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PUBLIC POLICY FOR VENTURE CAPITAL*

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Abstract

This paper proposes a simple partial equilibrium model to investigate the effects of government policy on venture capital backed investments. Giving up an alternative career, entrepreneurs focus their effort on a single, high risk venture each. Venture capitalists acquire an equity stake and offer a base salary as well. In addition to providing incentive compatible equity finance, they support the venture with managerial advice to raise survival chances. We analyze several policy measures addressed at venture capital activity: government spending on entrepreneurial training, subsidies to equipment investment, and output subsidies at the production stage. While these measures stimulate entrepreneurship, only cost-effective government services can improve welfare.

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1 Introduction

Much of innovative activity originates with pioneering entrepreneurs starting up new businesses. Lacking the required financial resources, entrepreneurs must usually rely on outside finance to start up a company. Unfortunately, outside financiers find it difficult to evaluate projects with acceptable reliability since the technological feasibility and commercial potential of new ventures are largely unknown. While many essential features of the project are known to the entrepreneur, he cannot credibly communicate them to outside financiers. Loans cannot be secured due to a lack of collateral. Neither is there any past track record that might help to gauge the future business potential. The problem is further aggravated by the fact that entrepreneurs usually lack commercial and managerial experience. More often than not they start with a professional career in engineering and natural sciences rather than in business. High risks and severe informational asymmetries tend to prevent bank loans or equity finance by independent investors. Venture capital has come to specialize in financing early stage businesses where managerial advice and control is often as necessary as financial resources.

This paper proposes a stylized model of venture capital backed investments, emphasizing two essential contributions of venture capitalists (VCs). First, they arrange for incentive compatible contracts to ameliorate problems of asymmetric information about entrepreneurial effort during the early stage of start-up investment. The entrepreneurial contribution is deemed critical, and incentive compatibility is a matter of survival. If the entrepreneur does not care, the venture is bound to fail for sure, resulting in a complete loss of invested funds. Second, drawing on industry wide experience in funding and promoting the development of new businesses, the VC is in a position to give valuable advice that further enhances the survival probability of early stage businesses.

Recently, the finance literature on venture capital has grown considerable, both theoretical and empirical [Gompers and Lerner (1999), Repullo and Suarez (1998), Bergemann and Hege (1998), Cornelli and Yosha (1997) and Sahlmann (1990), for example]. This literature is mainly preoccupied with screening, various contractual arrangements such

as convertible debt, stage financing, monitoring and other aspects of governance. A rigorous policy analysis is almost entirely neglected, public policy is mainly discussed in rather imprecise and informal terms. At the same time, governments in many countries are actively contemplating measures, both at the local and state levels, to stimulate entrepreneurial activity and to ensure that adequate financing and advice is present to back up business formation. This paper attempts to fill the gap and investigates how subsidies to the private sector and government programs for entrepreneurial training and advice might help to promote entrepreneurship and venture capital backed investment.[1] Partly, our study also relates to the more traditional public finance literature on entrepreneurship and risk-taking [Gordon (1998), Boadway et al. (1991), Kanbur (1980), Kihlstrom and Laffont (1983), and the literature mentioned in the survey by Buchholz and Konrad (1999)]. The exception is Poterba (1989) who points to the importance of capital gains taxation for the supply of venture capital finance. None of these papers, however, pays much attention to the typical contractual arrangements in venture capital finance and the productive contribution of VCs.

This paper offers some important insights: Both the investment and output subsidies stimulate entrepreneurship and industry supply in the entrepreneurial sector. Under an added assumption, the same holds for government services. The stimulus depends importantly on how these policy measures affect the extent of managerial advice and, in turn, cost to market of a typical venture. Notwithstanding a moral hazard problem, the entrepreneurial sector is free from any market distortions that public policy could usefully target. None of the subsidies therefore yields first order welfare gains. The government enhances welfare, however, if it supplies cost-effective services for entrepreneurial training and infrastructure. We investigate the welfare gains from marginal expenditures as well as their optimal level. The paper proceeds as follows. Section 2 sets up the model, discussing

[1] Keuschnigg and Nielsen (2000) investigate the relation between general taxes, entrepreneurial investment and venture capital within a general equilibrium model. This paper adopts a partial equilibrium framework to simplify policy analysis but extends the focus to include government spending targeted to start-up entrepreneurs.

the relevant individual choices including financial contracting and managerial advice on the part of venture capitalists, and industry equilibrium. Section 3 examines the impact of government policy on entrepreneurship and managerial advice while section 4 considers welfare implications. Section 5 closes with some remarks on related and future work.

2 A Simple Model of Venture Capital

2.1 Definitions

We propose a partial equilibrium model of venture capital backed investment and start with definitions and notation. We then study how VCs arrange the equity contract with potential entrepreneurs to overcome incentive problems arising from their informational disadvantage. The following subsection investigates the incentives of VCs to support the venture with valuable business advice. Finally, the industry equilibrium is solved.

