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Essays in venture capital finance

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John Howard LEWIS

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Composition du jury :

Edith GINGLINGER
Professeur, Université Paris Dauphine - PSL
Président

David ROBINSON
Professeur, Duke University
Rapporteur

Ludovic PHALIPPOU
Professeur, Oxford University
Rapporteur

Jose Miguel GASPAR
Professeur, ESSEC
Examinateur

Armin SCHWIENBACHER
Professeur de finance, SKEMA et Université Lille 2
Examinateur

Gilles CHEMLA
Directeur de recherches, CNRS, Université Paris Dauphine - PSL et Professeur, Imperial College Business School
Directeur de thèse

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Chapter 1

Introduction

1.1 L'industrie du capital risque

Le capital risque est une importante source de financement dans le processus de création des grandes entreprises côtées et de l'activité économique associée. Plus de 20% de la capitalisation des entreprises côtées en Bourse aux Etat-Unis provient de fonds spécialisés en capital risque. Ces fonds sont également responsables de 44% des dépenses en recherche et développement des entreprises côtées aux Etat-Unis (Gornall & Strebulaev, 2015). Les fonds de capital risque ont créé entre 5 et 7% des emplois (Puri & Zarutskie, 2012). De plus, les start-up financées par du capital-risque représentent 35% des introductions en Bourse (Da Rin, Hellmann, & Puri, 2013). Sans l'aide du capital risque, les nouvelles entreprises rencontreraient des difficultés pour se financer auprès des acteurs traditionnels comme les banques ou les marchés de capitaux.

Les sociétés de capital-risque sont des structures uniques organisées dans le but de fournir du capital risqué à forte rentabilité. Ces firmes investissent dans des entreprises qui n'ont pas encore une direction expérimentée, un marché ou un produit existant. De ce fait, la structure de l'industrie du capital risque et les instruments de financement utilisés sont adaptés à ces profils d'entreprises à risque élevé.

L'industrie du capital-risque est organisée en grande majorité en fonds de société en commandite. Les associés de chaque fonds fournissent des capitaux à responsabilité limitée et n'ont pas de responsabilités opérationnelles. La direction opérationnelle gère le fond ainsi que le processus d'investissement, et engage une responsabilité personnelle plus importante. La direction du fonds de capital risque travaille avec les entreprises faisant partie du portefeuille du fonds et reçoit un paiement de la part des associés du fonds pour leur travail (Sahlman, 1990).

Les fonds de capital risque se spécialisent dans le financement des entreprises en phase de démarrage. Ces entreprises sont généralement innovantes et ont une espérance de rentabilité élevée au moment de l'investissement. Toutefois, la majorité des investissements échouent. De ce fait, la direction du fonds de capital risque se concentre sur le financement d'entreprises pour lesquelles la sortie à fort taux de rendement à un horizon de 3 à 7 ans est possible (Sahlman, 1990; Puri & Zarutskie, 2012).

Les sociétés de capital risque recherchent typiquement à avoir un taux interne de rendement (TIR) positif. La direction du fonds reçoit généralement 1 à 2.5% du montant total de capital sous gestion en commissions et 20% des profits dépassant un seuil contractuellement fixé (Phalippou & Gottschalg, 2009). Un fonds de capital risque a en général une durée de vie comprise entre 5 et 10 ans avant que les revenus générés soient distribués aux associés du fond (Sahlman, 1990). La plupart des fonds sous gestion sont investis durant les trois premières années de vie du fonds

(Zarutskie, 2007).

Les capital-risqueurs à succès affirment souvent que les critères d'investissement des fonds de capital risque se basent sur une analyse de l'équipe ayant fondé l'entreprise et sur la taille du marché visé (T. F. Hellmann & Puri, 2000).

L'entreprise recevant un financement provenant d'un fonds de capital risque est examinée selon un processus propre à chaque fonds dans le but d'analyser l'équipe dirigeante, le marché visé, le produit conçu ainsi que les risques spécifiques à l'entreprise financée (Gorman & Sahlman, 1989; MacMillan, Siegel, & Narasimha, 1985). L'investissement a pour objectif d'accélérer le processus de croissance de la firme et, in fine, d'avancer la date de sortie du fonds en capital-risque. Au fil des tours de financement et à mesure que des investisseurs sont ajoutés, le fonds de capital risque est de moins en moins enclin à mettre fin au projet (Wiltbank, Dew, & Read, 2015).

Les informations sur les potentiels investissements sont suivis par les associés et les gérants du fonds de capital risque. Les sociétés de capital risque ne financent généralement pas la totalité du projet. Ils travaillent généralement avec un syndicat de co-investisseurs associés à d'autres fonds de capital risque pour financer le projet. Le syndicat de fonds recueille ensuite le maximum de données sur les entreprises financées afin d'éclairer le processus décisionnel lors du premier tour de financement ainsi que pour les suivants. De nombreux fonds de capital risque ont une base de données, propriétaire ou commerciale, répertoriant les actions des autres fonds de capital et leurs estimations de la valeur des entreprises qu'ils financent.

Lors du processus de syndication, les fonds de capital risque sont capables d'avoir une image claire des entreprises dans lesquelles les autres fonds de capital risque ont investi en analysant les résultats des investissements leur ayant été présenté. Généralement, un investisseur invité à joindre un syndicat reçoit des informations concernant les membres du syndicat. Même si un fonds de capital risque ne rejoint pas le syndicat, il peut avoir accès aux annonces relatives aux investissements du syndicat. Un fonds de capital risque peut juger de la qualité d'un autre fonds de capital risque en analysant leurs efforts de suivi (Hopp & Rieder, 2011).

Les sociétés de capital risque ont des orientations et charactéristiques différentes que celles des société de capital investissement et des entreprises côtées en Bourse (Boone & Mulherin, 2011). Les fonds de capital risque se concentrent en effet sur le financement des entreprises privées. Le syndicat d'investissement permet des transferts d'information concernant les entreprises financées entre les fonds du syndicat (Casamatta & Haritchabalet, 2007). L'interaction entre les fonds durant le processus de création du syndicat d'investissement (Lerner, 1994) crée potentiellement des biais comportementaux.

Puisque la plupart des fonds investissent la totalité du capital sous gestion durant

la troisième année de vie du fonds, le capital risqueur connaît une période de forte activité suivie par une activité de surveillance des entreprises financées. Durant la période de surveillance (de la troisième à la dixième année de vie du fonds), le capital-risqueur crée généralement un nouveau fonds afin de pouvoir réaliser de nouveaux investissements. Ainsi, le capital-risqueur lève des fonds régulièrement. Un taux de rendement interne positif pour le fonds existant du capital-risqueur renvoie un signal positif et l'aide à lever du capital pour son nouveau fonds de capital risque (Kuckertz, Kollmann, Röhm, & Middelberg, 2015).

Après qu'un fonds de capital risque cible une entreprise innovante, le fonds utilise divers instruments financiers afin d'assurer le financement des entreprises composant son portefeuille. Ces instruments comprennent notamment différents instruments de dette et de capital tels que les actions ordinaires, les actions privilégiées, la dette senior, convertible et autres instruments hybrides (P. A. Gompers, 1999; Marx, 1998). Ces instruments de financement peuvent être complexes et difficiles à comprendre par l'entrepreneur sans expérience ou dépourvu de conseil. La complexité des contrats a évolué de façon à limiter les risques des nouvelles technologies, des marchés non développés et des équipes de direction non expérimentées, ce qui est propre à l'investissement en capital risque (Chemla, Habib, & Ljungqvist, 2007).

Le montant de financement intégral n'est pas procuré en un seul transfert par le fonds. Le capital risqueur investit en plusieurs étapes. A chaque étape, l'entreprise de capital risque réévalue la firme et décide de continuer à y investir ou de réduire ses pertes (Kaplan & Strömberg, 2004; Sahlman, 1990). Le financement par étape est également utilisé pour s'assurer que l'entrepreneur fournit de l'effort et n'utilise pas des techniques d'habillage de comptes (Cornelli & Yosha, 2003). Krohmer, Lauterbach, and Calanog (2009) étudient le calendrier des différentes étapes et suggèrent que le recours au financement par étape au début de l'investissement augmente les chances de succès relativement à un recours plus tardif.

Les contrats ont évolué afin de gérer les risques et les problèmes liés au financement par le capital risque et cela peut être une source de frictions entre le capital risqueur et l'entrepreneur dès lors que l'entrepreneur découvre la signification et les effets des différentes variétés de clauses présentes dans les contrats. Tant les frictions que la complexité peuvent réduire la création de valeur des entreprises financées par le capital risque lorsque l'entrepreneur ou le capital risqueur abandonne le projet ou réduit ses efforts.

Etant donné que le capital risqueur travaille sur des horizons de long terme avec des informations intangibles, il pourrait y avoir une plus grande marge de manoeuvre pour réagir aux investissements dans le cadre de la finance comportementale. Collecter les fonds et trouver des bonnes entreprises nécessite une solide réputation sur le marché vis a vis des investisseurs et des entrepreneurs.

1.2 Thesis overview

Un des volets de la littérature sur le capital risque s'intéresse aux contrats (Admati & Pfleiderer, 1994; Chemla et al., 2007; Kaplan & Strömberg, 2004). Ces articles de recherche se concentrent notamment sur la structure du contrat entre le capital risqueur et l'entrepreneur. Les différentes clauses sont mises en place dans le but de maximiser la rentabilité du capital risqueur et d'inciter l'entrepreneur a fournir l'effort approprié. La recherche s'est essentiellement focalisée sur les clauses qui protègent l'entreprise de capital risque de résultats défavorables (clauses de liquidité préférentielle, de ratchets, de droits au prorata, d'obligation de sortie conjointe, de sortie forcée etc...). Toutefois, la littérature ne fait pas référence à la façon dont l'optimisation des contrats, en faveur du capital risqueur, pourrait réduire la rentabilité effective de la société de capital risque.

Dans le premier chapitre, nous avons créé, avec mes coauteurs Maija Halonen-Akatwijuka et Richard Fairchild, un modèle théorique de contrats comme points de références. Nous y avons discuté le cas où il pourrait être avantageux pour l'entreprise de capital risque de rendre une partie du surplus à l'entrepreneur. Le modèle suggère au capital risqueur d'accorder à l'entrepreneur un surplus afin de créer une meilleure relation. Malgré un pouvoir de négociation ex-ante, le capital risqueur n'est pas tenu de faire cela. Néanmoins, cela éviterait une dégradation de la relation ainsi que la réalisation d'une perte sèche.

Les travaux de Hart and Moore (2008) et Hart (2009) sur les contrats constituent le point de départ de ce modèle. Nous avons appliqué leurs idées aux contrats de capital risque en considérant qu'un surplus additionnel pourrait être favorable au capital risqueur dans le cas où la rentabilité espérée du projet deviendrait inférieure à sa valeur initiale espérée. Avec le surplus additionnel, l'entrepreneur a une incitation à exercer un effort et maximiser la potentielle valeur de sortie. Sans ce surplus, il pourrait abandonner le projet et créer une perte sèche.

La plupart des capital risqueurs soutiennent que leurs principaux critères d'investissement sont l'équipe de direction de l'entreprise et la taille du marché (T. F. Hellmann & Puri, 2000). Cependant, Bill Gross, un célèbre et brillant capital risqueur, a avancé que le timing avait été le facteur le plus important de ses deux décennies d'investissement. A partir des données de Thomson One Banker, il a été possible de représenter graphiquement les pics de l'activité d'investissement au cours du temps.

En partant de cette observation, nous avons examiné avec mon coauteur Caroline Genc, les vagues d'investissement dans le capital risque. Nous nous sommes appuyés sur la méthodologie utilisée pour les vagues de fusion-acquisition afin d'identifier les vagues d'investissement de capital risque. Après avoir mis en évidence ces vagues, nous avons construit le réseau social des syndicats d'investissement afin de déter-

miner si le réseau et le timing de l'investissement avaient des effets sur la performance de l'investissement.

Un autre sujet qui a retenu l'attention de la littérature est le financement et le financement par étape notamment. A ma connaissance, la littérature ne discute pas des investissements de court-terme et des crédits relais ("bridges loans"). Il s'agit d'investissements temporaires et de court terme mis en place jusqu'à l'obtention d'un financement permanent. Les prêts relais représentent un peu plus de 10 % de l'ensemble des investissements de la base de données Thomson One Banker, avec pour la plupart une durée supérieure à 6 mois.

Les capital risqueurs ont commencé à attirer l'attention sur l'utilisation de ces prêts relais dans l'industrie (Muse, 2016; Suster, 2010; F. Wilson, 2011). Leur analyse a conclu que le recours aux prêts relais n'était pas une évolution positive pour l'industrie. Leurs commentaires ainsi que le nombre de crédit relais enregistré dans la base de données ont servi de catalyseur pour le dernier chapitre sur les bridges loans. Plus particulièrement, ces prêts ont été étudiés au niveau des investissements et des fonds.

A l'échelle des investissements, c'est le taux de réussite des entreprises ayant reçu un prêt relais qui a été analysé. L'effet sur le succès des sorties, a également été examiné en s'appuyant sur le timing de tous les investissements et sur le timing des crédits relais pendant la durée de vie du fond de capital risque. Enfin, l'effet des prêts relais sur la capacité des entreprises de capital risque à lever d'autres fonds a été exploré.

1.3 The venture capital industry

Venture capital is an important source of financing for the creation of large public companies and the associated economic activity. Over 20 percent of the market capitalization of publicly listed companies in the United States received their initial financing through venture capital. These companies also accounted for 44 percent of the research and development expenditures by exchange traded firms (Gornall & Strebulaev, 2015). Venture companies created between 5 and 7 percent of new jobs (Puri & Zarutskie, 2012). Finally, startups financed with venture capital were 35 percent of Initial Public Offerings (IPO) (Da Rin et al., 2013). Even with these measures of economic activity, as startups the new firms would have difficulty raising funds from traditional sources of finance such as banks or the public markets.

Venture capital firms are unique structures organized to provide high-risk and high return investment capital. VC Firms will invest in companies which did not have a proven market, product or experienced management team. As such, the industry structure and financing instruments are specialized to this risk profile.

The venture capital industry is organized, for the most part, as limited partnership funds. The limited partners provide capital with limited liability and no management responsibilities. The managing partners manage the fund, accept a higher level of liability, manage the investment process, work with the portfolio companies and receive payment for their work on behalf of the limited partners (Sahlman, 1990).

The funds are focused on financing early stage companies. Typically these companies are innovative and had a high expected return at the time of investment. However, the majority of the investments do not succeed. Therefore, managing partners focus on financing companies which can exit with a high internal rate of return for the investment horizon of 3 to 7 years (Sahlman, 1990; Puri & Zarutskie, 2012).

Venture firms are typically focused on a positive Internal Rate of Return (IRR) for the fund. The managing partner is usually paid a 1% to 2.5% fee on funds under management and 20% of the profits above a hurdle rate (Phalippou & Gottschalg, 2009). A typical venture fund had a life of between 5 and 10 years before the proceeds are distributed to the limited partners (Sahlman, 1990). Most of the fund was invested in the first 3 years (Zarutskie, 2007).

The criteria for venture capital investments are often stated to be, by successful venture capitalists, an analysis of the founding team and the size of the market for the products of the funded company (T. F. Hellmann & Puri, 2000). The venture investment process was focused on analysis of these two factors.

The company which receives investment from the venture firm was vetted using a process, individual to each venture firm, which examines the entrepreneurial team, the market, product, risks and other factors (Gorman & Sahlman, 1989; MacMillan et al., 1985). The investment was intended to speed up the process of exiting the company at the terminal value determined during the due diligence and analysis of the company. As a venture firm invests in more rounds, and additional investors are added, the venture capitalists are less likely to terminate a project (Wiltbank et al., 2015).

Information on investment candidates was tracked by partners and associates. Venture firms do not usually finance the entire deal and work with a number of co-investors to syndicate the financing across several venture firms. The syndication efforts, personal introductions, databases queries, newsletters and press releases are used to build an information set on target companies. This information was used to make investment decisions in the first and subsequent investment rounds. Many venture firms had a database of the actions by their peers and relative valuations of companies or they subscribe to commercial databases with this information.

During the syndication process, venture firms are able to get a clear picture of

the companies other venture capitalists are actively investing by following the results of deals they were presented. Typically, a firm receives the basic information and an idea of the existing members in the syndicate when they are invited to participate. Even if a firm did not join the syndicate, they will be able to follow the results through announcements of the investment. An investment firm was able to gauge the quality and type of another firm that did invest in the company through their tracking efforts (Hopp & Rieder, 2011).

Venture investments have different guidelines and characteristics than private equity and public companies (Boone & Mulherin, 2011). Venture fund firms focus on private companies. This permits information transfer between cooperating investment firms as they build syndicates to make an investment (Casamatta & Haritchabalet, 2007). The interaction of the firms, as they build syndicates (Lerner, 1994), provides an opportunity for the propagation of behavioral factors. Venture firms learn about industries and companies that are receiving increased attention as other venture firms present companies for co-investment.

Since most funds fully invest their capital in the first third of the life of a fund, the venture capitalist had a period of high activity followed by monitoring companies for their exit. During the monitoring period of the fund (the latter half to two thirds) the venture capitalists must create another fund to support their structure through new investments. The venture capitalist has the perennial task of raising additional funds every few years. A positive IRR for their existing fund was beneficial to the venture capitalists as they raise capital for follow on funds (Kuckertz et al., 2015).

After a VC firm locates an innovative company, they use a variety of financial instruments to finance companies in their portfolio of investments. These instruments include different debt and equity instruments such as common equity, preferred equity, senior debt, convertible debt and other hybrids (P. A. Gompers, 1999; Marx, 1998). The investment instruments can be complex and difficult for an entrepreneur to understand without experience or specialized guidance. The complexity of the contracts evolved to limit the risks from new technologies, undeveloped markets and inexperienced management, which was inherent in venture funding (Chemla et al., 2007).

The full financing amount was not provided as one transfer of funds. The venture capitalist invests in stages. At each stage the VC firm can re-evaluate the company and decide to continue financing the venture or cut their losses (Kaplan & Strömberg, 2004; Sahlman, 1990). Staging was also used to ensure that the entrepreneur expends effort and was not window-dressing (Cornelli & Yosha, 2003). Krohmer et al. (2009) considered the timing of staging and suggested that staging at the beginning of the investment provided a greater chance for a successful exit rather than staging later in the investment.

The contracts evolved to handle the risks and problems with venture financing and may be a source of friction between the venture capitalist and the entrepreneur as the entrepreneur discovers the meaning and effects of the various contract clauses. Both the friction and the complexity may reduce the value-creating ability of venture capital backed firms as entrepreneur or venture capitalist abandon the project or apply less effort.

Since the venture capitalist works on long time horizons, with intangible information, there might be larger scope to react to investment under behavioral finance. Gathering funds and finding good companies requires a solid reputation in the market with both limited partners and entrepreneurs.

1.4 Thesis overview

One strand of the venture capital literature was concerned with the contracting of venture capital deals (Admati & Pfleiderer, 1994; Chemla et al., 2007; Kaplan & Strömberg, 2004). These research papers are concerned with the structure of the contract between the VC and the entrepreneur. The different clauses are analyzed with respect to maximizing the return for the VC and ensuring that the entrepreneur applied adequate effort. The research was predominantly for clauses which protected the VC firm from adverse outcomes (liquidity preferences, ratchets, puts, pro-rata rights, drag-along, tag-along, etc). The literature did not mention how the optimization of the contracts, in favor of the VC, may reduce the actual return the VC firms receive.

In the first essay, a theoretical model for contracts as reference points was created with my coauthors Maija Halonen-Akatwijuka and Richard Fairchild, we discussed the case where it might be advantageous for the VC Firm to give back some of the surplus to the entrepreneur. The model proposed that the venture capitalist grant some surplus to the entrepreneur in order to create a smoother relationship. The VC was not required to do so even though they had ex-ante bargaining power. This would avoid a souring of the relationship and a dead weight loss.

The starting point for this model was the work by Hart and Moore (2008) and Hart (2009) in their work on general contracts. We applied these ideas to the case of venture contracting where the additional surplus would benefit the venture capitalist if the expected return of the project dropped below the initial expected value. With the extra surplus, the entrepreneur had an incentive to exert effort and maximize the possible exit value. If the entrepreneur did not have this surplus, they might leave the project and create a dead loss.

Most venture capitalists state that their investment criteria are the company management team and the market size (T. F. Hellmann & Puri, 2000). However,

a well know and successful VC, Bill Gross, had stated that timing was the most important factor in his two decades of investing (Gross, 2015). From the data in Thomson One Banker, it was possible to graph spikes in investment activity over time.

Using this starting point, my coauthor, Caroline Genc, and I examined investment waves in venture capital. We used the methods for merger and acquisition waves to compute venture capital investments waves. After calculating the waves, we computed the social network for the investment syndicates to determine if there was an effect on the investment performance from the network and timing of the investment.

Another topic which had attention in the literature was financing and staging. As far as I know, there the literature did not discuss short-term investing and bridge loans. These are usually short-term and temporary investments until a permanent financing round can be completed. The number and duration of bridge loans in the Thomson One Banker database was just over 10% of all investment transactions and most were longer than 6-months in duration.

The venture capitalists raised the attention of the use of bridge loans in the industry (Muse, 2016; Suster, 2010; F. Wilson, 2011). Their analysis concluded that the use of bridge loans was not a positive development for the industry. From their comments, and the number of bridge loans recorded in the data base, this provided the catalyst for the final essay on bridge loans. In particular, the loans were examined at the deal and fund level.

At the deal level, the success rate for companies which received bridge loans was analyzed. The effect on successful exits based on the timing of all investments and the timing of bridge loans, within the life of the VC fund, was also examined. Finally, the effect of bridge loans on the ability of VC firms to raise follow-on funds was explored.

Chapter 2

Contracts as reference points in venture capital

joint work with Richard Fairchild, University of Bath
Maija Halonen-Akatwijuk, University of Bristol

Abstract : We apply contracts as reference points (Hart and Moore (2008) and Hart (2009)), to venture capital. We find that the venture capitalist, VC, chooses to leave some surplus above reservation utility for the entrepreneur, E, even when they have all ex ante bargaining power, to guarantee a smoother ex post relationship. However, renegotiation can occur in equilibrium leading to souring of the relationship and deadweight losses. Therefore not all profitable projects can be funded. VC benefits from costlier renegotiation as E will accept a lower equity share without triggering renegotiation. Under some parameter values even E can benefit from costlier renegotiation if it pushes VC to offer high equity share to E in order to avoid triggering renegotiation.

2.1 Introduction

Venture capitalists provide an important source of finance for new firms, who often have difficulty obtaining funds through traditional channels, such as banks or the general public. Hence, the venture capital sector has the potential to be a source of considerable economic growth and wealth-creation. However, the value-creating ability of venture-capital-backed firms may be adversely affected by the complex relationships that exist between venture capitalists and entrepreneurs. Hence, venture capitalists and entrepreneurs have developed sophisticated contracts that attempt to overcome these problems (Klausner & Litvak, 2001; Kaplan & Strömberg, 2003; Tykvová, 2007). In this paper we take the novel approach of contracts as reference points, as developed by Hart and Moore (2008) and Hart (2009), and apply it to venture capital. To our knowledge this is the first application of contracts as reference points to financial contracting.

The contract VC and E write forms expectations what each party is entitled to. If the party receives what they are entitled to under the original contract, they feel well treated. But if the other party forces renegotiation, the relationship sours and leads to ex post holdup. Despite the deadweight losses caused by holdup, a party may initiate renegotiation when they are in a strong bargaining position. We show that even when VC has all the ex ante bargaining power they choose to make an equity share offer that leaves some surplus to E above their reservation utility to ensure a smoother ex post relationship. Despite this, renegotiation can still occur in equilibrium reducing the surplus left for VC even further. Therefore VC's funding decision is inefficient.

We furthermore show that VC benefits from costlier renegotiation. Greater holdup benefits VC because E accepts a lower equity offer without challenging it. On the other hand greater holdup reduces surplus when renegotiation does occur. The positive effect is dominant because renegotiation occurs in equilibrium with probability less than half. E's payoff, on the other hand, broadly decreases in renegotiation costs since he has to accept a lower equity offer. However, under some parameter values it is possible that also E benefits from costlier renegotiation if it pushes VC to make a high equity offer to avoid renegotiation all together.

Indexing may help to eliminate inefficient renegotiation but E still receives surplus above their reservation utility and therefore the funding decision remains inefficient.

Kaplan and Strömberg (2003) analyze real-world venture capital contracts, relating their features to venture capital theory. They find that these contracts address agency problems, asymmetric information and the problems of incomplete contracts by separately allocating cash flow rights and control rights to VCs and Es. Further-

more, these rights are often contingent on observable performance measures. Consistent with Aghion and Bolton (1992) and Dewatripont and Tirole (1994), Kaplan and Strömberg (2003) suggests that control shifts between the E and the VC in different states. Furthermore, and particularly relevant to our model, Kaplan and Strömberg (2003) find that VCs include contractual devices, such as noncompete and vesting provisions, to mitigate the hold-up problem.

This paper proceeds as follows: The literature review is in section 2.2. Section 2.3 is a description of the model. In section 2.3.2, the model is modified for renegotiation. Section 2.4 is a discussion of the optimal contract and different cases. Extensions to the model are discussed in section 2.5. Section 2.6 concludes.

2.2 Related literature

Incentive problems may exist at all stages of the relationship. Double-sided effort-shirking at the initial venture-creation stage has been analyzed (Casamatta, 2003; Repullo & Suarez, 2004; Fairchild, 2004; Keuschnigg & Nielsen, 2004; T. Hellmann, 2006; De Bettignies & Brander, 2007; De Bettignies & Chemla, 2008), as well as hold-up/renegotiation problems as the venture nears IPO (Cestone, 2014; Bigus, 2006; Landier, 2001; Chemla et al., 2007; Ueda, 2004; Yerramilli, 2004; De Bettignies, 2008). Some of these papers have analyzed the use of control to mitigate these problems. Closer to our analysis, Chemla et al. (2007) analyze whether the negotiated cash flow rights (in the form of equity, options, drag-along and tag-along rights) can mitigate ex post hold-up/renegotiation problems.

