

Profit Taxation, Innovation and the Financing of Heterogeneous Firms

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Abstract

Innovative firms are frequently credit constrained and tend to earn an above normal return on capital. This paper considers a discrete R&D decision that splits firms into innovative and standard ones. Active intermediaries can facilitate access to credit and improve capital allocation. We find that (i) financial development boosts innovation and welfare; (ii) ACE and cash-flow taxes are neutral with respect to user cost and standard firm investment but restrict constrained investment and harm innovation and welfare; (iii) an ACE tax is less harmful than an equal yield cash-flow tax although they are equivalent in perfect capital markets; (iv) a self-financed R&D tax credit redistributes towards constrained firms and promotes innovation and welfare; (v) revenue neutral tax cut cum base broadening similarly boosts innovation and welfare.

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1 Introduction

Many firms – and typically the most innovative ones – are financially constrained. Innovative firms have more profitable investment opportunities and need large external funds to grow. R&D spending, on the other hand, drains own funds available for self-financing of equipment investment and restricts external leverage. These firms are often closely held companies driven by entrepreneurs who possess key technological know-how and inalienable human capital. Since their input is essential for the development of the company, they must keep a large enough stake to assure full effort and commitment to the firm which limits the external financing capacity. The combination of these characteristics, i.e. large investment opportunities, little own resources and potential moral hazard with respect to entrepreneurial effort, makes it likely that these firms face credit constraints. Compared to innovative firms, other companies with less potential to invest are also less likely to be restricted in external financing.

A large empirical literature emphasizes the prevalence of credit constraints. In general, young and small firms are more likely to be credit constrained than large firms (Beck et al., 2005; Aghion et al., 2007). Both entry and subsequent firm growth are limited by financial frictions (see Hubbard, 1998; Beck and Demirguc-Kunt, 2006; Aghion et al., 2007). Empirical research also finds that innovative firms face tighter financing restric-

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tions than non-innovative firms (Himmelberg and Petersen, 1994; Guiso, 1998; Hall and Lerner, 2010). Brown et al. (2009) report that better financial conditions for young high-tech firms can explain a large part of aggregate R&D changes. Young innovative firms are fast in adopting and developing new technologies or products and generate large investment opportunities. If access to external funding is limited, investment is restricted and earns a larger return on capital than is possible elsewhere. Rajan and Zingales (1998) document that external financial dependence differs across sectors. Wurgler (2000) finds evidence that more developed financial markets improve capital allocation, moving capital to sectors with high returns and withdrawing it from sectors with poor prospects. The most innovative firms often need venture capital, private equity or other forms of ‘active financing’, on top of standard bank financing. Active lenders exercise oversight and control and thereby create value by raising a firm’s debt capacity and enhancing investment. The empirical literature thus finds that venture capital backed companies perform better than comparable other firms (see, e.g., Bottazzi et al., 2008). Kortum and Lerner (2000) attribute roughly 14% of U.S. industrial innovation in 1998 to young venture capital backed firms although they spent only about 3% of total R&D funds.

Empirical research also documents that the determinants of investment are entirely different across constrained and unconstrained firms. Investment of unconstrained firms mainly depends on the user cost of capital. Hassett and Hubbard (2002) review the empirical literature and report estimates of investment elasticities with respect to the user cost in the range between -0.5 and -1.0. In contrast, investment becomes sensitive to cash-flow, own collateral and institutional country characteristics when firms are finance constrained (see Hubbard, 1998, for an early survey). Chirinko and Schaller (1995) and Hoshi, Kashyap and Scharfstein (1991) report elasticities of physical capital investment to cash-flow around 0.4-0.5. Estimates for total working capital are significantly higher and vary between 0.8 to 1.3 (see Fazzari and Petersen, 1993; Calomiris and Hubbard, 1995; and Carpenter and Petersen, 2002).

This paper explores how active financial intermediaries can alleviate – although not

entirely eliminate – credit constraints, improve capital allocation and promote innovation, investment and welfare. We propose a theoretical model with a discrete R&D decision which splits the production sector into innovative and standard firms. We assume that firms are endowed with sufficient own funds to fully self-finance R&D spending. R&D drains own resources but results in large investment opportunities if successful. In the subsequent expansion phase, restricted access to external financing prevents innovative firms to invest at the optimal scale, implying an excess return on capital larger than elsewhere (this part follows Holmstrom and Tirole, 1997, and Tirole, 2006). Expanding investment thus raises value and induces constrained innovative firms to demand ‘active financing’ on top of passive bank credit. Standard firms, in contrast, optimally invest at a smaller scale, are unconstrained, rely exclusively on passive bank credit, and earn no more than the normal market rate of return. Our analysis thus emphasizes the fact that financing constraints and the need for active capital tend to be concentrated among innovative firms with large growth potential. Endogenizing innovation also endogenizes the prevalence of financial frictions and the composition of the financial sector in passive and active intermediaries. We interpret financial development to mean that active intermediaries become more effective in exercising control and oversight. In relaxing financing constraints, financial development thereby benefits innovative firms by allowing them to expand investments with an excess return. Making innovative firms more valuable relative to others boosts aggregate innovation and welfare.

Active intermediaries would have no role and could not exist in a frictionless world. Their existence points to the importance of credit constraints for parts of the business sector even in financially well developed countries. The paper thus explores alternatives for welfare improving tax reform when financing constraints are concentrated among innovative firms. Our analysis highlights transmission channels for tax policy that are entirely different across firms. Taxes affect investment of standard firms exclusively by their impact on the user cost of capital (e.g. Hall and Jorgensen, 1967; Auerbach, 1983) while user costs are not directly relevant for investment of constrained innovative firms. We derive four novel results. First, tax systems that are neutral with respect to user cost and

investment of standard firms, still reduce investment of constrained firms and, in turn, discourage innovation and reduce welfare. In the absence of financing frictions, both an ACE (allowance for corporate equity) and a CF (cash-flow) tax would be fully neutral. In fact, Bond and Devereux (1995, 2003) have shown that these alternatives are equivalent if tax rates are appropriately chosen.¹ By way of contrast, our second result states that an ACE tax is less damaging to investment, innovation and welfare, compared to an equal yield CF tax. This result holds when innovative firms are severely constrained and must partly finance with more expensive monitoring capital on top of standard bank credit. Third, a revenue neutral increase in profit taxes to self-finance an R&D tax credit redistributes towards innovative firms and boosts aggregate productivity and welfare. The policy encourages innovation and magnifies subsequent investment of innovative firms.² Fourth, a revenue neutral tax cut cum base broadening policy favors the more profitable, innovative firms, relaxes their financing constraint, and consequently boosts innovation and welfare. Apparently non-discriminatory tax reforms can effectively redistribute across firms when they are in different financial regimes.

Our analysis of the effects of taxes on R&D, investment and the allocation of capital across constrained and unconstrained firms is, to the best of our knowledge, unique in the literature in public economics. It connects to early empirical research that emphasized the important role of internal funds and the different effects of taxes on investment in the presence of financing constraints (Fazzari, Hubbard and Petersen, 1988a,b, Hubbard, 1998). Existing theoretical literature has analyzed the implications of tax policy for entrepreneurship. Boadway and Keen (2006), e.g., discuss and synthesize the literature on adverse selection and entry. Another strand of the theoretical literature is based on moral hazard, see e.g. Hagen and Sannarnes (2007) and Keuschnigg and Nielsen (2004)

¹An ACE tax deducts interest on debt and equity. A CF tax deducts investment costs upfront but denies interest expensing. The tax reform literature holds no clear preference of one over the other. The CF tax was recommended by the U.S. President's Advisory Panel on Federal Tax Reform (2006). The Mirrlees Review (Mirrlees et al., 2011) suggested an ACE system.

²R&D subsidies are an important pillar of innovation policy, see OECD (2008). Bloom, Griffith and Van Reenen (2002), for example, empirically show how a reduction in R&D costs stimulates innovation.

with references therein. Hagen and Samnanes (2007) also show that an ACE tax is not neutral and leads to underinvestment of effort, but do not compare to a CF tax. Unlike the present paper, this literature mostly assumes a fixed investment scale. Our model endogenizes the scale of investment and provides a clear link to classical user cost theory. Another strand of the literature assumes a different type of agency problems along the lines of Jensen (1986) where self-serving, empire building managers divert free cash-flow to internal investments with a lower rate of return, compared to investment opportunities outside the firm (see Chetty and Saez, 2010).³ Clearly, this approach is complementary and relates to mature firms with diversified ownership which are not constrained in outside funding but rather face the opposite problem of having ‘free cash-flow’. The present paper instead focusses on innovative growth companies that are unable to invest up to the efficient scale because they have difficulty in raising external funds.

The paper proceeds as follows. Section 2 introduces the model. Section 3 shows how innovative firms can partly overcome finance constraints by raising active monitoring capital on top of passive bank credit. Section 4 presents the main results on the impact of taxes and subsidies in a finance constrained economy. Section 5 concludes. Technical results are relegated to the Appendix.

