Business Creation and the Stock Market

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Working Paper No. 0009
July 2000

We would like to thank Samuel Bentolila, Jose Manuel Campa, Ulrich Hege, Giovanna Nicodano, Rafael Repullo, Sheridan Titman, and seminar audiences at CEMFI and Toulouse for helpful comments. (Email addresses: c.michelacci@cemfi.es, suarez@cemfi.es.)
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Abstract

We claim that the stock market encourages business creation, innovation, and growth by allowing the recycling of "informed capital". Due to incentive and information problems, new start-ups face high flotation costs. Sustaining a tight relationship with a monitor (bank, venture capitalist) allows them to postpone their going public decision until profitability prospects are clearer or incentive problems are less severe. However, monitors' informed capital is in limited supply and the earlier young firms go public the quicker this capital is redirected towards new start-ups. Hence factors that lead to the emergence of a stock market for young firms also encourage business creation. Given the role of new businesses in innovation, our theory suggests a novel linkage between financial development and growth.

JEL classification: E44, G32, O40.
Key words: start-ups, financial life cycle, going public, venture capital, growth.

1 Introduction

During the last two decades, the US venture capital industry has been extremely active, many young innovative companies have become major players in their industries, and there has been unprecedented growth in the liquidity and value of Nasdaq, the stock market where most start-ups go public. This paper digs out some of the theoretical linkages between these phenomena and studies their implications for business creation, innovation, and economic growth.

There is wide consensus that venture capitalists, as well as some banks when involved in tight relationships with the firms that they finance, have special value for start-ups.[1] They use their expertise, reputation, and wealth (in brief, their *informed capital*) in order to monitor the activities of entrepreneurs that, due to incentive problems, find difficulties in raising funds from the general public.[2] It has been argued that the stock market facilitates the *recycling* of informed capital by allowing the sufficiently mature companies to go public and the monitors to redirect their resources towards new start-ups.[3] We bring this argument to general equilibrium and show its implications for business creation and growth. The result is a theory of financial development in which informed capital and the stock market play distinct but complementary roles.

We start modeling the financial life cycle of innovative start-ups. We consider an economy where start-ups are developed by entrepreneurs who are

[1] See Kortum and Lerner (1998a), for venture capital, and Petersen and Rajan (1994), for banks.

[2] The monitoring role of special classes of financiers has been emphasized by the literature on financial intermediation, including Diamond (1991), Rajan (1992), and Holmstrom and Tirole (1997).

[3] See, for example, Black and Gilson (1998).

liquidity constrained.[4] We postulate that, due to incentive and information problems, start-ups have to pay a large flotation cost in order to access the stock market.[5] Their alternative is to establish a tight financial relationship with a monitor (i.e. a bank or a venture capitalist), postponing the decision to go public until profitability prospects are clearer or the incentive problem is less severe.

Monitors' informed capital is, however, in limited supply.[6] Our preferred motivation for this is that monitoring skills are scarce, since they relate to experience which is hard to accumulate. The limitation might also be due to constraints to monitors' capacity to raise external funds.[7] Either way, informed capital tends to appropriate rents in equilibrium so the start-ups face a trade-off between paying some rents to informed capital and paying the cost of going public.

The equilibrium rental price of informed capital is positively related to the number of entrepreneurs that seek monitors' financial support. Therefore, when the economic environment becomes more favorable to entrepreneurship, the rental price of informed capital increases, the start-ups decide to go public

[4] Rajan and Zingales (1998) document that young US companies are much more dependent on external finance than their mature counterparts.

[5] As in most theoretical and empirical research on the going public decision, we exploit the trade-off between some flotation cost and the diversification, liquidity, and monitoring advantages (or disadvantages) of dispersed ownership. See Pagano et al. (1998) for a review of the literature.

[6] In reference to the US venture capital industry, *The Economist* (January 25th 1997, p. 21) writes: "The main problem is not a lack of investment opportunities, but a shortage of people expert enough to spot them. Because venture capitalists spend so much time with the companies they invest in, they tend to finance just a few firms a year each. Here is one difference between the venture capitalists and the firms they finance: successful high-tech firms can grow as big as Microsoft; venture capital houses stay small."

[7] Gompers and Lerner (1998) find that past performance and reputation are important determinants of venture capitalists' fundraising. In Holmstrom and Tirole (1997), monitors' limited supply of funds stems from wealth constraints. Monitors suffer from an incentive problem that requires them to finance a fraction of each monitored project with their own funds. Arguably, the accumulation of monitors' own funds is naturally bounded by life cycle considerations and risk aversion.

earlier, and the size of the stock market for young fast growing companies endogenously increases.

In our economy, entrepreneurs and monitors get matched after a process of search. In equilibrium a *multiplier* translates the fixed supply of informed capital into a flow of newly created firms. We find two channels whereby changes in fundamentals affect the multiplier and hence the rate of business creation. The first channel is *profitability*, which operates through the entrepreneurs' incentives to develop new projects and benefits business creation by accelerating the matching between entrepreneurs and free informed capital. The second channel is *recycling*, which operates through the firms' financial life cycle, determining how quickly the informed capital committed to existing firms gets freed to finance new ones.

At the point entrepreneurs and monitors set the terms of their relationships, their costs of entering and searching are already sunk so there is a natural incompleteness of contracts which may generate inefficiencies in the allocation of resources. We find that the going public decisions of start-ups are constrained efficient, while the number of entrepreneurs that decide to search for a monitor is generally not. For instance, if the ability of monitors to appropriate rents is too large, policies directed to encouraging entrepreneurship can improve welfare.

Our analysis reveals that bringing the rule whereby the parties share the surplus of their relationships closer to the efficient one increases the equilibrium rental price of informed capital and thus the incentives for start-ups to go public. This has two important implications. First, the size of the stock market for young companies becomes an indicator of the economy's level of efficiency. Second, institutions such as competition policy and prudential regulation may affect financial development through their impact on the ability of entrepreneurs and monitors to appropriate the rents of their relationships.

In the main extension of the model, we explore the connection between business creation and growth. Following the common view that start-ups are being the engine of innovation in the current growth wave, we assume that the success of each young innovative business produces some positive technological externality on the rest.[8] We first show that a higher rate of technological progress raises the profitability of new businesses and the rental price of informed capital and, consequently, encourages start-ups to go public earlier. Thus it promotes the emergence of a stock market for young companies. In turn, the development of such a market speeds up the recycling of informed capital and fosters technological progress through its positive effect on business creation. The result is a novel theory of the linkage between stock market development and growth.[9] Interestingly, the former affects the latter through a channel different from savings.[10] Furthermore, a financial underdevelopment trap may emerge where the underdevelopment of the stock market both induces and is induced by low growth.

In a second extension, we consider the possibility of liquidity externalities in the stock market for start-ups. They imply that the cost of going public in that market decreases with the number of firms listed therein.[11] These externalities create a strategic complementarity in the going public decisions of start-ups which may induce an inefficiently low number of IPOs. Moreover,

[8] Aghion and Tirole (1994) and Greenwood and Jovanovic (1999) provide reasons explaining why innovation may require the creation of new, independent businesses.

[9] See Levine (1997) for a survey of the literature on the theoretical and empirical links between financial development and growth.

[10] Levine and Zervos (1998) provide evidence that both bank development and stock market liquidity are strongly related to productivity growth while their linkage with savings is not significant.

[11] Pagano (1993) and Subrahmanyam and Titman (1999) provide microfoundations for this type of externalities.

multiple Pareto-ranked equilibria may emerge in which welfare is positively related to the number of start-ups that go public.

While the basic version of the model provided no clear reason for government interference in the going public decisions of start-ups, the technological and liquidity externalities considered in its two extensions might provide some rationale for government support to IPO activity, specially in countries with insufficiently developed stock markets. In particular, they suggest that governments may want to favor the recycling of informed capital in: (i) industries characterized by large technological spill-overs and where the scarcity of informed capital is likely to produce bottlenecks for the creation of new businesses, and (ii) market segments where the lack of a critical mass of similar listed companies makes individual flotations particularly costly.

The rest of the paper is organized as follows. In Section 2 we describe the model. Section 3 characterizes individual firm behavior. Section 4 analyzes equilibrium. In Section 5 we discuss the results on efficiency. Section 6 contains the extension on growth. Section 7 deals with liquidity externalities. The conclusions appear in Section 8.

2 The model

We consider an economy in continuous time where there is just one final good, which is the numeraire.