More recently, it has been recognized that venture-backed performance may also be affected by behavioral and emotional factors. The performance of venture capitalist/entrepreneur dyads may be affected (positively or negatively) by reciprocal feelings of fairness, trust, empathy and spite ((Busenitz, Moesel, Fiet, & Barney, 1997; Cable & Shane, 1997; Sapienza & Korsgaard, 1996; De Clercq & Sapienza, 2001; Shepherd & Zacharakis, 2001; Utset, 2002)).

Kaplan and Strömberg (2004) analyse real-world venture capital contracts, relating their features to venture capital theory. They find that these contracts address agency problems, asymmetric information and the problems of incomplete contracts by separately allocating cash flow rights and control rights to VCs and Es. Furthermore, these rights are often contingent on observable performance measures. Consistent with Aghion and Bolton (1992) and Dewatripont and Tirole (1994), Kaplan and Strömberg (2004)'s analysis suggests that control shifts between the E and the VC in different states. Furthermore, and particularly relevant to our model, Kaplan and Strömberg (2004) find that VCs include contractual devices, such as non-compete and vesting provisions, to mitigate the hold-up problem. De Bettignies and Chemla

(2008) considered the value of the outside option with the difference that they were concerned with star managers and not a model for all entrepreneurs.

2.3 The model

Consider an entrepreneur, E, who has an idea for an innovative start-up project, requiring investment funds $I > 0$. E lacks personal finance, and so approaches a venture capitalist, VC, for the required funds. VC has all the bargaining power ex ante and makes a take-it-or-leave-it offer on equity share α subject to E receiving their reservation utility $\overline{u}$. However, at some stage in the venture's development, the parties can threaten to holdup each other, possibly forcing renegotiation of the terms of the contract.

We take the view, developed by Hart and Moore (2008) and Hart (2009), that the original contract forms a reference point. The contract forms the expectations what each party is entitled. If the party receives what he is entitled to under the original contract, they feel well treated. But if the other party forces renegotiation, the relationship sours. As a consequence the parties withhold non-contractible helpful actions.

For the full project returns to be realized, each party must take helpful actions ex post. Helpful actions are too complex to be described in ex ante contract but ex post some helpful actions become contractible. If all helpful actions are taken, project value is R_H with probability p or R_L with probability $(1-p)$ where $R_L < R_H$ and $R = pR_H + (1-p)\,R_L$. If only contractible actions are taken, project value is $(1-\lambda)\,R_i$ for $i = L, H$. Withdrawal of noncontractible helpful actions leads to a loss of surplus equal to λR_i. Suppose the project value is close to $-\infty$ if no helpful actions are taken.

Agent is willing to be helpful if they feel well treated, that is, if they get the equity share under the original contract. Renegotiation leads to cold but correct relationship. Only contractible helpful actions are taken.

Staged financing and planned renegotiation are common in financial contracts between VC and E. In such a situation renegotiation creates a win-win and is friendly. Our focus is not on such renegotiation. We focus on unplanned renegotiation which may be framed in terms of raising funding but is triggered by high relative outside option of one party. Such renegotiation is unfriendly and leads to souring of the relationship.

Outside options at the time of potential renegotiation are assumed to be $r_E R_i$ for E and $r_{VC} R_i$ for VC where $0 \leq r_i \leq 1$ for $i = E, VC$. Consider a binary case where the outside options are $\underline{r}_{VC} > \underline{r}_E > 0$ with probability q and $\overline{r}_{VC} = \overline{r}_E > 0$ with probability $(1-q)$. Denote $\Delta r = (\underline{r}_{VC} - \underline{r}_E)$. We have two states: one where

VC is strong and second where the outside options are balanced. It is reasonable to assume that E is never in a stronger ex post bargaining position relative to VC.

Both VC and E are risk neutral and E is wealth-constrained. There is symmetric information.

We furthermore make the following assumptions.

Assumption 1. (i) $R > I + \overline{u}$. (ii) $(1-\lambda) > \max\left[\underline{r}_{VC} + \underline{r}_E, \overline{r}_{VC} + \overline{r}_E\right]$. (iii) $\overline{u} < \frac{1}{2}\left[(1-\lambda) - q\Delta r\right] R$

Assumption 1(i) guarantees that it is efficient to fund the project. According to (ii) it is not efficient for the agents to separate even under holdup. In (iii) we assume that E's reservation utility is limited but we will relax this assumption in Section 4.2.

The timeline is as follows.

Date 0. VC makes a take-it-or-leave-it offer of equity allocation $(\alpha, 1-\alpha)$ for E and VC respectively.

Date 1^-. State of the world (project returns and outside options) is realized. Date 0 contract may be renegotiated.

Date 1. Helpful actions are taken. The project is completed and the payoffs are realized.

2.3.1 No renegotiation

If the parties stick to the original contract, each party feels well treated and is willing to be helpful. The payoffs are then

$$U_E = \alpha R_i \tag{2.1}$$

$$U_{VC} = (1-\alpha) R_i \tag{2.2}$$

2.3.2 Renegotiation

Initiating renegotiation sours the relationship and the parties withhold noncontractible help. Parties have a cold and correct relationship yielding surplus $(1-\lambda) R_i$. Payoffs are determined by Nash bargaining.

$$\begin{aligned} U_E &= r_E R_i + \frac{1}{2}\left[(1-\lambda) - r_E - r_{VC}\right] R_i \\ &= \frac{1}{2}\left[(1-\lambda) + r_E - r_{VC}\right] R_i \end{aligned} \tag{2.3}$$

$$U_{VC} = \frac{1}{2}\left[(1-\lambda) - r_E + r_{VC}\right] R_i \tag{2.4}$$

E will not initiate renegotiation if and only if their payoff according to the original contract (2.1) is larger than what they can obtain by renegotiating (2.3).

$$\alpha \geq \frac{1}{2}\left[(1-\lambda) + r_E - r_{VC}\right] \equiv \alpha_L \tag{2.5}$$

Similarly, VC will not initiate renegotiation if and only if their payoff in (2.2) is greater than in (2.4).

$$(1-\alpha) \geq \frac{1}{2}\left[(1-\lambda) - r_E + r_{VC}\right]$$

$$\Leftrightarrow \alpha \leq \frac{1}{2}\left[(1+\lambda) + r_E - r_{VC}\right] \equiv \alpha_H \tag{2.6}$$

Therefore renegotiation and holdup can be avoided if and only if

$$\alpha_L \leq \alpha \leq \alpha_H \tag{2.7}$$

We refer to (2.7) as a self-enforcing range. To avoid holdup VC has to choose α at date 0 contract so that it falls in the self-enforcing range. The difficulty is that α_L and α_H are random variables realized at date 1^-. Furthermore, VC's main interest is not in avoiding the holdup but in maximizing their own expected payoff. Therefore VC aims to minimize α but they have to take into account that too low α may trigger holdup ex post.

Using equations (2.5) and (2.6) we can work out the self-enforcing range in each state.

$$\underline{\alpha}_L = \frac{1}{2}\left[(1-\lambda) - \Delta r\right] \tag{2.8}$$

$$\underline{\alpha}_H = \frac{1}{2}\left[(1+\lambda) - \Delta r\right] \tag{2.9}$$

$$\overline{\alpha}_L = \frac{1}{2}(1-\lambda) \tag{2.10}$$

$$\overline{\alpha}_H = \frac{1}{2}(1+\lambda) \tag{2.11}$$

Clearly $\underline{\alpha}_L < \underline{\alpha}_H$ and $\overline{\alpha}_L < \overline{\alpha}_H$. Since renegotiation causes deadweight losses, there is a range where renegotiation does not occur. Renegotiation is initiated only if one agent is in a sufficiently stronger bargaining position relative to the original agreement. Furthermore, $\underline{\alpha}_L < \overline{\alpha}_L$ and $\underline{\alpha}_H < \overline{\alpha}_H$. When VC is in a stronger bargaining position, E accepts a lower α and VC is willing to give a lower α to E.

The ranking that remains open is $\underline{\alpha}_H$ vs. $\overline{\alpha}_L$. If $\underline{\alpha}_H < \overline{\alpha}_L$, the self-enforcing

ranges are disconnected: $\underline{\alpha}_L < \underline{\alpha}_H < \overline{\alpha}_L < \overline{\alpha}_H$. α that falls within the self-enforcing range in one state is outside of it in the other state. While if $\overline{\alpha}_L \leq \underline{\alpha}_H$, the self-enforcing ranges are overlapping: $\underline{\alpha}_L < \overline{\alpha}_L \leq \underline{\alpha}_H < \overline{\alpha}_H$. Then it is possible to find α that is within the self-enforcing range in both states. Comparison of (2.9) and (2.10) shows that the self-enforcing ranges are overlapping if and only if

$$\lambda \geq \frac{1}{2}\Delta r.$$

$\overline{\alpha}_L$ is decreasing in λ since the worse is the holdup, the lower α E will accept. While $\underline{\alpha}_H$ is increasing in λ because the worse is the holdup, the higher share VC is willing to give away. Therefore for high enough λ we have $\overline{\alpha}_L \leq \underline{\alpha}_H$.

2.4 Optimal contract

2.4.1 Overlapping self-enforcing ranges

We start the analysis from the case of overlapping self-enforcing ranges as demonstrated in Figure 2.1. VC aims to minimize their offer of equity share to E but has to take into account potential ex post holdup.

If VC makes a high offer $\overline{\alpha}_L$, there is no renegotiation in either state as $\overline{\alpha}_L$ falls within the self-enforcing range in both states. VC's expected payoff is then

$$U_{VC}^1 = (1 - \overline{\alpha}_L) R \tag{2.12}$$

where superscript 1 denotes no renegotiation. It is never optimal to offer $\alpha > \overline{\alpha}_L$ since $\alpha = \overline{\alpha}_L$ is enough to avoid holdup in both states and higher α would simply give more surplus to E.

Alternatively VC can make a low offer $\underline{\alpha}_L$. By this offer VC can avoid holdup in the state where they are strong. But E will renegotiate in the state where the outside options are balanced (with probability $(1 - q)$). By renegotiating E gets half of the surplus but due to holdup the surplus drops to $(1 - \lambda) R$. VC's expected payoff is then

$$U_{VC}^2 = q (1 - \underline{\alpha}_L) R + (1 - q) \frac{1}{2} (1 - \lambda) R \tag{2.13}$$

where superscript 2 denotes E renegotiation. VC would never make an offer below $\underline{\alpha}_L$ because it would be renegotiated in every state leading to deadweight losses. Furthermore, any offer $\underline{\alpha}_L < \alpha < \overline{\alpha}_L$ is strictly dominated by $\alpha = \underline{\alpha}_L$. Offering more than is strictly required in the state where VC is strong would simply give surplus away to E as the offer is not high enough to avoid renegotiation in the

balanced state. Therefore VC's optimal offer is either $\overline{\alpha}_L$ or $\underline{\alpha}_L$.

VC makes the high offer $\overline{\alpha}_L$ if and only if it maximizes his expected payoff.

$$(1-\overline{\alpha}_L)\,R \geq q\,(1-\underline{\alpha}_L)\,R + (1-q)\,\frac{1}{2}\,(1-\lambda)\,R \tag{2.14}$$

(2.14) is equivalent to

$$q \leq \frac{(1+\lambda-2\overline{\alpha}_L)}{(1+\lambda-2\underline{\alpha}_L)} = \frac{2\lambda}{(2\lambda+\Delta r)} \equiv \widetilde{q}. \tag{2.15}$$

(2.15) gives our first Proposition.

Proposition 1. *Self-enforcing ranges are overlapping if and only if* $\lambda \geq \frac{1}{2}\Delta r$.

(i) VC makes the high offer $\overline{\alpha}_L$ *if and only if* $q \leq \widetilde{q}$. *There is no renegotiation in equilibrium.*

(ii) VC makes the low offer $\underline{\alpha}_L$ *if and only if* $q > \widetilde{q}$. *E initiates renegotiation when outside options are balanced (with probability (1-q)).*

(iii) $\partial\widetilde{q}/\partial\lambda > 0$, $\partial\widetilde{q}/\partial\Delta r < 0$ *and* $\widetilde{q} \geq 1/2$.

Proof. (i) and (ii) follow from equation (2.15) . $\widetilde{q} \geq 1/2$ if and only if $\lambda \geq \frac{1}{2}\Delta r$ which is satisfied in the overlapping case. The rest of the proof is straightforward. Q.E.D.

The benefit of the high offer $\overline{\alpha}_L$ is that renegotiation can be avoided in the state where outside options are balanced. However, the high offer gives E gets too much surplus in the state where VC is strong. If q is small, the expected cost of the high offer is small and it is optimal for VC to make the high offer.

Proposition 1 also shows that $\partial\widetilde{q}/\partial\lambda > 0$. The worse is the holdup, the greater is the benefit of avoiding renegotiation. Therefore VC makes the high offer for a wider parameter range. Furthermore, $\partial\widetilde{q}/\partial\Delta r < 0$. The stronger VC's bargaining position is in the unbalanced state, the lower is the low offer $\underline{\alpha}_L$. Therefore it is in VC's interest to make the low offer for a wider parameter range. Finally, $\widetilde{q} \geq \frac{1}{2}$ so that renegotiation occurs in equilibrium with probability less than $\frac{1}{2}$.

When the self-enforcing ranges are overlapping, it is possible to avoid the deadweight losses caused by renegotiation. Therefore any $\overline{\alpha}_L \leq \alpha \leq \underline{\alpha}_H$ is welfare maximizing. However, VC's interest is in maximizing their own expected payoff and for $q > \widetilde{q}$ they choose to make the low offer even though it triggers renegotiation with probability $(1-q)$.

2.4.2 Disconnected self-enforcing ranges

Disconnected self-enforcing ranges are illustrated in Figure 2.2. In this case there does not exist an α that avoids renegotiation in both states.

When VC makes the high offer $\overline{\alpha}_L$, E will not renegotiate it. However, VC himself will trigger renegotiation when they are in a strong bargaining position. VC's expected payoff from making the high offer $\overline{\alpha}_L$ is

$$U_{VC}^3 = q\frac{1}{2}\left[(1-\lambda)+\Delta r\right]R + (1-q)\left(1-\overline{\alpha}_L\right)R. \tag{2.16}$$

where superscript 3 denotes VC renegotiation. Alternatively, VC can make the low offer $\underline{\alpha}_L$ and E renegotiates it when outside options are balanced. VC's expected payoff from making the low offer $\underline{\alpha}_L$ is

$$U_{VC}^2 = q\left(1-\underline{\alpha}_L\right)R + (1-q)\frac{1}{2}(1-\lambda)R.$$

VC makes the high offer $\overline{\alpha}_L$ if and only if

$$q\frac{1}{2}\left[(1-\lambda)+\Delta r\right]R + (1-q)\left(1-\overline{\alpha}_L\right)R \geq q\left(1-\underline{\alpha}_L\right)R + (1-q)\frac{1}{2}(1-\lambda)R$$

$$\Leftrightarrow q \leq \frac{1+\lambda-2\overline{\alpha}_L}{2+2\lambda-2\overline{\alpha}_L-2\underline{\alpha}_L-\underline{r}_{VC}+\underline{r}_E} = \frac{1}{2}$$

This result is summarized in Proposition 2.

Proposition 2. *Self-enforcing ranges are disconnected if and only if $\lambda \leq \frac{1}{2}\Delta r$.*

(i) VC makes the high offer $\overline{\alpha}_L$ if and only if $q \leq \frac{1}{2}$. VC initiates renegotiation when they are in a strong bargaining position (with probability q).

(ii) VC makes the low offer $\underline{\alpha}_L$ if and only if $q > \frac{1}{2}$. E initiates renegotiation when outside options are balanced (with probability (1-q)).

In the disconnected case both $\overline{\alpha}_L$ and $\underline{\alpha}_L$ work well in one state but trigger costly renegotiation in the other state. VC's optimal offer then simply minimizes the probability of renegotiation. VC's interests are aligned with social welfare in this case.

Figure 2.3 summarizes Propositions 1 and 2. The disconnected case is in the lower half of the figure where $\lambda \leq \frac{1}{2}\Delta r$ and the overlapping case is in the upper half of the figure. Figure 2.3 shows that high λ induces VC to make the high offer so that very costly renegotiation is avoided in equilibrium. For very high values of q, however, the balanced state where renegotiation might occur is so unlikely that VC is better off making the low offer even for large values of λ and therefore E renegotiation region reaches to the maximum value of λ.[1]

Figure 2.3 also shows that renegotiation occurs in equilibrium with probability less than $\frac{1}{2}$ since in VC renegotiation region $q < \frac{1}{2}$ and in E renegotiation region

[1]Note that the range of λ is limited by Assumption 1.

$(1-q) < \frac{1}{2}$. Finally, the boundary between E renegotiation and no renegotiation is positively sloping. The payoffs within the no renegotiation region do not depend on q while within the E renegotiation region the higher is q the less likely it is that E triggers renegotiation. Therefore VC makes the low offer for higher values of λ resulting in the positively sloping boundary.

2.4.3 VC contracts as reference points

E's expected payoff when there is no renegotiation equals

$$U_E^1 = \overline{\alpha}_L R = \frac{1}{2}(1-\lambda) R. \tag{2.17}$$

While E's expected payoff when either they or the VC renegotiates is

$$U_E^2 = q\underline{\alpha}_L R + (1-q)\frac{1}{2}(1-\lambda) R = \frac{1}{2}[(1-\lambda) - q\Delta r] R \tag{2.18}$$

$$U_E^3 = q\frac{1}{2}[(1-\lambda) - \Delta r] R + (1-q)\overline{\alpha}_L R = \frac{1}{2}[(1-\lambda) - q\Delta r] R = U_E^2 \tag{2.19}$$

The expression for E's payoff does not depend on whether it is E or VC who triggers renegotiation. When VC makes the low offer $\underline{\alpha}_L$ E renegotiates it up to $\overline{\alpha}_L$ in the balanced state (although now $\overline{\alpha}_L$ includes the deadweight loss). While when VC makes the high offer $\overline{\alpha}_L$, they renegotiate it down to $\underline{\alpha}_L$ (including the deadweight loss) when they are in a strong bargaining position. That is why E's expected payoff equals $q\underline{\alpha}_L R + (1-q)\overline{\alpha}_L R = \frac{1}{2}[(1-\lambda) - q\Delta r] R$ no matter who initiates renegotiation. Note that although the expressions are equivalent in both renegotiation cases, the payoffs are not since the different regions arise in equilibrium for different parameter values. We will return to this later.

Equations (2.17) – (2.19) show that $U_E > \overline{u}$ under Assumption 1. VC aims to minimize the equity offer to E but has to take into account that too low offer can trigger costly renegotiation in some states. Although VC has all the bargaining power, he chooses to leave some surplus above $\overline{u}$ to E to guarantee a smoother ex post relationship. (In Section 4.2 we explore higher values of $\overline{u}$ in which case participation constraint can become binding for some parameter values.)

Proposition 3. *Under the optimal contract $U_E > \overline{u}$.*

VC's expected payoff for each region can be written as

$$U_{VC}^1 = (1-\overline{\alpha}_L) R = \frac{1}{2}(1+\lambda) R \tag{2.20}$$

$$\begin{aligned} U_{VC}^{2} &= q\left(1-\underline{\alpha}_{L}\right)R+\frac{1}{2}\left(1-q\right)\left(1-\lambda\right)R \\ &= \frac{1}{2}\left(1+\lambda\right)R+\frac{1}{2}q\Delta rR-\left(1-q\right)\lambda R \end{aligned} \tag{2.21}$$

$$\begin{aligned} U_{VC}^{3} &= \frac{1}{2}q\left[\left(1-\lambda\right)+\Delta r\right]R+\left(1-q\right)\left(1-\overline{\alpha}_{L}\right)R \\ &= \frac{1}{2}\left(1+\lambda\right)R+\frac{1}{2}q\Delta rR-q\lambda R \end{aligned} \tag{2.22}$$

We can show that VC's funding decision is inefficient. Not all profitable projects for which $R \geq I+\overline{u}$ will be funded. This is because E's payoff is strictly greater than $\overline{u}$ and, furthermore, renegotiation can occur in equilibrium leading to deadweight losses.

Proposition 4. *VC's funding decision is inefficient.*

Proof.

It is efficient to fund projects for which $R \geq I+\overline{u}$. VC funds projects for which $U_{VC} \geq I$. VC's funding decision is inefficient if and only if $U_{VC} < R-\overline{u}$ which is satisfied since

$$U_{VC}+\overline{u} < U_{VC}+U_{E} \leq R.$$

The first inequality is satisfied since E's participation constraint is not binding. The second (weak) inequality is satisfied since costly renegotiation may occur with positive probability.

Q.E.D.

We will next turn to comparative statics.

Proposition 5. *VC's expected payoff is increasing in λ and weakly increasing in q and Δr.*

Proof.

First, we examine the comparative statics within each region. It follows from (2.20) that $\frac{\partial U_{VC}^{1}}{\partial\lambda}=\frac{1}{2}R>0$, $\frac{\partial U_{VC}^{1}}{\partial q}=0$ and $\frac{\partial U_{VC}^{1}}{\partial\Delta r}=0$.

From (2.21) we have $\frac{\partial U_{VC}^{2}}{\partial\lambda}=\frac{1}{2}\left(2q-1\right)R>0$ since $q>\frac{1}{2}$ in the region where E renegotiates, $\frac{\partial U_{VC}^{2}}{\partial q}=\left(\lambda+\frac{1}{2}\Delta r\right)R>0$ and $\frac{\partial U_{VC}^{2}}{\partial\Delta r}=\frac{1}{2}qR>0$.

From (2.22) we obtain $\frac{\partial U_{VC}^{3}}{\partial\lambda}=\frac{1}{2}\left(1-2q\right)R>0$ since $q<\frac{1}{2}$ in the region where VC renegotiates, $\frac{\partial U_{VC}^{3}}{\partial q}=\left(\frac{1}{2}\Delta r-\lambda\right)R>0$ since this is the disconnected case and $\frac{\partial U_{VC}^{3}}{\partial\Delta r}=\frac{1}{2}qR>0$.

Second, we need to verify that VC's payoff is continuous when switching from one region to another. Since the critical boundary between the regions is determined by $U_{VC}^1 = U_{VC}^2$ and $U_{VC}^3 = U_{VC}^2$ we only need to verify the continuity between U_{VC}^1 and U_{VC}^3. Substituting the boundary value $\lambda = \frac{1}{2}\Delta r$ in the third term in (2.16), we obtain

$$U_{VC}^3 = \frac{1}{2}(1+\lambda)R + \frac{1}{2}q\Delta rR - q\frac{1}{2}\Delta rR = \frac{1}{2}(1+\lambda)R = U_{VC}^1.$$

Therefore VC's payoff is continuous between U_{VC}^1 and U_{VC}^3. Q.E.D.

Proposition 5 shows that VC benefits from costlier renegotiation. Higher λ has two effects on VC's expected payoff.

$$\frac{\partial U_{VC}^2}{\partial \lambda} = -qR\frac{\partial \underline{\alpha}_L}{\partial \lambda} - \frac{1}{2}(1-q)R > 0 \tag{2.23}$$

$$\frac{\partial U_{VC}^3}{\partial \lambda} = -\frac{1}{2}qR - (1-q)R\frac{\partial \overline{\alpha}_L}{\partial \lambda} > 0 \tag{2.24}$$

Higher λ results in E accepting a lower equity share without triggering renegotiation, $\frac{\partial \underline{\alpha}_L}{\partial \lambda} = \frac{\partial \overline{\alpha}_L}{\partial \lambda} = -\frac{1}{2}$, benefiting VC. On the other hand, when renegotiation does occur, higher λ reduces surplus and VC's payoff. The positive effect dominates because in equilibrium renegotiation occurs with probability less than $\frac{1}{2}$, that is, in equilibrium $(1-q) < \frac{1}{2}$ in (2.23) and $q < \frac{1}{2}$ in (2.24).

λ depends on the opportunity to holdup as only noncontractible helpful actions can be withdrawn. VC's expected payoff is then higher in an industry where higher proportion of ex post helpful actions are noncontractible such as human capital intensive industries. Furthermore, it may be in VC's interest to leave out from the contract some actions that could be contracted on.

Alternatively or additionally, λ depends on the strength of the reaction. VC would benefit from creating an environment with more hostile reaction to renegotiation and keeping E on their toes.[2] Then VC has two instruments to keep E from initiating renegotiation: ex ante equity offer that leaves E some surplus above $\overline{u}$ and a hostile reaction to ex post renegotiation.

VC's expected payoff is also (weakly) increasing in the probability that he is in a strong bargaining position, q, and the degree of their bargaining advantage, Δr.[3]

Since VC's payoff is increasing in λ and q, VC's payoff is the highest in the NE corner of E renegotiation region in Figure 2.3. VC makes the low offer which

[2]However, that is limited by E's participation constraint. λ cannot be so high that that E's expected payoff goes below $\overline{u}$.

[3]Within the no renegotiation region VC's payoff does not depend on q or Δr. In the renegotiation region their payoff is strictly increasing in q or Δr.

is low since λ is high and the low offer goes unchallenged with high probability q. Similarly, VC's payoff is the lowest in the SW corner of VC renegotiation region. VC makes the high offer which is high due to low λ and they renegotiate it down with low probability q. Furthermore, VC's payoff is continuous when moving from one region to another in Figure 2.3 although joint surplus increases discontinuously when moving from renegotiation to no renegotiation region. In the boundary between E renegotiation and no renegotiation VC is by definition indifferent between making the high or the low offer and therefore their payoff must be continuous. Their payoff is also continuous when moving from VC renegotiation to no renegotiation.