2 The Model

2.1 Overview

There is a mass 1 of risk-neutral agents with assets A per capita. A fixed fraction E is also endowed with a two stage investment project and starts a firm. A part $1 - E$ invests in the deposit market to obtain end of period wealth AR where $R \equiv 1 + r$ is a safe interest

³In the same vein, Desai, Dyck, and Zingales (2007) analyze how taxes influence corporate theft and diversion of funds. Gordon and Dietz (2008) present a signaling model of dividend taxation where managers pay dividends to signal to external investors that firms have more than enough cash on hand. Desai and Dharmapala (2008) offer a survey on taxes and corporate governance.

factor. Active entrepreneurs first choose to spend on R&D which may be either high or low, $k_i > k_n$, and splits firms into ‘innovative’ and ‘non-innovative’, denoted by subscripts i and n . For simplicity, we normalize low R&D spending to zero. At the subsequent stage, firms choose a variable scale of expansion investment I_j , conditional on prior R&D choice k_j . An R&D intensive firms is more productive, has larger investment opportunities, and earns higher expected profits, $\pi_i > \pi_n$, if R&D is successful. Entrepreneurial ability is reflected in a success probability $q' \in [0, 1]$ of early stage R&D which is distributed by $\Phi(q) = \int_0^q \phi(q') dq'$. With probability $1 - q'$, the firm fails and closes down after R&D spending. The expected net value of the firm is $\pi_i q' - k_i R$, if it spends on R&D, and $\pi_n q'$, if not. Only good projects $q' > q$ warrant R&D, given a cut-off value q . Other firms with low quality projects $q' < q$ do not innovate. Expected net profit ex ante is

$$\pi_E = \int_0^q \pi_n q' d\Phi(q') + \int_q^1 [\pi_i q' - k_i R] d\Phi(q'). \quad (1)$$

Starting with the same amount of wealth, and since R&D spending drains own resources, innovative firms are left with little own funds $A_i = A - k_i$ to self-finance equipment investment whereas standard firms are relatively cash-rich, $A_n = A$. However, innovation raises productivity, leads to a larger optimal scale of investment, $I_i > I_n$. Innovating firms thus require a much larger credit and are naturally dependent on external financing. The timing of events is: (i) Conditional on project type q' , the firm decides on R&D; (ii) If the early stage is successfully completed, it chooses expansion investment I_j and raises the required credit; (iii) The entrepreneur chooses managerial effort which determines the success probability of expansion investment and results in an *expected* profit level π_j ; (vi) The firm produces output and pays back credit if investment is successful. The model is solved by backward induction.

Innovation raises a firm’s productivity from $\theta_n = 1$ to $\theta_i = \theta > 1$. In contrast to heterogeneous R&D prospects, the success probability p of expansion stage investment is assumed symmetric but may be high or low, depending on managerial effort. The firm may either fail with probability $1 - q'$ early on or with probability $1 - p$ later. Investment at the beginning of period, if successful, yields end of period output $x_j = \theta_j f(I_j)$ which

is strictly concave in investment, $f' > 0 > f''$. Given a tax subsidy at a rate $\varepsilon\tau$ on equipment capital, the private cost of investment is $(1 - \varepsilon\tau)I_j = A_j + D_j + D_j^m$. By this financial identity, the firm draws on own funds and possibly two different sources of external credit,⁴ D_j from standard banks and D_j^m from active intermediaries which perform monitoring and active oversight.

When the firm fails, earnings are zero, all assets are lost and no credit is paid back. If successful, the firm pays out undepreciated capital and net earnings, after subtracting tax and repayment of credit where i and i^m are interest rates on risky loans. Taking account of the opportunity cost of own funds, the firm's expected profit is

$$\pi_j^e = pv_j^e - RA_j, \quad v_j^e \equiv I_j + x_j - (1 + i)D_j - (1 + i^m)D_j^m - T_j. \quad (2)$$

Intermediaries must raise funds on the deposit market at a cost RD_j and RD_j^m , respectively. Active banks, in addition, incur monitoring costs of cI_j and generate an expected profit of $\pi_j^m = p(1 + i^m)D_j^m - RD_j^m - cI_j$. Standard banks earn $\pi_j^b = p(1 + i)D_j - RD_j$. Adding up yields joint profit, $\pi_j = \pi_j^e + \pi_j^b + \pi_j^m$. We assume competitive capital markets, $\pi_j^b = \pi_j^m = 0$, so that the entire rent accrues to entrepreneurs. The loan rate for risky debt is thus given by the zero profit or no arbitrage condition $p(1 + i) = R$. Since active banks have to cover monitoring costs, they must charge a higher rate, $i^m > i$.

The government taxes profit at the rate τ . Parameters ε and λ are used to represent alternative tax systems. A firm's expected tax liability amounts to G_j in the expansion stage. At the beginning of period, the firm can expense a share ε of investment outlays, leading to a tax credit of $\varepsilon\tau$ per unit of capital. At the end of period, the deduction must be repaid and is added to the tax base. Alternatively, the government may grant deductions of a share λ of interest expenses on debt and equity,⁵

$$G_j = pT_j - \varepsilon\tau I_j R, \quad T_j = \tau [x_j - \lambda i(A_j + D_j) - \lambda i^m D_j^m + \varepsilon I_j]. \quad (3)$$

⁴We phrase external funding in terms of debt. In this simple two state model, new debt and new equity are, in fact, equivalent in the absence of tax. However, if there is a tax advantage of debt, agents would strictly prefer debt over equity.

⁵In reality, interest on debt is deductible while the opportunity cost iA_j of equity is not. The present paper focusses on the polar cases of ACE and CF taxes.

Setting $\lambda = 1$ and $\varepsilon = 0$ gives an ACE (allowance for corporate equity) system which grants full interest deductions on debt and equity but denies any upfront tax relief on investment spending. Setting $\lambda = 0$ and $\varepsilon = 1$ yields a cash-flow (CF) tax with immediate tax relief on investment but no interest deductions. Relative to an ACE system, the CF tax shifts the timing of the tax burden towards the end of the period. Finally, the tax code allows deduction of R&D spending which is often treated preferentially. In this case, deductions are in excess of 100 percent, leading to $\sigma > \tau$. The tax credit reduces private R&D cost to $k_i = (1 - \sigma)k$. Net of the subsidy, the total expected end of period value of an innovating firm's tax liability amounts to $G_i q' - \sigma k R$.

The zero profit conditions of banks, $p(1 + i) = R$ and $p(i^m - i)D_j^m = cI_j$, yield $\pi_j^e = \pi_j$. Use these, substitute tax liability and note the financial identity to get

$$\pi_j = (1 - \tau)p(x_j - uI_j) - (1 - \lambda\tau)cI_j, \quad u \equiv \frac{(1 - \lambda\tau)(1 - \varepsilon\tau)}{1 - \tau} \cdot i. \quad (4)$$

ACE and CF taxes are neutral with regard to the user cost of capital, i.e., $u = i$.

2.2 Investment

2.2.1 Standard Firms

Non-innovative firms adopt conservative investment strategies and need little external funds. By Assumption 1 below, they invest at unconstrained levels, take standard bank loans and have no demand for monitoring capital so that $D_n^m = 0$ and $c = 0$ above. Given investment and debt, the entrepreneur receives $v_n^e = I_n + x_n - (1 + i)D_n - T_n$ if the firm survives. Implementing investment requires managerial effort. When effort is high, the success probability and expected income pv_n^e will be high. Alternatively, shirking results in a low survival probability and low expected income $p_L v_n^e$, but the entrepreneur can enjoy private benefits BI_n . The incentive condition for high effort is

$$pv_n^e \geq p_L v_n^e + BI_n \Leftrightarrow v_n^e \geq I_n B / (p - p_L). \quad (5)$$

Incentive compatibility is assured only if the entrepreneur keeps a sufficiently large stake so that high effort raises expected income by more than foregone private benefits. The incentive problem of innovative firms is explained below. We focus on equilibria where innovative firms are credit constrained and standard firms are not:

Assumption 1 (i) At I_n given by $f'(I_n) = u$, the constraint is slack, $v_n^e > I_n B / (p - p_L)$.
(ii) At I_i given by $\theta f'(I_i) = u$, the constraint is violated, $v_i^e < I_i b / (p - p_L)$, where $b < B$.

Part (i) implies that standard firms are unconstrained. In maximizing expected wealth in (4), they invest until the return on capital is equal to the user cost,

$$\pi_n = (1 - \tau) p (x_n - u I_n), \quad f'(I_n) = u. \quad (6)$$

2.2.2 Innovative Firms

Innovative firms are highly productive and have large investment opportunities but little own funds as a result of prior R&D spending. Part (ii) of Assumption 1 means that they are financially constrained. To relax the constraint, they demand monitored finance in addition to standard bank credit. We proceed in two steps and first assume that the firm obtains monitored finance in addition to standard credit. We then state Assumption 2 which implies that mixed financing indeed yields higher value than passive credit alone.

