How did U.S. venture capital react to the crisis? Revisiting evidence

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Abstract

We employ a large dataset of venture capital investments to analyze the effect of the Global Financial crisis of 2007-2009 on U.S. venture financing. By using a multiplicative interaction model which controls for this effect conditional on development stage of the venture-backed company, we conclude that VCs changed investment strategies, boosting the size of investments on early development stages, while reducing their exposure to later stages companies. Investments directed to startups at the beginning of venture cycle generally increase in dollar amount and number of deals or do not significantly change respect to the previous period. However, there is clear evidence of severe funding gap (ranging from 20% to 30%) for companies at later stages, in both first and later rounds. There is significant evidence which shows that most of this response is connected to the behavior of experienced venture capitalists. Collectively, the results reinforce the hypothesis of stage selective investing in order to postpone IPOs, avoiding the lower valuation during a crisis.

Keywords: Venture capital, crisis, great recession.

JEL Code: G240, G010

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1 Introduction

The Global Financial crisis of 2007-2009 (hereafter crisis) has been widely considered as the worst recession period since the Great Depression of the 1930s. Despite the roots of the crisis were entrenched in excessive securitization of subprime mortgages market during the housing bubble (mid 2000s), clear signs only appeared on July 31st, 2007 when Bear Stearns liquidated two hedge funds that invested in various types of mortgage-backed securities. Following events intensely shook the financial sector leading to banking panic, bankruptcy and public bail-outs which rapidly spread globally to the real economy harsh recessions, private defaults and high unemployment rates. Venture capital intermediaries (hereafter VC), as the rest of financial sector, were not exempted from the financial turmoil.

So far, the literature has not widely analyzed the effect of the Global Financial crisis on venture financing. Important exceptions are Block and Sandner (2009) and Block et al. (2012). The former, using a regression analysis for a sample of US internet related companies, find that the average amount of funds raised per round decreased by 20% during the crisis. This effect is detectable only in later rounds. The latter approach the question on a wider perspective, measuring the effect with descriptive statistics across industries and countries. They conclude that the crisis has considerably dropped the number of first-round investments and it has led to a severe funding gap in the amount of funds raised, especially in later funding rounds. Nevertheless, both papers do not investigate the possible startup maturity conditionality or, putting it simply, the fact that the measured effect of the crisis on VC funding could also depend on the stage of development of the funded company. Firms may have adopted different strategies to react to the financial crisis. On the one hand, investors may have simply changed the composition of the companies in their portfolios, according to many dimensions (including development stage). On the other hand, above and beyond relative shares, they may have adopted a selective approach on funding size, depending on the stage of the company and on the period considered.

This article addresses the above gap in the empirical literature by using a multiplicative interaction model, including different company stages at financing, company and firms characteristics and sector and regional effects. It will revisit the above mentioned results, testing a differential effect during the crisis for each company stage. Moreover, this study will also answer to several related questions. Building on the previous literature which highlights the high responsiveness to market changes of experienced VCs (Lerner, 1994; Gompers et al., 2008; Cumming et al., 2005), this paper will test whether venture firms which have kept funding companies during the crisis are more experienced (according to different measures) than in the tranquil period. And if this result modifies conditional

on the company development stage. Lastly, it will investigate any geographical change in VCs' funding allocation by checking whether VCs have tended to finance closer companies during the crisis, as to "keep an extra eye" on their investments. For example, geographical proximity may allow the firm's general partners a more effective monitoring, increasing face to face relations and habitual presence in the board meetings (Lerner, 1995; Cumming and Dai, 2010).

The empirical results of this study can be summarized as follows. First, descriptive analysis shows how the effect of financial crisis on venture funding depends on company stage at financing. In fact, when the conditional effect is measured, the reduction in number of deals and size of financing appears to be concentrated only on later stages, while VCs increased follow-on investments for seed and early stage companies. Second, by using a multiplicative interaction model which controls for the conditional effect on development stage of the venture-backed company, there is a *ceteris paribus* effect of boosting the size of investments on early development stages, while reducing their exposure to later stages companies. Third, there is statistically significant evidence that, during the crisis, experienced venture capitalists reallocated their investments towards seed and early stage companies more than new and relatively inexperienced intermediaries. Forth, business angel and government sponsored programs have kept sustaining venture funding during the financial crisis, particularly in first rounds. Lastly, there is not enough evidence in support of the geographical proximity hypothesis.

The paper proceeds as follows. Section 2 illustrates the theoretical background by analyzing the well-known VC market cyclicality, highlighting the differences with an exogenous financial shock and depicting possible channels through which the economic turmoil may have affected VC finance. Section 3 describes the data and the crisis time-window selection, explaining the construction of the variables used in this study. Section 4 shows the empirical methodology and presents the descriptive and multivariate analyses to address a number of questions related to the strategy adopted by VC intermediaries to face the economic downturn. General results will be discussed in Section 5, while Section 6 concludes.

2 Venture capital, market cyclicality and the Global Financial crisis

A venture capital is a specialized financial intermediary which invests money raised from institutional investors or wealthy individuals, called 'limited partners', in promising startups characterized by prevalence of intangible assets, years of negative earnings, facing high-risk, but potentially with high-rewards. Among many distinctive VC finance characteristics, the provision of monitoring, mentoring and other value added services is key and goes along with the infusion of equity-based staged capital. The former mechanism em-

powers the VC firm with a significant control right and eases the problem of being held-up by the entrepreneur (Da Rin et al., 2011). Staged financing should not be confused with the company stage at financing. It refers to the maturity of the startup and the distance from the end of the venture-cycle. Venture financing usually classifies companies in four stages, from 'seed financing', the very first investment when the company uses money for market research and product developing, to 'later stage', when the company is ready to go public or being acquired. However, company stage signals also two other important features. The earlier is the stage of funded company, the greater is the potential return and the risk. VCs which prefer product potentiality over proved market acceptance invest more in early stage startups (Elango et al., 1995). In order to increase clarity, through the paper the term 'firm' will always identify the venture capital firm, while the term 'company' will refer to the startup financed.

Respect to bank financing, VC finance is optimal when the uncertainty is high, the firm's cash flow distribution is highly risky, positively skewed, with low probability of success and low liquidation value, but high returns if successful (Winton and Yerramilli, 2008). Theory also focuses on optimality of VC advising in reducing the agency costs related to external financing (Casamatta, 2003). Stemming from these considerations, a vast stream of empirical literature has measured the effects of VC on financed company performance, finding significant improvements in productivity (Chemmanur et al., 2011), firm growth (Baum and Silverman, 2004; Peneder, 2010; Puri and Zarutskie, 2012) and innovation (Kortum and Lerner, 1998, 2000; Da Rin and Penas, 2007; Hirukawa and Ueda, 2011; Popov and Roosenboom, 2012).

In general, VCs target enterprises and sectors where information asymmetries are stronger, typically young companies in high-tech sectors. Addressing this market failure by intense scrutiny and due diligence before providing capital and by monitoring afterwards, it helps to bridge the funding gap for young and innovative companies (Hall and Lerner, 2009). However, venture cycle, from raising a venture fund to exiting and returning capital to its investors, is closely linked to financial sector in each of its steps (Gompers and Lerner, 2001). A sudden and enduring decreasing of VC finance, due to a financial shock, may have jeopardized a pivotal source of funding in key sectors for growth and economic development.

Cyclicality in venture capital investments is a well-known phenomenon. Metrick and Yasuda (2010) provide a historical account, reviewing the patterns of venture capital industry from its start, right after the Second World War, to the end of 2000s. VC market has been frequently affected by boom-and-bust phases (Cumming and Johan, 2012). This is mostly due to the uneven adjustment of supply and demand curves for VC funds in the short-run, which in turn is connected to the intrinsic nature of venture funding. Lerner (2003) illustrates the mechanism. The supply of VC funds is determined by the

willingness of institutional investors to provide funds, which depends on the expected returns of VC investment in respect of the market returns in the same risk class. The demand curve is determined by the number of startups asking for funds, which varies with the rate of return anticipated by investors and the technological opportunities historically available. Return demanded by investors set up the minimum threshold for funding, while the presence of big technological opportunity (e.g. internet revolution) would increase the expected returns and the capacity of companies to meet this requirement. Supply and demand together determine the level of VC funding in the economy. However, these curves are not either fixed or smooth. Reaction to changes is slow due to information lags and illiquidity of private equity funds. Hence, investors realize the quality of their investments only after a significant amount of time and cannot adjust accordingly the capital committed, as they would do in public markets. When the adjustment happens, it is likely to fail to correctly estimate the expected revenues at the time of the investment and the impact of competitors on startups profits: it could overshoot the ideal amount, which in turn exacerbates cyclicality (Gompers, 2007).