The deadweight losses from renegotiation are eliminated when moving from renegotiation region to no renegotiation region in Figure 2.3. Since VC's payoff is continuous when switching between regions it must be that it is E who gets the full benefit of increased joint surplus. We examine this and further comparative statics in Proposition 6.

Proposition 6. *E's expected payoff is decreasing in λ with one exception. When higher λ causes a switch from E or VC renegotiation to no renegotiation, there is a discontinuous increase in E's expected payoff equal to $\frac{1}{2}q\Delta rR$. E's expected payoff is weakly (and at one point discontinuously) decreasing in q and Δr.*

Proof.

First, examine the comparative statics within each region. It follows from (2.17) that $\frac{\partial U_E^1}{\partial \lambda} = -\frac{1}{2}R < 0$, $\frac{\partial U_E^1}{\partial q} = 0$ and $\frac{\partial U_E^1}{\partial \Delta r} = 0$.

And from (2.19) $\frac{\partial U_E^2}{\partial \lambda} = \frac{\partial U_E^3}{\partial \lambda} = -\frac{1}{2}R < 0$, $\frac{\partial U_E^2}{\partial q} = \frac{\partial U_E^3}{\partial q} = -\frac{1}{2}\Delta rR < 0$ and $\frac{\partial U_E^2}{\partial \Delta r} = \frac{\partial U_E^3}{\partial \Delta r} = -\frac{1}{2}qR < 0$.

Second, we need to consider switching between the regions. E's expected payoff is obviously continuous when switching from VC to E renegotiation since $U_E^2 = U_E^3$. This will not be the case when the switch is from renegotiation to no renegotiation. In the proof of Proposition 5 we showed that VC's payoff is continuous. Therefore the discontinuous increase in surplus when moving to no renegotiation region, $\frac{1}{2}q\Delta rR$, must go to E (see equations (2.17) and (2.19)). Q.E.D.

The comparative statics for E's payoff within each region are the opposite to VC. E's payoff is decreasing in renegotiation costs λ, and in VC's expected bargaining advantage, q and Δr. However, when higher λ causes a switch from renegotiation region to no renegotiation region E's payoff increases discontinuously by $q\left(\overline{\alpha}_L - \underline{\alpha}_L\right) = \frac{1}{2}q\Delta rR$. E obtains $\overline{\alpha}_L$ in the balanced state even in the renegotiation region (either because VC offered it in the first place or because E renegotiated their payoff up to $\overline{\alpha}_L R$). In the no renegotiation region they obtain $\overline{\alpha}_L$ also in the state where VC is strong increasing their expected payoff by $q\left(\overline{\alpha}_L - \underline{\alpha}_L\right)$. For small values

of q this increase is quite minor and we can say that E broadly benefits from lower λ as illustrated in Figure 2.4. However, for higher values of q the increase is large and it is possible that E benefits from increase in λ if it is so large that it pushes them to the no renegotiation region. See Figure 2.5. Note that for the largest values of q VC would never make the high offer and they remain in E renegotiation region for all values of λ.

Therefore for non-intermediate values of q, E's payoff is higher in an industry where ex post actions are largely contractible. E would also prefer to include in the contract all contractible actions and would prefer a friendlier environment with VC. However, for high intermediate values of q, E prefers λ to be so large that it pushes VC to make the high offer which will not be renegotiated.

2.5 Extensions

2.5.1 Indexation

VC can lower their equity offer to E without triggering costly renegotiation by indexation. Suppose there is a verifiable signal that is perfectly correlated with outside options. Then VC offers a contract that gives E $\underline{\alpha}_L$ in the state where VC is strong and $\overline{\alpha}_L$ in the state where outside options are balanced. Such contract eliminates costly renegotiation and gives E expected payoff equal to

$$\begin{aligned} U_E &= q\underline{\alpha}_L R + (1-q)\,\overline{\alpha}_L R \\ &= \frac{1}{2}\left[(1-\lambda) - q\Delta r\right] R > \overline{u}. \end{aligned} \tag{2.25}$$

Indexation does not change E's payoff in the renegotiation region while in the no renegotiation region E's payoff is reduced by $\frac{1}{2}q\Delta rR$ as they are now not overpaid in the balanced state. However, E still gets more than their reservation utility.

Indexation increases VC's payoff since in the renegotiation region deadweight losses are eliminated while E's payoff is unaffected. Therefore the full benefit must go to VC. In the renegotiation region E's payoff is reduced, so VC's payoff must increase.

Perfect indexation can eliminate inefficient renegotiation but VC's funding decision is still inefficient because they have to leave E gets more than his reservation utility. This inefficiency can be removed if E can fund the project partially investing $I_E = \frac{1}{2}\left[(1-\lambda) - q\Delta r\right] R - \overline{u}$. However, if E is sufficiently wealth-constrained, this is not possible. Furthermore, indexation is not perfect in reality and therefore with imperfect signals inefficient renegotiation can still occur in equilibrium although it is less likely than with a non-indexed contract.

2.5.2 E's participation constraint

In Assumption 1 we assumed that E's reservation utility is limited, $\overline{u} < \frac{1}{2}\left[(1-\lambda) - q\Delta r\right] R$. Under this assumption E's participation constraint is not binding under the optimal contract. If $\overline{u}$ can take higher values, then VC has to increase their offer from $\underline{\alpha}_L$ or $\overline{\alpha}_L$ to satisfy E's participation constraint. Consider the case of perfect indexing.

The highest payoff VC can guarantee to E is to offer $\overline{\alpha}_H$ in the balanced state and $\underline{\alpha}_H$ in the state where VC is strong. This gives E expected payoff equal to

$$\begin{aligned} U_E &= q\underline{\alpha}_H R + (1-q)\,\overline{\alpha}_H R \\ &= q\frac{1}{2}\left[(1+\lambda) - \Delta r\right] R + (1-q)\,\frac{1}{2}\,(1+\lambda)\,R \\ &= \frac{1}{2}\left[(1+\lambda) - q\Delta r\right] R \end{aligned}$$

Therefore for any $\overline{u} \in \left[\frac{1}{2}\left[(1-\lambda) - q\Delta r\right] R, \frac{1}{2}\left[(1+\lambda) - q\Delta r\right] R\right]$ VC offers $\overline{\alpha} \in [\overline{\alpha}_L, \overline{\alpha}_H]$ and $\underline{\alpha} \in [\underline{\alpha}_L, \underline{\alpha}_H]$ such that E's participation constraint holds with equality. If $\overline{u} > \frac{1}{2}\left[(1+\lambda) - q\Delta r\right] R$, the relationship is not feasible as VC cannot guarantee to renegotiate down very large equity offers ex post.

2.5.3 n states

In our main model there are two states for outside options. Now suppose that there are n states and denote by Δr_i $i = 1, 2, ..., n$ the difference in outside options in state i. Denote by $\Delta r^{\max}$ the largest difference and assume that there exists a state where VC and E have balanced outside options but E is never in a stronger bargaining position than E so that the minimum value for Δr_i equals zero. Finally, denote by α_L^i and α_H^i the critical equity shares in state i.

Self-enforcing ranges are overlapping if max $\alpha_L^i \leq$ min α_H^i which is equivalent to $\lambda \geq \frac{1}{2}\Delta r^{\max}$. Then VC can avoid renegotiation by offering $\alpha = \frac{1}{2}(1-\lambda)$ to E. Otherwise VC renegotiates in all the states where $\alpha > \alpha_H^i$ and E renegotiates in all the states where $\alpha < \alpha_L^i$.

2.6 Conclusion

We have applied contracts as reference points approach to venture capital. We find that E's participation constraint is not binding even when VC has all ex ante bargaining power. VC chooses to leave some surplus to E to guarantee a smoother ex post relationship. Project funding is inefficient due to E's additional surplus

and renegotiation occurring in some states. VC's expected payoff is increasing in renegotiation costs as E will accept a lower equity offer.

We will extend the analysis to contractual clauses such as vesting arrangements and noncompete clauses which enable VC to lower the equity offer to E. Furthermore, we will relax the assumption that it is efficient for VC and E not to separate even under holdup and introduce a state where the company is liquidated or E is replaced.

2.7 Figures

Figure 2.1: Overlapping self-enforcing ranges

This figure represents the range of equity share α offered to the entrepreneur when the VC is in a strong position and when the E and VC have balanced outside options

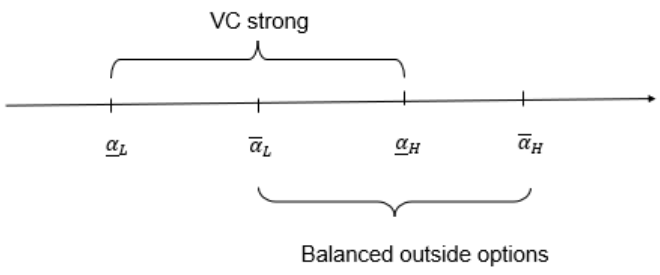


Figure 2.2: Disconnected self-enforcing ranges

This figure represents a range of equity offers which does not avoid renegotiation

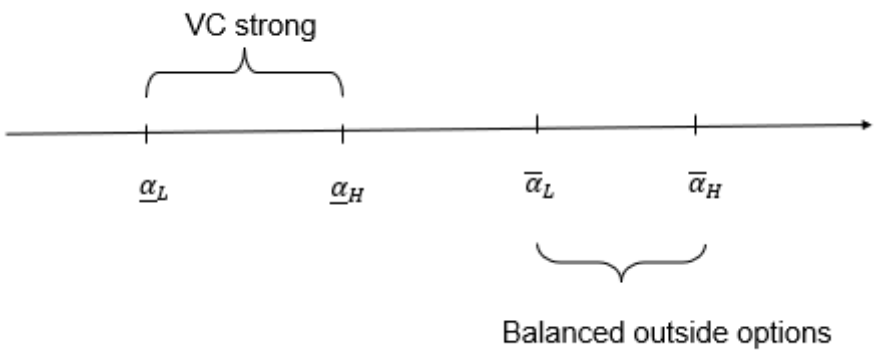


Figure 2.3: Graphical representation of propositions 1 and 2

This figure summarizes proposition 1 and 2. The upper portion depicts the connected self-organizing range of equity and the lower part of the graph depicts the disconnected self-organizing range

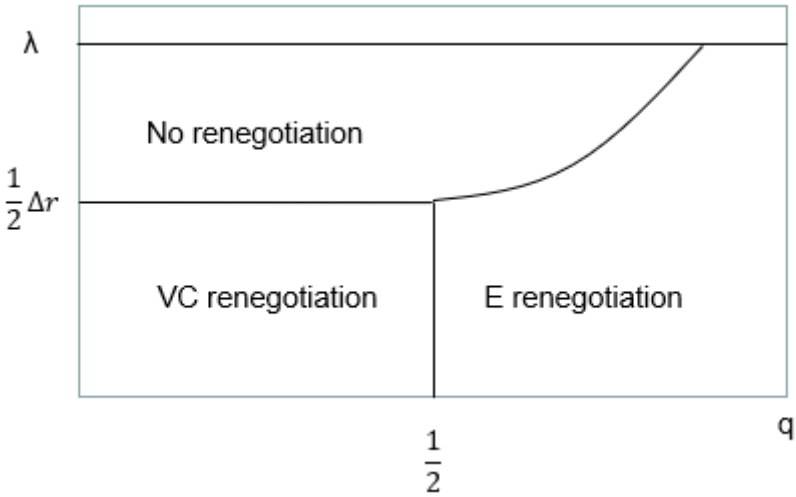


Figure 2.4: VC and E utility when q = 0.1

This figure represents the utility when the probability that the VC outside option is higher than the E outside option is q = 0.1, at different levels non-contractible help λ

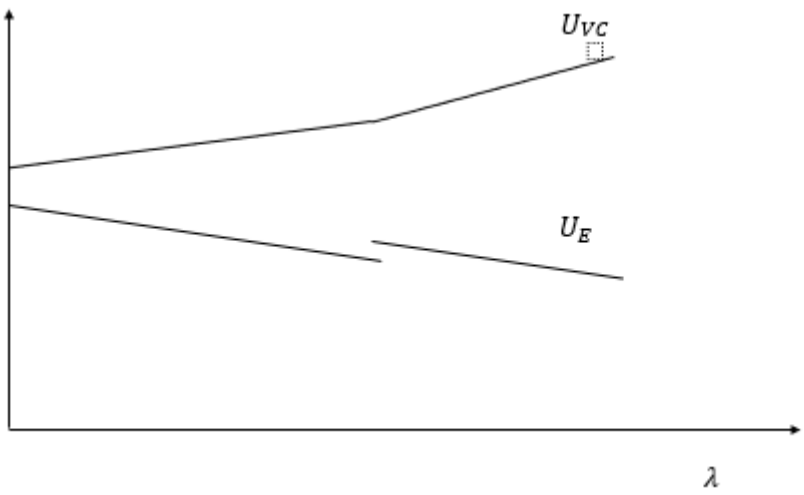
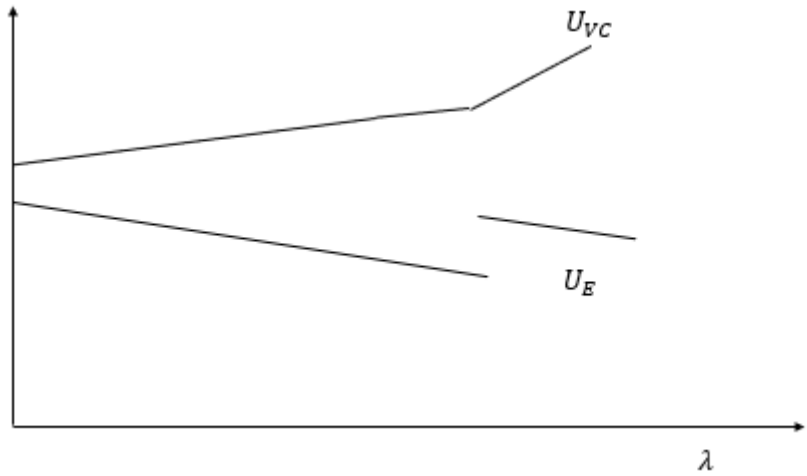


Figure 2.5: VC and E utility when q = 0.6

This figure represents the utility when the probability that the VC outside option is higher than the E outside option is q = 0.6, at different levels of non-contractible help λ



Chapter 3

Surf VC investment waves at your own risk

joint work with Caroline Genc, Université Paris Dauphine - PSL

Abstract : Although the volatility of the venture capital industry is well known, it is not known if investing in a wave or outside of a wave results in better or worse performance. In this paper, we investigated, in an investment wave context, the relationship between the timing of a venture capital investment and its performance. We argue that investments made before a wave, or early in a wave, provided a higher probability of success relative to those made in a wave or in any other period. We show that venture capitalists, with industry experience and high specialization, were more likely to invest earlier in waves when the VC were well connected to investors in an industry by a social network. Without industry connections, they delayed their investments, to within the wave, which had a lower success rate.

> "The bottom companies had intense funding, they even had business models in some cases, but they didn't succeed. I tried to look at what factors actually accounted the most for success and failure across all of these companies, and the results really surprised me.
>
> The number one thing was timing. Timing accounted for 42 percent of the difference between success and failure. Team and execution came in second, and the idea, the differentiability of the idea, the uniqueness of the idea, that actually came in third."
>
> *Bill Gross, TED talk: "The single biggest reason why startups succeed", March 2015*

3.1 Introduction

The founding team and the size of the market were usually identified as the most important factors for successes and failures of venture capital investments (T. F. Hellmann & Puri, 2000; P. Gompers, Gornall, Kaplan, & Strebulaev, 2020). Surprisingly, Bill Gross, the founder of IdeaLab, finds that the main determinant of success was the timing of an investment. However, if the volatility of the venture capital industry was well known, we observed that little attention was paid to venture capital investments waves (Dimov & De Holan, 2005; P. Gompers, Kovner, Lerner, & Scharfstein, 2008a; Phillips & Zhdanov, 2017; Brown et al., 2020). More specifically, to our knowledge, the relationship between the timing of a venture capital investment and its performance, with investment waves, had not been explored. Whether investing in a wave or outside of a wave results in better or worse performance was an open question we want to address in this paper.

Using a similar approach to Mitchell and Mulherin (1996) and consistent with Dimov and De Holan (2005) we identified the existence of venture capital investment waves in seven industries out of ten. Four industries had two waves. Based on quarterly data aggregated by industry, we counted consecutive quarters with above average investment. Following the two year time period from Mitchell and Mulherin (1996), we classified the start of a wave as the 8th consecutive quarter of above average investment. We then compared performance of investments made during wave and out of wave periods. To get more insight from a risk-return point of view, we distinguished early investments from late investments, with respect to the wave. That is, we split wave periods between early wave and in wave intervals. Similarly, for out of wave periods, we consider pre wave, post wave and other periods. Pre wave and post wave periods were defined as one year before and one year after an industry wave. The time period between the first above average investment quarter, the beginning of the wave, and within the wave, was labeled early wave.

Thus, pre wave and early wave investments were investments occurring in times of higher uncertainty compared to in wave or post wave investments. We classify the remaining investment times as out of wave or other periods.

We provided evidence that investments made before a wave, or early in a wave, present higher chances of success relative to those made in a wave or in any other period. As we did not have data on the actual returns of investments, we base our success definition on the nature of the exit. We consider that an investment was successful if the company went public, was acquired or merged (Cochrane, 2005; Hochberg, Ljungqvist, & Lu, 2007; Phalippou & Gottschalg, 2009; Nanda, Samila, & Sorenson, 2020) . Hence, our results suggested that, although pre wave and early wave periods were characterized as high uncertainty, investing in them had a higher success rate. On the contrary, in wave and post wave investments decrease the success probability by almost 3 percentage points. In our empirical specification, we control for time-varying economic conditions that potentially affect VC investments by including time fixed effects. We also control for time-invariant industry characteristics through industry fixed effects. Without year fixed effects, we observed an upward bias in our results, suggesting that the timing of the waves play an important role. Indeed, most of the first waves occur in periods of favorable economic conditions. By testing our hypothesis, individually, on the first industry waves and second waves, when they existed, we confirmed that first waves had larger effects than the second waves. Controlling for time fixed effects, we found that our main results were stronger for the first waves. This was probably due to the larger number of observations for the first waves. Nevertheless, we provided evidence that in industries with two waves, investments occurring in the second wave were still more likely to fail compared to out of wave periods.

Our findings were in line with the theoretical predictions of Lee and Sunesson (2008) concerning private equity waves. We empirically supported the decreasing pattern of performance during venture capital waves. Higher risk was thus associated with higher return. On the contrary, delaying investments to reduce risk or waiting to "share the blame" was more likely to predict failure. An alternative approach was that pre and early wave periods were less risky than they were perceived among venture capitalists. Those who invest in such periods may be more aware of the actual risk. Regarding the under performance of in wave investments, our results were consistent with prior research on private equity (Kaplan & Stromberg, 2009; Robinson & Sensoy, 2016) and merger wave (Moeller, Schlingemann, & Stulz, 2005; Yan, 2011; Duchin & Schmidt, 2013).

We further explored firm and fund level factors that influence the decision to invest in a given time category. For instance, P. Gompers et al. (2008a) showed that VC firms that invest the most during favorable public market signals were those

with the most industry experience. In addition, they argue that such VC firms did not overreact to public signals since there was no evidence of a negative impact on their performance.

In our analysis, we determine the profiles of VC firms that were more likely to invest in the different timing categories we study in this paper. More specifically, we examined industry specific characteristics like experience, specialization and social network. As liquidity was an important factor which drives wave (Harford, 2005), we also investigate if funds with more liquidity invest in specific periods. Without access to data about capital committed by limited partners, we base our analysis on a liquidity ratio, constructed from the amounts invested by funds at each investment date. All of these characteristics, as well as the outcome of an investment itself, were closely related to the quality of the VC. Even though Nanda et al. (2020) did not find evidence of VCs' ability to find optimal places and times to invest, they argue that initial successes had persistent effects explaining future success. Thus, we also concentrate on past fund performance.

We found that VCs with industry experience and industry specialization were more likely to invest in wave or one year after. Also, VC firms that were more specialized in an industry were less prone to invest in pre wave or early wave periods. These results suggested that experienced and specialized VC firms were less likely to take risk by investing in high uncertainty periods. This may appear quite surprising at first glance since concentrated expertise was expected to predict early entry in industry waves, as suggested by Dimov and De Holan (2005). One might expect VCs with better reputation, more industry experience or specialization to have enough knowledge and resources to invest earlier.

Considering that network was a key element in venture capital to detect good investment opportunities and to better perform (Hochberg et al., 2007), we reanalyze these characteristics while also including the social networks of VC firms. We observed that being well connected in the industry of the investment significantly decreases the probability of investing during an industry wave. VCs who had industry experience, and who were well connected in their industry, were more likely, by 35.9 percentage points, to invest early in a wave. Knowing that the performance associated with such investments was positive, VCs who were experienced and well connected in an industry might be more aware of the actual risk behind early investments. As far as more specialized VCs were concerned, we showed that being specialized and well connected in an industry reduces the probability of investing in wave by 25.4 percentage points. Therefore, specialized investors who invested in wave or post wave, were less connected. We did not find evidence that VCs invest in wave rather than early in a wave due to liquidity constraints. More fund liquidity increases the probability of investing early in a wave by 15.9 percentage points, less

liquidity did not increase the probability of investing in a wave. Hence, investors decide to delay their investments, probably due to the high perceived risk of early investments. However, we confirm that decisions to invest post wave may be related to liquidity issues. As less constrained VCs were probably those with more successful exit records, we verify if similar results were obtained with past performance. Consistently, we found that VCs with high successful exit rates were more likely to invest in the pre wave and early wave periods. Those with low past performance were more likely to invest post wave. By contrast, past fund exit rate did not influence the decision to invest in wave. If pre wave and early wave investments' outcome may be explained by VC firms' past successes, this was not the case for in wave investments. Our findings suggested that the actual risk of early investments might be lower than it appears. Experienced or specialized investors, who were well connected in an industry, may assess early investment risk more accurately.

This paper contributes to the literature in several aspects. To our knowledge, it was the first one to study the relationship between performance and the timing of venture capital investments with respect to waves. It was also the first empirical study on waves that clearly distinguished early wave and in wave investments and sheds light on the performance pattern during the wave. While prior research only compares in wave and out of wave investments, our approach enable us to examined it from a risk and return view. From a practical point of view, our findings imply that investors should reassess the risk associated with pre wave and early wave investments. In addition, our paper contribute to the venture capital literature by identifying the characteristics of VCs who time their investments. Compared to previous studies, with social network analysis, we were able to separate what was driven by experience, i.e the knowledge of the industry, and what was due to the social network of a VC firm.

The remainder of the paper was organized as follows: After reviewing the related literature in section 4.2, section 4.4 describes the data. Section 3.4 investigates the relation between timing and performance. VC firm timing decisions, with respect to their characteristics,were explored in Section 3.5. Section 3.6 concludes.

3.2 Related literature

Even though the venture capital industry was known to be volatile, there were few studies focusing on venture capital waves (Dimov & De Holan, 2005; P. Gompers et al., 2008a; Phillips & Zhdanov, 2017) or private equity waves (Lee & Sunesson, 2008; Brown et al., 2020). Most of the research on waves concentrated on M&A and IPO waves and investigated their drivers. More specifically, two hypotheses were competing in the literature to explain waves creation. The neoclassical one suggested

that waves emerge as a response to economic, regulatory or technological shocks (Gort, 1969; Mitchell & Mulherin, 1996; Mulherin & Boone, 2000; Maksimovic & Phillips, 2001; Andrade, Mitchell, & Stafford, 2001; Harford, 2005; Gugler, Mueller, & Yurtoglu, 2006). Harford (2005) also empathized that liquidity was required to trigger a wave. Without liquidity, the reallocation of assets was difficult and industry shocks were not sufficient to trigger the waves. The behavioral approach explained waves through overvaluation or overreaction to perceived investment opportunities (Shleifer & Vishny, 2003; Rhodes-Kropf & Viswanathan, 2004; Lamont & Stein, 2006). In line with these studies, while Dimov and De Holan (2005) provided support for the existence of venture capital investment waves, P. Gompers et al. (2008a) argue that VCs with the most industry experience react to public market signals, but they did not overreact. By exploring both VC investment and merger activity around the world, Phillips and Zhdanov (2017) supported that active M&A markets predicted VC investments waves.

However, little was known about the relationship between the timing of a venture capital investment and its performance in a wave context. Whether investing in a wave or outside of a wave resulted in better or worse performance was still an open question. Lee and Sunesson (2008) theoretically established that the average fund performance followed a decreasing pattern during private equity waves. Kaplan and Schoar (2005) showed that experienced and well-informed venture capitalists' performance was persistent and less sensitive to industry cycles and waves compared to new entrants, especially in boom periods. Nanda and Rhodes-Kropf (2018) argue that VC firms benefited from persistent effects of their initial success. They did not find evidence of VCs' ability to find optimal places and times to invest. Nevertheless, when choosing new industries or areas to invest, previous success did not help outperform those without any initial success (Nanda & Rhodes-Kropf, 2018). Considering private equity waves, Kaplan and Stromberg (2009) found that buyout funds raised in high fundraising years exhibited lower performance, in absolute terms, compared to funds raised in bust periods. Consistently, (Robinson & Sensoy, 2016) underlined that periods of high private equity fund raising predicted low cash flows and market returns. Regarding merger waves, even though Mitchell and Mulherin (1996) did not focus on performance, they suggested that takeovers occurring in these periods under performed. Moeller et al. (2005) showed that acquiring firm shareholders had large losses during the merger wave at the end of the 1990's. Consistently, on-the-wave mergers were shown to be value destroying as measured by the acquirer stock returns (Yan, 2011; Duchin & Schmidt, 2013). However, Maksimovic, Phillips, and Yang (2013) stated that mergers which occurred on-the-wave had higher productivity increases.