In the effort stage, financial contracts, i.e., investment, debt and interest rates, are predetermined. Banks are promised repayments of $v_i^m \equiv (1 + i^m) D_i^m$ and $(1 + i) D_i$, respectively, leaving residual earnings v_i^e as in (2). Neither managerial nor monitoring effort is contractible, leading to a double moral hazard. Both efforts are discrete, either high or low. As before, high managerial effort raises the success probability to $p > p_L$ while monitoring reduces private benefits to $b < B$, giving $b I_i$ if the entrepreneur is monitored, and $B I_i$ if she is not. Monitoring thus makes shirking less rewarding. With active monitoring, managerial effort is high if

$$\begin{aligned} p v_i^e &\geq p_L v_i^e + b I_i &\Leftrightarrow & v_i^e \geq \beta I_i, \quad \beta \equiv b / (p - p_L), \\ p v_i^m &\geq p_L v_i^m + c I_i &\Leftrightarrow & v_i^m \geq \gamma I_i, \quad \gamma \equiv c / (p - p_L). \end{aligned} \quad (7)$$

The second condition reflects the following trade-off. Suppose the managerial incentive constraint is tight when the bank monitors. Expected repayment to the bank, pv_i^m , then is high. If monitoring is neglected, the managing owner enjoys larger private benefits and prefers shirking which reduces the success probability to p_L . Expected repayment falls to $p_L v_i^m$, but the bank can assign employees hired for monitoring to other tasks generating income cI_i , leading to expected earnings equal to $p_L v_i^m + cI_i$. The incentive to monitor consists of the rise in expected income from disciplining the entrepreneur. We show in Appendix A that both constraints are binding when the firm is financially constrained. The role of monitoring is to limit managerial discretion so that entrepreneurs are incentivized with a smaller income stake. Monitoring thus raises a firm's pledgeable income and improves access to external funds.

At the prior contracting stage, banks compete to lend to firms and propose financing contracts which include monitored finance on top of standard bank credit. Optimal contracts maximize the surplus π_i^e of firms subject to incentive and participation constraints, see Appendix A for details. Intuitively, since active capital is more expensive, it is only offered the *minimum* repayment $v_i^m = \gamma I_i$ that induces monitoring effort in (7). Given this repayment, the contract demands funds D_i^m until the participation constraint binds,

$$D_i^m = (pv_i^m - cI_i) / R = (p\gamma - c) I_i / R. \quad (8)$$

Reserving part of cash-flow for repayment to monitors reduces the entrepreneur's residual income. To assure managerial effort, the owner must keep a minimum stake as in (7) which is lower with monitoring than without. Both incentive payments limit the repayment that can be pledged to passive banks. Hence, the firm's debt capacity is restricted by $v_i^e \geq \beta I_i$ or $(1+i) D_i \leq I_i + x_i - T_i - \gamma I_i - \beta I_i$. The amounts βI_i and γI_i of profit must go to the entrepreneur and the active bank to assure high management effort and monitoring. Note $pv_i^e = \pi_i + RA_i$ together with (4) and rewrite $v_i^e = \beta I_i$ as

$$\pi_i = (1 - \tau) p (x_i - uI_i) - (1 - \lambda\tau) cI_i = p\beta I_i - RA_i. \quad (9)$$

The financing constraint implicitly determines investment. Figure 1 illustrates. Uncon-

strained values are marked by a star. The firm raises a limited amount of monitoring capital as in (8) and obtains residual funds from passive banks.

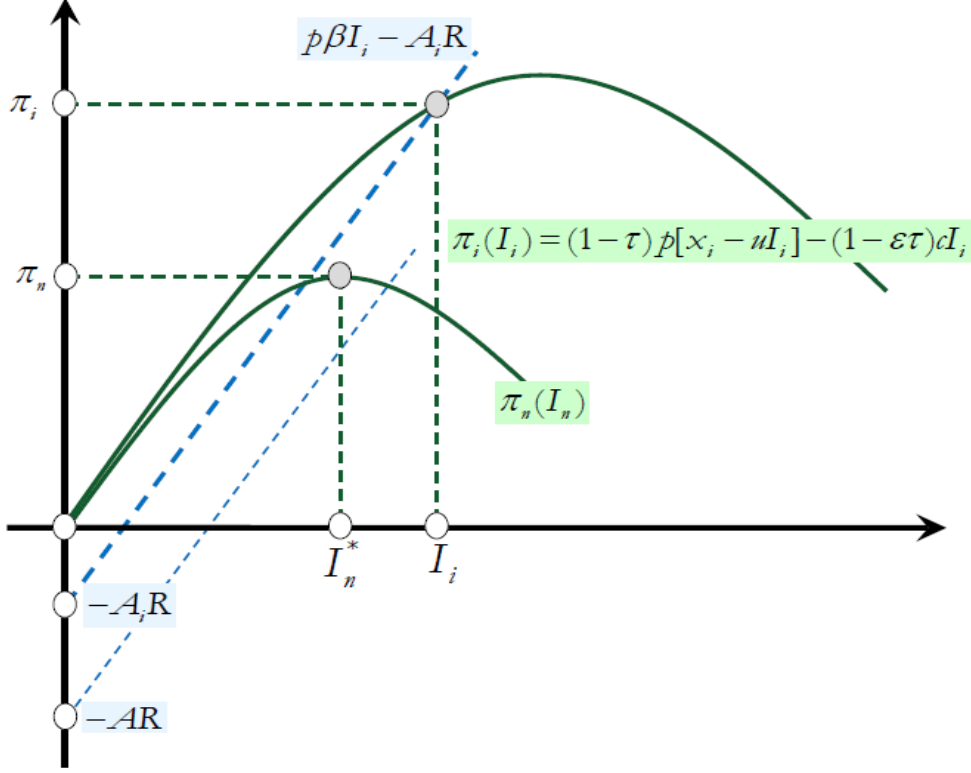


Fig. 1: Incentive Compatible Investment

At any investment level, expected profit of innovative firms is larger since they are more productive as a result of prior R&D. Standard firms invest until expected profit is at a maximum. They have undiminished wealth A so that the incentive line starts out at $-AR$.⁶ By Assumption 1, the constraint is slack at the optimal investment level I_n^* . If innovative firms had no financing problem, they would not ask for monitoring capital and could invest at the optimal level I_i^* . By Assumption 1, these firms remain credit rationed even though monitoring partly relaxes the constraint.⁷

⁶The incentive compatibility condition is $\pi_n = (1 - \tau)p(x_n - uI_n) > p\frac{B}{p-p_L}I_n - RA$.

⁷If the firm asked for a marginally larger credit, banks could still provide credit by raising the loan rate to $i_L > i$ until $(1 + i_L)p_L = R$. However, the firm's expected profit would fall by a large amount on account of a lower success probability. An equilibrium with shirking will never be preferred if $p_L \rightarrow 0$.

2.3 Innovation and Welfare

R&D boosts expected profit but creates additional costs. Firms differ by the entrepreneur's innate ability, i.e., the probability q' of successfully completing the R&D stage. With probability $1 - q'$, the firm fails and closes down. Any R&D investment is lost. Firms of type q' invest in R&D if $q'\pi_i - (1 - \sigma)kR \geq q'\pi_n$, giving a cut-off value

$$q = \frac{(1 - \sigma)kR}{\pi_i - \pi_n} < 1. \quad (10)$$

Firms with higher potential $q' > q$ invest in R&D, less promising ventures do not. Noting the distribution of firms in (1), a share s_k of all new firms innovate while a part $1 - s_k$ performs no R&D. Only a part $s_i < s_k$ of innovating firms and a part $s_n < 1 - s_k$ of standard firms survive the early stage:

$$s_n = \int_0^q q' d\Phi(q'), \quad s_i = \int_q^1 q' d\Phi(q'), \quad s_k = \int_q^1 d\Phi(q'). \quad (11)$$

To evaluate welfare, we note average or expected profit per start-up firm

$$\pi_E = s_n\pi_n + s_i\pi_i - s_k(1 - \sigma)kR > 0. \quad (12)$$

Expected profit $\pi_E = \int_0^1 \pi_n q' d\Phi(q') + \int_q^1 [(\pi_i - \pi_n)q' - (1 - \sigma)kR] d\Phi(q')$ is positive since the square bracket is zero at the cut-off but strictly positive for better types. All potential entrepreneurs strictly prefer entry and use own wealth A to start a firm rather than investing it in the capital market. Out of E firms, only a part $s_k E$ invest in R&D and only $s_j E$ survive the early stage. Out of these, a fraction $1 - p$ fails in the expansion stage, and only a part $ps_j E$ makes it to the production stage.⁸

Aggregate tax revenue amounts to $G_E E$. Noting (3), net tax per firm G_E is equal to

$$G_E = \sum_j s_j G_j - \sigma s_k kR. \quad (13)$$

⁸Suitable restrictions on parameters k , A , θ , and β will ensure that an interior equilibrium exists and satisfies four conditions: (i) standard firms are not constrained; (ii) innovative firms are credit rationed; (iii) innovative firms invest at a larger scale, $I_i > I_n$; and (iv) only a share of firms chooses R&D.

Given zero profits of banks, tax liability in (3) is $G_j = \tau g_j$ where the tax base amounts to $g_j = p(x_j - [\varepsilon + \lambda(1 - \varepsilon\tau)]iI_j) - \lambda cI_j$ where $c = 0$ for standard firms.