2.1 Agents

There are continuous masses E of *entrepreneurs*, M of *monitors*, and I of *investors*. All of them are infinitely lived, risk neutral, and maximize the expected present value of their income stream net of possible utility costs. Entrepreneurs have a subjective discount rate ρ and are able to develop one business project per unit of time. Monitors also have a discount rate ρ and can monitor one entrepreneur per unit of time. Finally, investors have a discount rate $r < \rho$ and are endowed with some (sufficiently large) exogenous flow of income that guarantees that their supply of funds is, on the relevant range, perfectly elastic at the rate r. Consequently, r will be the market interest rate in this economy. With the difference $\rho - r > 0$ we intend to capture the gains in terms of liquidity and risk diversification that associate with the issuance of public securities among investors as opposed to the holding of the private securities that characterizes entrepreneur-monitor relationships.

2.2 Technologies

At every instant t, a mass N of potential projects is randomly allocated among the entrepreneurs not involved in developing another project. To be operative, a project requires one unit of investment. To keep a project ready for the future rather than making it operative immediately, the entrepreneur has to incur a utility cost c per unit of time. Operative projects are called *firms.* A firm can be liquidated at any point in time at a constant liquidation value $Q \in (0, 1]$. When a firm is liquidated, the underlying project is lost for ever.

There are up to two stages in a firm's life: a *start-up stage*, in which it does not produce any income, and a *maturity stage*, in which it produces an income flow $\tilde{y}$ per unit of time. A fraction γ of the firms are *good* (or profitable) and have $\tilde{y} = y > 0$, while the rest are *bad* (or unprofitable) and have $\tilde{y} = 0$. Firm types are initially unknown, but they get discovered at maturity or, sometimes, before maturity.

The discovery of a firm's type and the transition to maturity are affected by a moral hazard problem. Both only occur if the entrepreneur devotes his effort to the firm. Conditional on this, a firm's type is early discovered and maturity is reached according to independent Poisson processes with arrival rates λ and μ, respectively.[12] Otherwise, the entrepreneur gets a flow of unverifiable private benefits from the firm, $b \leq \rho Q$, but neither early type discovery nor maturity occur. Once maturity is reached, no moral hazard problem exists.

2.3 Financing modes

We intend to model a situation where liquidity constrained entrepreneurs affected by a moral hazard problem rely on either monitors or a costly reorganization of their management control system in order to finance their firms. Accordingly, we first rule out the possibility that entrepreneurs save so as to self-finance their projects by assuming that E is large relative to N. This means that potential entrepreneurs have few chances to receive a project and, given the difference between their discount rate ρ and the market interest rate r, they never find optimal to accumulate any wealth. We further assume that the moral hazard problem is severe enough to rule out the possibility that, before reaching maturity, an entrepreneur can directly raise funds from the investors. As shown in the Appendix, if the stream of private benefits b is sufficiently large, the entrepreneur would not contribute his effort to a start-up whose returns have to be shared with some outside investors.

We consider two solutions to the financing problem of start-ups. The first is *informed capital financing,* which consists in the establishment of a tight relationship between the entrepreneur and an expert monitor. (We

[12] Of course, the entrepreneur's effort is required to reach maturity even after early discovering his firm's type.

will indistinctly refer to M as the number of monitors and the stock of informed capital in the economy.) We assume that the monitors' expertise allows them to obtain enough information and control on the entrepreneurs to guarantee that they devote their effort to the firms.[13] For simplicity and without loss of generality, we assume that monitors finance entrepreneurs with their own funds. Moreover, we assume that the provision of the funds for a project occurs at the point in which the monitor starts a relationship with an entrepreneur.[14]

The second solution is to reorganize the firm's management control system so as to guarantee (once and for all) that the entrepreneur contributes his effort. This reorganization gives the start-up access to *stock market financing* but involves an unrecoverable *flotation cost* F.[15] Under this arrangement funds are provided by the investors at the rate r.

2.4 Search frictions

The process whereby entrepreneurs access informed capital financing is subject to search frictions. The underlying assumption is that projects are heterogeneous and monitors are specialized in monitoring specific subsets of the

[13]Following Holmstrom and Tirole (1997), one could argue that monitors have exclusive access to a technology that reduces the flow of private benefits associated with shirking, making it unprofitable to the entrepreneur. In a more classical sense, monitoring might consist in making the entrepreneur's actions verifiable so as to enforce penalties in case of misconduct.

[14]Implicitly we assume that the monitors have some income or wealth with which to get started. However, given the difference between ρ and r, monitors want to commit as little wealth as possible to their activity. Monitors may form coalitions (such as banks or venture capital funds) that pool together the funds and risks involved in a large number of relationships. With such an arrangement, monitors may diversify away projects' idiosyncratic risk and guarantee the instantaneous availability of funds for their new relationships.

[15]In reality, the costs of going public include not only the administrative fees, the advertising expenses, and the underpricing that characterize IPOs, but also the direct and indirect costs of complying with tighter disclosure requirements and more transparent accounting standards.

possible projects. Since evaluating whether the characteristics of a project match the ability of a given monitor takes time, matching an entrepreneur with a suitable monitor also requires time. Following Pissarides (1990), we model the rate at which entrepreneurs match with suitable monitors using a homogeneous-of-degree-one matching function $h(e_t, m_t)$, where e_t and m_t denote, respectively, the time-t number of entrepreneurs searching for a monitor and of monitors searching for an entrepreneur. This function is assumed to be increasing, concave, and continuously differentiable. Accordingly, an entrepreneur will find a suitable monitor at the rate

$$q\left(\theta_t\right) = \frac{h(e_t, m_t)}{e_t} = h(1, \frac{1}{\theta_t}),$$

which is decreasing in $\theta_t = e_t/m_t$. Analogously, a free unit of informed capital will find a project to finance at the rate $\theta_t q(\theta_t)$, which is increasing in θ_t. This allows us to refer to θ_t as the level of *credit rationing* in the economy.[16] We further assume

$$\lim_{x \to 0} q(x) = \lim_{x \to \infty} xq(x) = \infty \quad \text{and} \quad \lim_{x \to \infty} q(x) = \lim_{x \to 0} xq(x) = 0, \tag{1}$$

in order to guarantee that the equilibrium value of θ_t is interior.

2.5 Contracts

If an entrepreneur and a suitable monitor who have just met separated, each would have to go through a time-consuming process of search before meeting a new suitable partner. Hence, there is some surplus from starting a relationship. The entrepreneur and the monitor sign a contract at the beginning of their relation establishing the conditions upon which the firm

[16] Search frictions generate a situation where some entrepreneurs willing to borrow from monitors at the terms that prevail in equilibrium are (temporarily) unable to obtain credit. This resembles the formal definition of equilibrium credit rationing (see Baltensperger, 1976).

will go public or be liquidated as well as the division of the associated surplus. In this respect, we focus for simplicity on straight equity claims whereby the entrepreneur and the monitor will receive a fraction α and $1-\alpha$, respectively, of any net revenue generated during their relationship. We assume that the terms of the contract correspond to a generalized Nash bargaining solution in which the bargaining powers of the entrepreneur and the monitor are $\beta \in (0,1)$ and $1-\beta$, respectively.

3 The financial life cycle of firms

We have introduced two financing modes: informed capital financing and stock market financing. Given the greater opportunity cost of monitors' funds, stock market financing dominates if flotation costs are zero, which is actually the case once firms mature.[17] Among start-ups, however, there is a trade-off between the flotation cost F and the gains from going public: namely, the liquidity gains associated with the difference between ρ and r and the recycling gains associated with the possibility of reusing the informed capital in some other entrepreneur-monitor relation.

When firms start up, their types are unknown. Some are discovered to be good or bad at maturity only. Others get their types discovered before maturity. We need to analyze their financing decisions in every possible state. Start-ups which are discovered to be bad, at or before maturity, are liquidated. Good start-ups which reach maturity produce under stock market financing. In the rest of this section we first study the case of the start-ups of

[17] Our assumption that the flotation cost is zero once a firm matures is just a normalization. What really matters is that the flotation cost is lower after maturity. With the possible exception of some administrative fees, the costs of going public tend to be higher for firms that have short track records and low visibility. This is suggested by the evidence surveyed in Ibbotson and Ritter (1995), which indicates that smaller and riskier IPOs suffer greater underpricing.

unknown type, deriving a condition that ensures that they rely on informed capital. Secondly, we characterize the going public decision of the start-ups that, in the context of an entrepreneur-monitor relationship, discover their type to be good before reaching maturity.

3.1 The need for informed capital

If entrepreneurs decided to finance their start-ups of unknown type by directly going public, no firm would ever use informed capital in this economy. We focus, instead, in the more interesting (and realistic) situation where F is large enough to rule out the access to stock market financing at such an early stage.