Risk, Effort and Advice: Venture capital is concerned with start-up investment that promises high returns but is subject to high risk as well. Survival chances critically depend on time and effort of entrepreneurs in the early stage of business formation. Due to a lack of own resources, they require the participation of outside investors to start up the venture. Venture capital finance, however, is no simple matter. Profit sharing with outside investors tends to weaken entrepreneurial incentives and may, thereby, endanger the success of the project. Since financiers are generally much less informed about developments inside the company, entrepreneurs might find it easy to pursue other lucrative activities not conducive to the success of the venture, thereby threatening the return to the investor. With this informational disadvantage, outside financiers find it difficult to retain influence and control and to secure a reasonably safe return on their investment. To capture the basic aspects of this moral hazard problem, we propose a simple formulation of effort e and assume that the entrepreneur must devote a minimum amount $0 < \delta < 1$ of time to the venture which is freely observable. Shirking is all too obvious if the entrepreneur

never shows up in her company. Given that total time endowment is unity, only the rest of time $1-\delta$ is under discretion and is assumed not to be observable by the VC. High effort means that, in addition to the basic activity δ, the entrepreneur also devotes $1-\delta$ of her time exclusively to the venture. Low effort or shirking means that time is directed to some lucrative outside activity, thus putting the proposed project at risk. The entrepreneur's contribution is critical in the sense that chances for business survival are zero if she neglects the venture. A positive survival chance requires high effort ($p > 0$ if $e = 1-\delta$) while the business fails for sure if effort is low ($p = 0$ if $e = 0$).[2] We suppress the effort variable in the probability p, knowing that it is positive only if the entrepreneur supplies high effort.

Notwithstanding the critical contribution of entrepreneurs, commercial success of a start-up company is typically enhanced by the activity of VCs who not only provide equity finance but also support the enterprise with valuable business advice and industry experience. In addition to the entrepreneur's effort, we thus postulate a productive contribution of the VC consisting of some managerial services a. Such business advice is badly needed in face of the managerial incompetence of fresh entrepreneurs in their early career. Quite often, governments also provide educational training and informational or technological services for potential entrepreneurs, invest in special infrastructure such as business incubators and science parks, and spend resources on removing regulatory and administrative obstacles to start-up activity. Some governments run their own venture capital funds to promote business formation.[3] Such public services, denoted by g, are also intended to raise survival rates. Both the VC's business advice and government services are assumed to enhance the success probability of new ventures according to

$$p = p(a,g), \quad \frac{\partial p}{\partial a} > 0 > \frac{\partial^2 p}{\partial a^2}, \quad \frac{\partial p}{\partial g} > 0, \quad p(0,0) = p_0 > 0, \quad \lim_{a,g\to\infty} p(a,g) < 1. \qquad (1)$$

[2] In this all or nothing situation, intermediate effort levels, $0 < e < 1-\delta$, are irrelevant.

[3] Governments often charge a fee which is mostly symbolic, however, and is ignored in our analysis. Storey and Tether (1998) provide a vivid account of the range of government activities intended to promote business formation in science based industries. See Lerner (1999) on the government as a venture capitalist.

For the sake of simplicity and shortness, we shall consistently use the notation

$$p' \equiv \frac{\partial p}{\partial a}, \quad p'' \equiv \frac{\partial^2 p}{\partial a^2}.$$

Any good advice of the VC as well as government support are completely wasted if the entrepreneur doesn't care, i.e. $p = 0$ in case of low effort. In this sense, entrepreneurial effort is critical. Managerial advice and government services, in contrast, are helpful but not essential. Finally, even with the most intensive private and public support, start-up investment remains a risky business.

The Portfolio Company: The typical life-cycle of a new firm may be roughly decomposed into two phases. In the first phase, considerable investments are required to set up the company. Early stage investment includes a base salary b to the entrepreneur for further product development and market research plus a fixed cost K for equipment. If the firm is a failure, these expenditures are lost. If it is successfully established, one unit of output is produced, earning a profit of $(1+\sigma)\,Q$ where Q is the demand price and σ an output subsidy. A *successful* firm thus earns net profits $(1+\sigma)\,Q - b - (1-z)\,K$ where equipment investment is possibly subsidized at a rate z. Apart from tax depreciation usually being more advantageous than true economic depreciation, governments often provide direct subsidies on R&D equipment as well. In case of business failure, the initial investment is lost without any return. Expected net profit is, thus,

$$pQ\,(1+\sigma) - b - (1-z)\,K.$$

The Venture Capitalist: By assumption, the founding entrepreneur lacks own funds. Her only capital is a business idea. To get the firm started, the VC must inject equity in the amount of

$$I = b + (1-z)\,K,$$

which is given in exchange for a share $1-s$ of gross profits $Q\,(1+\sigma)$. In addition to equity finance, the VC also supports the venture with managerial advice. The VC's

advisory activity uses a units of labor, giving a wage cost of aw per project. Note that the VC calculates with expected profits because she is assumed to hold a diversified portfolio of start-up companies that eliminates all income risk. Her expected profits are $(1-s)(1+\sigma)pQ - aw - I$ or

$$\Pi = (1-s)pQ(1+\sigma) - aw - b - (1-z)K. \tag{2}$$

The expected income c of the entrepreneur directly reduces the amount that may possibly be claimed by the VC,

$$c = spQ(1+\sigma) + b. \tag{3}$$

It will prove useful to write profits of the VC firm as

$$\Pi = pQ(1+\sigma) - aw - (1-z)K - c. \tag{4}$$

Government Expenditures: The government spends on subsidies z to equipment investment and on output subsidies σ. It also incurs expenditure on public training schemes and other business related services (g per project). In total, expected spending on each project amounts to

$$G \equiv \sigma pQ + zK + g. \tag{5}$$

The (expected) joint flows from a project to all parties involved (VC, entrepreneur, consultants, and government) sum up to

$$\Pi + c + aw - \sigma pQ - zK - g = pQ - K - g. \tag{6}$$

where c, the expected value of entrepreneurial income, must include a risk premium over alternative wage income w to compensate for risk-bearing.