An entrepreneur's expected end of period utility is $AR + \pi_E$ per capita, and investors consume AR . Adding aggregate tax revenue yields social welfare

$$V = AR + (\pi_E + G_E)E. \quad (14)$$

Since the aim of this study is to isolate the efficiency effects of profit taxes in the presence of financing constraints, we do not specify how tax revenues are used. Social expected welfare from a start-up firm is $\pi_E + G_E = \sum_j s_j (\pi_j + G_j) - s_k kR$. Note $\pi_j^e = \pi_j$, use (2) and (3), the zero profit conditions of banks, and the financial identity to get the social value of a firm in the expansion stage, $\pi_j^* \equiv \pi_j + G_j = p(I_j + x_j) - I_j R - cI_j$, where $c = 0$ for non-innovative firms. Noting early stage risk, expected social value of a start-up of type q' is $\pi_i^* q' - kR$ or $\pi_n^* q'$, depending on R&D choice. Appendix B closes the model by stating the equilibrium conditions on deposit and output markets. Given a fixed deposit rate, these conditions are not relevant for further analysis.

3 Financial Development

We now show the conditions when mixed financing yields a higher surplus and is preferred to exclusive financing with a standard bank credit. By assumption, investment of innovative firms is restricted by the binding constraint in (9). The slope $d\pi_i/I_i = \rho$ at the constrained investment level is the excess return. Firm value could be further increased if the firm could raise more external credit. Active banks monitor, perform oversight and thereby reduce private benefits of low effort, boost pledgeable income and improve access to external financing. We start in the absence of monitoring where $b = B$ and $c = 0$ and consider an introduction and marginal increase of monitoring intensity m , creating costs $dc = dm$ and reducing private benefits by $db/dm < 0$. Firms demand monitoring capital only if the gains from more investment due to additional funding exceed the cost

of monitoring, i.e. $d\pi_i = \rho dI_i - (1 - \tau\lambda) I_i dc > 0$ by the differential of (9). If the firm is severely constrained and excess return ρ is large, the additional investment augments profits by more than the extra monitoring costs. Firms demand active capital if the following assumption on ‘monitoring productivity’ is fulfilled:

Assumption 2 *The excess return $\rho \equiv (1 - \tau)p(\theta f'_i - u) - (1 - \tau\lambda)c$ satisfies*

$$\rho\mu > p\beta > \rho > 0, \quad \mu \equiv -\frac{p}{p - p_L} \frac{db}{dm} > 1.$$

Assumption 2 implies that (i) raising monitoring capital is valuable, and (ii) the firm is still constrained, earning an excess return, although less so than without monitoring. For a given scale I_i , monitoring squeezes agency costs by $pd\beta = \frac{p}{p - p_L} \frac{\partial b}{\partial m} dm = -\mu dm$ and thereby boosts pledgeable income and investment. The differential of (9) gives

$$dI_i = \delta I_i [\mu \cdot dm - (1 - \lambda\tau) \cdot dc], \quad d\pi_i = \rho \cdot dI_i - (1 - \tau\lambda) I_i \cdot dc, \quad (15)$$

where the multiplier $\delta \equiv 1/(p\beta - \rho)$ is positive due to (A2). If the firm is severely constrained and excess return is large, the larger investment substantially augments profit by ρdI_i . Given the monitoring cost, the introduction of active financing is desirable if the net impact on profit is positive. Substituting $dm = dc$ and noting (A2), we find indeed that active financing boosts investment, $dI_i = [\mu - (1 - \lambda\tau)] \delta I_i dm > 0$, and creates value, $d\pi_i = [\rho\mu - (1 - \tau\lambda)p\beta] \delta I_i dm > 0$.

Innovative firms have little own assets and large investment opportunities and heavily rely on external funds. They benefit from monitoring since it improves access to capital and allows them to invest more. Innovative firms thus finance themselves from multiple sources. The more productive monitoring is, the more external funds firms can raise, and the closer they come to the unconstrained regime.⁹ We interpret financial development to mean that active banks get more experienced, i.e., the effectiveness of monitoring rises relative to an *unchanged* marginal cost, $dm > 0$ and $dc = 0$. Since more productive

⁹We consider only a marginal increase in monitoring productivity so that credit constraints are only partly relaxed and innovative firms are still rationed.

monitoring reduces private benefits, the incentive line for innovative firms in Figure 1 becomes flatter and rotates clockwise around the intercept. In reducing the entrepreneur's incentive income, monitoring boosts debt capacity and leads to a larger level of investment and higher profit of innovative firms. By (15),

$$dI_i = \mu \delta I_i \cdot dm, \quad d\pi_i = \rho \mu \delta I_i \cdot dm. \quad (16)$$

Standard firms are not affected as they do not demand active capital. In boosting innovative firm value, financial development induces R&D. By (10),

$$dq = -\frac{q}{\pi_i - \pi_n} \cdot d\pi_i = -\frac{\rho \mu q}{\pi_i - \pi_n} \delta I_i \cdot dm < 0. \quad (17)$$

Clearly, the share of R&D intensive firms rises at the expense of standard firms,

$$q \cdot ds_k = ds_i = -ds_n = -qg(q) \cdot dq > 0. \quad (18)$$

In the absence of taxes, aggregate welfare in (14) changes by $dV = Ed\pi_E$. By (12), expected profit of entrepreneurs changes by $d\pi_E = s_i d\pi_i - [(\pi_i - \pi_n)q - kR]g(q)dq$. When the firm doesn't innovative, financial development is inconsequential, $d\pi_n = 0$. The square bracket is zero by discrete choice, so that aggregate welfare changes by

$$dV = \rho \cdot \mu \delta I_i s_i E \cdot dm > 0. \quad (19)$$

Proposition 1 (*Financial Development*) *Financial development raises investment and net value of innovative firms and stimulates R&D. Welfare rises in proportion to the excess return on investment of innovative firms.*

4 Tax Reform

Seemingly non-discriminatory taxes can redistribute and effectively discriminate among firms in non-trivial ways when part of them are finance constrained. To illustrate, we

consider an introduction of a profit tax with an allowance for corporate equity (ACE) which has no impact on the user cost of capital. In a world without frictions, an ACE tax would thus neither affect investment nor innovation and would be fully lump-sum. In the present framework, innovative firms are financially constrained and earn an excess return on investment. In this situation, the same tax restricts investment of innovative firms, imposes a relatively larger tax burden on them compared to standard firms, and thus discourages innovation. In the next two subsections, we analyze the consequences of introducing an ACE tax and then compare it with an equal yield cash-flow (CF) tax.

4.1 An ACE Profit Tax

An ACE tax defines the tax base by setting $\lambda = 1$ and $\varepsilon = 0$ and has no effect on the user cost of capital. When R&D spending is tax deductible without any further tax preference, we also have $\tau = \sigma$. Appendix C reports comparative static results of changing tax parameters. The present scenario sets $d\tau = d\sigma$ and $d\lambda = 0$. By starting from an untaxed initial position, we exclude complicated tax base effects. Since the tax does not affect the user cost of capital, there is no change in investment by standard firms, $dI_n = 0$. The tax simply reduces the profit of a standard firm by $d\pi_n = -g_n \cdot d\tau$, where $g_n = p(x_n - iI_n)$ is the tax base.

Innovative firms are financially constrained and investment is sensitive to cash-flow. The tax drains pledgeable earnings and thereby reduces investment which is particularly harmful since these firms earn an excess return on investment. The impact on net value is magnified. Evaluating (C.2-C.3) with $d\tau = d\sigma$ yields

$$\frac{dI_i}{d\tau} = -(g_i - kR) \delta < 0, \quad \frac{d\pi_i}{d\tau} = -[g_i + \rho(g_i - kR) \delta] < 0, \quad (20)$$

where $\rho = (1 - \tau)[p(x'_i - i) - c]$ is the excess return with an ACE tax in place. Since $\pi_j = (1 - \tau)g_j$, the R&D choice in (10) is equivalent to $g_i q - kR = g_n q > 0$, so that $g_i > kR$ a fortiori. Clearly, the tax reduces the profit differential between innovative and standard firms, $d\pi_i - d\pi_n = \rho \cdot dI_i - (g_i - g_n) \cdot d\tau < 0$, but it also subsidizes R&D spending.

Evaluating (C.4) and noting $\pi_j = (1 - \tau) g_j$, the impact on R&D choice is

$$\frac{dq}{d\tau} = \rho \delta \frac{g_i - kR}{\pi_i - \pi_n} q > 0. \quad (21)$$

Even though identical rules apply to all firms, the tax nevertheless discriminates against innovative firms and, thereby, discourages R&D. This contrasts with a first-best world where innovative firms are unconstrained, have no demand for informed capital, and earn no more than a normal return, $\rho = 0$. An ACE tax with full R&D deduction would be fully neutral with respect to investment and innovation.

