grow by internal funds, issuing no more shares, and paying no dividends until the marginal productivity of capital is equated to the rate of interest. Though no parametric expression for the cost of new equity is obtained from this analysis, Sinn finds, for "mild assumptions" about the form of the firm's production function, that the marginal productivity of capital subsequent to the issue of new equity is *higher* than suggested by King-Fullerton (1984) and others[4].

The purpose of this paper is to reconsider Sinn's claim that earlier research underestimated the cost of new issues of equity. More generally, we examine how the seize of the dividend tax distortion is determined by the character of the so called "equity trap". We set up a dynamic model of an all equity firm, which includes two varieties of the equity trap: The first is the same as posited by Sinn, namely where it is impossible for the firm to pay cash to its shareholders that is not taxed as dividends. This is technically captured by constraining new share issues to be non-negative. Though this a common requirement in tax models of the firm, its full implication – turning the dividend tax into a combination of a tax on (distributed) profits and a capital levy on issues of new equity - is seldom made clear. The second variety of the equity trap allows the shareholders a tax-free return of the original capital contributed through the new issues. This means that negative new share issues (or other forms of tax-free cash distributions) are allowed, but only to the extent of the amount contributed by the shareholders through new share issues.

We conclude from this analysis that Sinn's comparison between the cost of capital in his model, following the new issue, and King and Fullerton's expression for the cost of new equity, is misleading and is in fact a comparison between apples and oranges. The reason for

[4] Sinn (1991), p. 284.

this is that Sinn and King-Fullerton rely on different assumptions not only about dividend behavior but also, and more importantly, about the equity trap, that is, the design of the tax code. Sinn's model explicitly relies on the strong form of the equity trap, including both retained earnings and new equity, whereas the cost-of-capital expressions of the King-Fullerton type implicitly assume that shareholders are allowed a tax-free return of original capital, leaving new share issues outside the trap.

Paying dividends subsequent to a new issue of equity does not constitute optimal behavior under neither of the two varieties of the equity trap. However, the King-Fullerton assumption that dividends are paid subsequent to a new issue does not cause a downward bias in estimating the cost of capital, as Sinn suggests. With dividends being paid in the year following the new issue, the cost of capital rather turns out to be *higher* than is the case when the firm behaves optimally (what is optimal behavior depends on the equity trap).

The remainder of this paper is organized as follows. Section 2 presents the theoretical model of an all equity firm, and derives general expressions for the cost of capital for two versions of the equity trap. Optimal behavior following a new issue of equity is determined in section 3, which also includes numerical simulations to compare the firm's optimal behavior under the two versions of the equity trap. Section 4 concludes.

2. The model

We derive the firm's cost of capital by setting up a dynamic model in discrete time with a personal tax on dividends τ as the only tax parameter. The owner is assumed to maximize the after-tax dividend stream given by

$$\sum_{s=t}^{\infty} \frac{\theta D_s - N_s}{(1+r)^{s-t}}, \qquad (1)$$

where D denotes dividends as defined in the firm's accounts, N is the amount of new share issues, *r* is the discount rate and θ is the after-tax value of a unit of dividends, $\theta \equiv 1-\tau$. The firm's budget constraint in period *s* is a cash flow identity, where capital inflow equals capital outflow

$$F\left(K_{s-1}\right)+N_s=D_s+I_s\,. \tag{2}$$

The production function $F\left(K\right)$ depends only on the stock of capital, where the stock in period $s-1$ becomes fully efficient in production in period *s*. To keep the model simple, capital depreciation is ignored, which implies that the stock of capital evolves over time as

$$K_{s-1}+I_s=K_s\,. \tag{3}$$

As usual, dividends must be non-negative

$$D_s\geq 0\,. \tag{4}$$

In the following, we distinguish between two varieties of the model. In the first of these we require issues of new equity to be non-negative

$$N_s\geq 0\,. \tag{5}$$

Though this constraint is standard in tax models of the firm (e.g. Sinn (1991)), its full implication is seldom made clear. With (5), there is no way for the shareholders to withdraw cash from the firm except as dividends. The effect of this is that not only current and past profits (as emphasized by the new view), but also the new issues of equity injected into the firm are trapped by the dividend tax. Put differently, constraint (5) models the dividend tax as a combination of a tax on (distributed) profits and a capital levy on issues of new equity. We will denote this variety of the model the *full equity trap-case,* or *F-case*, for short.