In this paper, we compared performance of investments made during venture

capital wave and out of wave years. For that purpose, we split wave periods between early wave and in wave intervals. Similarly, for out of wave periods, we consider pre wave, post wave and other periods. To our knowledge, this study was the first one to investigate investment performance in venture capital wave context. In addition, we explore firm and fund level factors that influence the decision to invest in a given time category.

Investing earlier in a wave or before it, that was in periods of high uncertainty, meant accepting a high degree of risk. After the initial move into an industry, an increase in the valuation of investments may occur and trigger the wave (Goriatchev, 2002). In a dynamic behavioral approach of private equity waves, Lee and Sunesson (2008) stated that the average fund performance followed a decreasing pattern, so that the latest entrants under performed the industry. We empirically explored if these predictions held for venture capital investment waves. Thus, we expected early wave investments to be more likely to succeed relative to in wave or post wave investments. Hence, higher risk should be associated with higher return. On the contrary, delaying investments to reduce such a risk or waiting to "share the blame" was expected to predict failure.

Moreover, Lee and Sunesson (2008) showed that younger partnerships performed badly and were less likely to raise a follow-on fund. This likelihood was even lower when they entered the market in boom times as expectations were high. Syndication was a common feature in venture capital industry. As it was more frequently observed, when the uncertainty level was high (Bygrave, 1987; Robbie, Wright, & Chiplin, 1997), we should have observed an increase in the number of syndications at the beginning of waves or early in waves. Among the reasons that justified the willingness to syndicate, there was risk diversification (R. Wilson, 1968), information sharing (Bygrave, 1987), mitigation of information asymmetries between the initial investor and later round investors (Admati & Pfleiderer, 1994), sharing evaluation skills for a second opinion (Lerner, 1994) or benefit from complementary skills and resources (Brander, Amit, & Antweiler, 2002). Brander et al. (2002) showed that returns and volatility were higher when investments were syndicated relative to independent investments. Casamatta and Haritchabalet (2007) attributed this to an improvement in the selection process by gathering information on investment opportunities through syndication. While there was no significant evidence about the relationship between syndicate size and the level of excess returns (Hege, Palomino, & Schwienbacher, 2008), the quality of a VC's informal network was shown to be positively correlated with his performance (Hochberg et al., 2007). Hence, among VC firm level characteristics, we examined whether highly connected investors were more likely to invest in periods of greater uncertainty and whether they performed well in such periods. In addition, we explore the role played by experience in tim-

ing investments with respect to waves. P. Gompers et al. (2008a) found VC firms with more industry experienced were those who reacted the most to public signals without reducing their performance. We then analyzed if more experienced or more specialized VCs preferred to invest earlier or later relative to waves. Lastly, we verified if liquidity and past performance explained investment timing choices.

3.3 Data

Our dataset included venture capital deals contained in the Thompson One Banker Private Equity data base from 1995 to 2017. Available data from 1990 through 1994 were excluded due to missing observations and to the smaller number of deals. As this paper was focused on venture capital investment waves, after defining the waves and our main variables, we restricted our analysis to investments made between January 1997 and September 2016. To identify industry waves, we followed Mitchell and Mulherin (1996) and considered that a wave begins after two years of above average investment in an industry. We removed the first two years of data as we created the beginning of the two year moving average to compute waves. For each wave, we were interested in observations from the pre-wave (here defined as one year before the wave) to the post-wave (one year after the wave) periods. The last wave we had in our dataset ended in March 2016 for the consumer related industry. Hence, for most of our observations, we did not know if the last year of data was a pre-wave period. This was why we stopped our analysis, before the end of our data set, in September 2016.

Even though the data source did not cover all venture capital deals, it provided round level information that was useful to track the history of investments at the VC firm, fund and company level. However, data reported by the venture firms were not always updated. Thus, we verified through internet searches if the firms reported as active were actually active. Further verification showed, when the full history and closing documents were available, the totals reported in Thomson One Banker were coherent with the deal documents except for information by round which did not match exactly. This may be due to venture firms reporting both the totals for the investment round and their individual contribution to the round.

We then restricted our attention to investments made in the USA where the venture capital industry was more active. This provided a significant number of observations to study waves. Our sample consisted of 211 117 unique investments made in 33 330 different companies by 7585 VC firms and 14 560 funds. Table 3.1 to 3.3 described our data at the VC firm, fund and company levels. For our main analysis, we did not exclude follow on investments by a venture capital firm in a same company. A portfolio company may appear multiple times for the same VC

firm or fund if they reinvested in it. To identify effects of timing on performance, we keep the re-investments for VC firms. Limiting the sample to the initial investment made by a VC firm in a company would introduce some bias. Indeed, if a failure was due to an investment made in the wave while the first investment was made out of the wave, keeping only the first investment would attribute the failure to the out of wave timing. However, for robustness concerns, we also test our regressions on a sub-sample excluding follow on investments and including controls for their timing.

3.4 VC investment waves and performance

3.4.1 Identification of waves

To identify venture capital investment waves, we followed the methodology of Mitchell and Mulherin (1996). We considered that a wave existed if, during a period of two years, the number of investments in an industry exceeded the average number of investments in that industry. Our analysis was based on quarterly data aggregated by industry. We compared the total number of quarterly investments made in an industry (Industry Total) to the moving averages of the industry (Industry Total MA). We then counted consecutive quarters for which Industry Total was higher than Industry Total MA. Once the count met the defined threshold, we considered that the start of the wave. Once this threshold had been reached, all following quarters with above average investments belonged to the in Wave period for that industry. The time period between the first above average investment quarter, that was the beginning of the wave, and the in wave period was called the early wave period. We also define pre wave and post wave periods as one year before and one year after the wave. The final above average investment quarter (the final in wave quarter) indicated the end of the wave. The main results reported in this paper were obtained with a threshold of two years as in Mitchell and Mulherin (1996).

In Figure 3.1, we observed the evolution of the number of investments in each industry over time. Figure 3.2 visualized industry waves created from the counts of consecutive above average quarters for each industry. A count higher than 7 was accepted as an industry wave. Thus, we found that there were two waves in four of the industries while there was no wave in Communications and Media, Computer Hardware and Other Products industries.

In table 3.4, we reported the dates and the length of the waves for each industry. The first wave occurred during the last quarter of 1997 in the two main industries of our sample. The last wave was the second one for the Consumer Related industry which started during the last quarter of 2013 and ended during the 1st quarter of 2016. The Biotechnology sector had the longest wave of the sample with 23 quarters.

The number of successful exits was reported in table 3.5. For each phase of the wave, as defined in section 4.4, the total number of successful exits were listed. The total exits were further broken down by the status of the company at the exit. A final row contained the results for all other time periods not defined by a wave. The wave periods had 44,190 successful exits compared to 43,789 for all other periods. The majority of successful exits were investments made in one of the wave periods even though the longest wave was 23 quarters and the total investment time, for the other periods, was 76 quarters.

Table 3.6 contained the descriptive statistics for the variables used in the analysis of the investment waves. The table was split into panels for the full sample in the database, then, each phase of the wave and a final panel for post wave. The mean Success Rate was the highest for the Pre Wave in Panel B, at 56%, followed by Early Wave at 53%. Early Wave and Pre Wave had a roughly 13 to 15 percent higher success rate than the mean rates for the other periods. These two phases of the wave also had the highest mean Fund Sequence by 0.11 to 0.19. The highest mean Industry Specialization and Industry Experience were during the In Wave period.

3.4.2 Performance Measure

To identify the timing effects on performance, we based our analysis on a commonly accepted definition of a successful exit. Determining whether an investment in a company was successful or not was hard to accurately measure without the full investment history and exit information for the company. The Thomson One Banker Database had sparse investment information such as the amount invested, the valuation at investment, exit purchase price and deal terms (liquidity preferences, ratchet, etc.). Without this information, we calculated the success variable based on available information. This was difficult as, for example, an acquisition could be a success to the VC firm holding a liquidity preference and a failure to other firms and the entrepreneurs, who did not hold a liquidity preference. When companies reported the status of “active” or “acquisition”, it was not possible to determine how well the company performed and whether or not it provided a positive return to the VC firm. Without a complete investment history and purchase price, we were not able to compute the internal rate of return. Therefore, we based our success definition on the nature of the exit only. Following a widely used definition of success, we consider an investment as successful if it resulted either in an IPO, a Merger or an Acquisition (Cochrane, 2005; Hochberg et al., 2007; Nanda et al., 2020; Phalippou & Gottschalg, 2009). We extended this definition to companies that were “Active”; in “Pending Acquisition”, or “In Registration” for robustness checks. Regarding firms with an “Active” status for this second definition, we excluded those

who were marked as such for more than 7 years, following the method of (Phalippou & Gottschalg, 2009), since a typical VC fund life was 10 years (Sahlman, 1990) and most investments were made within the first 3 years (Zarutskie, 2010).

In addition to the binary success variable, we also defined an Exit Rate variable. For most observations, Exit was informative about the future outcome of the investment. Exit Rate was the current rate, from the previous investments, of the fund when it makes an investment in a new company at the investment date. The Exit Rate was not updated until the last investment of a company. If, at the last investment date, the reported stage was "Seed", "Early Stage" or "Bridge Loan" we did not consider that the firm was in stage which would normally exited and was not counted as a success.

Almost 80% of the successful exits corresponded to an acquisition. As half of the observations were from Computer Software and Services and Internet Specific industries, half of the mergers and acquisitions appear in these industries as well. Almost 30% of the IPOs were in these two sectors while 17% were in the Biotechnology sector. We also observed that 46% of the companies in the Communications and Media industry were successful while they only represent 7% of all successful companies. Regarding the whole sample, around 34% of the companies, which received 46% of the investment rounds, agreed with our definition of success.

3.4.3 Performance with respect to waves

We first examined how investing in the different timing categories changed the likelihood of a successful exit. We explored whether investments made before a wave, or early in a wave, were less likely to exit through an IPO or M&A , compared to other periods. We also documented the success rate of investments made during a wave or after it.

Our main estimation approach was a series of linear probability models. We chose this method to introduce year and industry fixed effects. The waves were industry specific and occurred at different time periods. Time fixed effects enabled us to control for time-varying economic conditions that potentially affected VC investments. With industry fixed effects we controlled for time-invariant industry characteristics. Thus, we were able to isolate what was due to the time period or industry.

The following equation corresponds to our empirical specification that identified how the outcome was affected by the timing of an investment:

$$Exit_i = \beta_0 + \beta_1 \text{Pre Wave}_{is} + \beta_2 \text{Early Wave}_{is} + \beta_3 \text{In Wave}_{is} + \beta_4 \text{Post Wave}_{is} + \beta' X_i + \eta_s + \eta_t + \epsilon_i$$

where $Exit_i$ was a dummy variable that equals one if investment i made in industry

s at time t had a successful exit (either IPO or M&A). Pre Wave$_{is}$, Early Wave$_{is}$, In Wave$_{is}$ and Post Wave$_{is}$ were dummy variables which take the value one if the investment date corresponded to one of the timing categories of industry s. The reference group here was Other Periods$_{is}$ which had the value of 1 when the investment date was not in one of the named wave time periods. η_s and η_t were respectively industry and time fixed effects. X_i represented a vector of additional controls such as the lagged fund exit rate, the number of VC firms investing in a company and the fund sequence. We had not included variables that were correlated with the timing categories or explain the past fund success rate.

Table 3.7 reported the results obtained when considering all waves from all industries. Columns (1) and (2) included only industry fixed effects. Time fixed effects were added in columns (3) and (4). Column (1) confirmed that there were significant differences between investing earlier and investing later in a wave relative to out of wave periods. An early wave investment had a 9.5 percentage higher chance to succeed compared to investments made outside of a wave period. On the contrary, investing in wave decreased the success probability by 1.2 percentage points. Column (2) introduced pre-wave and post-wave periods which respectively represented one year before and one year after a wave. The results reported in this column were interpreted with respect to out of wave periods that were neither pre or post wave. The probability of having a successful exit, increased significantly, by more than 10 percentage points, when an investment was made one year before a wave (12.5 percentage points) or early in a wave (10.7 percentage points). While column (2) did not suggest that in wave or post wave investments decreased this likelihood, including time fixed effects in column (4) supported it. With time fixed effects, columns (3) and (4) indicated that the results in columns (1) and (2) were subjected to an upward bias, due to the timing of the waves themselves. Some of the industry waves, especially the first waves, occurred during favorable macroeconomic conditions. After controlling for time fixed effects, our results supported that the timing of an investment, with respect to a wave, played an important role. When the decision to invest in a specific industry was made before, or just when the industry begins a wave, the probability of success increased by more than 1.5 percentage points. If, however, the decision to invest was made once the industry attracted many VC firms, the probability of ending up with a successful exit fell by almost 3 percentage points.

The decision to invest before or early in a wave was a risky one. There was higher perceived uncertainty in such periods compared to in wave or post wave periods. However, our findings suggested that VC firms that accepted more risk, by investing earlier, did not reduce their performance. Hence, the risk as measured by the volatility of success was not as high as it may appear.

Since we did not have the investment deal terms, we could not compare the valuations across companies and wave periods. It was possible that the higher success rate was due to risk adjusted pricing. Investments early in the wave may have a lower valuation and require a lower exit price. It may also be possible that the in wave valuations were higher and were too high for a successful exit. The early investments had an advantage on pricing and provided time to reach traction for an exit. Without detailed deal information, we cannot rule out this reason for the results. However, for whatever reason, under-priced risk or accurately priced risk, the results for investment timing were supported by the analysis.

Table 3.10 presents the coefficients for each timing category alone, to enable comparisons with all other periods. It includes both time and industry fixed effects. The results were in line with the above analysis.

The results were stronger when we focused on the first waves of each industry. Table 3.8 confirms that the first waves occurred during favorable conditions. The coefficients in the first two columns, were all positive and significant. Investing in any timing category, was associated with an increase in the success probability until we added time fixed effects. Early wave and pre wave investments, made during the first industry waves, had an almost 20 percent higher chance to succeed relative to investments occurring in other periods. Note that the other period variable now included the second wave investments. Once adding time fixed effects, the last two columns demonstrated that, although the magnitude was lowered, pre wave and early wave investments were still positively correlated with success. However, as observed in the last column, the coefficients' signs flip for in wave and post wave. This supported the idea that late wave and post wave investments reduced the likelihood of a successful exit by almost 4 percentage points.

Table 3.9 concentrated only on second waves. Thus, the results should be analyzed with respect to all other periods, including the first wave. Columns (1) and (2) suggested that investing during the second wave of an industry, or after it, decreased the probability of success relative to investing outside of these periods. This was consistent with table 3.8, supporting the conjecture that first waves occurred in economic periods more favorable to success. After applying time fixed effects, found in columns (3) and (4), we observed that, with the exception of in wave, all other timing categories lost significance. This result was still robust when we restrict our sample to industries with two investment waves. To avoid any downward bias, we also excluded industries for which the end of the second wave was close to our last sample date (Computer Software and Services / Consumer Related). There was no significant change.

3.5 Who invests when ?

Very little was known about firm-level or fund-level characteristics that could explain the decisions to invest during a wave period. P. Gompers et al. (2008a) showed that VC firms that invest the most, during favorable public market signals, were those with the most industry experience. In addition, they argue that such VC firms did not overreact to public signals since there was no evidence of a negative impact in their performance. However, we did not know who invests the most during VC investment waves. The following subsection examined the profiles of VC firms who invested in the different timing categories we studied in this paper. The characteristics we examined were mainly related to the investment experience and the social network of the VC firm. As liquidity was an important factor driving a wave (Harford, 2005), we also investigated when firms with more fund liquidity timed their investment. Unfortunately, we did not have access to data about capital committed by limited partners. We base our analysis on a liquidity ratio constructed from the amounts invested by funds at each investment date. This will enable us to understand whether VC firms investing before, or early in a wave, was due to fund liquidity.

3.5.1 Explanatory variables

Industry experience was a dummy variable which equaled one when the total number of investments made by the VC firm, in the corresponding industry, was higher than the average number of investments in that industry. A VC firm was considered experienced in an industry if they had more investments in an industry than the average.

Industry specialization represented the share of the VC firm's portfolio in the industry in which the investment was made. The higher this ratio, the more specialized a VC firm was in the industry.

Industry eigen corresponded to the eigen vector centrality measure of the VC firm, computed for the industry in which the investment was made. It reflected how well connected was a VC firm throughout the industry in which it invests.

Fund exit rate reflected the proportion of a fund's investments that exited via IPO or M&A. It was a lagged value. See section 3.4.2 for more detail.

Fund liquidity represented the ratio of the difference between the total amount invested by a fund and the amount invested up to the investment date, over the total amount invested. A high fund liquidity ratio meant that the VC firm had not invested a high proportion of their total capital.

3.5.2 Experience and network

Table 3.11 reported how industry experience, specialization and social network contributed to the investment in the timing category defined, which was the dependent variable. It suggested that being experienced in an industry implied that the VC firm was more likely to invest in wave. Similarly, industry specialization increased this probability by 8.3 percentage points. We observed that industry specialization lowered the probability of investing in pre wave or early wave periods. These results suggested that experienced and specialized VC firms were less likely to accept risk by investing in high uncertainty periods. This may appear quite surprising at first glance since concentrated expertise was expected to predict early entry in industry waves, as suggested by Dimov and De Holan (2005). One might expect VCs with a better reputation, more industry experience or specialization to have the knowledge and resources to invest earlier.

We considered that a large social network was a key element in venture capital to detect good investment opportunities and higher fund returns (Hochberg et al., 2007), we reevaluated investment experience and industry experience with a social network measure. When we looked at the coefficients associated with Industry Eigen, we saw that being well connected in the industry of the investment decreased the probability of investing in wave. However, it did not confirm that a well connected VC firm was more likely to invest earlier. We reanalyzed these last results in table 3.12 through interaction effects, to better understand how industry experience, specialization and network influenced investment decisions.

While the results observed in table 3.11 did not show a clear picture on early investments and social networks, table 3.12 provided more information. When we interacted industry experience and the eigen vector centrality measure (Exp $\times$ Eigen), we observed that the probability to invest in the increasing part of a wave increased by 35.9 percentage points. Hence, being well connected in an industry conditionally on being experienced increased significantly the probability of investing earlier in a wave. VC firms with the most industry experience accepted more risk if they were well connected. This finding was in line with the positive correlation between early wave investments and success. We also noticed that well connected and experienced VC Firms did not invest in periods that were far from the waves. Regarding industry specialization, column (3) revealed that being specialized did not systematically increase the probability of investing in wave. On the contrary, being specialized and well connected in an industry reduced the probability of investing in wave by 25.4 percentage points. Therefore, specialized investors who were shown to invest in wave or post wave, were essentially the less connected ones. The VC firms who were experienced or specialized and also well connected in an industry, might be

more aware of the actual risk behind early and late investments.

3.5.3 Past performance and liquidity

Tables 3.13 and 3.14 reported how liquidity and past fund exit rates explained the decision to invest in a specific time period. Fund exit rate reflected the proportion of a fund's investments that exited via IPO or M&A. Fund liquidity was the ratio of, the difference between the total amount invested by a fund and the amount invested up to the investment date, over the total amount invested. To interpret our results as predictions, we used lagged values for both of these variables.

Table 3.13 established that both explanatory variables significantly impacted the decision to invest. One of the most important drivers of early investments appeared to be fund liquidity. More available liquidity at a fund level increased the probability of investing early in a wave by 15.9 percentage points. Therefore, VCs who invested early, were not necessarily motivated due to their ability to identify good investment opportunities. It may have been be due to lower liquidity constraints compared to other VCs who invested later. Columns (2) and (5) showed that funds with high successful exit rates were more likely to invest in pre wave and early wave periods. This finding implied that, one of the reasons why pre wave and early wave periods predicted a successful exit, may be the quality of the VC firms investing in such periods or the persistence of their initial success (Nanda et al., 2020).

While we could extend the previous explanations to post wave investments, they did not hold for in wave investments. Column (1) of table 3.14, showed that fund liquidity increased the probability of investing in wave as well. Hence, it was not only a matter of liquidity why VCs decided whether to invest earlier or later in a wave. In column (2), we observed that the past fund exit rate did not influence the decision to invest in wave. This lead us to think that in wave investments predict failure independently of VCs' quality.

Nevertheless, columns (3) and (4) supported that, post wave investments were more likely to occur if a fund did not have liquidity and if it had a low exit rate. Investing one year after a wave did not seem to be a choice made by VCs. However, columns (5) and (6) provided further insights. Low fund liquidity increased the probability of investing in periods that were far from waves. At the same time, such funds were more likely to exhibit lower success rates compared to those investing post wave. Therefore, we cannot attribute a post wave investment failure to the quality of the VC. Indeed, post wave investments were less likely to succeed relative to investments made in other periods.

3.6 Conclusion

In this paper we investigated, for the first time, in a wave context, the relationship between the timing of a venture capital investment and its performance. We explore whether investing in a wave or outside of a wave impacts the investment outcome. More specifically, we split wave periods between early wave and in wave periods, to better understand the pattern of performance during the wave. In addition, regarding out of wave periods, we examined quarters preceding and following waves. Based on a similar approach to Mitchell and Mulherin (1996) and using quarterly data aggregated by industry, we identified 11 industry waves. Two out of ten industries had two waves while three of them had none.

We provided evidence that, although pre wave and early wave periods were characterized by high uncertainty, investing in such periods presented higher chances of success relative to in wave or any other period. On the contrary, in wave and post wave investments decreased the success probability by almost 3 percentage points. This result was consistent with prior research on private equity (Kaplan & Stromberg, 2009; Robinson & Sensoy, 2016) and merger waves (Moeller et al., 2005; Yan, 2011; Duchin & Schmidt, 2013). Our findings empirically supported the decreasing pattern of performance during venture capital waves. Higher risk was thus associated with higher return. On the contrary, delaying investments to reduce risk or waiting to "share the blame" was more likely to predict failure. Therefore, investors should reassess the risk associated with pre wave and early wave investments. Those who already invest in early periods, were probably aware of the actual risk behind early investments. We found that they were VCs with industry experience and specialization who were well connected in their industry. In addition, they were more likely to have liquidity and high past success records. However, those investing in wave did not appear to have any liquidity constraint. Delaying their investments until in wave seemed to be a decision they take. Such a preference had, however, more chances to predict a failure, independently of the quality of the VC firm.