By (14), welfare depends on expected firm value and the value of net taxes. To avoid complicated tax base effects, we consider a small tax, starting from an initial situation of $\tau = 0$. Evaluating (C.5), denoting aggregate variables by a bar, e.g., $\bar{g} \equiv s_i g_i + s_n g_n$, and noting $\pi_i = g_i$ and $\pi_E = \bar{g} - s_k kR$ in an untaxed equilibrium yields

$$\frac{d\pi_E}{d\tau} = -[\pi_E + \rho(\pi_i - kR) s_i \delta], \quad \frac{dG_E}{d\tau} = \pi_E, \quad \frac{dV}{d\tau} = -\rho \delta (\pi_i - kR) s_i E. \quad (22)$$

The revenue from introducing an ACE tax reflects the mechanical effects of applying the tax rate to a given tax base. Since the tax rate is zero at the outset, the revenue from the behavioral impact on the tax base is negligible. Setting $\tau = \nabla_T = 0$ in (C.8) yields the second equation. The last equation states the change in welfare, $dV = E(d\pi_E + dG_E)$ from (14). Since innovative firms are constrained, they have unexploited investment opportunities with a strictly positive net social value. By further reducing profitable investment, the tax imposes a first order welfare loss even when the tax rate is zero. The welfare loss is proportional to the excess return ρ earned by constrained firms, and to the share s_i of these firms in the business sector. In summing up, we state

Proposition 2 (*Profit Tax*) *The consequences of introducing a small ACE profit tax which is neutral with respect to the user cost of capital, are: (i) the tax is neutral towards investment of standard firms but reduces investment of constrained, innovative firms; (ii) it reduces profits of innovative firms by relatively more than profits of standard firms and, thereby, discourages innovation; (iii) it leads to a first order welfare loss.*

The tax discriminates against constrained, innovative firms. Without frictions ($\rho = 0$), an ACE tax would be fully neutral, having no effect on investment, innovation and welfare.

4.2 An Equal Yield CF Tax

In the absence of financial frictions, ACE and CF taxes are both neutral towards investment since neither of them has any effect on the user cost of capital. These taxes differ in the timing of tax over a firm's life-cycle, but are otherwise fully equivalent if the same present value of tax revenue is raised. We now show that, in the present framework, an ACE tax is preferable to an equal yield CF tax, defined by $\lambda = 0$ and $\varepsilon = 1$. In this subsection, we use superscript A (C) to refer to an ACE (CF) tax. By (13), innovative firms have a smaller tax base under an ACE tax, $g_i^A = p(x_i - iI_i) - cI_i$, compared to a CF tax, $g_i^C = p(x_i - iI_i)$. The reason is that these firms attract monitoring capital to partly overcome the financing constraint and, thus, pay more interest per unit of capital. Non-innovative firms finance investment with standard bank credit, implying that the tax base $g_n = p(x_n - iI_n)$ is identical under both systems. No upper index is needed. To avoid complicated tax base effects, we start from an initial position with zero tax rates, implying $\pi_n = g_n$ and $\pi_i = g_i^A = g_i^C - cI_i$, i.e., $g_i^C > g_i^A$. To be comparable, the two systems must raise equal revenue which requires to set tax rates differently. Introducing an ACE tax yields revenue $dG_E^A = \left[\sum_j s_j g_j^A - s_k k R \right] d\tau^A$ while a CF yields $dG_E^C = \left[\sum_j s_j g_j^C - s_k k R \right] d\tau^C$. Equating tax revenue determines equal yield tax rates,

$$d\tau^C = \phi \frac{g_i^A}{g_i^C} \cdot d\tau^A < d\tau^A, \quad \phi \equiv \frac{s_i + (s_n g_n - s_k k R) / g_i^A}{s_i + (s_n g_n - s_k k R) / g_i^C} > 1, \quad (23)$$

where $\phi > 1$ and $\phi \frac{g_i^A}{g_i^C} = \frac{s_i g_i^A + s_n g_n - s_k k R}{s_i g_i^C + s_n g_n - s_k k R} < 1$ iff $g_i^C > g_i^A$. Since the CF tax has a larger base, it requires a smaller tax rate to generate the same revenue.

Both systems have no effect on the user cost and are neutral towards investment of standard firms, $dI_n = 0$. For a given scale, innovative firms report a smaller tax base under an ACE than under a CF tax. If the tax rate is raised by the same amount, the ACE

tax generates a lower tax liability and is, *ceteris paribus*, less damaging for investment. By (C.3), investment declines by $dI_i^C = -(g_i^C - kR) \delta d\tau^C$ and $dI_i^A = -(g_i^A - kR) \delta d\tau^A$. Divide through and substitute for $d\tau^C$ from (23). Since $\phi > 1$ and $g_i^C > g_i^A$, we find

$$\frac{dI_i^C}{dI_i^A} = \frac{1 - kR/g_i^C}{1 - kR/g_i^A} \phi > 1. \quad (24)$$

A CF tax reduces investment of innovative firms by more than an equal yield ACE tax, $dI_i^C < dI_i^A < 0$. To get the same aggregate revenue, the ACE tax must be applied with a relatively *larger rate to all firms*. While the tax bases are identical for standard firms, the ACE tax implies a *smaller tax base for innovative firms* than a CF tax. In consequence, the ACE tax extracts less revenue from innovative firms and relatively more from standard firms, compared to an equal yield CF tax. An ACE tax is thus less damaging for investment of innovative firms. The differential impact results from the fact that innovative firms have different financing needs than standard firms. If there were no active financing, i.e., $c = 0$ and $b = B$, innovative firms would be more constrained. However, their tax base would be the same under both alternatives, $g_i^A = g_i^C$ so that $\phi = 1$ in (23). The two tax systems would be equivalent, i.e., both would reduce investment by exactly the same amount, $0 > dI_i^A = dI_i^C$.

Evaluating (C.4), the tax raises the R&D threshold by $dq = \frac{\rho q}{\pi_i - \pi_n} (\pi_i - kR) \delta d\tau$, where we have also used the R&D condition $(\pi_i - \pi_n) q = kR$. Noting $\pi_i = g_i^A$ and using (24), the ACE tax affects the R&D decision by

$$dq^A = -\frac{\rho q}{\pi_i - \pi_n} \cdot dI_i^A, \quad dq^C = -\frac{\rho q}{\pi_i - \pi_n} \cdot dI_i^C - \frac{\rho q \delta c I_i}{\pi_i - \pi_n} \cdot d\tau^C. \quad (25)$$

A CF tax implies $\pi_i = g_i^C - cI_i$ which leads, together with the investment response noted prior to (24), to the second equation. Since an equal yield CF tax extracts relatively more revenue from innovative than from standard firms, it makes the R&D strategy less attractive and discourages innovation relative to an ACE tax ($dq^C > dq^A > 0$). Again, this differential impact arises because innovative firms attract expensive monitoring capital to get access to more external funding and to better exploit investment opportunities. In allowing for interest deductions rather than upfront investment expensing, the ACE tax

thus treats innovative firms more favorably. If monitoring capital were not available ($c = 0$), both taxes would have equivalent effects on investment and innovation.

The ACE tax is also less harmful to welfare. Starting from an untaxed equilibrium, and using (C.5) and (C.8) to evaluate the change in welfare, $dV = E(d\pi_E + dG_E)$, yields $dV = -\rho(g_i - kR) s_i \delta E \cdot d\tau < 0$. Both taxes reduce welfare since they further restrict profitable investments with an excess return and strictly positive net present value. To compare the welfare effect of ACE and CF taxes, divide through and use (23),

$$\frac{dV^C}{dV^A} = \frac{1 - kR/g_i^C}{1 - kR/g_i^A} \cdot \phi > 1. \quad (26)$$

By the same argument as in (24), a CF tax is more harmful in terms of welfare than an equal yield ACE tax. If monitoring capital were not available ($c = 0$, implying $\phi = 1$ and $g_i^C = g_i^A$), both taxes would have equivalent effects on welfare.

Proposition 3 (*Equal Yield Taxes*) *An ACE tax, compared to an equal yield CF tax, favors innovative firms relative to non-innovative ones, and is less harmful to investment, innovation and welfare. In the absence of monitoring capital and identical sources of external financing, the two tax systems are equivalent.*

4.3 A Self-financed R&D Tax Credit

The following subsections explore revenue neutral tax reforms that boost investment, productivity and welfare. We first discuss the merits of introducing a self-financed R&D tax credit, starting from an initial situation where R&D spending and financing costs are fully tax deductible (an ACE tax, $\tau = \sigma > 0$ and $\lambda = 1$, $\varepsilon = 0$). In reality, R&D spending on personnel etc. is tax deductible, but governments often grant additional subsidies, making $\sigma > \tau$. Even if it is self-financed with a revenue neutral increase in the tax rate, the policy redistributes towards innovative firms since the higher tax rate extracts revenue from all firms while the subsidy is limited only to those with R&D spending. We show that this policy can potentially encourage private R&D and boost welfare.

Tax rates are now positive at the outset. To impose revenue neutrality, set $dG_E = 0$ in (C.8). Note $\nabla_T = 0$ in (C.9), use $\sigma = \tau$ and $\bar{\pi} = (1 - \tau) \bar{g}$, and substitute the investment response in (C.3) to obtain the required increase in the tax rate,

$$d\tau = \mu_{\tau,\sigma} \cdot d\sigma, \quad \mu_{\tau,\sigma} \equiv \frac{(1 - \tau) s_k - \tau \rho s_i \delta}{\bar{\pi} - \tau \rho s_i g_i \delta} kR < 1. \quad (27)$$

Clearly, a higher R&D subsidy requires a higher tax rate to keep revenues constant. The tax rate needs to rise relatively less if the elasticity is smaller than one which is guaranteed if $\pi_E > \tau \rho s_i \delta (g_i - kR)$. This condition is fulfilled when the tax rate is small, $\tau \rightarrow 0$. Subsection 4.1 showed that raising revenue with an ACE tax discriminated against innovative and financially constrained firms. By way of contrast, the revenue neutral restructuring of the profit tax in this subsection redistributes in the opposite direction. While the higher tax rate extracts revenue from all, the *disproportionate* increase in the subsidy favors innovative firms.

