Financing early-stage ventures: the role of uncertainty and financial markets in the investment choices of venture capitalists

Eric Nasica, Dominique Dufour

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Our paper sheds light on the reasons for which a rational venture capitalist decides to reallocate his or her portfolio from later to early-stage investment. We explain why, during certain periods, there is a strong correlation between the performance of financial markets and the funds invested in early-stage ventures while, during other periods, the performance of financial markets does not affect such investments. Some hypotheses inferred from our theoretical model, and notably the existence of successive periods of "easy financing" and "lasting rationing" for early-stage firms in the United States venture capital industry, are tested and empirically validated.

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Introduction

The venture capital financing of firms according to their stage of development has been the object of a number of empirical works in recent years (Ruhnka and Young 1991; Carter and Van Auken 1994; Elango, Fried, Hisrich, and Poloncheck 1995, Seppä and Laamanen 2001; Pintado, Pérez de Lema, and Van Auken 2007). However, few works have specifically focused upon the reasons which drive a venture capitalist to alter, in time, the allocation of his or her investment portfolio between "early-stage" ventures, that is investment in young – and generally small – unquoted firms and "later-stage" ventures, that is investment in more mature (and larger) unquoted firms. This kind of question is nevertheless central if we try to understand the problems of rationing undergone during the last decade by early stage firms on behalf of venture capitalists to the detriment of more mature companies.

The aim of this paper is to show that the funds obtained by venture capital-backed companies at different stages of development strongly depend on a "portfolio failure avoidance strategy" adopted by venture capitalists. We show that this strategy is a rational behavior for venture capitalists seeking to invest in a decision-making environment characterized not only by asymmetric information but also by strong uncertainty. This strategy leads venture capitalists to make a trade-off between early and later-stage investments. The paper is organized as follows.

First, we recall why the financing relationship between venture capitalists and venture capital-backed firms is characterized by strong uncertainty. We also recall why the level of

informational opacity and of risk is higher for early stage firms than for businesses reaching later stages of development.

Secondly, we develop a model formalizing the investment behavior of venture capitalists. This model is founded on analytical tools drawn from two areas of research: the theoretical literature on bounded rationality and the empirical literature on decision-making under uncertainty (in particular results found by cognitive psychologists). This sheds light on the reasons for which a rational venture capitalist, by adopting a rule-governed behavior, decides to reallocate his or her portfolio from later to early-stage investment. This model also explains why, during certain periods, there is a strong correlation between the performance of financial markets (an economic indicator frequently considered as a central determinant of venture capital) and the funds invested in early stage ventures while, during other periods, the performance of financial markets does not affect the amount of venture capital invested in these firms.

Finally, we develop a statistical analysis of the United States venture capital industry. Some hypotheses inferred from our theoretical model and, notably, the existence of successive periods of "easy financing" and "lasting rationing" for early stage firms, are tested and empirically validated.

1. Risk, uncertainty and the early-stage/later-stage trade-off

Venture capital is typically defined as the investment by professional investors of long-term, equity finance in new firms where the primary reward is a possible capital gain, supplemented by dividend yield. Venture capital investments are made in companies not quoted on stock markets, where the investor trades-off the short term illiquidity in the shares

held for the prospects of a greater future return (Wright and Robbie 1998; Gompers and Lerner 2001).

According to most works on venture capital, venture capital backed companies are characterized by the problems of informational asymmetry between insiders and outsiders, where there is a need for relatively close monitoring (Tykvova 2007). The tools that venture capital firms have to address these information issues are to scrutinize firms intensively before providing capital and then to monitor them afterwards. The monitoring and information tools include: meting out financing in discrete stages over time (Sahlman 1990); syndicating investments with other capital firms (Gompers and Lerner 2004; Manigart et al. 2006; Lerner 1994); taking seats on a firm's board of directors (Lerner, 1995); and compensation arrangements including stock options (Sahlman 1990).

A key feature of the works under asymmetric information is their assumption that venture capitalists investment decisions are made under *risk*: the venture capitalist (and the entrepreneur) while not knowing which specific outcome will result from a decision, know all of the possible outcomes of the decision as well as the probability of occurrence attached to each such outcome. However, venture capital involves the financing of firms which contrast in many informational ways to established companies quoted on a stock market. This implies that venture capital is distinct from other forms of corporate finance in several ways.

First, the venture capitalist trades-off the short-term illiquidity in the shares held for the prospects of a greater future return. Second, the portfolios of venture capitalists are likely to be relatively undiversified compared to those of institutional investors. Third, venture capital is particularly appropriate in a specific subset of firms which have non-redeployable or highly specialised assets (Wright and Robbie 1998). Finally, venture capitalists can essentially be viewed as seeking a return on their specific and distinctive skills in identifying, investing and monitoring new and/or radically changing firms (such as management buy-outs and buy-

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ins undergoing restructuring). When a business concept involves a new product or service, for example, both the investee and the VC can only have opinions about crucial factors such as the degree of future market acceptance of the product or service, or how quickly competitors may arise. This is particularly true for companies whose performance is difficult to assess such as high technology companies with a high reliance on R&D (Gompers and Lerner 2001). Investing in new ventures thus involves a high risk of failure. As pointed out by Ruhnka and Young (1991), a popular rule of thumb in venture capital industry is that about 30 percent of venture capital investees will ultimately be "winners", another 30 percent will be "living dead" [1]. The remaining 40 percent will be "losers" losing some or all of the investment.

Venture capitalists investment decisions are thus made under *uncertainty* rather than under risk: the venture capitalist knows the possible outcomes of a decision, but, generally has no way of knowing the probability of occurrence of each outcome. In this uncertain decision-making environment, the risk reduction strategies of venture capitalists can be appreciably different from the ones used to reduce asymmetric risk. For any investor, an usual way of dealing with uncertainty is to move towards "less risky" assets when an unexpected adverse event occurs. For a venture capitalist, this "portfolio failure avoidance strategy" (Ruhnka and Young 1991) consists of allocating a larger proportion of portfolio funds to "safer" investments that have a higher probability of achieving positive returns and also of producing earlier cash flow.

This type of strategy can drive venture capitalists to modify the diversification of their portfolios in terms of investees' stages of development. The life-cycle of venture capital-backed companies is frequently modeled as a sequential series of stages. Companies are seen to advance gradually from the seed stage to the start-up stage, then to the third stage, to the

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[1] "Living dead" companies stay alive and progress modestly, but their shares remain illiquid and they are not able any more to raise additional venture capital financing because they fail to meet the expected 25-35% portfolio target rate of return.

fourth stage, and so on, to finally reach the exit stage. At the exit stage, the shares of the company become liquid in a public offering or a trade sale.

However, as Berger and Udell (1998) point out, the degree of informational opacity is a key feature that distinguishes small business finance from large business finance. In the first stages of development, small businesses, such as "seed stage" or "start-up" ventures, typically do not have audited financial statements, do not have many business assets that can be easily evaluated or pledged as collateral, and have little repayment history or record of profitability upon which external suppliers of funds can rely[2].

In these circumstances, it is likely that the risk of loss associated with venture capital investment decreases steadily as the venture reaches later stages of development. This particular point is analyzed in depth by Ruhnka and Young (1991) who underline that risk estimates for early stage ventures include *all* the probable risks that a venture will face, both internal and external, up to the exit stage. Internal risks are for instance poor management, the impossibility to produce a workable prototype or to attract funding for next stage or to achieve adequate profit margin. External (or market-determined) risks are for example the emergence of competitors, technological shifts, or economic downturn that slow market growth or prevent initial public offerings. External risks are in many cases uncontrollable for the venture capitalist. According to Ruhnka and Young, this distinction between internal and external risk is crucial: it explains why the decline in aggregate risk over the successive stages of development is entirely due to reductions in internally determined risks. These reductions occur when ventures through time overcome technical problems, build management competencies, etc. The anticipated external competitive risks that a venture will face in the later stages of its development are embedded in the aggregate risk expectations for its earlier

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[2] For such early-stage firms, outsiders often put considerable weight on the creditworthiness and reputation of the entrepreneur, who may have a longer credit history, more pledgeable assets, and personal data that are easier to evaluate than the records of the firm.

stages of development, but do not begin to predominate considerably until the later stages of development, when the venture really gets exposed to competitive market forces.

Empirically, the risk-return profile of such staged investments has been studied with survey and interview methods (Wetzel 1981; Ruhnka and Young 1991; Chiampou and Kallett 1989). These studies show that the risk of loss associated with venture capital investment decreases steadily as the venture reaches later stages of development. Also the venture capitalists' rate of return requirement has been found to decline in a similar fashion.