The second variety of the model – the *partial equity trap-case*, or *P-case* – assumes instead that shareholders are allowed a tax-exempt return of funds injected into the firm by issues of new equity. We model this assumption by letting *A* be the remaining stock of past (positive or negative) equity injections, and requiring that

$$A_s\geq 0\,. \tag{6}$$

where the stock A evolves as

$$A_{s-1} + N_s = A_s . \tag{7}$$

Constraint (6) implies that negative issues of equity are allowed ($N < 0$), but only within the limit set by the requirement that the sum total of past equity injections (positive or negative) be non-negative. Replacing constraint (5) by constraint (6) and the motion (7) therefore confines the dividend tax to be a tax on distributed profits, leaving any withdrawals of funds to the extent of the original investment of the shareholders free of tax.

The model (for both varieties of the equity trap) defines a discrete-time control problem with control variables *N*, *D* and *I*, and state variables *K* and *A*. By imposing shadow values for the constraints and motions – μ^D for (2), μ^K for (3), λ^D for (4), λ^N for (5), λ^A for (6), μ^A for (7) – and maximizing the owners' after-tax dividend stream the optimization problem takes the form $\max \sum_{s=t}^{\infty} \frac{\Lambda(\cdot)}{(1+r)^{s-t}}$. The Λ -function reads as

$$\Lambda = \theta D_s - N_s + \mu_s^D \left(F\left(K_s\right) + N_s - I_s - D_s\right) + \mu_s^K \left(K_{s-1} + I_s - K_s\right) + \lambda_s^D D_s + \lambda_s^N N_s$$

for the *F-case*, and as

$$\Lambda = \theta D_s - N_s + \mu_s^D \left(F\left(K_s\right) + N_s - I_s - D_s\right) + \mu_s^K \left(K_{s-1} + I_s - K_s\right) + \lambda_s^D D_s + \lambda_s^A A_s + \mu_s^A \left(A_{s-1} + N_s - A_s\right).$$

for the *P-case*.

The first order conditions for *D*, *I* and *K* are the same for both varieties of the model

D_s $$\theta - \mu_s^D + \lambda_s^D = 0 , \tag{8}$$

I_s $$-\mu_s^D + \mu_s^K = 0 , \tag{9}$$

K_s $$-\mu_s^K + \frac{\mu_{s+1}^K}{1+r} + \frac{\mu_{s+1}^D}{1+r} F_{K_s} = 0 . \tag{10}$$

Equations (9) and (10) yield the general expression for the cost of capital

$$F_{K_s} = \frac{\mu_s^K \left(1+r\right) - \mu_{s+1}^K}{\mu_{s+1}^K} , \tag{11}$$

that is, the cost of capital is determined by the rate of interest and the marginal valuation of capital, μ^K, for two consecutive periods.

The long-run cost of capital

For a firm that relies on retained earnings as the marginal source of finance and also pays dividends, the shadow value of the dividend constraint appearing in (8) is zero, $\lambda^D = 0$. Since $\mu^K = \mu^D$ (eq. 9) the first order condition for *D* (eq. (8)) then implies that in long-run equilibrium $\mu_s^K = \mu_{s+1}^K = \theta$. The general expression for the cost of capital in (11) is therefore

$$F_K = r . \tag{12}$$

With $\mu^K = \theta$, the owner is indifferent between retaining earnings and receiving dividends, and as a result of this, the dividend tax does not distort the steady state value of the firm's capital stock. This is of course is the well-known result from the new view of equity.

New equity as the marginal source of finance

The first order condition specific to the *F-case* is

N_s $$-1 + \mu_s^D + \lambda_s^N = 0 , \tag{13}$$

while those specific to the *P-case* are

N_s $$-1 + \mu_s^D + \mu_s^A = 0 , \tag{14}$$

A_s $$-\mu_s^A + \frac{\mu_{s+1}^A}{1+r} + \lambda_s^A = 0\,. \tag{15}$$

New shares are issued by the firm only occasionally as a response to exogenous disturbances to the productivity of capital when retained earnings are insufficient to finance the required addition to the capital stock. A *F-case* firm hit by a productivity shock in period *t* will issue new equity sufficient to depress the marginal value of capital to unity, $\mu_t^K = 1$[5]. The cost of capital associated with the new issue of equity is then obtained from the general expression in (11) as

$$F_{K_t} = \frac{(1+r) - \mu_{t+1}^K}{\mu_{t+1}^K}\,. \tag{16}$$

Since the marginal value of capital in the period subsequent to the new issue, μ_{t+1}^K, cannot be determined without further assumptions, equation (16) means that no parametric expression for the cost of capital is available for the *F-case* firm. However, in the special case where the firm pays dividends immediately following the new issue, $\mu_{t+1}^K = \theta$, and with $\theta \equiv 1-\tau$, (16) simplifies to

$$F_{K_t} = \frac{r+\tau}{1-\tau}\,, \tag{17}$$

which corresponds to a result derived by Auerbach (1983, p. 925).

When the *P-case* firm issues new shares in period *t*, $A_t > 0$. This means that the shadow value $\lambda_t^A = 0$, and by equation (9) and the first order conditions for *N* and *A* (eqs. (14) and (15)) we derive $\mu_{t+1}^K = \mu_t^K(1+r) - r$. Using the general expression for the cost of capital (eq. (11)) we therefore derive the *P-case* firm’s cost of capital following the new equity issue as

$$F_{K_t} = \frac{r}{\mu_{t+1}^K}\,. \tag{18}$$

[5] See equations (9) and (13).

Again, no parametric expression is available.[6] In case the firm pays dividends following the new issue $\mu_{t+1}^{K} = \theta$, and with $\theta \equiv 1-\tau$, we get

$$F_{K_t} = \frac{r}{1-\tau}, \tag{19}$$

as the expression for the cost of capital for a *P-case* firm. This is King and Fullerton's (1984) well-known expression for the cost of new equity.

For ease of comparison, the expressions for the costs of capital derived above are summarized in Table 1. The character of the equity trap clearly has important implications for the cost of new issues of equity. When the marginal value of capital in the period subsequent to the new issue, μ_{t+1}^{K}, is the same in the two cases, the *F-case* firm has a higher cost of capital. The intuition for this result is particularly clear when the firm pays dividends, see equations (17) and (19). The pre-tax marginal rate of return of the *F-case* firm must then be sufficiently high to compensate not only for the tax on the income from the marginal investment but also for the tax upon the return of the original capital (i.e. the tax code turns the dividend tax into a combination of a tax on (distributed) profits and a capital levy).

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[6]A simple and interesting alternative to (7) would be to let the (net) stock of remaining equity injections, *A*, be augmented annually by stockholders' rate of return requirement, that is $A_{s-1}(1+r) + N_s = A_s$. Replacing (7) by this motion yields $F_{K_t} = r$, that is independent of tax. Such a modified scheme is basically similar to both the Swedish Annell-deduction (a tax benefit based on new issues), see Auerbach (2002), p. 15, and the new Norwegian Shareholder Income Tax, see Sørensen (2005).

Table 1. Summary of results for *F*- and *P-cases*

	Full Equity Trap	**Partial Equity Trap**
Tax code	All cash paid to shareholders is taxed as dividends	Shareholders are allowed a tax-free return of the original capital
Relevant constraints	Issues of new equity must be non-negative: $N_s \geq 0$	Accumulated amount of past equity injections must be non-negative: $A_s \geq 0$, where $A_{s-1} + N_s = A_s$
Cost of new share issues		
General expression	$F_{K_t} = \frac{(1+r) - \mu_{t+1}^K}{\mu_{t+1}^K}$ (16) Sinn (1991)	$F_{K_t} = \frac{r}{\mu_{t+1}^K}$ (18)
Special case: Firm pays dividends following the new issue	$F_{K_t} = \frac{r+\tau}{1-\tau}$ (17) Auerbach (1983)	$F_{K_t} = \frac{r}{1-\tau}$ (19) King-Fullerton (1984)

Sinn's (1991) results reconsidered

One of the important conclusions from Sinn's (1991) analysis is that, for "mild assumptions" about the form of the firm's production function, the cost of capital subsequent to an issue of new equity is *higher* than obtained from the expression for new equity derived by King-Fullerton, that is $F_{K_t} = r/(1-\tau)$.

Equations (1)-(5) above, which explicitly require new issues of equity to be non-negative, give a discrete-time variant of Sinn's continuous-time model, and the resulting equation (16) for the *F-case*, corresponds to Sinn's expression for the cost of new equity. We notice moreover that King-Fullerton's cost of new equity is given by equation (19), as a special case of the tax regime where shareholders are allowed a tax-free return of original capital, contributed through new issues (*P-case*). Sinn's criticism of the King-Fullerton model for underestimating the cost of new equity is hence based on a comparison between two different tax regimes, with different implications for the equity trap and for the cost of capital.