As Figure 1 clearly shows, the last 16 years did not come as an exception. The total amount of funds raised per quarter (solid line), along with the number of funding rounds (dashed line), significantly fluctuated around different investment levels. Using BBQ algorithm (Bry and Boschan Quarterly), developed by Harding and Pagan (2002), it is possible to identify from the data the turning points in the total amount raised series and the chronology of funding cycles.[1] The algorithm highlights 4 peaks and 4 troughs from 1998 to 2014, indicated by black diamonds in the figure. During the biggest boom-and-bust period, the dot-com bubble, funding increased from around 5 billions per quarter at the beginning of 1998, peaking at 28 billions two years later, to crash at 4 billions in the first quarter of 2003. The following period shows a general recovery trend, with a cycle of smaller width, interrupted only by the Global Financial crisis. During this event, the total amount disbursed halved in approximately one-year period. So did the number of rounds, decreasing from more than 1000 to about 600 per quarter. Shaded areas show economic contractions as officially registered by NBER.[2] VC funding contraction, started in the last quarter of 2007 and ended in the first quarter of 2009, seems to sync almost perfectly with the economy recession period led by the downturn. Afterwards, despite the negative predictions about a future general downsize of the VC industry expressed by many commentators at the beginning of 2009 (Mason, 2009), we observe a rapid recovery, followed by a milder contraction, forming a 4-year cycle. Starting from 2013, VC market

[1]The algorithm defines a peak as y_{t-2} ; $y_{t-1} < y_t > y_{t+1}$; y_{t+2} and a trough as y_{t-2} ; $y_{t-1} > y_t < y_{t+1}$; y_{t+2}. This algorithm identifies a set of potential turning points which have to comply with an extra censoring rule: expansion and contraction phases must be at least 2 quarters long, and complete cycles must have a minimum duration of 5 quarters.

[2]See http://www.nber.org/cycles/cyclesmain.html for NBER recession definition and time-line.

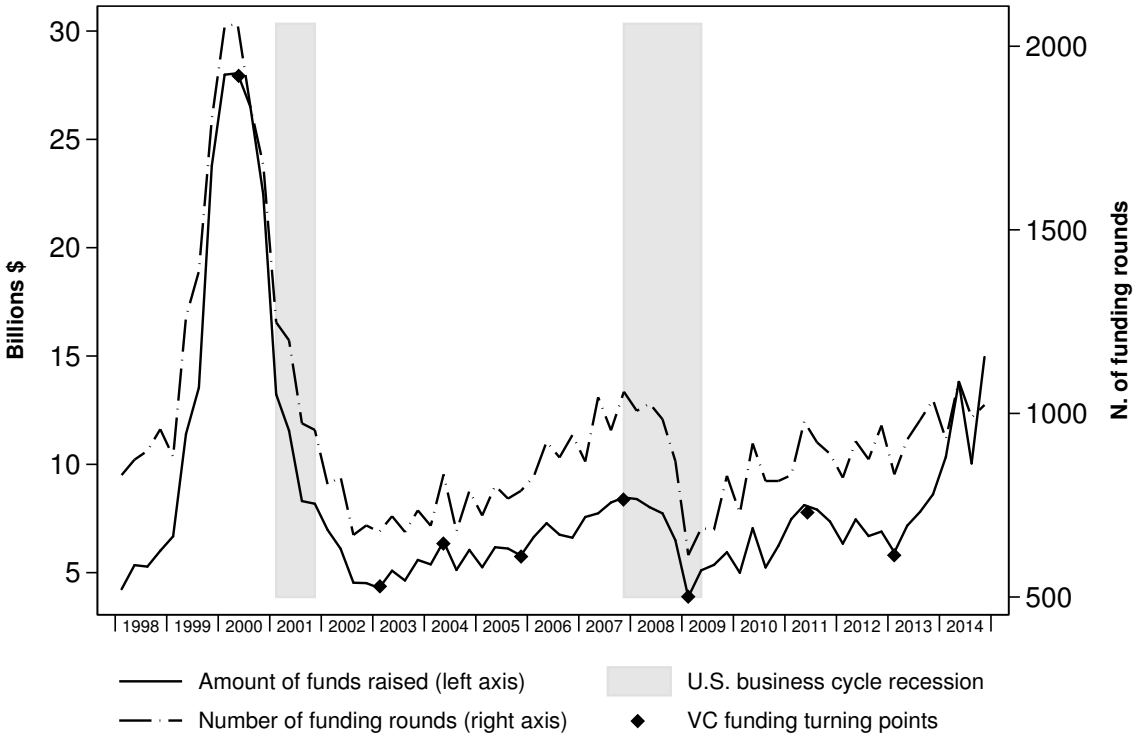

Figure 1: Total amount and number of deals by quarter (1998Q1 -2014Q4)

underwent on extraordinary growth in amount invested which may possibly result into another boom-and-bust event.

In summary, between 1998 and 2014, we observe 4 full cycles of different duration and width, although with a general trend on increasing the level of amount invested and number of deals concluded. In fact, Metrick and Yasuda (2011) report how institutional investors tripled average share of portfolio allocation to private equity firms between 1997 and 2007. However, while 3 cycles, including the dot-com one, appear to be mainly driven by endogenous causes, it is apparent that the economic recession due to the financial crisis can be considered as mainly exogenous to venture capital market.[3] The VC finance contraction is largely due to the effect of VC reaction to an external change of environment which modified firms expectations and strategies.

Financial shocks may affect venture funding in manifold ways, operating in different phases of venture cycle. On the one hand, shocks may reduce the firm capacity to raise a fund or the investors' ability to meet the capital requirements. On the other hand, they may lower companies valuations and consequently their exit perspectives, which in

[3]Despite the argument of the fundamental contribution of shadow banking sector in the collapse of the financial system (Acharya et al., 2009), venture finance can be hardly considered part of that sector, missing the most important, and dangerous, characteristic: the asset/liability mismatch. In VC market there is not maturity transformation, as the VCs (general partners) impose illiquidity on their counterpart (limited partners) in order to ward off the liquidity shocks (Lerner and Schoar, 2004).

turn influence the future capital contributions to VC funds. The first argument relates to the initial phase, when firms raise money through a vehicle, the venture fund. The average lifetime of a typical fund is around 10 years, during which investors face liquidity restrictions, though compensated by a higher return (Lerner and Schoar, 2004). A shock may negatively affect new funds formation, making new investors' search more difficult. However, as the capital committed is not disbursed upfront, but at capital call demanded by VCs, firms are not completely shielded by liquidity shocks even in active funds. During an economic downturn, some of the limited partners may need to hoard liquidity to face the crisis, increasing the risk of unfunded commitment. The second argument is connected to company exits. Negative business cycle pushes down IPOs valuation and fund returns, which in turn have a negative effect on venture fundraising. Lerner (1994), using a sample of 350 venture-backed biotechnology companies, shows how venture capitalists (in particular the experienced ones) take firms public when equity valuations are at peaks and postpone it, employing private financing, when values are lower. This finding connects us to an important strategy employed by firms during a period of expected illiquidity of exit markets (as it is during a crisis). During a cold IPO market period, firms invest proportionately more in early-stage companies in order to distance their investments from the trough. Conversely, when exit markets are liquid, venture capitalists rush to exit by investing more in later-stage firms (Cumming et al., 2005). This hypothesis will be empirically tested in this paper by analyzing the evidence of stage selective investing, during the Global Financial crisis.

However, adaptation strategies are not limited to funding size or stage selection. A significant change in VCs' market experience or geographical proximity during a recession may be the result of an active risk reduction strategy. Gompers et al. (2008) finds that the largest response in number of investments during market booms is not by new or inexperienced venture capitalists, but rather by specialized firms with remarkable sector experience. Therefore, the involvement and the behavior of experienced intermediaries may change during a bust. Regarding geographic proximity, VCs may want to reduce information asymmetry and moral hazard problems associated with distance. In fact, proximity is a key factor that influences VCs' behavior as it significantly decreases information asymmetry and the cost of monitoring (Lerner, 1995; Cumming and Dai, 2010). Even these hypotheses will be tested in Section 4.

