Financing SMEs and Entrepreneurial Opportunities: Firm- and Regional-Level Investigations from Europe / Christian Masiak

Dissertation / PhD Thesis

Financing SMEs and Entrepreneurial Opportunities: Firm- and Regional-Level Investigations from Europe

Universität Trier

Financing SMEs and Entrepreneurial Opportunities: Firm- and Regional-Level Investigations from Europe

DISSERTATION

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vorgelegt von

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Abbreviations of countries

AT	Austria	FR	France	NL	Netherlands
BE	Belgium	GR	Greece	NO	Norway
BG	Bulgaria	HR	Croatia	PL	Poland
CY	Cyprus	HU	Hungary	PT	Portugal
CZ	Czech Republic	IE	Ireland	RO	Romania
DE	Germany	IT	Italy	SE	Sweden
DK	Denmark	LT	Lithuania	SI	Slovenia
EE	Estonia	LU	Luxembourg	SK	Slovakia
ES	Spain	LV	Latvia	UK	United Kingdom
FI	Finland	MT	Malta	US	United States

Other abbreviations

API	Application programming interface
BA	Business angel
BBSR	Bundesinstitut für Bau-, Stadt- und Raumforschung
BLS	Business Longitudinal Survey
CF	Cohesion Fund
COSME	Competitiveness of Enterprises and SMEs
CVC	Corporate venture capital
DLT	Distributed ledger technology
DSGV	Deutscher Sparkassen- und Giroverband
EAFRD	European Agricultural Fund for Rural Development
EC	European Commission
ECB	European Central Bank
ED. / eds.	Editor / editors
EIB	European Investment Bank
EIBIS	EIB Group Survey on Investment and Investment Finance
EIF	European Investment Fund
EMFF	European Maritime and Fisheries Fund
ENSR	European Network for SME Research
EPO	European Patent Office

List of abbreviations (continued)

ERDF	European Regional Development Fund
ESF	European Social Fund
EU	European Union
EUR	Euro
FGF	Förderkreis Gründungs-Forschung
GDP	Gross domestic product
GVC	Governmental venture capital
H1	First half-year
ICO	Initial Coin Offering
IFC	International Finance Corporation
INKAR	Indikatoren und Karten zur Raum- und Stadtentwicklung
IP	Intellectual property
IVC	Independent venture capital
KfW	Kreditanstalt für Wiederaufbau
m	Million
NACE	Nomenclature statistique des activités économiques dans la Communauté européenne
NUTS	Nomenclature des unités territoriales statistiques
OECD	Organisation for Economic Co-operation and Development
RQ	Research question
SABI	Sistema de Análisis de Balances Ibéricos
SAFE	Survey on the access to finance of enterprises
SME	Small and medium-sized enterprise
UNSD	United Nations Statistics Division
USD	United States dollar
VAR	Vector Autoregression
VC	Venture capital
VIF	Variane inflation factor
WBES	World Business Environment Survey
ZEW	Zentrum für Europäische Wirtschaftsforschung

Zusammenfassung

Auf politischer Ebene hat die Finanzierung von Kleinstunternehmen, kleinen und mittleren Unternehmen (KMU) durch die europäische Finanz- und Wirtschaftskrise eine hohe Bedeutung erhalten, da mehr als 99% aller europäischen Unternehmen in Europa dieser Kategorie angehören. Als Reaktion auf die oftmals schwierige Finanzierungssituation von KMU, die maßgeblich zur Gefährdung der Innovationsfähigkeit und der Entwicklung der europäischen Wirtschaft beitragen kann, wurden spezielle staatliche Programme aufgelegt. Trotz des vermehrten Interesses auf politischer und akademischer Ebene bezüglich KMU-Finanzierung, gibt es jedoch auf europäischer Ebene nur wenig empirische Evidenz. Diese Dissertation beschäftigt sich daher in fünf verschiedenen empirischen Studien zu aktuellen Forschungslücken hinsichtlich der Finanzierung von Kleinstunternehmen, kleinen und mittleren Unternehmen in Europa und mit neuen Finanzierungsinstrumenten für innovative Unternehmen oder Start-Ups.

Zunächst wird basierend auf zwei empirischen Untersuchungen (Kapitel 2 und 3) der Status Quo der KMU-Finanzierung in Europa dargelegt. Die Finanzierung von KMU in Europa ist sehr heterogen. Einerseits sind KMU als Gruppe keine homogene Gruppe, da Kleinstunternehmen (< 10 Mitarbeiter), kleine (10–49 Mitarbeiter) und mittlere (50–249 Mitarbeiter) Unternehmen sich nicht nur in ihren Charakteristiken unterscheiden, sondern auch unterschiedliche Finanzierungsmöglichkeiten und -bedürfnisse besitzen. Andererseits existieren Länderunterschiede in der Finanzierung von KMU in Europa. Die Ergebnisse dieser beiden Studien (Kapitel 2 und 3), die auf einer Umfrage der Europäischen Zentralbank und der Europäischen Kommission („SAFE survey“) beruhen, verdeutlichen dies: KMU in Europa verwenden unterschiedliche Finanzierungsmuster und nutzen Finanzierungsmuster komplementär oder substitutiv zueinander. Die verschiedenen Finanzierungsmuster sind wiederum gekennzeichnet durch firmen-, produkt-, und länderspezifische Charakteristika, aber auch durch makroökonomische Variablen (z. B. Inflationsraten).

In Kapitel 3 der Dissertation werden gezielt die Unterschiede zwischen der Finanzierung von Kleinstunternehmen im Vergleich zu kleinen und mittleren Unternehmen untersucht. Während kleine und mittlere Unternehmen eine Vielzahl an verschiedenen Finanzierungsinstrumenten parallel zueinander nutzen (z. B. subventionierte Bankkredite parallel zu Banken-, Überziehungs- und Lieferantenkrediten), greifen Kleinstunternehmen

auf wenige Instrumente gleichzeitig zurück (insbesondere kurzfristiges Fremdkapital). Folglich finanzieren sich Kleinstunternehmen entweder intern oder über Überziehungskredite. Die Ergebnisse der Dissertation zeigen somit, dass die Finanzierung der KMU nicht homogen ist. Insbesondere Kleinstunternehmen sollten als eine eigenständige Gruppe innerhalb der KMU mit charakteristischen Finanzierungsmustern behandelt werden.

Innovative Firmen und Start-Ups gelten als wichtiger Motor für die Entwicklung der regionalen Wirtschaft. Auch sie werden in der akademischen Literatur häufig mit Finanzierungsschwierigkeiten in Verbindung gebracht, die das Wachstum und Überleben dieser Unternehmen erschwert. Der zweite Teil der Dissertation beinhaltet daher zwei empirische Studien zu dieser Thematik. Zunächst werden in Kapitel 4 in einer ersten Studie die regionalen und firmenspezifischen Faktoren untersucht, die den Output des geistigen Eigentums erhöhen. Insbesondere regionale Faktoren wurden bisher unzureichend untersucht, welche jedoch speziell für die politischen Entscheidungsträger von besonderer Relevanz sind. Die Ergebnisse dieser Studie zeigen, dass der Erhalt von Venture Capital neben der Firmengröße einen signifikanten Einfluss auf die Höhe des geistigen Eigentums haben. Zwar spielen technische Universitäten keine Rolle bezüglich des Outputs, jedoch zeigt sich ein signifikant positiver Effekt der Studentenrate auf den jeweiligen Output des geistigen Eigentums. Basierend auf diesen Ergebnissen wird in einer zweiten Studie gezielt auf das Finanzierungsinstrument Venture Capital eingegangen und zwischen verschiedenen VC Typen unterschieden: staatliche, unabhängige und Corporate Venture Capital Firmen. Die Ergebnisse zeigen, dass insbesondere Regionen mit einem Angebot an qualifiziertem Humankapital staatliche Venture Capital Investitionen anziehen. Des Weiteren investieren insbesondere Corporate und staatliche Venture Capital Firmen vermehrt in ländliche Regionen.

Als neues Finanzierungsinstrument für besonders innovative Unternehmer hat sich das „Initial Coin Offering (ICO)“ in den letzten Jahren herauskristallisiert, womit sich Kapitel 5 näher beschäftigt. Mithilfe einer Zeitreihenanalyse werden Marktzyklen von ICO Kampagnen, bitcoin und Ether Preisen analysiert. Die Ergebnisse dieser Studie zeigen, dass vergangene ICOs die folgenden ICOs positiv beeinflussen. Zudem haben ICOs einen negativen Einfluss auf die Kryptowährungen Bitcoin und Ether, wohingegen sich der Preis des bitcoin positiv auf den Preis des Ethers auswirkt.

1 Introduction

1.1. Motivation

Financing plays a considerable role in the innovation and growth of micro, small and medium-sized firms, and consequently in economic and regional development (e.g., Beck and Demirgüç-Kunt 2006; Protogerou et al. 2017; Söderblom et al. 2015). In particular, policy makers in Europe and academia are concerned with 1) market imperfections 2) financing gaps of smaller firms, and 3) regional innovation and cluster development (e.g., Broekel and Brenner 2011; Carpenter and Petersen 2002a; Chen et al. 2010; Revest and Sapio 2012). This dissertation therefore addresses several research gaps related to the financing of micro, small and medium-sized enterprises and regional development.

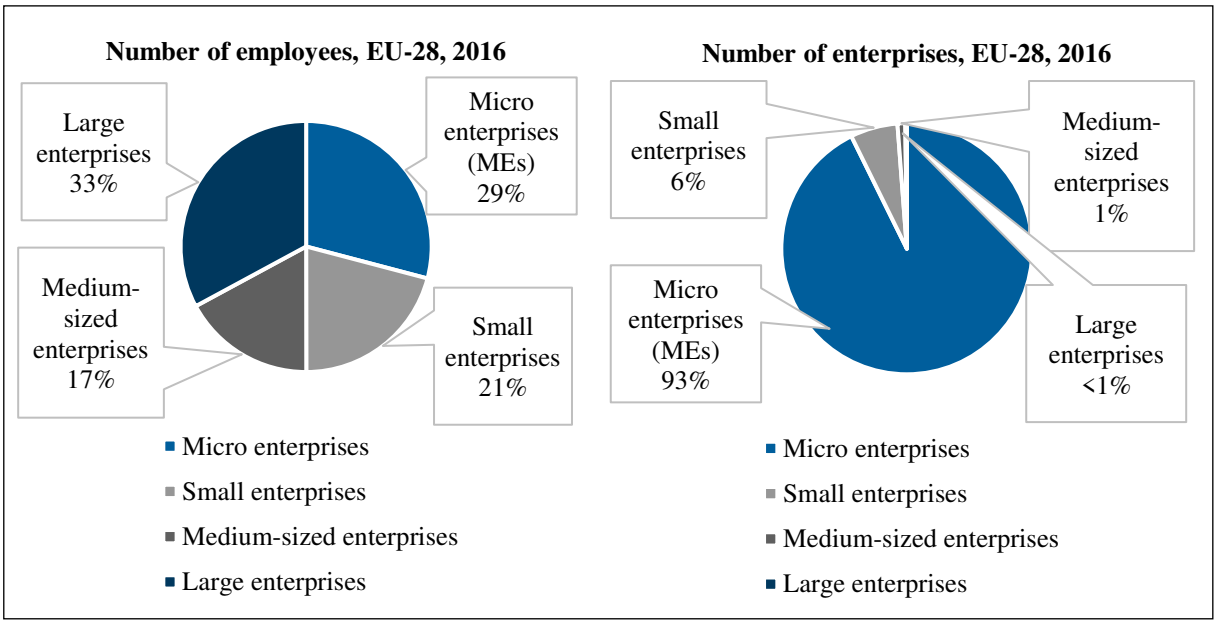
The following two subsections explain the background to the dissertation and highlight the practical and academic relevance of the topics discussed. Subsequently, the research questions and the dissertation's structure are set out in detail.

1.1.1. Research context: Financing micro, small and medium-sized enterprises

Ongoing discussions in the political and academic world are concerned with access to finance for SMEs (e.g., Beck et al. 2013; Block et al. 2018a; Lee et al. 2015; Rostamkalaei and Freel 2017). In particular, the European crisis has shifted the focus of European initiatives to micro, small and medium-sized enterprises at the political level. For instance, the three programs Horizon 2020, COSME and European Structural Funds aim to help to achieve the goals set by Europe 2020 and especially concentrate on smaller enterprises. In particular, the COSME (Competitiveness of Enterprises and SMEs) supports SMEs gain access to finance through the Loan Guarantee Facility and the Equity Facility for Growth. Additional goals of the COSME are better access to markets for SMEs and promoting entrepreneurship. Nevertheless, the several European as well as national programs often treat SMEs as a homogeneous group instead of differentiating between micro, small, medium-sized and large firms. Micro firms in particular are an important part of the European economy. Figure 1-1 shows the number of micro, small, medium-sized and large enterprises, and their corresponding employee numbers. Micro firms make up the largest share (around 93%) of non-financial companies in Europe and are important for economic development and growth, as they employ approximately 30% of the European workforce (Kraemer-Eis et al. 2016).

Furthermore, mirco firms generate approximately 21% of total added value (Kraemer-Eis et al. 2018).

Figure 1-1: Number of SMEs and employment in the EU-28.



Reference: Kraemer-Eis (2018).

However, the challenges for micro firms to gain external financing are even greater than for other small and medium-sized enterprises, since micro firms differ from other firms in a number of ways, especially in terms of their ownership structure, resource availability, and cost structure. These characteristics directly influence the costs for obtaining external capital and hence the financing structure of these companies (Baas and Schrooten 2006; Freeman et al. 1983; Nooteboom 1993; Rao et al. 2008). In light of this relatively unexplored research field, this dissertation addresses various important aspects of the differences between financing of micro, small, and medium-sized enterprises.

1.1.2. Research context: identifying and financing entrepreneurial opportunities and innovative firms

Both politicians and academia highlight the importance of entrepreneurs for regional development and the positive contribution of start-ups to economic growth (e.g., Bosma et al. 2018; Faggian et al. 2017). Among others, governments and policy makers are interested in building innovation clusters to attract entrepreneurial firms, due to the value added and the positive knowledge spillover effects for the regions concerned (e.g., Colombelli and Quatraro 2018). Governments and regions worldwide, for instance, have longer tried to understand and replicate the success factors of the most well-known innovation cluster “Silicon Valley” (e.g.,

Neves and Sequeira 2018). Although similar clusters have emerged in Europe in recent years, such as *Paris-Saclay* in France, *Isar Valley* in Germany, *Silicon Docks* in Ireland, or *Silicon Fen* in the United Kingdom, the phenomenon of Silicon Valley has not yet been deciphered and perfectly reproduced.

Despite highly skilled and, in some cases, overqualified workers in Europe, European countries and regions lack entrepreneurs who commercialize innovation (Congregado et al. 2016; Oughton et al. 2002) and innovation clusters. The term *European Innovation Paradox,* introduced in a European Commission Green Paper in 1995, refers to the failure of European countries and regions to commercialize scientific advances and knowledge (European Commission 1995). In other words, Europe requires start-ups and enterprises that are able to successfully exploit (entrepreneurial) opportunities and convert scientific achievements into marketable innovations. To improve the European situation, the European Commission and the EU countries have established the European Structural and Investment Funds that aim to support economic, social, and territorial cohesion for the period 2014 to 2020 (European Commission 2018). In total, the European Structural and Investment Funds consist of five different funds (European Regional Development Fund (ERDF); European Social Fund (ESF); Cohesion Fund (CF); European Agricultural Fund for Rural Development (EAFRD); European Maritime and Fisheries Fund (EMFF)). Whereas the CF is especially targeted at less-developed regions, the EAFRD and EMFF are tailored to rural and maritime regions. All EU regions, however, can receive funding from the ERDF and ESF.

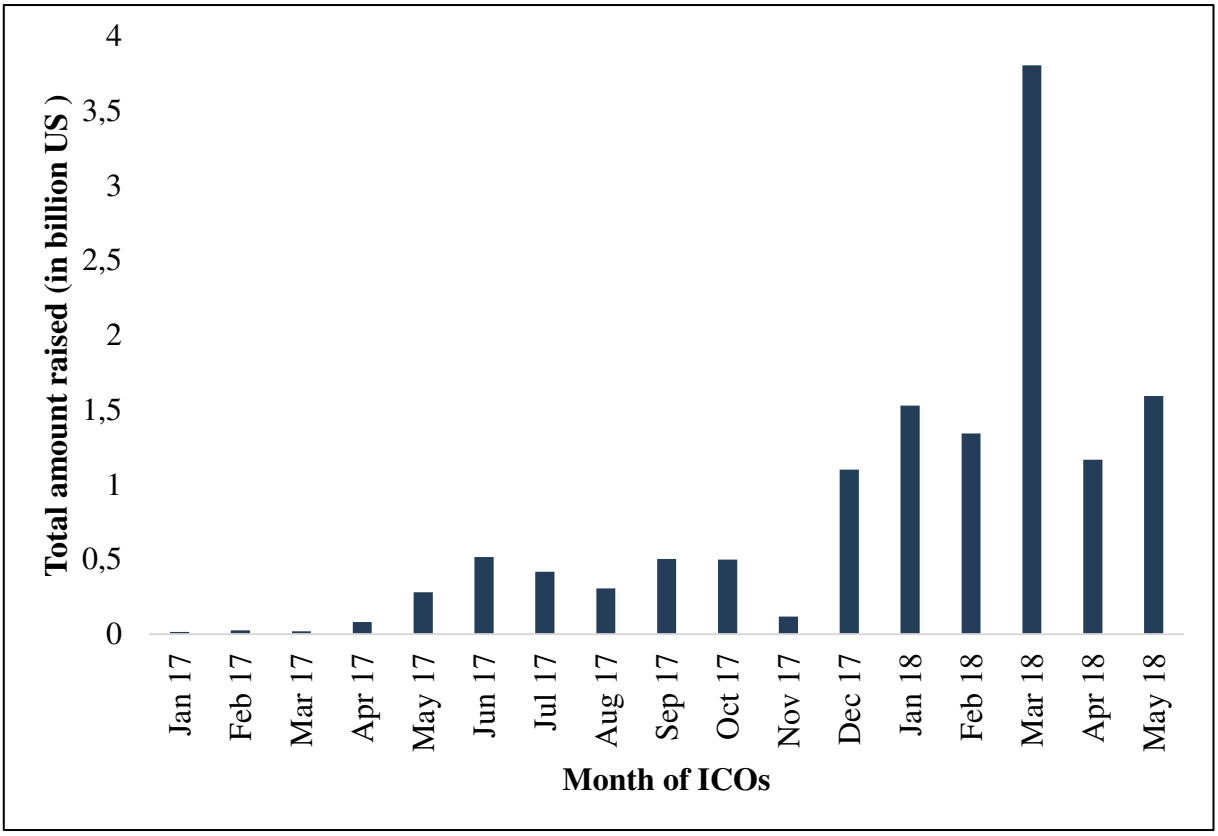
Ongoing discussions in the practical and academic world, however, are still concerned with whether political intervention is required and appropriate to resolve access-to-finance problems for innovative entrepreneurs and SMEs, since these firms require financial resources to exploit entrepreneurial opportunities, or to successfully grow and develop their business (Block et al. 2018a; Oughton et al. 2002). Prior research has shown that non-bank alternatives in particular, such as venture capital (VC), appear to be an important source of funding for innovative and entrepreneurial firms (Block et al. 2018a; Cumming and Zhang 2016; Denis 2004; Gompers and Lerner 2001). According to Suzuki et al. (2002), entrepreneurs in Silicon Valley, for instance, especially benefit from excellent professional services, university spillovers and access to venture capital.

To foster the development of an active VC market, European policy makers have explicitly highlighted the provision of VC in the Europe 2020 political agenda (e.g., European Commission 2011). Hence, VC has become one of the key priorities in EU politics (Da Rin et

al. 2006; Guerini and Quas 2016). From a government's point of view, VC firms are important for both realizing the objectives set by Europe 2020 and spurring innovational and economic development in European regions (Bertoni and Tykvová 2015; Colombo et al. 2016; Guerini and Quas 2016). European and national policy makers, however, not only want to foster economic growth, but also prevent regional disparities and inequalities (Bottazzi et al. 2004; Tykvová 2006). However, as prior research shows, VC is not equally distributed across countries, regions, and industries (e.g., Chen et al. 2010; Cumming and MacIntosh 2003; Fritsch and Schilder 2008; Jeng and Wells 2000; Sorenson and Stuart 2001).

To date therefore, little is known about a regional VC (equity) gap for young and innovative firms in Europe (exceptions are, for instance, Lutz et al. 2013; Martin et al. 2005; Streletzki and Schulte 2013). Furthermore, prior research has primarily focused on decision-making criteria of venture capitalists at the firm level (e.g., Hall and Hofer 1993; Kirsch et al. 2009; MacMillan et al. 1985; Zhou et al. 2016), but has not fully explored a potential regional dimension of VC firms' investment patterns. From a policy perspective, however, it is of utmost importance to develop regional clusters and to reveal regional characteristics, in order to attract VC investments. Hence, the second part of this dissertation focuses on regional entrepreneurial opportunities and the activities of VC at a regional level. Whereas European policy makers are aware of the importance of developing an active VC market and have already implemented this in the political agenda, ongoing discussions in both the academic and political world are concerned with a new emerging financing instrument, namely Initial Coin Offering (ICO). ICO is a non-bank financing alternative based on distributed-ledger technology, in which entrepreneurial firms are able to create a cryptocurrency and offer tokens to investors ("the crowd") in exchange for capital (Fisch 2019). This financing instrument is a very recent phenomenon and could be an appropriate solution to finance high-growth and innovative entrepreneurial firms. News headlines such as "*ICOs: The New Gold Rush*" reflect considerable public interest in this financing instrument. Furthermore, market data highlights the enormous relevance of ICOs (see Figure 1-2), as entrepreneurial firms have already raised more than US $11.3 billion in approximately 556 ICO campaigns since 2016 (CoinSchedule 2018).

Figure 1-2: Total amount raised in ICO campaigns between January 2017 and May 2018.



Reference: CoinSchedule (2018).

In light of this relatively unexplored research field, this dissertation addresses several aspects of regional innovation output and the financing of entrepreneurial opportunities and innovative entrepreneurial/smaller firms by focusing particularly on the financing instruments VC and ICO.

1.2. Research questions

1.2.1. Financing patterns of micro, small and medium-sized enterprises: firm-level investigation (Chapters 2–3)

First, this dissertation addresses the topic of financing micro, small, and medium-sized enterprises in Europe. The previous section outlined the importance of these enterprises for the European economy (European Commission 2016). Nevertheless, SMEs are often confronted with financing constraints due to high information asymmetries, insufficient collateral, agency risks and high transaction costs for capital providers (e.g., Artola and Genre 2011; Berger and Udell 1998; Block et al. 2018a; Brealey et al. 1977; Chong et al. 2013; Ferrando and Griesshaber 2011; Popov and Udell 2012; Ryan et al. 2014; Sogorb-Mira 2005). Although research in SME financing has increased over recent years, little is known about the

substitutive or complementary usage of several financing instruments (exceptions are, for example, Beck et al. 2008; Casey and O'Toole 2014; Lawless et al. 2015; Moritz et al. 2016). Moritz et al. (2016), for instance, have taken a holistic approach to investigating SME financing patterns in Europe by using cluster analysis, and identified six different SME financing clusters in Europe. Furthermore, the authors found that SMEs in the clusters differ regarding firm-, product-, industry-, and country-specific characteristics, such as age, firm size, or ownership structure, which is in line with other related research (e.g., Berger and Udell 1998; Chavis et al. 2011; Ferrando and Griesshaber 2011). However, it remains unclear whether the financing patterns identified by Moritz et al. (2016) are stable over time. Furthermore, country differences appear to have the strongest impact on SME financing patterns (Moritz et al. 2016). However, both country and macroeconomic variables have been somewhat neglected in previous research. In this regard, this dissertation aims to answer the following research questions:

RQ 1.1: What financing patterns exist among European SMEs? Are the financing patterns found by Moritz et al. (2016) stable over time?

RQ 1.2: Which macroeconomic variables determine the financing patterns of European SMEs?

While there are a few studies that investigate the financing patterns of small, medium-sized and large firms (Chavis et al. 2011; Lawless et al. 2015; Moritz et al. 2016; Moritz et al. 2015), little is known about the financing patterns of micro firms. This is a critical oversight, as micro firms differ from other small and medium-sized firms in a number of ways, particularly in their ownership structure, resource availability and cost structure (e.g., Abdulsaleh and Worthington 2013; Berger and Udell 1998; Marwa 2014). These characteristics of micro firms directly influence the costs for obtaining external capital, and consequently their financing patterns (Baas and Schrooten 2006; Binks et al. 1992; Freeman et al. 1983; Nooteboom 1993; Rao et al. 2008). In spite of the characteristics of micro, small, and medium-sized enterprises that have already been investigated, there is little research into the financing patterns of micro firms, as these firms are typically seen as a single category together with other small firms. In this dissertation, however, micro firms are defined as firms that have less than 10 employees, and are consequently considered distinct from small firms. Therefore, this dissertation aims to answer the following research question:

RQ 2: Do financing patterns of micro firms differ from small and medium-sized enterprises?

1.2.2. Financing of entrepreneurial opportunities: firm-level and regional-level investigations (Chapters 4–5)

Chapter 4 outlines two studies focusing on regional aspects of entrepreneurial opportunities and VC investments. Entrepreneurial opportunities are investigated by analyzing the determinants of firms' intellectual property output (IP output) at the firm level and at the regional level (e.g., Galende and De la Fuente 2003; Huergo and Jaumandreu 2004; Madrid-Guijarro et al. 2009). Prior research has shown that different types of regional knowledge spillovers exist which affect entrepreneurial opportunities, namely Marshall-Arrow-Romer (MAR) spillovers, Jacobian spillovers, and university spillovers. Whereas MAR spillovers occur due to knowledge transfer between firms in the same industry, Jacobian spillovers are related to firms in different industries (Arrow 1962; Jacobs 1969; Marshall 1890; Romer 1986). Furthermore, universities/universities of applied science and research institutes produce knowledge and are partially able to transfer this knowledge to regional actors (Audretsch et al. 2005; Siegel and Wright 2015). The different types of knowledge spillovers (MAR, Jacobian, and university knowledge spillovers) can create entrepreneurial opportunities and consequently lead to the foundation of start-ups (Block et al. 2013). Venture capitalists, for instance, look out for such entrepreneurial opportunities and the concentration of knowledge in a region due to the positive effects on start-ups (Mueller 2007). Previous research, however, has neglected the combination of firm-level data with the corresponding regional data (Naz et al. 2015). This dissertation combines firm- and regional-level data, and uses patents and trademarks (intellectual property output) as proxies for innovation and consequently entrepreneurial opportunities. Hence, the dissertation investigates:

RQ 3.1: Which firm-level factors drive the IP output of high-tech SMEs?

RQ 3.2: Which regional-level factors drive the IP output of high-tech SMEs?

Furthermore, the majority of prior research focuses on the US market (e.g., Chen et al. 2010; Elango et al. 1995; Florida and Kenney 1988a, 1988b). Thus, little is known to date about whether a regional VC (equity) gap for young and innovative firms exist in Europe (exceptions are, for instance, Lutz et al. 2013; Martin et al. 2005; Streletzki and Schulte 2013). In addition, prior research has primarily focused on decision-making criteria of venture capitalists at the firm level (e.g., Hall and Hofer 1993; Kirsch et al. 2009; MacMillan et al. 1985; Zhou et al. 2016), but has neglected both a potential regional dimension of VC and a differentiation between VC types. From a policy perspective, however, it is essential to

develop regional clusters and to reveal regional characteristics, in order to attract specific VC firms. Hence, the second study in Chapter 4 focuses on the regional dimension of different VC firm types. In particular, the dissertation aims to differentiate between different venture capital types, namely governmental venture capital (GVC), independent venture capital (IVC), and corporate venture capital (CVC), and analyzes whether local biases exist in that particular VC firms only invest in high-tech firms that are located close to them.

RQ 3.3: Which characteristics of regions help to explain geographical patterns in VC investment?

RQ 3.4: How do particular types of VC investors, namely governmental venture capital (GVC), independent venture capital (IVC), and corporate venture capital (CVC) firms differ in their geographical investment patterns?

Due to the lack of VC investments, stock market opportunities, or other types of external financing, new financing instruments emerge in particular for highly innovative and technology-based start-ups. ICO campaigns include specific characteristics and mechanisms of Initial Public Offerings (IPOs) and crowdfunding campaigns. Whereas prior research has extensively analyzed both market cycles of IPOs (e.g., Alti 2005; Lowry 2003; Yung et al. 2008), and mechanisms and success factors of different types of crowdfunding (e.g., Block et al. 2018a; Moritz and Block 2014; Moritz 2015), little is known about the new financing instrument “ICO”. Hence, the dissertation provides a detailed investigation into whether the same underlying dynamics of other financing instruments (e.g., crowdfunding, IPOs) apply to ICOs in the sense that ICO market cycles exist. Due to the specific characteristics of ICO campaigns (e.g., provision of tokens in ICO campaigns and exchange of tokens for cryptocurrencies), the dissertation further analyzes the effects of cryptocurrencies on the amount raised by ICOs.

RQ 4.1: Does the outcome of past ICO campaigns influence subsequent ICO campaigns?

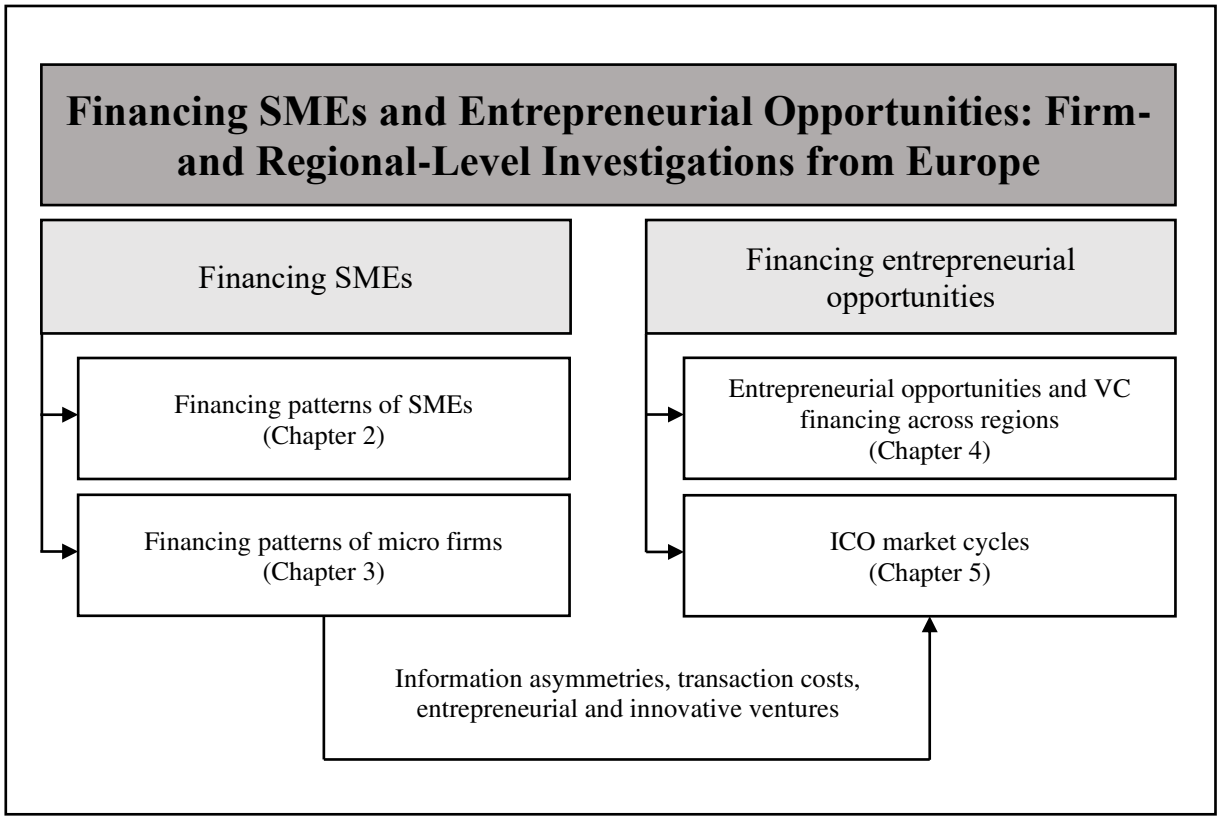
RQ 4.2: Do bitcoin and Ether prices influence the outcome of an ICO (and vice versa)?

1.3. Structure of the dissertation

This dissertation consists of six chapters. **Chapter 2** focuses on financing patterns of SMEs, while **Chapter 3** analyzes the financing of micro firms. **Chapter 4** investigates the effects of regional- and firm-level factors on the intellectual property output (i.e., patents and

trademarks) and on regional determinants that attract VC investments. It compares different VC firm types, namely GVC, IVC, and CVC firms to finance entrepreneurial opportunities and firms with a high IP output. **Chapter 5** analyzes the new financing instrument ICO, while **Chapter 6** concludes with a summary of the findings, provides implications for both theory and practice, and mentions avenues for future research. Figure 1-3 illustrates the structure of the dissertation.

Figure 1-3: Structure of the dissertation.



Reference: Own illustration.

Chapter 2 addresses the unexplored facets of the substitutive and complementary usage of several financing instruments (Beck et al. 2008; Laweless et al. 2015; Moritz et al. 2016). Previous research has mainly concentrated on either one or a small number of financing instruments (e.g., Hall et al. 2004; Mac an Bhaird and Lucey 2010). Furthermore, little is known about macroeconomic determinants that shape financing patterns of SMEs in Europe (e.g., Booth et al. 2001; Bopkin 2009; La Porta et al. 1997). To address these shortcomings, Chapter 2 develops an empirical taxonomy of SME financing patterns in Europe by applying cluster analyses using the SAFE dataset collected in 2015. In order to investigate the cluster stability over time, the approach by Moritz et al. (2016), who used the SAFE data from 2013, is replicated. In addition, the dissertation extends that study by looking at the role of the

country-specific, macroeconomic, and institutional environment in the financing patterns of SMEs.

Chapter 3 deals specifically with the financing of micro firms in Europe. Although the vast majority of firms in Europe are micro firms (< 10 employees), we know little about their financing patterns (exceptions are, for instance, Beck et al. 2015; Daskalakis et al. 2013). This is a critical oversight, as micro firms differ from other firms in a number of ways (e.g., ownership structure, resource availability, and information asymmetries) (Daskalakis et al. 2013; Marwa 2014). Using a large European firm-level dataset (SAFE survey), this dissertation addresses this unexplored phenomenon and analyzes the financing of micro firms (< 10 employees) in comparison to other small (10–49 employees) and medium-sized (50–249 employees) firms. Whereas Chapters 2 and 3 provide insights into the financing of micro, small and medium-sized enterprises in Europe**,** the subsequent Chapters (4 and 5) deal with the occurrence of entrepreneurial opportunities and how these opportunities are financed.

Chapter 4 investigates the IP output of high-tech firms and the financing of these entrepreneurial opportunities and innovative firms. First, we look into the effects of regional- and firm-level factors on the intellectual property (IP) output (i.e., patents and trademarks) of high-tech firms. So far, little is known about how regional factors influence the IP output of high-tech firms, since only a small number of studies have combined high-tech firm-level and relevant regional-level data in a study using an aggregated IP output (e.g., Naz et al. 2015; Smit et al. 2015). By combining 8,317 German high-tech firms' data with regional data, this study investigates which firm- and regional-level factors drive the IP output of high-tech firms by performing various regression analyses. The IP output is measured by the number of patents and trademarks granted.

Second, Chapter 4 analyzes financing of these entrepreneurial opportunities by investigating the distribution of venture capital (VC) investments across German regions, and explores the geographical determinants of these VC investments at a regional level. Prior research has primarily focused on decision-making criteria of venture capitalists at the firm level (e.g., Hall and Hofer 1993; Kirsch et al. 2009; MacMillan et al. 1985; Zhou et al. 2016), but has neglected a potential regional dimension to VC firms' decision-making criteria. Moreover, little is known about how particular types of VC investors differ in their geographical investment patterns. Therefore, this dissertation aggregates firm-level VC investments to a regional level, and adds further regional data obtained from the Federal Office for Building and Regional Planning (BBSR), Gründungsatlas, Higher Education

Compass and European Patent Office (EPO) to the dataset. Furthermore, the dissertation differentiates between three different types of VC firms, namely independent venture capital (IVC), governmental venture capital (GVC), and corporate venture capital (CVC) firms, and analyzes both the investment pattern and the regional characteristics that attract a specific VC type.

Chapter 5 focuses more specifically on the emerging financing instrument known as ICO. This Chapter investigates the effects of prior ICOs and cryptocurrencies (bitcoin and Ether) on the amount raised by ICOs. Not only bitcoin and Ether prices, but also the ICO amount raised, are used to measure the future development of capital raised in ICOs. In total, the dataset covers 68 weekly observations for a period between 2017 and 2018, including the variables: cumulative amount raised in ICO campaigns, the price of bitcoin, and the price of Ether. Using both a Vector Autoregression (VAR) model and an impulse response function, the dissertation reveals market cycles of ICOs and cryptocurrencies, and the corresponding interdependencies.

Chapter 6 concludes with a summary of the main findings of this dissertation and provides theoretical and practical implications for micro, small and medium-sized firms, entrepreneurs and policymakers. Finally, the dissertation closes with limitations and avenues for future research.

2 Financing patterns of European SMEs

This study investigates financing patterns of European SMEs by looking at a large number of different financing instruments and their complementary and substitutive effects, using the SAFE dataset collected in 2015. We develop an empirical taxonomy of SME financing patterns in Europe, applying cluster analyses. In order to investigate the cluster stability over time, we replicate the approach taken in a previous study by Moritz et al. (2016), who used the SAFE data from 2013. In addition, we extend that study by looking at the role of the country-specific macroeconomic and institutional environment for the financings patterns of SMEs. Our results confirm the results of Moritz et al. (2016) and show that European SME financing is not homogeneous, but that different financing patterns exist. Our cluster analysis identifies seven distinct SME financing types based on the financing instruments used: mixed-financed SMEs with a focus on other loans, mixed-financed SMEs with a focus on retained earnings or sale of assets, state-subsidized SMEs, debt-financed SMEs, trade-financed SMEs, asset-based financed SMEs, and internally-financed SMEs. Moreover, the SME financing types can be profiled according to their firm-, product-, industry-, and country-specific characteristics. Our findings can support policy makers in assessing the impact of changes to policy measures for SME financing.[1]

[1] This chapter is published as an EIF Working Paper: Masiak, C., Moritz, A., and Lang, F. (2017): Financing Patterns of European SMEs Revisited: An Updated Empirical Taxonomy and Determinants of SME Financing Clusters, EIF Working Paper. Available at: http://www.eif.org/news_centre/publications/EIF_Working_Paper_2017_40.htm. Accessed 01 August 2018.

2.1. Introduction

Small and medium-sized enterprises (SMEs) are a significant driver of the European economy, as approximately 99.8% of all European non-financial enterprises are SMEs, generating around EUR 3.9 trillion value added per year (European Commission 2016). Nevertheless, SMEs are often confronted with financing constraints due to high information asymmetries, insufficient collateral, agency risks and high transaction costs for capital providers (e.g., Artola and Genre 2011; Berger and Udell 1998; Chong et al. 2013; Ferrando and Griesshaber 2011; Popov and Udell 2012; Ryan et al. 2014; Sogorb-Mira 2005).

Although research in SME financing has increased in recent years, little is known about the substitutive or complementary usage of several financing instruments (Beck et al. 2008; Casey and O'Toole 2014; Lawless et al. 2015; Moritz et al. 2016). Moritz et al. (2016) have taken a holistic approach to investigating SME financing patterns in Europe by using cluster analysis. They identified six different SME financing clusters in Europe: mixed-financed SMEs, state-subsidized SMEs, debt-financed SMEs, flexible-debt financed SMEs, trade-financed SMEs, and internally-financed SMEs. The authors found that SMEs in the clusters differ with regard to firm-, product-, industry-, and country-specific characteristics, such as age, firm size, or ownership structure, which is in line with previous research (e.g., Berger and Udell 1998; Chavis et al. 2011; Ferrando and Griesshaber 2011). Our study is based on Moritz et al. (2016), but complements it in two respects: first, it remained unclear whether the financing patterns identified are stable over time. By using SME financing data collected in 2015, we investigate how the financing patterns differ from those identified using data from 2013. Second, Moritz et al. (2016) found that country differences seem to have the strongest impact on cluster differences. However, the authors did not further investigate the reasons for these differences. In our study we explore this by including macroeconomic variables (e.g., Beck et al. 2008; Camara 2012; Demirgüç-Kunt and Maksimovic 1999; Hernández-Cánovas and Koëter-Kant 2011).

As per Moritz et al. (2016), we also use the "Survey on the access to finance of enterprises (SAFE survey)", which is conducted on behalf of the European Central Bank (ECB) and the European Commission (EC). The SAFE survey contains information on approximately 17,950 firms in 39 countries (wave 2015H1). Since the majority of firms in the SAFE survey are SMEs (approximately 90%), the survey is ideally suited for our research question. Moreover, the SAFE survey contains information about a large number of different financing instruments (e.g., bank loan, credit line, bank overdraft or credit card overdrafts,

debt securities issued, equity capital, factoring, grants and subsidized bank loans, leasing or hire-purchase, loans from family and friends, retained earnings or sale of assets, trade credit), as well as firm-, product-, industry- and country-specific information. We use the different financing instruments as active variables in our cluster analysis to identify financing patterns of SMEs in Europe. To profile the different financing patterns, we use the firm-, product-, industry-, and country-specific characteristics provided in the SAFE survey. To complement these profiles, we added a number of relevant macroeconomic variables to our dataset, such as GDP per capita, inflation rate and volatility, unemployment rate, and property rights. Finally, we compare our results with the results by Moritz et al. (2016) in order to investigate the stability of SME financing patterns over time.

Our findings contribute to the literature on SME financing in different ways (e.g., Beck et al. 2008; Casey and O'Toole 2014; Lawless et al. 2015; Moritz et al. 2016). To date, little is known about the complementary and substitutive use of different financing instruments (Beck et al. 2008; Casey and O'Toole 2014). Our findings suggest that the financing patterns identified by Moritz et al. (2016) are relatively stable over time and various financing instruments are used as complements and substitutes by European SMEs. Moreover, our study extends the research of Moritz et al. (2016) by adding macroeconomic variables to the dataset. We contribute to the literature by investigating the influence of country characteristics on small firms' financing (e.g., Beck et al. 2008; Camara 2012; Demirgüç-Kunt and Maksimovic 1999; Hernández-Cánovas and Koëter-Kant 2011; Mokhova and Zinecker 2014).

The remainder of the paper is set out as follows: Section 2.2 provides a literature review focused on macroeconomic variables influencing SME financing. Section 2.3 explains the dataset (SAFE survey), the method applied and a description of the variables used in the empirical analysis. In Section 2.4 we provide the results of the cluster analysis, the determinants of the financing patterns, and the comparison of our findings with those of Moritz et al. (2016). Section 2.5 summarizes the results, discusses limitations and suggests further research areas.

2.2. Literature review

Prior research identified a significant effect of country-, firm-, and industry-specific factors on SMEs' usage of different financing sources (e.g., Chittenden et al. 1996; Ferrando and Griesshaber 2011; Hall et al. 2004; Mac an Bhaird and Lucey 2010). However, many previous studies focused on a single financing instrument and did not investigate the

complementary and substitutive use of different debt and equity instruments (exceptions are, for example, Beck et al. 2008; Casey and O'Toole 2014; Lawless et al. 2015; Moritz et al. 2016). Moritz (2015) provides a comprehensive and detailed literature review on SME financing and its influencing factors.

To avoid repetition, we focus our literature review on previous research that analyzed the effects of macroeconomic variables on the financing of firms (e.g., Booth et al. 2001; Bopkin 2009; La Porta et al. 1997). The Gross Domestic Product (GDP) is an indicator for a country's economic development and its influence on the capital structure of firms has been widely investigated (e.g., Bopkin 2009; Mokhova and Zinecker 2013). Prior research found that there is a negative relationship between GDP, GDP growth, and the firm's capital structure (Bopkin 2009; Gajurel 2006). The unemployment rate is also used as an indicator for economic development. However, prior findings on the influence of a country's unemployment rate on the capital structure of firms have been mixed, such as the finding of a non-significant effect or a significant positive effect on the leverage level of firms (Camara 2012; Mokhova and Zinecker 2013). Moreover, empirical studies investigated the effect of the inflation rate on the financing of firms, but also with mixed findings. Whereas Camara (2012), Hanousek and Shamshur (2011), and Sett and Sarkhel (2010) found a positive effect on a firm's leverage, Gajurel (2006) reported a negative influence of the inflation rate on total leverage. Beside these factors, prior research investigated the effect of macroeconomic indexes, such as the legal system index or the property right index (e.g., Duan et al. 2012). It has been found that companies in countries with better protection of property rights use external financing to a larger extent, especially bank and equity finance, as better protection of property rights increases the security for capital providers (Beck et al. 2008; Psillaki and Daskalakis 2009).

However, most prior studies are either focused on larger firms and/or did not investigate the complementary and substitutive use of different financing instruments (e.g., Beck and Demirgüç-Kunt 2006; Bopkin 2009; Chavis et al. 2011). We tap into this research gap by developing an empirical taxonomy of SME financing patterns and characterize the patterns according to the macroeconomic variables. Table 2-1 provides an overview of relevant empirical studies regarding the effects of macroeconomic variables on SMEs' capital structure.

Table 2-1: Literature review on SME financing patterns and their macroeconomic determinants.

Authors	Main findings	Main data source/Main method	Country
Agarwal and Mohtadi (2004)	Stock market development is negatively linked to the debt levels of firms relative to their equity level, whereas the banking sector development is positively linked to debt level of firms relative to their equity level.	WorldScope, IFC, World Development Indicators/ regression analyses	Worldwide
Ayyagari et al. (2007)	The business environment, for instance better credit information, is positively linked to a larger size of the SME sector in a country.	World Bank Doing Business Database/ regression analyses	Worldwide
Bas et al. (2009)	The financing decisions of large and listed firms are influenced less by economic conditions than are small and private firms.	World Bank Enterprise Survey (WBES)	Developing countries
Beck and Demirgüç-Kunt (2006)	The improvement of financial and legal institutions can alleviate the access to finance constraints for SMEs.	Literature review	Worldwide
Beck et al. (2008)	Protection of property rights has a positive effect on external financing of small firms. Firm size determines the capital structure. Both financial and institutional development have an impact on financing of small and large firms.	WBES/ regression analyses	Worldwide
Berger and Udell (1998)	Government policies and national structures affect credit availability through lending technologies. Beside company-characteristics, the macroeconomic environment determines the financing of SMEs.	Literature review	Worldwide
Booth et al. (2001)	The capital structure choices are influenced by similar variables for both developed and developing countries. Country-specific fixed effects explain approximately 43% of firm leverage variation in developing countries.	International Finance Corporation (IFC)/ regression analyses	Worldwide
Bopkin (2009)	Inflation has a significantly positive effect on the choice of short-term debt over equity, whereas GDP per capita negatively affects the capital structure choices.	Accounting data/regression analyses	Worldwide
Chavis et al. (2011)	Younger firms rely more on informal financing and less on bank financing. More mature firms substitute informal financing with bank financing (substitution effect hold for different industries and countries). These effects hold for firms in countries with different GDP per capita rates.	WBES/ regression analyses	Worldwide
Daskalakis and Psillaki (2008)	Firm size has a positive relationship with leverage. Profitability and asset structure (ratio of tangible assets divided by the total assets of the firm) have a significant negative impact on leverage. Firm-specific rather than country-specific factors explain capital structure (at least for SMEs in France and Greece).	AMADEUS database/ regression analyses	France and Greece
Frank and Goyal (2009)	Median industry leverage, tangibility, log of assets and expected inflation positively influence market leverage, whereas market-to-book assets ratio and profits negatively affect market leverage.	Compustat, Center for Research in Security Prices, public databases/ regression analyses	United States
Giannetti (2003)	The leverage of individual unlisted firms significantly influences institutional variables (e.g., stock market development, legal enforcement, or creditor protection).	AMADEUS database/ regression analyses	Europe
Hall et al. (2004)	Firm-specific determinants (firm size, firm age, profit, growth, asset structure) have partly a significant influence on the capital structure of SMEs but there exists variations between countries.	Dun & Bradstreet/ regression analyses	Europe

Table 2-1: Literature review on SME financing patterns and their macroeconomic determinants (continued).

Authors	Main findings	Main data source/Main method	Country
Hanousek and Shamshur (2011)	Both the GDP growth and the corruption perception index are positively related to the firm's leverage ratio.	AMADEUS database/ regression analyses	Europe
Hernández-Cánovas and Koëter-Kant (2011)	SMEs in countries with high protection rights are more likely to obtain long-term bank loans. The institutional environment effect is more pronounced for micro firms.	ENSR Survey/ regression analyses	Europe
Jõeveer (2013)	The explanatory power of country-specific factors is higher for small firms than it is for larger firms. The leverage of a firm varies according to the firm size.	AMADEUS database/ ANOVA and regression analyses	Western Europe
La Porta et al. (1997)	Countries with poorer investor protections have smaller capital markets. Common law countries have better investor protections and developed capital markets than have French civil law countries.	WorldScope Database/ regression analyses	Worldwide
Levine (2002)	The legal system has an influence on the financial sector development.	Country publications and national regulatory authorities/ regression analyses	Worldwide
López-Gracia and Sogorb-Mira (2008)	Both trade-off and pecking order theory are appropriate theoretical approaches in order to explain the financial behavior of SMEs. Growth opportunities, firm size, age, internal resources and non-debt tax shields are important determinants of SME capital structure.	SABI database/ regression analyses	Spain
Mac an Bhaird and Lucey (2010)	The variables firm age, firm size, ownership structure, level of intangible activity and provision of collateral are substantial factors which determine the capital structure of SMEs. The findings are similar across industry sectors. Findings support the appropriability of the pecking order theory for SMEs.	Survey/ regression analyses	Ireland
Moritz et al. (2016)	SME financing in Europe appears to be heterogeneous, but several financing patterns exist. SME financing types differ according to their firm-, product-, industry- and country-specific characteristics.	SAFE/ cluster analysis	Europe
Öztürk and Mrkaic (2014)	Firm size and age are positively linked to access to finance of SMEs. Subsidies significantly improve access to finance of SMEs. Increased bank funding costs as well as borrower leverage have a negative impact on the access to finance of SMEs.	SAFE/ baseline analysis and regression analyses	Europe
Psillaki and Daskalakis (2009)	Firm-specific determinants, such as profitability, asset structure, firm size or risk, rather than country factors appear to explain differences in capital structure in a country.	AMADEUS database/ regression analyses	Europe
Rajan and Zingales (1995)	The effective personal and corporate tax rate should be included to measure the effect of taxes on the aggregate leverage of a firm in a country.	Morgan Stanley Capital International Perspective/ regression analyses	Worldwide
Sett and Sarkhel (2010)	Both the inflation rate and the effective rate of corporate tax positively influence the firm's debt-equity ratio.	RBI/ Regression analyses	India
Sogorb-Mira (2005)	Non-debt tax shields and profitability negatively influence SME leverage. Asset structure, growth options and firm size have a significant positive impact on SME capital structure.	SABI database/ regression analyses	Spain

2.3. Data, method and variables

2.3.1. The SAFE survey

The main dataset used for our analysis is obtained from the "Survey on the access to finance of enterprises (SAFE survey)", which is conducted on behalf of the European Central Bank (ECB) and the European Commission (EC). The SAFE survey is run on a bi-annual basis by the ECB, while it is carried out once a year (since 2013) as a cooperation between EC and ECB (European Central Bank 2018; European Commission 2015). The difference between the bi-annual and annual questionnaire is the number of questions asked and the participating countries. The firms in the sample are selected randomly from the Dun & Bradstreet database by a specialist research institute, to underline the fact that it is anonymous and professional.

The SAFE survey contains various firm-specific information, such as firm size (turnover, number of employees), firm age, ownership structure, main activity (industry, trade, construction, service), growth, innovation activity and financing information (e.g., current financing sources, evaluation of the access to finance). According to the size categories, the SAFE differentiates between micro (1–9 employees), small (10–49 employees), medium-sized (50–249 employees), and large enterprises (> 250 employees). The sample of the SAFE survey is artificially distorted due to the sampling process. Therefore, we used post-stratification weights (calculated on the basis of Eurostat data) in order to restore the non-distorted proportions based on the approach applied by Moritz et al. (2016). For our analysis, we used the joint EC/ECB wave number 13 that was conducted between April and September 2015. In total, the sample includes 17,950 firms in 39 European countries.

2.3.2. Method

In order to identify an empirical taxonomy of SME financing patterns, we conduct a hierarchical cluster analysis. Cluster analysis is an appropriate method to identify groups of firms that use similar financing instruments. The goal is to identify clusters which are relatively homogeneous within the clusters but are distinctively different from each other (e.g., Hair et al. 2010; Moritz et al. 2016; Özari et al. 2013).

Different hierarchical cluster analysis algorithms were tested (single linkage, average linkage, complete linkage and Ward's method) in order to identify an empirical taxonomy of SMEs in Europe. We decided to use Ward's method because this algorithm generated

relatively homogeneous clusters with balanced cluster sizes, whereas the other methods provided unbalanced cluster sizes or clusters with a high intra-cluster heterogeneity (Backhaus et al. 2013). Furthermore, this approach allows us to directly compare our results with the analysis by Moritz et al. (2016), without causing differences due to the application of a variety of methods. Consistent with Ward's algorithm, we used the squared Euclidean distance as a measure of proximity. Based on the validation tests (Test of Mojena and Elbow Criterion), as well as face validity and theoretical foundation (Backhaus et al. 2013; Mojena 1977), we identified seven distinct SME financing clusters.

2.3.3. Variables

2.3.3.1. Active cluster variables

In the SAFE survey, the participating SMEs are asked about the financing of their company, and in particular, the financing instruments used. The question consists of two parts: first, the enterprise was asked whether it had used the specific financing instrument in the past or would consider using it in the future (i.e., whether the financing instrument was relevant to the firm). Second, the company was asked whether it had used the financing instrument during the past six months. The following financing instruments were queried: (a) retained earnings or sale of assets, (b) grants or subsidized bank loans, (c) credit line, bank overdraft or credit card overdrafts, (d) bank loans (both short and long-term), (e) trade credit, (f) other loans (for example from family and friends, a related enterprise or shareholders), (g) leasing or hire-purchase, (h) factoring (i) debt-securities issued, (j) equity (quoted shares, unquoted shares or other forms of equity provided by the owners or external investors, such as venture capital companies or business angels), (k) other sources of financing (subordinated debt instruments, participating loans, peer-to-peer lending, crowdfunding).

As we are also interested in firms which did not use any of these financing instruments, we added an additional variable that indicated whether a company had not used any external financing in the past six months. To be able to compare the cluster results with the analysis by Moritz et al. (2016), we combined the financing instruments "factoring" and "leasing or hire-purchase", as these financing instruments were combined in one category in 2013. The different financing instruments are used as active cluster variables in order to identify financing patterns of European SMEs and to create a comprehensive taxonomy of European SME financing.

2.3.3.2. Passive cluster variables

To characterize the different financing patterns, several firm-, product-, industry-, and country-specific determinants are included as passive cluster variables. The majority of the variables are retrieved from the SAFE survey (see Table 2-2). To analyze the country-specific differences, we add macroeconomic variables provided by the OECD, the European Commission, the Heritage Foundation and the World Bank.

Table 2-2: Passive cluster variables.

Passive cluster variables	Coding	Comments
Firm size (1): Number of employees How many people does your company currently employ either full- or part-time in [country] at all its locations?	1 = from 1 employee to 9 employees 2 = 10 to 49 employees 3 = 50 to 249 employees 4 = 250 employees or more	Category 4 was excluded from the analysis
Firm size (2): Turnover What was the annual turnover of your enterprise in 2014?	5 = up to EUR 500,000 6 = more than EUR 500,000 and up to EUR 1m 7 = more than EUR 1m and up to EUR 2m 2 = more than EUR 2m and up to EUR 10m 3 = more than EUR 10m and up to EUR 50m 4 = more than EUR 50m	Category 5, 6 and 7 are recoded to "up to EUR 2m"
Firm age In which year was your enterprise first registered?	1 = 10 years or more 2 = 5 years or more but less than 10 years 3 = 2 years or more but less than 5 years 4 = less than 2 years	Recoded in the dataset
Ownership Who owns the largest stake in your enterprise?	1 = public shareholders 2 = family or entrepreneurs 3 = other enterprises or business associates 4 = venture capital enterprises or business angels 5 = one owner only 7 = other	
Growth in the past (1): Employee growth Over the last three years (2012-2014), how much did your firm grow on average per year in terms of employment regarding the number of full-time or full-time equivalent employees?	1 = over 20% per year 2 = less than 20% per year 3 = no growth 4 = got smaller	
Growth in the past (2): Turnover growth Over the last three years (2012-2014), how much did your firm grow on average per year in terms of turnover?	1 = over 20% per year 2 = less than 20% per year 3 = no growth 4 = got smaller	
Growth expectation Considering the turnover over the next two to three years (2015-2017), how much does your company expect to grow per year?	1 = grow substantially – over 20% per year 2 = grow moderately – below 20% per year 3 = stay the same size 4 = become smaller	
Profit Has profit decreased, remained unchanged or increased over the past six months?2[2]	1 = increased 2 = remained unchanged 3 = decreased	
Access to finance problems How important have the following problems been for your enterprise in the past six months? (scale 1–10)	1 = it is not at all important 10 = extremely important	Recoded in the dataset: 1 = low (1–3) 2 = medium (4–6) 3 = high (7–10)
Product-related innovativeness During the past 12 months have you introduced a new or significantly improved product or service to the market?	1 = yes 2 = no	
Sector of main activity What is the main activity of your company?	1 = industry 2 = construction 3 = trade 4 = services	Recoded in the dataset
Country	39 European countries	27 EU countries[3]

[2] The actual SAFE question is „Have the following indicators decreased, remained unchanged or increased over the past six months", and profit is one of nine queried indicators.

[3] Excluding Malta since the original weights could not be restored.

Table 2-2: Passive cluster variables (continued)

Passive cluster variables	Coding	Comments
Access to finance problems	1 = low (1–3) 2 = medium (4–6) 3 = high (7–10)	
Inflation rate	1 = deflation (0%) 2 = 0 to less than 0.5 3 = more than 0.5	Data source: World Bank
Inflation volatility	1 = 0 to less than 0.5 2 = 1 to less than 1.5 3 = 1.5 to less than 2 4 = more than 2	Data source: World Bank
Total tax rate	1 = low (0–25%) 2 = medium (26–50%) 3 = high (> 50%)	Data source: OECD
GDP per capita (in US-Dollar)	1 = very low (0–20,000) 2 = low (20,001–40,000) 3 = high (40,001–60,000) 4 = very high (> 60,000)	Data source: World Bank
Average of annual GDP growth rate (averaged through 2011–2015)	1 = less than 0% 2 = 0 to less than 1% 3 = 1 to less than 2% 4 = 2 to less than 3% 5 = more than 3%	Data source: World Bank
Unemployment rate	1 = low (0–6%) 2 = medium (7–13%) 3 = high (> 13%)	Data source: World Bank
Property Rights	1 = very low (30–50) 2 = low (51–70) 3 = high (71–90) 4 = very high (> 90)	Data source: Heritage Foundation
Economic Freedom Index	1 = low (50–60) 2 = medium (61–70) 3 = high (> 70)	Data source: Heritage Foundation

Firm level variables

Firm size. The SAFE survey contains two different measures with regard to the size of the firm. We include both variables – the number of employees and the annual turnover – in our analysis (categorical variables). Empirical research indicates that the size of a firm has a significant impact on its capital structure (e.g., Berger and Udell 1998; Cassar 2004; Hall et al. 2004). Due to the specific characteristics of SMEs, such as informational opacity, liability of smallness and liability of newness (Stinchcombe 1965; Zimmerman and Zeitz 2002), the capital structure of SMEs differs from that of larger enterprises (Berger and Udell 1998; Moritz et al. 2016; Psillaki and Daskalakis 2009; Watson and Wilson 2002). Previous research found that the effect of size is particularly significant for accessing bank financing (e.g., Canton et al. 2013; Jõeveer 2012; Öztürk and Mrkaic 2014). In addition, recent studies

have found validity in the pecking-order theory[4] for SMEs (López-Gracia and Sogorb-Mira 2008; Mac an Bhaird and Lucey 2010; Watson and Wilson 2002), with the result that smaller enterprises prefer internal financing or short-term external debt over long-term debt and equity (Mac an Bhaird and Lucey 2010).

Firm age. The survey contains information about firm age (categorical variable). Previous research has shown a significant effect of firm age on the capital structure of SMEs (e.g., Chavis et al. 2011; Chittenden et al. 1996). Younger firms rely more on informal financing, whereas older firms appear to use more formal financing such as bank loans (Chavis et al. 2011). More mature firms are more likely to receive formal financing, as they already have track records, a credit history and established relationships, which decreases information asymmetries for capital providers (Berger and Udell 1998; Chavis et al. 2011). Formal capital providers such as banks are more inclined to provide short-term debt for young firms as this is more flexible and the contract is easier to terminate if the firm does not develop as expected (Huyghebaert and Van de Gucht 2007).

Growth. The SAFE survey gathers information about future growth expectations and past growth rates. Whereas the former is measured in terms of turnover growth rates, the latter considers turnover growth as well as the number of full-time or full-time equivalent employees. Former studies suggest that the growth of small firms is constrained by the availability of financing. When internal financing sources are depleted, external financing is required for further growth (Becchetti and Trovato 2002; Carpenter and Petersen 2002a). In particular, SMEs with high growth ambitions require external financing sources in order to finance their future objectives (Cassar 2004).

Ownership. This variable concerns the main owner of the firm. Since previous studies have shown that ownership structure affects business financing (e.g., Chittenden et al. 1996; Ferrando and Griesshaber 2011; Moritz et al. 2016), we included all different ownership types included in the SAFE survey in our analysis. Previous research has found that family firms, single-owner firms and owner-teams differ from other firm types (e.g., Millán et al. 2012), and consequently appear to avoid external sources of financing due to a possible loss of control rights (Bathala et al. 2004; Chittenden et al. 1996).

[4] The pecking-order theory assumes that firms prefer internal financing over external financing due to higher information costs associated with external financing (Myers 1984; Myers and Majluf 1984). However, if external financing is required, firms prefer debt to equity, since equity has not only the highest information costs but also leads to a dilution of control (López-Gracia and Sogorb-Mira 2008; Mac an Bhaird and Lucey 2010; Myers 1984).

Profit. According to former research, profitability is negatively related to gearing. In other words, SMEs with a higher profitability appear to prefer internal (e.g., retained earnings) to external financing instruments (e.g., Hall et al. 2000; Michaelas et al. 1999). In particular, firms with higher profits appear to use less debt (Frank and Goyal 2009). In the past, the SAFE survey contained information about the development of the profit margin as a measure of profitability. However, since 2015 the survey has not covered information about the profit margin. Therefore, we include the change in profit of the firm as a proxy for profitability in our analysis.

Access to finance. The SAFE survey contains a variable concerning the most pressing problem of the firm in the past six months. Companies were asked to indicate how important a specific problem (including access to finance) was on a scale from 1 (not at all important) to 10 (extremely important). As SMEs are typically more opaque than larger firms, they are likely to have more difficulties accessing external finance (e.g., