Entrepreneurial Bankruptcies and Moral Hazards at the times of prosperity and Crisis: An Artificial Intelligence Model Application to PLS and Debt Financing

EL FAKIR, Adil <http://orcid.org/0000-0002-0922-7274>, LAMRANI ALAOUI, Youssef and TKIOUAT, Mohamed

Entrepreneurial Banckrupcies and Moral Hazards at the times of prosperity and Crisis
An Artificial Intelligence Model Application to PLS and Debt Financing

Adil EL Fakir[a,1,*], Youssef Lamrani[b,2], Mohamed Tkiouat[c,2]

[a]*Sheffield Business School, Sheffield Hallam University, Sheffield, UK*
[b]*Ecole Marocain des Sciences de l'Ingenieur*
[c]*Laboratory of Research and Studies in Applied Mathematics, LERMA, IFE-Lab , Mohammadia School of Engineering, Rabat, Morocco*

Abstract

In this paper we try to compare the performnace of profit and loss sharing contract and debt contracts in the face of economic crisis such as Covid 19. Our approch relies on an artificial intelligence model using Netlogo to predict the probability of defaults (banckrupcies) of entrepreneurial contracts. We have found simulation evidence that PLS contracts have lower number of defaults than debt contracts during a crisis. The fact that PLS contracts provide the advantage of sharing losses reduces the chances of banckrupcies compared to debt contracts where the entreprenurs bears wholly the risk of projects failure. On the other hand we found that Debt contracts provide less banckrupcies during normal conditions. This suggest that failure of PLS contracts is not only due to economic conditions but to high level of moral hasard.

Keywords: Finance, Optimal contracts, Moral hazards, Profit and loss sharing

*Corresponding Author: Adil ELFakir
Email address: aelfakir@hotmail.com a.el-fakir@shu.ac.uk (Adil EL Fakir)
URL: https://www.shu.ac.uk/about-us/our-people/staff-profiles/adil-elfakir (Adil EL Fakir)
[1]Senior Lecturer of Finance and Banking
[2]Assistant Professor in Applied Mathematics
[3]Professor of Industrial Economics and Game theory

contracts, Span of Negotiation.

---

1. Introduction

This paper looks at at PLS contracts as a model of equity finance and compare it with debt financing in the face of Crisis such as Covid. Debt financing by conventional banks has experienced crises both in the 1930s , 1980s and and more recently in the 2007-2008 financial crisis with the savings-and-loan (S & L) and banking crises in the United States. in the 1930's , and 10980's the U.S. answer was to institute deposit insurance in order to eliminate or at least minimize bank runs Akacem and Gilliam (2002) while more regulatory rules (Basel III) were introduced to face up to the last financial crisis of 2007-2008. However, that has caused both banks and S & Ls to assume more risk at the cost of greater taxpayer exposure because they lacked the incentive to be risk averse. The current U.S. banking model of debt finance together with an implicitly unlimited3 deposit insurance results in the socializing of loss and the privatizing of gain Akacem and Gilliam (2002). Recessions has shown an increase in the number of firms filing for bnackrupcies . For example the increase was substantially steeper during the great recession (60,837 in 2009, from 28,322 in 2007) Skeel (2020). Debt overhang creates a distortion leading these firms to fire workers, forgo expenditures that maintain enterprise value and therfore filing for banckrupcies Brunnermeier et al. (2020) . The problem with debt financing, in our opinion , lies in its biased, rather unfair treatment of the participants. First debt financing charges intersts which are fixed periodic paymnets that do not take into consideration the worsening economic conditions. The financier , such as a bank, is guranteed a fixed payment , if economic conditions are prosperous. The finnacier is also guranteed a collteral if the economic conditions are worsening.

Under profit and loss (PLS) contracts, both the supplier of the capital and the entrepreneur share in the risks: both prosper when returns are favourable and suffer together when returns are poor Ahmed (2008).