Moreover, although the assumption that profits from marginal investment projects are paid as dividends (as in King-Fullerton) does affect the cost of capital, the direction of this effect is opposite to that suggested by Sinn: With no dividends being paid in the year following the new issue, the shadow value equals $\mu_{t+1}^{K} > \theta$. A simple comparison between (16) and (17) or between (18) and (19) makes it clear that the cost of capital then is lower than would be the case when the firm pays dividends, that is

$$F_{K_t} = \frac{(1+r) - \mu_{t+1}^{K}}{\mu_{t+1}^{K}} < \frac{r+\tau}{1-\tau} \tag{20}$$

for the *F-case* firm and

$$F_{K_t} = \frac{r}{\mu_{t+1}^{K}} < \frac{r}{1-\tau} \tag{21}$$

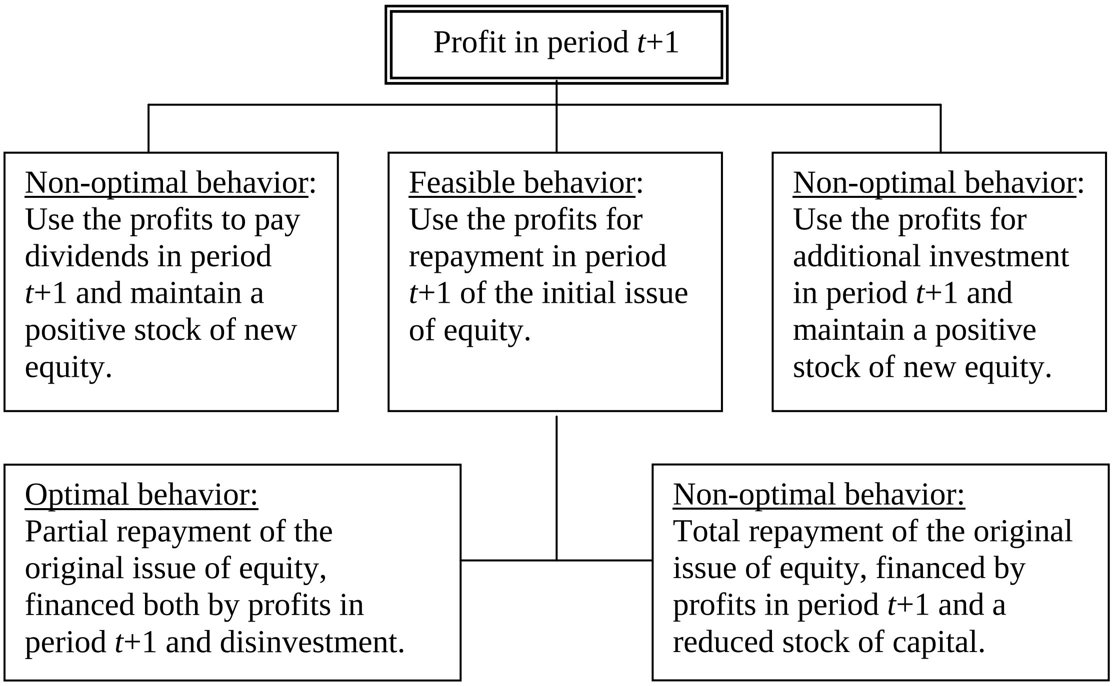
for the *P-case* firm. This means that optimal behavior, which in Sinn's case amounts to retaining earnings and embarking upon a growth path, is associated with a lower cost of capital than follows from a policy of paying dividends subsequent to the new issue.

3. Optimal behavior and simulation of the growth path

Optimal behavior in the Sinn – *F-case* – model following a new issue of equity was briefly described in section 1 above, and readers looking for a formal and detailed treatment are referred to Sinn's paper. This section first explains the incentives faced by the *P-case* firm, and then proceeds to illustrate and compare the optimal behavior of the two types of firms making use of a few numerical simulations.

There are three alternative routes for the *P-case* firm to follow subsequent to a new share issue in period *t*, see the Chart 1 below. We refer to Appendix A for the technical details. We rule out two of these alternatives, which both imply that the firm would maintain a constant and positive stock of new equity (*A>0*), and use its profits either for paying dividends or for additional investment. Behaving optimally, the *P-case* firm will first use current profits and some disinvestment to undertake a gradual repayment of the original issue of equity. Once the new issue has been repaid (*A=0*), the firm will retain profits earned in subsequent periods and add to its capital stock. This second phase corresponds to the growth path analyzed by Sinn, where the firm continues to grow by internal funds, paying no dividends until the new long-run equilibrium is reached.

Chart 1. Alternative routes for a *P-case* firm following a new share issue.