Suppose that the investors value at R^0 the future income from an unknown start-up to which the entrepreneur devotes his effort. Then, if $R^0 < 1 + F$, buying the machine and paying the flotation cost will not be feasible. This condition is equivalent to imposing

$$F > F^0, \tag{2}$$

where

$$F^0 = \frac{\lambda[\gamma R^d + (1-\gamma)Q] + \mu R^m}{\lambda + \mu + r} - 1, \tag{3}$$

$R^d = \frac{\mu}{\mu+r}Y$, $R^m = \gamma Y + (1-\gamma)Q$, and $Y = \frac{y}{r}$. To explain these expressions notice that R^m is just the average revenue that an unknown start-up generates at its maturity, while Y and R^d are, respectively, the investors' value of the income of a good firm at maturity and at the early discovery of its type. They can be obtained from the asset pricing formulas $rR^d = \mu(Y - R^d)$ and $rY = y$. Similarly, R^0 can be thought of as the value of an asset whose returns are described by the equation $rR^0 = \lambda[\gamma R^d + (1-\gamma)Q - R^0] + \mu(R^m - R^0)$. Hence $R^0 < 1 + F$ is equivalent to (2).

Under (2) entrepreneurs have to rely on informed capital to start up their projects, postponing the going public decision to either maturity (when going public is always optimal) or the early discovery of their firms' type. We analyze the latter decision below, in the context of an entrepreneur-monitor relationship.

3.2 The entrepreneur-monitor relationship

Consider what happens when an entrepreneur who is trying to finance a project of unknown type meets a free suitable monitor. They have to agree on the sharing rule $\alpha \in [0,1]$ according to which they will divide the revenue generated during their relationship. They also have to decide whether the start-up will go public in case it is discovered to be good before maturity. We formally represent this *financial life cycle* decision by the probability $f \in [0,1]$ of going public at that point.

Let B^u and L^u respectively denote the entrepreneur's and the monitor's value of a relationship in which the firm's type is unknown. The postulated generalized Nash bargaining solution implies that α and f solve

$$\max_{(\alpha,f)\in[0,1]\times[0,1]} \left(B^u - U\right)^{\beta}\left(L^u - 1 - V\right)^{1-\beta}, \tag{4}$$

where U and V are the values of the outside options of each party, which from the point of view of the maximization are taken as constants, and -1 accounts for the funds provided by the monitor in order to make the project operative.[18]

The entrepreneur's value of the relationship solves

$$\begin{aligned} \rho B^u &= \lambda[\gamma f \alpha (R^d - F) + \gamma (1-f) B^d + (1-\gamma)\alpha Q - B^u] \\ &\quad + \mu(\alpha R^m - B^u), \end{aligned} \tag{5}$$

[18] In the next section, we discuss how the values of U and V are determined in equilibrium.

where the first term in the right hand side captures the capital gain associated with the early discovery of type and the second the capital gain at maturity. To explain the first, notice that if the firm is discovered to be bad it gets liquidated at a value Q. On the other hand, if it is discovered to be good, it goes public with probability f, which yields a total net revenue of $R^d - F$, while the relationship is continued with probability $1 - f$, which has a value B^d to the entrepreneur. This value solves

$$\rho B^d = \mu(\alpha Y - B^d), \tag{6}$$

reflecting that, once the good firm matures, going public yields a total revenue of Y and the relationship with the monitor terminates.

Analogously, the monitor's value of the relationship while firm type is unknown solves

$$\begin{aligned} \rho L^u &= \lambda[\gamma f (1-\alpha)(R^d - F) + \gamma (1-f) L^d + (1-\gamma)(1-\alpha) Q - L^u] \\ &\quad + \mu [(1-\alpha) R^m - L^u] + [\lambda + \mu - \lambda\gamma (1-f)] V, \end{aligned} \tag{7}$$

The first two terms in the right hand side are symmetric to those in (5). The new third term reflects the *recycling* of informed capital, worth V, that takes place when the relationship with the entrepreneur breaks up. This occurs upon the arrival of any news, except if the firm is discovered to be good before maturity in which case there is a probability $1 - f$ that the relation continues. The equation

$$\rho L^d = \mu[(1-\alpha) Y + V - L^d] \tag{8}$$

gives the monitor's value of continuing with the relation in this case.

The first order condition for the choice of α in (4) implies that

$$B^u = U + \beta S, \tag{9}$$

$$L^u = 1 + V + (1 - \beta)\, S, \tag{10}$$

where $S = (B^u + L^u - 1) - (U + V)$ represents the surplus from starting the relationship.

Given (4), (9) and (10), the parties will agree on the financial life cycle decision f that maximizes S. To obtain an expression for S conditional on f, we first add up (5) and (7), using (6) and (8). Then we group together the terms which include $B^u + L^u$ and add and subtract constants so as to replace the resulting expression with S. This yields:

$$\begin{aligned} S &= \frac{\lambda}{\lambda + \mu + \rho}\left[\gamma f (R^d - F) + \gamma (1 - f)\,(R^w - \tfrac{\rho}{\mu+\rho} V) + (1 - \gamma)\, Q\right] \\ &\quad + \frac{\mu}{\lambda + \mu + \rho} R^m - \frac{\rho}{\lambda + \mu + \rho} V - U - 1, \end{aligned} \tag{11}$$

where $R^w = \frac{\mu}{\mu+\rho} Y$ represents the sum of the entrepreneur's and the monitor's value of the revenue that they will receive if the start-up which is known to be good is sold to investors at its maturity.

The surplus S is affected linearly by the financial life cycle decision f. Deriving with respect to f in (11) identifies a critical value

$$F^d = R^d - R^w + \frac{\rho}{\mu + \rho} V = \frac{\rho - r}{\mu + \rho} R^d + \frac{\rho}{\mu + \rho} V \tag{12}$$

such that it is optimal to set f according to the rule

$$f = \begin{cases} 1 & \text{if} \quad F \leq F^d, \\ 0 & \text{otherwise.} \end{cases} \tag{13}$$

F^d measures the shadow value of the stock market for a start-up discovered to be good. It captures two gains from going public. The first is the *liquidity gain* associated with selling the firm earlier to investors whose lower discount rate reflects the greater liquidity of their financial positions. Specifically, investors are willing to buy the firm at a price R^d once its type has been discovered to be good (and F has been paid), while the entrepreneur's and monitor's value of the revenue that they will receive by selling the firm at maturity amounts to $R^w < R^d$ since $\rho > r$. The second is the *recycling gain* associated with freeing the informed capital of the monitor (which is worth V) at this point in time rather than at maturity. The discount factor $\frac{\rho}{\mu+\rho}$ accounts for the expected cost of the random time interval till maturity.

The presence of V in (12) and its subsequent influence on the financial life cycle decision f indicates the existence of a general equilibrium feedback. As we further analyze in the next section, equilibrium V will both determine and be determined by the speed of recycling of informed capital associated with the endogenous going public decisions of start-ups.

4 Equilibrium

The equilibrium in our economy can take three possible configurations, depending on whether the creation of new firms (which is a source of growth in aggregate output) is ultimately constrained by the stock of informed capital M, the flow of new projects N, or both. We are going to focus on the first of these configurations by assuming that M is small relative to N. This situation is intended to describe a period of "technological revolution", in which investment opportunities are flourishing under the impetus of new products and technologies, but the expertise needed to monitor them is rather limited.[19]

Formally, an equilibrium is a level of credit rationing $\theta \in [0, \infty)$ and a con-

[19] Various sources indicate that the US economy is experiencing a technological revolution. Kortum and Lerner (1998b) attribute the recent jump in patenting to a sharp increase in innovation. Moreover, Krusell et al. (1999) note a significant acceleration in the part of technological change which is investment specific. More specifically, they observe that the rate of technological change that is specific to capital equipment has been 2.7 percentage points higher in the period after 1975 than before.

tract $(\alpha, f) \in [0,1] \times [0,1]$ governing each entrepreneur-monitor relationship, such that no privately profitable business opportunity remains unexploited. With M small relative to N, the latter requirement means that, in addition to (α, f) being fixed according to (9)-(13), the value from searching must be zero for a free entrepreneur, $U = 0$, while the value from searching must be positive for a free monitor, $V > 0$.

We characterize the unique equilibrium of our economy by reducing the different equilibrium conditions to a single equation that uniquely determines θ. The discussion focuses on equilibrium θ and the unique equilibrium life cycle f associated with it. Afterwards we analyze the equilibrium rate of creation of new businesses, commenting on the incidence of financial imperfections and flotation costs on this rate.

4.1 Credit rationing and the financial life cycle

The values from searching, U and V, solve the equations

$$\rho U = -c + q(\theta)(B^u - U), \tag{14}$$

$$\rho V = \theta q(\theta)(L^u - 1 - V), \tag{15}$$

where c measures the utility cost required of an entrepreneur to maintain his project during the process of search, $q(\theta)$ and $\theta q(\theta)$ account for the rates at which the corresponding agent finds a partner with whom to start a relationship, and $B^u - U$ and $L^u - 1 - V$ measure each party's net gain from starting the relationship.