One of the studies done in indonesia using a two year data set scale , has shown that , equity financing , such as profit and loss sharing contracts performed better than debt-based financing . On eof the reasons that could be atrbuted to this is the fact that under equity finnacing entrepreneurs coild benefit from the expertise of equity providers , such as Angels or VCs, Casamatta (2003) compared to other forms of financing such as debt or angel financing. Of course equity , such as PLS contracts, financing comes with its own risks to providers

of funds. First PLS financiers face uncertain circumstances, called external risks as cited by Kaplan and Strömberg (2004). These include, demand for new products, competitors' response to new product, perception of financial markets when it comes to selling the project stakes at exit stage. These problems are obvious in times of crisis such COVID 19. Second Equity , such as PLS, in general face agency problemsSahlman (1990), Amit et al. (1990),Cochrane (2005), Baierl et al. (2002), Hall and Lerner (2010)MacIntosh and Cumming (1997),Gompers and Lerner (1999) Gompers and Lerner (1999), Jain (2001) Jain (2001), and Kaplan and Strömberg (2003) and Tykvová (2007). Casamatta (2003) Elitzur and Gavious (2003) Keuschnigg and Nielsen (2003b), Keuschnigg and Nielsen (2003a) And Neher (1999). There are multiple sources of agency problems. One of them is moral hazards in the form of the entreprenur shirking. The shirking of entreprenurs during econoic crisis could even make the prformance of PLS financing worse. The shirking of the entreprenur in debt financing is less of a concern to the lender as the latter's funds are secured through guranteed interstr payments or , in the worst case, throughseizing of a collateral.

So given the above arguments which method of financing could perform better. Indeed the risk of banckrupcies are common to both , debt and PLS financing, but which method could prove more resilient in the face up to crisis?.

To answr this question , we provide an Artificial inteelligence model using an agent based simulation platform. We will compare PLS financing and Debt financing in terms of their resilience to financial crisis. Our benchmark of resilience will be the number of banckrupacies in both models.

Our model is based on the sharing of profits and losses. Therefore, it is implemented through the model that Profit is determined based on expected future profits and not as a fixed amount or as a percentage of investment. i.e. there should be no guaranteed returns to the financier as in the case of debt standard VC contracts and there should be no guaranteed return to the entrepreneur as in the case of fixed wages.

The rest of the paper is organized as follows:
Section 2 proposes our model. Section 3 presents the methodology. Section 4 represents the results and discussion. Finally, section 5 concludes with a summary and possible extensions.

2. The model

We will try to compare the number of banckrupcies under debt and PLS financing. The entreprenur is in need of funds to complement the funding of a project costing I. He is endowd with an initial wealth of A and a collateral K. Therfore he needs I – A.

3. Debt financing model

The entreprenur can get the funding from a bank , through debt, costing him interst rate : i. The project return R depends on the economic conditions γ_i such that$i \in \{n, c\}$. n=Normal , c=Crisis. If the project fails the entrepreneur loses his funds A and a collateral K. We assume that the entrepreneur would excecise a high effort under debt financing since he would lose his initial wealth A and collateral if the project fails. Therfore there is no moral hazards in this case.

$$E(R|\gamma_i) = \int_0^R Rf(R|e_i)dR \tag{1}$$

where the share of the manager is R_m and the share of the financier is R_f such that R = R_m+ R_f . This output can take upper values $\overline{R} \geq I$ and lower values $0 \leq \underline{R} \leq I$ suc that:

$$E(\overline{R}|\gamma_n) = \int_I^R Rf(R|\gamma_n)dR \tag{2}$$

and

$$E(\underline{R}|\gamma_c) = \int_0^I Rf(R|\gamma_c)dR \tag{3}$$

4. PLS financing model

In this model we add the extra layer of risk , entrepreneur's shirking, besides the risk of an economic crisis . As we explained before, in contrast to debt financimg , beacuse the finacier would share the losses in case of project failure, ther is more of a temptation for the entrepreneur to shirk. The model therfore would strives to reduce the moral hazard problem in a PLS context. The success of the project, therfore, not only depend on the economic conditions γ but also on the entrepreneurs effort, (high or low), $e_i : i \in \{l, h\}$ of the manager. The project

is estimated to result in a stochastic verifiable output R conditional on a high or low managerial effort e_i: $i \in \{l, h\}$:

$$E(R|e_i, \gamma_i) = \int_0^R Rf(R|e_i, \gamma_i)dR \tag{4}$$

where the share of the manager is R_m and the share of the financier is R_f such that R = R_m+ R_f . This output can take upper values $\overline{R} \geq I$ and lower values $0 \leq \underline{R} \leq I$ suc that:

$$E(\overline{R}|e_i) = \int_I^R Rf(R|e_i)dR \tag{5}$$

and

$$E(\underline{R}|e_i) = \int_0^I Rf(R|e_i)dR \tag{6}$$

Accordingly the share of the manager and the financier respectively are $\overline{R}_m$, $\overline{R}_f$ in case of success and $\underline{R}_m$, $\underline{R}_f$ in case of project failure. It is worth to note that a high return can result even if a lower effort is being undertaken by the manger. However, the chance of achieving a higher profit is augmented if the manager performs a high effort. Therefore, it can safely be noted that the cumulative density function conditional on e_i first-order stochastically dominates the cdf conditional on e_l under any economic condition:

$$F(R|e_h, \gamma_i) \leq F(R|e_l, \gamma_i) \text{ for all R} \in [\underline{R}, \overline{R}]$$

and therfore the expected return under the high effort is greater than that under low effort. i.e.

$$E(R|e_h, \gamma_i) = \int_0^R Rf(R|e_h, \gamma_i)dR > E(R|e_l, \gamma_n) = \int_0^R Rf(R|e_l, \gamma_i)dR \tag{7}$$

We can note $\theta_h \geq$ the probability that the manger will excerse a high effort . This probability itself is drawn from a normal probability distribution $g(\theta_h)$ Without contracts, the financier has an opportunity of 0. While the manager receives his reservation payoff U.

The profits are shared according to a predetermined rate α given to the PLS financier. On the other hand losses are shared according to each partners's capital contribution ratio. In this case β is the share of the financier in the invested capital. This a very big distinction between PLS financing and Debt financing. Indeed under debt financing , the entrepreneur could lose more than his ratio of the capital. While under PLS he would not.

5. Results

While the payoffs to the participants under debt financing are straightforward, the payoffs under PLS financing. In the latter not only economic conditions are taken into considerations but also entrepreneurial moral hasard (shirking). Therfore the determination of the profit share needs to take into consideration these factors

5.1. Case 1: The model under observable effort

Under this scenario, the manager can't deviate from providing his commitments of high effort and therefore the financier is in a comparative advantage in terms of profit sharing ratio negotiations. In other words, the objective of the financer is to minimize the remuneration R_m of the manager subject to the manager breaking even. Formally:

$$\min_{R_m(R)} \int_I^R \overline{R}_m f(R|e_h,\gamma_i)dR + \int_0^I \underline{R}_m f(R|e_h,\gamma_i)dR$$

S.t

$$\int_I^R \overline{R}_m f(R|e_h,\gamma_i)dR + \int_0^I \underline{R}_m f(R|e_h,\gamma_i)dR - D(e_h) \geq U$$

Taking the First order derivative with respect to $\overline{R}_m$ and applying lagrange multiplier λ. we get:

$$-\int_I^R f(R|e_h,\gamma_i)dR + \lambda \int_I^R f(R|e_h,\gamma_i)dR = 0$$

this gives

$$\lambda = 1 \tag{8}$$

we can then conclude that the participation constraint can be set to equality:

$$\int_I^R \overline{R}_m f(R|e_h,\gamma_i)dR + \int_0^I \underline{R}_m f(R|e_h,\gamma_i)dR - D(e_h) = U \tag{9}$$

One of the essential consideration is that the profit and loss sharing ratios have to be fixed in advance in our PLS contract before the signature of the contract. Therfore, those terms can't be changed during the projects. So we can replace $\overline{R}_m$ by $(1-\alpha)\,\overline{R}$ and $\underline{R}_m$ by $(1-\beta)\,\underline{R}$ So we can reset equation 3 and taking off the fixed ratios from the integrals:

$$(1-\alpha)\int_I^R \overline{R} f(R|e_h,\gamma_i)dR + (1-\beta)\int_0^I \underline{R} f(R|e_h,\gamma_i)dR - D(e_h) = U \tag{10}$$

We can then extract a closed formula for the financier profit sharing ratio:

$$\alpha = 1 - \frac{U + D(e_h) - (1-\beta)\int_0^I \underline{R} f(R|e_h, \gamma_i) dR}{\int_I^R \overline{R} f(R|e_h, \gamma_i) dR} \tag{11}$$

we can give a shorthand formula using equation 1:

$$\alpha = 1 - \frac{U + D(e_h) - (1-\beta) E(\underline{R}|e_h, \gamma_i)}{E(\overline{R}|e_h, \gamma_i)} \tag{12}$$

5.2. Case 1: The model under unobservable effort

In this case the financier is facing a situation with regards to the type of the manager. In other words the financier is questioning wether the manger is going to excercice a high effort or not while undertaking the project. The financier then works out his payoff taking into consideration two probabilities:

- type probabilities θ_h: regarding the probability that a manger is going to perform a high effort. this itself is drawn from a normal probability distribution.
- performance conditional probabilities: regarding the probability that the project will be successful conditional on the manager's effort. This is reflected through the probability distribution of return $f(R|e_i, \gamma_i)$

This situation give rise to private benefits S drawn by the manager if he performs a lower effort. Taking this into consideration, the financier is in a competitive disadvantage and therefore his objective will be to at least break even.