2.2 Venture Capital Contract

The founding entrepreneur, by assumption, lacks any own resources to start the firm but contributes to the venture mainly with her business idea. In exchange for a reasonably

large equity share, the VC must therefore pay for start-up cost. A typical entrepreneur pursues a single project and is exposed to existential income risk associated with her equity share. Having no other income and being risk-averse, she must insist on some form of insurance. Since the VC manages a sufficiently large collection of projects, she is able to diversify risk and could costlessly provide insurance to the entrepreneur.[4] In the absence of incentive problems, efficient risk-sharing calls for complete insurance. After the VC contract is signed, however, the success of a project still rests on the entrepreneur's effort. Since the financier cannot observe and verify effort, the contract cannot be made contingent on it. To preserve incentives, the entrepreneur must share in the project risk. Insurance is limited by the extent of a moral hazard problem. A typical VC contract thus combines a base salary and a profit share to partially insure the entrepreneur and at the same time make her sufficiently interested in success.[5]

The sequence of events starts with the VC designing and offering a contract after being approached by an entrepreneur, and promising a verifiable level of advice.[6] Government support is an exogenously determined policy variable. Given the profit share and base salary as specified in the contract, and given the level of external support, the entrepreneur chooses effort. All three activities jointly determine the probability of success. Eventually, after success or failure of the project is determined, payments are made according to the provisions of the contract. As (4) suggests, the maximization problem of the VC is conveniently decomposed into two parts. First, given a level of advice and an associated success rate p, she chooses a profit share s and a base salary b to minimize expected payments c to the entrepreneur, subject to incentive compatibility (IC) and participation constraints (PC). Incentive compatibility requires that the entrepreneur must find it optimal to supply high effort, otherwise the VC is left without revenues. The contract must also be generous enough to prevent the entrepreneur from pursuing an alternative

[4] The assumption of complete risk diversification may seem unrealistic to some degree. In any case, our qualitative results below should not change if incomplete risk diversification were allowed for.

[5] On the optimality of this scheme, see fn. 8 below.

[6] We thus assume that the VC's contribution is not subject to moral hazard. For a discussion of double sided moral hazard in a similar context, see Kanniainen and Keuschnigg (2000).

career (PC). The minimized cost of the contract depends on the survival rate p which is controlled by an appropriate amount of advice. Second, the VC chooses her managerial input a to maximize her overall returns.

We start with the first part of the VC's decision problem. The financial contract consists of a profit share and a base salary that the VC (principal) offers to the entrepreneur (agent). In choosing s and b, the VC thus concedes an income to the entrepreneur equal to $s \cdot Q(1+\sigma) + b$, if the venture succeeds, but only b, if it fails. If the entrepreneur shirks, the business always fails. In this case the entrepreneur is left with a modest base salary b, but may reap some outside income $(1-\delta)w$ from shirking, giving $b + (1-\delta)w$ in total. Defining

$$\theta \equiv s \cdot Q(1+\sigma),$$

the entrepreneur receives an expected income of $c = p\theta + b$ if effort is high. To keep the analysis tractable, we confine ourselves to preferences featuring constant relative risk aversion. In fact, we assume the relative risk aversion coefficient to be equal to unity, implying that the entrepreneur's utility from income is logarithmic: $u(y) = \ln(y)$.[7] The VC's problem is now,

$$\begin{aligned} c = \quad & \min_{\theta,b} \quad p\theta + b \qquad s.t. \\ & PC: \quad p\ln(\theta+b) + (1-p)\ln(b) \geq \ln(w), \\ & IC: \quad p\ln(\theta+b) + (1-p)\ln(b) \geq \ln(b + (1-\delta)w). \end{aligned} \tag{7}$$

The terms of the contract must be generous enough so that potential entrepreneurs are willing to give up an alternative income from a safe manufacturing job which earns a wage w. The participation constraint (PC) ensures that expected utility from entrepreneurship is at least as high as utility from a safe worker's salary. Furthermore, the principal must make sure that the agent supplies high effort, otherwise she would have no chance to collect revenues since entrepreneurial neglect results in business failure for sure. The

[7] Generalizing from a unitary to a non-unitary relative risk aversion coefficient does not change qualitative results, but only adds to complexity.

incentive compatibility constraint (IC) states that expected utility from supplying high effort is at least as high as utility derived from shirking.[8]

As a benchmark, consider first the full information case. When effort is verifiable, the contract may be conditioned on effort without any incentive problems. When the incentive constraint is dropped, the cost minimizing solution is $b = w$ and $\theta = 0$. It is efficient to provide full insurance, otherwise expected cost would only be inflated by the required risk premium over safe wage income. The risk-averse entrepreneur faces a non-diversifiable income risk since she pursues a single project only. Since the VC holds a diversified portfolio with independent risks, she can costlessly provide insurance.