3 Data

3.1 Source of data

Data on deals, financed startups and VC firms' characteristics are collected from the commercial database Thomson One by Thomson Reuters (formerly known as Venture

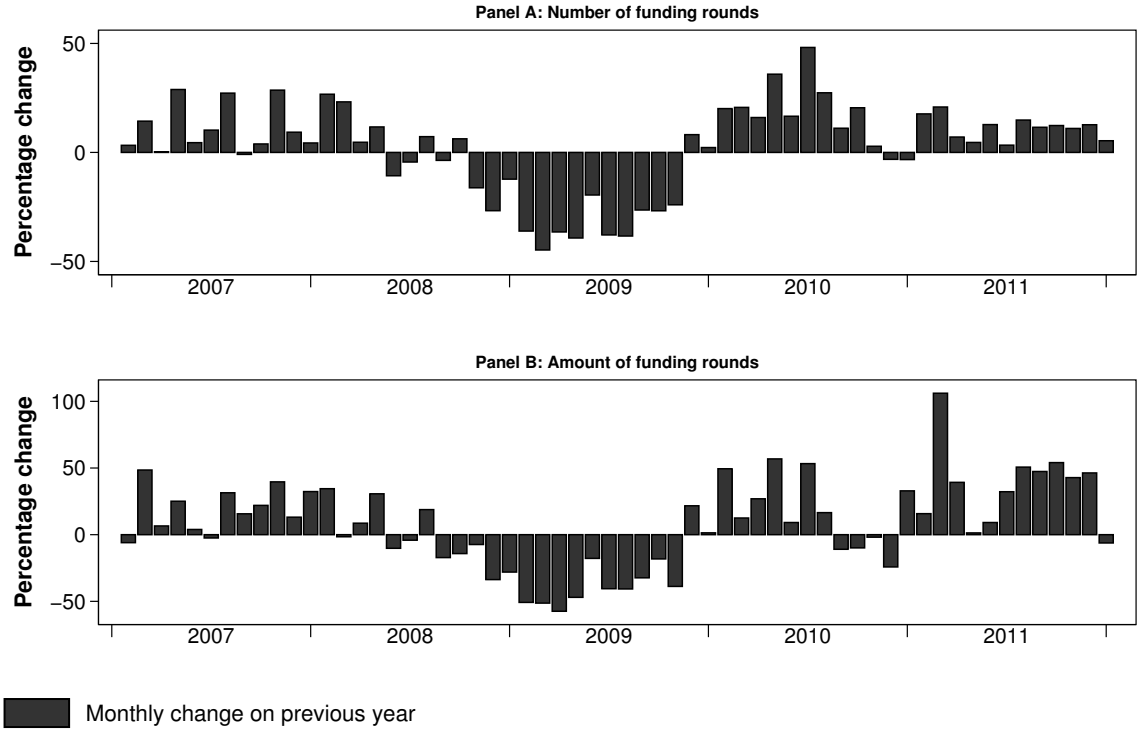

Figure 2: Monthly percentage change on the previous year (Jan 2007 - Dec 2011)

Xpert or Venture Economics). Thomson One dataset has been widely used in academic research and its completeness and accuracy has been assessed in Lerner (1994) and Kaplan et al. (2002). The latter compares a small sample of VC contracts with the information provided in the dataset, concluding that it excludes roughly 15% of the financing rounds, but provides relatively unbiased measures of the amount financed. Thompson One surveys quarterly private equity intermediaries, reporting investments made by all private equity sector including venture capital, buyout firms, business angels, corporate venture capital and investment banks. However, the present paper will study only venture investing, either private or public, which does not include buyout, mezzanine and fund of fund investing.

The database identifies 41,391 investment rounds between 2003 and 2014, made by traditionally venture focused firms. Approximately 30% consists in first rounds of financing, while the remaining 70% are second or later rounds. The sample is limited to funding rounds in which the amount invested is disclosed and the company headquarter is within the United States. We will start by descriptively overlooking the most important deal characteristics through the last decade and the first part of 2010's, to later focus the empirical analysis mainly on the analysis of the crisis period (2008-2009) compared to the tranquil period preceding it (2003-2008).

3.2 Dating the financial crisis period

In order to highlight whether any significant change happened during the crisis and to measure its consequences, we have to clearly define when the financial crisis started hitting the VC market and when its effects disappeared. Figure 1 shows the turning points in VC financing. However, these cut-offs do not take into account seasonal fluctuations in venture funding. In fact, the time series of VC funding data between 2007 and 2011 shows periodicity and the inspection of autocorrelation and partial autocorrelation plots finds spikes at lag 12 and 24. Block et al. (2012) use a simple method to determinate the correct time-window, adjusted for seasonality. They compare the monthly growth rate in the number of funding rounds in comparison with the previous year. For example, the starting point of an enduring switch from positive to negative growth rate is a candidate to be the initial cut-off of our time-window. Figure 2 employs the same methodology for both number and amount invested. Panel A depicts the percentage change in number of funding rounds. We observe negative growth from October 2008 (right after Lehman Brothers filed for bankruptcy) to October 2009, inclusive. However, the growth rate had started declining since the beginning of 2008, with an unclear situation during the months immediately preceding the Lehman Brothers crash. Panel B illustrates a similar situation with respect to the amount invested. Nevertheless, the initial cut-off can be dated earlier than in Panel A, around May 2008. Consequently, two different time-windows are adopted here. A shorter one (October 2008-October 2009), where effects seem to be more concentrated, will be presented first, while a longer one (May 2008-October 2009) will constitute the robustness check in the regression analysis, shown in the Appendix A.

3.3 Variables

This paper deals with the effects of the financial crisis on venture funding. The change in funding size will be addressed using both descriptive and multivariate analysis, while the related questions concerning VC experience and geographical proximity will be mostly analyzed using mean and median test difference. The unit of analysis is the funding round and each variable refers to it, to the characteristics owned by company, or VC, prior to the date of the deal. The regression dependent variable is the logarithm of the total amount raised in each funding round (*total investment*). It includes equity and debt funding and it is measured in US millions $. All other variables used throughout the paper are described as follows. *Financial crisis* dummy indicates whether the funding round occurred during the crisis time-window, while *syndication*, *business angel*, *government program* and *non-US VC* are VC-specific dummies, equals to one if the financier is an investment consortium and if there is the presence of at least one business angel, government sponsored program or a foreigner venture firm. *Lead investor* is defined as

the VC firm contributing for the largest amount of cash. In a syndicated investment, the lead investor typically is in charge of overseeing most of the negotiation, legal work, due diligence, and following monitoring. *Stage at financing* describes the stage of a company when it received the financing. Thomson One defines four stages: 'seed financing', 'early stage', 'expansion' and 'later stage'. *Company age* is the age (in years) of the financed company since the funding date. *VC firm age* and *Company-VC distance* are the age of the financiers and the geographical distance between VCs and company. In case of syndicated investments both measures are constructed as the weighted averages between all firms in the consortium. *General experience*, *sector experience* and *specialization* are variables expressing VC specific characteristics in the domain of VC market experience. They will be referred only to the lead investor and calculated prior to the time of each financing round. Lastly, industry and regional effects are captured by nine *industry* dummies and six *region* dummies, referring to the industry and area of the funded company. Table 1 provides a detailed account on the construction of all the variables used in this paper.

4 Empirical analysis

4.1 Descriptive analysis: Empirical facts on venture financing before, during and after the crisis

Tables 2 and 3 illustrate the principal characteristics of VC funding activity. The tables include the period before, during and after the Global Financial crisis, distinguishing between first and later rounds. Pre-crisis and post-crisis periods are 69 and 62 months long, respectively, while the length of the crisis period is 13 months. The variables employed in this first analysis refers to the investment characteristics, as number of deals, amount raised by month, syndication, investor type and sector allocation. Moreover, using contingency tables for number and raised amount, it is possible to control for stage at financing of the funded company.