The solution to the bargaining problem, (9) and (10), allows us to write (14) and (15) as

$$\rho U = -c + q(\theta)\beta S, \tag{16}$$

$$\rho V = \theta q(\theta)(1-\beta) S. \tag{17}$$

Then $U = 0$ implies

$$\rho V = \frac{(1-\beta)\,c}{\beta}\theta, \tag{18}$$

which substituted in (12) yields a new expression for the shadow value of the stock market for a start-up found to be good:

$$F^d\,(\theta) = \frac{\rho - r}{\mu + \rho}R^d + \frac{(1-\beta)\,c}{(\mu+\rho)\,\beta}\theta, \tag{19}$$

where θ is the only endogenous variable.

This expression together with (13) allows us to account for the optimal choice of the break-up probability f in (11). Then, with $U = 0$ and using (17) to substitute for V, we obtain that the surplus from the relationship is

$$S\,(\theta) = \frac{\lambda\{\gamma R^d - \gamma \min[F, F^d\,(\theta)] + (1-\gamma)\,Q\} + \mu R^m - (\lambda + \mu + \rho)}{\lambda + \mu + \rho + (1-\beta)\,\theta q\,(\theta)}, \tag{20}$$

where again θ is the only endogenous variable. Notice that $S(\theta)$ is strictly decreasing in θ since both $F^d\,(\theta)$ and $\theta q\,(\theta)$ are strictly increasing in θ.[20] Intuitively, this result is mostly driven by the fact that, as θ increases, monitors become relatively more scarce and can find suitable partners quicker, hence the value of each monitor's outside option increases, which goes in the detriment of the surplus from the relationship.

Finally given $S = S\,(\theta)$, imposing $U = 0$ in (16) leads to the equilibrium *free-entry condition* for entrepreneurs:

$$\beta q\,(\theta)\,S\,(\theta) = c. \tag{21}$$

The left hand side of this equation is continuous and strictly decreasing in θ; moreover, $\lim_{x\to\infty} q\,(x)\,S\,(x) = 0$ and $\lim_{x\to 0} q\,(x)\,S\,(x) = \infty$ by (1). So (21) does always have a unique solution $\theta \in (0,\infty)$. (Notice also that $\theta > 0$ and (18) implies, as required, $V > 0$.)

[20] This argument implicitly assumes that $S\,(\theta)$ is positive for all θ. A sufficient condition for this is: $\lambda[\gamma R^d - \gamma F + (1-\gamma)Q] + \mu R^m > \lambda + \mu + \rho$.

Given the solution for equilibrium θ that arises from (21), one can determine the (generically) unique equilibrium financial life cycle of firms, f, by using (13) and (19).[21] We comment on the comparative statics of θ and f with respect to some of the parameters of the model at the end of the next subsection.

4.2 The equilibrium rate of business creation

In our economy the existence of a moral hazard problem during the start-up stage together with condition (2) (the excessive cost of going public before a firm is known to be good) imply the need for informed capital. When, as assumed, the stock of informed capital M is small relative to the flow of new projects N, the creation of new firms ends up constrained by the former. We show below how this constraint relates to the equilibrium values of θ and f and thus to the parameters that determine them.

Let u_t denote the pool of start-ups of unknown type (all of which are in a entrepreneur-monitor relationship) and let d_t denote the pool of start-ups discovered to be good which remain in a relationship. Then the stock of free informed capital at time t will be $m_t = M - d_t - u_t$ and the flow of newly created firms at time t will be

$$n_t = \theta q(\theta)(M - d_t - u_t), \tag{22}$$

since each free unit of informed capital matches with a suitable entrepreneur at the rate $\theta q(\theta)$.

The evolution of u_t is in turn driven by the entry of the newly created firms and the exit of those that either mature or get their type discovered.

[21] Similarly one can determine the unique equilibrium value of $\alpha \in (0, 1)$ using equations (5)-(10). We omit the details for brevity.

Thus,

$$\dot{u}_t = n_t - (\lambda + \mu) u_t. \tag{23}$$

Analogously d_t is increased by the flow of start-ups discovered to be good that do not go public and decreased by the exit of those that reach maturity, so

$$\dot{d}_t = \lambda\gamma (1 - f) u_t - \mu d_t. \tag{24}$$

Setting $\dot{d}_t = \dot{u}_t = 0$ in the previous equations, we obtain the steady-state rate of creation of new firms:

$$n = \theta q(\theta) m = \frac{\theta q(\theta)(\lambda + \mu) M}{\lambda + \mu + [1 + \frac{\lambda\gamma}{\mu}(1 - f)]\theta q(\theta)}, \tag{25}$$

which is the product of the rate at which one unit of free informed capital finds a project to finance, $\theta q(\theta)$, and the stock of free informed capital in steady state, m. Note that m is larger the larger is f, i.e., the quicker the informed capital used in relationships gets recycled.

The rate n is important since a fraction γ of the newly created start-ups eventually become mature good firms, so in steady state the pool of mature good firms and aggregate income (the output they produce) grow linearly at the rates γn and $\gamma y n$ respectively.[22] The rate n can be compared with what it would be in the absence of the moral hazard problem, $\tilde{n} = N$, or in the absence of search frictions, $\hat{n} = [1 + \frac{\lambda\gamma}{\mu}(1 - \hat{f})]^{-1}(\lambda + \mu) M$, where $\hat{f} \geq f$ denotes the going public decision of discovered-good start-ups that would characterize such an economy.[23] Clearly $\tilde{n} > \hat{n} > n$, which means that

[22] This economy exhibits linear rather than exponential growth. In Section 6 we model explicitly the externalities that are required to sustain exponential growth.

[23] The life cycle decision $\hat{f}$ is driven by (12) and (13), as in our economy. What makes the problem different is the different equilibrium value of informed capital without search frictions, say $\hat{V}$. If entrepreneurs and monitors match immediately, they do not need to be compensated for any cost incurred during the process of search, hence $0 = \hat{U} = \hat{B}^u$ and $\hat{V} = \hat{L}^u - 1$ and all the net revenue from a relationship, $\hat{B}^u + \hat{L}^u - 1$, will be appropriated by the monitor. Since this revenue is no smaller than in our economy, we have $\hat{V} = \hat{B}^u + \hat{L}^u - 1 \geq B^u + L^u - 1 > U + V = V$, which implies $\hat{f} \geq f(\theta)$.

both the moral hazard problem that affects the start-ups and the frictions that affect their search for informed capital have a negative impact on firm creation.

The various parameters that describe the financial structure of the economy (e.g., F, M, and the difference between ρ and r) influence business creation through two different channels. First, there is a *profitability channel* that relates with the incentives of entrepreneurs to develop their projects. The larger the number of entrepreneurs searching, the quicker free informed capital finds new businesses to finance. To see this formally, consider, for instance, the effect of an increase in the flotation cost F.[24] Suppose that in equilibrium $F < F^d(\theta)$, so $f = 1$. From (20), increasing F decreases $S(\theta)$ and, thereby, has a negative impact on the profitability of entrepreneurship, U. Then restoring the equilibrium free-entry condition for entrepreneurs, (21), requires a lower level of credit rationing. However, a lower θ implies that the free units of informed capital will match with entrepreneurs at a slower rate. As (25) reflects, the steady state rate of business creation n will consequently fall.

Secondly, there is a *recycling channel* that relates to firms' financial life cycle decisions. The earlier they decide to go public, the earlier the informed capital committed in on-going relationships gets freed to search for new businesses. To see the operation of this channel in the above example, notice that as F increases, θ decreases, so V and thus $F^d(\theta)$ decrease. This leads eventually to $F > F^d(\theta)$, discouraging good start-ups from going public. But then informed capital gets stuck for longer in ongoing relationships so, as re-

[24]Rajan and Zingales (1998) and Kumar et al. (1999) provide evidence that suggests accounting standards as an empirically relevant source of cross-country variability for our parameter F. The listing requirements of the different stock exchanges is another source. The recent creation of "new markets" within the traditional European stock exchanges has been explicitly justified as an attempt to reduce the flotation costs for young companies.

flected in (25), the steady state stock of free informed capital m and, hence, the steady state rate of creation of new firms n fall.