With an ACE tax in place, the reform is inconsequential for investment but squeezes profits of standard firms, $dI_n = 0$ and $d\pi_n = -g_n d\tau$. For innovative firms, (C.3) implies

$$dI_i = kR\delta \cdot d\sigma - g_i\delta \cdot d\tau = (kR - g_i\mu_{\tau,\sigma}) \delta \cdot d\sigma. \quad (28)$$

If $\mu_{\tau,\sigma} = 1$, the investment response is identical to (20). Raising the ACE tax rate discriminates against innovative firms and reduces their investment. The present scenario, in contrast, may favor innovative firms since the tax rate rises by a smaller amount. Innovative firms become less constrained and grow larger if

$$kR - g_i\mu_{\tau,\sigma} > 0 \Leftrightarrow \chi(q) = \frac{\int_0^q q' d\Phi(q')}{\int_q^1 (1 - q') d\Phi(q')} = \frac{s_n}{s_k - s_i} > \frac{\pi_i}{\pi_n}. \quad (29)$$

If this condition holds, the bracket in (28) is positive. Clearly, the ratio χ rises with the cut-off, $\chi'(q) > 0$. If innovation is costly, few firms innovate and the ratio gets large. For a given π_j , there is a cost k such that the R&D threshold q comes close to unity. Hence, an equilibrium with relatively few innovating and many standard firms implies a very large probability ratio so that the condition is certainly fulfilled. In this case, a higher R&D

subsidy self-financed with a higher profit tax rate indeed redistributes towards innovative firms, relaxes the financing constraint and boosts investment, $dI_i > 0$.

Given the effect on profits of innovative firms in (C.2), $d\pi_i = -g_i d\tau + \rho dI_i$, the innovation threshold prior to (C.4) changes by

$$dq = -\frac{(1 - \mu_{\tau,\sigma}) q}{1 - \tau} \cdot d\sigma - \frac{\rho q}{\pi_i - \pi_n} \cdot dI_i < 0. \quad (30)$$

The cut-off falls. The policy directly benefits innovative firms ($\mu_{\tau,\sigma} < 1$). It also favors them by boosting investment which earns an above normal return. This strengthens profits of innovative relative to standard firms and induces more firms to spend on R&D.

Since the tax reform is revenue neutral, $dG_E = 0$, welfare changes in line with net expected profit, $dV = Ed\pi_E$. Evaluating (C.5) results in

$$d\pi_E = \left[(s_k kR - \bar{g} \mu_{\tau,\sigma}) + \rho s_i \delta (kR - g_i \mu_{\tau,\sigma}) \right] \cdot d\sigma. \quad (31)$$

Under the conditions mentioned above, the policy stimulates investment of constrained firms which adds to higher expected profit π_E . When starting from an untaxed equilibrium, $\mu_{\tau,\sigma} = kRs_k/\bar{\pi}$ and $\bar{g} = \bar{\pi}$, so that the first bracket is zero. A small self-financing R&D subsidy thus boosts expected profit and welfare by the second term which is positive by the assumption of (29). Substituting $\mu_{\tau,\sigma}$ into the first bracket yields

$$s_k kR - \bar{g} \mu_{\tau,\sigma} = (\bar{g} - s_k g_i) \tau \rho s_i kR \delta / (\bar{\pi} - \tau \rho s_i g_i \delta) > 0.$$

Again, the term $\bar{g} - s_k g_i = s_n g_n - (s_k - s_i) g_i > 0$ is positive by (29) so that the first term of (31) is also positive. With few innovative firms, a self-financed R&D subsidy raises welfare. If all firms were unconstrained, coefficients in (31) would all be zero. Without frictions, the ACE tax would support a Pareto-optimal allocation. A marginal, self-financed increase in the R&D subsidy would have no welfare effect!

Proposition 4 (*R&D Tax Credit*) *A revenue neutral increase in the R&D tax credit, leading to a subsidy larger than the tax rate, (i) redistributes towards constrained innovative firms and boosts R&D. (ii) If there are relatively few innovative firms, the tax credit*

also stimulates investment of constrained firms and, (iii) yields first order welfare gains relative to non-discriminatory taxation.

4.4 Tax Cut Cum Base Broadening

An apparently non-discriminatory tax can redistribute between more and less profitable firms. For example, tax cut cum base broadening restricts interest deductions (lower λ) to broaden the tax base and uses the extra revenue to cut the tax rate. While restricting deductions hurts all firms, the tax cut favors innovative firms relatively more than standard ones. On net, we find that the revenue neutral policy redistributes from standard towards innovative firms. In reducing their tax, it relaxes the financing constraint, boosts investment and profits, and induces more firms to spend on R&D. The policy yields a welfare gain in proportion to the excess return on constrained investment.

Formally, the policy consists of a reduction in λ accompanied by a revenue neutral cut in τ where σ is kept constant. As before, we start with an ACE tax in place ($\tau = \sigma$, $\lambda = 1$, $\varepsilon = 0$). To simplify, and since none of the arguments depend on it, we abstract from active financing and set $c = 0$ in this subsection. Innovative firms are constrained and receive only standard bank financing. The initial equilibrium thus implies $\pi_j = (1 - \tau) g_j$ with $g_j = p(x_j - \lambda i I_j)$. Limiting interest deductions $d\lambda < 0$ broadens the tax base which allows to cut the tax rate, $d\tau < 0$, such that revenue stays constant. Setting (C.8) to zero, noting (C.3), and using $\nabla_T = 0$ as shown in (C.9) yields

$$d\tau = \mu_{\tau,\lambda} \cdot d\lambda, \quad \mu_{\tau,\lambda} \equiv \tau \cdot \frac{pi\bar{I} - \frac{\tau}{1-\tau}\rho p i s_i I_i \delta}{\bar{g} - \frac{\tau}{1-\tau}\rho s_i g_i \delta}, \quad (32)$$

where $\mu_{\tau,\lambda} > 0$ as long as the excess return and the tax rate are not too large.

Although applying the same rules to all firms, the policy effectively discriminates, i.e., redistributes from standard towards innovative firms. This is most easily seen by starting first with the direct, *mechanical effect* when investment remains fixed. In this case, (32) implies a revenue neutral cut in the tax rate equal to $d\tau = (\tau pi\bar{I}/\bar{g}) d\lambda$. The

mechanical effect on a firm's tax liability $G_j = \tau g_j$ is $dG_j = g_j d\tau - \tau p i I_j d\lambda$ or, upon substitution, $dG_j = \tau p i I_j (\bar{I}/\bar{g}) (g_j/I_j - \bar{g}/\bar{I}) d\lambda$. The rent per unit of capital is larger for constrained firms,¹⁰ so that $g_i/I_i > \bar{g}/\bar{I} > g_n/I_n$, where $\bar{g}/\bar{I}$ is an average.¹¹ Hence, the mechanical effect *reduces* the tax liability of innovative firms and raises it for others so that tax revenue remains constant on average, $dG_i < 0 < dG_n$. If all investment were unconstrained, $x'_i = i$ and $g_j/I_j = \bar{g}/\bar{I}$, there would be no redistribution across firms.

Turning to the *behavioral effect*, we find that a lower deduction ($d\lambda < 0$) raises the user cost while the reduction in the tax rate has no impact. On net, the policy harms investment of standard firms. The lower tax liability of innovative firms relaxes their financing constraint and boosts investment, leaving an asymmetric investment response, $dI_i > 0 > dI_n$. Taking account of the behavioral effect, the total change in the tax rate is a magnification of the mechanical effect,

$$\mu_{\tau,\lambda} > \tau p i \bar{I}/\bar{g} \quad \Leftrightarrow \quad g_i/I_i > \bar{g}/\bar{I}. \quad (33)$$

Being constrained, innovative firms earn a larger rent per unit of capital as noted above, implying a magnification. If all investment were unconstrained, $g_j/I_j = \bar{g}/\bar{I}$, there would be no magnification effect, leaving $\mu_{\tau,\lambda} = \tau p i \bar{I}/\bar{g}$.

Investment of standard firms does not depend on the tax rate since a marginal tax change does not affect the user cost. In contrast, restricting interest deductions harms investment by $dI_n = u_\lambda d\lambda < 0$ as in (C.1). Since the tax cut cum base broadening policy redistributes towards innovative firms, it relaxes their financing constraint and boosts investment (evaluate C.3 and use $\mu_{\tau,\lambda}$) if

$$dI_i = - [g_i \mu_{\tau,\lambda} - \tau p i I_i] \delta \cdot d\lambda > 0 \quad \Leftrightarrow \quad g_i/I_i > \bar{g}/\bar{I}. \quad (34)$$

¹⁰The average rent per unit of capital is $\tilde{g}(I_j) \equiv [\theta_j f(I_j) - i I_j]/I_j$ and, by concavity, satisfies $\tilde{g}'(I_j) = -\theta_j [f(I_j) - I_j f'(I_j)]/I_j^2 < 0$. Unconstrained investment satisfies $\theta_j f'(I_j^*) = i$. With isoelastic technology $f(I) = I^\alpha$, $0 < \alpha < 1$, investments are $I_j^* = (\theta_j \alpha / i)^{1/(1-\alpha)}$ so that *average rent* is independent of θ_j , $\tilde{g}(I_j^*) = i(1-\alpha)/\alpha$. If all firms are unconstrained, the productive ones invest more but have the same gross rent $\tilde{g}$ per unit of capital. However, since $\tilde{g}'(I_j) < 0$, the average rent of innovative firms rises when investment gets constrained *below* the optimal level, implying $\tilde{g}_i > \tilde{g}_n$.