The tables refer to the sub-sample of funding rounds divided by first and later rounds. The first round constitutes the initial contact between the entrepreneur and her investors. Typically, this is even when external financiers are given company ownership for the first time. Usually this happens after a period in which the entrepreneur relied mostly on her personal finance, the so called 'bootstrap'. In comparison with later rounds, first one is characterized by higher information asymmetries and uncertainty. It is the first time the team and company business model is extensively screened and the odds of a rejection are extremely high. Later rounds represent a follow-on to sustain company needs or they signal the achievement of designed milestones. Clearly, the abandonment of the project is an option, but it is costly. Instead, incumbent VCs can play an influential role

Variable Name	Description
Financial crisis	Dummy variable equal to 1 if the investment occurred during the crisis time-windows (October 2008-October 2009 or May 2008-October 2009).
Syndication	Dummy variable equal to 1 if there is more than one investor in the funding round.
Business angel	Dummy variable equal to 1 if there is at least one business angel in the funding round. Business angel category includes angel groups and individuals. The latter have been tracked in Thomson One identifying first name and surname in investor names.
Government program	Dummy variable equal to 1 if there is at least one government sponsored program in the funding round.
Non-US VC	Dummy variable equal to 1 if there is at least one foreigner VC firm in the funding round.
Lead investor	Constructed as the VC firm with the highest investment share in the round. In case of equal share, the first financier with the highest share is considered to be the lead investor. As robustness check "lead investor" has been compared with the variable "firm preferred role" in Thomson One. Historical changes are not registered in this variable, but it refers only to the point of time of data download (Jan 2016). However, "lead investor" shows high correlation with the value "deal originator" in "Firm preferred role" variable.
Stage at financing	Company development stage as reported by Thomson one. Four different stages are considered: "seed", "early stage", "expansion" and "later stage". Excluded dummy is "seed" stage.
Company age	Constructed as the difference (in years) between investment date and company date of founding.
Lead VC distance	Constructed as the distance (in hundreds of miles) on the earth surface between company and firm headquarters (geocoded at zip-code level). It uses the Vincenty's formulae and measures the geographical distance "as the crow flies", using the coordinates of two points.
VC firm age	Constructed as the difference (in years) between investment date and firm date of founding. In case of syndicated investment, firm age represents the average age at financing, weighted by the respective investment share of each firm in the consortium.
Company-VC distance	Constructed as the distance (in hundreds of miles) on the earth surface between company and firm headquarters (geocoded at zip-code level). It uses the Vincenty's formulae and measures the geographical distance "as the crow flies", using the coordinates of two points. In case of syndicated investment, distance represents the average distance, weighted by the respective investment share of each firm in the consortium.
General experience	Similarly to Gompers et al. (2008), constructed as the total number of investments made by the lead investor from its founding date to the time of the current investment.
Sector experience	Similarly to Gompers et al. (2008), constructed as the total number of investments made by the lead investor from its founding date to the time of the current investment, but in the same sector of the funded company. It considers 17 sectors as defined by Thomson One "Moneytree industry" variable.
Specialization	Similarly to Gompers et al. (2008), measured as the percentage ratio of "sector experience" to "general experience". It indicates how much a particular lead investor is specialized in the current investment sector at the time of the investment.
Industry	All investments are aggregated in 9 broad sector dummies, which refers to the industry of the company. Dummy equal to 1 if the sector is: "Biotechnology", "Computer & Electronics", "Healthcare", "Industrial/Energy", "IT Services & Telecom", "Media and Entertainment", "Services & Retailing/Distribution", "Software", "Financial Services & Others". Excluded dummy is "Biotechnology".
Region	All investments are aggregated in 6 broad areas dummies, which refers to the headquarter region of the company. Dummy equal to 1 if the area is: "California", "East Coast", "South-West", "Midwest & South-East", "North & Other". Excluded dummy is "California".

Table 1: Definition of variables

Variable	Pre-crisis Mean (Std. Dev.) (1)	Crisis Mean (Std. Dev.) (2)	Post-crisis Mean (Std. Dev.) (3)	Mean difference (2)-(1)	Mean difference (3)-(2)
Number of rounds per month:	81 (24.7)	55 (18.1)	92 (18.7)	***	***
by Stage at financing:					
Seed	20 (10.5)	16 (5.9)	16 (6.9)	-	-
Early Stage	40 (9.9)	25 (7.6)	58 (15.5)	***	***
Expansion	16 (6.9)	9 (4.7)	12 (4.7)	***	*
Later Stage	6 (3)	5 (3.3)	6 (2.4)	-	-
Raised amount per funding round:	5.89 (9.6)	5.05 (8.6)	4.73 (10.3)	**	-
by Stage at financing:					
Seed	3.46 (6.5)	4.39 (7.5)	3.69 (7.3)	**	-
Early Stage	5.22 (7.3)	4.38 (7.6)	3.79 (7.0)	**	-
Expansion	8.77 (12.9)	6.24 (8.9)	7.74 (18.7)	**	-
Later Stage	11.32 (15.7)	8.52 (13.7)	11.08 (16.5)	**	-
Investment consortium (%)	66.94	52.50	64.37	***	***
Business angel (%)	13.76	13.75	24.52	-	***
Government program (%)	7.16	10.42	6.69	***	***
Firm age (in years)	2.7 (3.8)	2.8 (3.7)	2.2 (3.3)	-	***
Industry (%):					
Biotechnology	11.71	13.61	8.17		
Computer & Electronics	10.90	8.33	3.92		
Financial Services and Others	2.76	1.67	2.03		
Healthcare	10.50	11.11	6.53		
Industrial/Energy	7.89	10.28	5.72		
IT Services & Telecom	12.18	11.81	10.67		
Media and Entertainment	10.27	9.44	13.39		
Services & Retailing/Distribution	7.66	7.08	8.22		
Software	26.13	26.67	41.37		
N funding rounds	5,617	720	5,669		

NOTE: This table shows descriptive statistics on first rounds of financing. Periods are specified as follows: "Before crisis" (Jan 2003 - Sept 2008), "During crisis" (Oct 2008 - Oct 2009) and "After crisis" (Nov 2009 - Dec 2014). Raised amount measured in mil $. Differences in mean are analyzed using two-sample t test Symbols ***, ** and * denote significance level of 1%, 5% and 10%, respectively.

Table 2: Descriptive analysis. VC funding before, during and after the crisis. First rounds

looking for new investors, which do rely on the information signaled by the quality of incumbents (Pearce and Barnes, 2006). Previous analyses on the effects of financial crisis on VC funding rely mostly on this dichotomy. Despite there is a clear prevalence of initial (later) stages companies in first (later) rounds, we may observe how even a significant amount of relatively older (younger) firms have been selected and financed in those type of rounds. This paper contributes on existing literature by going deeper than first/later rounds dichotomy, also considering the differential effects at different stage of financing.

The evolution of the average number of monthly investments through the period considered is shown in the first row of Table 2. There was a clear and significant dip in the number of deals during the crisis, a drop of about 30%, that were promptly absorbed in the post-crisis period. Considering the stage of the funded company, we observe that the fall is mainly concentrated at mid-level of company development, while seed and later stage financing seem more stable, with a slight increase in relative shares during the crisis period. Considering the funding amount, we observe, on average, a drop of about 800,000 $ per single investment (significant at 5%). Interestingly, results change controlling for stage of the company. Each funded company at seed stage benefited from almost a million dollars more in first investment size during the crisis than the previous and following periods. Conversely, companies in expansion and later stage experienced a drop in average amount invested, of 1.5 and 2 millions, respectively.

Variable	Pre-crisis Mean (Std. Dev.) (1)	Crisis Mean (Std. Dev.) (2)	Post-crisis Mean (Std. Dev.) (3)	Mean difference (2)-(1)	Mean difference (3)-(2)
Number of rounds per month:	200 (43.0)	181 (31.1)	213 (34.2)	-	***
by Stage at financing:					
Seed	6 (3.9)	11 (4.5)	6 (4.2)	***	***
Early Stage	34 (10.9)	46 (9.8)	77 (19.1)	***	***
Expansion	82 (19.0)	58 (12.4)	69 (12.1)	***	***
Later Stage	77 (23.1)	67 (14.2)	62 (11.9)	-	-
Raised amount per funding round:	8.44 (11.2)	7.96 (14.7)	10.43 (30.4)	**	***
by Stage at financing:					
Seed	3.19 (4.7)	6.01 (7.1)	4.71 (6.6)	***	*
Early Stage	5.45 (7.0)	6.39 (8.9)	7.69 (17.0)	***	*
Expansion	8.48 (11.8)	9.25 (21.4)	12.62 (42.6)	-	**
Later Stage	10.15 (11.9)	8.24 (11.2)	11.95 (27.9)	***	***
Investment consortium (%)	81.73	72.94	72.24	***	-
Business angel (%)	9.97	5.45	9.28	***	***
Government program (%)	2,63	4,35	4,24	***	-
Firm age (in years)	5.4 (3.8)	5.8 (4.2)	6.1 (4.4)	***	**
Industry (%):					
Biotechnology	13.19	16.02	14.54		
Computer & Electronics	16.68	12.19	7.92		
Financial Services and Others	1.70	1.49	1.41		
Healthcare	10.68	12.48	11.36		
Industrial/Energy	4.75	7.41	7.24		
IT Services & Telecom	12.49	10.86	10.01		
Media and Entertainment	6.39	8.56	8.92		
Services & Retailing/Distribution	4.58	5.07	5.35		
Software	29.52	25.91	33.26		
N funding rounds	13,787	2,347	13,222		

NOTE: This table shows descriptive statistics on later rounds of financing. Periods are specified as follows: "Before crisis" (Jan 2003 - Sept 2008), "During crisis" (Oct 2008 - Oct 2009) and "After crisis" (Nov 2009 - Dec 2014). Raised amount measured in mil $. Differences in mean are analyzed using two-sample t test
Symbols ***, ** and * denote significance level of 1%, 5% and 10%, respectively.

Table 3: Descriptive analysis. VC funding before, during and after the crisis. Later rounds

In general, results show a clear trend towards investing relatively more in younger companies and less in older ones. Other deal characteristics depict a situation which agrees with previous findings in the literature (De Vries and Block, 2011; Sohl, 2008). Syndicated investments plunged during the financial crisis, while the share of investments involving a business angel remained constant. As it would be expected, the involvement of government sponsored venture programs in investment consortia increased in connection with the economic downturn (the share moves from 7.2% to 10.4% to diminish at 6.7% with the aftermath of the crisis, both significant at 1%). Finally, age and sector shares do not seem to be significantly affected by the financial crisis.

Table 3 presents descriptive evidence for later rounds. Surprisingly, the average number of rounds per month decreased by only 10% (from 200 in pre-crisis period to 181 during the crisis period) and this difference in mean is not significant at conventional levels. However, the pattern remarkably changes analyzing the trend by stage at financing. As noted above, the dichotomy between first and later rounds does not proxy particularly well for stage at financing. Even in later rounds, despite the increasing weight of later stages, there is a substantial part of finance still directed to companies in the initial phase of development. Through stage breakdown, almost all the differences in mean become statistically significant, describing a two-fold behavior. VCs boosted their investments in seed and early stage companies and, on the contrary, diminished the number of rounds for

companies at later stages. Relative shares of investment in young companies increased, consequently reducing the investment share in older ones, in particular those in expansion stage. As for first round financing, it is worth noting that the number of follow-up financing in early stage kept growing significantly even during the post-crisis period, signaling a persistent change in venture capitalists' investment strategy. Similarly, average funding size almost doubled for seed stage, from 3.2 to 6 million $, then reducing to 4.7 $ right after the crisis. Early stage investment size slightly increased, while, as noted for first rounds, funding in later stage companies plummeted during the crisis to return at previous size in post crisis period. The change in syndication and government programs funding followed the pattern registered in the first rounds, while in contrast, the presence of business angels significantly diverged from first rounds, decreasing only in the crisis period.

In summary, descriptive analysis highlights a number of important results that will be later examined in depth. First, as described in the previous literature, there is a statistically significant evidence of a structural break during the crisis, compared to both pre-crisis and post-crisis periods. Temporary effects of the crisis are generally later reabsorbed or overcome. Second, unlike the above mentioned literature, this analysis shows how first/later rounds break is not sufficient to describe the differential impact of the crisis. Stage at financing is the most important discriminating factor, in particular for funding size. During the crisis, companies in their early stages benefited from more deals and investment size premium than the previous and following periods. Conversely, later stages companies discounted a loss during the crisis both in number and size of financing. Third, the analysis of deal characteristics offers a more nuanced vision to the numbers presented above. Government program and business angels sustained venture financing during the crisis (for angel financing this is true only for first rounds), while syndicated investments substantially decreased their relative share during the economic downturn. Finally, there is evidence of sector reallocation, but the data do not show a clear pattern in this dynamics. Yet, the above general picture lack of a *ceteris paribus* analysis which disentangles the partial contribution of each component. The following section using a multiplicative interaction regression model will carry out this study.

4.2 Regression analysis

Table 4 presents the findings on the relation between the effect of financial crisis, deal characteristics and average amount of funds provided by venture capitalists. The analysis is conducted at the funding round level. Thus, each round concluded between January 2003 and October 2009 represents a unit of observation. As described in Section 3, the crisis cut-offs are October 2008 - October 2009. A longer time-window is introduced later as robustness check. Moreover, as in the descriptive statistics, the whole sample is divided

by first and later rounds, as to introduce interaction terms in the model in the clearest way.

Formally, venture funding is modeled as:

$$\begin{aligned} Log(Y_{ir}) &= \alpha + \beta_1 Crisis_r + \beta_2 Age_{ir} + \beta_3 Syndic_r + \beta_4 Angel_r + \beta_5 GovProg_r + \beta_6 NonUS_r + \\ &+ \beta_7 Stage_{ir} + \beta_8 Stage_{ir} XCrisis_r + \beta_9 VCage_r + \beta_{10} Distance_{ir} + \psi_i + \phi_i + \epsilon_{ir} \end{aligned}$$

The response variable is the natural logarithm of the total amount of the investment (measured in million of dollars and inclusive of equity and debt financing) to company i in round r. The use of semi-logarithmic regression equation eases the interpretation, as the regression coefficients multiplied by 100 (or more precisely $[exp(\beta) - 1] \times 100$ in case of dummy variables) is interpreted as semi-elasticities which gives the percentage change of the predicted y with respect to a change of x. Standard errors are given in square brackets below the coefficient estimates and are robust to heteroskedasticity, allowing for clustering by company in the case of later rounds.

Each specification includes also the average age of the firms in the consortium and the geographical distance between financed company and firm. The first and second columns of each group (namely, columns 1-2 and 4-5) fit a linear model which does not include any interaction effect. Thus, the interpretation of the dummy variable *financial crisis* is the usual semi-elasticity in respect of the average amount raised. Instead, the third column of each group (namely, columns 3 and 6) fits a multiplicative interaction model between *financial crisis* dummy and three out of four values of the variable *stage at financing*. Here, the dummy representing the effect of the crisis cannot be interpreted as such, but it is the *ceteris paribus* change in funded amount due to the crisis for the base category (*seed stage*). Relative changes for the other categories are rendered by each interaction term. In all specifications, eight industry and five regional effects (ψ and ϕ) are included to account for sector and geographic reallocation.

Column 1 fits a simple model for crisis effect on first rounds, including only some deal characteristics, industry and region effects. Not surprisingly, the regression suggests that financial crisis reduces investment size at 1% of significance. The coefficient of -.181 indicates that during the economic downturn funding reduces by about 17%. As the second column shows, once other deal characteristics, such as the syndication, the presence of angel financing, or government programs in the consortium and stage at financing are controlled for, the coefficient of the crisis dummy reduces more than two times and now is only significant at the 5% level. The crisis funding discount implied by the regression for first round financing is only at 7%. Interestingly, the estimated coefficients for *stage at financing* dummies are all highly statistically significant and confirm empirical findings of

the descriptive statistics. Therefore, funding size does change according to development stage even within the type of round (first or later stage). The dollar amount of an average *early stage* round is 31% higher than a *seed* one, while *expansion* round is 81% and *later stage* is 111% bigger. Thus, size of the investment depends on the company stage in the venture cycle. As illustrated in Section 2, the choice to invest at different company stages is endogenous at firm level and depends on multiple factors, as for example the current state of the public markets. Neglecting to control for stage at financing may result in an omitted variable bias, inflating the crisis coefficient. The inclusion of stage at financing rules out every possible compositional effect from the regression model.