5 Efficiency

In this section we compare the competitive equilibrium of our economy to the constrained social optimum. Since the welfare of the population of investors is invariant to the equilibrium allocation, we define social welfare W as the net present discounted value of the aggregate income flows of the monitors and the entrepreneurs. The social planner will take as given the moral hazard problem inherent in financing a start-up as well as the search frictions involved in allocating informed capital. At any point in time, the state of the economy is fully summarized by the quantities u_t and d_t that represent, respectively, the pools of unknown start-ups and of good start-ups that remain financed through informed capital after being early discovered to be so. Without loss of generality, we consider time invariant allocations described by a level of credit rationing θ and a financial life cycle f.[25]

Let $R(f)$ denote the average net revenue generated by a start-up whose type is unknown,

$$R(f) = \lambda[\gamma f(R^d - F) + (1-\gamma)\,Q] + \mu R^m, \tag{26}$$

then, we can implicitly define the social welfare function $W(u, d; \theta, f)$ by the equation

$$\rho W(u_t, d_t; \theta, f) = R(f)u_t + \mu Y d_t - [c\,\theta + \theta q\,(\theta)]\,(M\text{-}d_t\text{-}u_t) + W_u \dot{u}_t + W_d \dot{d}_t \tag{27}$$

[25] Under a time invariant configuration of parameters, neither the competitive equilibrum nor the solution to the social planner problem will exhibit time variation in θ and f. In principle such variation might be induced by the evolution of the state variables. However, neither the equilibrium (as seen in the previous section) nor the social optimum (as can be deduced from the analysis below) imply values of θ and f that depend on u and d. So the analysis that follows implies no loss of generality.

where $W_u = \frac{\partial W}{\partial u_t}$, $W_d = \frac{\partial W}{\partial d_t}$, and $\dot{u}_t$ and $\dot{d}_t$ are described by (23) and (24), respectively. To explain this equation, notice that the first term accounts for the net flow of income produced by start-ups of unknown type, the second for that produced by start-ups which are known to be good, and the third for the outflows associated with the maintenance of the projects of the entrepreneurs in search and the investment required by projects that become operative. The last two terms indicate the welfare gains derived from the time variation in the number of unknown and good start-ups, respectively.

Now we can state our first result on efficiency: conditional on the equilibrium level of credit rationing θ, firms' financial life cycle decisions f, as agreed by entrepreneurs and monitors in their relationships, are socially efficient, that is, maximize W. The proof contained in the Appendix shows that the marginal contribution of f to welfare in equilibrium is proportional to $F^d(\theta) - F$. Hence $F^d(\theta)$ measures the private as well as the social shadow value of the stock market for the start-ups which are discovered to be good.

The same cannot be said about the equilibrium level of credit rationing. To see this, let η denote the elasticity of the matching function with respect to the number of entrepreneurs that search for monitors. η is a measure of the marginal contribution of the former to the creation of new businesses and can be computed as $\eta = \frac{q(\theta)+\theta q'(\theta)}{q(\theta)}$. In the Appendix we show that in a steady state equilibrium, unless $\beta = \eta$, social welfare might increase by raising the value of θ if $\beta < \eta$ and lowering it if $\beta > \eta$.[26]

This finding relates to the highly decentralized mechanism whereby the economy allocates informed capital to projects. After a entrepreneur meets with a suitable monitor, the division of the surplus is determined by their

[26] The result that, in an economy with search frictions, a constrained efficient allocation of resources requires bargaining powers to reflect the contribution of each side to the creation of new relations is originally due to Hosios (1990); see also Pissarides (1990).

bargaining powers, β and $1-\beta$. Ex ante the anticipated division plays a crucial role in encouraging or discouraging entrepreneurs to search for a monitor. However, opposite to a Walrasian price, β and $1-\beta$ may not adjust to reflect the marginal social value of searching. For instance, if $\beta < \eta$, monitors are "too strong": entrepreneurs appropriate too little surplus (relative to the first best) so they enter the process of search at an inefficiently low level (θ is too low). This implies that "too strong" venture capitalists (or bankers) may be an obstacle for entrepreneurship and growth, justifying policies (such as subsidies or tax exemptions) oriented to increase the number of entrepreneurs.

An alternative way of increasing efficiency might be to reform the institutions that determine the division of the surplus. Specifically, welfare can be raised by increasing (decreasing) β if $\eta > \beta$ ($\eta < \beta$). We prove in the Appendix that these reforms will not only increase welfare but also the equilibrium value of informed capital V. From (12) a higher V implies a higher $F^d(\theta)$, which may encourage firms to go public earlier.[27] In words: economies that divide the surplus more efficiently will value more the recycling role of the stock market. The emergence or not of a market for young fast growing companies such as Nasdaq may then be explained by the institutions behind surplus division —e.g., the level of competition among monitors, the extent to which their informational monopolies are legally protected, or the posting of financial contracts that might help direct entrepreneurs towards suitable monitors.[28]

This finding may throw some light on a question that has been repeat-

[27] When the matching function exhibits a constant η (e.g., in a Cobb-Douglas), W, V, and $F^d(\theta)$ are globally maximized under the (unique) rule $\beta = \eta$.

[28] Acemoglu and Shimer (1999), among others, have shown the possibility of restoring efficiency through contract posting in labor market environments subject to search frictions.

edly raised in Europe: Is the lack of a well-functioning market for young fast growing companies a cause of the apparent weakness of European entrepreneurship?[29] If the lack of a stock market for fast growing companies is due to some exogenous deficit in terms of financial integration and regulation that makes F larger in Europe than in the US, the results obtained at the end of Section 4 imply that the answer is yes.[30] Yet our findings in this section suggest that the "problem" of Europe might come from some deeper inefficiency in the allocation of resources. If the monitors (arguably, universal banks in the case of Europe) are too strong, the lack of a market for young fast growing companies might just be one more effect of the problem that causes the lack of entrepreneurship, reduces the value of informed capital, and discourages firms from going public early.

6 Growth

Our model has implications for the linkage between financial development and growth. This is because some innovations require the creation of new businesses. Descriptions of the current growth wave commonly identify start-ups as a powerful engine of technological innovation.[31] Aghion and Tirole (1994) and Greenwood and Jovanovic (1999) provide reasons explaining why

[29] According to a Communication of the European Comission (1998, p.1), "what is at stake is the creation of a new entrepreneurial culture in Europe. The real political challenge is to provide the tools, enabling technologies and financial instruments for a new generation of European entrepreneurs to start up and succeed."

[30] *The Economist* (January 15th, 2000, pp 67-68) writes that "European stock exchanges typically emphasize investor protection more than their American counterparts, a tendency that might make it more difficult for European entrepreneurs to cash out locally and recycle the fruits of their successes into new ventures". Indeed, Pagano et al. (1998) find that the typical newly listed company is much larger and older in Italy than in the US.

[31] Academic analyses also support this view. Greenwood and Jovanovic (1999) and Hobijn and Jovanovic (1999) document that, differently from previous technological revolutions, the main winners of the 'IT revolution' have been some newly created firms rather than the incumbents.

at least part of the innovations cannot occur inside the corporations that already exist.[32]

Formally we look at the implications for growth by extending the model to incorporate the rate of technological progress. First, we analyze its effects on the financial life cycle of start-ups and on stock market development. Secondly, we endogenize it by assuming that the success of some start-ups generates a positive externality on the rest of them.

6.1 The effect of growth on financial development

Assume that all relevant quantities in the life of a firm are scaled up by a factor X_t that identifies the state of technology at time t and, due to technological progress, grows at a constant exponential rate $g = \frac{\dot{X}_t}{X_t} < r$. Thus, at time t, the investment required to make a project operative is X_t, the liquidation value of a firm is $Q_t = QX_t$, the flow of private benefits that the entrepreneur can obtain from not devoting his effort to the firm is $b_t = bX_t$, and the cost of going public is $F_t = FX_t$. Analogously, if a firm successfully reaches maturity at time t its output is $y_t = yX_t$ from that time onwards. This economy has a balanced-growth equilibrium path where aggregate output is

$$O_t = \int_{-\infty}^{t} yX_s\dot{k}_s ds = \frac{y\gamma n}{g}e^{gt},$$

which grows at rate g, while both the level of credit rationing θ and the contract (α, f) that governs the entrepreneur-monitor relationships are constant over time. As in the basic model, we can reduce the different equilibrium

[32] Aghion and Tirole (1994) consider the holdup problem that affects an innovator and the potential user of the innovation, showing that, when the incentives of the former are important, the optimal solution involves making him the owner of his innovation, that is, creating a new firm.

conditions to a single equation that uniquely determines θ and then obtain f recursively.

Specifically, the value at time t of the surplus of a relationship in which firm type is unknown is given by the product of X_t and the quantity

$$S(\theta, g) = \frac{\lambda\{\gamma R^d(g) \text{-} \gamma \min[F, F^d(\theta, g)] + (1\text{-}\gamma) Q\} + \mu R^m - (\lambda + \mu + \rho - g)}{\lambda + \mu + \rho - g + (1-\beta)\theta q(\theta)}, \tag{28}$$

where

$$F^d(\theta, g) = \frac{\rho - r}{\mu + \rho - g} R^d(g) + \frac{(1-\beta)c}{(\mu + \rho - g)\beta}\theta \tag{29}$$

and $R^d(g) = \frac{\mu Y}{\mu + r - g}$. After scaling up by X_t, these quantities have the same interpretation as our previous variables $S(\theta)$, $F^d(\theta)$, and R^d, respectively, from which they only differ in that r has been replaced by $r - g$ and ρ by $\rho - g$. Notice that all these quantities are increasing in g.