These results have been confirmed by more recent studies: Seppä and Laamanen (2001), using the valuation data of 421 venture capital transactions, found that early-stage ventures have higher implied risk and higher implied volatility of the returns than more established ones. Manigart et al (2002), with a sample of 200 venture capital companies located in five countries, found that on average, venture capitalists require a return between 36 percent and 45 percent for early-stage investments and between 26 percent and 30 percent for expansion later-stage investments such as acquisitions and buyouts. Stage-specific-required rates of return reported are comparable to those in Elango et al. (1995) who found a 42 percent rate of return for early-stage investments and 33 percent for later-stage investments.

All these results lead us to suppose that, in an uncertain decision-making environment, a reallocation of their portfolio from "higher-risk / early-stage" to "lower-risk / later-stage" investments can be a rational response adopted by venture capitalists confronted with the occurrence of an unexpected adverse event. The next section is devoted to a very simple formalization of this idea, founding our argument on results drawn from two areas of research: theoretical literature on bounded rationality and the empirical literature on decision-making under uncertainty (in particular results found by cognitive psychologists).

2. Modeling the portfolio choices of venture capitalists in an uncertain environment

We develop below a simple model formalizing the investment behavior of venture capitalists under uncertainty (2.1). Then the dynamics of the model is studied focusing on the rational behaviors adopted by venture capitalists when confronted with an unexpected adverse shock in financial markets (2.2).

2.1. The Reliability Condition

Consider a venture capitalist (VC) that must choose an optimal portfolio diversification among (riskier) early-stage ventures and (safer) later-stage ventures. Because of the uncertain decision-making investment environment, we suppose, following Heiner (1983), that there is a *competence-difficulty (« C-D ») gap* between the venture capitalist competence and the complexity of the decision problem [3]. We assume that initially, the VC is limited to a fixed repertoire of "lower-risk" actions. More precisely, there is only one action possible in the VC's repertoire: "Investing in later stage ventures". The problem faced by our VC is the following: in what circumstances, would it be rational to raise the proportion of "higher-risk" early-stage investments in portfolio? In other words, will this greater flexibility to select an additional action improve the VC's portfolio performance?

In certain conditions, the new action (investing in early-stage) will take preference over the initial action in the VC's repertoire (the "right" time to select the new action), but otherwise it will be less favored than this initial action (the "wrong" time to select the new

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[3] Ronald Heiner (1983) has proposed a theory of predictable behavior which has its roots in what Heiner labels a competence-difficulty (C-D) gap. This gap is a measure of the spread between an economic agent's competence to make an optimizing decision and the difficulty of the decision problem. Heiner argues that as the C-D gap widens, the agent is increasingly likely to follow rule-governed behavior, and it is this rule-governed behavior that produces observed regularities in economic behavior. If there is no C-D gap, Heiner argues that rule-governed behavior would disappear and, along with it, the observed regularities. Instead, unpredictable behavior, characterized by constant perturbation, would replace predictable behavior.

action). The probabilities of the right or wrong time to select the new action are written as Π and $(1 - \Pi)$ respectively.

Because of uncertainty, the VC will not necessarily select the new action when it is the right time to do so. The conditional probability of selecting the action when it is actually the right time is written r. When this happens, the resulting gain in performance (compared to staying within the initial repertoire) is written g. Similarly, the conditional probability of selecting the new action when it is actually the wrong time is written w, with consequent loss in performance of l.

Let E be the action: "Investing in early-stage ventures". The VC chooses to enlarge its repertoire of actions to the riskier action E, that is to invest in early-stage if and only if:

$$\Leftrightarrow \Pi\, r\, g > (1 - \Pi)\, w\, l \qquad (1)$$

The left-hand side of the inequality represents the expected gain from allowing flexibility to select another action; the right-hand side the expected loss on allowing the action to be selected. Hence, simple rearrangement yields the following *Reliability Condition*:

$$(r/w) > (l/g)[(1 - \Pi)/\Pi] \qquad (2)$$

Or, in a more condensed way,

$$\rho > T \qquad (2')$$

Where $\rho = (r/w)$ is a reliability ratio which measures the probability of "correctly" responding under the right circumstances relative to the probability of "mistakenly" responding under the wrong circumstances. This ratio can be interpreted as the *confidence* of the VC in its investment choices. More precisely this ratio measures the level of confidence with which the VC decides to widen its repertoire of actions to early-stage ventures.

$T = (l/g)[(1- \Pi)/\Pi]$ represents a threshold or tolerance limit which the reliability ratio must satisfy.

Finally, if $\rho > T$ the VC will have a "flexible" or "accommodative" behavior toward demands for financing from early-stage ventures. That is to say it will take into consideration investment opportunities *both* in later-stage and in early-stage ventures.

On the other hand, if $\rho < T$ the VC will adopt a "rigid" behavior: it will only take into account "lower risk" investment opportunities in later-stage ventures and will ignore "higher risk" investment opportunities in early-stage ventures.

2.2. Understanding the venture capitalist's portfolio reallocation in the presence of uncertainty

Let us now examine the main factors influencing each side of the reliability condition, beginning by the right-hand side. For a given *(l/g)*, the threshold *T* depends on probability (*1- Π)* which measures the probability of "wrong" circumstances for investing in the early-stage ventures.

Empirical studies have identified several potential determinants of venture capital investments: initial public offerings, stock market opportunities, GDP, the basic legal and tax structures (such as the Corporate Gains tax rate in US), the labor market legislation, the level and growth of pension funds, industrial and academic R&D expenditures, the level of interest rates (See for instance Jeng and Wells 2000; Romain and Van Pottelsberghe 2004). An unexpected adverse evolution of any of these determinants is thus a "wrong" circumstance for investing in early-stage.

In this paper, we choose to focus on one of these factors: the financial market performance. To understand the influence of financial markets on venture capital activity, it is

useful to explicit what Gompers and Lerner (2001) call the "venture cycle": *The venture capital cycle starts with raising a venture fund; proceeds through the investment in, monitoring of, and adding value to firms; continues as the venture capital exits successful deals and returns capital to its investors; and renews itself with the venture capitalist raising additional funds*" (Gompers and Lerner 2001, p. 152).

The exit phase is crucial since it enables one to measure the value created by the different mechanisms of screening, expertise and monitoring set up by the venture capitalist.

There are five principal types of venture capital exits (Cumming and MacIntosh 2003): (i) listing the company through an IPO, in which a significant portion of the firm is sold into the public market; (ii) an acquisition by industrial trade buyers, in which the entire firm is bought by a third party; (iii) a secondary sale, often a financial buyout by other private equity firms; (iv) a buyback, in which the VC's shares are repurchased by the entrepreneurs; and, (v) a write-off, in which the VC walks away from the investment.

There is a general belief in academic literature that going public is the most profitable and prestigious exit route for venture capitalists (for example Black and Gilson 1998; Jeng and Wells 2000; Barnes, Cahill and McCarthy 2003). In the venture capital industry, bringing a company public is a signal of success for the venture capital firm backing the issuing company. Apart from the obvious profitability measure, VCs typically measure their success in terms of the number of companies they have taken public (Barnes, Cahill and McCarthy and McCarthy 2003). Jeng and Wells (2000) found that IPOs are the strongest driver of VC investing. Black and Gilson (1998) state that US venture capital funds earned on average 60 percent annual return on investment in IPO exits, compared to 15 percent on acquisition exits. A similar result is found by a study of Venture Economics (1988).

A period of favorable evolution of financial markets can thus be considered as a "right time" to invest in early-stage ventures. On the contrary, an unexpected adverse shock (such as

a financial crash or more generally a slump of a reference index) on financial markets is typically a "wrong" circumstance for investing in the early-stage. In our reasoning, we will thus consider that (*1- Π)* is the probability that financial markets undergo a slump.

The state of knowledge with regard to this probability is far from being complete. Venture capitalists know only that there is a small but finite probability that such sharp drop in financial markets can happen. However, like other financial market participants, they do not have sufficient evidence to infer this probability from the historical record. Moreover, such a dramatic event occurs so infrequently that it may be disregarded with impunity by investors for long periods.

As underlined by Guttentag and Herring (1984, 1999), a pertinent way to study this kind of low-probability, high-loss phenomenon is to refer to concepts and methods developed by cognitive psychologists[4]. Two of the heuristics the latter have found – the availability heuristic and the threshold heuristic – provide interesting insights into the behavior of investors confronted with uncertainty.

The availability heuristic is a psychological mechanism by which people evaluate the likelihood of an event. In the terminology of Kahneman and Tversky (1982, p. 164), the "availability heuristic" is employed whenever a person "estimates frequency or probability by the ease with which instances or associations can be brought to mind". Frequent events are usually easier to recall than infrequent events. But ease of recall is also affected by other factors such as the time elapsed since the last occurrence. These factors can give rise to an availability bias. A commonplace example of this phenomenon is the behavior of a driver who has just witnessed an automobile accident. The driver's immediate response is to drive much more cautiously, as if the probability of an accident had suddenly increased. But gradually, as

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[4] Guttentag and Herring analyze the accuracy of credit models with special emphasis on the difficulty for banks of estimating low-frequency, high severity losses.

time passes and the image of the accident recedes from memory, caution declines. The tendency for the subjective probability (as evaluated by the agent) to decline during long periods in which no disaster has occurred is termed "disaster myopia".

At some point, long after the occurrence of a disaster, the subjective probability of the recurrence of a disaster may become so low that it is treated as if it were zero. This is an example of the "threshold heuristic" – an implicit rule through which decision-makers allocate one of their scarcest resources – managerial attention.

In our model, the automobile accident takes the form of a sharp drop of a financial markets' performance index. In the event of such an adverse shock, the subjective probability ($1- \Pi$) that financial markets may once again suffer a slump (that is, the probability of "wrong" circumstances for investing in the early-stage) will rise. Another expected implication of the availability heuristic is that the VC's subjective probability will quite likely overshoot the true probability of the occurrence of a new drop in the performance of financial markets[5].

The increase in probability ($1- \Pi$) induces a rise in the tolerance limit T. If this rise is sufficiently important, the reliability condition writes $\rho < T$: VCs will ignore investment opportunities in early-stage ventures. As long as this situation continues, early-stage ventures may suffer from a strong rationing in venture capital markets.

We thus formulate the following assumption:

H1 ("availability heuristic"): When an unexpected adverse shock occurs in financial markets, VCs will tend to decrease the proportion of early-stage ventures in their investment portfolio. In other words, during a post-crisis period, a *positive correlation* between the

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[5] See Guttentag and Herring (1984) for an application of this theory to the credit market.

performance of financial markets and the proportion of early-stage ventures is likely to be observed.

This result is reinforced by the sharp fall in the left-hand side of the inequality that follows a slump in financial markets. Indeed, the reliability ratio $\rho = (r/w)$ measures the confidence with which the VC decides to enlarge its repertoire of actions to early-stage ventures. Taking into account the empirical positive influence of financial markets on early-stage ventures recalled above, we can legitimately suppose that an improvement (respectively a degradation) of a performance index of financial markets will induce, all other things being equal, an increase (respectively a fall) in the level of ρ.

Note however that a rise in confidence will have an observable influence on the level of VCs' early-stage investment if *and only if* ρ exceeds the tolerance limit *T*. It is obvious that the latter situation (where $\rho > T$) applies all the better if the tolerance limit *T* reaches a low level. This will be typically observed whenever venture capitalists form expectations after a long period in which no financial crises has occurred. Indeed, in these circumstances, the probability (*1- Π*) will gradually decline (if disaster myopia apply) or will be treated as if it were zero (according to threshold heuristic).

From the above argument, we infer the following hypothesis:

H2 ("disaster myopia"): If the confidence of VCs toward early-stage investment is high enough and/or if sufficient time elapses since the last financial turmoil, the improved performance of financial markets will induce a rise in the proportion of early-stage ventures in the investment portfolio of VCs. In other words, after a long period of "financial tranquility", a *positive correlation* between the performance of financial markets and the proportion of early stage ventures is likely to be observed.

Otherwise, if the increase in ρ is not sufficient to reverse the reliability condition, an improvement in the performance of financial markets will not have any observable positive effect on VCs' early-stage investments. It will be notably the case in our model as long as the image of a slump in financial markets is still present in the memory of VCs, which maintains the probability ($1- \Pi$) at a high level and thus also the tolerance limit T. Hence the following hypothesis:

H3 ("memory effect"): Even if the performance of financial markets improves after a slump, the proportion of early-stage ventures in the portfolio of VCs stays durably at a low level as long as the memory of the slump influences the expectations of VCs: no correlation between the performance of financial markets and the proportion of early-stage ventures is likely to be observed.

The next section is designed to test empirically our three hypotheses.

3. Statistical analysis

We develop below a statistical analysis of investment choices in the United States venture capital market. First, we test empirically the relationship between the proportion of funds invested in the early-stage and the performance of financial markets (3.1). Secondly, we compare the results of the statistical analysis to those of our theoretical model (3.2).

3.1. Early- versus later-stage investment: the example of the United States market

We use venture capital data from the MoneyTree Report, the database of NVCA (National Venture Capital Association)-PriceWaterhouseCoopers. The MoneyTree Report measures cash-for-equity investments by the professional venture capital community in private emerging companies in the United States. These quarterly data provide information

about investments (such as amounts invested, number of deals, sector and stage of development) in the US venture capital industry.

In accordance with the literature on ventures' stages of development and with the remarks made in the first part of this paper, the risk of loss associated with venture capital investment decreases as the venture reaches later stages of development. Thus, we put together two categories of the MoneyTree Report, "early-stage" and "expansion-stage" where the profitability of the product is relatively uncertain, in one and the same category representative of "early-stage/high-risk investments"[6]. For the same reason, we consider the MoneyTree Report "later-stage" as representative of "later-stage/low-risk investments"[7].

Table 1 reports the proportion of funds invested in the different stages of development and the Nasdaq Composite Index during the period 1995-2008. On this chart, time is on the horizontal axis, the percentage of funds invested on the left-vertical axis and the Nasdaq Composite Index value on the right-vertical axis.

Table 1 here

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[6] Clearly, the level of risk is not homogenous between early- and expansion- stages. "*Early-Stage*: the company has a product or service in testing or pilot production. In some cases, the product may be commercially available. May or may not be generating revenues. Usually in business existing for less than three years. *Expansion-Stage*: Product or service is in production and commercially available. The company demonstrates significant revenue growth, but may or may not be showing a profit. Usually in business existing for more than three years*" (NVCA, MoneyTree Report).* Nevertheless, what is important for our argument is that both early and expansion-stage investment are riskier than later-stage investments.

[7] "*Later-Stage*: Product or service is widely available. Company is generating on-going revenue; probably positive cash flow. More likely to be, but not necessarily profitable. May include spin-outs of operating divisions of existing private companies and established private companies*" (NVCA, MoneyTree Report).*

The Nasdaq Index trend may be divided into three periods: bubble (1995-1 to 2000-3), fall (2000-4 to 2003-1) and growth (after 2003-1). We must note that this growth has come to a halt since 2007-4.

It can be seen that after a steady increase from 1995 to 2000, the proportion of funds invested in "high risk" stages decreases after the Stock Market Crash of 2000. The minimum is reached for the third quarter of 2005. After that time an irregular trend appears.

After years of stability, investments in the "low-risk" stage begin to climb after the Stock Market Crash of 2000. A peak is obtained for the third quarter of 2005. At this time the proportion of funds invested in the "low-risk" stage is higher than the proportion of funds invested in "high risk" stages.

Table 1 also clearly shows that the Stock Market Crash of 2000 has deeply changed the behavior of venture capitalists. From 1995-1 to 2003-1, funds invested in "high risk" stages and the Nasdaq Index seem to be linked. On the other hand, the Stock Market's recovery after 2003 does not seem to affect the evolution of the proportion of funds invested in "high risk" stages.

We use a simple regression model to test the link between Funds raised (F) and the Nasdaq Index. The specification used is:

$$F_t = c_0 + c_1 \text{ Nasdaq Index}_t + u_t$$

$$\text{with } u_t = \rho_1 u_{t-1} + \rho_2 u_{t-2} + ... + \varepsilon_t$$

Table 1 suggests to study three periods: 1995-1: 2000-3; 2000-4: 2003-1 ; 2003-2: 2008-4. Tables 2, 3 and 4 report results from univariate OLS regressions for these three periods, namely:

- coefficients of regression estimations ;
- t-Statistic for statistical significance of the coefficients ;

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- R² ;

- F-test value and statistical significance ;

- F-Breusch-Godfrey test value and statistical significance. The null hypothesis of this test is that there is no serial correlation in the residuals up to the specified order,

Table 2 here

Table 3 here

Table 4 here

3.2. Interpretation of the results

When comparing the results of the statistical analysis to those of our theoretical model, it is possible to highlight a *break* in the investment behavior of venture capitalists in recent years.

First of all, during the period 1995-2002, Nasdaq is a strongly significant explanatory variable for the early-stage investments of VCs. The reasons for the adoption of this investment behavior are nevertheless different according to the considered sub-period. Indeed, between 1995 and 2000, that is before the e-crash, the "disaster myopia hypothesis" applies: the positive correlation between financial markets and investment is explained by an increase in confidence due to the improvement in Nasdaq performance. The minimum threshold of the reliability ratio, T, is low because venture capitalists, in the absence of recent unfavorable shocks, consider that the probability of occurrence of an unfavorable event on the venture capital market is low. The reliability condition of our model is thus such as $\rho > T$ and a rise in the proportion of early-stage ventures in VCs' investment portfolio is logically observed, in accordance with hypothesis H2.

On the other hand, during the second sub-period, between 2000 and 2002, immediately after the e-crash, the consequences of the adoption of a availability heuristic by venture capitalists are fully felt: they lead to a sharp rise in the minimum threshold T due to the "over-reaction" affecting the probability $(1\text{-}\Pi)$. Since, in parallel, venture capitalists' confidence ρ strongly decreases as a result of the collapse of the Nasdaq, a reversal of the reliability condition logically follows. The latter becomes such as $\rho < T$. Consequently, when financial markets collapse, VCs decrease the proportion of early-stage ventures in their investment portfolio, in accordance with hypothesis H1.

Since 2003, Nasdaq has no longer been a significant explanatory variable for early-stage investments: despite the favorable evolution of the index observed since the first quarter of 2003, this kind of investment does not recommence and most funds continue to be invested in later-stage investments. In other words, early-stage investments appear to have disconnected from the performance of financial markets. Our model provides an explanation for this break in the behavior of VCs: despite the favorable evolution of the Nasdaq, which has contributed to the improvement in confidence ρ since the first quarter of 2003, the memory of e-crash is still present in the minds of investors. Indeed, the "memory-effect" associated with the availability heuristic used by venture capitalists maintains at a high level their estimate of the probability $(1\text{-}\Pi)$ and, therefore, the minimum ratio of reliability, T. Consequently, in spite of the increase in ρ, the reliability condition is not reversed and remains such as $\rho < T$. A situation where the proportion of early-stage ventures in the portfolio of VCs remains durably at a low level is observed, in accordance with hypothesis H3.

Conclusion

In recent years, venture capital investments in the United States have been characterized by three successive and clearly defined periods. Firstly, before the e-crash, a favorable period for early-stage ventures during which the proportion of funds obtained by this kind of firm increased regularly and significantly compared to funds allocated to more mature companies. Then, immediately after the e-crash, came a period during which the proportion of investment in early-stage ventures collapsed. Finally, from 2003, a period during which early-stage ventures underwent a lasting rationing by venture capitalists, the latter favoring the funding of more mature businesses.

Our paper gives a degree of explanation for this phenomenon by analyzing the specific behavior of venture capitalists which is essential for an understanding of their early-stage / later-stage trade-off. The originality of our approach consists in considering that this trade-off is strongly influenced by the specific nature of the decision-making environment which characterizes the venture capital industry. We show in fact that the portfolio failure avoidance strategy adopted by venture capitalists is directly linked to the fact that financing decisions are made, on one hand, in situations of strong uncertainty, and, on the other hand, concerns firms at different stages of development and thus implying different risks. This particular decision-making environment makes the investment decisions of venture capitalists difficult to analyze using traditional optimization tools. The rational behavior of venture capitalists implies the integration within the analysis of elements often underestimated or ignored in most models based on information asymmetries in a mere environment of probabilistic risk. Among these elements omitted in the literature, we have focused on key features such as confidence and specific heuristic procedures used by venture capitalists in situations of uncertainty.

The main result of our paper is that these elements strongly influence the way venture capitalists interpret the signals emitted by financial markets and echo these signals on their

investment portfolio diversification in terms of the investees' stages of development. During certain periods, changes in the confidence of venture capitalists affect the relative amount of investment in early-stage ventures. In this case, we found that, in accordance with the conclusions of the literature on the determinants of venture capital, one observes a positive correlation between early-stage investments and the performance of financial markets. On the other hand, during other periods, such as the recent period, the heuristic procedures used by venture capitalists render their investment behavior more "rigid". They then durably refocus their activity on the least risky forms of investment, namely later-stage investment. In that case, contrary to the results of the literature, there is no observable relationship between performance of financial markets, confidence of venture capitalists and investment in early-stage ventures.