The third column adds the interaction terms between *financial crisis* dummy and *stage at financing*. Breaking down the effect of the crisis by company stage controls for firms' selection in funding size. Thus, interaction terms are interpreted as the change in funding size between pre-crisis and crisis periods at each stage of development. The regression indicates that there is no relation between crisis and funding size at *seed* stage, as the *financial crisis* coefficient is not statistically significant at conventional level. However, all the companies in other stages suffer a highly significant decrease directly proportional to their progress in the venture cycle. During the crisis, compared to the previous period, a typical *early stage*, *expansion* and *later stage* company sees its investment size decrease by 16%, 26% and 29%, respectively. VCs selectively decreased the size of funding of those closer to the end of venture cycle. In respect of the column 2, other coefficients remain substantially stable and they can be interpreted as follows. In the sub-sample of first round financing, controlling for other characteristics, an increase of one year in company age is associated with a 1% rise in funding. The low effect registered may be due to the fact that part of the company maturity is captured by the stage variables. Syndicated investments are on average 63% bigger than the individual ones. Interestingly, the presence of business angels or government sponsored investors is associated with a decrease (significant at 1%) of the amount invested by 27% and 52%, meaning that investment targets are smaller compared to those of venture firms, especially in the case of public programs. Lastly, VC experience, proxied by the average age of financier, is positively associated with an increase in funding by 2%, while distance between company and investors is positive and highly significant. A possible explanation to the latter is that, in case of geographical distance, only bigger investments may justify the cost of monitoring a distant company. However, despite the coefficient being highly statistically significant, the economic significance is low (.7% for each 100 miles of distance).

Columns 4 to 6 repeat the previous regressions for the sub-sample of later rounds. The results in column 4 indicate that financial crisis is associated with a reduction of funding size (at 1 % of significance) of about 14% for later rounds, controlling for industry and region effects as well as VC distance and age. This effect is somewhat lower than the one

Dependent variable: ln(Total Investment - Million of $)						
	First rounds			**Later rounds**		
	(1)	(2)	(3)	(4)	(5)	(6)
Financial crisis (dummy)	-.181***	-.074**	.091	-.156***	-.027	.199**
	[.034]	[.031]	[.055]	[.023]	[.021]	[.085]
Company age (in years)		.010***	.010***		-.017***	-.016***
		[.004]	[.004]		[.003]	[.003]
Syndication (dummy)		.493***	.491***		.858***	.857***
		[.021]	[.021]		[.020]	[.020]
Business angel (dummy)		-.316***	-.315***		-.058**	-.057**
		[.028]	[.028]		[.026]	[.026]
Government program (dummy)		-.751***	-.744***		-.172***	-.175***
		[.033]	[.033]		[.046]	[.046]
Non-US VC (dummy)		.024	.023		.310***	.309***
		[.051]	[.050]		[.029]	[.029]
Stage at Financing dummies						
Early Stage		.271***	.294***		.288***	.310***
		[.023]	[.025]		[.039]	[.041]
Expansion		.596***	.631***		.605***	.656***
		[.034]	[.035]		[.039]	[.041]
Later Stage		.747***	.792***		.709***	.776***
		[.055]	[.057]		[.043]	[.044]
*Fin.crisis*Early Stage*			-.180***			-.068
			[.069]			[.093]
*Fin.crisis*Expansion*			-.304***			-.225**
			[.100]			[.093]
*Fin.crisis*Later Stage*			-.339**			-.362***
			[.132]			[.092]
VC firm age	.025***	.019***	.019***	.018***	.015***	.015***
	[.001]	[.001]	[.001]	[.001]	[.001]	[.001]
Company-VC distance	.012***	.007***	.007***	.010***	.003***	.003***
	[.001]	[.001]	[.001]	[.001]	[.001]	[.001]
Industry effects	YES	YES	YES	YES	YES	YES
Region effects	YES	YES	YES	YES	YES	YES
Constant	1.229***	.847***	.824***	1.864***	.715***	.660***
	[.043]	[.043]	[.044]	[.039]	[.048]	[.049]
R-squared	.126	.337	.339	.100	.272	.274
Adj R-squared	.124	.335	.336	.099	.271	.272
P-value	<.001	<.001	<.001	<.001	<.001	<.001
Observations	6,012	6,012	6,012	15,680	15,680	15,680

NOTE: Crisis period is specified as Oct 2008 - Oct 2009. Standard errors are robust and clustered at company level for later rounds.
Symbols *, ** and *** denote significance level of 10%, 5% and 1%, respectively.

Table 4: Multiplicative interaction model for VC funding

registered for first rounds. However, when all deal characteristics and the stage of financed companies are included (column 5), *financial crisis* coefficient turns out to be insignificant at conventional levels. All other terms are significant at 1%, with the exception of *business angel* coefficient which is significant at 5%. The omission of these characteristics can bias the results, by hiding the actual transmission mechanism which ties financial crisis to average amount invested. In fact, it is unlikely that the financial crisis uniformly influences follow-on investments causing a uniform funding gap of 14%, as for example, measured in column 4. Hence, the effect is mediated by the actions and the adaptation strategies of the VCs, which in turn determine the average effect on investments. Again, by targeting younger companies, which correlate to smaller investment needs as it is apparent from the magnitude of *stage at financing* dummies, VCs may have indirectly lowered the amount provided to each company. The regression indicates that the inclusion of company stage and deal characteristics completely absorbs every direct negative effect. However, direct effects may still be measured at different stage levels.

The sixth column again adds interaction terms between crisis and stage at financing. As for first rounds, the coefficient *financial crisis* now measures the effect of the crisis for the base category (*seed stage*). There is a premium in funding size of 22% in comparison with the tranquil period (significant at 5%). This is not surprising and it confirms the preliminary evidence of descriptive statistics. VCs not only made more follow-on deals with younger companies, but also invested on average 22% more dollars on them, controlling for all other characteristics (the descriptive analysis shows a doubling in funding size, but it does not take into account all other variables). The interaction term *fin.crisis*early stage* is not significant, meaning that there is not a statistically significant effect on the dollars invested before and during the crisis. Differently, the terms *fin.crisis*expansion* and *fin.crisis*later stage* are negative and significant (at 5% and 1%, respectively). Those companies in expansion stage discounted a 20% reduction, while for those in later stage the reduction was higher, about 30% less than previous period. As in the first rounds regression, there is evidence of a selective funding by venture capitalists, conditional on company stage at financing. In column 5, the direct average effect of financial crisis is hidden by the opposite directions of stage effects. Funding gap in follow-on investments does exist, albeit limited to later stages (expansion and later stages), while companies still in seed stage received a premium.

Regarding the other coefficients, an important question to ask is whether the sign, the significance and the magnitude of the effects estimated in the current regression are similar to those estimated for first round financing. Columns 3 and 6 show that *stage at financing* dummies in column 6 have the same sign, significance and they are of a comparable magnitude than the ones of column 3, signaling that proportional change in funding size remains fixed across first/later stage dichotomy. Also *VC firm age* has a

similar sign and magnitude. However, all the remaining variables are sensibly modified compared with the regression of first rounds financing. *Company age* coefficient is negative and highly significant, meaning that, *ceteris paribus*, each year since the founding date decreases the funding size by 1.6%. As expected, syndicated investments correlates more with higher funding in later rounds, while controlling for other variables. A switch from a single financier to a consortium increases the funding size by 136%, more than twice the measure registered in first rounds. Business angels and government programs decrease their negative effects with average size of the funding (-5% and -16%, respectively). This pattern may reflect the substantial drop in angel and public contribution registered in later rounds. A possible explanation may be the qualitative variation on intermediaries involved in later rounds (for example a switch from wealthy individuals to organized angel groups or bigger public programs which are able to focus on more complex projects). Lastly, *non-US VC* is now positive and significant, associating the presence of a foreign VC with 36% more funding in the round. The positive sign may reflect the size needed to justify higher monitor costs, while the significance may be explained by their principal interest to later rounds, where the riskiness of new financing in foreign markets is mitigated by the information provided by the other partners.

In order to determine whether the analysis undertaken is robust with a different time-window specification, as described in Section 3, Table A1 repeats the regression including 5 months more in the financial crisis window. Basic patterns hold, including sign, significance and magnitude of coefficients. Differences are restricted to decimals (or few percentage points in semi-elasticity interpretation). In general, enlarging the sample size soften slightly the effects, showing how the acme of the crisis in concentrated in the shorter time-window. The descriptive analysis and the multiplicative interaction regressions undertaken in this section clearly establish a more nuanced vision of the effect of financial crisis on venture finance and in particular on the existence of a funding gap for venture backed firms. Those results, together with the VC experience and proximity findings, will be discussed in Section 5.

4.3 Venture capital experience

Table 5 summarizes the data on venture capital experience before and during the economic downturn. Following Gompers et al. (2008), experience here is proxied by three different measures. *General experience* is the number of investments made by the lead investor from its founding date to the time of the current investment. *Sector experience* considers only same industry deals with respect to the financed company and describe the industry-specific knowledge of the venture capitalist. Lastly, *specialization* is a percentage share and indicates how much a particular lead investor is specialized in the current investment sector at the time of the investment. Obviously, the first two measures may show a

positive trend due to the fact that experience increases automatically over time for venture capitalists who remain active in the market. Considering the limited time span and the magnitude of the change registered, the inclusion of a trend adjustment is not necessary. However, in order to be on the safe side, only significant differences both in mean and median will be commented. Finally, the reason of restricting the analysis of venture capital experience to the lead investor is both theoretical and computational. On the one hand, as explained in Section 3, lead investor does the great part of venture job in selecting and managing the deal. Followers instead rely mostly on lead investors' reputation in choosing to join the deal. Averaging venture experience among all deal participants is not going to add much information, but noise. On the other hand, due to computational constraints, is not possible to construct the measures for all the investors, accounting experience since 1946 to each investment date.

The breakdown of first rounds by company stage does not exhibit any clear pattern before the financial crisis. However, the substantial distances between average and median measures signal the presence of outliers. Average and median number of deals or specialization shares of the financier are usually very similar among stages and there is not one stage that consistently prevails over the others on different measure of experience. By contrast, during the crisis only seed stage shows a statistically significant jump (at 1%) in venture experience in all the variables. Average (median) number of deals prior to the current investment increases from 215 (58) to 350 (126), while the sector experience leaps from 39 (8) to 61 (18). Even average (median) specialization share of the investor between pre-crisis and crisis period is up from 20 (11) to 26 (16).

Later rounds depict a similar pattern. General and sector experience registers a discontinuity, with a positive and highly significant rise during the downturn. Breaking down by stage highlights an upswing in investor experience for seed and early stage companies. With respect to the previous period, average experience in seed stage doubles (or triples considering median values). Even early stage companies experience a milder increase, albeit not significant at conventional levels for specialization.

These results, measured across different dimensions, clearly show a sudden increase in average and median investors' experience of early stages companies, which cannot be accounted solely by a mechanical positive trend. This is suggestive of the fact that experienced venture capitalists reallocated their investments towards seed and partially on early stage companies more than new and relatively inexperienced intermediaries. Correlating this evidence with the boom of deals in early stages, as delineated in the previous section, it is indicative of their major role in the highlighted phenomenon. All together, the results support the hypothesis that more experienced venture capitalists are the most responsive in shaping adaptation strategies even during a recession period.

Variable	First Rounds				Later Rounds			
	Before Crisis	During Crisis			Before Crisis	During Crisis		
	Mean (Median)	Mean (Median)	ΔMean	ΔMedian	Mean (Median)	Mean (Median)	ΔMean	ΔMedian
General experience	234 (57)	255 (62)	-	-	303 (117)	341 (141)	***	**
by Stage at financing:								
Seed	215 (58)	350 (125.5)	***	***	210 (65)	426 (191)	***	***
Early Stage	258 (70.5)	228 (53)	*	*	273 (93)	342 (149)	***	***
Expansion	204 (37)	201 (46.5)	-	-	312 (118)	327 (107)	-	-
Later Stage	230 (42)	186 (60)	-	-	314 (132)	341 (152)	-	-
Sector experience	37 (7)	44 (8)	*	-	53 (17)	63 (21)	***	***
by Stage at financing:								
Seed	39 (8)	61 (18)	***	***	47 (11)	96 (42)	***	***
Early Stage	40 (9)	40 (5.5)	-	***	49 (14)	68 (20)	***	***
Expansion	31 (4)	27 (4)	-	-	52 (17)	57 (17)	-	-
Later Stage	32 (4)	36 (8)	-	-	55 (19.5)	61 (22)	*	-
Specialization	18 (9)	20 (11)	-	**	24 (17)	26 (18)	***	-
by Stage at financing:								
Seed	20 (11)	26 (16)	***	***	29 (21)	35 (28)	**	**
Early Stage	19 (9.5)	19 (10)	-	-	25 (18)	27 (19)	-	-
Expansion	16 (6.5)	15 (5.5)	-	-	23 (16)	24 (15.5)	-	-
Later Stage	17 (7)	19 (12.5)	-	-	24 (16.5)	26 (18)	*	-

NOTE: This table measures VC experience divided by first and later financing rounds. Periods are specified as follows: "Before Crisis" (Jan 2003 - Sept 2008), "During Crisis" (Oct 2008 - Oct 2009). Differences are analyzed using two-sample t test for equality of means and Mood's median non-parametric test on the equality of medians. Symbols *, ** and *** denote significance level of 10%, 5% and 1%, respectively.

Table 5: Venture capital experience

4.4 Venture capital proximity

Table 6 illustrates the evolution of geographical distance between VC firms and venture-backed companies before and during the financial crisis. Due to the limited computational constraints, proximity here is calculated both as the weighted average distance using all firms in the consortium and as the pair distance between lead investor and company headquarter. However, as it is apparent from the data, both variables are closely related in magnitude and significance. First rounds do not exhibit any particular change over time, but it can be noted as average and median proximity decreases by stages. Companies at early stages are relatively closer to the investor with respect to later ones. Moreover, the difference between average and median distance points out the influence of the outlier observations. Later rounds depict a slightly different situation. Both mean and median differences decreases significantly for later stages companies and concurrently geographical distance rises for seed stage. However, the magnitudes of the mean change are still limited. Collectively, the evidence in support of the geographical proximity hypothesis remains weak, limited to later stages and not conclusive.

5 Discussion

Results presented in Section 4 revisit the empirical nexus between the Global Financial crisis and venture financing. By including stage of development of the funded company in a descriptive and multivariate setting, a longer time span and analyzing several related questions, this paper broadens the scope of previous literature on the topic.

Descriptive analysis shows how the major recession affects venture funding with temporary effects which are later absorbed or reversed during post-crisis period. As highlighted

Variable	First Rounds				Later Rounds			
	Before Crisis	During Crisis			Before Crisis	During Crisis		
	Mean (Median)	Mean (Median)	ΔMean	ΔMedian	Mean (Median)	Mean (Median)	ΔMean	ΔMedian
Company-VC distance	870 (235)	865 (141)	-	***	1,080 (735)	1,005 (591)	***	***
by Stage at financing:								
Seed	780 (93)	729 (56)	-	-	998 (200)	1,008 (538)	-	**
Early Stage	848 (236)	823 (122)	-	**	920 (369)	931 (346)	-	-
Expansion	1,026 (354)	1,072 (282)	-	-	1,073 (711)	1,012 (484)	-	**
Later Stage	915 (387)	1,121 (423)	-	-	1,165 (916)	1,049 (715)	***	***
Lead VC distance	875 (114)	910 (88)	-	-	1,090 (325)	1,004 (203)	***	***
by Stage at financing:								
Seed	789 (34)	686 (31)	-	-	979 (35)	1,048 (403)	-	**
Early Stage	839 (68)	907 (105)	-	-	934 (188)	923 (84)	-	**
Expansion	1,063 (261)	1,106 (282)	-	-	1,084 (327)	1,027 (180)	-	***
Later Stage	906 (320)	1,268 (572)	*	-	1,171 (413)	1,035 (320)	***	**

NOTE: This table measures VC proximity divided by first and later financing rounds. Periods are specified as follows: "Before Crisis" (Jan 2003 - Sept 2008), "During Crisis" (Oct 2008 - Oct 2009). Differences are analyzed using two-sample t test for equality of means and Mood's median non-parametric test on the equality of medians. Symbols *, ** and *** denote significance level of 10%, 5% and 1%, respectively.

Table 6: Venture capital proximity

by Block et al. (2012), total number of deals dramatically drops during the crisis, in particular in first rounds. However, once the effect is measured by stage at financing, as in the present paper, the reduction appears to be concentrated only in later stages, while VCs increased follow-on investments for seed and early stage companies. These conclusions are still valid even considering the amount raised by each deal. In general, companies in their early stages benefited from an investment size premium compared to the previous and following periods, while later stages experienced a significant deduction. Hence, considering only first/later rounds dichotomy is not sufficient to describe the differential impact of the crisis.

The multiplicative regression model suggests that results obtained through a simple linear model which does not control for stage at financing and its interaction terms may be biased. First, the crisis effect is mediated by the adaptation strategies of the VCs, which include targeting younger companies during the financial crisis. Once stage is included, the inflated crisis coefficient reduces its magnitude by more than two times (from 17% to 7%) or turns to be insignificant (in later rounds). Moreover, strong and significant direct effects may be found conditional on company development stage. The analysis finds differential effects by stage. Seed financing benefited from financial crisis, by receiving more funds. Evidence on early stage companies is mixed, varying from a reduction of 16% in first rounds to no significant change in follow-on investments. There is clear evidence of a severe funding gap for expansion and later stages companies, in both first and later rounds. The reduction varies from 20% to 26% for expansion stage and it is between 29% and 30% for later stage companies. The key dividing line appear to be the stage of the financed companies (early/later stages) more than the stage of financing (first/later rounds).

These findings are supportive of the argument related to public market liquidity (Cumming et al., 2005) exposed in Section 2. The risk connected to the stock market crash of 2008-2009 is likely to have modified VCs investment strategies, boosting investments on

early development stage, while reducing their exposure to later stage companies in order to postpone an IPO and avoid a lower valuation at exit. However, demand-side effects have not been introduced in this picture, yet. Entrepreneurs at first financing round may have tried to avoid general low valuations, by postponing their 'pitch decks' to raise money till a future positive outlook, while those in later rounds could not have avoided this deduction. Clearly, we cannot test this hypothesis with a VC commercial database. However, the presence of differential effects even in first round financing is suggestive that the impact of demand-side effects is relatively limited and that the leading mechanism is more related to supply side factors, in particular the end of venture cycle (IPOs and acquisitions).

There are other interesting findings in this paper. First, the paper finds proof in support of the hypothesis that the experienced VCs are indeed the most responsive even to negative market stimuli. There is statistically significant evidence that, during the crisis, experienced (and possibly more successful) venture capitalists reallocated their investments towards seed and early stage companies more than new and relatively inexperienced intermediaries. This argument closely relates to Lerner (1994) and Cumming et al. (2005). Experienced VCs are more in tune with the market, adapting their investment strategy to the external conditions. Second, business angels and government sponsored programs have kept sustaining venture funding during the financial crisis, particularly in first rounds. Business angel share of investments remained constant over the crisis, but decreased in follow-on investments, while the proportional contribution of public VCs substantially increased during the downturn. Lastly, there is not enough evidence in support of the geographical proximity hypothesis. The geographical distance between investors and their investments only partially changed during the financial crisis and this dynamic is limited to later rounds.

6 Conclusion

Venture capital market has been historically highly cyclical and volatile as demonstrated by persisting fluctuations in number of investments and amount raised. The Global Financial crisis shook this industry, coming as an external shock, which obliged intermediaries to adapt and react to the changing environment. This paper aims to revisit the empirical evidence by shedding new light on VCs' behavior during a negative business cycle and measuring the effects in number of investments and funding size.

By using a multiplicative interaction model which controls for development stage of the venture-backed company, this paper concludes that VCs changed investment strategies to boosting the size of investments on early development stages, while reducing their exposure to later stage companies. There is clear evidence of a severe funding gap for

expansion and later stages companies, in both first and later rounds. The reduction in funding size varies from 20% to 26% for expansion stage and from 29% to 30% for later stage companies. There is evidence that shows that most of this response is connected to the behavior of experienced venture capitalists. Collectively, the results reinforce the hypothesis of stage selective investing in order to postpone an IPO, avoiding a lower valuation at exit.

This paper contributes to the current VC discourse by highlighting how VCs reacted during the economic downturn, identifying the companies which "won" or "lost" according to their development stage, and measuring the magnitude of the funding premium or gap. The question whether the highlighted behavior has been profitable for investors is of interest for market experts and scholars, albeit out of the scope of the present paper. However, despite it could constitute a possible topic for future analyses, the evaluation still needs time to pass till the end of the venture cycle, and it requires detailed information on venture investment returns.

Implications on VC-backed companies of the strategy described above are instead of general interests for scholars and policy makers (above and beyond the positive or negative future returns for investors). The existence of a funding gap for later stage companies might have delayed, harmed, or cancelled ongoing positive improvements in innovation and growth. Conversely, the funding size premium towards seed and early stage companies might have accelerated their innovative pattern or just diverged part of the money into bigger offices. Klingler-Vidra (2016), maintaining that the surge of seed funding since the Global Financial crisis provides an increasingly 'patient capital' to VC-backed companies, predicts that long-term value creation will prevail on short-term profits, while limiting the overall short-termism of the capital markets financial system. However, net effects are *ex-ante* unclear. Moreover, this paper accounts for just one dimension of the venture capital selection (the one connected to the stage of the company), while the Global Financial crisis might have impacted also on other dimensions. For example, Pianeselli (2017) carrying out a cohort analysis between 2001 and 2010, finds a strong negative effect on patent innovation for the 2009 funding cohort, even controlling for company stage and investment size. This is indicative of the presence of other selection patterns during the financial crisis, which might have impacted companies' outputs. Even this promising topic may open new avenues for future research.

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Appendix A

Dependent variable: ln(Total Investment - Million of $)						
	First rounds			**Later rounds**		
	(1)	(2)	(3)	(4)	(5)	(6)
Financial crisis (dummy)	-.152***	-.054**	.113**	-.108***	-.011	.168**
	[.028]	[.025]	[.044]	[.020]	[.018]	[.072]
Company age (in years)		.010***	.010***		-.017***	-.016***
		[.004]	[.004]		[.003]	[.003]
Syndication (dummy)		.494***	.492***		.859***	.858***
		[.021]	[.021]		[.020]	[.020]
Business angel (dummy)		-.315***	-.317***		-.056**	-.055**
		[.028]	[.028]		[.026]	[.026]
Government program (dummy)		-.751***	-.741***		-.173***	-.175***
		[.033]	[.033]		[.046]	[.046]
Non-US VC (dummy)		.023	.025		.310***	.310***
		[.051]	[.050]		[.029]	[.029]
Stage at Financing dummies						
Early Stage		.270***	.315***		.288***	.319***
		[.023]	[.026]		[.039]	[.044]
Expansion		.594***	.645***		.607***	.669***
		[.034]	[.036]		[.039]	[.044]
Later Stage		.748***	.834***		.710***	.789***
		[.055]	[.061]		[.043]	[.047]
*Fin.crisis*Early Stage*			-.208***			-.060
			[.056]			[.080]
*Fin.crisis*Expansion*			-.246***			-.180**
			[.081]			[.079]
*Fin.crisis*Later Stage*			-.349***			-.270***
			[.104]			[.078]
VC firm age	.025***	.019***	.019***	.017***	.015***	.015***
	[.001]	[.001]	[.001]	[.001]	[.001]	[.001]
Company-VC distance	.012***	.007***	.007***	.010***	.003***	.003***
	[.001]	[.001]	[.001]	[.001]	[.001]	[.001]
Industry effects	YES	YES	YES	YES	YES	YES
Region effects	YES	YES	YES	YES	YES	YES
Constant	1.234***	.849***	.809***	1.863***	.712***	.646***
	[.043]	[.043]	[.044]	[.039]	[.048]	[.052]
R-squared	.126	.337	.340	.099	.272	.273
Adj R-squared	.124	.335	.337	.098	.270	.272
P-value	<.001	<.001	<.001	<.001	<.001	<.001
Observations	6,012	6,012	6,012	15,680	15,680	15,680

NOTE: Crisis period is specified as May 2008 - Oct 2009. Standard errors are robust and clustered at company level for later rounds. Symbols *, ** and *** denote significance level of 10%, 5% and 1%, respectively.

Table A1: Multiplicative interaction model for VC funding