3.7 Figures

Figure 3.1: Investments over time by industry

This figure plots the evolution of the number of investments in each industry over time from 1997 to 2017

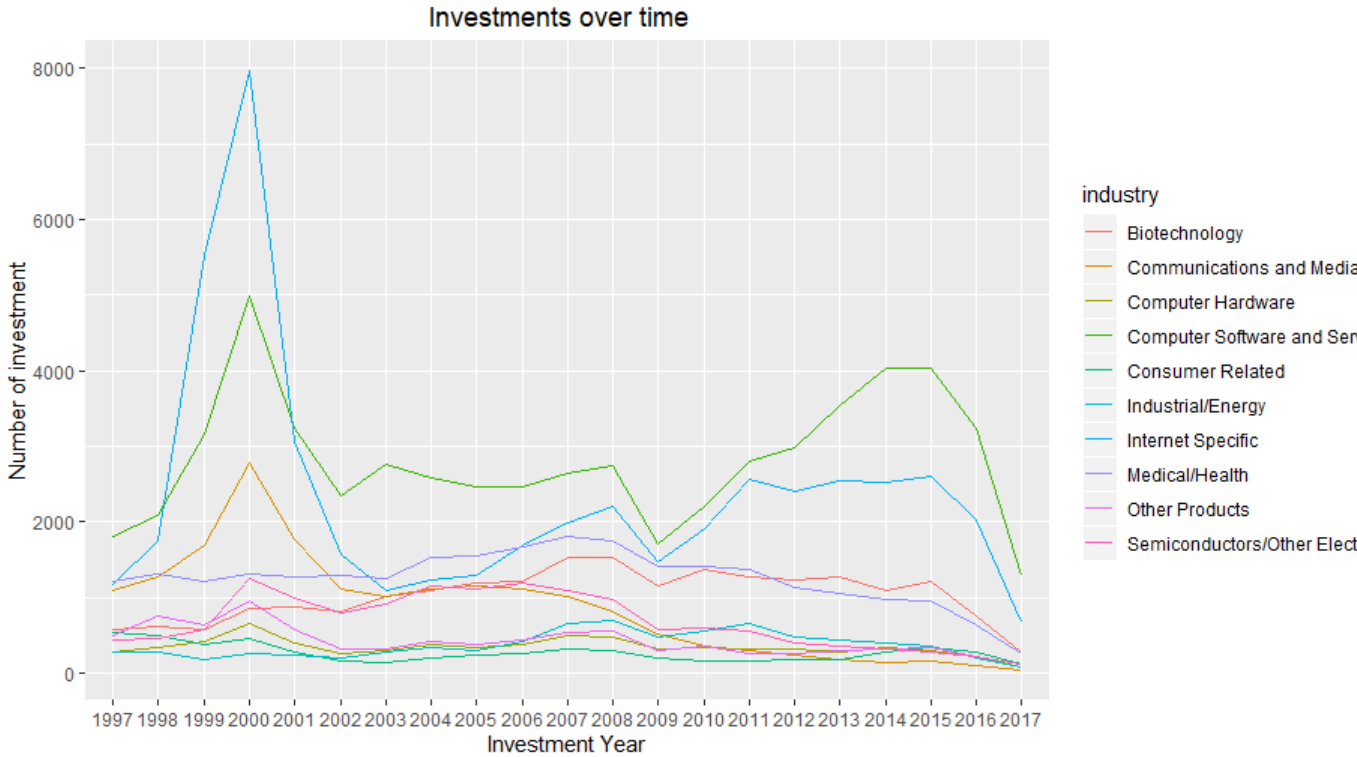
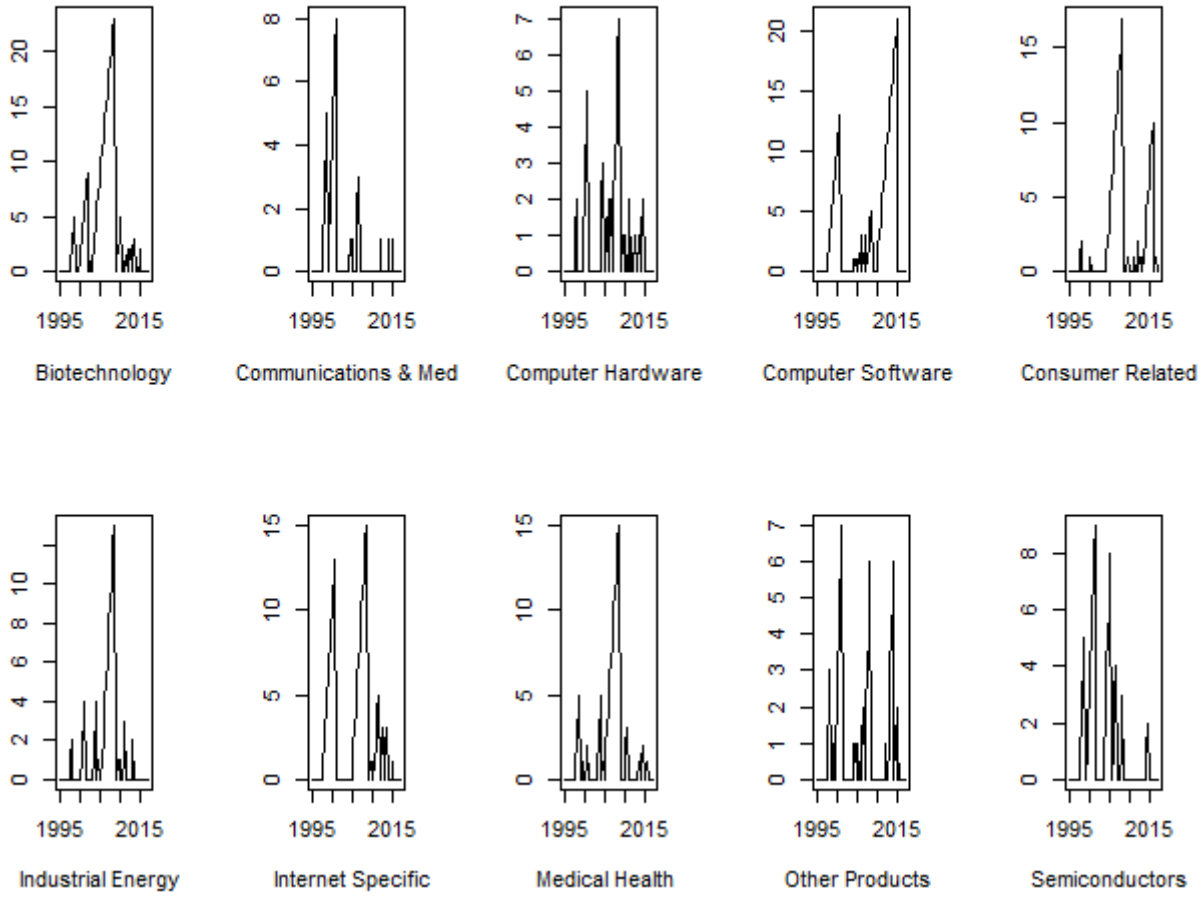


Figure 3.2: Wave count by industry

These graphs represent the counts of consecutive above average quarters for each industry. The counts exceeding 8 correspond to industry waves.



3.8 Tables

Table 3.1: VC Firm level description

This table describes our
data restricted to US investments, from January 1997 to September 2016, at VC firm level.

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
Total Investment (deal)	7,585	27.84	94.81	1	1	16	2,342
Nb of company	7,585	12.81	34.59	1	1	10	788
Nb of Industry	7,585	2.98	2.36	1	1	4	10
Nb of Fund	7,585	1.93	2.26	1	1	2	66
Successful Cie	7,585	12.58	48.67	0	0	6	1,182
Total Fund Size	7,585	4,882.45	53,914.56	0	0	341	3,075,562
Investment size (M)	7,585	80.25	353.77	0.00	1.99	37.90	10,870.02
Avg investment size (M)	7,585	3.07	10.12	0.00	0.78	3.30	693.37

Table 3.2: Fund level description

This table describes our data restricted to US investments, from January 1997 to September 2016, at VC fund level.

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
Total Investment (deal)	14,560	14.50	35.96	1	1	13	1,341
Nb of company	14,560	8.11	18.15	1	1	8	570
Nb of Industry	14,560	2.75	2.04	1	1	4	10
Nb of VC	14,560	1.00	0.30	1	1	1	37
Successful Cie	14,560	6.55	17.46	0	0	6	575
Total Fund Size	14,560	2,543.50	19,130.53	0	0	395.1	1,180,000
Investment size (M)	14,560	3.13	11.03	0.00	0.77	3.31	840.41
Avg investment size (M)	14,560	1.07	0.70	0.00	0.57	1.46	6.74

Table 3.3: Company level description

This table describes our data restricted to US investments, from January 1997 to September 2016, at company level.

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
Total Investment (deal)	33,330	6.34	8.98	1	1	8	419
Nb of VCs	33,330	2.91	2.78	1	1	4	28
Nb of funds	33,330	3.54	3.82	1	1	5	52
Nb of industry	33,330	1.00	0.02	1	1	1	2
Investment size (M)	33,330	18.26	46.93	0.00	0.75	19.49	2,473.47
Avg investment size (M)	33,330	3.16	13.66	0.00	0.35	3.17	1,390.00

Table 3.4: Waves description by industry

This table reports, for each industry, the beginning and end dates (year.quarter) for the first and second waves when they existed. It also indicates the wave length in terms of quarters. The wave length corresponds to the number of consecutive quarters during which the number of investments in an industry exceed the moving average of this industry investments.

Industry	Wave 1			Wave 2		
	Beginning	End	Length (Qtr)	Beginning	End	Length (Qtr
Biotechnology	2000.1	2002.1	9	2003.2	2008.4	23
Communications and Media		-			-	
Computer Hardware		-			-	
Computer Software and Services	1997.4	2000.4	13	2010.2	2015.2	21
Consumer Related	2004.3	2008.3	17	2013.4	2016.1	10
Industrial/Energy	2005.4	2008.4	13		-	
Internet Specific	1997.4	2000.4	13	2005.2	2008.4	15
Medical/Health	2005.2	2008.4	15		-	
Other Products		-			-	
Semiconductors/Other Elect.	1999.3	2001.3	9		-	

Table 3.5: Status by timing category

This table reports the total number of successful exits in each phase of a wave and the final company status which attributed to the success.

	Nb of Success	Acquisition	Mergers	IPO
Pre Wave	5018	3634	173	1211
Early Wave	15922	11542	440	3940
In Wave	16829	13036	413	3380
Post Wave	6421	5145	152	1124
Other Periods	43789	33146	1158	9485

Table 3.6: Descriptive Statistics

This table reports the descriptive statistics for the variables used in the analysis of investment waves. Panel A was for the full sample in the database. Panel B were investments made in the Pre Wave phase. Panel C were investments made in the Early Wave. Panel D were investments made during the Wave. Panel E contains the descriptive statistics for the investments made Post Wave.

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
Panel A: Full Sample							
Fund Exit Rate	162,309	0.46	0.33	0.00	0.17	0.67	1.00
Nb of VC/cie	210,292	3.33	2.84	1	1	4	29
Fund Sequence	210,292	1.66	1.36	0	0	3	3
Industry Specialization	210,292	0.34	0.24	0	0.2	0.5	1
Industry Experience	210,292	0.46	0.50	0	0	1	1
Industry Eigen	198,859	0.04	0.15	0.00	0.0000	0.01	1.00
Successful Exit	210,292	0.43	0.49	0	0	1	1
Panel B: Pre Wave							
Fund Exit Rate	6,493	0.53	0.34	0.00	0.33	0.79	1.00
Nb of VC/cie	8,988	3.54	2.94	1	1	5	24
Fund Sequence	8,988	1.77	1.33	0	0	3	3
Industry Specialization	8,988	0.33	0.24	0.004	0.16	0.43	1.00
Industry Experience	8,988	0.46	0.50	0	0	1	1
Industry Eigen	8,563	0.04	0.15	0.00	0.0000	0.01	1.00
Successful Exit	8,988	0.56	0.50	0	0	1	1
Panel C: Early Wave							
Fund Exit Rate	21,770	0.54	0.34	0.00	0.30	0.80	1.00
Nb of VC/cie	29,851	3.57	2.97	1	1	5	24
Fund Sequence	29,851	1.70	1.34	0	0	3	3
Industry Specialization	29,851	0.34	0.24	0.004	0.17	0.46	1.00
Industry Experience	29,851	0.48	0.50	0	0	1	1
Industry Eigen	28,324	0.04	0.15	0.00	0.0000	0.01	1.00
Successful Exit	29,851	0.53	0.50	0	0	1	1
Panel D: In Wave							
Fund Exit Rate	32,726	0.44	0.33	0.00	0.05	0.67	1.00
Nb of VC/cie	42,434	3.28	2.82	1	1	4	27
Fund Sequence	42,434	1.58	1.35	0	0	3	3
Industry Specialization	42,434	0.39	0.24	0.002	0.23	0.50	1.00
Industry Experience	42,434	0.49	0.50	0	0	1	1
Industry Eigen	40,329	0.03	0.13	0.00	0.0000	0.01	1.00
Successful Exit	42,434	0.40	0.49	0	0	1	1
Panel E: Post Wave							
Fund Exit Rate	12,892	0.39	0.32	0.00	0.00	0.60	1.00
Nb of VC/cie	16,110	3.35	2.89	1	1	4	26
Fund Sequence	16,110	1.64	1.36	0	0	3	3
Industry Specialization	16,110	0.38	0.24	0.003	0.21	0.50	1.00
Industry Experience	16,110	0.46	0.50	0	0	1	1
Industry Eigen	15,154	0.04	0.14	0.00	0.0000	0.01	1.00
Successful Exit	16,110	0.40	0.49	0	0	1	1

Table 3.7: VC investment waves and performance - All waves

This table reports linear probability model estimates to predict the exit outcome of investments made in different timing categories. The sample consists of VC deals made in the US from January 1997 to September 2016 in industries that had at least one VC investment wave. The dependent variable was a dummy variable that takes the value of one if the investment went public, was acquired or merged. Early Wave, In Wave, Pre Wave and Post Wave were dummy variables equal to one when the investment date (in quarter) belongs to the corresponding timing category of the industry in which the investment was made. A wave occurs if 8 consecutive quarters of an industry had above average investments. All the above average investment quarters starting from the 8th one were labeled as In Wave. Early Wave was defined as the time period between the first above average investment quarter, that was the beginning of the wave, and the in wave period. Pre Wave and Post Wave periods were defined as one year before and one year after an industry wave. Control variables include the past successful exit rate (Lagged Exit Rate) computed at fund level, the number of VCs investing in the company up to the investment date (Nb of VCs) and the fund sequence. Columns (1) and (2) includes only industry fixed effects while columns (3) and (4) includes both industry and time fixed effects. Clustered standard errors at VC firm level were reported in parentheses. *,** and *** refer to significance at 10, 5 and 1% levels, respectively.

	Dependent variable:			
	Exit via IPO or M&A			
	(1)	(2)	(3)	(4)
Early Wave	0.095***	0.107***	0.015**	0.015**
	(0.006)	(0.007)	(0.006)	(0.007)
In Wave	−0.012**	−0.0004	−0.028***	−0.029***
	(0.005)	(0.006)	(0.006)	(0.006)
Pre Wave		0.125***		0.017*
		(0.009)		(0.009)
Post Wave		0.005		−0.028***
		(0.006)		(0.007)
Lagged Exit Rate	0.231***	0.227***	0.114***	0.113***
	(0.010)	(0.010)	(0.008)	(0.008)
Nb of VCs	0.019***	0.019***	0.015***	0.015***
	(0.001)	(0.001)	(0.001)	(0.001)
Fund Sequence	0.028***	0.027***	0.007***	0.007***
	(0.003)	(0.003)	(0.002)	(0.002)
Time FE	No	No	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Observations	122,582	122,582	122,582	122,582
Adjusted R^2	0.059	0.061	0.145	0.146

Table 3.8: VC investment waves and performance - First waves

This table reports linear probability model estimates to predict the exit outcome of investments made in different timing categories of the first industry waves. The sample consists of VC deals made in the US from January 1997 to September 2016 in industries that had at least one VC investment wave. The dependent variable was a dummy variable that takes the value of one if the investment went public, was acquired or merged. Early Wave , In Wave , Pre Wave and Post Wave were dummy variables equal to one when the investment date (in quarter) belongs to the corresponding timing category of the industry in which the investment was made. The number associated with each timing category (1) refers to the industry's wave number (first waves). A wave occurs if 8 consecutive quarters of an industry had above average investments. All the above average investment quarters starting from the 8th one were labeled as In Wave. Early Wave was defined as the time period between the first above average investment quarter, that was the beginning of the wave, and the in wave period. Pre Wave and Post Wave periods were defined as one year before and one year after an industry wave. Control variables include the past successful exit rate (Lagged Exit Rate) computed at fund level, the number of VCs investing in the company up to the investment date (Nb of VCs) and the fund sequence. Columns (1) and (2) includes only industry fixed effects while columns (3) and (4) includes both industry and time fixed effects. Clustered standard errors at VC firm level were reported in parentheses. *,** and *** refer to significance at 10, 5 and 1% levels, respectively.

	Dependent variable:			
	Exit via IPO or M&A			
	(1)	(2)	(3)	(4)
Early Wave 1	0.174***	0.192***	0.033***	0.032***
	(0.008)	(0.008)	(0.008)	(0.009)
In Wave 1	0.092***	0.110***	−0.043***	−0.043***
	(0.007)	(0.007)	(0.009)	(0.009)
Pre Wave 1		0.204***		0.040***
		(0.012)		(0.012)
Post Wave 1		0.131***		−0.038***
		(0.008)		(0.010)
Lagged Exit Rate	0.216***	0.208***	0.114***	0.113***
	(0.010)	(0.010)	(0.008)	(0.008)
Nb of VCs	0.018***	0.018***	0.015***	0.015***
	(0.001)	(0.001)	(0.001)	(0.001)
Fund Sequence	0.027***	0.025***	0.007***	0.007***
	(0.003)	(0.002)	(0.002)	(0.002)
Time FE	No	No	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Observations	122,582	122,582	122,582	122,582
Adjusted R^2	0.065	0.073	0.146	0.146

Table 3.9: VC investment waves and performance - Second waves

This table reports linear probability model estimates to predict the exit outcome of investments made in different timing categories of the second industry waves. The sample consists of VC deals made in the US from January 1997 to September 2016 in industries that had two VC investment wave. The dependent variable was a dummy variable that takes the value of one if the investment went public, was acquired or merged. Early Wave , In Wave , Pre Wave and Post Wave were dummy variables equal to one when the investment date (in quarter) belongs to the corresponding timing category of the industry in which the investment was made. The number associated with each timing category (2) refers to the industry's wave number (second waves). A wave occurs if 8 consecutive quarters of an industry had above average investments. All the above average investment quarters starting from the 8th one were labeled as In Wave. Early Wave was defined as the time period between the first above average investment quarter, that was the beginning of the wave, and the in wave period. Pre Wave and Post Wave periods were defined as one year before and one year after an industry wave. Control variables include the past successful exit rate (Lagged Exit Rate) computed at fund level, the number of VCs investing in the company up to the investment date (Nb of VCs) and the fund sequence. Columns (1) and (2) includes only industry fixed effects while columns (3) and (4) includes both industry and time fixed effects. Clustered standard errors at VC firm level were reported in parentheses. *,** and *** refer to significance at 10, 5 and 1% levels, respectively.

	Dependent variable:			
	Exit via IPO or M&A			
	(1)	(2)	(3)	(4)
Early Wave 2	−0.032***	−0.048***	−0.006	−0.006
	(0.008)	(0.008)	(0.009)	(0.009)
In Wave 2	−0.132***	−0.150***	−0.015**	−0.015**
	(0.008)	(0.008)	(0.007)	(0.007)
Pre Wave 2		0.002		−0.003
		(0.012)		(0.012)
Post Wave 2		−0.214***		−0.003
		(0.010)		(0.009)
Lagged Exit Rate	0.232***	0.220***	0.114***	0.114***
	(0.010)	(0.010)	(0.008)	(0.008)
Nb of VCs	0.019***	0.019***	0.015***	0.015***
	(0.001)	(0.001)	(0.001)	(0.001)
Fund Sequence	0.027***	0.025***	0.007***	0.007***
	(0.003)	(0.003)	(0.002)	(0.002)
Time FE	No	No	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Observations	122,582	122,582	122,582	122,582
Adjusted R^2	0.060	0.066	0.145	0.145

Table 3.10: VC investment waves and performance - All waves

This table reports linear probability model estimates to predict the exit outcome of investments made in different timing categories. The sample consists of VC deals made in the US from January 1997 to September 2016 in industries that had at least one VC investment wave. The dependent variable was a dummy variable that takes the value of one if the investment went public, was acquired or merged. Early Wave, In Wave, Pre Wave and Post Wave were dummy variables equal to one when the investment date (in quarter) belongs to the corresponding timing category of the industry in which the investment was made. A wave occurs if 8 consecutive quarters of an industry had above average investments. All the above average investment quarters starting from the 8th one were labeled as In Wave. Early Wave was defined as the time period between the first above average investment quarter, that was the beginning of the wave, and the in wave period. Pre Wave and Post Wave periods were defined as one year before and one year after an industry wave. Control variables include the past successful exit rate (Lagged Exit Rate) computed at fund level, the number of VCs investing in the company up to the investment date (Nb of VCs) and the fund sequence. All estimations include both industry and time fixed effects. Clustered standard errors at VC firm level were reported in parentheses. *,** and *** refer to significance at 10, 5 and 1% levels, respectively.

	Dependent variable:			
	Exit via IPO or M&A			
	(1)	(2)	(3)	(4)
Early Wave	0.021***			
	(0.006)			
In Wave		−0.031***		
		(0.006)		
Pre Wave			0.018**	
			(0.009)	
Post Wave				−0.028***
				(0.007)
Lagged Exit Rate	0.114***	0.114***	0.114***	0.114***
	(0.008)	(0.008)	(0.008)	(0.008)
Nb of VCs	0.015***	0.015***	0.015***	0.015***
	(0.001)	(0.001)	(0.001)	(0.001)
Fund Sequence	0.007***	0.007***	0.007***	0.007***
	(0.002)	(0.002)	(0.002)	(0.002)
Time FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Observations	122,582	122,582	122,582	122,582
Adjusted R^2	0.145	0.145	0.145	0.145

Table 3.11: Industry experience, specialization and network

This table reports linear probability model estimates to analyze which characteristics of VCs predict their likelihood to invest in a given time period with respect to an industry wave. The sample consists of VC deals made in the US from January 1997 to September 2016 in industries that had at least one VC investment wave. The dependent variables are dummy variables equal to one when the investment date (in quarter) belongs to the corresponding timing category of the industry in which the investment was made. A wave occurs if 8 consecutive quarters of an industry had above average investments. All the above average investment quarters starting from the 8th one were labeled as In Wave. Early Wave was defined as the time period between the first above average investment quarter, that was the beginning of the wave, and the in wave period. Pre Wave and Post Wave periods were defined as one year before and one year after an industry wave. Other Periods were periods that belong to none of the previous four categories. Among the explanatory variables, Industry Experience was a dummy variable equals to one whenever the total number of investments made by the VC firm, in the corresponding industry, was higher than the average number of investments of that industry. A VC was considered as experienced in an industry if they had more investments in this industry than the average. Industry Specialization represents the share of the VC firm's portfolio in the industry in which the investment was made. The higher was this ratio the more specialized was a VC firm in an industry. Industry Eigen was a network measure. It corresponds to the eigen vector centrality of the VC firm, computed for the industry in which the investment was made. Namely, it reflects how well connected was a VC firm in the industry in which it invests. All estimations include industry fixed effects. Clustered standard errors at VC firm level were reported in parentheses. *,** and *** refer to significance at 10, 5 and 1% levels, respectively.

	Dependent variable:				
	Pre Wave	Early Wave	In Wave	Post Wave	Other Periods
	(1)	(2)	(3)	(4)	(5)
Industry Experience	−0.002	−0.001	0.016**	0.001	−0.013
	(0.002)	(0.005)	(0.006)	(0.003)	(0.008)
Industry Specialization	−0.036***	−0.081***	0.083***	0.033***	0.002
	(0.004)	(0.012)	(0.011)	(0.006)	(0.019)
Industry Eigen	0.007	0.014	−0.055***	0.001	0.030
	(0.008)	(0.026)	(0.018)	(0.010)	(0.044)
Industry FE	Yes	Yes	Yes	Yes	Yes
Observations	149,928	149,928	149,928	149,928	149,928
Adjusted R^2	0.004	0.005	0.052	0.007	0.073

Table 3.12: Industry experience, specialization and network

This table reports linear probability model estimates to analyze which characteristics of VCs predict their likelihood to invest in a given time period with respect to an industry wave. The sample consists of VC deals made in the US from January 1997 to September 2016 in industries that had at least one VC investment wave. The dependent variables are dummy variables equal to one when the investment date (in quarter) belongs to the corresponding timing category of the industry in which the investment was made. A wave occurs if 8 consecutive quarters of an industry had above average investments. All the above average investment quarters starting from the 8th one were labeled as In Wave. Early Wave was defined as the time period between the first above average investment quarter, that was the beginning of the wave, and the in wave period. Pre Wave and Post Wave periods were defined as one year before and one year after an industry wave. Other Periods were periods that belong to none of the previous four categories. Among the explanatory variables, Industry Experience was a dummy variable equals to one whenever the total number of investments made by the VC firm, in the corresponding industry, was higher than the average number of investments of that industry. A VC was considered as experienced in an industry if they had more investments in this industry than the average. Industry Specialization represents the share of the VC firm's portfolio in the industry in which the investment was made. The higher was this ratio the more specialized was a VC firm in an industry. Industry Eigen was a network measure. It corresponds to the eigen vector centrality of the VC firm, computed for the industry in which the investment was made. Namely, it reflects how well connected was a VC firm in the industry in which it invests. Exp × Eigen was an interaction term between industry experience and industry network. Specialization × Eigen was an interaction term between industry specialization and network. All estimations include industry fixed effects. Clustered standard errors at VC firm level were reported in parentheses. *,** and *** refer to significance at 10, 5 and 1% levels, respectively.

	Dependent variable:				
	Pre Wave	Early Wave	In Wave	Post Wave	Other Periods
	(1)	(2)	(3)	(4)	(5)
Industry Experience	−0.002	−0.003	0.014**	0.001	−0.010
	(0.002)	(0.005)	(0.006)	(0.003)	(0.008)
Industry Specialization	−0.038***	−0.079***	0.090***	0.035***	−0.008
	(0.004)	(0.011)	(0.011)	(0.006)	(0.018)
Industry Eigen	−0.075	−0.305*	−0.285	0.076	0.568
	(0.087)	(0.168)	(0.219)	(0.123)	(0.385)
Exp × Eigen	0.061	0.359**	0.329	−0.043	−0.679*
	(0.087)	(0.160)	(0.213)	(0.125)	(0.366)
Specialization × Eigen	0.056	−0.096	−0.254**	−0.083	0.357
	(0.072)	(0.257)	(0.111)	(0.074)	(0.432)
Industry FE	Yes	Yes	Yes	Yes	Yes
Observations	149,928	149,928	149,928	149,928	149,928
Adjusted R^2	0.004	0.005	0.052	0.007	0.073

Table 3.13: Liquidity, performance and early investments

This table reports linear probability model estimates to analyze how potentially available liquidity and past performance impacted VCs' likelihood to make early times investments. The sample consists of VC deals made in the US from January 1997 to September 2016 in industries that had at least one VC investment wave. The dependent variables were dummy variables equal to one when the investment date (in quarter) belongs to the corresponding timing category of the industry in which the investment was made. A wave occurs if 8 consecutive quarters of an industry had above average investments. Early Wave was defined as the time period between the first above average investment quarter, that was the beginning of the wave, and the 8th above average quarter. Pre Wave was defined as one year before an industry wave. The two explanatory variables were lagged variables. Fund Exit Rate reflects the proportion of a fund's investments that exited via IPO or M&A. It was computed in a way to capture information at the investment date. Namely, a success was considered as realized after the last investment date of the company if the reported stage was "Seed", "Early Stage" or "Bridge Loan". Fund liquidity represents the ratio of, the difference between the total amount invested by a fund and the amount invested up to the investment date, over the total amount invested. All estimations include industry fixed effects. Clustered standard errors at VC firm level were reported in parentheses. *,** and *** refer to significance at 10, 5 and 1% levels, respectively.

	Dependent variable:			
	Pre Wave		Early Wave	
	(1)	(2)	(3)	(4)
Fund Liquidity	0.043***		0.159***	
	(0.003)		(0.006)	
Fund Exit Rate		0.026***		0.102***
		(0.003)		(0.008)
Industry FE	Yes	Yes	Yes	Yes
Observations	163,129	122,582	163,129	122,582
Adjusted R^2	0.005	0.004	0.019	0.011

Table 3.14: Liquidity, performance and late investments

This table reports linear probability model estimates to analyze how potentially available liquidity and past performance impacted VCs' likelihood to make late wave or out of wave investments. The sample consists of VC deals made in the US from January 1997 to September 2016 in industries that had at least one VC investment wave. The dependent variables were dummy variables equal to one when the investment date (in quarter) belongs to the corresponding timing category of the industry in which the investment was made. A wave occurs if 8 consecutive quarters of an industry had above average investments. All the above average investment quarters starting from the 8th one were labeled as In Wave. Post Wave periods were defined as one year before and one year after an industry wave. Other Periods were periods that belong to none of the four timing category we examined in this paper (pre, early, in and post wave). The two explanatory variables were lagged variables. Fund Exit Rate reflects the proportion of a fund's investments that exited via IPO or M&A. It was computed in a way to capture information at the investment date. Namely, a success was considered as realized after the last investment date of the company if the reported stage was "Seed", "Early Stage" or "Bridge Loan". Fund liquidity represents the ratio of, the difference between the total amount invested by a fund and the amount invested up to the investment date, over the total amount invested. All estimations include industry fixed effects. Clustered standard errors at VC firm level were reported in parentheses. *,** and *** refer to significance at 10, 5 and 1% levels, respectively.

	Dependent variable:					
	In Wave		Post Wave		Other Periods	
	(1)	(2)	(3)	(4)	(5)	(6)
Fund Liquidity	0.051***		− 0.073***		−0.176***	
	(0.007)		(0.005)		(0.009)	
Fund Exit Rate		0.007		−0.051***		−0.083***
		(0.008)		(0.005)		(0.012)
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	163,129	122,582	163,129	122,582	163,129	122,582
Adjusted R^2	0.054	0.051	0.013	0.011	0.089	0.077

Chapter 4

Are Bridge Loans a Bridge to Nowhere?

Abstract : Bridge loans are temporary loans between financing rounds or as a stopgap to failure. Just under 11% of the 35,939 venture funded companies in the Thomson One Banker, from 1995 through 2017, received bridge loans. In that universe of companies, 6% went public while 0.06% of companies with bridge loans went public. By a broader measure of success, 40% of the companies successfully exited while it was 0.7% for companies with bridge loans. This paper examines why venture capitalists used bridge loans in a significant number of their investments even though the instrument had a low success rate. The analysis provides evidence that bridge loans may be employed to manage fund IRR, be a result of local bias and an example of late-staging.

4.1 Introduction

Venture capitalists use a variety of financial instruments to fund companies in their portfolio. These instruments include debt and equity instruments such as common equity, preferred equity, senior debt, convertible debt and bridge loans (P. A. Gompers, 1999; Marx, 1998). Even though 11 percent of the transactions in Thomson One Banker, from 1995 to 2017 were bridge loans, the existing literature did not explore bridge loans and the circumstances which make them an efficient choice.

The goal of this paper is to examine the economics of bridge loans and their affect on investment outcomes for the general partners, limited partners and portfolio company. I examined the characteristics of the venture capital firms who used bridge loans as a financing instrument and the companies which received them to determine if there were identifiable strategies and benefits of using bridge loans. Due to the length of the history, it was possible to determine if bridge loans contributed to positive exits.

To explore why 11% of the companies had bridge loans and determine the characteristics of the VC firms and companies with bridge loans, the 228,418 venture investment transactions from Thomson One Banker, covering 1995 to 2017, were analyzed (Descriptive statistics are in tables 4.1 to 4.3). The data had information about the VC firm, VC fund, the company and the investment characteristics. The status of companies in the database are listed in table 4.4 to 4.6.

Across the 15,593 distinct funds in the data base, 3,676 funds used bridge loans and 2,236 used more than one bridge loan. An even smaller amount, 383 funds, used more than ten bridge loans. Independent private partnerships (table 4.5) financed firms with the highest number of bridge loans at 2,708. As a percentage of their total investments, some venture types used a high percentage of bridge loans. Some examples were: government programs, the largest, at 31%, evergreen funds at 14% and business angels at 14%. Even though the percentages were high, the total number of bridge investments for these 3 types was less than those by independent private partnerships. Evergreen funds contained, among other structures, family offices and trusts.

Companies which received bridge loans had a 0.7% success rate, using a broad measure of success, compared to 40% for companies without a bridge loan. Using an IPO as the measure of success, 0.06% of companies with bridge loans went public while it was 6% for those without bridge loans. For comparison, companies with standard venture debt had a 56% success rate. The failure rate for companies with bridge loans was similar to firms in financial distress (Gilson, 1997; Kahl, 2002).

There are numerous papers on the structure of venture capital firms and the use of staging in venture investments (Kaplan & Strömberg, 2004; Sahlman, 1990).

The work by Kaplan and Strömberg did not include bridge loans as a financing instrument or as one of the investment stages. This paper will concentrate solely on bridge loans. Cornelli and Yosha (2003) provided a rationale for the use of staging to cancel poor performance investments and window-dressing by the entrepreneur. As with Kaplan and Strömberg, Cornelli and Yosha did not consider bridge loans or window-dressing by the venture capitalist.

VC firms may used bridge loans due to incentive conflicts with the payout structure of the funds they manage for the limited partners. Bridge loans prevent a portfolio company from failing and, thereby, reducing the fund internal rate of return. Barber and Yasuda (2017) demonstrate that private equity firms manage their fund net asset value when raising a new fund without discussing how it could be managed. This paper provides evidence consistent with these findings that VC fund general partners can manage the fund IRR with bridge loans.

Since VC firms receive a 2 percent management fee on the assets in the fund (Klonowski, 2010), there was a direct benefit to the VC firm from temporarily rescuing the portfolio company from failure when the VC firm was raising a new fund. This temporary improvement in fund IRR assists the VC firm when they raise a fee generating follow-on fund (Kollmann, Kuckertz, & Middelberg, 2014) or make capital calls and prolong the life of the fund. Using bridge loans, as examined in this paper, an inexperienced VC may temporarily improve the fund IRR while they raise a fee generating follow-on fund. An experienced venture capitalist did not use bridge loans when they raised a new fund. However, an experienced VC would benefit from maintaining a stable fund IRR to continue receiving capital calls. Ninety seven percent of VC funds, who used bridge loans, employed the bridge loan in the last quarter of the life of the fund (table 4.6) while, in the universe of all VC funds, invested just 25% in the final quarter.

The VC firm, in another form of an incentive conflict, may use bridge loans to show effort and activity when they did not have good projects to fund. This was similar to the problem Special Purpose Acquisition Companies (SPAC) had when forced to make an investment within a short time-frame. VC firms had a limited time to invest and return capital. It may be, as Dimitrova (2017) had found with SPACs, that it was beneficial to the managing partners to make a bad investment while it destroys value in the SPAC. Bridge loans had a negative impact on fund IRR but demonstrate activity and effort.

Key findings of the paper were that companies which were financed with bridge loans had a very low success rate; VC Firms used bridge loans with a local bias to companies within the same state; Experienced VC firms used fewer bridge loans; A larger number of co-investors reduced the use of bridge loans; As the use of bridge loans increased in a fund, there was a greater chance it was the last fund; Investments

at the end of the fund life had a low success rate; As fund liquidity decreased, the success rate of investments decreased; and over 95% of bridge loans were utilized in the last quarter of the fund life.

I extend the results from Barber and Yasuda (2017) that bridge loans may be a method VC firms used to manage interim fund performance. I extend the papers by Atanasova and Chemla (2020) and Hochberg and Rauh (2013) and provide evidence that bridge loans were an indicator of a familiarity bias which was used to support companies in the same American state as the VC firm. It is possible that VC firms want to show effort to the local limited partners or believe that more time and attention would improve the outcome. To test this conjecture, the firm, fund and company characteristics were regressed against a dummy variable which was set to 1 if the company received a bridge loan. The results (table 4.7) provided evidence that the use of a bridge loan was influenced by local bias, experience of the VC firm and the number of previous successes.

As mentioned above, companies financed with a bridge loan had a lower success rate. The dummy variable indicating success, which was a modified measure created by Phalippou and Gottschalg (2009), was regressed against VC firm and company characteristics. Table 4.8 demonstrates that the largest indicator for a failed investment, of those in the data base, was the use of a bridge loan. The VC firm internally decided to extend a bridge loan to their portfolio company. The analysis was checked for self-selection using the Heckman correction (table 4.9) and confirmed that there was self-selection which leads to a higher failure rate.

To test whether bridge loans contributed to the inability of VC firms to raise a new fund, a dummy variable was created for a VC Firm's last fund. This dummy variable was regressed against VC fund characteristics to examine if bridge loans were used more often by firms in their last fund. The results (table 4.10) demonstrates that this was the case unless the VC firm had high experience. A high experience VC used fewer bridge loans. However, if a high experience VC did use a large number of bridge loans, there was interaction between bridge loans and experience which provided a slight increase in the probability the the firm had raised its last fund. This was also checked for self-selection with a maximum likelihood Heckman correction , which supported the conjecture that there was self selection and the use of bridge loans increased the chance that the current fund was the last fund.

The decision to raise a new fund was endogenous to the VC firm. The assumption in the paper was that the VC Firm chose to raise a new fund and was unsuccessful. It is also possible that the VC Firm chose to close the firm without raising a new fund.

From an analysis of the investment dates, relative to the life of the fund, most

bridge loans were made in the last quarter of the fund life. To test if the time an investment was made during the life of a fund had an impact on the success rate, the success rate was regressed against the elapsed time for bridge loans and all investments. A further regression was made on the liquidity of the fund to determine if there was a relation between the liquidity of the fund and the timing of investments and bridge loans. The results (table 4.12) illustrated that the closer an investment was made to the end of a fund, the lower the success rate. As fund liquidity decreased, the success rate of investments decreased.

This paper proceeds as follows: Section 4.2 is a short review of related literature. Section 4.3 is a short discussion of bridge loans and their use in both venture capital and real estate. Section 4.4 describes the data and descriptive statistics. Section 4.5 examines the use of bridge loans. Section 4.6 looks at the effect bridge loans had on the success of an investment. Section 4.7 focused on the use of bridge loans and the last fund. Section 4.8 is an analysis of the effect on success the timing of investment, during the life of the fund, for bridge loans and all investments. Robustness checks were discussed in section 4.9. Section 4.10 concludes.

4.2 Related literature

Barber and Yasuda (2017) demonstrated firms practice NAV management when raising a follow-on fund with interim results of the previous fund. The analysis in this paper suggests VC firms may manage their IRR with bridge loans when raising a follow-on fund. Arcot, Fluck, Gaspar, and Hege (2015) discussed investment strategies of firms under pressure to raise a fund or exit. Bridge loans may be a method for handling this pressure compared to the secondary buyouts in their paper.

Krohmer et al. (2009) discuss staging at different times in the life of a VC firm. They provided evidence that staging as an initial investment reduces the effect of asymmetric information with the entrepreneur while staging, after the initial investment, had a negative effect on investment returns. They did not discuss the type of instruments for late staging. This paper suggests bridge loans were an investment instrument for, unplanned, late staging.

Giot and Schwienbacher (2007) discuss the characteristics of the deal structure and timing for a successful exit. They used a hazard function to determine the probability of an IPO or a trade sale based on the age of the firm and the timing of the investments. Venture capitalist may use a bridge loan to extend the life of a firm to permit a trade sale.

Cumming and Dai (2010) demonstrated that venture capitalists prefer to invest in companies which were physically close to their offices. Giot and Schwienbacher (2007) found that the success of a trade sale increased if there was one venture

capitalist in proximity. The local bias might be influenced by the limited partners. Hochberg and Rauh (2013) provided evidence that state pension plans and investment authorities invest in local fund managers (VC, Mutual, Pension) and this may be a motivation for VC firms to use bridge loans to avoid company closures in their home state. This was supported by Atanasova and Chemla (2020), who found that pension plans overweight venture investments in local managers and related industry investments. Financing from investors in the same state as the venture firm were an important source of Limited Partner investment and the VC firms may want to ensure continued investment. This paper provides evidence, consistent with previous research, that local limited partners had an influence on the investment policy and success rate in venture capital.

There is heavy pressure on venture capitalists, as reported by Ljungqvist and Richardson (2003), to raise new funds before the investments in their current fund exited. An important factor in raising a new fund was the performance of the previous fund. Kaplan and Schoar (2005) demonstrated that higher performing funds had an easier time raising a new fund. This was supported by Kollmann et al. (2014) as they found that it was the most important factor in raising a new fund. For funds that did not have companies which exited, they must report interim results when raising capital. This leads to NAV manipulation as found by Barber and Yasuda (2017). The use of bridge loans was a way for venture capitalists to manage the reported returns of their open fund and delay bad news.

4.3 Bridge loans

Bridge loans are temporary financial instruments used by venture capitalists to provide short term financing, rescue firms from financial distress or as an initial investment (Glazer, 1989). Although bridge loans were widely used, there was little research about their contribution to the return on investment in a venture funded company or the motivation for using this financing instrument. Of 100,532 finance rounds, from the Thomas One Banker database, examined in this paper, 10,200 were funded with bridge loans by 16,391 co-investors. Venture capital firms used bridge loans in a significant number of their investments despite numerous venture capitalists (VC) stating that bridge loans provide negative return for both the VC firm and the entrepreneur (Muse, 2016; Suster, 2010; F. Wilson, 2011). The failure rate for companies with bridge loans was similar to firms in financial distress (Gilson, 1997; Kahl, 2002).

Bridge loans were also employed in real-estate and corporate finance deals (Glazer, 1989) where the purchase of a property was contingent on the sale of another property or the property was to be held for a short period. Bridge loans in venture

backed firms were not related to bridge loans in other areas as the collateral was usually intangible assets as opposed to real property.

The classic case was a bridge loan which provides temporary financing while more permanent financing was under negotiation. The negotiation for the long-term financing had begun, with a high probability of completion, before the bridge loan was granted. The bridged financing can be a normal venture round or the lead-up to an initial public offering (IPO) (Sahlman, 1990).

For the expenses of an Initial Public Offering (IPO), the bridge funding, which was a debt instrument, had lower legal fees and was easier to negotiate (Marx, 1998). This was the case for 25 companies, of the 3,877, which received bridge loans.

Pre-IPO and short-term bridge loans were not discussed in this paper. The focus of this paper was on bridge loans made to companies which cannot raise funding from outside their current investors.

There were several operational issues which may prompt the need for a short-term bridge loan. All venture firms in a syndicate might not have the time to review the documents or their outside legal counsel might not be available. There ciuld be occasions when one or more of the venture syndicate might have to make a capital call to their limited partners. There could also be situations where one firm may want to fund their commitment in the next quarter or month to avoid an unscheduled capital call.

Delays in funding, by one or more venture firms, were temporary operational problems. They were not strategy problems or a reflection on the suitability of the company for investment. The company has negotiated a follow-on round and was within performance levels specified by the venture firms.

The short-term bridge loan, due to VC firm operational issues, was repaid from the proceeds of the permanent financing. Failure to provide the funding, after the agreed upon delay, will cause the shirking firm to be excluded from future co-investment opportunities with the remaining group of investors. The strong social factors in venture funding were important to keep the bridge loan a true short term loan (Bénabou & Tirole, 2006).

The venture capitalist may genuinely have had confidence in the company although it was not self-financing, nor can it attract investment from a third party. The bridge loan was intended to rescue the company from a temporary hardship or provide time to find a new investor. If a new firm did not invest, the bridge loan becomes a long-term investment without reimbursement in the near-term. The bridge loans rescue the portfolio company, in the short-term, from failing.

4.4 Data

The data was a subset of venture capital deals from the Thomson One Banker Private Equity database. Daily transactional data for venture capital transactions, recorded in the United States, from 1995 through June 2017 were downloaded. After removing records with missing identifiers and erroneous entries, there were 228,418 transactions within 100,532 investment rounds for 35,939 companies. For reference, there were a further 215,533 transactions for the rest of the world during this period.

The database includes information about the company which received the investment, the venture firm which made the investment, a few deal parameters and the investor syndicate which made the investment. Each investment round for a company was captured in the database. There were 37 variables downloaded for each transaction. This paper used a subset of 19 variables with 7 variables computed from the downloaded variables, which were listed in table 4.1.

Table 4.1 reports summary statistics, at the individual round level, for the variables in the database. The average VC firm was an independent private partnership which had invested just over half of their capital. Their mean total investment was 168 Million USD and the deals had a 53% mean success rate.

Table 4.2 aggregated the deal level data, of table 4.1, to company level. At the company level, the average fund had $143 million of capital and the mean investment was $47 million. Forty percent of the companies had a successful exit. 10.8% of the companies received a bridge loan.

Aggregated to the fund level, in table 4.3, the mean investment was $3.05 million in 14.04 companies. The fund had an average of 1.36 IPOs and 7.51 companies with a successful exit. The variables at the fund level were the sum of the deal level variables.

VC firms report the status of their companies, in Thomson One Banker, as one of the following: Acquisition, Active, Bankruptcy – Chapter 11, Bankruptcy – Chapter 7, Defunct, In Registration, LBO, Merger, Pending Acquisition and Went Public. The status variable did not have a more descriptive range for companies which were marked as active. It was not possible to determine from the status of "Acquisition," whether the company provided a return on capital or the amount.

Stating if an investment in a company was successful was difficult to determine without the full investment history and exit information. The Thomson One Banker had sparse investment information such as the amount invested, the valuation at investment, exit purchase price and deal terms such as liquidity preference.

Without deal terms, the label of success from the investment direction variable would be arbitrary as it is possible to show a higher valuation but negate it with a liquidity preference, among other methods. In this case, an acquisition could be

a success to the VC firm holding the liquidity preference and a failure to the cc-investors and entrepreneurs, who did not hold a liquidity preference. The sale of the company for the return of some capital rather than a return on capital, would be marked as a success and, therefore, the successful exits were over-counted in this paper.

Even with these limitations, there were two generally accepted methods to label an investment as a success or failure. P. Gompers, Kovner, Lerner, and Scharfstein (2008b) accepted any status except bankruptcy and defunct as a success. This paper follows a stricter definition of success as used by Phalippou and Gottschalg (2009) and Tian (2011). Firms which were in the database and marked as 'Active' for more than 7 years, without additional financing rounds, were marked as a failure.

The companies go through an additional filter which marks a company as a failure if the status was set to 'Active' for 3 or more years after the fund made its last investment. A typical VC fund had a life of 10 years (Sahlman, 1990) and most investments were made within the first 3 years (Zarutskie, 2007). After the 10-year life of the fund, there was a monitoring period for several years, on behalf of the limited partners, for companies which did not exit. The hope was that the company will exit within that time frame. In this paper, it assumed that a company which did not exit after three years of monitoring will not exit. After this process was applied, the companies had their status changed from active to Computed Defunct. In table 4.4, 49.3% of the companies where changed to Computed Defunct.

A recent paper by Wiltbank et al. (2015), stated that 75% of founders received no payment at the sale of the company. This was evidence that success at exit was not necessarily for all participants in a deal and supports the use of the computed defunct method.

Even with this over-counted success variable, the analysis was supported by the data. Changing the success variable to include just companies with an IPO, the effects were stronger. This paper used the over-counted success rate for analysis.

Table 4.4 includes the counts for each status, as reported by the venture capitalist. In the third column, the statuses for all companies with bridge loans were broken out. Just 0.064% of the companies with bridge loans went public (status of "In Registration" was added to "Went Public") while the full database of companies had 6.35% go public. Very few of the companies, which received bridge loans, had further investment or exits. The vast majority simply stayed in the VC fund portfolio without further activity.

The venture firms self-reported the stage of the company receiving the investment (Seed, Series A, Bridge Loan, etc.). The analysis was concerned with the self-reported stage of bridge loan. From this variable, *Bridge Loan* was set to true for the round the company received a bridge loan investment.

A binary variable for the *Last Fund* was set to true if this was the last fund for a VC Firm. It is possible to set this variable by looking ahead and checking if a new fund was raised after the existing fund. There may have been cases where the venture firm attempted to raise a follow-on fund without raising the fund. The VC firms did not self-report if they were raising a follow-on fund. It is not possible to determine if the VC Firm could not raise a fund or simply decided to close the firm. Therefore, the decision may be self-selected by the VC Firm.

The VC firms report a fund size, which was stored in the variable *Fund Size*, in millions of USD. The year the fund was created was stored in *Fund Year*.

Equity Bin was a variable which put the total investment, in a company, into one of 7 bins based on the investment amount. The VC funds had different levels of funds under management and therefore, had different limits on the amounts they may invest in each portfolio company. To provide a linear range, the amount invested in each company is placed in one of seven bins.

In Thomson One Banker, the funds were labeled with a specific type. The VC types were alpha numeric characters and the ordering was not useful for analysis. The variable *VC Type*, for the type of VC firm, contains a numeric identifier to maintain the following order: Business/Community Development Program, University Development Program, Individuals, Angel, Government, Non-Private Equity, SBIC, Other, Other Banking/Financial Institution, Corporate PE/Venture Fund, Independent Private Partnership, Endowment, Foundation or Pension Fund, Fund of Funds, Investment Bank, Investment Advisory Affiliate, Retail, Secondary Purchase, and Evergreen. The ordering moves from temporary one-off programs, to governmentally assisted programs and then to longer-term funds. VC types at the beginning of the order tend to provide initial funding while those at the end fund later stage investments.

Table 4.5 lists the number of VC types within the full database. It also lists the use of bridge loans by VC Type. The majority of bridge loans were offered by Independent Private Partnership, the largest VC type, at 2708 bridge loans.

Liquidity of the fund, stored in *Pct Fund Invested* was calculated by taking the cumulative amount invested, at each investment, and dividing it by the total amount invested by the fund. This was a proxy for the liquidity of the fund as the venture firms did not report the capital committed, or called, from their limited partners.

Each company had the total amount invested, both equity and debt, stored in the variable *Tot Est Equity*. It was cumulative over each investment round. The round number, for each transaction, was stored in *Round*. The date of the round was in *Investment Date*. The data base was indexed by *Investment Date*, *Company*, *VC Fund Name* and *Round*.

The *Total Investors* contained the sum of investors for each company. The

variable *Pct Same State* was the sum of investors located in the same state as the company divided by *Total Investors*.

Investment Elapsed Time was the time, as a percentage of the life of the fund, for the investment in a company. *Bridge Elapsed Time* was the same, but for bridge loan investments. For companies with bridge loans, Bridge Elapsed Time and Investment Elapsed Time were the same for the investment round where the company received a bridge loan.

Table 4.6 contains the elapsed investment times, for all investments and bridge loans, by quarter. It also splits out the timing for the largest VC Type, Independent Private Partnership and a separate row for all VC types. Bridge loans were almost entirely (97%) done in the last quarter of the fund life. In comparison, just over half of the non-bridge loan investments were made in the first half of the fund and 30%, or less, were made in the last quarter of the fund.

The final calculated variable was *Experienced VC*. This variable was set to one if the fund invested in more than the mean number of investments in an industry during the life of the fund.

4.5 Funds and companies with bridge loans

Before determining if bridge loans influenced the success rate of investments, it would be useful to explore the conditions and characteristics which prompt the use of a bridge loan in a financing round.

With an emphasis on interpersonal relationships with their portfolio companies and industry peers, venture capitalists become very involved with the management teams they fund. The venture capitalist may genuinely believe the firm needs a small bridge loan to step through temporary under-performance. It was not possible to determine the thought process of the venture capitalists when deciding to use a bridge loan. However, it was possible to see some identifying characteristics of the VC firm and company in the bridge loan transaction.

The analysis was done with a series of linear regressions on the dependent variable
ln(SumBridgeLoans), the number of bridge loan investments made by the VC fund The following equation contains the different factors which were significant in determining the use of bridge loans in an investment round (table 4.7).

$$\begin{aligned} ln(SumBridgeLoan) = \; & \beta_0 + \beta_1 \text{Round}_{\text{it}} + \beta_2 \text{EquityBin}_{\text{it}} + \beta_3 \text{ln(Fund Size)}_{\text{it}} \\ & + \beta_4 \text{ln(Total Investors)}_{\text{it}} + \beta_5 \text{Pct Fund Invested}_{\text{it}} \\ & + \beta_6 \ln\left(\text{ln(Numb IPOs)}_{\text{it}}\right) + \beta_7 \text{ln(Numb Successes)}_{\text{i,t}} \\ & + \beta_8 \text{ln(Experienced VC)}_{\text{it}} + \beta_9 \text{Pct Same State}_{\text{it}} \\ & + \eta_f + \eta_g + \eta_h \end{aligned} \tag{4.1}$$

Where *ln(Sum Bridge Loans)* was the number of bridge loan investments made by the VC fund *u*. *Round* was the median investment round number for each fund *Equity Bin* was the placement of the median equity amount in 7 bins. *ln(Fund Size)* was the natural log of the fund size for fund *u*. *Total Investors* was the maximum number of co-investors for the fund *Pct Fund Invest* was the maximum percentage of the fund invested. The number of companies from fund *u*, which exited with an IPO, was in *Number IPOs*. *Number Success* was the count of successful exits, for fund *u*, which was the broader measure of success, as discussed in section 4.4. *Experienced VC* was the the number of experienced VC investments as defined in section 4.4. *Pct Same State* was the percentage of investments, by all co-investors, which were in the same state as the VC Firm The analysis was across different groupings of indicators and fixed effects for fund year, VC Type and domicile state. The variables were described in section 4.4.

The first four columns of table 4.7 had the investment information from the deal and information about the VC Fund. They had the same variables and differed by the application of fixed effects. In the first column there were no fixed effects. The following columns added fixed effects for the *Fund Year*, *VC Type* and the *Fund State*. Column 5 (IPO) controlled for the number of IPOs a fund generated. In column 6 (Success) the control variable for the number of successes by the VC fund was added while the IPO variable was removed. The next column (Experience) adds the experience the VC fund had in different industries and retained the success variable. The final column (State) added the percentage of investors in the same state.