As explained above, our model cannot be used to derive parametric expressions for the short run costs of capital. Because the model is written in discrete time, we are still able to make considerable progress in illustrating and comparing the behavior of the two types of firms by resorting to numerical simulations. We will assume that there occurs an exogenous disturbance to the firms that raises the marginal productivity of capital, and that the resulting investment needs cannot be financed from retained earnings.

The *F-case* firm will then issue new equity sufficient to depress μ^K to unity. A growth path financed by retained earnings follows, and continues until the marginal valuation of capital has fallen to unity minus the dividend tax rate. For the *P-case* firm the starting condition is, likewise, that the marginal valuation of the injection of new equity equals unity, but this comes from two conceptually different sources: The first is the direct increase in the productive capacity of the firm, which is valued at the shadow price of capital, μ^K. The second derives from the fact that the new equity enables the owner a tax-free return of capital, valued at the shadow price μ^A. The condition $\mu^K + \mu^A = 1$ then holds all along the firm's optimal path, with μ^K falling from its initial value in period *t* in the range $\theta < \mu_t^K < 1$, to its long-run value of unity minus the dividend tax rate.

We refer to Appendix B for a step-by-step account of the simulations. In general terms, we make use of the first order conditions to determine the development over time of the marginal valuation of capital, μ^K, the pre-tax marginal rate of return, F_K, the capital stock, K, and – in the *P-case* – the stock of new equity, *A*. We specify the firm's production function in the Appendix and we assume that the market rate of interest is 5 per cent.

The results of the simulations are illustrated in *Figures 1-2* for a dividend tax rate of 30 percent (τ =0.3). The cost of capital is initially 6.22 percent for the *P-case* firm, or 1.24 times the long-run cost of capital (of 5 percent), compared to 12.73 percent for the *F-case* firm, or 2.55 times the long-run cost of capital. As a result of these differences, there is a striking difference between the firms in the amount of new equity injected by the shareholders: The *P-case* firm starts its adjustment path with a capital stock which is more than four times as large as that of the *F-case* firm. Following the new issue, the *F-case* firm uses all profits for internal investment, and completes its growth path in 13 years. The adjustment phase of the *P-case* firm is of approximately the same length, but during first half of this phase, the firm uses both current profits and disinvestment to repay the original new equity to the shareholders.

With a reduction in the dividend tax from 30 to 15 percent, the adjustment periods of both firms are shortened, but the effect is stronger for the *F-case* firm than for the *P-case* firm, see *Figures 3-4*. The tax cut also reduces the cost of new equity and increases the seize of the initial equity injection, for both firms. The distorting effects of dividend taxation remain considerably larger for the *F-case* firm than for the *P-case* firm.

The gradual adjustment towards the long-run equilibrium obviously causes a loss in output, compared to a hypothetical case where the firms could immediately reach their new long-run capital stocks and output levels. The annual output losses, accumulated over the adjustment period, add up to 32 percent (of the hypothetical no-tax output level) for the *F-case* firm, and to 18.9 percent for the *P-case* firm, when the dividend tax rate is 30 percent. With a 15 percent tax on dividends, the output losses are 19.3 and 10.5 percent, respectively[7].

[7] The numbers ignore the effect of discounting.

Figure 1: The cost of capital following a new equity issue in the *F*- and *P-cases* when the dividend tax is 30 percent.

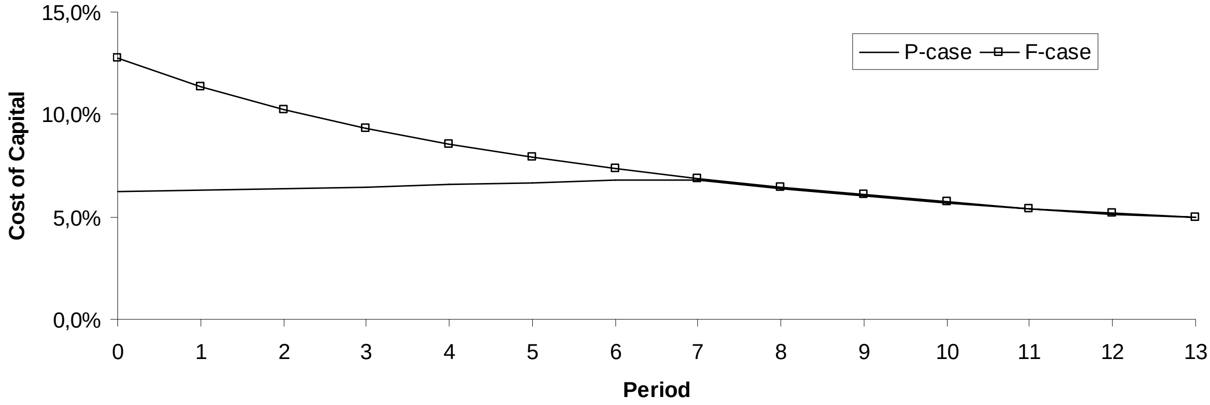


Figure 2: The development of the capital stocks in *F*- and *P-cases* when dividend tax is 30 percent.