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Table 1

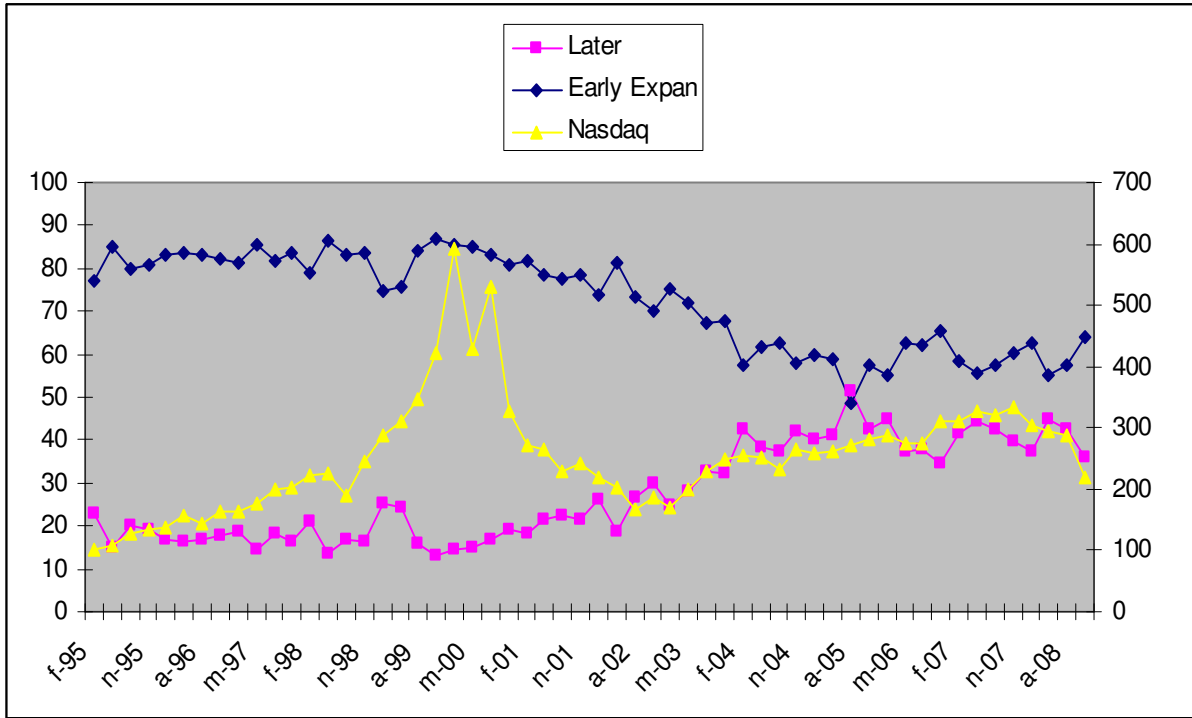**The early/later stage trade-off and the financial market performance**

Table 2

Regression Result

Period 1995-1: 2000-3.

Early/Expansion Funds

Independent Variable	Regression Coefficient		t-Statistic
C	0.695203		29.17***
Nasdaq Index	0.000221		2.82**
AR(1)	0.177220		0.72
AR(2)	0.023984		0.11
R²		0.283	
F		4.500**	
F Breusch Godfrey		1.720***	

* Significant at 10 percent
** Significant at 5 percent
*** Significant at 1 percent

Table 3

Regression Result

Period 2000-4: 2003-1

Early/Expansion Funds

Independent Variable	Regression Coefficient		t-Statistic
C	0.672395		25.79***
Nasdaq Index	0.000368		3.55**
AR(1)	- 0.152396		- 0,51
AR(2)	- 0.473523		- 1,27
R²		0.586	
F		2.887*	
F Breusch Godfrey		0.531***	

* Significant at 10 percent
** Significant at 5 percent
*** Significant at 1 percent

Table 4

Regression Result

Period 2003-2: 2008-4

Early/Expansion Funds

Independent Variable	Regression Coefficient		t-Statistic
C	0.745541		5.88***
Nasdaq Index	- 0.000629		- 1.40
AR(1)	0.358445		- 0.51
AR(2)	0.167898		1.59
AR(3)	- 0.005315		- 0.02
R²		0.362	
F		4.119**	
F Breusch Godfrey		0.547***	

* Significant at 10 percent
** Significant at 5 percent
*** Significant at 1 percent