Over the first 4 columns there were no significant differences with different fixed effects applied. The variables remained economically important and significant. Without controlling for success rates and venture capital experience (column 4), the use of bridge loans was higher in later investment rounds, when a larger amount was invested in the company, the fund size was larger and there were more co-investors. The only variable which had a negative coefficient was the *Pct Fund Invested*.

When the variable *ln(Numb IPOs)* was added in column 5, the variable *Equity Bin* changed sign to negative and remained negative in the following columns. Com-

panies which had a large investment (equity bin was large), a bridge loan, which were in the first two bins, would not suffice to finance a company in the latter bins. The coefficient for *ln(Numb IPOs)* was positive and may reflect the use of bridge loans to finance the expenses for going public, although those instances were few in number (25 cases).

In column 6 the number of IPOs was dropped and the number of successful exits was added to the equation. The coefficient for the variable *ln(Numb Success)* was economically important and significant. The variable for the total number of co-investors changed to negative and increased in magnitude. Based on the definition of success (section 4.4), if co-investors did not believe that the company would have an IPO or high return at exit, they would be less likely to vote to add a bridge loan financing round. In the next section (4.6) evidence was provided that there was a lower success rate with the use of bridge loans.

In a syndicate of many VC firms, some may have a policy against the use of bridge loan, others would not be constrained by a low success rate or the need to raise additional funds. With a large syndicate, it would be more difficult to have all participants agree to fund a failing company or employ a bridge loan.

The variable for the percentage of the fund invested also changed sign to positive in column 6. As with the change in sign for total investors, a VC firm would possibly make an investment, while their liquidity was low, to provide an exit in a lower return portfolio company while they might cut their losses and save their capital for another opportunity with higher expected return.

In column 8 (State) the percentage of co-investors who were in the same state as the company and VC firm, was added to the regression. With this addition *Pct Fund Invested* was no longer significant. Having a larger percentage of investors in the same state increased the use of bridge loans. Venture firms which raise and invest funds in the same state as their portfolio companies may have had more pressure from limited partners, potential limited partners and fear of reputation damage that may encourage them to keep companies solvent (Atanasova & Chemla, 2020; Hochberg & Rauh, 2013).

4.6 Success of investments with bridge loans

There was a limit to the number of negative IRR projects the venture capitalist can fund, which may enhance their personal cash flows, before their reputation was damaged by poor investment results. Therefore, the venture capitalist manages exits and cash flows strategically. The investment in negative IRR projects, as discussed by Ljungqvist and Richardson (2003), include the market conditions and the need to build a reputation in the market.

Negative IRR projects may not be apparent to limited partners in venture capital funds due to the way the fund IRR is calculated. Over time, the limited partners will be able to see companies in the portfolio which did not grow, received additional investment or exited. The venture capitalist may carry an investment at the valuation from the last transaction for the life of the fund irregardless of the current value. Phalippou and Gottschalg (2009) compute the returns of private equity over a long term and assign an IRR of zero to investments which remain in the fund without further investment or an exit at the liquidation of the fund. Using this method they computed lower actual returns than those published by private equity firms. The final IRR cannot be computed until the fund was liquidated. Until that time, absent an offer to purchase or invest, the venture capitalist had discretion in determining the valuation of the investments.

The inability of firms, with bridge loans, to exit with a positive IRR was similar to other firms in financial distress as described by Gilson (1997). Similar results were found by Kahl (2002) where he further suggested that the workout from a distressed financial position was actually a controlled liquidation. The venture capitalists might also have used the bridge loan as a liquidation method to reduce the loss from an immediate shutdown of the firm.

To determine if companies with bridge loans had a lower success rate, the following equation was tested with a probit regression (table 4.8):

$$\begin{aligned} Success_{i,t} = \beta_0 &+ \beta_1 \text{BridgeLoan}_{i,t} + \beta_2 Round_{i,t} + \beta_3 \ln(\text{Tot Est Equity})_{i,t} \\ &+ \beta_4 \ln(\text{Fund Size})_{i,t} + \beta_5 \text{Total Investors}_{i,t} + \beta_6 \text{Pct Fund Invested}_{i,t} \\ &+ \beta_7 ExperieincedVC_{i,t} + \ \beta_8 PctSameState_{i,t} \end{aligned} \tag{4.2}$$

Where *Success* was a dummy variable which was set to 1 if the company had a successful exit, and 0 otherwise, as described in section 4.4. *Bridge Loan* was a dummy variable which was set to 1 if the company received a bridge loan in the current round of funding. The current investment round was in the variable *Round* for company i at time t. The variable *ln(Tot Est Equity)* was the natural log of the total estimated investment received by the company i at time t. The natural log of the size of the fund, making the investment in the company i and time t, was in the variable emphln(Fund Size). The variable *Total Investors* was the total number of investors, in the company, at the current round. *Pct Fund Invested* was the percentage of the VC fund invested at time t. *Experienced VC* was a calculation of the previous investment experience by the VC fund which invested in the company. *Pct in Same State* was the percentage of investors, in company i at time t, who were located in the same state as the company. The variables were described in section

4.4.

The first column of table 4.8 (Bridge) examined the effect on success with just the dummy variable *BridgeLoan* The variable was significant and the coefficient for *BridgeLoan* was -1.720. The results provided evidence that bridge loans were a significant negative indicator of success.

In column 2 (Investment), the round and total estimated equity invested in the company were added. The coefficients were both positive, economically important and significant. As a company attracts capital in multiple rounds, there was a greater chance of success. This was also true for total estimated equity. There was an increased chance of success as more capital was invested in the company. A company which was able to attract a large amount of capital, over multiple investment rounds, would have a high expected return and market traction.

The next column (Experience) added information about the VC firm and their experience. The natural log of the fund size was significant but not economically important. A larger fund would be able to invest a larger amount in a company while staying below their percentage of funds limit. The Total Investors in the company had an economically important and significant effect on a successful exit. With more investors, there was more available capital and a greater chance of finding a champion within the co-investors and, therefore, more investment.

The percentage of the VC fund invested had a significant negative impact on a successful exit. As VC Firms run to the end of their fund, they may hit their limit of investment in a company or lack the liquidity to provide additional funds to their portfolio company.

An experienced VC had a significant positive effect on the success of the portfolio company. Experienced VC may pick higher quality companies and may also assist in the acquisition of their portfolio companies.

The final column (State) includes the variable *Pct in Same State*, which was the percentage of total investors who were in the same state as the portfolio company. A higher percentage of investors in the same state had a negative impact on the success of the portfolio company and was a significant variable. This may be due to the local bias discussed in the previous sections.

The results in table 4.8 demonstrated that the use of a bridge loan was the highest negative magnitude for the success of a portfolio company. There was the question of self-selection for the variable *Bridge Loan*. The venture capitalist decided to use a bridge loan as a financial instrument. There were no external triggers for the bridge loan. To determine if the self-selection problem was significant, a maximum likelihood Heckman correction was performed for the variable *BridgeLoan* (table 4.9).

The selection formula was based on the regression found in table 4.8 for the

bridge loan. The Heckman correction used the method by Certo, Busenbark, Woo, and Semadeni (2016) and emphtoomet2008sample. The results confirm that the use of bridge loans was self selected (ρ = -0.766 and significant) and reduced successful exits. Thus, the results from table 4.8 were supported by the original regression and the Heckman correction. A detailed discussion of the Heckman correction, as it was applied here, was in section 4.9.

4.7 Bridge loans and the last fund

Bridge loans may benefit the venture firm for reasons not directly related to company results. The VC firm may keep the company in the portfolio with a neutral IRR until other investments provide covering positive returns. The introduction of a negative IRR investment may be important when raising follow-on funds. Ljungqvist and Richardson (2003) discuss the pressures on the venture partners to raise follow-on funds several years after the previous fund had been fully invested. The new fund must be raised before the existing fund had many, or any, exits; especially high IRR exits. Without the counterbalancing high IRR companies, there could be reluctance to recognize low or negative IRR investments.

A reputation for successful investments was required to attract high quality entrepreneurs and raise funds for succession venture funds. Kaplan and Schoar (2005) stated that better performing funds had an easier time raising follow on funds. Kollmann et al. (2014) determined that the track record of a firm was the most important factor in raising a new fund. They found the trust and controllability by limited partners were also important factors. Kuckertz et al. (2015) refine the interplay of track record and trust in fund raising. Track record was, in their paper, the third most important factor.

There was a timing mismatch between the realized investments in portfolio companies and the need to raise additional capital for the active investment process. A venture capitalist had an incentive to invest in a company that did not perform well so as to prevent it from damaging the internal rate of return in the fund. The main selling point for a new fund was the IRR of the current fund. Until the companies have had a public offering or trade sale, the IRR was largely computed based on the valuation of follow-on investment rounds or appraisals by the venture firm. Venture capitalists called attention to this behavior (Ehrenberg, 2010) due to the difficult climate in raising funds following the financial crisis of 2007.

The limited partners of the venture firm may have an agency problem with their venture capitalist general partners based on the pay structure and the control the venture capitalist had over timing and valuation of investments. Sahlman (1990) demonstrated that the general partner had the ability to increase the value of their

option on successful exits by making negative IRR investments in portfolio companies.

Bartlett III (2006) discussed the agency risk in his analysis of a large universe of venture deals where he examined the contracts for both the limited partners in the VC firm and the companies which received an investment from the VC firm. The limited partners had a claw-back mechanism to take back 20 percent payments from venture capitalists which were artificially elevated. The return of performance payments to the venture capitalists would be returned if the fund IRR drops from one period to the next. This might happen if one or more companies in the portfolio were closed and the loss recognized. This may explain the large number of companies which receive bridge loans and then no further investment for many years.

To examine if VC firms used bridge loans when they raised new venture funds, the following equation was used in a probit regression (table 4.10):

$$\begin{aligned} LastFund_{t+1} = \beta_0 &+ \beta_1 \ln(\text{Sum Bridge Loans})_{i,t} + \beta_2 \ln(\text{Fund Year})_{i,t} \\ &+ \beta_3 \ln(\text{Fund Size})_{i,t} + \beta_4 \text{VC Type}_{i,t} + \beta_5 \ln(\text{Total Investors})_{i,t} \\ &+ \beta_6 \ln(\text{Sum Experienced VC})_{i,t} + \beta_7 \ln(\text{Sum Same State}_{i,t} \\ &+ \beta_8 \text{Interact Bridge:Exp}_{i,t} \end{aligned} \tag{4.3}$$

Where *Last Fund* was a dummy variable set to 1 if the current fund was the last fund for VC firm, and 0 otherwise. *ln(Sum Bridge Loan* was the sum of bridge loans the fund used for investments *Fund Year* was a variable which contains the year the fund was created. *Ln(Fund Size)* was the natural log of the dollar amount of the fund. *VC Type* was the type of VC Firm for the fund *ln(Total Investors)* was the maximum number of co-investors the fund had in their investments. *ln(Sum Experienced VC)* was the sum of experienced VC investments, as described in 4.4. *ln(Sum Same State)* was the percentage of co-investors who were located in the same state as the company. *Interact Bridge:Exp* was the interaction variable between *Bridge Loan)* and *ln(sum Experienced VC)* The independent variables were discussed in Section 4.4.

Table 4.10 provides evidence that experienced venture capitalists were more likely to raise a follow-on fund and their current fund would not be their last fund. If the experience of the venture capitalist was not considered, the use of bridge loans would prevent the current fund from being the last fund, as shown in column 1.

In the second column (VC firm) additional indicators for the VC firm were added to the regression. The use of bridge loans, having a large fund, and a VC Type at the higher range (independent partnership, corporate venture capital, investment fund or evergreen fund) were beneficial in preventing the current fund from becoming

the last fund. Having a large amount of co-investors increased the chance that the current fund would be the last fund.

When the experience of the VC was added in the third column, the sign of bridge loan switched from negative to positive. As in table 4.8, experienced VC contributed to the success of raising a new fund. With the inclusion of the indicator for an experienced VC, the use of a bridge loan was not a beneficial factor in raising a new fund.

It is possible that some experienced VC used bridge loans when they were trying to raise a fund. That was tested in column 5 (Experience Interact) which added an interaction variable between *Bridge Loan* and *ln(Sum Experienced VC)*. The variable, which was positive, significant and economically relevant, increased the chance of the current fund becoming the last fund.

Experienced VC were aware of the use of bridge loans and may use them tactically rather than as a blanket policy. The use of bridge loans was consistent with the following theory that experienced VC may solicit other funds to join them in issuing bridge loans to failing companies during a period when they were raising a fund. If the cooperating fund was not already a co-investor on the deal in question, the outside VC firm can provide a third party valuation. This can increase the valuation on a small investment, further aiding the original VC firm as they raise a fund.

The external VC firm would benefit if this was a reciprocal agreement. At some time in the future, the external VC firm may need a VC firm to provide a valuation for a bridge round or provide the final piece for a syndication.

Limited partners may very well be aware of the tactical use of bridge loans and take that into account when investing in a follow-on fund with a VC firm. The interaction term may be demonstrating this mechanism.

When the sum of investors in the same state was added, column 6, the significance of the interaction term was removed, the magnitude decreases and the error term increases considerably. The local bias leads to the use of more bridge loans, lower chances of a follow-on fund and successful exits. However, it did not eliminate successful and follow-on funds. There may be adequate success for a VC firm to continue following a local bias so as to create a new fund and receive management fees.

The use of a bridge loan was a decision made by the venture firm. There was no external requirement that they provide a company with a bridge loan. For the regressions in table 4.10, a Heckman correction was run on the variable *Bridge Loan*. The results of the Heckman correction were in table 4.11.

The basis for the selection equation on the bridge loan variable was the equation from table 4.8. The results confirm that the use of a bridge loan was self-selected ($\rho = 0.565$ and significant) and increased the chance that the current fund was the

last fund. A detailed discussion of the Heckman correction, as it was applied here, was in section 4.9.

4.8 Success of investments and elapsed time of fund

Puri and Zarutskie (2012) state that venture capital was patient capital for the first 4 to 5 years following investment. After 5 years the failure rate for VC backed firms increases. They argued that it was due to the patience of the venture capitalist while they wait for the investment idea to come to fruition. At the end of the 5 years, they hypothesize, the venture firm concentrated effort on the investments that were expected to return high multiples on investment.

The 5 year point also coincides with the full commitment timing in a venture fund by Zarutskie (2010). She measures the lifespan of venture funds at 10 years with most investment completed in the first 3 years of the fund. Typical investments last between 3 and 5 years before exit. Raising new funds coincides with the first exits and the full commitment of the existing fund. The 5-year patient capital may be until the new fund was raised.

Investing after the 5 year period would be an example of late staging, as described by Krohmer et al. (2009). They further stated that late staging did not reduce the asymmetric information, as did early investment staging, and was not a successful investment strategy. From 95 to 97 percent of bridge investments were in the last quarter of the life of the fund (table 4.6). Using the investment timing definitions from Zarutskie (2010) and Puri and Zarutskie (2012), bridge loans were late stage investments in both the life of the portfolio companies and the fund. To determine if the late stage investments and late stage bridge loans had different success rates, the following probit regressions was used, at the deal level, for bridge investments and all investments:

$$\begin{aligned}\text{Success}_{i,t} = \beta_0 + \beta_1 \text{Pct Fund Invested}_{i,t} + \beta_2 \text{Bridge Elapsed Time}_{i,t} \\ + \beta_3 \text{Investment Elapsed Time}_{i,t}\end{aligned} \tag{4.4}$$

Where *Success* was a dummy variable which was set to 1 if the company had a successful exit, and 0 otherwise, as described in section 4.4. *Pct Fund Invested* was the percentage of the fund which has been invested at the time an investment was made in company i at time t. *Bridge Elapsed Time* was the percentage of time, since the first investment by the fund, when a bridge loan was offered to company i at time t. The final variable, *Investment Elapsed Time* was the percentage of time,

since the first investment by the fund, when an investment was made in company i at time t.

Pct Fund Invested was included in the equation as a control to determine if liquidity was the main factor or if the late staging was the predominant factor. Column 1, of table 4.12, had Pct Fund Invested as the sole independent variable. The coefficient was large (-0.519) and significant. As more of the total available funds, liquidity, were utilized, there was a lower chance of a successful exit.

In column 2 *Bridge Elapsed Time* was the only variable regressed against success and had a much higher negative, and significant, coefficient (-2.356). The timing of a bridge loan was a strong indicator of a failed investment. Combining both liquidity and the timing of the bridge loan, column 3, both variables keep a similar magnitude and significance.

In column 3 the marginal effects of the Bridge Elapsed Time was -90% and for Pct Fund Invested was -15%. The use of bridge loans late in the life of the fund, and when the fund was mostly invested, might be similar to the liquidity premium discussed by Robinson and Sensoy (2016). Venture firms may use a bridge loan to manage the IRR to ensure inflows of capital via capital calls. Since the data base did not have the history of capital calls and IRR computations, this cannot be verified. It is a possible explanation worthy of further analysis given a more complete data base.

In comparison, when the success was regressed against the Investment Elapsed Time (column 4), the coefficient was negative (-0.426) and significant. This provides evidence that investments late in the life of the fund and, by definition, in the life of the companies in the portfolio, were less successful. The coefficient for all investments (-0.426) was considerably lower than that for bridge loan timing (-2.356). This was an indicator that bridge loans were almost always a failure while elapsed time for all investments had companies which were on their way to a successful exit. Some non-bridge loan investments did fail, but far less than investments that received bridge loans.

Column 5 was a final regression to examine liquidity and timing, for all investments on the success of investments. The coefficient for the *Investment Elapsed Time* drops by about 50% to -0.215. Liquidity, and other factors, had more of an influence on the success for non-bridge loan investments than for bridge loans.

Bridge loans were almost exclusively late staging with a very high failure rate. Late staging for the remainder of investments (non bridge loan) also had a negative influence on success, yet at a much lower rate.

4.9 Robustness checks

Several methods were used to check the robustness of the regressions. The regressions were reported with robust errors. To test for self-selection, a Heckman correction both the maximum likelihood and 2-step methods were applied to the variable emphBridge Loan as the firm self-selected to use that instrument.

The regressions in tables 4.7, 4.8, 4.10 and 4.12 were reported with robust errors using the R packages Sample Selection (Toomet, Henningsen, et al., 2008) and Stargazer (Hlavac, 2015). The robust errors were calculated using different methods, in addition to those provided by the package Sample Selection. The different calculation methods provided similar results.

The difference between the standard errors and robust errors was in the third or fourth decimal place. There was no discernible difference in the error terms for tables 4.7 to 4.12. Therefore, the standard errors were not reported in the paper.

Computing the Heckman correction on the variable bridge loan was done with both the maximum likelihood and 2-step methods. In the 2-step method, the Inverse Mills Ratio was computed. For the maximum likelihood method, ρ was calculated directly. The outcomes from both methods were similar in sign, magnitude and significance.

The variable *Bridge Loan* was a dummy variable set to 1 if the VC firm selected a bridge loan as the financing instrument in a transaction. The variable was aggregated to the fund level, from the transaction data, and stored in *Sum Bridge Loans*. The use of a bridge loan was self-selected by the VC firms. There were no regulatory or other requirements to use a bridge loan. Therefore, Heckman correction for the hypotheses in this paper should indicate a self-selection bias. In the case of the use of bridge loans, when the variable was used in the analysis of successful exits in section 4.6, the inverse Mills ratio regression should be negative and significant. This was interpreted as the self-selected use of a bridge loan reduced the chance of a successful exit from an investment in a portfolio company. When the Heckman correction was applied to the use of bridge loans in the last fund, as presented in section 4.7, the inverse Mills ratio should be positive and significant. This was interpreted as the use of a bridge loan was self-selected and increases the chance of the fund being the last fund for a VC firm. This was the case for the Heckman correction using both the 2-step and maximum likelihood method.

The selection equation for the bridge loan was based on the regressions in section 4.5 and in table 4.7. The Heckman correction required a boolean variable as the independent variable of the selection equation. The variable *ln(Sum Bridge Loan)* was converted to a boolean by setting the variable *Bridge Loan*, stored in the fund aggregated data base, to 1 if the variable *(Sum Bridge Loan)* was greater than zero,

otherwise it was set to 0. The remainder of variables, for the Heckman correction, were taken directly from table 4.7.

The equation for the Heckman correction for successful exits was as follows (the description of the variables can be found in section 4.4) :

$$\begin{aligned} BridgeLoan = \beta_0 &+ \beta_1 \text{Round}_{\text{it}} + \beta_2 \text{EquityBin}_{\text{it}} + \beta_3 \text{VC Type}_{\text{it}} \\ &+ \beta_4 \ln(\text{Fund Size})_{\text{it}} + \beta_5 \ln(\text{Total Investors})_{\text{it}} \\ &+ \beta_6 \ln(\text{Experienced VC})_{\text{it}} + \beta_7 \text{Pct Same State}_{\text{it}} \end{aligned} \tag{4.5}$$

The outcome equation was as follows:

$$\begin{aligned} ln(SumSuccess) = \beta_0 &+ \beta_1 \ln(\text{Experienced VC})_{\text{it}} + \beta_2 \ln(\text{Tot Est Equity})_{\text{it}} \\ &+ \beta_3 \text{Pct Fund Invested}_{\text{it}} \end{aligned} \tag{4.6}$$

The variables in the outcome equation were the variables in the equation for success (table 4.7) which did not overlap with the selection equation, except for the variable *ln(Experienced VC)*. The overlapped variable had a high magnitude coefficient for the success equation in section 4.6. If *ln(Experienced VC)* was removed, the results of the Heckman correction were similar with a much higher constant in the outcome equation regression results.

The regression results for this equation were stored in table 4.9, for the maximum likelihood method, and table 4.13 (in the appendix), for the 2-step method. The value of ρ, under the maximum likelihood method was -0.766 and significant to $p<0.01$. For the 2-step method, the value for ρ was -0.406 and the inverse Mills ratio was -0.306 with significance $p<0.01$. Both methods support the hypothesis presented in section 4.6.

The equation for the Heckman correction for the last fund was as follows (it was identical to the previous selection equation):

$$\begin{aligned} BridgeLoan = \beta_0 &+ \beta_1 \text{Round}_{\text{it}} + \beta_2 \text{EquityBin}_{\text{it}} + \beta_3 \text{VC Type}_{\text{it}} \\ &+ \beta_4 \ln(\text{Fund Size})_{\text{it}} + \beta_5 \ln(\text{Total Investors})_{\text{it}} \\ &+ \beta_6 \ln(\text{Experienced VC})_{\text{it}} + \beta_7 \text{Pct Same State}_{\text{it}} \end{aligned} \tag{4.7}$$

The outcome equation was as follows:

$$\begin{aligned} LastFund = \beta_0 &+ \beta_1 \ln(\text{Experienced VC})_{\text{it}} + \beta_2 \text{Pct Same State}_{\text{it}} \\ &+ \beta_3 \text{Fund Year}_{\text{it}} \end{aligned} \tag{4.8}$$

As for the previous Heckman equation, the selection equation came from table 4.7. The outcome equation came from table 4.10. The two overlapping high magnitude variables were *ln(Experienced VC)* and *ln(Same State)*. The non-overlapping variable was *Fund Year*.

There were differences between the maximum likelihood and 2-step methods. They both had the same sign and were significant. With the maximum likelihood method, the value for ρ was 0.565 and significant to $p<0.01$. For the 2-step method, ρ was 0.271 and the inverse Mills ratio was 0.125, significant to $p<0.1$. Both methods support the hypothesis from section 4.7 that using a bridge loan was self selected and increases the chance of the current fund being the last fund for the VC firm. The 2-step method had a lower significance, yet adequate for the hypothesis.

4.10 Conclusion

In this paper I examined, for the first time, bridge loans in venture capital. I explored why 11% of venture backed companies received a bridge loan as a financing instrument even though the success rate was very low (less than 1%).

An empirical examination of the full set of venture capital investments in the United States during the period from 1995 through 2017, as found in Thomson One Banker, was done to explain the use of bridge loans by VC firms. From the sample of 228,418 transactions, it was determined that companies which received bridge loans had a lower success rate; VC firms tactically utilized bridge loans to manage IRR when they raised new funds. Bridge loans were a late staging instrument which occurred at the same time a typical fund would raise a new fund. VC Firms demonstrated a local bias through the use of bridge loans with companies in their home state.

These results were consistent with prior research in venture capital investments (Giot & Schwienbacher, 2007; Kaplan & Strömberg, 2004; Sahlman, 1990). The local bias was consistent with existing findings for venture capital, mutual funds and pension funds (Atanasova & Chemla, 2020; Bénabou & Tirole, 2006; Hochberg & Rauh, 2013). It was also consistent with the research on managing fund IRR (Barber & Yasuda, 2017; Giot & Schwienbacher, 2007; Krohmer et al., 2009).

Bridge loans seem to benefit general partners more than they assist companies in the VC firm portfolio or limited partners. There were a very small amount of bridge loans which were used to cover the expenses of going public (25 out 3,676). This strategic use for IPOs was also widely known. Limited partners may also be aware the tactical use of bridge loans, as discussed in this paper, and may make their investment choices where a minimal number of bridge loans were permitted in the portfolio.

With a more detailed data base (deal terms, valuations and exit terms) it would be possible to make more absolute conclusions. Despite the limited information available from Thomson One Banker, a suggestion for the industry was possible. Limited partners should add a question to their due diligence checklist about the use of bridge loans by the VC firms under review for investment.