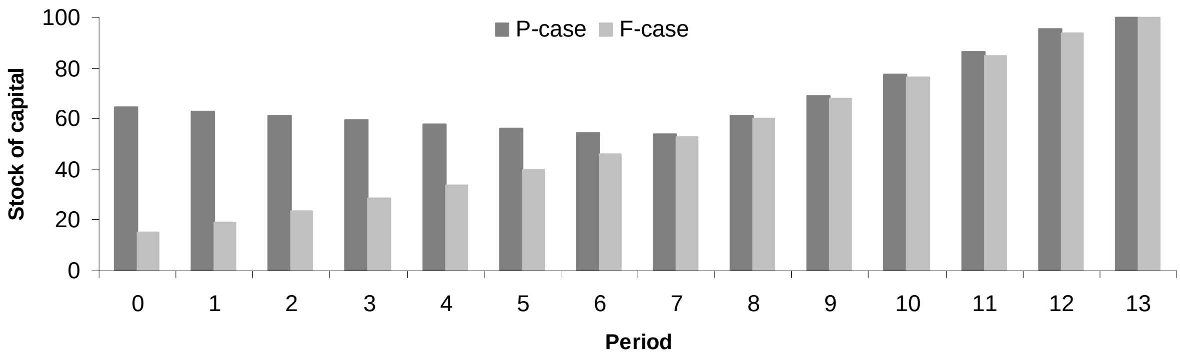


Figure 3: The cost of capital following a new equity issue in the *F*- and *P-cases* when the dividend tax is 15 percent.

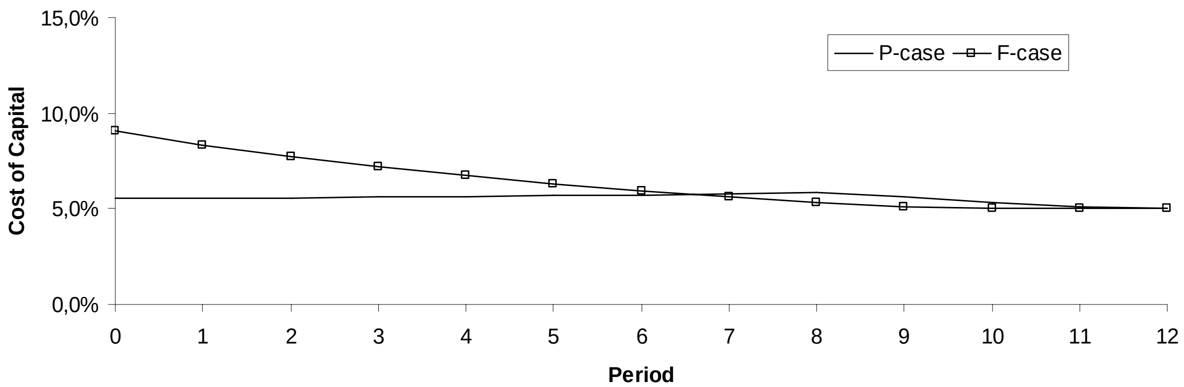
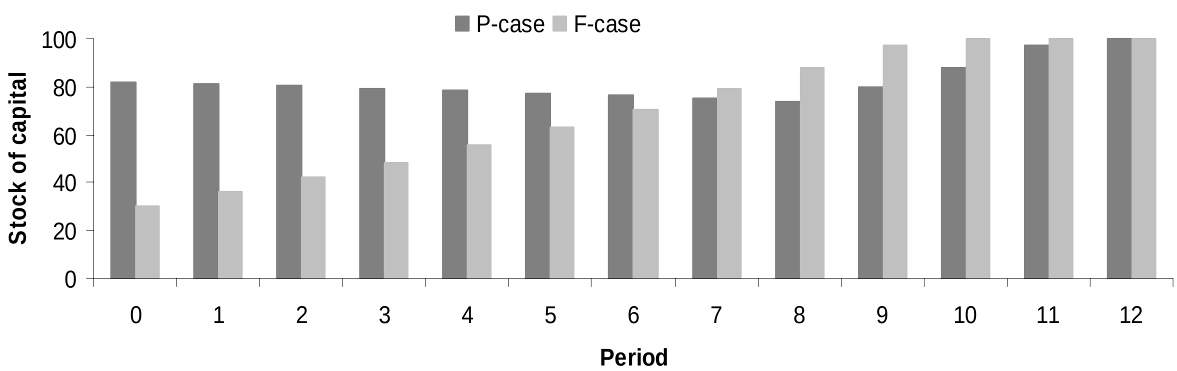


Figure 4: The development of the capital stocks in *F*- and *P-cases* when dividend tax is 15 percent.