The equilibrium level of credit rationing θ is the unique solution to the free-entry condition for entrepreneurs:

$$\beta q(\theta) S(\theta, g) = c, \tag{30}$$

while the firms' financial life cycle is determined by the rule

$$f = \begin{cases} 1 & \text{if} \quad F \leq F^d(\theta, g), \\ 0 & \text{otherwise,} \end{cases} \tag{31}$$

analogous to (13).

We can now show how an increase in the rate of technological progress g raises the equilibrium level of credit rationing and promotes stock market development. The free-entry condition (30) describes a relationship between θ and g that we have represented by the upward sloping curve *FE* in Figure 1. This relationship reflects that, for given θ, a larger g implies a larger surplus $S(\theta, g)$ and a greater incentive for entrepreneurs receiving a project

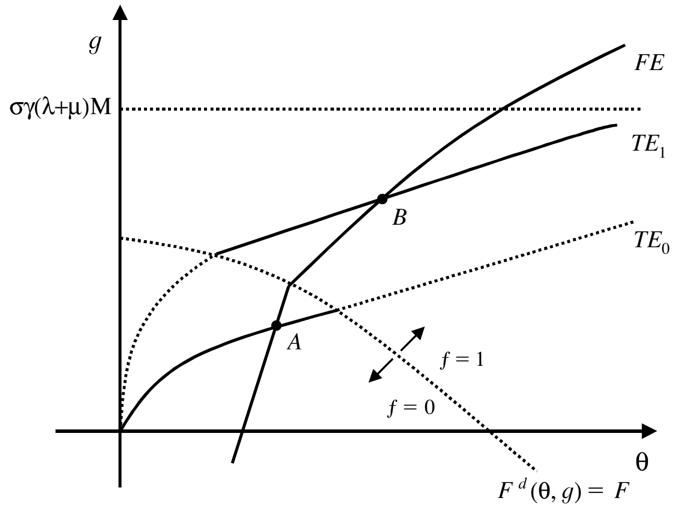

Figure 1: Growth and financial development

to search for a monitor, hence restoring the free entry condition requires a higher level of credit rationing θ.

Figure 1 also depicts the schedule $F^d(\theta, g) = F$, which is negatively sloped because the shadow value of the stock market for start-ups is increasing not only in θ but also in g, which affects positively the liquidity and recycling gains that appear in (29). In the region below the schedule, we have $F^d(\theta, g) < F$ so firms set $f = 0$ and the stock market for start-ups does not emerge. In contrast in the region above the schedule, there is a stock market where the start-ups discovered to be good go public. Notice that the curves *FE* and $F^d(\theta, g) = F$ intersect at most once. Moreover, there is always a sufficiently large g that, together with the θ induced when moving along *FE,* makes the stock market for start-ups to emerge.

6.2 Endogenous growth

We now endogenize the rate of technological progress g by introducing a positive technological externality related to the success of new businesses. In particular, we assume that X_t grows at a rate proportional to the density of good firms that reach maturity, $\dot{k}_t$.[33] In steady state we have $\dot{k}_t = \gamma n$ so the rate of technological progress g is, by (25),

$$g = \sigma\gamma n = \frac{\sigma\gamma\,(\lambda+\mu)\,\theta q\,(\theta)\,M}{\lambda+\mu+[1+\frac{\lambda\gamma}{\mu}(1-f)]\theta q\,(\theta)}, \tag{32}$$

where σ measures the size of the externality. To guarantee the existence of a steady state with $g < r$, we assume that $\sigma\gamma(\lambda+\mu)M < r$. Equation (32) together with (30) and (31) solve for the steady-state equilibrium of the model with endogeneous growth.

For each value of f, equation (32) defines a positive relationship between θ and g, reflecting that with a higher level of credit rationing θ free informed capital gets matched more quickly, which raises the rate of business creation n and, through the externality, the rate of technological progress g. Figure 1 depicts the curves TE_0 and TE_1 defined by (32) with $f = 0$ and $f = 1$, respectively. The second yields above the first because $f = 1$ speeds up the recycling of informed capital, which increases n and thus g. Both curves are continuous, pass through the origin, and are bounded above by the line $g = \sigma\gamma\,(\lambda+\mu)\,M$. Hence both cross the FE curve at least once, like in points A and B in Figure 1. The intersections provide the candidate steady-state equilibria in the $\theta - g$ space. In equilibrium, however, f is fixed according to (31) so only the intersections occurring on the solid sections of TE_0 and TE_1 (respectively below and above the $F^d\,(\theta, g) = F$ curve) are actual equilibria of the model. In Figure 1 both A and B are equilibria of the model. Point

[33] This follows Caballero and Jaffe (1993) and Aghion and Howitt (1998), among others. A natural interpretation is that there is a continuum of increasingly productive techniques indexed by a real number which corresponds to the log of its productivity parameter. Maturity means that the good firm has succeeded in discovering a new technique and all start-ups can hereafter search for the next technique in the continuum. So, at any point in time, the rate of technological progress is proportional to the flow of firms that reach maturity at that time.

B always involves a higher rate of technological progress and a larger level of credit rationing (more "entrepreneurship") than point A.

We can now show that the flotation cost F is negatively correlated with both stock market development, as measured by f, and the equilibrium rate of technological progress, g. One reason for this is that an increase in F reduces the coordinates θ and g of point B. A second reason is that further increasing (decreasing) F eventually leaves A (B) as the only equilibrium. To see this, notice that if F increases the section of FE that is in the $f = 1$ region will rotate towards the left and the $F^d(\theta, g) = F$ curve will move towards the right, whereas TE_0 and TE_1 will remain unchanged. Therefore increasing F moves point B down along TE_1, while point A remains unchanged. Moreover, further increasing F eventually pushes B into the $f = 0$ region, so A becomes the only equilibrium. By the same logic, reducing F expands the $f = 1$ region, which eventually "absorbs" point A, leaving B as the only equilibrium.

This analysis shows the possibility of a *financial underdevelopment trap.* Like in point A, growth may stagnate because the stock market does not provide enough recycling of informed capital and this, in turn, may occur because the lack of growth depresses profitability and the value of informed capital.

Finally the analysis suggests instances in which government support to IPO activity may be welfare improving. The reason is that the presence of technological externalities makes the private shadow value of the stock market $F^d(\theta, g)$ lower than the social one. Consider, for instance, the polar situation in which F is equal to (or only just above) $F^d(\theta, g)$ so that all good start-ups are choosing $f = 0$. In this situation, differently from the model without technological externalities, encouraging firms to go public would increase welfare. Specifically, it would favor the recycling of informed capital and, by stimulating business creation, would raise growth both over the transition path and in the new steady state. This privately non-internalized effect of f on growth is additional to the effects that arise in our benchmark model —where going public decisions were shown to be constrained efficient— and makes welfare increase. In practical terms this means that governments might want to be active in reducing the private cost of going public in industries characterized by large technological spill-overs and in which the scarcity of informed capital is perceived to be constraining the creation of new firms.

7 Liquidity externalities

Nasdaq has been claimed to be an 'IT facility' that allowed previously fragmented over-the-counter markets to merge into an increasingly liquid one.[34] Its success reveals the importance of liquidity externalities in determining the attractiveness of a market.[35] Liquidity externalities create a strategic complementarity in the going public decisions of start-ups and provide an alternative answer to the question on why a stock market for young fast growing companies like Nasdaq in the US might or might not emerge. The analysis identifies fragmentation as a possible cause for stock market underdevelopment and provides a rationale for promoting IPO's.[36]

Formally we capture the liquidity externalities in our model by assuming that the flotation cost F is negatively related to the number of start-ups

[34] See Smith et al. (1998) for a description of the history and functioning of Nasdaq.

[35] For the microfoundations for this type of externalities, see Pagano (1993) and Subrahmanyam and Titman (1999).

[36] In European countries which had relatively underdeveloped financial markets in the early eighties, such as Spain, the massive programs of privatization of state-owned companies via IPOs seem to have contributed substantially to increase the liquidity of the equity market, which partly explains the subsequent boom in private company flotations.

discovered to be good that are already public, say p.[37] In particular, we assume $F = F(p)$ with $F'(p) < 0$, $\lim_{p \to 0} F(p) = \infty$, and $F(\lambda\gamma M/\mu) > F^0$.

