

Tennert, Julius; Lambert, Marie; Burghof, Hans-Peter

**Working Paper**

## Moral hazard in VC finance: More expensive than you thought

Hohenheim Discussion Papers in Business, Economics and Social Sciences, No. 02-2017

**Provided in Cooperation with:**

Faculty of Business, Economics and Social Sciences, University of Hohenheim

*Suggested Citation:* Tennert, Julius; Lambert, Marie; Burghof, Hans-Peter (2017) : Moral hazard in VC finance: More expensive than you thought, Hohenheim Discussion Papers in Business, Economics and Social Sciences, No. 02-2017, Universität Hohenheim, Fakultät Wirtschafts- und Sozialwissenschaften, Stuttgart,  
<https://nbn-resolving.de/urn:nbn:de:bsz:100-opus-13315>

This Version is available at:

<https://hdl.handle.net/10419/155310>

**Standard-Nutzungsbedingungen:**

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

**Terms of use:**

*Documents in EconStor may be saved and copied for your personal and scholarly purposes.*

*You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.*

*If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.*

UNIVERSITY OF HOHENHEIM

FACULTY OF BUSINESS, ECONOMICS AND SOCIAL SCIENCES



HOHENHEIM DISCUSSION PAPERS  
IN BUSINESS, ECONOMICS AND SOCIAL SCIENCES

Research Area INEF

DISCUSSION PAPER 02-2017

**MORAL HAZARD IN VC FINANCE:  
MORE EXPENSIVE  
THAN YOU THOUGHT**

**Julius Tennert**

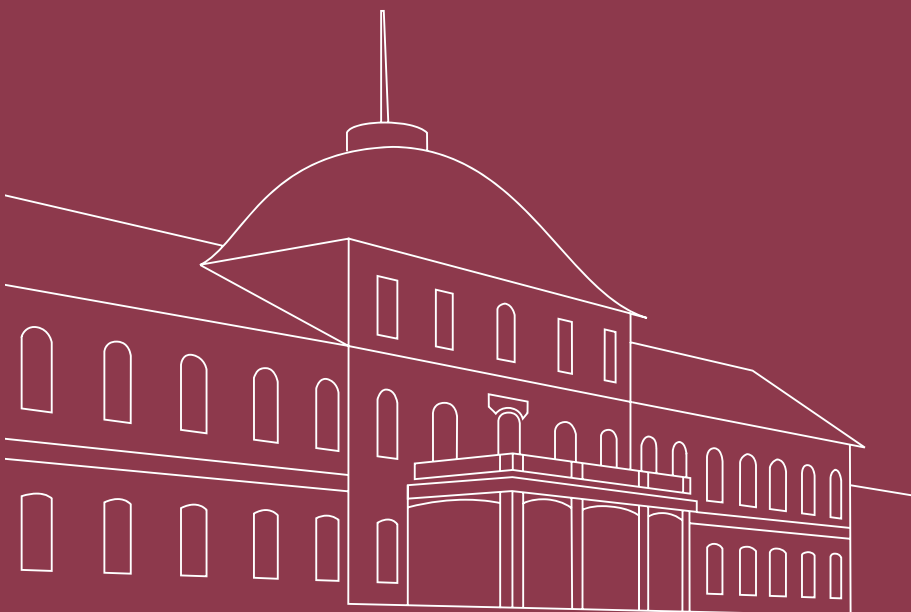
University of Hohenheim

**Marie Lambert**

University of Liège

**Hans-Peter Burghof**

University of Hohenheim



[www.wiso.uni-hohenheim.de](http://www.wiso.uni-hohenheim.de)

Discussion Paper 02-2017

**Moral Hazard in VC Finance: More Expensive than You Thought**

Julius Tennert, Marie Lambert, Hans-Peter Burghof

*Research Area "INEF – Innovation, Entrepreneurship and Finance"*

Download this Discussion Paper from our homepage:

<https://wiso.uni-hohenheim.de/papers>

ISSN 2364-2076 (Printausgabe)  
ISSN 2364-2084 (Internetausgabe)

Die Hohenheim Discussion Papers in Business, Economics and Social Sciences dienen der schnellen Verbreitung von Forschungsarbeiten der Fakultät Wirtschafts- und Sozialwissenschaften. Die Beiträge liegen in alleiniger Verantwortung der Autoren und stellen nicht notwendigerweise die Meinung der Fakultät Wirtschafts- und Sozialwissenschaften dar.

---

Hohenheim Discussion Papers in Business, Economics and Social Sciences are intended to make results of the Faculty of Business, Economics and Social Sciences research available to the public in order to encourage scientific discussion and suggestions for revisions. The authors are solely responsible for the contents which do not necessarily represent the opinion of the Faculty of Business, Economics and Social Sciences.

# Moral Hazard in VC Finance: More Expensive than You Thought

Julius Tennert<sup>1</sup>, Marie Lambert<sup>2</sup>, and Hans-Peter Burghof<sup>1</sup>

<sup>1</sup>University of Hohenheim

<sup>2</sup>HEC Management School, University of Liège

January 9, 2017

## Abstract

Venture projects are fraught with exogenous market risk and endogenous agency risk. We apply a real options perspective to analyze the investment decision of the venture capitalist (VC) in this set-up. The solutions presented are conflictive: the VC reduces his exposure to exogenous risk by delaying investments to wait for informational updates (delay option), but he mitigates endogenous risk by advancing investments to discover entrepreneur's effort. So far, papers focus on the optimal timing of investments considering independence of exogenous and endogenous risk. We show that interdependence of exogenous risk and endogenous risk exists. We find that endogenous risk prompts the VC to accelerate the discovery process when exogenous risk is high, and to abandon the delay option when it is most valuable.

*Keywords:* Venture Capital; Real Option; Agency Cost; Moral Hazard

*JEL classification:* G11; G12; G24; D53

**Acknowledgments:** We acknowledge the DALAHO Hohenheim for extant access to their databases. We acknowledge Dow Jones to provide Venture Source, to Standard and Poors to provide Compustat Global, to Thomson Reuters to provide Datastream, and to Eurostat to provide data to our research.

We thank George Huebner, Christos Koulovatianos, Thomas Bonesire, Tereza Tykvová and the participants of the HVB Doctoral Colloquium, 14th Corporate Finance Day at the KU Leuven, 2nd and 3rd Hohenheim Finance Workshop at the University of Hohenheim, 4th International PhD Colloquium on Financial Topics during a Time Period of Financial and Monetary Changes at the RWTH Aachen University, World Finance and Banking Symposium at the University of Dubai, and the Research Seminar - Finance & Law at the HEC Management School Liège for their valuable comments.

# 1 Introduction

Venture firms operate in highly dynamic markets, where future market conditions are particularly uncertain and can change very fast. In this environment, the venture capitalist (VC) has to cope with two tasks: he has to manage his investment risk with respect to market uncertainty, and he has to manage the project with respect to agency conflicts. The market uncertainty describes an exogenous risk that impacts the prospects of the venture project, such as technological progress within the industry, trending consumer behavior or competitor's response to new products and services. It is out of the control of the VC or the entrepreneur, making the venture project basically a bet on future market conditions. The agency conflicts between the VC and the entrepreneur describe an endogenous risk that impacts the successful realization of the project, such as uncertainty about the effort of the entrepreneur.

In this set-up, we analyze the investment decision of the VC in a real options framework. Real options describe future decision rights, rights but not obligations to take some action in the future. This provides a decision maker flexibility to act upon informational updates (Dixit & Pindyck, 1994; McDonald & Siegel, 1982; Trigeorgis, 1996). The real options theory suggests that investments are exposed to two types of risks: the exogenous risk that is irreducible through organizational activity, and the endogenous risk that can be substantially influenced by organizational activity (Folta, 1998; McGrath *et al.*, 2004).

By applying staged capital infusion, the VC creates future investment opportunities. Once the VC committed an initial investment to a venture project, he receives the right to participate in future financing rounds of the project. Furthermore, the VC decides whether to immediately commit funds to advance the development of the project, or to defer investments to slow down the development.

On the one hand, the VC can reduce his exposure to the exogenous risk by deferring investments to wait for informational updates about future market conditions: if market conditions turn out to be favorable, the VC commits additional funds to capitalize on the growth prospects of the project. Conversely, if market conditions turn out to be bad, the VC abandons the project to confine high downside losses (Li, 2008). On the other hand, the VC mitigates the endogenous risk by learning about the behavior of the entrepreneur (Chi & McGuire, 1996): by investing the VC observes the performance of the project and aggregates beliefs about the effort of the entrepreneur.

The solutions presented to exogenous and endogenous risks are conflictive: with respect to the exogenous risk, the VC defers investments to confine downside losses. With respect to the endogenous risk, the VC advances investments to discover the effort of the entrepreneur. So far, papers focus on the optimal timing of investments considering independence of exogenous and endogenous risks (Li, 2008; Gompers, 1995; Neher, 1999; Bergemann & Hege, 1998). Interdependence of exogenous and endogenous risks have not been considered yet. We assume that this interdependence exists. The reason is as follows: entrepreneurs will have motivation to expend their effort if future market conditions are seemingly favorable and prospects of the venture firm are high but their motivation might decrease if expectations about future market conditions change and depress the firm's prospects. The interdependence of exogenous and endogenous risk refers to the idea of a relative value of private benefits. In periods of high market uncertainty, the entrepreneur's expected payoff from the project is downgraded. Private benefits from managing the firm become more attractive to the entrepreneur relative to the successful realization of the project. As a consequence, the entrepreneur's incentive to behave opportunistically increases.

We introduce a formal model to show how agency conflicts tighten in a world of uncertainty and analyze the resulting decision making of the VC. To manage agency

conflicts in times of high market risk, the VC has to accelerate investments to advance the learning process. As a consequence, the VC suffers opportunity loss because he abandons the delay option when it is most valuable. We find empirical support for our theory. We analyze a sample of individual European VC funding from 2003 to 2015. The joint effect of time-serial market risk and cross-sectional agency risk accelerates investments to venture projects.

The remainder proceeds as follows: section 2 gives an overview of the related literature, in section 3 we introduce a formal model to analyze the decision making of the VC, in section 4 we test the implications from the formal model empirically and conduct robustness checks, section 5 concludes.



## 2 Related Literature

In a set-up with exogenous and endogenous risks, the VC's funding decision can be analyzed in a real options framework (Hsu, 2010; Li, 2008). Real options are future decision rights; rights but not obligations to take some action in the future. Future decision rights offer a decision maker flexibility to act upon informational updates (Dixit & Pindyck, 1994; McDonald & Siegel, 1982; Trigeorgis, 1996). In the real world, decisions are not static. For example, a decision maker can defer the initiation of a project to wait for additional information about future market condition. Once started the project, he can abandon it at any given stage of development if environmental conditions turn out to be bad, or he can expand the project if environmental conditions turn out to be positive (Trigeorgis, 1996). In venture finance, VCs use stage financing to create future investment opportunities. Once the VC committed an initial investment to a venture project, he usually receives the right to participate in future financing rounds (Li, 2008). Furthermore, this gives the VC the opportunity whether to concentrate funds in early stages of the project or defer investments shifting them to later stages. This decision is based on the information available and the information gathering process.

The exogenous risk in venture projects is related to unexpected market developments, e.g. technological progress within the industry, trending consumer behavior or competitor's response to new products and services that depress the project's expected value (Li, 2008). Exogenous risk is out of the control of a decision maker and resolves primarily with the passage of time (McGrath, 1997; Pindyck, 1993; Dixit & Pindyck, 1994). In this case, the timing of investments can be seen as a decision whether to hold the current option to invest and wait for informational updates about the market conditions or to invest immediately and capitalize on the information available (delay

option) (Li, 2008). If market conditions turn out to be favorable, the VC commits additional funds to earn a high return. Conversely, if market conditions turn out to be bad, the VC abandons the project to confine high downside losses (Li, 2008). If uncertainty about future market conditions is high, the option to wait for informational updates is economically more valuable than immediate investment (Dixit & Pindyck, 1994; McDonald & Siegel, 1982; Trigeorgis, 1996). Recent research shows that VCs delay the initiating and continuation of venture projects when market uncertainty is particularly severe (Li, 2008; Li & Mahoney, 2011).

The endogenous risk in venture projects is related to agency conflicts between the VC and the entrepreneur. The entrepreneur inhibits the role of a contracting agent and owns human capital, such as specific skills or knowledge, essential to realize the venture project (Hart & Moore, 1994). Furthermore, venture projects are characterized through a high fraction of intangible assets and growth opportunities giving great discretion to the action of the entrepreneur (Amit *et al.*, 1998; Bergemann & Hege, 1998; Cornelli & Yosha, 2003; Burchardt *et al.*, 2014; Gompers, 1995; Neher, 1999). The entrepreneur might be unwilling to expend effort to maximize shareholder's value (Gompers, 1995; Chan *et al.*, 1990; Hansen, 1992), or be willing to extract informational rents from information asymmetries (Aghion & Bolton, 1992; Hellmann, 1998; Kirilenko, 2001).