4.11 Tables

Table 4.1: Descriptive statistics for bridge loan variables at the deal level

This table describes the data for venture investments of American companies used in this paper. The data was from 1995 through 2017. The data contains all investment rounds. Detailed descriptions are in section 4.4. Source: Thomson One Banker

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
Investment Date	228,418	2,005.94	6.09	1,995.10	2,000.30	2,011.20	2,017.20
Fund Year	210,503	1,996.93	12.37	1,834.00	1,995.00	2,003.00	2,017.00
Fund Size	228,418	169.11	494.60	0	0	167.9	22,887
Last Fund	228,418	0.41	0.49	0	0	1	1
VC Type	228,418	10.66	2.03	0	11	11	18
Experienced VC	228,418	0.78	0.42	0	1	1	1
Total Investors	228,418	3.30	2.81	1	1	4	29
Equity Bin	228,418	2.75	0.87	1	2	3	7
Round	228,418	3.71	2.82	1	2	5	29
Pct Fund Invested	227,270	0.53	0.32	0.00	0.25	0.83	1.00
Tot Est Equity	228,418	164.83	348.31	−5.00	18.00	191.80	18,917.32
Pct Same State	163,168	0.68	0.74	0.00	0.00	1.00	10.00
Bridge Elapsed Time	228,370	0.04	0.16	0.00	0.00	0.00	1.00
Investment Elapsed Time	209,967	0.46	0.30	0.00	0.21	0.71	1.00
Bridge Loan	228,418	0.07	0.26	0	0	0	1
Success	228,418	0.53	0.50	0	0	1	1

4.12 Appendix

Table 4.2: Descriptive statistics for bridge loan variables at the company level

This table describes the data for venture investments of American companies used in this paper. The data was from 1995 through 2017. The data was aggregated to the company level. Detailed descriptions are in section 4.4. Source: Thomson One Banker

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
Investment Date	35,939	2,007.24	6.68	1,995.10	2,000.40	2,013.40	2,017.20
Fund Year	33,483	1,998.49	12.33	1,851.00	1,995.00	2,006.00	2,017.00
Fund Size	35,939	143.59	493.53	0	0	114.2	22,887
Last Fund	35,939	0.48	0.50	0	0	1	1
VC Type	35,939	10.30	2.50	0	11	11	18
Experienced VC	35,939	0.64	0.48	0	0	1	1
Total Investors	35,939	2.11	1.98	1	1	2	28
Equity Bin	35,939	2.29	0.88	1	2	3	7
Round	35,939	3.13	2.82	1	1	4	29
Pct Fund Invested	35,113	0.58	0.34	0.00	0.27	0.92	1.00
Tot Est Equity	35,939	47.53	179.38	−5.00	1.00	36.63	18,917.32
Pct Same State	30,481	0.49	0.64	0.00	0.00	0.93	10.00
Bridge Elapsed Time	35,911	0.06	0.21	0.00	0.00	0.00	1.00
Investment Elapsed Time	31,122	0.50	0.33	0.00	0.20	0.80	1.00
Bridge Loan	35,939	0.11	0.31	0	0	0	1
Success	35,939	0.40	0.49	0	0	1	1

Table 4.3: Descriptive statistics for variables aggregated to fund level

This table describes the data for venture investments of American companies used in this paper. The data was from 1995 through 2017. The data was aggregated to the VC fund level. Detailed descriptions are in section 4.4. Source: Thomson One Banker

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
Fund Size	15593	107.76	507.40	0	0	70	22887
Numb of Investments	15593	14.04	35.54	1	1	13	1352
Round	15593	3.05	2.13	1	1.5	4	23
Equity Bin	15593	2.44	0.76	1	2	3	7
Total Est Equity	15593	104.91	513.58	0.00	2.20	55.56	31561.25
Total Investors	15593	5.93	4.43	1	2	8	29
Sum IPOs	15593	1.36	4.67	0	0	1	180
Sum Successes	15593	7.51	21.93	0	0	6	891
Sum Bridge Loans	15593	1.01	3.92	0	0	0	150
Pct Fund Invested	14818	0.69	0.26	0.00	0.50	1.00	1.00
Sum Same State	7528	1.94	5.65	0.00	0.00	1.61	189.03
Total Experienced VC	15593	10.91	35.32	0	0	7	1352
Last Fund	15593	0.49	0.50	0	0	1	1

Table 4.4: Status of companies with computed defunct companies

This table describes the status of the companies, as self-reported by the venture firms. The computed defunct status was described in section 4. The data was aggregated to the company level. The first column was the reported status. It was followed by the count of companies in that status. Column 3 was the percentage of companies by status. Column 4 was the count of companies which had a bridge loan in an investment round. Column 5 had the status percentages for those companies. Detailed descriptions are in section 4.4. Source: Thomson One Banker

Status	Count	% Total	Bridge Loans	% Bridge Loans
Acquisition	8432	23.460%	101	0.280%
Active	2343	6.520%	135	0.380%
Bankruptcy - Chapter 11	106	0.290%	1	0.003%
Bankruptcy - Chapter 7	90	0.250%	0	0
Defunct	3717	10.340%	0	0
LBO	648	1.800%	5	0.010%
Merger	331	0.920%	1	0.003%
Other	16	0.040%	12	0.030%
Pending Acquisition	259	0.720%	12	0.030%
Went Public	2225	6.190%	19	0.050%
In Registration	41	0.110%	4	0.010%
Private Company (Non-PE)	1	0.003%	0	0
Computed Defunct	17730	49.330%	3599	10.010%

Table 4.5: Use of bridge loans by VC type

This table presents the use of bridge loans by VC type. Column 1 was the name of the VC type provided by Thomson One Banker. Column 2 was the rank ordering applied to the VC types, as described in section 4. Column 3 was the total number of firms in the VC Type from 1995 to 2017. Column 4 was the count of bridge loans by VC type. Column 5 was the percentage of bridge loans by VC type. Detailed descriptions are in section 4.4. Source: Thomson One Banker

Description	VC Type	Total Firms	Total Bridge Loans	Percent Bridge Loans
Business/Community Development Program	1	709	80	11.283%
University Development Program	2	63	4	6.349%
Individuals	3	109	11	10.092%
Angel	4	809	117	14.462%
Government	5	1327	415	31.274%
Non-Private Equity	6	7	0	0
SBIC	7	1260	160	12.698%
Other	8	20	1	5.000%
Other Banking/Financial Institution	9	1550	97	6.258%
Corporate PE/Venture Fund	10	2583	120	4.646%
Independent Private Partnership	11	25385	2708	10.668%
Endowment, Foundation or Pension Fund	12	115	6	5.217%
Fund of Funds	13	237	0	0
Investment Bank	14	928	72	7.759%
Investment Advisory Affiliate	15	280	15	5.357%
Retail	16	19	1	5.263%
Secondary Purchase	17	21	0	0
Evergreen	18	488	69	14.139%

Table 4.6: Timing of investment for bridge loans by VC type

This table presents the percentage of investments in the first half, second half and third quarter for bridge loans and all investments. It was further broken down by the VC type of independent private partnership and all other firms except independent private partnerships Detailed descriptions are in section 4.4. Source: Thomson One Banker

Investor Type	First Half of Fund Life	Second Half of Fund Life	Last Qtr of Fund Life
VC Type 11 w/ Bridge Loan	3.00%	97.00%	97.00%
All Except VC Type 11 w/ Bridge Loan	5.00%	95.00%	95.00%
VC Type 11 w/out Bridge Loan	53.00%	47.00%	27.00%
All Except 11 w/out Bridge Loan	50.00%	50.00%	30.00%
All VC Types and Investments	57.00%	43.00%	25.00%

Table 4.7: Number of bridge loans at the VC fund level

This table presents the results of a series of linear regressions of the number of bridge loans a VC Firm used to finance a company when investments are aggregated to the fund level. The dependent variable was *ln(Sum Bridge Loans)*, the number of bridge loan investments made by VC fund *u*. *Round* was the median investment round number for each fund *Equity Bin* was the placement of the median equity amount in 7 bins. *ln(Fund Size)* was the natural log of the fund size for fund *u*. *Total Investors* was the maximum number of co-investors for the fund *Pct Fund Invest* was the maximum percentage of the fund invested. The number of companies from fund *u*, which exited with an IPO, was in *Numb IPOs*. *Numb Success* was the count of successful exits, for fund *u*, which was the broader measure of success, as discussed in section 4.4. *Experienced VC* was the the number of experienced VC investments as defined in section 4.4. *Pct Same State* was the percentage of investments, by all co-investors, which were in the same state as the VC Firm The analysis was across different groupings of indicators and fixed effects for fund year, VC Type and domicile state. Robust errors are reported in parentheses. Note: *p<0.1; **p<0.05; ***p<0.01

	Dependent variable:							
	Total Number of Bridge Loans by Fund							
	Fund	Fund	Fund	Fund	IPO	Success	Experience	State
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
round	0.022***	0.023***	0.025***	0.025***	0.024***	0.030***	0.024***	0.012***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Equity Bin	0.016**	0.008	0.015**	0.020***	−0.024***	−0.054***	−0.044***	−0.018***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.006)	(0.006)	(0.005)
ln(Fund Size)	0.042***	0.040***	0.040***	0.039***	0.032***	0.014***	0.001	−0.004***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)
ln(Total Investors)	0.061***	0.059***	0.065***	0.064***	0.037***	−0.051***	−0.030***	−0.016***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.005)	(0.005)
Pct Fund Invest	−0.402***	−0.404***	−0.371***	−0.304***	−0.207***	0.198***	0.227***	0.026
	(0.017)	(0.018)	(0.018)	(0.017)	(0.018)	(0.019)	(0.018)	(0.017)
ln(Numb IPOs)					0.045***			
					(0.005)			
ln(Numb Success)						0.299***	0.090***	−0.019*
						(0.007)	(0.008)	(0.010)
ln(Experienced VC)							0.214***	0.102***
							(0.006)	(0.012)
Pct Same State								0.022***
								(0.002)
Constant	0.209***	0.246***	0.234***	0.219***	0.230***	0.046	−0.065	−0.014
	(0.026)	(0.031)	(0.051)	(0.060)	(0.051)	(0.050)	(0.044)	(0.026)
Fund Year FE	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
VC Type FE	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Fund State FE	No	No	No	Yes	Yes	Yes	Yes	No
Observations	14,818	13,938	13,938	13,938	13,938	13,938	13,938	6,855
R^2	0.084	0.103	0.121	0.152	0.252	0.360	0.426	0.367
Adjusted R^2	0.084	0.096	0.114	0.140	0.242	0.351	0.418	0.358

Table 4.8: Successful investments

This table presents the results of a series of probit regressions on the success of venture capital portfolio company exit at the deal level. The dependent variable was *Success* a dummy variable which was set to 1 if the company had a successful exit, and 0 otherwise, as described in section 4.4. *Bridge Loan* was a dummy variable which was set to 1 if the company received a bridge loan in the current round of funding. The current investment round was in the variable *Round* for company i at time t. The variable *ln(Tot Est Equity)* was the natural log of the total estimated investment received by the company i at time t. The natural log of the size of the fund, making the investment, in the company i and time t, was in the variable ln(Fund Size), The variable *Total Investors* was the total number of investors, in the company, at the current round. *Pct Fund Invest* was the percentage of the fund invested by the current round. *Experienced VC* was a calculation of the previous investment experience by the VC fund which invested in the company. *Same State* was the percentage of investors, in company i at time t, who were located in the same state as the company. Robust errors are reported in parentheses.

	Dependent variable:			
	Successful Investment Exit			
	Bridge	Investment	Experience	State
	(1)	(2)	(3)	(4)
Bridge Loan	-1.720^{***}	-1.784^{***}	-1.746^{***}	-1.697^{***}
	(0.017)	(0.017)	(0.017)	(0.019)
Round		0.035^{***}	0.039^{***}	0.040^{***}
		(0.001)	(0.001)	(0.001)
ln(Tot Est Equity)		0.107^{***}	0.098^{***}	0.113^{***}
		(0.003)	(0.003)	(0.004)
ln(Fund Size)			0.008^{***}	0.004^{***}
			(0.001)	(0.001)
Total Investors			0.032^{***}	0.032^{***}
			(0.001)	(0.001)
Pct Fund Invested			-0.536^{***}	-0.479^{***}
			(0.009)	(0.011)
Experienced VC			0.210^{***}	0.197^{***}
			(0.007)	(0.008)
Pct in Same State				-0.011^{**}
				(0.005)
Constant	0.164^{***}	-0.131^{***}	-0.137^{***}	-0.170^{***}
	(0.006)	(0.006)	(0.009)	(0.011)
Observations	228,418	228,418	227,270	162,151
Note:	*p<0.1; **p<0.05; ***p<0.01			

Table 4.9: Heckman selection on success for firms with bridge loans

This table presents the results of the Heckman correction for a sample selection of firms who use bridge loans and the final success of the investment. This was a correction for the analysis presented in table 4.8. The venture capitalist decided to use a bridge loan as a financial instrument. There were no external triggers for the bridge loan. To determine if the self-selection problem was significant, a maximum likelihood Heckman correction was performed for the variable *Bridge Loan*. The selection formula was based on the regression found in table 4.8 for the bridge loan. All variables except *ln(Tot Est Equity)* and *Pct Fund Invested*, were used in the selection equation. The variables *ln(Tot Est Equity)* and *Pct Fund Invested*, plus several variables from the selection equation were used in the outcome equation. The analysis confirms self-selection and less success when VC firms self-selected to use bridge loans Standard errors are reported in parentheses.

	Dependent variable:	
	VC Fund used a bridge loan	
	selection	*outcome*
	(1)	(2)
Round	0.060***	
	(0.010)	
Equity Bin	−0.190***	
	(0.031)	
VC Type	−0.015*	
	(0.009)	
ln(Fund Size)	−0.027***	
	(0.010)	
ln(Total Investors)	0.083***	
	(0.028)	
ln(Experienced VC)	0.450***	0.006
	(0.028)	(0.041)
ln(Same State)	0.313***	
	(0.024)	
ln(Tot Est Equity)		0.194***
		(0.015)
Pct Fund Invested		−0.081
		(0.102)
Constant	−1.266***	1.414***
	(0.110)	(0.152)
Observations	7,447	7,447
ρ	−0.766*** (0.044)	−0.766*** (0.044)
Note:	*p<0.1; **p<0.05; ***p<0.01	

Table 4.10: Current fund was the VC firm's last fund

This table presents the results of a series of probit regressions on data aggregated to the fund level on a VC firm's last fund. The dependent variable was *Last Fund*, a dummy variable set to 1 if the current fund was the last fund raised by the VC firm, *ln(Sum Bridge Loan* was the sum of bridge loans the fund used for investments. *Fund Year* was a variable which contains the year the fund was created. *Ln(Fund Size)* was the natural log of the dollar amount of the fund. *VC Type* was the type of VC Firm for the fund. *ln(Total Investors)* was the maximum number of co-investors the fund had in their investments. *ln(Sum Experienced VC)* was the sum of experienced VC investments, as described in 4.4. *ln(Sum Same State)* was the percentage of co-investors who were located in the same state as the company. *Interact Bridge:Exp* was the interaction variable between *Bridge Loan)* and *ln(sum Experienced VC)*. The independent variables were discussed in Section 4.4. Robust errors are reported in parentheses.

	Dependent variable:					
			Last fund			
	Bridge Loan	VC Firm	Experience	State	Experience Interact	State Interact
	(1)	(2)	(3)	(4)	(5)	(6)
ln(Sum Bridge Loans)	−0.293***	−0.140***	0.190***	0.305***	0.124***	0.290***
	(0.020)	(0.023)	(0.027)	(0.084)	(0.034)	(0.098)
Fund Year		0.004***	0.002**	0.003**	0.002**	0.003**
		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
ln(Fund Size)		−0.311***	−0.295***	−0.283***	−0.295***	−0.283***
		(0.006)	(0.006)	(0.008)	(0.006)	(0.008)
VC Type		−0.030***	−0.027***	−0.034***	−0.027***	−0.034***
		(0.006)	(0.005)	(0.007)	(0.005)	(0.007)
ln(Total Investors)		0.102***	0.183***	0.189***	0.182***	0.189***
		(0.014)	(0.015)	(0.020)	(0.015)	(0.020)
ln(Sum Experienced VC)			−0.237***	−0.568***	−0.266***	−0.573***
			(0.011)	(0.038)	(0.015)	(0.047)
ln(Sum Same State)				0.059***		0.059***
				(0.018)		(0.018)
Interact Bridge:Exp					0.063***	0.017
					(0.019)	(0.069)
Constant	0.029***	−6.857***	−3.614*	−4.450*	−3.519*	−4.428*
	(0.011)	(1.847)	(1.912)	(2.405)	(1.923)	(2.406)
Observations	15,593	14,673	14,673	7,528	14,673	7,528
Note:	*p<0.1; **p<0.05; ***p<0.01					

Table 4.11: Heckman selection for use of bridge loans on last fund for VC Firm

This table presents the results of the Heckman correction for sample selection for firms who use bridge loans when examining the last fund. The venture capitalist decided to use a bridge loan as a financial instrument. There were no external triggers for the bridge loan. To determine if the self-selection problem was significant, a maximum likelihood Heckman correction was performed for the variable *Bridge Loan*. The selection formula was based on the regression found in table 4.8 for the bridge loan. All variables except *Fund Year*, were used in the selection equation. The variables *Fund Year*, plus several variables from the selection equation were used in the outcome equation. The analysis confirms self-selection and supports the hypothesis that the current fund was more likely to be the last fund when the VC firms self-selected to use bridge loans. Standard errors are reported in parentheses.

	Dependent variable:	
	Last fund for VC firm	
	selection	*outcome*
	(1)	(2)
Round	0.098***	
	(0.010)	
Equity Bin	−0.308***	
	(0.030)	
VC Type	−0.018*	
	(0.010)	
ln(FundSize)	−0.018	
	(0.012)	
ln(Total Investors)	−0.021	
	(0.030)	
ln(Experienced VC)	0.435***	−0.372***
	(0.027)	(0.078)
ln(Same State)	0.330***	0.338***
	(0.022)	(0.041)
Fund Year		−0.008**
		(0.004)
Constant	−0.918***	14.273*
	(0.117)	(7.710)
Observations	7,528	7,528
ρ	0.565*** (0.126)	0.565*** (0.126)
Note:	*p<0.1; **p<0.05; ***p<0.01	

Table 4.12: Successful investments by time of investment in life of VC fund

This table presents the results of a series of probit regressions for success of venture capital portfolio company exit, at the deal level, based on the time of the investment,within the life of the fund, or the liquidity of the fund. The dependent variable was *Success*, a dummy variable which was set to 1 if the company had a successful exit, and 0 otherwise, as described in section 4.4. *Pct Fund Invested* was the percentage of the fund which had been invested by the time an investment was made in company i at time t. *Bridge Elapsed Time* was the percentage of time, since the first investment by the fund, when a bridge loan was offered to company i at time t. The final variable, *Investment Elapsed Time* was the percentage of time, since the first investment by the fund, when an investment was made in company i at time t. Pct Fund Invested was included in the equation as a control to determine if liquidity was the main factor or if the late staging was the predominant factor. Column 1, of the table had *Pct Fund Invested* as the sole independent variable. In column 2, Bridge Elapsed Time was the only variable regressed against success. Column 3 utilized both liquidity and the timing of the bridge loan as independent variables. Robust errors are reported in parentheses. Note:*p<0.1; **p<0.05; ***p<0.01

	Dependent variable:				
	Successful Investment Exit				
			probit		
	Pct Invested	Bridge	Bridge and Pct	All	All and Pct
	(1)	(2)	(3)	(4)	(5)
Pct Fund Invested	−0.519***		−0.400***		−0.326***
	(0.008)		(0.009)		(0.011)
Bridge Elapsed Time		−2.356***	−2.265***		
		(0.037)	(0.039)		
Investment Elapsed Time				−0.426***	−0.215***
				(0.009)	(0.012)
Constant	0.354***	0.147***	0.359***	0.368***	0.442***
	(0.005)	(0.003)	(0.005)	(0.005)	(0.006)
Observations	227,270	228,370	227,258	209,967	209,184

Table 4.13: Heckman selection on success for firms with bridge loans - 2-step method

This table presents the results of the Heckman correction for a sample selection of firms who use bridge loans and the final success of the investment. This was a correction for the analysis presented in table 4.8. The venture capitalist decided to use a bridge loan as a financial instrument. There were no external triggers for the bridge loan. To determine if the self-selection problem was significant, a 2-step Heckman correction was performed for the variable *Bridge Loan*. The selection formula was based on the regression found in table 4.8 for the bridge loan. All variables except *ln(Tot Est Equity)* and *Pct Fund Invested*, were used in the selection equation. The variables *ln(Tot Est Equity)* and *Pct Fund Invested*, plus several variables from the selection equation were used in the outcome equation. The analysis confirms self-selection and less success when VC firms self-selected to use bridge loans Standard errors are reported in parentheses.

	Dependent variable:	
	VC Fund used a bridge loan	
	selection	*outcome*
	(1)	(2)
Round	0.084***	
	(0.010)	
Equity Bin	−0.154***	
	(0.032)	
VC Type	−0.019**	
	(0.009)	
ln(Fund Size)	−0.038***	
	(0.011)	
ln(Total Investors)	0.026	
	(0.031)	
ln(Experienced VC)	0.451***	0.178***
	(0.030)	(0.043)
ln(Same State)	0.334***	
	(0.025)	
ln(Tot Est Equity)		0.192***
		(0.016)
Pct Fund Invested		−0.149
		(0.109)
Constant	−1.304***	0.740***
	(0.118)	(0.172)
Observations	7,447	7,447
ρ	−0.406	−0.406
Inverse Mills Ratio	−0.306*** (0.083)	−0.306*** (0.083)
Note:	*p<0.1; **p<0.05; ***p<0.01	

Table 4.14: Heckman selection for use of bridge loans on last fund for VC Firm - 2-step method

This table presents the results of the Heckman correction for sample selection for firms who use bridge loans when examining the last fund. The venture capitalist decided to use a bridge loan as a financial instrument. There were no external triggers for the bridge loan. To determine if the self-selection problem was significant, a 2-step Heckman correction was performed for the variable *Bridge Loan*. The selection formula was based on the regression found in table 4.8 for the bridge loan. All variables except *Fund Year*, were used in the selection equation. The variables *Fund Year*, plus several variables from the selection equation were used in the outcome equation. The analysis confirms self-selection and supports the hypothesis that the current fund was more likely to be the last fund when the VC firms self-selected to use bridge loans. Standard errors are reported in parentheses.

	Dependent variable:	
	Last fund for VC firm	
	selection	*outcome*
	(1)	(2)
Round	0.099***	
	(0.009)	
Equity Bin	−0.293***	
	(0.031)	
VC Type	−0.019**	
	(0.009)	
ln(Fund Size)	−0.037***	
	(0.011)	
ln(Total Investors)	−0.015	
	(0.030)	
ln(Experienced VC)	0.446***	−0.171***
	(0.029)	(0.024)
ln(Same State)	0.322***	0.112***
	(0.024)	(0.021)
Fund Year		−0.003**
		(0.001)
Constant	−0.913***	6.152**
	(0.110)	(2.884)
Observations	7,528	7,528
ρ	0.271	0.271
Inverse Mills Ratio	0.125* (0.066)	0.125* (0.066)
Note:	*p<0.1; **p<0.05; ***p<0.01	

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RÉSUMÉ

Cette thèse analyse les contrats de financement utilisés par les fonds de capital risque, les vagues d'investissement réalisées ainsi que l'utilisation des crédits relais. Le premier chapitre présente un modèle théorique de contrat financement. Ce modèle propose un contrat offrant plus de profits à l'entrepreneur dans le but de créer une relation moins conflictuelle, bien que ce dernier ait initialement un pouvoir de négociation supérieur. La plupart des fonds de capital affirment réaliser l'investissement initial dans une entreprise en se basant sur l'analyse de l'équipe fondatrice et la taille du marché visé par l'entreprise. En analysant les investissements de fonds en capital risque, nous avons pu mettre en lumière l'existence de vagues d'investissement de fonds en capital risque, similaire aux vagues de fusions-acquisitions. Le deuxième chapitre de cette thèse analyse les effets causés par ces vagues d'investissement et l'impact du réseau du syndicat sur le taux de succès des investissements. Nous montrons que le réseau du syndicat d'investissement impactent le taux de succès des investissements. Dans le dernier chapitre de cette thèse, une analyse de l'utilisation des crédits relais a été menée du fait de son utilisation relativement importante par les fonds de capital risque. L'analyse a montré que les entreprises financées par crédit relais ont de faibles taux de succès (0.7%) et que les fonds de capital risque ayant recours à ce type d'instruments ont un taux de succès plus faible pour lever un nouveau fonds de capital risque.

MOTS CLÉS

capital-risque, contrats comme points de référence, prêts relais, réseaux sociaux, syndication de capital-risque

ABSTRACT

This thesis examined venture capital financing contracts as reference points, investment waves in venture investing and the use of bridge loans as a financing method for venture backed companies. In the first essay, a theoretical model for contracts as reference points was proposed. This model proved a method to grant the entrepreneur a surplus of returns to create a smoother relationship even though the VC had ex-ante bargaining power. This protects the VC firm if the value of the project drops as the entrepreneur continues to apply effort due to the incentive from the increased share of surplus. For the initial investment in the project, most VC state that they selected their investment based on the founding team and market size for the company. Through an analysis of venture investments over a 30 year period we were able to compute investment waves as found in mergers and acquisitions. The second essay explores the effect VC investment waves and the social network created from investment syndicates had on the investment success. We provided evidence that the timing of the investment and the VC social network impacted the success rate of investments. In the final essay, short-term bridge loans were explored due to industry comment on their use and the fact that over 10 percent of venture investment transactions were bridge loans. The analysis provided evidence that companies with bridge loans had a very low success rate (0.7%) and that VC firms who used bridge loans had a lower success rate raising a follow-on fund.

KEYWORDS

venture capital, contracts as reference points, bridge loans, social networks, venture syndication.