Following the same steps as in Section 4, we obtain that the steady state value of p will be given by

$$p(\theta, f) = \frac{\frac{\lambda\gamma}{\mu} f \theta q(\theta) M}{\lambda + \mu + \left[1 + \frac{\lambda\gamma}{\mu}(1-f)\right]\theta q(\theta)},$$

which is increasing in both θ and f. For given f, equation (21) and the condition

$$F(p(\theta, f)) = F \tag{33}$$

solve for a candidate steady state equilibrium in the $\theta - F$ space. This candidate will indeed be an equilibrium if f satisfies the decision rule (13).

Actually (13) and (33) imply that multiple equilibria can emerge. This is because there is a strategic complementarity in the choice of the life cycle variable f. In particular, there is always an equilibrium with $f = 0$, since if this is the case we have $p = 0$ and F goes to infinity, so indeed good start-ups do not want to go public. However, there may also be an equilibrium with $f = 1$. The idea is that if f is high, p is high so the stock market for start-ups is highly liquid and F is low, in which case choosing $f = 1$ may be an equilibrium. This is indeed the case if, assuming $f = 1$, the value of θ that solves (21) and (33) satisfies $F(p(\theta, 1)) < F^d(\theta)$. These two equilibria are Pareto-ranked and the one with $f = 1$ associates with larger welfare. Therefore, if the economy is stuck in the equilibrium with $f = 0$, a subsidy to the firms that go public (or any other measure that contributes to reduce the private cost of going public) might help unblock the situation, lead to

[37] Any premium associated with the lack of liquidity will be ultimately borne by the entrepreneur and the monitor in the form of a price discount when selling the start-up's shares to investors. We model this discount as part of F. Implicitly, we are assuming segmentation between the stock market for start-ups and that for mature companies.

the "good" equilibrium, and thereby improve welfare.[38]

With liquidity externalities, the rationale for government support to IPO activity is more general: in particular it does not require multiple equilibria. To see this, consider a simple generalization of our model in which heterogeneous start-ups, indexed by j, differ in their cost of going public $F_j(p)$, where $F_j'(p) < 0$. Then a start-up will decide to go public if its $F_j(p)$ is below the critical value $F^d(\theta)$. However, since each start-up does not internalize the effects of its going public decision on the cost of going public of the others, the equilibrium number of IPOs will be suboptimal. In other words, the private shadow value of the stock market for good start-ups, $F^d(\theta)$, will be below the social one and closing the gap between the two can improve welfare. In practical terms this points out to a second target for government support to IPOs: stock market segments where the lack of a critical mass of similar listed companies makes flotations particularly costly.

8 Conclusions

We have analyzed how various aspects of the economy's financial structure (informed capital, the stock market) affect business creation and growth. The analysis has implications on how institutional differences in securities markets may produce cross-country differences in the patterns of firm creation and in the speed at which technological innovations are adopted. For example our model suggests that the lack of a well developed market for small fast growing companies in Europe might explain why Europe has fallen behind the US in taking advantage of the IT revolution and, more generally, in the adoption of

[38] An explicit evaluation of the gains from moving from an equilibrium with $f = 0$ to one with $f = 1$ is, however, complicate since during the transition the endogenous variables θ and f would be functions of the state variables of the system, u_t, d_t, and p_t.

high-tech technologies.[39] We have explored some possible causes of financial underdevelopment and provided a framework for an explicit evaluation of the welfare implications of potential policy responses.

In the time series dimension, our model provides a plausible linkage between some remarkable features of the current US growth wave: the impetus of its venture capital industry, the proliferation of start-ups aiming at growing large, and the consolidation of Nasdaq as a stock market for high-tech start-ups. A "virtuous circle" may have been produced by the combination of the abundant entrepreneurial opportunities originated by the new technologies with the accumulated business experience of venture capitalists who found in the new electronic-based Nasdaq an increasingly liquid market through which the returns from their start-ups could be effectively cashed out.

Behind the recent experience of the US venture capital industry, there may have also been a significant increase in the supply of informed capital. For analytical convenience we have modelled this supply as fixed, but our theoretical framework could be extended to accommodate a positively sloped supply of informed capital. In this case, changes in fundamentals (including financial factors) that affect the profitability of an entrepreneur-monitor relationship would operate not only through entrepreneurs' incentives to develop their projects but also through the incentives of potential venture capitalists to become active. Insofar as the induced supply of informed capital does not turn out to be perfectly elastic (and any heterogeneous cost of becoming active would ensure this), the main logic of the paper would still apply —including the importance of the recycling of informed capital.

[39] See OECD (1994) for a cross-country analysis showing that EC countries are significantly under-specialized in high-tech industries relative to the US, and that the gap has generally widened over the period 1970-1992.

Appendix

Impossibility of stock market financing without paying F

To rule out the possibility that entrepreneurs finance their start-ups through the stock market without paying F, it suffices to guarantee that even if the firm were known to be good such an arrangement would not be feasible. Consider a good start-up and let $\tilde{\alpha}$ describe a contract whereby the entrepreneur and some investor get some fractions $\tilde{\alpha}$ and $1-\tilde{\alpha}$, respectively, of the value of the firm at its maturity, Y. Under such contract, the entrepreneur's value Π from running the firm given his optimal effort choice is given by the Bellman equation:

$$\rho\Pi = \max\{b, \mu(\tilde{\alpha}Y - \Pi)\}$$

and the contract $\tilde{\alpha}$ will provide incentives for effort if and only if $\mu(\tilde{\alpha}Y - \Pi) \geq b$, that is

$$\tilde{\alpha} \geq \frac{\mu+\rho}{\mu Y}\frac{b}{\rho}. \tag{34}$$

Let D denote the value of the investor's stake in the project when this condition holds. Then,

$$\rho D = [(1-\tilde{\alpha})Y - D]$$

and the investor will be willing to finance the project only if $D \geq 1$, that is,

$$(1-\tilde{\alpha}) \geq \frac{\mu+r}{\mu Y}. \tag{35}$$

When b is sufficiently large, the inequalities (34) and (35) are not compatible. Specifically, if we assume

$$\frac{b}{\rho} > \frac{\mu Y}{\mu+\rho} - \frac{\mu+r}{\mu+\rho}, \tag{36}$$

then this form of financing will not be feasible.

Results on efficiency

In this section we prove our results on efficiency. We start obtaining the dynamics of the costate variables W_u and W_d that appear in (27). Time indices are omitted, for brevity. Partially deriving (27) with respect to u and d we obtain

$$\rho W_u = R(f) + [c\theta + \theta q(\theta)] + W_{uu}\dot{u} + W_{ud}\dot{d} + W_u \frac{\partial \dot{u}}{\partial u} + W_d \frac{\partial \dot{d}}{\partial u},$$

$$\rho W_d = \mu Y + [c\theta + \theta q(\theta)] + W_{ud}\dot{u} + W_{dd}\dot{d} + W_u \frac{\partial \dot{u}}{\partial d} + W_d \frac{\partial \dot{d}}{\partial d}.$$

We can now substitute $\dot{W}_u = \frac{dW_u}{dt}$ for $W_{uu}\dot{u} + W_{ud}\dot{d}$ and $\dot{W}_d = \frac{dW_d}{dt}$ for $W_{ud}\dot{u} + W_{dd}\dot{d}$, and use (23) and (24) to obtain the partial derivatives of $\dot{u}$ and $\dot{d}$. Solving for $\dot{W}_u$ and $\dot{W}_d$ and collecting terms leads to

$$\dot{W}_u = [\lambda + \mu + \rho + \theta q(\theta)] W_u - \lambda\gamma(1-f) W_d - R(f) - [c\theta + \theta q(\theta)], \quad (37)$$

$$\dot{W}_d = \theta q(\theta) W_u + (\mu + \rho) W_d - \mu Y - [c\theta + \theta q(\theta)]. \quad (38)$$

These equations define a linear system with constant coefficients in W_u and W_d that is globally unstable. Hence W_u and W_d are two jump variables that must satisfy the conditions $\dot{W}_u = \dot{W}_d = 0$ at every point in time. Using (37) and (38) this implies

$$W_u = \frac{\lambda\gamma(1-f)[\mu Y + c\theta + \theta q(\theta)] + (\mu+\rho)[c\theta + \theta q(\theta) + R(f)]}{(\mu+\rho)[\lambda + \mu + \rho + \theta q(\theta)] + \lambda\gamma(1-f)\theta q(\theta)}, \quad (39)$$

$$W_d = \frac{(\lambda+\mu+\rho)[\mu Y + c\theta + \theta q(\theta)] + \theta q(\theta)[\mu Y - R(f)]}{(\mu+\rho)[\lambda + \mu + \rho + \theta q(\theta)] + \lambda\gamma(1-f)\theta q(\theta)}. \quad (40)$$

1. Firms' financial life cycle. We want to prove that, conditional on the equilibrium value of θ, the firms' choice of f maximizes W. Deriving in (27) with respect to f one can immediately get:

$$\frac{\partial W}{\partial f} = \frac{\lambda\gamma}{\rho}(R^d - F - W_d)u_t, \quad (41)$$

which, from (40), has the same sign as

$$\begin{aligned} B(\theta) \quad = \quad & (\mu+\rho)[\lambda+\mu+\rho+\theta q(\theta)](R^d - R^w - F) + \theta q(\theta) R(1) \\ & -(\lambda+\mu+\rho)[c\theta + \theta q(\theta)]. \end{aligned} \quad (42)$$

Notice that $B(\theta)$ does not depend on f. For a given value of θ, the constrained socially optimal financial life cycle is $f = 1$, if $B(\theta) \geq 0$, and $f = 0$, otherwise.