When risks can be substantially influenced by organizational activity, the VC can reduce his exposure by learning (Chi & McGuire, 1996): by investing the VC observes the performance of the project and aggregate beliefs about the effort of the entrepreneur. To avoid an inefficient continuation of the venture project, the VC implements various mechanisms like contingent control allocation (Chan *et al.*, 1990; Kirilenko, 2001), convertible securities (Casamatta, 2003; Cornelli & Yosha, 2003; Repullo & Suarez, 2004; Schmidt, 2003), and staging (Bergemann & Hege, 1998; Neher, 1999).

We argue that investing is always possible. Hence, in a world of uncertainty, the option to defer investments is economically more valuable than investing. Any characteristics of the project that force the VC to abandon the delay option must arise opportunity loss.

## 3 Formal Model

### 3.1 The Venture Project

We describe a venture project as a one-shot (static) problem. A financially constrained entrepreneur  $E$  owns a project with uncertain returns. The project is financed by a venture capitalist  $VC$ .  $E$  provides effort  $\varepsilon$ , with  $\varepsilon = \{0, 1\}$ . The effort of the entrepreneur is a critical resource for the success of the firm. Physical assets purchased have no value to the  $VC$  without the effort of the entrepreneur (Hart & Moore, 1994).

The  $VC$  and the  $E$  are considered to be risk-neutral. The  $VC$  provides the total investment in equity financing only. The  $VC$  and  $E$  agree on a sharing contract in  $t = 0$ . The sharing contract defines the entrepreneur's share  $S_E$  of the project's payoff and the timing of the investments. The project requires a total investment  $I$  to be completed.

The  $VC$  follows an investment path  $i_0, \dots, i_T$  to provide funds. The investment path gives the  $VC$  the opportunity to time his investments. The funding is completed at time  $T$  with  $0 \leq T \leq 1$  and  $I_T = I = \sum_0^T i_t$ . Investments are sunk once committed to the project. Time is standardized to the interval  $[0, 1]$ . The discount rate is  $d = 0$ .

In  $t = 1$ , an exogenous stochastic shock  $\pi$  is realized with probability  $(1 - p)$ , with  $p \in [0, 1]$ . Probability  $(1 - p)$  is related to the level of exogenous risk and is ex-ante known by the  $E$  and the  $VC$ . The project is valueless if the shock is realized, otherwise the project generates the payoff  $V(\varepsilon)$ . The project's value follows a Bernoulli distribution

$$V(\varepsilon) = \begin{cases} 0 & \text{w. Pr. } (1 - p) \\ V(\varepsilon) & \text{w. Pr. } p \end{cases} \quad (1)$$

with  $V(1) > 0$  and  $V(0) = 0$ . In other words, the  $E$  has to expend effort to realize the

project.

Probability  $(1 - p)$  is out of the control of the  $E$  and the  $VC$ , and resolves with the passage of time. There is a confidence level  $\theta_\pi(T)$  at time  $T$  that  $\pi$  is realized in  $t = 1$ . It describes the aggregation of beliefs about the future market conditions over time.  $\theta_\pi(T)$  is based on the square-root-of-time rule. The rule allows higher frequency risk estimates to be scaled down to a lower frequency. It is commonly used when financial risk is time aggregated. The confidence level  $\theta_\pi(T)$  is

$$\theta_\pi(T) = T^{0.5} \quad (2)$$

### 3.2 Maximization Function of the Venture Capitalist

Exogenous risk  $(1 - p)$  constrains the project's expected payoff.  $I_0$  is a non-arbitrary staging path of the  $VC$  that immediately invests  $I$  in  $t = 0$ . The  $VC$ 's expected payoff  $P(0)^{VC}$  is

$$P(0)^{VC} = -I_0 + (1 - S_E)pV(\varepsilon) \quad (3)$$

Over time, the  $VC$  becomes more confident about the exogenous stochastic shock  $\pi$  being realized in  $t = 1$ .  $I_1$  is a non-arbitrary investment path, where the investment process is completed in  $t = 1$ . To show the impact of delaying investments, we simplify the staging path  $I_1$  to the situation where the VC invest  $I$  in  $t = 1$ . Hence, the total investment is delayed until uncertainty about the realization of the shock is revealed. The VC only invests if  $\pi$  is not realized. The expected payoff  $P(1)^{VC}$  is

$$P(1)^{VC} = (-I_1 + (1 - S_E)V(\varepsilon))p \quad (4)$$

The staging path provides the *VC* the option to delay investments until he is more confident about the realization of the exogenous stochastic shock. The economic value of this delay option  $D(T)$  is positively related to the probability  $(1 - p)$ , and delay  $T > 0$ .

$$D(T) = P(T)^{VC} - P(0)^{VC} \quad (5)$$

$$= \theta_\pi(T)[-I(p - 1)] \quad (6)$$

The *VC* maximizes his total payoff  $P(T)^{VC}$

$$P(T)^{VC} = \operatorname{argmax}_T \{(1 - S_E)pV(\varepsilon) - I + \theta_\pi(T)[-I(p - 1)]\} \quad (7)$$

### 3.3 Participation Constraint of the Entrepreneur

$E$  chooses between the two effort levels  $\varepsilon = 1$ , and  $\varepsilon = 0$ . If  $E$  expend effort ( $\varepsilon = 1$ ), he can realize  $V(1)$  with probability  $p$ . Since  $E$  does not provide funds, the delay of investments has no economic value to him. His expected payoff  $P(t, \varepsilon)^E$  is  $P(1, \varepsilon)^E = P(0, \varepsilon)^E = P(\varepsilon)^E$ , where  $P(1, \varepsilon)^E$  specifies the case when the *VC* invests  $I$  in  $t = 1$  and  $P(0, \varepsilon)^E$  specifies the case when the *VC* invests  $I$  in  $t = 0$ .

Since tasks of the entrepreneur are highly interdependent and can not be monitored accurately, his effort level  $\varepsilon$  can not be observed directly. The *VC* discovers the effort of the entrepreneur by aggregating beliefs conditional on the performance of the project. The discovery process is characterized by some imprecision  $\alpha$ , with  $\alpha \in [0, 1]$ . Imprecision  $\alpha$  is equal to zero if the effort of the entrepreneur and the performance of the firm are perfectly correlated. Conversely, if the effort of the entrepreneur and the performance of the firm are not perfectly correlated, it is  $\alpha > 0$ . This describes the

level of project's endogenous risk. Endogenous risk differs across projects and is related to the discretion project's assets provide to the action of the  $E$ , e.g. when tasks of the entrepreneur are highly interdependent, observing the performance of the project will provide only little information about his true effort (Zenger, 1994).

In that,  $\alpha$  defines a certain fraction of the investment  $I$  that  $E$  can divert for private use if he choose  $\varepsilon = 0$ . Choosing  $\varepsilon = 0$ ,  $E$  degrades the project in  $T$  and earns imprecision cost  $C$ . It describes his dis-utility of effort.

Given imprecision, the  $VC$  has to discover the effort  $\varepsilon$  in an endogenous process to efficiently reduce agency risk: he updates his expectation about  $E$ 's effort  $\varepsilon$  conditional on the performance of the project. A bad performance indicates  $\varepsilon = 0$ . The performance of the project is observed when it is continued; funds are required to purchase assets to continue the project. In that, the discovery process is controlled by the  $VC$  conditional on the rate of investments. A high investment rate (small values of  $T$ ) allows the  $VC$  to observe the performance of the project early and to discover entrepreneur's true effort  $\varepsilon$  sooner. By investing, the  $VC$  implements a set of binding provisions to reduce agency conflicts and confine imprecision costs. Hence, imprecision cost  $C$  is conditional on the rate of investments.

$$C = \alpha IT \tag{8}$$

Hellmann (1998) predicts that the more wealth constrained the entrepreneur is, the more likely is investor's control. Furthermore, Kaplan & Stromberg (2003) show that  $VC$ 's control rights are allocated in a way that the  $VC$  obtain full control if the venture project performs poorly. If the  $VC$  discovers true effort  $\varepsilon = 0$  in  $T$ , then the  $VC$  gains full control over the project to punish  $E$ . In this case,  $E$  can not divert funds for private use. However, since the  $VC$  cannot realize the project without  $E$ , payoff  $P(T)^{VC}$  is

zero as well.  $E$  maximizes

$$P(\varepsilon)^E = \operatorname{argmax}_{\varepsilon} \{s_{EP}V(\varepsilon) - C\} \quad (9)$$

The entrepreneur will choose  $\varepsilon = 0$  if

$$C > s_{EP}V(\varepsilon) \quad (10)$$

$$\frac{C}{s_{EP}V(\varepsilon)} > 1 \quad (11)$$

The ratio describes the relative value of private benefits. This is the amount of funds diverted for private use ( $E$  chooses  $\varepsilon = 0$ ), relative to the payoff from the project ( $E$  chooses  $\varepsilon = 1$ ).  $E$ 's incentive to behave opportunistically (to chooses  $\varepsilon = 0$ ), is positively related to probability  $(1 - p)$  that the exogenous shock  $\pi$  occurs, and the level of imprecision  $\alpha$ . The entrepreneur is indifferent between  $\varepsilon = 1$  and  $\varepsilon = 0$  when his expected payoff from the project equals imprecision cost  $C$ . The participation constraint  $P.C.^E$  that incentivizes  $E$  to chose  $\varepsilon = 1$  is

$$s_{EP}V(1) \geq C \quad (12)$$

$$s_{EP}V(1) - \alpha It \geq 0 \quad (13)$$

### 3.4 Solution without Imprecision

In the first best case, there is no imprecision. By definition this is  $\alpha = 0$  and there is no imprecision cost.

$$C = \alpha It = 0 \quad (14)$$



Inserting  $C = 0$  into the participation constraint of the entrepreneur  $P.C.^E$ , the minimum payoff  $P(1)^E$  to incentivize  $E$  to choose  $\varepsilon = 1$  is

$$P(1)^{E^{**}} = 0 \quad (15)$$

The  $E$  earns no surplus over his cost of capital. The  $VC$  maximizes  $P(T)^{VC}$ .  $T^{**}$  and  $S_E^{**}$  is

$$T^{**} = 1 \quad (16)$$

$$S_E^{**} = 0 \quad (17)$$

The payoff to the  $VC$  is

$$P(T^{**})^{VC} = [-I + V(1)]p \quad (18)$$

The  $VC$  earns all the payoff from the project and the total value of the delay option.

### 3.5 Solution with Imprecision

In the second best case, imprecision exists. By definition this is  $\alpha > 0$ . The effort of the  $E$  is not perfectly correlated with the observed performance of the project. For  $T > 0$  imprecision cost  $C$  arise. The  $VC$  has to vest share  $S_E$  of project's payoff to  $E$  to incentivize him to choose  $\varepsilon = 1$ . With respect to the participation constraint of the entrepreneur  $P.C.^E$ ,  $S_E$  is

$$P.C.^E : s_E p V(1) = \alpha IT \quad (19)$$

$$S_E = \frac{\alpha IT}{pV(1)} \quad (20)$$

For  $I = 1$  and  $V(1) = 1$ , we maximize the payoff  $P(T)^{VC}$  of the  $VC$ .  $T^*$  and  $S_E^*$  are

$$T^* = \frac{(p-1)^2}{4\alpha^2} \quad (21)$$

$$S_E^* = \frac{(p-1)^2}{4\alpha p} \quad (22)$$

Endogenous risk  $\alpha$  and exogenous risk  $(1-p)$  increase the share  $S_E$  vested to the entrepreneur and reduce the residuum share of the  $VC$ . The payoffs to the  $VC$  and the  $E$  are

$$P(T^*)^{VC} = (1 - S_E^*)pV(1) - I + \theta_\pi(T^*)[-I(p-1)] \quad (23)$$

$$P(1)^E = \alpha IT^* \quad (24)$$

The  $VC$  and  $E$  share the surplus from the project. The  $E$  earns the imprecision cost over his cost of capital. The  $VC$  receives the residuum payoff and the value of the delay option.

### 3.6 Opportunity Loss from Imprecision

In a world of uncertainty  $(1-p) > 0$ , the option to delay investments is economically more valuable than immediate investing. This is shown in (6): the value of delay option  $D(T)$  is positively related to the probability  $(1-p)$  that the exogenous shock is realized. Since delay  $T^*$  is negatively related to the level of imprecision  $\alpha$ , agency risk forces the  $VC$  to advance investments. If  $(1-p)$  is high, opportunity loss must arise. Opportunity loss is present if  $D(T) < D(1)$ .

In the first best solution, the  $VC$  invests  $I$  in  $t = 1$  and realizes  $D(1)$ . There is no opportunity loss. In the second best solution, the  $VC$  maximizes his payoff  $P(T)^{VC}$  with respect to the participation constraint of the entrepreneur  $P.C.^E$ . For  $T > 0$

imprecision cost  $C$  arise. For  $C > 0$ , the  $VC$  has to vest share  $S_E > 0$  to  $E$ , to incentivize him to choose  $\varepsilon = 1$ . The  $VC$  will benefit from deferring investments as long as the marginal profits from the delay option exceed the marginal compensation of  $E$ .

$$\frac{\partial P(0)^{VC}}{\partial t} + \frac{\partial D(T)}{\partial t} < \frac{\partial P(1)^E}{\partial t} \quad (25)$$

$$\frac{\partial([1 - \frac{\alpha T}{pV(1)}]pV(1) - I + T^{0.5}[-I(p-1)])}{\partial t} < \frac{\frac{\alpha T}{pV(1)}pV(1)}{\partial t} \quad (26)$$

For  $I = 1$  and  $V(1) = 1$ ,

$$-\alpha - \frac{(p-1)}{2T^{0.5}} < \alpha \quad (27)$$

The  $VC$  realizes the total value of the delay option if  $T = 1$ . For  $T = 1$ , (27) is

$$\alpha^* < \frac{(1-p)}{4} \quad (28)$$

The result shows the critical level of imprecision  $\alpha^*$  at which the  $VC$  realizes the total value of the delay option  $D(1)$ . Formula (28) demonstrates that the critical level of imprecision  $\alpha^*$  is multiplicative with respect to the probability  $(1-p)$ .

In table 1 and figure 1, we give a numerical example to illustrate the impact of exogenous and endogenous risks on the  $VC$ 's optimal timing of investments  $T^*$ . For  $(1-p) > 0$  and  $T^* < 1$  opportunity loss arise. We present the resulting opportunity loss  $D(1) - D(T^*)$  in table 1 and figure 2. For any level of endogenous risk  $\alpha$ , opportunity loss decreases in exogenous risk  $(1-p)$ . This means that the  $VC$  defers investments to capitalize on informational updates if exogenous risk is high. Conversely, for any level of exogenous risk  $(1-p)$ , opportunity loss increases in the level of endogenous risk  $\alpha$ . This means that the  $VC$  accelerates investments and abandons a fraction of the delay option to initiate the discovery of entrepreneur's effort if endogenous risk is high. In

that, endogenous risk restricts the value of the delay option.

The VC accelerates the discovery of entrepreneur's effort in exogenous risk  $(1 - p)$ . This is because the relative value of entrepreneur's private benefit  $\frac{C}{s_{ED}V(\varepsilon)}$  increases in exogenous risk, increasing his incentive to behave opportunistically. As a consequence, the VC has to abandon a larger proportion of the delay option when it is most valuable. This accelerates his opportunity loss. We derive three testable hypotheses:

- Hypothesis 1:** VCs delay investments if exogenous market risk is high.
- Hypothesis 2:** VCs advance investments if endogenous agency risk is high.
- Hypothesis 3:** VCs accelerate investments if exogenous market risk and endogenous agency risk are high.

Table 1: Numerical Illustration

	T*					D(1)-D(T*)				
	$\alpha$					$\alpha$				
	0.4	0.45	0.5	0.55	0.6	0.4	0.45	0.5	0.55	0.6
$(1-p)$ 0.75	0.879	0.694	0.563	0.465	0.391	0.047	0.125	0.188	0.239	0.281
0.7	0.766	0.605	0.490	0.405	0.340	0.088	0.156	0.210	0.255	0.292
0.65	0.660	0.522	0.423	0.349	0.293	0.122	0.181	0.228	0.266	0.298
0.6	0.563	0.444	0.360	0.298	0.250	0.150	0.200	0.240	0.273	0.300
0.55	0.473	0.373	0.303	0.250	0.210	0.172	0.214	0.248	0.275	0.298

We illustrate the optimal timing of the investment as a function of the delay of investments  $T^*$  in Fig. 1, and the resulting opportunity loss  $D(1) - D(T^*)$  in Fig. 2; for  $\alpha \in [0.4, 0.6]$ ;  $(1-p) \in [0.55, 0.75]$ .

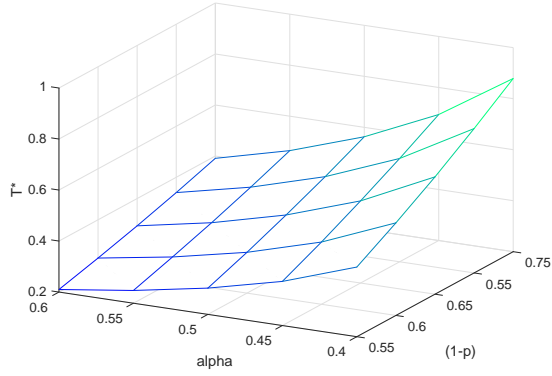


Figure 1: Delay  $T^*$

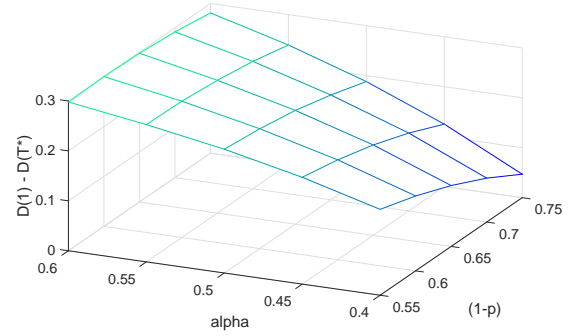


Figure 2: Opportunity Loss  $D(1) - D(T^*)$

## 4 Empirical Approach

### 4.1 Data

Our sample covers individual financing rounds from venture projects based in 15 European countries<sup>1</sup> for the period from 2003/01/01 to 2015/12/31 from Dow Jones Venture Source. The sample period covers the post-dotcom bubble period and the financial crisis of 2007. Furthermore, the sample period covers the European sovereign debt-crisis in 2009 that came along with an expansive monetary policy of the European Central Bank.

We exclude venture firms from the energy and utilities sector. Energy-related infrastructure projects, and renewable energy production was strongly supported and highly regulated by the European Union within the sample period.

We use sector classifications provided by Dow Jones Venture Source. Sector classifications are matched to the GICS (Global Industry Classification Standard) classification scheme based on industry descriptions. We aggregate industries' end-of-the-year business ratios of listed firms from Compustat global.

### 4.2 Econometric Method

We analyze the the duration of a financing round. This is defined as the time between the completion of two subsequent financing rounds. An increasing duration characterizes the delay of an investment. Conversely, a decreasing duration characterizes an advancement of investments (Gompers, 1995; Li, 2008).

We use a difference-in-difference approach to analyze the joint effect of exogenous and endogenous risks on the duration of the financing round. The method allows us

---

<sup>1</sup>Belgium, Austria, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, United Kingdom, Denmark, Finland, Sweden

to separately estimate a time-series effect of the exogenous risk, a cross-sectional effect of the endogenous risk, and a joint effect of exogenous and endogenous risks.

We use an accelerated-failure time model to fit information about the duration into a parametric regression model. We model duration by the survival time of the financing round. Failure is the completion of the round. The censoring date is the date of the initial public offering, acquisition or bankruptcy. Ongoing investments are censored after five years (1825 days). To follow each event for five years, we restrict our analysis to financing events that took place between 2003/01/01 and 2010/12/31. This leaves us with 7,336 observations.

The survival function  $S(t)$  is the probability that a financing round is completed later than  $t$

$$S(t) = P(T > t)$$

The failure time is modeled by a linear effect composed of the covariates and a random disturbance term  $\epsilon$ .  $\epsilon$  is a vector of errors assumed to come from a known distribution and  $\sigma$  is an unknown scale parameter. We fit the model to the natural logarithm of the duration and Weibull distribution of the error term. The model fits the paper's focus on the timing of investments since the estimation parameters in the accelerated failure time model can be interpreted as the influence of the explanatory variables on the failure time. This model is commonly used in duration studies (Gompers, 1995; Li, 2008). The parameters are estimated by maximum likelihood method with a Newton-Raphson algorithm. The standard errors of the parameter estimates are estimated

from the inverse of the observed information matrix. The model is

$$\begin{aligned} \text{Log}(\textit{Duration}) &= \alpha + \gamma_t(\textit{Exogenous}_t) + \beta_i(\textit{Endogenous}_i) \\ &\quad + \delta_{t,i}(\textit{Exogenous}_t^* \textit{Endogenous}_i) \\ &\quad + \zeta_i(\textit{Controls}_i) + \sigma\epsilon_{t,i} \end{aligned}$$

where *Duration* is the duration of the financing round; *Exogenous*<sub>*t*</sub> is a time-series variable that captures the exogenous market risk,  $\gamma_t$  estimates the time-series effect of exogenous market risk on the duration of the financing round. *Endogenous*<sub>*i*</sub> is a vector of cross-sectional variables that captures firm's exposure to the endogenous agency risk.  $\beta_i$  estimates the cross-sectional effect of endogenous agency risk on the duration of the financing round.  $\delta_{t,i}$  is the joint effect of exogenous and endogenous risks on the duration of the financing round. *Controls*<sub>*i*</sub> is a vector of individual control variables,  $\zeta_i$  is the vector of its estimation parameters.

## 4.3 Measures

### 4.3.1 Exogenous Risk

The exogenous market risk is related to unexpected market developments that are out of the control of the entrepreneur and the VC (Li, 2008; McGrath, 1997; Pindyck, 1993; Dixit & Pindyck, 1994). We relate the exogenous risk to market price volatility. It captures the level of accumulated market uncertainty (Cochrane, 2005). VCs delay investments to ongoing projects and the initiation of new projects if the aggregate market volatility is high (Li, 2008, Li & Mahoney 2011). We use the level of the Euro Stoxx 50 Volatility Index (VStoxx 50) at the funding date to measure the exogenous risk. The index is based on Euro Stoxx 50 options prices and reflects the one year ahead market expectation of volatility.



### 4.3.2 Endogenous Risk

We relate the endogenous agency risk to tasks of a start-up entrepreneur in developing an innovative product, and scaling the venture firm. First, tasks in developing an innovative product are highly interdependent (Bishop, 1987), e.g. technological process might accelerate or constrain the speed of developing an innovative product. The early performance of the project is conditional on technological process in that the entrepreneur reaches milestones faster if the technological environment is favorable. From the perspective of the VC, it is difficult to discover whether a good performance is solely up-on the effort of the entrepreneur or results from a favorable technological environment. This is in particular the case for tasks where the entrepreneur has to expend primarily cognitive effort, because the entrepreneur's true cognitive effort can not be discovered by observing his actions (Zenger, 1994). When the correlation of entrepreneur's true effort and the performance of the firm is highly imprecise, the VC has to advance the development of the firm to aggregate beliefs about the entrepreneur's true effort. As a consequence, agency risk is high if the project requires substantial cognitive effort to develop a new innovative product. We relate the effort required to develop an innovative product to the R&D intensity of the industry. The development will require substantially more effort of the entrepreneur if the industry is R&D intense. VCs advance investments to ongoing projects if they operate in R&D intense industries (Gompers, 1995; Li, 2008). We measure R&D intensity by industry's median R&D-expenditures-to-sales ratio at previous year's end (Gompers, 1995; Li, 2008).

Second, scaling the venture firm is related to the realization of growth opportunities. Nonetheless, from the perspective of the VC, it is difficult to discover whether a favorable performance - e.g. increasing sales volumes - results from high effort of the entrepreneur or are due to a favorable growth environment. This is especially the

case because growth opportunities provide the entrepreneur the chance to manipulate the growth signal revealed to the VC (Cornelli & Yosha, 2003). For example the entrepreneur might engage in short term sales activities to reveal a more positive signal to the VC without increasing his true (long-term) sales effort. When the performance revealed to the VC is manipulated in such a way, the correlation of entrepreneur's true effort and the observed performance of the firm is highly imprecise. The VC has to advance the development of the firm to aggregate beliefs about the entrepreneur's true effort. Agency risk is high if the the venture project implies strong growth opportunities. Firm's growth opportunities are substantially larger if the industry is characterized by strong growth opportunities. VCs advance investments to ongoing projects if they operate in an industry characterized by high growth opportunities (Gompers, 1995; Li, 2008). Strong growth opportunities are signaled by a high market-to-book ratio (Chan & Chen, 1991). We measure growth opportunities by industry's median market-to-book ratio at previous year's end (Gompers, 1995; Li, 2008).

### **4.3.3 Contract Design**

The financing instrument defines whether the VC is more actively involved in the operations of the project or inherits a passive role. By equity investments the VC receives power in the board of directors. This provides him with the opportunity to monitor endogenous performance and approve significant decisions. It possesses strong governance abilities when compared to debt instruments since it emphasizes behavior control of the entrepreneur (Fama & Jensen, 1983). This reduce exposure to endogenous risk and might encourage the VC to take rather advantage of the delay option than to advance the discovery process. We classify debt-like and an equity-like instruments. We assume pure debt and convertible debt to posses the characteristics of a debt instrument, whereas equity swaps and pure equity posses the characteristics

of an equity instrument.

Small funding amounts limit opportunistic behavior of the entrepreneur in that they reduce the bargaining power of the entrepreneur (Neher, 1999). A small funding amount will prevent the investor's claim from a bid down. This reduce exposure to endogenous risk and might encourage the VC to take advantage of the delay option.

VCS syndicate to obtain a second opinion about the quality of the entrepreneurial project in the pre-investment phase and to provide improved value-adding in the investment phase (Lerner, 1994; Brander *et al.*, 2002). Moreover, those tasks are not independent from each other as an efficient selection of the project increase the effectiveness of the VC's involvement (Casamatta & Haritchabalet, 2007). VCs that syndicate their investment will perform more efficiently allowing them to implement monitoring and control mechanisms at lower cost. This allows the syndicate to implement closer monitoring and control activities. We classify deals with two or more investors involved as syndicated investments.

#### **4.3.4 Firm-specific Information**

Firm-specific information such as financial statements and interviews with employees reveals the entrepreneur's management ability, its motivation and effort. The availability of such a type of information is linked to the project's age (Amit *et al.*, 1998). It acts as a track-record of entrepreneur's past activities. When uncertainty about the entrepreneur's type is reduced, imprecise contracting diminishes. The VC can take advantage of the delay option instead of initiating a discovery process. We calculate project's age counting the days between the start date of the project and the date of the financing event.

Moreover, venture projects differ in quality. The VC gathers this information in the screening process (Casamatta & Haritchabalet, 2007; Sahlman, 1990). The screening

process, however, is exposed to adverse selection concerns. Higher quality projects have a more urgent need for capital to finance their future growth (Li, 2008). As a consequence, entrepreneurs initiating low quality projects have incentive to imitate higher quality projects to increase their funding. Hence, staging is more important for projects that pretend to be of high quality, since staged financing rejects low promising firms (Sahlman, 1990). By controlling for the quality of the project, we separate adverse selection risk and moral hazard risk, that is the concerns about a misrepresentation of project's quality and the concerns about the true effort of the entrepreneur. Moreover, effort of the entrepreneur is necessary but not sufficient for the success of the firm: even high quality projects will not succeed without entrepreneur's effort; however, even if the entrepreneur expend high effort to a low quality project, it will not succeed. We measure quality by an ex-post indicator of success which is an exit of the firm (Gompers, 1995; Li, 2008; Brander *et al.*, 2002; Gompers & Lerner, 2000; Sorenson & Stuart, 2001). We use information about an exit of the firm based on the information available on Venture Source at the date of data generation. We classify projects that had an IPO or tradesale as high quality projects.

#### **4.3.5 Environmental Conditions**

VCS adjust their investments according to market signals such as the general boom and bust cycles of the public equity markets, and economic growth. We control for total VC funding in the previous year which is positively related to good funding conditions (Gompers *et al.*, 2008; Cherif & Gazdar, 2011; Félix *et al.*, 2013).

Favorable institutional environments such as a strong corporate governance and investor protection increase the power to mitigate agency conflicts (Cumming *et al.*, 2010; Jeng & Wells, 2000). We control for the home country of the venture firm to address the impact of different institutional environments.

At last, we control for venture firm's industry sector to account for unobserved sector-specific fixed effects.

#### 4.4 Empirical Results

In our sample, the average duration of a financing round is 593 days, approximately 19.5 months. Table 2 presents descriptive statistics and correlations of the variables. None of the correlations are sources of concern for multi-collinearity.

To apply the difference-in-difference approach, we identify firms fraught with endogenous risk based on industries' R&D-to-sales ratio and market-to-book ratio; and financing rounds exposed to exogenous risk based on the aggregate level of market price volatility at the funding date. We use log rank test statistic to estimate break-point values of the variables. For any R&D-expenditures-to-sales ratio, market-to-book ratio, or level of the VStoxx 50 Index above the break-point value, we assign the project, resp. the financing round to be exposed to endogenous, resp. exogenous risk. We apply the method of Contal & O'Quigley (1999) to estimate the break-point values. The method is an outcome-oriented approach to compute break-point values corresponding to its most significant relation with the outcome, and is designed for survival analysis with censored data. We compare our break-point values to median values in Table 3. The break-point value of the R&D-expenditures-to-sales ratio is higher than its median value. The higher break-point value indicates that only high levels of R&D intensity increase endogenous risk. The break-point value for market-to-book ratio equals its median value. The break-point value for the VStoxx 50 Index is lower than its median value. The lower break-point value indicates that even low levels of exogenous risk provide the VC an opportunity to take advantage of the delay option.

We show the results from the duration analysis in Table 4. Estimation (1) is the baseline model that includes the control variables. We find that VCs adjust the

timing of investments according to the contract design, the availability of firm-specific information, and environmental conditions. Estimations (2) to (6) add information about exogenous and endogenous risk. The new information does not change the impact of the control variables.

The first hypothesis states that VCs delay subsequent investments to wait for informational updates about the market conditions when exogenous risk is high. We include the dummy variable *Market Uncertainty* in estimations (2), (4), (5) to analyze the impact of exogenous risk on the duration of the financing round. *Market Uncertainty* is equal to one if the VStoxx 50 Index is above the break-point value, and zero otherwise. We find that VCs defer investments with respect to exogenous risk. In estimation (2), we model the duration based on the control variables and *Market Uncertainty*. *Market Uncertainty* increases the duration by approximately two months. This corresponds to 9% of the average duration of a financing round. In estimation (4), we add information about project's endogenous risk. The impact of the variable *Market Uncertainty* remains unchanged. In estimation (5), we consider interdependence of exogenous and endogenous risk. The impact of the variable *Market Uncertainty* increases compared to estimations (2) and (4); in estimation (5) *Market Uncertainty* increases the duration by approximately three months. This corresponds to 14% of the average duration of a financing round. We explain this observation by a high value of the delay option. Considering interdependence of exogenous and endogenous risk, we find that the impact of *Market Uncertainty* increases. This indicates that endogenous risk restricts the delay of investments.

The second hypothesis states that VCs advance subsequent investments to advance the discovery process when endogenous risk is high. We include the dummy variables *R&D Intensity* and *Growth Opportunities* in estimations (3), (4), (5) to analyze the impact of endogenous risk on the duration of financing events. *R&D Intensity*, resp.

*Growth Opportunities* is equal to one if industries' R&D-to-sales ratio, resp. market-to-book ratio is above the break-point value, and zero otherwise. We find that VCs advance investments with respect to endogenous risk. In estimation (3), we model the duration based on the control variables and *R&D Intensity* and *Growth Opportunities*. *R&D Intensity* decreases the duration by approximately two and a half months. This corresponds to 13% of the average duration of a financing round. *Growth Opportunities* does not impact the duration. In estimation (4), we add information about exogenous risk at the funding date. The impact of the variables remains unchanged. When interdependence of exogenous and endogenous risk is considered in estimation (5), the impact of the variable *R&D intensity* slightly increases compared to estimations (3) and (4); in estimation (5) *R&D Intensity* decreases the duration by approximately three months. This corresponds to 14% of the average duration of a financing round. *Growth Opportunities* increase the duration for a low exogenous risk but decrease duration for a high exogenous risk. We explain the results by the initiation of a discovery process.

The third hypothesis states that VCs accelerate subsequent investments when exogenous and endogenous risk are high. In estimation (5), we consider interdependence of exogenous and endogenous risk by an interaction term of *Market Uncertainty*, and *R&D Intensity*, resp. *Growth Opportunities*. The interaction terms are equal to one if *Market Uncertainty*, and *R&D intensity*, resp. *Growth Opportunities* are equal to one, and zero otherwise. We find that interaction of exogenous and endogenous risk accelerates investments. *Market Uncertainty* does not affect the duration of financing rounds differently with respect to *R&D Intensity*. *Market Uncertainty* does not accelerate investments to projects that are fraught with endogenous risk, when measured by industries *R&D Intensity*. *Market Uncertainty*, however, affects the duration of financing rounds differently with respect to *Growth Opportunities*.

*Market Uncertainty* accelerates investments to projects that are fraught with endogenous risk, when measured by industries *Growth Opportunities* by approximately two and a half months. This corresponds to 13% of the average duration of a financing round. We explain the result by an acceleration of the discovery process.



Table 2: Descriptive Statistics and Correlation Matrix

	Mean	Std.	Min	Max	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
<i>Internal Risk</i>													
(a) R&D-expenditures-to-sales	0.200	0.291	0.000	1.004									
(b) Market-to-book	6.188	3.561	1.070	28.927	-0.002								
<i>External Risk</i>													
(c) VStoxx	0.235	0.101	0.116	0.875	-0.022 *	-0.185 ***							
<i>Contract Design</i>													
(d) Debt	0.099	0.299	0.000	1.000	0.583	0.424	0.893						
(e) Funding Size (mio. e)	3.185	8.705	0.002	502.740	0.095 ***	-0.019	-0.003	-0.025 **					
(f) Syndication	0.576	0.494	0.000	1.000	0.054 ***	0.020 *	-0.008	-0.083 ***	0.125 ***				
					0.000	0.080	0.502	0.000	0.000				
<i>Endogenous Information</i>													
(g) Firm's Age (Days)	1871	1987	0	38130	0.008	-0.020 *	-0.006	0.066 ***	0.068 ***	-0.019			
(h) IPO	0.060	0.238	0.000	1.000	0.141 ***	0.022 *	-0.004	0.002	0.108 ***	0.036 ***	0.066 ***		
(i) Tradesale	0.266	0.442	0.000	1.000	-0.021 *	0.102 ***	-0.053 ***	0.051 ***	0.047 ***	0.067 ***	0.013	-0.152 ***	
					0.069	0.000	0.000	0.000	0.000	0.000	0.274	0.000	
<i>Environmental Conditions</i>													
(j) Total VC Funding (mio. e)	3707	927	2671	5529	-0.014	-0.057 ***	0.461 ***	0.064 ***	-0.031 ***	-0.001	-0.013	0.006	0.045 ***

Table 3: Variable Break-points

We identify firms fraught with endogenous risk based on industries' R&D-to-sales ratio and market-to-book ratio; and financing rounds fraught with exogenous risk based on the aggregate level of market price volatility at the funding date. We apply the method of Contal & O'Quigley (1999) to dichotomize the variables and use log rank test statistic to estimate break-point values of the variables. For any R&D-expenditures-to-sales ratio, market-to-book ratio, or level of the VStoxx 50 Index above the break-point value, we assign the project, resp. the financing round to be exposed to endogenous, resp. exogenous risk. The method of Contal & O'Quigley (1999) is an outcome-oriented approach to compute break-point values corresponding on its most significant relation with the outcome, and is designed for survival analysis with censored data.

	R&D-expenditures-to-sales	Market-to-book	VStoxx 50
Median	0.071	5.573	21.160
Break-point (Contal and O'Quigley, 1999)	0.113	5.538	19.900

Table 4: Duration Analysis

Accelerated failure time model. Weibull distribution of the error term. Dependent: Duration of a financing round, defined as the time between two subsequent financing events. The model is fit to the natural logarithm of the duration. Independent: R&D Intensity is a dummy variable equal to 1 if venture firm's industry R&D-expenditures-to-sales ratio is above the Contal and O'Quigley (1999) break-point value, and zero otherwise. Growth Opportunities is a dummy variable equal to 1 if venture firm's industry market-to-book ratio is above the Contal and O'Quigley (1999) break-point value, and zero otherwise. Market Uncertainty is a dummy variable equal to 1 if the VStoxx 50 Index is above the Contal and O'Quigley (1999) break-point value at the funding date, and zero otherwise. The interaction variables are equal to 1 if Market Uncertainty and R&D Intensity, resp. Growth Opportunities are equal to 1, and zero otherwise.

\*\*\* indicates significance at the 1% significance level, \*\*indicates significance at the 5% significance level, \* indicates significance at the 10% significance level. <sup>a</sup> indicates that the classification variables are significant at the 1% significance level based on type-3-effect analysis.

	(1)	(2)	(3)	(4)	(5)	(6)
Intercept	11.354 *** 1.257	13.100 *** 1.410	11.286 *** 1.252	12.894 *** 1.411	12.678 *** 0.131	8.699 *** 1.579
<i>Endogenous Risk</i>						
R&D Intensity			-0.120 *** 0.032	-0.113 *** 0.032	-0.134 *** 0.044	-0.096 ** 0.045
Growth Opportunities			0.017 0.029	0.030 0.029	0.099 ** 0.043	0.069 0.044
<i>Exogenous Risk</i>						
Market Uncertainty		0.085 *** 0.030		0.078 ** 0.030	0.131 *** 0.043	0.212 *** 0.045
<i>Joint Effect of Endogenous and Exogenous Risk</i>						
Market Uncertainty*R&D Intensity					0.022 0.057	0.012 0.057
Market Uncertainty*Growth Opportunities					-0.121 ** 0.057	-0.119 ** 0.057
<i>Contract Design</i>						
Debt	-0.489 *** 0.042	-0.485 *** 0.042	-0.481 *** 0.042	-0.478 *** 0.042	-0.478 *** 0.042	-0.466 *** 0.042
Log (Funding Size)	-0.018 * 0.010	-0.019 * 0.010	-0.017 * 0.010	-0.017 * 0.010	-0.017 * 0.010	-0.024 ** 0.010
Syndication	-0.077 *** 0.028	-0.076 *** 0.028	-0.078 *** 0.028	-0.077 *** 0.028	-0.077 *** 0.028	-0.072 ** 0.028
<i>Firm-specific Information</i>						
Log (Firm's Age)	0.062 *** 0.009	0.060 *** 0.009	0.061 *** 0.009	0.060 *** 0.009	0.059 *** 0.009	0.058 *** 0.009
IPO	-1.019 *** 0.052	-1.013 *** 0.052	-1.014 *** 0.052	-1.009 *** 0.052	-0.827 *** 0.030	-0.994 *** 0.051
Tradesale	-0.845 *** 0.030	-0.835 *** 0.030	-0.834 *** 0.030	-0.827 *** 0.030	-0.478 *** 0.042	-0.813 *** 0.030
<i>Environmental Conditions</i>						
Log (Total VC Funding)	-0.183 *** 0.057	-0.264 *** 0.064	-0.179 *** 0.056	-0.254 *** 0.064	-0.245 *** 0.065	-0.219 *** 0.064
Firm's Country	included	a	included	a	included	a
Firm's Industry Sector	included	a	included	a	included	a
<i>Market Timing of the VC</i>						
Log (Stock Market)						0.431 *** 0.077
N	7,336	7,336	7,336	7,336	7,336	7,336
Weibull Shape	1.079	1.079	1.079	1.080	1.080	1.083
Log Likelihood	-10,120	-10,116	-10,113	-10,110	-10,108	-10,092

## 4.5 Robustness Checks

In estimation (6), we control for the aggregate level of equity valuation by the Euro Stoxx 50 Equity Price Index. This is done for two reasons: first, fund managers window dress their investments towards extant valuations to impress sponsors (Lakonishok *et al.*, 1991). Exogenous risk might be related to window dressing of the VC if market uncertainty and market valuation is correlated. If so, the impact of exogenous risk might account for window dressing activities instead of a strategic investment decision. Second, endogenous risk estimated by the market-to-book ratio might be biased toward the aggregate level of equity valuation. By its nature, the level of the market-to-book ratio is impacted by market valuation in the time series. We might assign more projects to be fraught with growth opportunities whose funding take place in periods of high a market valuation. In estimation (6), *Market Uncertainty* increases the delay of investments by approximately four and a half months. This corresponds to 24% of the average duration of a financing round. The impact of *Market Uncertainty* does not vanish when controlling for window dressing activities, indicating that *Market Uncertainty* comprises strategic investing. *Growth Opportunities* do not impact the duration for a low level of exogenous risk, indicating that the positive impact estimated in estimation (5) is driven by the selection bias. The interaction term *Market Uncertainty\* Growth Opportunities* is still negative, its magnitude does not change when compared to estimation (5).

Krohmer *et al.* (2009) analyze the investment decision of the VC related to endogenous and exogenous risk by the development stage of the project: they argue that endogenous risk is more present in early stages of the project when uncertainty about entrepreneur's effort and ability is high; whereas exogenous risk is more present in later stages of the project when the VC decides about an exit, or writing off the project. We

do sub-sample regressions based on project's investment status. We model failure time of projects' initial financing round to address timing of investments in the early stage of the project; and failure time of subsequent financing rounds of the same project to address timing of investments in later stages of the projects. Results are shown in table 5.

In estimation (7) and (8), we model the duration based on projects' initial financing round. The average duration of the financing rounds is 664 days, approximately 22 months. In estimation (7) we estimate the effects of exogenous and endogenous risk separately. In estimation (8) we consider interdependence of exogenous and endogenous risk. *Market Uncertainty* has no impact on the duration in estimation (7), but has a slightly significant impact in estimation (8). Exogenous risk only slightly impact the duration of early stage projects, indicating that the delay of investments is not valuable in early stages. *R&D Intensity* strongly decreases the duration by almost seven months, corresponding to 30% of the average duration of a financing round. *Growth Opportunities* do not impact the duration.

In estimation (9) and (10), we model the duration based on the same projects' subsequent financing rounds. The average duration of the financing rounds is 564 days, approximately 18.5 months. In estimation (9) we estimate the effects of exogenous and endogenous risk separately, in estimation (10) we consider interdependence of exogenous and endogenous risk. *Market Uncertainty* increases the duration by approximately two and a half months in estimation (9), corresponding to 14% of the average duration of a financing round; and by almost four months in model (10), corresponding to 20% of the average duration of a financing round. *R&D Intensity* decreases the duration by approximately one month in model (9), corresponding to 7% of the average duration of a financing round; and by almost two month in estimation (10), corresponding to 10% of the average duration of a financing round. *Growth Opportunities* do

not impact the duration in estimation (9); and increase duration by almost two month in model (10), corresponding to 10% of the average duration of a financing round. The interaction term *Market Uncertainty\*Growth Opportunities* is negative. The magnitude is the same when compared to estimation (5) and (6). We find that the delay option is valuable in later stages of the project, when compared to early stages. Consequently, opportunity loss is more present in later stages of the project.

We test the fit of estimation (5) compared to alternative parametric estimations. We present likelihood-ratio statistics and correlations of predicted and observed failure times in table 6. Log-likelihoods are slightly higher for an exponential and log-normal distribution of the error term when compared to the Weibull model we use. Our results do not change if we apply an exponential or log-normal model. To calculate correlations of predicted and observed failure times, we proceed as follows: we predict individual failure time  $P$  by estimation (5) that includes all information about endogenous and exogenous risk. We transform the predicted failure times into censored data. We censor predicted failure times that exceed the pre-fixed time of five years. We correlate the simulated sample and the true sample to estimate the correlation coefficients. The correlation coefficients are approximately 0.38 for all models, and statistically significant at  $p < 0.01$ .

Table 5: Duration Analysis: Early Stage and Later Stages

Accelerated failure time model. Weibull distribution of the error term. Model (7) and (8) estimate the duration based on projects' initial financing round. Model (9) and (10) estimate the duration based on the same projects' subsequent financing rounds. Dependent: Duration of a financing round, defined as the time between two subsequent financing events. The model is fit to the natural logarithm of the duration. Independent: R&D Intensity is a dummy variable equal to 1 if venture firm's industry R&D-expenditures-to-sales ratio is above the Contal and O'Quigley (1999) break-point value, and zero otherwise. Growth Opportunities is a dummy variable equal to 1 if venture firm's industry market-to-book ratio ratio is above the Contal and O'Quigley (1999) break-point value, and zero otherwise. Market Uncertainty is a dummy variable equal to 1 if the VStoxx 50 Index is above the Contal and O'Quigley (1999) break-point value at the funding date, and zero otherwise. The interaction variables are equal to 1 if Market Uncertainty and R&D Intensity, resp. Growth Opportunities are equal to 1, and zero otherwise. Additionally we control for the financing instrument and quality more precisely; financing instruments are Debt, Convertible Debt, Equity Swap; and including a control for bankruptcy, indicating low quality. \*\*\* indicates significance at the 1% significance level, \*\* indicates significance at the 5% significance level, \* indicates significance at the 10% significance level. <sup>a</sup> indicates that the classification variables are significant at the 1% significance level based on type-3-effect analysis. <sup>c</sup> indicates that the classification variables are significant at the 10% significance level based on type-3-effect analysis.

	(7)		(8)		(9)		(10)	
Intercept	10.571	***	10.059	***	14.082	***	13.898	***
	2.605		2.632		1.694		1.713	
<i>Endogenous Risk</i>								
R&D Intensity	-0.260	***	-0.256	***	-0.066	*	-0.093	*
	0.060		0.080		0.037		0.053	
Growth Opportunities	0.035		0.113		0.021		0.093	*
	0.052		0.076		0.034		0.052	
<i>Exogenous Risk</i>								
Market Uncertainty	0.041		0.128	*	0.132	***	0.185	***
	0.054		0.074		0.037		0.053	
<i>Joint Effect of Endogenous and Exogenous Risk</i>								
Market Uncertainty*R&D Intensity			-0.045				0.032	
			0.105				0.067	
Market Uncertainty*Growth Opportunities			-0.151				-0.125	*
			0.100				0.068	
<i>Contract Design</i>								
Debt	-1.642	***	-1.619	***	-0.280	***	-0.279	***
	0.399		0.399		0.060		0.072	
Convertible Debt	-1.351	***	-1.351	***	-0.463	***	-0.466	***
	0.185		0.185		0.037		0.053	
Equity Swap					0.097	***	0.092	***
					0.059		0.170	
Log (Funding Size)	0.034	*	0.034	*	-0.030	**	-0.030	**
	0.018		0.018		0.013		0.013	
Syndication	-0.047		-0.047		-0.049		-0.049	
	0.048		0.048		0.035		0.035	
<i>Firm-specific Information</i>								
Log (Firm's Age)	0.077	***	0.076	***	0.120	***	0.118	***
	0.012		0.012		0.020		0.021	
IPO	-0.809	***	-0.803	***	-0.970	***	-0.971	***
	0.108		0.107		0.060		0.060	
Tradesale	-0.645	***	-0.641	***	-0.787	***	-0.788	***
	0.058		0.058		0.037		0.037	
Bankrupt	0.509	***	0.514	***	0.319	***	0.324	***
	0.088		0.088		0.059		0.059	
<i>Environmental Conditions</i>								
Log (Total VC Funding)	-0.183		-0.161		-0.328	***	-0.320	***
	0.119		0.120		0.076		0.077	
Firm's Country	included	a	included	a	included	a	included	a
Firm's Industry Sector	included	c	included	c	included	a	included	a
N	2,421		2,421		4,915		4,915	
Weibull Shape	1.137		1.138		1.076		1.077	
Log Likelihood	-3,095		-3,094		-6,915		-6,913	

Table 6: Fit Statistics

The sample is the observed failure time, in days.  $P_{Weibull}$  is the predicted failure time by the accelerated failure time model using Weibull distribution of the error term.  $P_{Exponential}$ ,  $P_{Gamma}$ ,  $P_{Logistic}$ ,  $P_{Lnormal}$  are the predicted failure from exponential, general-Gamma, log-logistic modeling, and log-normal modeling. The log likelihood is reported for the respective models.

	Log Likelihood	Sample		$P_{Weibull}$		$P_{Exponential}$		$P_{Gamma}$		$P_{Logistic}$	
Sample											
$P_{Weibull}$	-10,108	0.380	***								
$P_{Exponential}$	-10,128	0.379	***	0.999	***						
$P_{Gamma}$	-10,041	0.380	***	0.995	***	0.995	***				
$P_{Logistic}$	-10,024	0.377	***	0.978	***	0.978	***	0.993	***		
$P_{Lnormal}$	-10,136	0.376	***	0.974	***	0.974	***	0.991	***	0.997	***



## 5 Conclusion

In this paper, we analyze the optimal timing of investments in a set-up with exogenous and endogenous risk. We consider interdependence of exogenous and endogenous risk in that the strength of endogenous agency risk is related to the level of exogenous market risk. This refers to the idea of a relative value of private benefits: in periods of high market uncertainty, the entrepreneur's expected payoff from the project is downgraded. Private benefits from managing the firm become more attractive to the entrepreneur relative to the successful realization of the project. As a consequence, his incentive to behave opportunistically increases.

We analyze the investment decision from a real options perspective. The VC can reduce his exposure to exogenous risk by delaying investment and mitigate endogenous risk by investing. If exogenous risk is particularly high, the VC has to increase the share vested to the entrepreneur to keep him expending effort in the hard times. Also, the tightened agency risk forces the VC to accelerate investments to aggregate information about the effort of the entrepreneur. As a result, the VC abandons a fraction of his delay option. In that, the discovery restricts the value of the delay option. This strongly decreases the value of his investment and thus arises high opportunity loss.

The interdependence of exogenous and endogenous risk on the timing of investments is economically significant in the real world. We find that VCs accelerate investments to projects fraught with endogenous risk in periods of high market uncertainty by approximately two and a half months when compared to periods of low market uncertainty. This corresponds to 13% of the average duration of a financing round. Furthermore, we find that the delay option is more valuable in later stages of a project when the VC decides about an exit, or writing off the project. Consequently, opportunity loss is more present in the later stages of a venture project.

Our paper has several implications for theory and practice. This study contributes to the extant research on agency risk in venture finance. So far, papers have considered agency conflicts in venture projects to be time invariant (Bergemann & Hege, 1998; Neher, 1999; Cornelli & Yosha, 2003). We show that this assumption is not realistic. Moreover, the strength of agency conflicts is influenced by exogenous factors and varies over time. We present one of those, namely market uncertainty.

On the one hand, our results might help to explain observed return patterns of VC portfolios by an agency perspective. Since agency conflicts are the main reason for the existence of a VC industry (Amit *et al.*, 1998), it is reasonable that they have a considerable impact on the realized returns. Cochrane (2005) shows that return patterns of VC portfolios characterize through a high alpha and a high market beta. First, the alpha accounts for abnormal return that can not be explained by common risk factors. The real options perspective might explain the phenomenon: VC investors successfully apply stage financing to reduce downside losses. This results in an option like payoff structure, where the option premium accounts for the alpha. Second, the high market beta accounts for a high sensitivity of the return to market risk. Our idea of a relative value of private benefits might explain the phenomenon: agency risk tightens in a period of high market uncertainty and forces the VC to accelerate investments. As a result, the timing of VC investments is biased toward periods of high market risk.

The results suggest the implementation of contractual claims that focus in particular on the mitigation of agency conflicts in an environment of high exogenous risk. From the perspective of the entrepreneur, exogenous market risk can be viewed as a high-risk employment situation. The entrepreneur will lose his employment and future income if the VC decides to abandon the project. Amernic (1984) and Eisenhardt (1989) show that the principal has to compensate the cost of risky employment to retain managers

in high-risk situations. A fix compensation payment in periods of high exogenous risk acts like a put-option: the entrepreneur can sell his shares to the VC at a pre-fixed price if the project's value is below a critical level. The compensation payment reduces the relative value of private benefits in periods of high market risk, relaxing entrepreneur's incentive to behave opportunistically. This will allow the VC to capitalize on a larger proportion of the delay option when it is most valuable.

## References

- Aghion, Philippe, & Bolton, Patrick. 1992. An incomplete contracts approach to financial contracting. *The review of economic Studies*, **59**(3), 473–494.
- Amernic, JH. 1984. A look at agency theory for the novice: Part I. *CAMagazine*, November, **90**, 97.
- Amit, Raphael, Brander, James, & Zott, Christoph. 1998. Why do venture capital firms exist? Theory and Canadian evidence. *Journal of business Venturing*, **13**(6), 441–466.
- Bergemann, Dirk, & Hege, Ulrich. 1998. Venture capital financing, moral hazard, and learning. *Journal of Banking & Finance*, **22**(6), 703–735.
- Bishop, John. 1987. The recognition and reward of employee performance. *Journal of Labor Economics*, S36–S56.
- Brander, James A, Amit, Raphael, & Antweiler, Werner. 2002. Venture-capital syndication: Improved venture selection vs. the value-added hypothesis. *Journal of Economics & Management Strategy*, **11**(3), 423–452.
- Burchardt, Jens, Hommel, Ulrich, Kamuriwo, Dzidziso Samuel, & Billitteri, Carolina. 2014. Venture capital contracting in theory and practice: implications for entrepreneurship research. *Entrepreneurship Theory and Practice*.
- Casamatta, Catherine. 2003. Financing and advising: optimal financial contracts with venture capitalists. *The Journal of Finance*, **58**(5), 2059–2086.
- Casamatta, Catherine, & Haritchabalet, Carole. 2007. Experience, screening and syndication in venture capital investments. *Journal of Financial Intermediation*, **16**(3), 368–398.

- Chan, KC, & Chen, Nai-Fu. 1991. Structural and return characteristics of small and large firms. *The Journal of Finance*, **46**(4), 1467–1484.
- Chan, Yuk-Shee, Siegel, Daniel, & Thakor, Anjan V. 1990. Learning, corporate control and performance requirements in venture capital contracts. *International Economic Review*, 365–381.
- Cherif, Mondher, & Gazdar, Kaouthar. 2011. What drives venture capital investments in Europe? New results from a panel data analysis. *Journal of Applied Business and Economics*, **12**(3), 122–139.
- Chi, Tailan, & McGuire, Donald J. 1996. Collaborative ventures and value of learning: Integrating the transaction cost and strategic option perspectives on the choice of market entry modes. *Journal of International Business Studies*, **27**(2), 285–307.
- Cochrane, John H. 2005. The risk and return of venture capital. *Journal of financial economics*, **75**(1), 3–52.
- Contal, Cécile, & O’Quigley, John. 1999. An application of changepoint methods in studying the effect of age on survival in breast cancer. *Computational statistics & data analysis*, **30**(3), 253–270.
- Cornelli, Francesca, & Yosha, Oved. 2003. Stage financing and the role of convertible securities. *The Review of Economic Studies*, **70**(1), 1–32.
- Cumming, Douglas, Schmidt, Daniel, & Walz, Uwe. 2010. Legality and venture capital governance around the world. *Journal of Business Venturing*, **25**(1), 54–72.
- Dixit, Avinash K, & Pindyck, Robert S. 1994. *Investment under uncertainty*. Princeton university press.

- Eisenhardt, Kathleen M. 1989. Agency theory: An assessment and review. *Academy of management review*, **14**(1), 57–74.
- Fama, Eugene F, & Jensen, Michael C. 1983. Separation of ownership and control. *The Journal of Law & Economics*, **26**(2), 301–325.
- Félix, Elisabete Gomes Santana, Pires, Cesaltina Pacheco, & Gulamhussen, Mohamed Azzim. 2013. The determinants of venture capital in Europe - Evidence across countries. *Journal of Financial Services Research*, **44**(3), 259–279.
- Folta, Timothy B. 1998. Governance and uncertainty: The trade-off between administrative control and commitment. *Strategic management journal*, 1007–1028.
- Gompers, Paul, & Lerner, Josh. 2000. Money chasing deals? The impact of fund inflows on private equity valuation. *Journal of financial economics*, **55**(2), 281–325.
- Gompers, Paul, Kovner, Anna, Lerner, Josh, & Scharfstein, David. 2008. Venture capital investment cycles: The impact of public markets. *Journal of Financial Economics*, **87**(1), 1–23.
- Gompers, Paul A. 1995. Optimal investment, monitoring, and the staging of venture capital. *The journal of finance*, **50**(5), 1461–1489.
- Hansen, E. 1992. *Venture capital contracts with conversion option*, Reserve Bank of New Zealand. Tech. rept. Discussion Paper 24.
- Hart, Oliver, & Moore, John. 1994. *Debt and seniority: An analysis of the role of hard claims in constraining management*. Tech. rept. National Bureau of Economic Research.
- Hellmann, Thomas. 1998. The allocation of control rights in venture capital contracts. *The Rand Journal of Economics*, 57–76.

- Hsu, Yao-Wen. 2010. Staging of venture capital investment: a real options analysis. *Small Business Economics*, **35**(3), 265–281.
- Jeng, Leslie A, & Wells, Philippe C. 2000. The determinants of venture capital funding: evidence across countries. *Journal of corporate Finance*, **6**(3), 241–289.
- Kaplan, Steven N, & Stromberg, Per. 2003. Financial contracting theory meets the real world: An empirical analysis of venture capital contracts. *The Review of Economic Studies*, **70**(2), 281–315.
- Kirilenko, Andrei A. 2001. Valuation and control in venture finance. *The Journal of Finance*, **56**(2), 565–587.
- Krohmer, Philipp, Lauterbach, Rainer, & Calanog, Victor. 2009. The bright and dark side of staging: Investment performance and the varying motivations of private equity firms. *Journal of Banking & Finance*, **33**(9), 1597–1609.
- Lakonishok, Josef, Shleifer, Andrei, Thaler, Richard, & Vishny, Robert. 1991. *Window dressing by pension fund managers*. Tech. rept. National Bureau of Economic Research.
- Lerner, Joshua. 1994. The syndication of venture capital investments. *Financial management*, 16–27.
- Li, Yong. 2008. Duration analysis of venture capital staging: A real options perspective. *Journal of Business Venturing*, **23**(5), 497–512.
- Li, Yong, & Mahoney, Joseph T. 2011. When are venture capital projects initiated? *Journal of Business Venturing*, **26**(2), 239–254.
- McDonald, Robert L, & Siegel, Daniel. 1982. *The value of waiting to invest*.

- McGrath, Rita Gunther. 1997. A real options logic for initiating technology positioning investments. *Academy of management review*, **22**(4), 974–996.
- McGrath, Rita Gunther, Ferrier, Walter J, & Mendelow, Aubrey L. 2004. Real options as engines of choice and heterogeneity. *Academy of Management Review*, **29**(1), 86–101.
- Neher, Darwin V. 1999. Staged financing: an agency perspective. *The Review of Economic Studies*, **66**(2), 255–274.
- Pindyck, Robert S. 1993. Investments of uncertain cost. *Journal of financial Economics*, **34**(1), 53–76.
- Repullo, Rafael, & Suarez, Javier. 2004. Venture capital finance: A security design approach. *Review of finance*, **8**(1), 75–108.
- Sahlman, William A. 1990. The structure and governance of venture-capital organizations. *Journal of financial economics*, **27**(2), 473–521.
- Schmidt, Klaus M. 2003. Convertible securities and venture capital finance. *The Journal of Finance*, **58**(3), 1139–1166.
- Sorenson, Olav, & Stuart, Toby E. 2001. Syndication networks and the spatial distribution of venture capital investments<sup>1</sup>. *American journal of sociology*, **106**(6), 1546–1588.
- Trigeorgis, Lenos. 1996. *Real options: Managerial flexibility and strategy in resource allocation*. MIT press.
- Zenger, Todd R. 1994. Explaining organizational diseconomies of scale in R&D: Agency problems and the allocation of engineering talent, ideas, and effort by firm size. *Management Science*, **40**(6), 708–729.



## Hohenheim Discussion Papers in Business, Economics and Social Sciences

The Faculty of Business, Economics and Social Sciences continues since 2015 the established "FZID Discussion Paper Series" of the "Centre for Research on Innovation and Services (FZID)" under the name "Hohenheim Discussion Papers in Business, Economics and Social Sciences".

### Institutes

510	Institute of Financial Management
520	Institute of Economics
530	Institute of Health Care & Public Management
540	Institute of Communication Science
550	Institute of Law and Social Sciences
560	Institute of Economic and Business Education
570	Institute of Marketing & Management
580	Institute of Interorganisational Management & Performance

### Research Areas (since 2017)

INEPA	"Inequality and Economic Policy Analysis"
TKID	"Transformation der Kommunikation – Integration und Desintegration"
NegoTrans	"Negotiation Research – Transformation, Technology, Media and Costs"
INEF	"Innovation, Entrepreneurship and Finance"

Download Hohenheim Discussion Papers in Business, Economics and Social Sciences from our homepage: <https://wiso.uni-hohenheim.de/papers>

No.	Author	Title	Inst
01-2015	Thomas Beissinger, Philipp Baudy	THE IMPACT OF TEMPORARY AGENCY WORK ON TRADE UNION WAGE SETTING: A Theoretical Analysis	520
02-2015	Fabian Wahl	PARTICIPATIVE POLITICAL INSTITUTIONS AND CITY DEVELOPMENT 800-1800	520
03-2015	Tommaso Proietti, Martyna Marczak, Gianluigi Mazzi	EUROMIND-D: A DENSITY ESTIMATE OF MONTHLY GROSS DOMESTIC PRODUCT FOR THE EURO AREA	520
04-2015	Thomas Beissinger, Nathalie Chusseau, Joël Hellier	OFFSHORING AND LABOUR MARKET REFORMS: MODELLING THE GERMAN EXPERIENCE	520
05-2015	Matthias Mueller, Kristina Bogner, Tobias Buchmann, Muhamed Kudic	SIMULATING KNOWLEDGE DIFFUSION IN FOUR STRUCTURALLY DISTINCT NETWORKS – AN AGENT-BASED SIMULATION MODEL	520
06-2015	Martyna Marczak, Thomas Beissinger	BIDIRECTIONAL RELATIONSHIP BETWEEN INVESTOR SENTIMENT AND EXCESS RETURNS: NEW EVIDENCE FROM THE WAVELET PERSPECTIVE	520
07-2015	Peng Nie, Galit Nimrod, Alfonso Sousa-Poza	INTERNET USE AND SUBJECTIVE WELL-BEING IN CHINA	530

<b>No.</b>	<b>Author</b>	<b>Title</b>	<b>Inst</b>
08-2015	Fabian Wahl	THE LONG SHADOW OF HISTORY ROMAN LEGACY AND ECONOMIC DEVELOPMENT – EVIDENCE FROM THE GERMAN LIMES	520
09-2015	Peng Nie, Alfonso Sousa-Poza	COMMUTE TIME AND SUBJECTIVE WELL-BEING IN URBAN CHINA	530
10-2015	Kristina Bogner	THE EFFECT OF PROJECT FUNDING ON INNOVATIVE PERFORMANCE AN AGENT-BASED SIMULATION MODEL	520
11-2015	Bogang Jun, Tai-Yoo Kim	A NEO-SCHUMPETERIAN PERSPECTIVE ON THE ANALYTICAL MACROECONOMIC FRAMEWORK: THE EXPANDED REPRODUCTION SYSTEM	520
12-2015	Volker Grossmann Aderonke Osikominu Marius Osterfeld	ARE SOCIOCULTURAL FACTORS IMPORTANT FOR STUDYING A SCIENCE UNIVERSITY MAJOR?	520
13-2015	Martyna Marczak Tommaso Proietti Stefano Grassi	A DATA–CLEANING AUGMENTED KALMAN FILTER FOR ROBUST ESTIMATION OF STATE SPACE MODELS	520
14-2015	Carolina Castagnetti Luisa Rosti Marina Töpfer	THE REVERSAL OF THE GENDER PAY GAP AMONG PUBLIC-CONTEST SELECTED YOUNG EMPLOYEES	520
15-2015	Alexander Opitz	DEMOCRATIC PROSPECTS IN IMPERIAL RUSSIA: THE REVOLUTION OF 1905 AND THE POLITICAL STOCK MARKET	520
01-2016	Michael Ahlheim, Jan Neidhardt	NON-TRADING BEHAVIOUR IN CHOICE EXPERIMENTS	520
02-2016	Bogang Jun, Alexander Gerybadze, Tai-Yoo Kim	THE LEGACY OF FRIEDRICH LIST: THE EXPANSIVE REPRODUCTION SYSTEM AND THE KOREAN HISTORY OF INDUSTRIALIZATION	520
03-2016	Peng Nie, Alfonso Sousa-Poza	FOOD INSECURITY AMONG OLDER EUROPEANS: EVIDENCE FROM THE SURVEY OF HEALTH, AGEING, AND RETIREMENT IN EUROPE	530
04-2016	Peter Spahn	POPULATION GROWTH, SAVING, INTEREST RATES AND STAGNATION. DISCUSSING THE EGGERTSSON- MEHROTRA-MODEL	520
05-2016	Vincent Dekker, Kristina Strohmaier, Nicole Bosch	A DATA-DRIVEN PROCEDURE TO DETERMINE THE BUNCHING WINDOW – AN APPLICATION TO THE NETHERLANDS	520
06-2016	Philipp Baudy, Dario Cords	DEREGULATION OF TEMPORARY AGENCY EMPLOYMENT IN A UNIONIZED ECONOMY: DOES THIS REALLY LEAD TO A SUBSTITUTION OF REGULAR EMPLOYMENT?	520

<b>No.</b>	<b>Author</b>	<b>Title</b>	<b>Inst</b>
07-2016	Robin Jessen, Davud Rostam-Afschar, Sebastian Schmitz	HOW IMPORTANT IS PRECAUTIONARY LABOR SUPPLY?	520
08-2016	Peng Nie, Alfonso Sousa-Poza, Jianhong Xue	FUEL FOR LIFE: DOMESTIC COOKING FUELS AND WOMEN'S HEALTH IN RURAL CHINA	530
09-2016	Bogang Jun, Seung Kyu-Yi, Tobias Buchmann, Matthias Müller	THE CO-EVOLUTION OF INNOVATION NETWORKS: COLLABORATION BETWEEN WEST AND EAST GERMANY FROM 1972 TO 2014	520
10-2016	Vladan Ivanovic, Vadim Kufenko, Boris Begovic Nenad Stanisic, Vincent Geloso	CONTINUITY UNDER A DIFFERENT NAME. THE OUTCOME OF PRIVATISATION IN SERBIA	520
11-2016	David E. Bloom Michael Kuhn Klaus Prettnner	THE CONTRIBUTION OF FEMALE HEALTH TO ECONOMIC DEVELOPMENT	520
12-2016	Franz X. Hof Klaus Prettnner	THE QUEST FOR STATUS AND R&D-BASED GROWTH	520
13-2016	Jung-In Yeon Andreas Pyka Tai-Yoo Kim	STRUCTURAL SHIFT AND INCREASING VARIETY IN KOREA, 1960–2010: EMPIRICAL EVIDENCE OF THE ECONOMIC DEVELOPMENT MODEL BY THE CREATION OF NEW SECTORS	520
14-2016	Benjamin Fuchs	THE EFFECT OF TEENAGE EMPLOYMENT ON CHARACTER SKILLS, EXPECTATIONS AND OCCUPATIONAL CHOICE STRATEGIES	520
15-2016	Seung-Kyu Yi Bogang Jun	HAS THE GERMAN REUNIFICATION STRENGTHENED GERMANY'S NATIONAL INNOVATION SYSTEM? TRIPLE HELIX DYNAMICS OF GERMANY'S INNOVATION SYSTEM	520
16-2016	Gregor Pfeifer Fabian Wahl Martyrna Marczyk	ILLUMINATING THE WORLD CUP EFFECT: NIGHT LIGHTS EVIDENCE FROM SOUTH AFRICA	520
17-2016	Malte Klein Andreas Sauer	CELEBRATING 30 YEARS OF INNOVATION SYSTEM RESEARCH: WHAT YOU NEED TO KNOW ABOUT INNOVATION SYSTEMS	570
18-2016	Klaus Prettnner	THE IMPLICATIONS OF AUTOMATION FOR ECONOMIC GROWTH AND THE LABOR SHARE	520
19-2016	Klaus Prettnner Andreas Schaefer	HIGHER EDUCATION AND THE FALL AND RISE OF INEQUALITY	520
20-2016	Vadim Kufenko Klaus Prettnner	YOU CAN'T ALWAYS GET WHAT YOU WANT? ESTIMATOR CHOICE AND THE SPEED OF CONVERGENCE	520

<b>No.</b>	<b>Author</b>	<b>Title</b>	<b>Inst</b>
01-2017	Annarita Baldanzi Alberto Bucci Klaus Prettner	CHILDRENS HEALTH, HUMAN CAPITAL ACCUMULATION, AND R&D-BASED ECONOMIC GROWTH	INEPA
02-2017	Julius Tennert Marie Lambert Hans-Peter Burghof	MORAL HAZARD IN VC FINANCE: MORE EXPENSIVE THAN YOU THOUGHT	INEF

## FZID Discussion Papers

(published 2009-2014)

### Competence Centers

IK	Innovation and Knowledge
ICT	Information Systems and Communication Systems
CRFM	Corporate Finance and Risk Management
HCM	Health Care Management
CM	Communication Management
MM	Marketing Management
ECO	Economics

Download FZID Discussion Papers from our homepage: [https://wiso.uni-hohenheim.de/archiv\\_fzid\\_papers](https://wiso.uni-hohenheim.de/archiv_fzid_papers)

Nr.	Autor	Titel	CC
01-2009	Julian P. Christ	NEW ECONOMIC GEOGRAPHY RELOADED: Localized Knowledge Spillovers and the Geography of Innovation	IK
02-2009	André P. Slowak	MARKET FIELD STRUCTURE & DYNAMICS IN INDUSTRIAL AUTOMATION	IK
03-2009	Pier Paolo Saviotti, Andreas Pyka	GENERALIZED BARRIERS TO ENTRY AND ECONOMIC DEVELOPMENT	IK
04-2009	Uwe Focht, Andreas Richter and Jörg Schiller	INTERMEDIATION AND MATCHING IN INSURANCE MARKETS	HCM
05-2009	Julian P. Christ, André P. Slowak	WHY BLU-RAY VS. HD-DVD IS NOT VHS VS. BETAMAX: THE CO-EVOLUTION OF STANDARD-SETTING CONSORTIA	IK
06-2009	Gabriel Felbermayr, Mario Larch and Wolfgang Lechthaler	UNEMPLOYMENT IN AN INTERDEPENDENT WORLD	ECO
07-2009	Steffen Otterbach	MISMATCHES BETWEEN ACTUAL AND PREFERRED WORK TIME: Empirical Evidence of Hours Constraints in 21 Countries	HCM
08-2009	Sven Wydra	PRODUCTION AND EMPLOYMENT IMPACTS OF NEW TECHNOLOGIES – ANALYSIS FOR BIOTECHNOLOGY	IK
09-2009	Ralf Richter, Jochen Streb	CATCHING-UP AND FALLING BEHIND KNOWLEDGE SPILLOVER FROM AMERICAN TO GERMAN MACHINE TOOL MAKERS	IK

<b>Nr.</b>	<b>Autor</b>	<b>Titel</b>	<b>CC</b>
10-2010	Rahel Aichele, Gabriel Felbermayr	KYOTO AND THE CARBON CONTENT OF TRADE	ECO
11-2010	David E. Bloom, Alfonso Sousa-Poza	ECONOMIC CONSEQUENCES OF LOW FERTILITY IN EUROPE	HCM
12-2010	Michael Ahlheim, Oliver Frör	DRINKING AND PROTECTING – A MARKET APPROACH TO THE PRESERVATION OF CORK OAK LANDSCAPES	ECO
13-2010	Michael Ahlheim, Oliver Frör, Antonia Heinke, Nguyen Minh Duc, and Pham Van Dinh	LABOUR AS A UTILITY MEASURE IN CONTINGENT VALUATION STUDIES – HOW GOOD IS IT REALLY?	ECO
14-2010	Julian P. Christ	THE GEOGRAPHY AND CO-LOCATION OF EUROPEAN TECHNOLOGY-SPECIFIC CO-INVENTORSHIP NETWORKS	IK
15-2010	Harald Degner	WINDOWS OF TECHNOLOGICAL OPPORTUNITY DO TECHNOLOGICAL BOOMS INFLUENCE THE RELATIONSHIP BETWEEN FIRM SIZE AND INNOVATIVENESS?	IK
16-2010	Tobias A. Jopp	THE WELFARE STATE EVOLVES: GERMAN KNAPPSCHAFTEN, 1854-1923	HCM
17-2010	Stefan Kirn (Ed.)	PROCESS OF CHANGE IN ORGANISATIONS THROUGH eHEALTH	ICT
18-2010	Jörg Schiller	ÖKONOMISCHE ASPEKTE DER ENTLOHNUNG UND REGULIERUNG UNABHÄNGIGER VERSICHERUNGSVERMITTLER	HCM
19-2010	Frauke Lammers, Jörg Schiller	CONTRACT DESIGN AND INSURANCE FRAUD: AN EXPERIMENTAL INVESTIGATION	HCM
20-2010	Martyna Marczak, Thomas Beissinger	REAL WAGES AND THE BUSINESS CYCLE IN GERMANY	ECO
21-2010	Harald Degner, Jochen Streb	FOREIGN PATENTING IN GERMANY, 1877-1932	IK
22-2010	Heiko Stüber, Thomas Beissinger	DOES DOWNWARD NOMINAL WAGE RIGIDITY DAMPEN WAGE INCREASES?	ECO
23-2010	Mark Spoerer, Jochen Streb	GUNS AND BUTTER – BUT NO MARGARINE: THE IMPACT OF NAZI ECONOMIC POLICIES ON GERMAN FOOD CONSUMPTION, 1933-38	ECO

<b>Nr.</b>	<b>Autor</b>	<b>Titel</b>	<b>CC</b>
24-2011	Dhammika Dharmapala, Nadine Riedel	EARNINGS SHOCKS AND TAX-MOTIVATED INCOME-SHIFTING: EVIDENCE FROM EUROPEAN MULTINATIONALS	ECO
25-2011	Michael Schuele, Stefan Kirn	QUALITATIVES, RÄUMLICHES SCHLIEßEN ZUR KOLLISIONSERKENNUNG UND KOLLISIONSVERMEIDUNG AUTONOMER BDI-AGENTEN	ICT
26-2011	Marcus Müller, Guillaume Stern, Ansgar Jacob and Stefan Kirn	VERHALTENSMODELLE FÜR SOFTWAREAGENTEN IM PUBLIC GOODS GAME	ICT
27-2011	Monnet Benoit, Patrick Gbakoua and Alfonso Sousa-Poza	ENGEL CURVES, SPATIAL VARIATION IN PRICES AND DEMAND FOR COMMODITIES IN CÔTE D'IVOIRE	ECO
28-2011	Nadine Riedel, Hannah Schildberg-Hörisch	ASYMMETRIC OBLIGATIONS	ECO
29-2011	Nicole Waidlein	CAUSES OF PERSISTENT PRODUCTIVITY DIFFERENCES IN THE WEST GERMAN STATES IN THE PERIOD FROM 1950 TO 1990	IK
30-2011	Dominik Hartmann, Atilio Arata	MEASURING SOCIAL CAPITAL AND INNOVATION IN POOR AGRICULTURAL COMMUNITIES. THE CASE OF CHÁPARRA - PERU	IK
31-2011	Peter Spahn	DIE WÄHRUNGSKRISEUNION DIE EURO-VERSCHULDUNG DER NATIONALSTAATEN ALS SCHWACHSTELLE DER EWU	ECO
32-2011	Fabian Wahl	DIE ENTWICKLUNG DES LEBENSSTANDARDS IM DRITTEN REICH – EINE GLÜCKSÖKONOMISCHE PERSPEKTIVE	ECO
33-2011	Giorgio Triulzi, Ramon Scholz and Andreas Pyka	R&D AND KNOWLEDGE DYNAMICS IN UNIVERSITY-INDUSTRY RELATIONSHIPS IN BIOTECH AND PHARMACEUTICALS: AN AGENT-BASED MODEL	IK
34-2011	Claus D. Müller-Hengstenberg, Stefan Kirn	ANWENDUNG DES ÖFFENTLICHEN VERGABERECHTS AUF MODERNE IT SOFTWAREENTWICKLUNGSVERFAHREN	ICT
35-2011	Andreas Pyka	AVOIDING EVOLUTIONARY INEFFICIENCIES IN INNOVATION NETWORKS	IK
36-2011	David Bell, Steffen Otterbach and Alfonso Sousa-Poza	WORK HOURS CONSTRAINTS AND HEALTH	HCM
37-2011	Lukas Scheffknecht, Felix Geiger	A BEHAVIORAL MACROECONOMIC MODEL WITH ENDOGENOUS BOOM-BUST CYCLES AND LEVERAGE DYNAMICS	ECO
38-2011	Yin Krogmann, Ulrich Schwalbe	INTER-FIRM R&D NETWORKS IN THE GLOBAL PHARMACEUTICAL BIOTECHNOLOGY INDUSTRY DURING 1985–1998: A CONCEPTUAL AND EMPIRICAL ANALYSIS	IK

<b>Nr.</b>	<b>Autor</b>	<b>Titel</b>	<b>CC</b>
39-2011	Michael Ahlheim, Tobias Börger and Oliver Frör	RESPONDENT INCENTIVES IN CONTINGENT VALUATION: THE ROLE OF RECIPROCITY	ECO
40-2011	Tobias Börger	A DIRECT TEST OF SOCIALLY DESIRABLE RESPONDING IN CONTINGENT VALUATION INTERVIEWS	ECO
41-2011	Ralf Rukwid, Julian P. Christ	QUANTITATIVE CLUSTERIDENTIFIKATION AUF EBENE DER DEUTSCHEN STADT- UND LANDKREISE (1999-2008)	IK



<b>Nr.</b>	<b>Autor</b>	<b>Titel</b>	<b>CC</b>
42-2012	Benjamin Schön, Andreas Pyka	A TAXONOMY OF INNOVATION NETWORKS	IK
43-2012	Dirk Foremny, Nadine Riedel	BUSINESS TAXES AND THE ELECTORAL CYCLE	ECO
44-2012	Gisela Di Meglio, Andreas Pyka and Luis Rubalcaba	VARIETIES OF SERVICE ECONOMIES IN EUROPE	IK
45-2012	Ralf Rukwid, Julian P. Christ	INNOVATIONSPOTENTIALE IN BADEN-WÜRTTEMBERG: PRODUKTIONSCLUSTER IM BEREICH „METALL, ELEKTRO, IKT“ UND REGIONALE VERFÜGBARKEIT AKADEMISCHER FACHKRÄFTE IN DEN MINT-FÄCHERN	IK
46-2012	Julian P. Christ, Ralf Rukwid	INNOVATIONSPOTENTIALE IN BADEN-WÜRTTEMBERG: BRANCHENSPEZIFISCHE FORSCHUNGS- UND ENTWICKLUNGSAKTIVITÄT, REGIONALES PATENTAUFKOMMEN UND BESCHÄFTIGUNGSSTRUKTUR	IK
47-2012	Oliver Sauter	ASSESSING UNCERTAINTY IN EUROPE AND THE US - IS THERE A COMMON FACTOR?	ECO
48-2012	Dominik Hartmann	SEN MEETS SCHUMPETER. INTRODUCING STRUCTURAL AND DYNAMIC ELEMENTS INTO THE HUMAN CAPABILITY APPROACH	IK
49-2012	Harold Paredes- Frigolett, Andreas Pyka	DISTAL EMBEDDING AS A TECHNOLOGY INNOVATION NETWORK FORMATION STRATEGY	IK
50-2012	Martyna Marczyk, Víctor Gómez	CYCLICALITY OF REAL WAGES IN THE USA AND GERMANY: NEW INSIGHTS FROM WAVELET ANALYSIS	ECO
51-2012	André P. Slowak	DIE DURCHSETZUNG VON SCHNITTSTELLEN IN DER STANDARDSETZUNG: FALLBEISPIEL LADESYSYSTEM ELEKTROMOBILITÄT	IK
52-2012	Fabian Wahl	WHY IT MATTERS WHAT PEOPLE THINK - BELIEFS, LEGAL ORIGINS AND THE DEEP ROOTS OF TRUST	ECO
53-2012	Dominik Hartmann, Micha Kaiser	STATISTISCHER ÜBERBLICK DER TÜRKISCHEN MIGRATION IN BADEN-WÜRTTEMBERG UND DEUTSCHLAND	IK
54-2012	Dominik Hartmann, Andreas Pyka, Seda Aydin, Lena Klauß, Fabian Stahl, Ali Santircioglu, Silvia Oberegelsbacher, Sheida Rashidi, Gaye Onan and Suna Erginkoç	IDENTIFIZIERUNG UND ANALYSE DEUTSCH-TÜRKISCHER INNOVATIONSNETZWERKE. ERSTE ERGEBNISSE DES TGIN- PROJEKTES	IK
55-2012	Michael Ahlheim, Tobias Börger and Oliver Frör	THE ECOLOGICAL PRICE OF GETTING RICH IN A GREEN DESERT: A CONTINGENT VALUATION STUDY IN RURAL SOUTHWEST CHINA	ECO

<b>Nr.</b>	<b>Autor</b>	<b>Titel</b>	<b>CC</b>
56-2012	Matthias Strifler Thomas Beissinger	FAIRNESS CONSIDERATIONS IN LABOR UNION WAGE SETTING – A THEORETICAL ANALYSIS	ECO
57-2012	Peter Spahn	INTEGRATION DURCH WÄHRUNGSUNION? DER FALL DER EURO-ZONE	ECO
58-2012	Sibylle H. Lehmann	TAKING FIRMS TO THE STOCK MARKET: IPOS AND THE IMPORTANCE OF LARGE BANKS IN IMPERIAL GERMANY 1896-1913	ECO
59-2012	Sibylle H. Lehmann, Philipp Hauber and Alexander Opitz	POLITICAL RIGHTS, TAXATION, AND FIRM VALUATION – EVIDENCE FROM SAXONY AROUND 1900	ECO
60-2012	Martyna Marczak, Víctor Gómez	SPECTRAN, A SET OF MATLAB PROGRAMS FOR SPECTRAL ANALYSIS	ECO
61-2012	Theresa Lohse, Nadine Riedel	THE IMPACT OF TRANSFER PRICING REGULATIONS ON PROFIT SHIFTING WITHIN EUROPEAN MULTINATIONALS	ECO

<b>Nr.</b>	<b>Autor</b>	<b>Titel</b>	<b>CC</b>
62-2013	Heiko Stüber	REAL WAGE CYCLICALITY OF NEWLY HIRED WORKERS	ECO
63-2013	David E. Bloom, Alfonso Sousa-Poza	AGEING AND PRODUCTIVITY	HCM
64-2013	Martyna Marczak, V́ctor Ǵmez	MONTHLY US BUSINESS CYCLE INDICATORS: A NEW MULTIVARIATE APPROACH BASED ON A BAND-PASS FILTER	ECO
65-2013	Dominik Hartmann, Andreas Pyka	INNOVATION, ECONOMIC DIVERSIFICATION AND HUMAN DEVELOPMENT	IK
66-2013	Christof Ernst, Katharina Richter and Nadine Riedel	CORPORATE TAXATION AND THE QUALITY OF RESEARCH AND DEVELOPMENT	ECO
67-2013	Michael Ahlheim, Oliver Frór, Jiang Tong, Luo Jing and Sonna Pelz	NONUSE VALUES OF CLIMATE POLICY - AN EMPIRICAL STUDY IN XINJIANG AND BEIJING	ECO
68-2013	Michael Ahlheim, Friedrich Schneider	CONSIDERING HOUSEHOLD SIZE IN CONTINGENT VALUATION STUDIES	ECO
69-2013	Fabio Bertoni, Tereza Tykvová	WHICH FORM OF VENTURE CAPITAL IS MOST SUPPORTIVE OF INNOVATION? EVIDENCE FROM EUROPEAN BIOTECHNOLOGY COMPANIES	CFRM
70-2013	Tobias Buchmann, Andreas Pyka	THE EVOLUTION OF INNOVATION NETWORKS: THE CASE OF A GERMAN AUTOMOTIVE NETWORK	IK
71-2013	B. Vermeulen, A. Pyka, J. A. La Poutré and A. G. de Kok	CAPABILITY-BASED GOVERNANCE PATTERNS OVER THE PRODUCT LIFE-CYCLE	IK
72-2013	Beatriz Fabiola López Ulloa, Valerie Møller and Alfonso Sousa- Poza	HOW DOES SUBJECTIVE WELL-BEING EVOLVE WITH AGE? A LITERATURE REVIEW	HCM
73-2013	Wencke Gwozdz, Alfonso Sousa-Poza, Lucia A. Reisch, Wolfgang Ahrens, Stefaan De Henauw, Gabriele Eiben, Juan M. Fernández-Alvira, Charalampos Hadjigeorgiou, Eva Kovács, Fabio Lauria, Toomas Veidebaum, Garrath Williams, Karin Bammann	MATERNAL EMPLOYMENT AND CHILDHOOD OBESITY – A EUROPEAN PERSPECTIVE	HCM

<b>Nr.</b>	<b>Autor</b>	<b>Titel</b>	<b>CC</b>
74-2013	Andreas Haas, Annette Hofmann	RISIKEN AUS CLOUD-COMPUTING-SERVICES: FRAGEN DES RISIKOMANAGEMENTS UND ASPEKTE DER VERSICHERBARKEIT	HCM
75-2013	Yin Krogmann, Nadine Riedel and Ulrich Schwalbe	INTER-FIRM R&D NETWORKS IN PHARMACEUTICAL BIOTECHNOLOGY: WHAT DETERMINES FIRM'S CENTRALITY-BASED PARTNERING CAPABILITY?	ECO, IK
76-2013	Peter Spahn	MACROECONOMIC STABILISATION AND BANK LENDING: A SIMPLE WORKHORSE MODEL	ECO
77-2013	Sheida Rashidi, Andreas Pyka	MIGRATION AND INNOVATION – A SURVEY	IK
78-2013	Benjamin Schön, Andreas Pyka	THE SUCCESS FACTORS OF TECHNOLOGY-SOURCING THROUGH MERGERS & ACQUISITIONS – AN INTUITIVE META- ANALYSIS	IK
79-2013	Irene Prostoplow, Andreas Pyka and Barbara Heller-Schuh	TURKISH-GERMAN INNOVATION NETWORKS IN THE EUROPEAN RESEARCH LANDSCAPE	IK
80-2013	Eva Schlenker, Kai D. Schmid	CAPITAL INCOME SHARES AND INCOME INEQUALITY IN THE EUROPEAN UNION	ECO
81-2013	Michael Ahlheim, Tobias Börger and Oliver Frör	THE INFLUENCE OF ETHNICITY AND CULTURE ON THE VALUATION OF ENVIRONMENTAL IMPROVEMENTS – RESULTS FROM A CVM STUDY IN SOUTHWEST CHINA –	ECO
82-2013	Fabian Wahl	DOES MEDIEVAL TRADE STILL MATTER? HISTORICAL TRADE CENTERS, AGGLOMERATION AND CONTEMPORARY ECONOMIC DEVELOPMENT	ECO
83-2013	Peter Spahn	SUBPRIME AND EURO CRISIS: SHOULD WE BLAME THE ECONOMISTS?	ECO
84-2013	Daniel Guffarth, Michael J. Barber	THE EUROPEAN AEROSPACE R&D COLLABORATION NETWORK	IK
85-2013	Athanasios Saitis	KARTELLBEKÄMPFUNG UND INTERNE KARTELLSTRUKTUREN: EIN NETZWERKTHEORETISCHER ANSATZ	IK

<b>Nr.</b>	<b>Autor</b>	<b>Titel</b>	<b>CC</b>
86-2014	Stefan Kirn, Claus D. Müller-Hengstenberg	INTELLIGENTE (SOFTWARE-)AGENTEN: EINE NEUE HERAUSFORDERUNG FÜR DIE GESELLSCHAFT UND UNSER RECHTSSYSTEM?	ICT
87-2014	Peng Nie, Alfonso Sousa-Poza	MATERNAL EMPLOYMENT AND CHILDHOOD OBESITY IN CHINA: EVIDENCE FROM THE CHINA HEALTH AND NUTRITION SURVEY	HCM
88-2014	Steffen Otterbach, Alfonso Sousa-Poza	JOB INSECURITY, EMPLOYABILITY, AND HEALTH: AN ANALYSIS FOR GERMANY ACROSS GENERATIONS	HCM
89-2014	Carsten Burhop, Sibylle H. Lehmann-Hasemeyer	THE GEOGRAPHY OF STOCK EXCHANGES IN IMPERIAL GERMANY	ECO
90-2014	Martyna Marczak, Tommaso Proietti	OUTLIER DETECTION IN STRUCTURAL TIME SERIES MODELS: THE INDICATOR SATURATION APPROACH	ECO
91-2014	Sophie Urmetzer, Andreas Pyka	VARIETIES OF KNOWLEDGE-BASED BIOECONOMIES	IK
92-2014	Bogang Jun, Joongho Lee	THE TRADEOFF BETWEEN FERTILITY AND EDUCATION: EVIDENCE FROM THE KOREAN DEVELOPMENT PATH	IK
93-2014	Bogang Jun, Tai-Yoo Kim	NON-FINANCIAL HURDLES FOR HUMAN CAPITAL ACCUMULATION: LANDOWNERSHIP IN KOREA UNDER JAPANESE RULE	IK
94-2014	Michael Ahlheim, Oliver Frör, Gerhard Langenberger and Sonna Pelz	CHINESE URBANITES AND THE PRESERVATION OF RARE SPECIES IN REMOTE PARTS OF THE COUNTRY – THE EXAMPLE OF EAGLEWOOD	ECO
95-2014	Harold Paredes-Frigolett, Andreas Pyka, Javier Pereira and Luiz Flávio Autran Monteiro Gomes	RANKING THE PERFORMANCE OF NATIONAL INNOVATION SYSTEMS IN THE IBERIAN PENINSULA AND LATIN AMERICA FROM A NEO-SCHUMPETERIAN ECONOMICS PERSPECTIVE	IK
96-2014	Daniel Guffarth, Michael J. Barber	NETWORK EVOLUTION, SUCCESS, AND REGIONAL DEVELOPMENT IN THE EUROPEAN AEROSPACE INDUSTRY	IK

## IMPRINT

University of Hohenheim

Dean's Office of the Faculty of Business, Economics and Social Sciences

Palace Hohenheim 1 B

70593 Stuttgart | Germany

Fon +49 (0)711 459 22488

Fax +49 (0)711 459 22785

E-mail [wiso@uni-hohenheim.de](mailto:wiso@uni-hohenheim.de)

Web [www.wiso.uni-hohenheim.de](http://www.wiso.uni-hohenheim.de)