¹¹Write $\bar{g}/\bar{I} = (s_i I_i / \bar{I}) \cdot g_i / I_i + (s_n I_n / \bar{I}) \cdot \pi_n / I_n$. Weights $s_j I_j / \bar{I}$ add up to unity.

Since (33) must hold, the revenue neutral reform boosts innovative firm investment.

The mechanical effect redistributes and shifts profits from standard to innovative firms. By the envelope theorem, the reduction in standard investment has no further effect on profits of unconstrained firms. In stimulating constrained investment which earns an excess return, the policy favors profits of innovative firms. R&D becomes more attractive, leading to a lower innovation threshold. Appendix D proves

$$dq/d\lambda < 0 \quad \Leftrightarrow \quad g_i/I_i > \bar{g}/\bar{I} > g_n/I_n. \quad (35)$$

There would be no impact on innovation in the absence of financing constraints.

Finally, given revenue neutrality, welfare changes in proportion to net expected profit. Evaluating (C.5) and using $d\tau = \mu_{\tau,\lambda}d\lambda$ yields

$$d\pi_E = - \left[(\mu_{\tau,\lambda} - \tau p i \bar{I} / \bar{g}) \bar{g} + \rho s_i \delta (g_i \mu_{\tau,\lambda} - \tau p i I_i) \right] \cdot d\lambda > 0, \quad (36)$$

where $g_i \mu_{\tau,\lambda} - \tau p i I_i > 0$ was shown in (34). The magnification effect $\mu_{\tau,\lambda} > \tau p i \bar{I} / \bar{g}$ holds by (33). As all terms in the square bracket are positive, tax cut cum base broadening boosts welfare. The unconstrained case with $\rho = 0$ implies $\mu_{\tau,\lambda} = \tau p i \bar{I} / \bar{g}$ since rent per unit of capital is identical across all firms. Hence, the marginal welfare gain is reduced to zero. The welfare result is intuitively clear when recognizing that the only distortion in the present model is the financing constraint on expansion investment of innovative firms. Since the policy relaxes this constraint, it allows for more investment and, thereby, creates net income gains in proportion to the excess return of innovative firms.

Proposition 5 (*Tax Cut Cum Base Broadening*) *Starting with an undistorted user cost, enacting a smaller deduction of financing costs and a revenue neutral cut in the tax rate redistributes towards innovative firms and (i) boosts innovation; (ii) expands (reduces) investment of innovative (standard) firms; and (iii) raises welfare.*

5 Conclusions

Even with a mature financial sector, some firms – and typically the most innovative ones – are financially constrained. When credit is restricted, firms are unable to fully exploit investment opportunities. In consequence, constrained innovative firms earn a return on capital larger than the normal return available elsewhere. This calls for a reallocation of capital from unconstrained towards constrained firms. The presence of constrained firms creates demand for active financing by venture capital and other specialized intermediaries. Active lenders exercise oversight and control, thereby raise a firm’s debt capacity and facilitate additional investments. Although ‘active capital’ is more expensive, firms can benefit if they are severely constrained and if more investment yields a very high return. Non-innovative firms are less financially dependent and can rely exclusively on standard bank credit. We found that financial development where active intermediaries become more productive, boosts innovation, aggregate investment and welfare.

The presence of constrained firms has implications for tax policy. While taxes affect investment of standard firms via the traditional user cost channel, user costs are not directly relevant for constrained firms. Instead, investment becomes sensitive to future cash-flow, own assets, or institutional characteristics such as the quality of a country’s legal and financial system. A key finding of our analysis is that apparently non-discriminating taxes that apply the same rules to all firms, can effectively redistribute from unconstrained towards constrained firms. This mechanism yields a number of results that would not hold in an economy without financial frictions. For example, an ACE tax favors constrained firms and is less harmful to innovation, investment and welfare, compared to an equal yield cash-flow tax. In a world without financial frictions, the two taxes would be equivalent. In the same vein, a revenue neutral increase in the profit tax rate to finance larger R&D subsidies tends to redistribute towards innovative firms, relax their financing constraints, and boost welfare. Finally, a revenue neutral tax cut cum base broadening policy redistributes towards innovative firms and thereby stimulates constrained investment, leading to more innovation and higher welfare.

Appendix

A. Financial Contract Appendix A derives the solution of Section 2.2.2 when taxes are set to zero. The extension to positive taxes is straightforward. Suppose monitoring capital is scarce and earns a rent $\pi_i^m \geq \rho^m D_i^m$ which reduces the entrepreneur's surplus. The main text refers $\rho^m \rightarrow 0$ with perfect competition and free entry. Banks compete by offering contracts i^m, D_i^m, i and I_i that maximize entrepreneurial surplus subject to incentive and participation constraints and the financial identity $D_i = I_i - A_i - D_i^m$. Noting $v_i^e = I_i + x_i - (1+i) D_i - (1+i^m) D_i^m$ together with $\pi_i^m \geq \rho^m D_i^m$, the program is

$$\begin{aligned} \mathcal{L} = & \max_{i, i^m, D_i^m, I_i} p v_i^e - R A_i + \mu^e [p v_i^e - p \beta I_i] + \mu^m [p (1+i^m) D_i^m - p \gamma I_i] \quad (\text{A.1}) \\ & + \lambda^b [p (1+i) - R] D_i + \lambda^m [p (1+i^m) D_i^m - (R + \rho^m) D_i^m - c I_i]. \end{aligned}$$

The necessary conditions are

$$\begin{aligned} 0 &= - (1 + \mu^e - \lambda^b) p D_i, \quad 0 = - (1 + \mu^e - \mu^m - \lambda^m) p D_i^m, \\ 0 &= - (1 + \mu^e) p (i^m - i) + (\mu^m + \lambda^m) p (1 + i^m) - \lambda^m (R + \rho^m) - \lambda^b [p (1+i) - R], \\ 0 &= (1 + \mu^e) p (x_i' - i) - \mu^e p \beta - \mu^m p \gamma + \lambda^b [p (1+i) - R] - \lambda^m c. \end{aligned}$$

The first and second conditions imply $\mu^m + \lambda^m = 1 + \mu^e = \lambda^b$. The third one requires $\lambda^m (R + \rho^m) = \lambda^b R$ so that $\lambda^b \geq \lambda^m \Leftrightarrow \rho^m \geq 0$. This, in turn, implies $\mu^m \geq 0$. Banks maximize π^e until their participation constraint binds, $p (1+i) = R$ and $\lambda^b > 0$. Use these relations to replace shadow prices in the last condition and get

$$\lambda^b = \frac{p \beta}{p \beta - \rho + (p \gamma - c) \rho^m / (R + \rho^m)}, \quad \rho \equiv p (x_i' - i) - c > 0. \quad (\text{A.2})$$

A small rent ($\rho^m \rightarrow 0$) implies $\lambda^b \rightarrow p \beta / (p \beta - \rho) > 1$ and $\mu^e = \lambda^b - 1 > 0$. Hence, all shadow prices are positive and all constraints are binding which yields

$$p (1+i) = R, \quad (1+i^m) D_i^m = \gamma I_i, \quad D_i^m = \delta^m I_i, \quad \delta^m \equiv (p \gamma - c) / (R + \rho^m). \quad (\text{A.3})$$

A share δ^m of assets is financed with monitored funds. Finally, investment follows from $y_i^e = \beta I_i$. Using the financial identity, this is equivalent to

$$\pi_i^e = \pi_i - \pi_i^m = p (x_i - i I_i) - (c + \rho^m \delta^m) I_i = p \beta I_i - R A_i. \quad (\text{A.4})$$

The limit $\rho^m \rightarrow 0$ implies $\pi_i^m = \rho^m D_i^m = 0$, leading to (9) when taxes are set to zero.

B. Capital and Output Markets: Supply and demand for loanable funds are in equilibrium if $A(1 - E) + A_i(s_k - s_i)E + A(1 - s_k - s_n)E = \sum_j (I_j - A_j)s_jE + \sigma k s_k E + Z$. The left hand side states supply of funds consisting of (i) savings of $1 - E$ investors; (ii) residual savings $A_i = A - (1 - \sigma)k$ of failed innovators; and (iii) savings A of failed standard firms. Demand on the right hand side consists of (i) credits to both types of firms; (ii) public debt to pay R&D subsidies at the beginning of period; and (iii) investments in a safe Z -technology. Rearranging yields

$$A - K \cdot E = Z, \quad K \equiv s_k k + \sum_j s_j I_j, \quad (\text{B.1})$$

where K denotes total investment per firm and Z is residual savings invested in the Ricardian sector where capital earns a constant and safe return r per unit invested.

Aggregate consumption amounts to $Y = (AR + \pi_E)E + AR(1 - E) + G_E E$ and is equal to end of period wealth of investors and entrepreneurs plus tax revenue. Noting the steps following (14), defining aggregate output $X \equiv \left[\sum_j p s_j (I_j + x_j) - c s_i I_i \right] E$ of the entrepreneurial sector, and using (B.1) yields output market clearing $Y = ZR + X$. If ZR is end of period output from investments in the Ricardian technology, then consumption Y is equal to aggregate sectoral output.

C. Comparative Statics: The analysis of tax reform either starts from an untaxed equilibrium or from an equilibrium with an ACE tax ($\lambda = 1$, $\varepsilon = 0$ and $\sigma = \tau$). The user cost of capital is $u = i$. Given zero profits of banks, tax liability in (3) is $G_j = \tau g_j$ where the tax base amounts to $g_j = p(x_j - [\varepsilon + \lambda(1 - \varepsilon\tau)]iI_j) - \lambda c I_j$. With an ACE system in place, firms earn $\pi_j = (1 - \tau)g_j$ where the tax base is $g_n = p(x_n - iI_n)$ and $g_i = p(x_i - iI_i) - cI_i$ for standard and innovative firms, respectively. We calculate the effect of changes in tax parameters τ , λ and σ .

Investment and Profits: Standard firms are unconstrained and invest until the return on capital equals the user cost, $u = f'(I_n)$. Starting with an ACE tax in place, the user cost changes by $du = -\frac{\tau}{1-\tau} i d\lambda$. Defining $u_\lambda \equiv -\frac{\tau}{1-\tau} \frac{f'(I_n)}{f''(I_n)} > 0$ and noting the

envelope theorem, investment and profit of standard firms change by

$$dI_n = u_\lambda \cdot d\lambda, \quad d\pi_n = -g_n \cdot d\tau + \tau pi I_n \cdot d\lambda. \quad (\text{C.1})$$

Investment of constrained, innovative firms is implicitly determined by (9) where expected profit changes by

$$d\pi_i = \rho \cdot dI_i - g_i \cdot d\tau + \tau (pi + c) I_i \cdot d\lambda, \quad (\text{C.2})$$

where the excess return is $\rho = (1 - \tau) [p(x'_i - i) - c]$ when an ACE tax is in place. The effect on the financing constraint is $d\pi_i = p\beta dI_i + kRd\sigma$. Use $\delta \equiv 1/(p\beta - \rho)$ and get

$$dI_i = -g_i \delta \cdot d\tau + \tau (pi + c) I_i \delta \cdot d\lambda + kR\delta \cdot d\sigma. \quad (\text{C.3})$$

Innovation: The cut-off value q in (10) changes by $dq = -\frac{q}{\pi_i - \pi_n} (d\pi_i - d\pi_n) - \frac{q}{1-\sigma} d\sigma$. Inserting profit changes from (C.2-C.3) and using $\pi_j = (1 - \tau) g_j$ yields

$$dq = \zeta_\tau \cdot d\tau - \zeta_\lambda \cdot d\lambda - \zeta_\sigma \cdot d\sigma, \quad (\text{C.4})$$

where $\zeta_\tau \equiv \left[1 + \rho \frac{\pi_i}{\pi_i - \pi_n} \delta\right] \frac{q}{1-\tau}$, $\zeta_\sigma \equiv (1 + \rho q \delta) \frac{q}{1-\sigma}$ and $\zeta_\lambda \equiv \tau q \frac{pi(I_i - I_n) + cI_i + \rho(pi + c)I_i \delta}{\pi_i - \pi_n}$ are all positive. If all firms are unconstrained ($\rho = 0$) and R&D spending is fully deductible, the tax is neutral towards innovation. Starting from $\tau = \sigma$ and keeping $d\tau = d\sigma$ yields $dq/d\tau = \zeta_\tau - \zeta_\sigma = 0$ in this case. When financing constraints bind, a higher tax with full R&D deductions discourages innovation, $dq/d\tau = \rho \delta \frac{\pi_i - (1-\tau)kR}{\pi_i - \pi_n} \frac{q}{1-\tau} > 0$. The numerator is positive since $q\pi_i - (1 - \sigma) kR = q\pi_n$.

Welfare: By (14), welfare depends on expected firm value which changes by $d\pi_E = \sum_j s_j d\pi_j + s_k kR d\sigma$. Discrete R&D choice in (10) implies that the compositional effect due to $ds_i = q ds_k = -ds_n$ cancels out. Substitute (C.1-C.3) and use $\bar{I} \equiv s_i I_i + s_n I_n$,

$$\begin{aligned} d\pi_E &= -(\bar{g} + \rho s_i g_i \delta) \cdot d\tau + (s_k + \rho s_i \delta) kR \cdot d\sigma \\ &: + \tau \left[(\bar{I} + \rho s_i I_i \delta) pi + (1 + \rho \delta) c s_i I_i \right] \cdot d\lambda. \end{aligned} \quad (\text{C.5})$$

With an ACE system, tax liability amounts $G_j = \tau g_j$, where $g_n = p(x_n - \lambda i I_n)$ and $g_i = p(x_i - \lambda i I_i) - \lambda c I_i$ where we keep λ to capture the effects of changing λ . Evaluating

at the initial situation of $\lambda = 1$, we note $\pi_j = (1 - \tau) g_j$ as mentioned above. Tax liability of innovative firms changes by

$$dG_i = g_i \cdot d\tau - \tau (pi + c) I_i \cdot d\lambda + \frac{\tau}{1 - \tau} \rho \cdot dI_i, \quad (\text{C.6})$$

while $dG_n = g_n \cdot d\tau - \tau pi I_n \cdot d\lambda$ for standard firms. Using $ds_n = qg(q)dq = -ds_i = -qds_k$, total tax net of R&D subsidies is $G_E = \sum_j s_j G_j - \sigma k R s_k$ and changes by

$$dG_E = \sum_j s_j \cdot dG_j - k R s_k \cdot d\sigma - \nabla_T g(q) \cdot dq, \quad (\text{C.7})$$

where $\nabla_T \equiv (G_i - G_n) q - \sigma k R$ is the change in total tax liability when a marginal firm switches the innovation status. Substituting (C.6) yields

$$\begin{aligned} dG_E &= \bar{g} \cdot d\tau - \tau (pi\bar{I} + cs_i I_i) \cdot d\lambda - k R s_k \cdot d\sigma \\ &: + \rho \frac{\tau}{1 - \tau} s_i \cdot dI_i - \nabla_T g(q) \cdot dq. \end{aligned} \quad (\text{C.8})$$

The first three terms are direct, mechanical effects. The last two terms reflect behavioral responses which will be substituted later, depending on the specific scenario.

Finally, we need to sign ∇_T when an ACE tax is in place ($\lambda = 1$, $\varepsilon = 0$ and $\sigma = \tau$). Since $\pi_j = (1 - \tau) g_j$, the innovation cut-off becomes $(g_i - g_n) q = kR$ so that

$$\nabla_T = (G_i - G_n) q - \sigma k R = \tau [(g_i - g_n) q - kR] = 0. \quad (\text{C.9})$$

Expected tax does not change when a firm switches the innovation status.

D. Proof of (35): Evaluating (C.4) yields $dq/d\lambda = \zeta_\tau \mu_{\tau,\lambda} - \zeta_\lambda < 0$ in (35). Use $\mu_{\tau,\lambda} > \tau pi\bar{I}/\bar{g}$ as shown in (33) and substitute ζ -coefficients to get

$$\zeta_\tau \mu_{\tau,\lambda} - \zeta_\lambda > \frac{q\tau pi}{1 - \tau} \left[\left(\frac{\bar{I}}{\bar{g}} - \frac{I_i - I_n}{g_i - g_n} \right) + \frac{\rho \delta I_i}{g_i - g_n} \frac{\bar{I}}{\bar{g}} \left(\frac{g_i}{I_i} - \frac{\bar{g}}{\bar{I}} \right) \right] > 0.$$

The first round bracket is rewritten, by appropriately expanding, as

$$\frac{\bar{I}}{\bar{g}} - \frac{I_i - I_n}{g_i - g_n} = \frac{(g_i - g_n) \bar{I} - (I_i - I_n) \bar{g}}{(g_i - g_n) \bar{g}} = \frac{[g_i/I_i - \bar{g}/\bar{I}] I_i \bar{I} + [\bar{g}/\bar{I} - g_n/I_n] I_n \bar{I}}{(g_i - g_n) \bar{g}} > 0.$$

In the unconstrained case, $\rho = 0$ and $\mu_{\tau,\lambda} = \tau pi\bar{I}/\bar{g}$. The above equation would become $\zeta_\tau \mu_{\tau,\lambda} - \zeta_\lambda = \frac{q\tau pi}{1 - \tau} \left[\frac{\bar{I}}{\bar{g}} - \frac{I_i - I_n}{g_i - g_n} \right] = 0$ since average rents g_j/I_j would be identical across firm types. There would be no effect on innovation in the absence of financing constraints.

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