The contract being assigned need to take into consideration three main constraints:

- Participation constraints PCF and PCM: where both participants (Financier Manger) are at least breaking even.
- Incentive compatibility constraints ICM: where only the manager is Offred a profit sharing ratio that will encourage him to exert high effort rather than shirking.

So, the objective of the financier is to maximize his return subject to the above mentioned constraints. Formally:

$$\max_{R} \int_0^1 \theta_i g(\theta_i) d\theta_i \int_0^R R_f f(R|e_i, \gamma_i) dR \tag{13}$$

subject to constraints:

$$PCF : \int_0^1 \theta_i g(\theta_h) d\theta_i \int_0^R R_f f(R|e_i, \gamma_i) dR \geq \beta I \tag{14}$$

$$PCM : \int_I^R \overline{R}_m f(R|e_h, \gamma_i) dR + \int_0^I \underline{R}_m f(R|e_h, \gamma_i) dR - D(e_h) \geq U \tag{15}$$

$$ICM : \int_I^R \overline{R}_m f(R|e_h, \gamma_i) dR + \int_0^I \underline{R}_m f(R|e_h, \gamma_i) dR - D(e_h) \geq \int_I^R \overline{R}_m f(R|e_l, \gamma_i) dR + \int_0^I \underline{R}_m f(R|e_l, \tag{16}$$

In this case we proceed by solving for he sharitng ratio α using game theory.

The bottom line is first to identify the minimum acceptable ratio ,α_{pcm}, for the agent to break even. i.e. to fulfil his participation constraints:

$\int_I^R \overline{R}_m f(R|e_h, \gamma_i) dR + \int_0^I \underline{R}_m f(R|e_h, \gamma_i) dR - D(e_h) \geq U$ Replacing $\overline{R}_m$ by $(1-\alpha)\overline{R}$ and $\underline{R}_m$ by $(1-\beta)\underline{R}$. We get:

$$\alpha \leq 1 - \frac{U + D(e_h) - (1-\beta) \int_0^I \underline{R} f(R|e_h) dR}{\int_I^R \overline{R} f(R|e_h) dR} \tag{17}$$

We can give a shorthand formula using equation 1:

$$\alpha \leq \alpha_{pcm} = 1 - \frac{U + D(e_h) - (1-\beta) E(\underline{R}|e_h, \gamma_i)}{E(\overline{R}|e_h, \gamma_i)} \tag{18}$$

The second step is to identify α_{icm} that motivates the manager to engage in high effort. To simplify the process, we first transform the integrals in the incentive compatibility equation to expectation forms. we get

$$(1-\alpha)E(\overline{R}|e_h)+(1-\beta)E(\underline{R}|e_h,\gamma_i)-D(e_h) \geq (1-\alpha)E(\overline{R}|e_l,\gamma_i)+(1-\beta)E(\underline{R}|e_l,\gamma_i)-D(e_h)+S \tag{19}$$

solving for α we get:

$$\alpha_{inc} \leq 1 - \frac{S + \Delta D - (1-\beta)\Delta\underline{R})}{\Delta\overline{R}} \tag{20}$$

where: $\Delta D = D(e_h)-D(e_l); \Delta\underline{R} = E(\underline{R}|e_h)-E(\underline{R}|e_l); \Delta\overline{R} = E(\overline{R}|e_h,\gamma_i)-E(\overline{R}|e_l,\gamma_i)$

So, for α to be both fulfil the incentive and participation constraints of the manger we must have:

$$\alpha \leq \min\{\alpha_{icm}; \alpha_{pcm}\} \tag{21}$$

Now, we turn to the less competitive participant in this game, the financer. He needs a sharing ratio α_{pcf} that enables him to at least break even. We extend the integrals of the financier participation constraints as follows:

$$\int_0^1 \theta_h g(\theta_h)d\theta_h[\int_0^I \underline{R}_f f(R|e_h,\gamma_i)dR \int_I^R \overline{R}_f f(R|e_h)$$
$$+(1-\int_0^1 \theta_h g(\theta_h)d\theta_h)[\int_0^I \underline{R}_f f(R|e_l,\gamma_i)dR \int_I^R \overline{R}_f f(R|e_l) \geq \beta I$$

We should note that $\int_0^1 \theta_h g(\theta_h)d\theta_h$ is the expected probability $E(\theta)$ that the agent is of a high effort type. now we formalize our integrals using expected values and replacing $\overline{R}_f$ by $\alpha\overline{R}$ and $\underline{R}_f$ by $\beta\underline{R}$. we get:

$$E(\theta_h)[\beta E(\underline{R}|e_h) + \alpha E(\overline{R}|e_h,\gamma_i]) + (1 - E(\theta_h)[\beta E(\underline{R}|e_l) + \alpha E(\overline{R}|e_l,\gamma_i]) \geq \beta I$$

Solving for α we get:

$$\alpha \geq \alpha_{pcf} = \frac{B[I - \theta_h\Delta\underline{R} - E(\underline{R}|e_l,\gamma_i)}{\theta_h\Delta\overline{R} + E(\overline{R}|e_l,\gamma_i)} \tag{22}$$

the final step is to find the span of negotiation between the financier and the manager. We can notice that this is achievable as α has to lie down between two

values α_{pcf} and $\min\{\alpha_{inc}; \alpha_{mpc}\}$. In other words, the optimal contract should respect the following profit sharing ratio:

$$\alpha_{pcf} \leq \alpha \leq \min\{\alpha_{icm}; \alpha_{pcm}\} \tag{23}$$

The span of negotiation is then

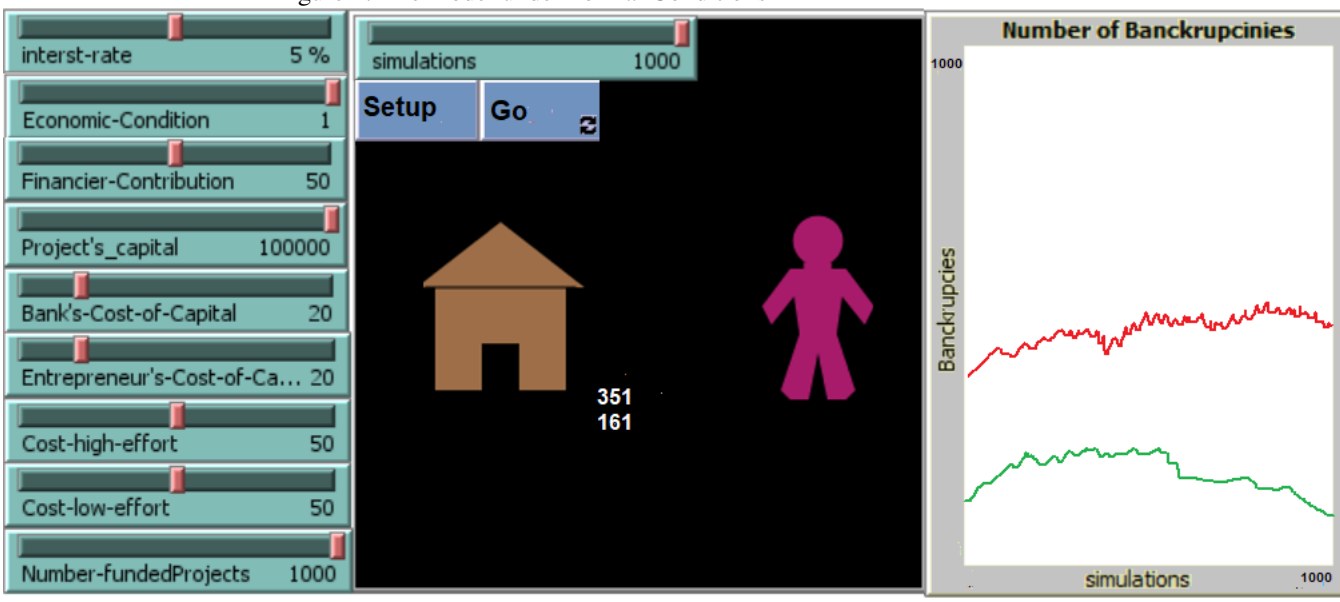
$$\min\{\alpha_{icm}; \alpha_{pcm}\} - \alpha_{pcf} \tag{24}$$

6. Agent Based Simulation

In this section we presents the results of the agent based simulation. Our approach is based on an artificial intelligence platform called Netlogo. We simulate the results under normaleconomic conditions and a crisis for both debt financing and PLS financing:

Figure 1: The model under Crisis Conditions

Figure 2: The model under normal Conditions



The simulation shows two important findings. First under normal conditions PLS banckrupcies are higher than debt financing. This shows that under these conditions the moral hazard problem , which differentiate PLs from debt, is of major concern to financier and of great attraction to financier. Second , under crisis conditions , PLS banckrupcies are lower than the ones under debt finacing. This shows that albeit risky for financier, PLS contract can reduce the risk of bancrupcies in a crisis, and therfore allowing for more entreprises continuities.

7. Conclusion

In this paper we have tried to compare two modes of financing under diffeent economic conditions: Normal and Crisis. Using an artificial intellegence model , Netlogo, we found simulation evidence that PLS Contract provide for less banckrupcies during economic crisis. On the hand Debt financing provides for less banckrupcies during economic prospereties. The fact that PLS suffers from high banckrupcies during normal conditions is therfore a reflection of how accute the moral hazard problem under these contracts. This paper provides extra venues for extentions. One venue is to collect real data after the COVID crisis in order to add more realism to the results. indeed the real banckrupcies data could be compared to the simulation results model. The results of the comparison would suggest further improvments to the model.

References

References

Ahmed, G.A., 2008. The implication of using profit and loss sharing modes of finance in the banking system, with a particular reference to equity participation (partnership) method in sudan. Humanomics .

Akacem, M., Gilliam, L., 2002. Principles of islamic banking: Debt versus equity financing. Middle East Policy 9, 124.

Amit, R., Glosten, L., Muller, E., 1990. Entrepreneurial ability, venture investments, and risk sharing. Management science 36, 1233–1246.

Baierl, G.T., Kaplan, P.D., et al., 2002. Venture capital and its role in strategic asset allocation. The Journal of Portfolio Management 28, 83–89.

Brunnermeier, M., Krishnamurthy, A., et al., 2020. Corporate debt overhang and credit policy, in: BPEA conference.

Casamatta, C., 2003. Financing and advising: optimal financial contracts with venture capitalists. The Journal of Finance 58, 2059–2085.

Cochrane, J.H., 2005. The risk and return of venture capital. Journal of financial economics 75, 3–52.

Elitzur, R., Gavious, A., 2003. Contracting, signaling, and moral hazard: a model of entrepreneurs,'angels,'and venture capitalists. Journal of Business Venturing 18, 709–725.

Gompers, P., Lerner, J., 1999. The venture capital cycle mit press cambridge massachusetts usa .

Hall, B.H., Lerner, J., 2010. The financing of r&d and innovation, in: Handbook of the Economics of Innovation. Elsevier. volume 1, pp. 609–639.

Jain, B.A., 2001. Predictors of performance of venture capitalist-backed organizations. Journal of Business Research 52, 223–233.

Kaplan, S.N., Strömberg, P., 2003. Financial contracting theory meets the real world: An empirical analysis of venture capital contracts. The review of economic studies 70, 281–315.

Kaplan, S.N., Strömberg, P.E., 2004. Characteristics, contracts, and actions: Evidence from venture capitalist analyses. The Journal of Finance 59, 2177–2210.

Keuschnigg, C., Nielsen, S., 2003a. Public policy for start-up entrepreneurship with venture capital and bank finance .

Keuschnigg, C., Nielsen, S.B., 2003b. Tax policy, venture capital, and entrepreneurship. Journal of Public economics 87, 175–203.

MacIntosh, J., Cumming, D., 1997. Venture capital exits in canada and the united states .

Neher, D.V., 1999. Staged financing: an agency perspective. The Review of Economic Studies 66, 255–274.

Sahlman, W.A., 1990. The structure and governance of venture-capital organizations. Journal of financial economics 27, 473–521.

Skeel, D., 2020. Bankruptcy and the coronavirus. Brookings Economic Studies .

Tykvová, T., 2007. What do economists tell us about venture capital contracts? Journal of Economic Surveys 21, 65–89.