We will prove that in equilibrium the sign of $F^d(\theta) - F$ coincides with that of $B(\theta)$, which implies that, given the rule (13) whereby firms choose f, equilibrium f is constrained efficient.

Notice from (12) and (19) that, in equilibrium,

$$R^d - R^w = F^d(\theta) - \frac{(1-\beta)c\theta}{(\mu+\rho)\beta}. \tag{43}$$

Consider first the case in which $F^d(\theta) > F$. Then (20) and (26) imply

$$R(1) = [\lambda + \mu + \rho + (1-\beta)\theta q(\theta)]\, S(\theta) + (\lambda + \mu + \rho),$$

since $\min[F, F^d(\theta)] = F$. Then, by (21), we can write

$$R(1) = [\lambda + \mu + \rho + (1-\beta)\theta q(\theta)]\, \frac{c}{\beta q(\theta)} + (\lambda + \mu + \rho). \tag{44}$$

Using this expression to substitute for $R(1)$ and (43) to substitute for $R^d - R^w$ in (42) leads, after some algebra, to

$$B(\theta) = (\mu+\rho)\,[\lambda + \mu + \rho + \theta q(\theta)]\,[F^d(\theta) - F],$$

which proves the result for the case in which $F^d(\theta) > F$. In the case in which $F^d(\theta) < F$, (20) and (26) imply

$$R(1) = [\lambda + \mu + \rho + (1-\beta)\theta q(\theta)]\, S(\theta) + (\lambda + \mu + \rho) + \lambda\gamma[F^d(\theta) - F],$$

since $\min[F, F^d(\theta)] = F^d(\theta)$, and, by (21), we can write

$$R(1) = [\lambda + \mu + \rho + (1-\beta)\theta q(\theta)]\, \frac{c}{\beta q(\theta)} + (\lambda + \mu + \rho) + \lambda\gamma[F^d(\theta) - F].$$

Using this expression to substitute for $R(1)$ and (43) to substitute for $R^d - R^w$ in (42) we obtain

$$B(\theta) = (\mu+\rho)\,[\lambda + \mu + \rho + \theta q(\theta) + \lambda\gamma\theta q(\theta)]\,[F^d(\theta) - F],$$

which proves the result also for the case in which $F^d(\theta) < F$.

2. Equilibrium $\boldsymbol{\theta}$. We want to evaluate the effect on welfare of changing θ in a steady state equilibrium. A marginal change in θ may have a direct impact on W as well as an indirect impact through f. However, changing θ

will only change equilibrium f if $F^d(\theta) = F$, in which case the constrained efficiency of equilibrium f implies $\partial W/\partial f = 0$. Hence we can always evaluate the effect of changing θ on W through the partial derivative $\partial W/\partial\theta$. From (27) we find that

$$\rho\frac{\partial W}{\partial\theta} = [\eta q(\theta)(W_u - 1) - c]\,(M - d - u) + \frac{\partial W_u}{\partial\theta}\dot{u} + \frac{\partial W_d}{\partial\theta}\dot{d}. \tag{45}$$

We will first prove that in equilibrium

$$W_u = 1 + \frac{c}{\beta q(\theta)}. \tag{46}$$

Start with the case where $F^d(\theta) > F$, so $f = 1$. Then (46) can be immediately obtained by evaluating W_u using (39) and (44). In the case where $F^d(\theta) < F$, we have $f = 0$ and $\min[F, F^d(\theta)] = F$. Equations (20) and (26) imply then that

$$R(0) = [\lambda + \mu + \rho + (1-\beta)\theta q(\theta)]\,S(\theta) + (\lambda + \mu + \rho) - \lambda\gamma[R^d - F^d(\theta)].$$

We can next use (19) to substitute for $F^d(\theta)$ and (21) to substitute for $S(\theta)$. Plugging the resulting expression in (39) so as to evaluate W_u at $f = 0$ yields, after some algebra, (46). Finally, in a steady state ($\dot{u} = \dot{d} = 0$), substituting (46) into (45) yields

$$\frac{\partial W}{\partial\theta} = \frac{c}{\rho\beta}(\eta - \beta)(M - d - u), \tag{47}$$

whose sign is given by that of $\eta - \beta$. Hence $\beta = \eta$ is a necessary condition for efficiency. More generally, W can be increased by raising the value of θ if $\beta < \eta$ and lowering it if $\beta > \eta$.

3. Welfare and the value of informed capital. We want to show that in a steady state the sign of the effects of a marginal change in β on both W and V is given by $\eta - \beta$. So changes in β that increase (decrease) W also increase (decrease) V.

(i) Effect on W. A marginal change in β may impact W through θ as well as through f. However, changing β will only change equilibrium f if $F^d(\theta) = F$, in which case the constrained efficiency of equilibrium f implies $\partial W/\partial f = 0$. Hence only the first effect matters. The continuity of (20) and

(21) in θ and β implies that θ varies continuously with β. In points with $F^d(\theta) \neq F$, a marginal change in β does not change f so we have

$$\frac{dW}{d\beta} = \frac{\partial W}{\partial \theta}\frac{d\theta}{d\beta}. \tag{48}$$

In Part 2 we have already shown that in a steady state equilibrium $\partial W/\partial\theta$ has the same sign as $\eta - \beta$. Moreover, differentiating equations (20) and (21) with respect to θ and β, one can check that

$$\frac{d\theta}{d\beta} = \frac{[\lambda + \mu + \rho + \theta q(\theta)]\,\theta}{\beta\,[(1-\eta)(\lambda+\mu+\rho) + (1-\beta)\,\theta q(\theta)]} > 0, \tag{49}$$

when $F^d(\theta) > F$, and

$$\frac{d\theta}{d\beta} = \frac{[(\mu+\rho)(\lambda+\mu+\rho) + \theta q(\theta)(\lambda\gamma+\mu+\rho)]\,\theta}{\beta\,[(\mu+\rho)(\lambda+\mu+\rho)(1-\eta) + (\lambda\gamma+\mu+\rho)(1-\beta)\,\theta q(\theta)]} > 0, \tag{50}$$

when $F^d(\theta) < F$. Hence in both cases the sign of $dW/d\beta$ is that of $\eta - \beta$. This also implies that, even at the non-differentiability point where $F^d(\theta) = F$, W is increasing in β if $\eta - \beta > 0$ and decreasing if $\eta - \beta < 0$.

(ii) Effect on V. First notice that the continuity of θ in β (see (i) above) together with (18) implies that V varies continuously with β. Yet there is a non-differentiability point at $F^d(\theta) = F$. At any other point, the effect on V of a change in β can be measured by differentiating (18):

$$\frac{dV}{d\beta} = -\frac{c\theta}{\rho\beta^2} + \frac{(1-\beta)\,c}{\rho\beta}\cdot\frac{d\theta}{d\beta}.$$

When $F^d(\theta) > F$ (49) implies

$$\frac{dV}{d\beta} = \frac{c\theta\,(\lambda+\mu+\rho)}{(1-\eta)(\lambda+\mu+\rho) + (1-\beta)\,\theta q(\theta)}\cdot\frac{\eta-\beta}{\rho\beta^2},$$

whereas when $F^d(\theta) < F$ (50) implies

$$\frac{dV}{d\beta} = \frac{c\theta\,(\mu+\rho)(\lambda+\mu+\rho)}{(\mu+\rho)(\lambda+\mu+\rho)(1-\eta) + (\lambda\gamma+\mu+\rho)(1-\beta)\,\theta q(\theta)}\cdot\frac{\eta-\beta}{\rho\beta^2}.$$

Hence in both cases the sign of $dV/d\beta$ coincides with that of $\eta - \beta$. This also implies that, even at the non-differentiability point, V is increasing in β if $\eta - \beta > 0$ and decreasing if $\eta - \beta < 0$.

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