With asymmetric information, both constraints are binding. The cost minimizing solution is obtained by computing the intersection of them. We obtain $\ln(b+(1-\delta)\,w) = \ln w$, or $b = \delta w$. The PC then gives $\ln(w) = p\ln(\theta+b) + (1-p)\ln(b)$, or

$$\theta = b\left(\delta^{-1/p} - 1\right), \qquad b = \delta w. \tag{8}$$

To proceed with the second part of the VC's decision problem, we need to know how the cost of an incentive compatible contract in (7) depends on the success probability p and, thereby, on the extent of managerial support. In the event of a failure, the contract just compensates for the foregone income on the observable part δ of the entrepreneur's time input. This base salary does not depend on p. In the event of a success, a higher survival chance affects the entrepreneur's share in project income according to

$$\frac{d\theta}{dp} = -\mu\frac{\theta}{p} < 0, \qquad \frac{d^2\theta}{dp^2} = \mu\frac{\theta}{p^2}\left\{2 + \frac{\theta}{\theta+b}\mu\right\} > 0, \tag{9}$$

where the elasticity $\mu \equiv -\frac{p}{\theta}\frac{\partial\theta}{\partial p}$ satisfies

$$\mu = \frac{\theta+b}{\theta}\ln\left(\frac{\theta+b}{b}\right) > 1, \qquad \frac{d\mu}{dp} = \frac{b\mu^2}{(\theta+b)\,p} - \frac{\mu}{p} = \frac{\mu}{p}\left(\frac{b\mu}{\theta+b} - 1\right). \tag{10}$$

[8] With two states of nature, any desired income allocation across states can be replicated by a profit share cum base salary. Given also discrete, two-level effort, the equity contract is optimal, see Salanié (1997, ch. 5) or Mas-Colell et al. (1995, ch. 14).

The elasticity is positive and, in fact, larger than unity in value. To see this, use (8) and write $\frac{\theta+b}{b} = \delta^{-1/p}$ and $\frac{\theta+b}{\theta} = 1/\left(1-\delta^{1/p}\right)$. With these transformations, $\mu > 1$ is equivalent to $-\ln\left(\delta^{1/p}\right) > 1-\delta^{1/p}$ which is fulfilled by concavity of the ln-function.

Given a market price Q and an output subsidy σ, the solution in (8) implicitly determines the entrepreneur's share in project revenues, $s = \theta/\left[(1+\sigma)Q\right]$. A higher survival probability leads the VC to squeeze the entrepreneur's part of profits, $\frac{\partial\theta}{\partial p} < 0$, implying a lower equity share s. For any given survival rate and wage, the incentive payment θ is fixed by the fact that the entrepreneur's PC ties her reward to wage from her alternative career option. For example, if an output subsidy boosts profits, the VC simply cuts the profit share such as to leave the entrepreneur with the same incentive income θ in case of success. For the same reason, a higher price Q also translates into a lower share s and, thus, remains without effect on the entrepreneur's income in the good state.

According to (9), a higher survival rate reduces risk and, therefore, allows the principal to cut the agent's profit share. The VC's cost of the contract $c = p\theta + b$ now depends on the success probability according to[9]

$$\begin{aligned} (a) \quad c' &= \theta + p\tfrac{\partial\theta}{\partial p} = \theta\left(1-\mu\right) < 0, \\ (b) \quad c'' &= \left(1-\mu\right)\tfrac{d\theta}{dp} - \theta\tfrac{d\mu}{dp} = \tfrac{(\theta\mu)^2}{p(\theta+b)} > 0. \end{aligned} \tag{11}$$

There are two offsetting influences of p on cost. On the one hand, a higher survival rate implies that high income is paid with higher probability, raising cost by θ. On the other hand, when project risk declines, the principal is able to ensure participation of the agent with a smaller risk premium. With an elasticity μ larger than unity, the second effect dominates and marginal cost falls. Furthermore, the cost function is convex in the survival rate. The contract cost c is also proportional to the wage rate w. Furthermore, as a larger part δ of the entrepreneur's time input becomes freely observable, the moral hazard problem is alleviated, allowing to increase insurance and squeeze the risk premium without corroborating incentives. Contract cost falls on this account. In the rest of the paper, both δ and w are held fixed.

[9] Again, we use $c' \equiv dc/dp$ to save notation.

2.3 Managerial Advice

Only successfully launched businesses eventually contribute to the VC's revenues. In supporting the venture with valuable business advice, she may herself contribute to higher survival chances of her portfolio companies. In doing so, she incurs operating costs equal to aw per project. Managerial advice is chosen to maximize profits. The problem is most easily analyzed by rewriting (4) as

$$\Pi = \max_{a} \; p\left[Q\left(1+\sigma\right) - m\right], \qquad m \equiv \frac{c\left(p\right) + aw + \left(1-z\right)K}{p}. \tag{12}$$

We refer to m as 'cost to market' which is the expected cost incurred in order to establish a company successfully.[10] The benefits of advice are twofold. In raising the survival rate $p = p\left(a, g\right)$, it squeezes cost to market because a smaller number of projects need to be started for each successful one. It indirectly squeezes cost because it allows to reduce incentive compatible compensation as in (11). On the negative side, increasing advice inflates operational costs. An optimal level of advice must satisfy[11]

$$\Pi' = p'\left\{\left(1+\sigma\right)Q - m\right\} - pm' = p'\left[\left(1+\sigma\right)Q - c'\right] - w = 0. \tag{13}$$

As $\Pi'' = p''\left\{\left(1+\sigma\right)Q - m\right\} - 2p'm' - pm'' = p''\left[\left(1+\sigma\right)Q - c'\right] - p'p'c'' < 0$, the second order condition is fulfilled which is guaranteed by the curvature properties of $p\left(a, g\right)$ and $c(p)$. The next section investigates how industry equilibrium with free entry of entrepreneurs and competitive VCs shapes incentives for managerial advice.

2.4 Industry Equilibrium

Given a demand function $D\left(\cdot\right)$, the industry is in equilibrium if

$$D(Q) = p\left(a, g\right)E, \qquad D'(Q) < 0. \tag{14}$$

[10] On average, one must start $1/p$ projects to establish one project successfully.

[11] p', m' and Π' denote derivatives with respect to a, while c' denotes the derivative w.r.t. p.

In a small market, the supply of entrepreneurs is infinitely elastic as long as the venture capital contract satisfies the participation constraint. As long as they make additional profits, VCs attract ever more entrepreneurs E and start more businesses. Industry output expands along with the number pE of successful projects. The price must decline until the market clears. The equilibrium price Q is then determined by the zero profit condition relating to (12), $\Pi = 0$, or

$$(1+\sigma)\,Q = \frac{c\,(p) + aw + (1-z)\,K}{p} \equiv m. \tag{15}$$

Free entry and zero profits equate the cost to market m with the producer price, inclusive of the output subsidy σ.

Consulting and the market price are determined simultaneously in equilibrium. Impose the zero profit condition (15) on the optimality condition of the VC in (13),

$$\Pi' = -pm' = p'\,(m - c') - w = 0, \tag{16}$$

where $c\,(p)$, $\theta\,(p)$ and $\mu\,(p)$ depend on a only via its effect on p. This equation fixes the equilibrium level of advice autonomously from the rest of the model. In equilibrium, the VC's marginal benefit of supplying more managerial advice is $p'\,(m - c')$. More advice boosts survival rates which directly reduces cost to market, and indirectly so because less risk allows for a smaller expected income of the entrepreneur on account of a lower premium over the safe wage income. In providing more advice, the VC incurs a marginal cost equal to w. Optimal advice just balances marginal benefits and marginal costs. Once cost to market is known, the zero profit condition (15) fixes the demand price Q. The level of entrepreneurial activity can then be read from the demand curve (14). This recursive structure of the model greatly simplifies policy analysis.

2.5 Government Services

Many different types of government initiatives may impact on the success of start-up firms, among these educational programs, informational or technological services, and initiative

to remove regulatory or administrative barriers to entrepreneurship. The important question is whether government support and private VC advice are complements or substitutes. If $\partial p'/\partial g > 0$, for example, increased government activity directly strengthens incentives of VCs to expand their own consulting. Both activities thus tend to be complementary. A few examples may illustrate the potential interaction between public services and private advice. Suppose first that the probability of success is $p = j(a)+i(g)$, where both $i(\cdot)$ and $j(\cdot)$ are increasing and concave functions. Then $p' = j'(a)$ and $\partial p'/\partial g = 0$. Accordingly, the marginal effect of private advice on the likelihood of success remains independent of government support. There are, however, other more indirect channels through which government activity changes private incentives for managerial advice.

Another possibility is $p = f(a+g)$, f being an increasing and concave function, such that $\partial p'/\partial g = f''(a+g) < 0$. Government services reduce the marginal effect of managerial advice on the survival rate. This assumption implies that more government services partly crowd out venture capitalists' managerial advice as will become evident in a moment. Finally, one may specify more generally $p = f(y)$ where $y = [\alpha a^{-\rho} + (1-\alpha)g^{-\rho}]^{-1/\rho}$ is a CES aggregate of g and a, and f again is an increasing and concave function. Simple computations reveal that

$$\frac{\partial p'}{\partial g} < 0 \quad \text{iff} \quad -\frac{yf''(y)}{f'(y)} > \rho + 1.$$

Extra government services reduce the marginal effect of private advice on survival chances if and only if the f function is sufficiently concave relative to the inverse of the elasticity of substitution of both inputs to the CES aggregate. This more general formulation holds an ambiguous sign of $\partial p'/\partial g$ and implies, as will become evident in the next section, that government advice might actually stimulate rather than dampen private advice.

3 Public Policy

Cost to Market: Government policies such as training etc. or subsidies to capital investment potentially reduce cost to market of start-up firms, m, thus stimulating en-

trepreneurship and expansion of innovative industries. The marginal effect of policy on managerial advice is, however, inconsequential for cost to market as long as advice is optimally chosen by VCs. To see this, note that condition (16) coincides with $m' = 0$ which is required for $m = \min_a \frac{c(p)+aw+(1-z)K}{p}$. Consequently, profit maximization combined with free entry is equivalent to cost minimization and yields the same level of advice.[12] From (7) and (8), it is evident that policy instruments can influence expected income of the entrepreneur c, or the cost of the contract to the VC, only via their effects on the survival probability. None of them has any direct impact. Applying the envelope theorem to the minimization problem, the policy effects are

$$\frac{\partial m}{\partial g} = -\frac{m - c'}{p}\frac{\partial p}{\partial g} < 0, \qquad \frac{\partial m}{\partial z} = -\frac{K}{p} < 0, \qquad \frac{\partial m}{\partial \sigma} = 0. \tag{17}$$

The purpose of government training programs and other business related services is to avoid unnecessary business failures. In raising survival rates, the government is able to cut the effective cost to market because less projects need to be started to get one company going and less costs are thus expensed to obtain the required revenues. Furthermore, reducing the income risk squeezes the cost of risk-bearing, allows to cut back on entrepreneurial compensation ($c' < 0$) and further reduces cost to market. A subsidy z to start-up investment cost obviously reduces cost to market. In zero profit equilibrium, an output subsidy has no effect on cost to market but is reflected only in the demand price Q. Using (17), the zero profit condition yields

$$dQ = -\frac{m - c'}{(1+\sigma)\,p} \cdot \frac{\partial p}{\partial g} dg - \frac{K}{(1+\sigma)\,p} dz - \frac{Q}{1+\sigma} d\sigma. \tag{18}$$

Generally, a reduction in cost to market m strengthens VC profits. They start to attract more entrepreneurs and will bring more start-up companies to market. The expansion of industry then drives down the market price until, in equilibrium, profits are squeezed to zero and no more projects get funded. In reducing start-up costs, government services expand the industry and force down prices. The same holds for an investment subsidy z.

[12] Imposing the zero profit condition (15) on (13), the necessary and sufficient conditions of the two problems are related according to $\Pi' = -pm' = 0$ and $\Pi'' = -pm'' < 0$ whence m is indeed convex.

Finally, an output subsidy raises VC revenues but leaves cost to market unaffected. More projects are started until prices fall sufficiently to eliminate profits.

Managerial Advice: Condition (16) reflects the incentives to provide managerial support in zero profit equilibrium. Taking the differential thereof reveals to what extent public policy induces VCs to advise entrepreneurs in matters of business survival,

$$\Pi'' da = -\left[(m - c')\frac{\partial p'}{\partial g} - \left(p'c'' + \frac{w}{p}\right)\frac{\partial p}{\partial g}\right] dg + \frac{p'K}{p} dz.$$

Public policy thus influences the extent of consulting according to

$$\frac{\partial a}{\partial g} < 0 \quad \text{if} \quad \frac{\partial p'}{\partial g} \leq 0, \qquad \frac{\partial a}{\partial z} < 0, \qquad \frac{\partial a}{\partial \sigma} = 0. \tag{19}$$

Government training of start-up entrepreneurs and other specialized business services hold ambiguous incentives for private consulting. If government activity makes private advice less valuable at the margin, $\frac{\partial p'}{\partial g} \leq 0$, then VCs will definitely scale back their own managerial support for entrepreneurs. The same holds if the effect on p' is positive but small. If government does the job for them, VCs don't need to incur consulting costs themselves. For private advice and government business services to be complementary, the effect on p' must be powerful. An investment subsidy discourages managerial advice in equilibrium and thereby squeezes survival chances of start-up companies. It reduces the costs $(1 - z) K$ that can be saved by more intensive advice and thereby reduces incentives for advice. Since the output subsidy affects neither survival chances nor cost to market, VCs have no reason to revise the extent of managerial advice.

Entrepreneurship: How does public policy affect entrepreneurship? The number of entrepreneurs that is supported in industry equilibrium, importantly depends on the survival rate among business start-ups which, in turn, reflects the intensity of managerial advice by VCs and the extent of government training and business support. For this reason, one must carefully distinguish the number of entrepreneurs E willing to start a new project, and the number of successfully established businesses, pE, which is equal

to industry output. Industry equilibrium requires $d(pE) = D'dQ$ by the market clearing condition (14). In taking the differential of (14) together with (18) and (19), we learn how public policy affects entrepreneurship [we repeatedly use (14) and (15) and the demand elasticity $\eta \equiv -QD'/D$]:

$$\frac{dE}{E} = \left[\eta\frac{K}{pm} - \frac{p'}{p}\frac{\partial a}{\partial z}\right] dz + \eta\frac{d\sigma}{1+\sigma} + \left[\eta\frac{m-c'}{m}\frac{1}{p}\frac{\partial p}{\partial g} - \frac{1}{p}\frac{\partial p}{\partial g} - \frac{p'}{p}\frac{\partial a}{\partial g}\right] dg. \tag{20}$$

An investment subsidy clearly encourages entrepreneurship, both via a demand and a supply effect. It cuts the equilibrium price on account of lower cost to market and, thereby, calls for more entrepreneurs to accommodate increasing industry demand. Since it holds negative incentives for managerial advice and thereby increases the rate of business failure, more start-ups are needed to accommodate any given level of demand. An output subsidy stimulates entrepreneurship only via the demand effect on account of a lower market price. Since the subsidy does not interfere with the quality of VC finance, there is no supply effect on the survival rate.

Government programs that aim at reducing the risks associated with entrepreneurial activity, such as training, informational services and the like, at first sight actually seem to have ambiguous effects on entrepreneurship. First, in boosting the survival rate, they squeeze cost to market m and along with it the competitive output price which calls for more entrepreneurs to accommodate the ensuing demand effect. Second, if a larger part of the start-ups are successful, as is intended by these programs, fewer entrepreneurs are needed to supply a given level of industry output. Finally, the last term in (20) corresponds to an indirect supply effect via the impact on private advice and works in the opposite direction. If $\frac{\partial p'}{\partial g} < 0$, government activity crowds out private advice and thereby raises the rate of business failure. More entrepreneurs are then needed to supply a given output level. This offsets the direct supply effect and reinforces the demand effect but the overall result remains ambiguous. Intuitively, though, if the demand effect is strong enough, government services will surely stimulate entrepreneurship. Collecting the terms multiplying with $\partial p/\partial g$ in (20), we learn that the net effect is positive if the demand elasticity exceeds a critical value $\eta \geq m/(m-c')$ which is less than one. If we further

assume $\partial p'/\partial g \leq 0$, then the effect on private advice is negative according to (19). Under these conditions, government services will surely boost the number of entrepreneurs.

Result 1 *(Entrepreneurship) Investment and output subsidies both raise the number of entrepreneurs E. Government services stimulate entrepreneurship, provided that $\partial p'/\partial g \leq 0$ and $\eta \geq \eta^* \equiv m/(m-c')$ where $\eta^* < 1$. All policy measures boost industry supply pE by reducing the market price Q as in (18) and stimulating demand.*

4 Welfare

Public policy towards business formation and venture capital should be guided by its welfare implications. To obtain the welfare measure for our partial equilibrium analysis, we follow Mas-Colell et al. (1995, chs. 3, 10 and 15) and assume that the innovative sector supported by venture capital is small relative to the rest of the economy and that wealth effects from government intervention in the sector can be ignored. For simplicity, we also take the government's marginal cost of public funds to be unity in the following.[13] It is straightforward to include marginal costs of public funds larger than unity. The results as to subsidies will remain unchanged, and the effects of government services are altered in an intuitive way without affecting the gist of our results. Finally, with a unitary marginal cost of funds, the government's overall budget constraint is automatically fulfilled when we account for market costs of resources used for subsidies or government training etc.

To set up the partial equilibrium welfare (social surplus) measure we proceed in steps. We start with the expected surplus created by the individual project as in (6), $\Pi + c + aw - G = pQ - K - g$, giving total income generated by all E projects equal to $(pQ - K - g)\,E$. A comprehensive welfare measure, however, must take account of a number of additional benefits and costs. First, welfare must in the usual manner include the consumer surplus $CS \equiv \int_0^{D(Q)} D^{-1}(X)\,dX - D(Q)\,Q$ on inframarginal projects. Sec-

[13] The marginal cost of public funds could be unity, because taxes used to finance government training or subsidies are small, or because the government has access to some nondistortionary source of taxation.

ond, the creation of surplus in the innovative sector obviously comes at the cost of using resources which are then no longer available for production in the rest of the economy. These resources comprise entrepreneurs and consultants who are assumed to be salaried elsewhere according to their marginal product there. Hence welfare will be reduced by the forgone wage income that entrepreneurs and consultants could have earned in other sectors, $w(1+a)E$. Third, the expected remuneration of entrepreneurs, cE, which forms part of the initial surplus measure $(pQ-K-g)E$ is uncertain, having a lower certainty equivalent of wE due to risk aversion. The contribution of expected entrepreneurial income to welfare is therefore overestimated by the difference to its certainty equivalent. The risk premium $(c-w)E = [p\theta-(w-b)]E$ must thus be deducted. Adding up all parts, we arrive at the welfare measure

$$W = CS + QpE - (K+g)E - w(1+a)E - (c-w)E. \tag{21}$$

The first two terms reflect the total value of projects including consumer surplus. The third is the resource cost of start-up investment and government spending on business-related services. The fourth term subtracts the opportunity costs of advisers and entrepreneurs, and the last one deducts the cost of risk bearing. To see the influence of public policy, it is useful to rewrite this expression. Subtract profits in (4) which are zero in the free entry equilibrium, and get

$$W = CS - E[g + zK + \sigma pQ]. \tag{22}$$

This formula is perhaps more intuitive than (21). The welfare contribution of the venture capital backed industry amounts to the excess of consumer surplus over government outlays on services and subsidies in this sector. Armed with this expression we investigate, in terms of welfare, the merits of public policy towards venture capital backed investments.

Government Services: What is the optimal level of government spending g on start-up investments? Such activities are intended to promote business formation and boost survival chances of start-up firms. Storey and Tether (1998) mention training of prospective

entrepreneurs, exchange of technological and commercial information, business related infrastructure such as science parks and business incubators, and other services. As we ignore any deadweight costs of raising taxes, gE appropriately reflects the costs of public services to start-up firms. Setting $\sigma = z = 0$, we also ignore any revenue effects from expanding or contracting the sector. When the government spends more on training, the effect on consumer surplus is $d(CS) = -DdQ$, and welfare changes along with

$$dW = -DdQ - gdE - Edg.$$

In zero profit equilibrium, we have $dQ = dm = \frac{\partial m}{\partial g} dg$. Furthermore, dE is given in (20). Making the appropriate substitutions and rearranging, we altogether have

$$dW = \left\{ -p\frac{\partial m}{\partial g} + g\left[\frac{1}{p}\left(\frac{\partial p}{\partial g} + p'\frac{\partial a}{\partial g} \right) + \frac{\eta}{Q}\frac{\partial m}{\partial g} \right] - 1 \right\} Edg. \tag{23}$$

Note $\frac{\partial m}{\partial g} = -\frac{m-c'}{p}\frac{\partial p}{\partial g} < 0$ according to (17). The welfare term becomes ambiguous if government spending is increased from already positive levels. However, if government were initially inactive, we obtain

$$\left.\frac{dW}{dg}\right|_{g=0} = \left\{ -\frac{\partial m}{\partial g}p - 1 \right\} E > 0 \qquad \Leftrightarrow \qquad (m - c')\frac{\partial p}{\partial g} > 1. \tag{24}$$

Public training schemes are thus recommended only if they are sufficiently productive in boosting survival rates among start-ups. Government activity should then be expanded until the marginal benefit is equated to the marginal cost of public funds equal to unity. Note that $\frac{\partial p}{\partial g}$ and, therefore, $\frac{\partial m}{\partial g}$ approach zero with higher levels of g. With ever higher levels of public expenditure, the square bracket in (23) tends to become more negative, making marginal spending ever less effective. The optimal level where further expenditure fails to deliver welfare gains, is lower if (i) the demand elasticity η for industry output is high; (ii) the effect on the survival rate disappears rapidly, i.e. p is very concave in g; and (iii) private and government advice are strong substitutes, i.e. $\frac{\partial a}{\partial g}$ is very negative. The presence of subsidies z and σ makes the analysis more complicated due to tax base effects but does not change the principal conclusion.

Investment Subsidy: Should the government resort to an investment subsidy to promote venture capital backed business formation? To keep things simple, we set $\sigma = z = g = 0$ initially and introduce a small subsidy in the absence of any other public policy measures. With $W = CS - zKE$ according to (22), and using $\frac{\partial Q}{\partial z} = \frac{\partial m}{\partial z} = -\frac{K}{p}$ as well as $pE = D$, the welfare effect is

$$dW = -E\left(p\frac{\partial m}{\partial z} + K\right)dz = 0. \tag{25}$$

Without other taxes on VC activity, a subsidy to equipment investment is not advised.

Output Subsidy: An output subsidy is effective in stimulating entrepreneurship and industry output. Unlike the investment subsidy, it does not affect managerial advice at all. It stimulates demand and therefore attracts more entrepreneurs. It seems no surprise that we find again a welfare effect that is zero to the first order:

$$dW = mDd\sigma - QpEd\sigma = 0. \tag{26}$$

Our simple model of a competitive venture capital industry with free entry and zero profits thus cannot rationalize any public policy except possibly a productive contribution such as training and other business related services. The non-standard feature of our model is moral hazard on the part of entrepreneurs. A social planner who cannot observe and verify effort any better than private VCs faces the same participation and incentive constraints and must allocate entrepreneurial income as indicated by (8). With two states of nature and discrete effort choice, any desired income allocation across states can be replicated be a profit share cum base salary. The venture capital contract is, thus, optimal. The only relevant decision margins other than the contract are occupational choice and managerial advice. There are no obvious distortions in these decisions either:

Result 2 *(Welfare) The welfare effects of small subsidies to output and equipment investment are zero to the first order. Introducing entrepreneurial training and other government services raises welfare if they are cost-effective,* $(m - c')(\partial p/\partial g) > 1$. *As government support is expanded, it becomes ever less cost effective until the net gains from further expansion vanish at the optimal level.*

5 Conclusions

Business formation and entrepreneurship are crucial for the development and expansion of new industries. Start-up entrepreneurs typically lack commercial experience and badly need managerial support. More often than not, the roots of business failure can be traced to management mistakes. Another barrier to start-up investment is a lack of own capital which tend to be rather negligible compared to the investment requirements to launch a business. Their main capital is a business plan and a technological or organizational innovation with yet untested commercial potential. In such circumstances, the entrepreneur's knowledge and commitment to the project are crucial but are difficult if not impossible to evaluate by outside investors. Standard sources of outside finance such as bank credits or equity by independent investors are thus often not available.

Venture capital has come to specialize in financing early stage investments with high risk but also high potential. Venture capitalists finance most of the initial investment in exchange for an equity stake, giving them considerable control and influence. Since entrepreneurs have superior knowledge about the technological characteristics of the project and the developments inside the new company, their effort and commitment is crucial but difficult if not impossible to observe and verify from outside. To prevent business failure, moral hazard must be contained. To preserve incentives and to provide at the same time insurance to risk averse entrepreneurs, venture capitalists typically arrange for a combination of an equity share and a modest base salary. In addition, venture capitalists actively help with managerial advice and essential industry experience in the early stages of business development. Such active support, certainly not a feature of standard bank finance, helps to prevent failures due to avoidable management mistakes and boosts survival chances. The role of public policy towards venture capital is discussed in rather informal terms and has not been the subject of rigorous analytical work.

Having developed a simple, competitive model of entrepreneurship and venture capital, we found that a subsidy to equipment investment induces venture capitalists to cut back on managerial support, thereby increases the risk in starting new firms and requires an

adjustment in profit sharing. An output subsidy, in contrast, is neutral with respect to advice and the structure of the contract. In lowering cost to market, both subsidies reduce prices, stimulate demand and, thus, attract more entrepreneurs to the industry. However, with no obvious distortions in our competitive benchmark model, we found no welfare based justification for stimulating venture capital activity and start-up investment. Only a productive contribution of the government such as entrepreneurial training, technological and informational services and specialized business infrastructure is called for if it is cost effective. It reduces cost to market and stimulates industry output and entrepreneurship. It is, however, likely to crowd out private managerial support to some extent. Such government services yield first order welfare gains if they are cost effective.

Our results are best seen as a benchmark case that could be developed further in many interesting directions. Such extensions could possibly provide some rationale for government activity other than the productive contribution emphasized in this paper. For example, public policy might have to address the potential distortions stemming from informational spillovers and learning in the venture capital community. Furthermore, financial contracts might not always be optimal if there are more than two states and effort is continuous. In such context, distortions would arise from financial contracting in the presence of informational asymmetries [see Greenwald and Stiglitz (1986), or Hoff (1994)]. Among the more traditional reasons for government intervention would be imperfect competition and strategic interactions among venture capitalists.

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