4. Concluding comments

This paper has examined how the distortions caused by dividend taxation differ depending on the character of the equity trap. We compare two different tax regimes, one where it is impossible for the firm to pay cash to its shareholders that is not taxed as dividends (the full equity trap), the other where the shareholders are allowed a tax-free return of the original capital contributed through new issues (the partial equity trap). For both regimes, adjustments following an initial distortion take place gradually with no dividends being paid until the firm is in a new long-run equilibrium. With a full equity trap (*F-case*), as assumed in Sinn's analysis, the firm embarks upon a growth path following the new issue, using retained earnings as the source of funds, whereas with a partial equity trap (*P-case*), the growth path is preceded by a phase where the original capital injected into the firm is repaid to the shareholders. Our numerical simulations indicate a substantial difference between the *F*- and *P-cases* in the seize of the initial equity injections, and a resulting difference in the output losses over the adjustment periods.

We conclude from our analysis that Sinn's criticism of the King-Fullerton model for underestimating the cost of new equity is misleading as it amounts to a comparison across different tax regimes – the *F-case* and the *P-case*. Contrary to Sinn, we also find that with optimal behavior following a new issue, the cost of capital is lower than suggested by conventional formulae.

The constraint on new share issues for the *P-case* was designed to clarify the assumptions implicit in King-Fullerton-type expressions for the cost of new equity. It is evident, moreover, that these assumptions do have some foundation in company and tax law. Though the tax code varies across countries, most countries would allow shareholders a tax-free recovery of their initial equity following a winding-up decision. Techniques such as share re-purchases and combinations of splits and share redemptions, have also gained in importance in most countries. These procedures may trigger capital gains taxation, but the deductibility of the acquisition costs of shares sold or redeemed ensures that the original contributions of equity capital do escape the equity trap.

Different limitations on the tax-free return of new external equity are easily incorporated into the present framework, as intermediate cases between the *F*- and *P-cases*. The general result from such extensions is that the more circumscribed is the possibility of returning original capital, the smaller will be the original new issue, and the shorter the initial phase where profits are used for redemption of equity. Even though the present model thus may be extended to other cases, the specific rules governing the shareholders' right to a tax-free return of the original capital still seems to be a subject worthy of further study.

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Appendix A: Technical details on optimal behavior

This appendix explores the behavior of the *P-case* firm subsequent to a new share issue. A new share issue at time *t* implies a positive stock of new equity, i.e. $A_t > 0$, and, because of this, $\lambda_t^A = 0$. Since $\mu^K = \mu^D$ (eq. 9) and by the first order conditions for *N* and *A* (eqs. (14) and (15)) we derive

$$\mu_{t+1}^K = \mu_t^K \left(1 + r\right) - r = \mu_t^K - r(1 - \mu_t^K) < \mu_t^K, \tag{22}$$

which may be interpreted to mean that whenever the stock of new equity is positive, the marginal valuation of capital will decrease from the current period to the next. Two alternative routes for the firm to follow subsequent to the new issue of equity at time *t* may now be ruled out.

The first is where the firm would use the profits earned in period *t+1* to pay dividends and maintain a positive stock of new equity, $A_{t+1} > 0$. With $\lambda_{t+1}^A = 0$, this would mean a continued reduction in the marginal value of capital, $\mu_{t+2}^K < \mu_{t+1}^K$. However, since payment of dividends requires that the marginal valuation of capital take its minimum value $\mu_{t+1}^K = \theta$, such a further reduction for time *t+2* is impossible. We conclude therefore that the firm will not simultaneously pay dividends and keep a positive stock of new equity.

A second route, following the initial equity injection, would be to use current profits in period *t+1* for additional investment, which would mean $K_{t+1} > K_t$. However, with $A_{t+1} > 0$ and $\lambda_{t+1}^A = 0$ as before, we derive

$$F_{K_{t+1}} = \frac{r}{\mu^K_{t+2}} \tag{23}$$

and since $\mu^K_{t+2} < \mu^K_{t+1}$ when $\lambda^A_{t+1} = 0$, the cost-of-capital expression $F_{K_t} = r/\mu^K_{t+1}$ (eq. (18)) and equation (23) give that $K_{t+1} < K_t$. Hence, the firm's first order conditions imply a *decrease* in the capital stock. Also the second route, where the firm would use current profits to add to its capital stock must be ruled out.

The only feasible use of profits for period *t*+1 is therefore for repayment of the initial issue of equity. Assuming first that repayment takes place gradually, that is with $A_{t+1} > 0$ and $\lambda^A_{t+1} = 0$, we may use equations (22) and (23), to solve for the firm's capital stock, K_{t+1} and, by using the budget constraint, also for the remaining stock of new equity, A_{t+1}. Since $\lambda^A_{t+1} = 0$ implies that $K_{t+1} < K_t$, this partial repayment of the original issue of equity is financed both by current profits and disinvestment. Alternatively, the firm may choose to repay the entire issue of new equity at time *t*+1, by a further reduction in the stock of capital. However, such a reduction is not compatible with the first order conditions, since $\lambda^A_{t+1} > 0$ when $A_{t+1} = 0$, yields a *lower* cost of capital, implying a *larger* capital stock. Repaying the entire issue of equity at time *t*+1 is therefore ruled out.

We conclude that following an issue of new equity, the firm will use its profits neither to pay dividends, nor to add to its capital stock, but to repay the new equity. Repayment takes place gradually, and if profits in, say, time period *s*-1, is insufficient to return the remaining stock of new equity, that is $F\left(K_{s-1}\right) < A_{s-1}$, a positive stock will be kept for the following period, $A_s > 0$. If, on the other hand, $F\left(K_{s-1}\right) \geq A_{s-1}$, the return of the initial equity issue will be completed in period *s*, possibly in conjunction with an addition to the capital stock (if $F\left(K_{s-1}\right) > A_{s-1}$).

Appendix B: Technical details on the simulations

For the *P-case* firm, we begin by choosing, tentatively, a starting value for μ_t^K in the feasible interval $\theta < \mu_t^K < 1$. With $\lambda_t^A = 0$, because of the new issue, we then determine μ_{t+1}^K from equation (22) in Appendix A and solve for the initial stock of capital from the cost-of-capital expression $F_{K_t} = r/\mu_{t+1}^K$ (eq. (18)). Since $\lambda_{t+1}^A = 0$ when $A_t > F(K_t)$ (by the argument presented above), we use an updated version of equation (22) to compute μ_{t+2}^K, and solve for the firm's capital stock, K_{t+1}, implicitly given by equation (23) in Appendix A. From the firm's budget constraint we also determine the remaining stock of new equity, A_{t+1}. This procedure is repeated until $F(K_{s-1}) \geq A_{s-1}$. The repayment of the initial equity issue is then completed in period *s*, possibly in conjunction with an addition to the capital stock (if $F(K_{s-1}) > A_{s-1}$). Having repaid the new equity, the firm will then use all of the profits earned in subsequent periods for investment, which means that we add $I_v = F(K_{v-1}), v = s+1, s+2.....$ to the capital stock of the previous year, K_{v-1}. This "growth process" is continued until the marginal productivity of capital is equated to the rate of interest. If the marginal valuation of capital in the first round of simulations then happens to exceed (fall below) θ, the whole procedure is repeated, using a lower (higher) starting value for μ_t^K.

We compute the behavior of the *F-case* firm in a similar way. Since the firm's starting condition for period *t* is that the marginal valuation of capital equals unity, we choose, tentatively, a value for the marginal valuation of capital in the next period, $\mu_{t+1}^K < 1$. From (16), we then compute the initial capital stock, K_t, and by adding investment equal to $F(K_t)$, we obtain the capital stock and the marginal productivity of capital for the following year, *t*+1. This step-wise procedure is continued until the marginal productivity of capital equals the rate of interest. If then, as described above, the marginal valuation of capital happens to exceed (fall below) θ, the whole simulation procedure is repeated, picking a lower (higher) starting value for μ_{t+1}^K.

The simulations require a specification of the firm's production function. We let

$$F\left(K\right)=CK^{\alpha} \tag{24}$$

represent the firm's output, where *C* determines the level of technology, and α is capital's share of output. With α = 0.5, *C* = 1 and the market interest rate *r* = 0.05, the long-run capital stock, as determined by $F_K = r$ (eq. (12)), is *K*=100.

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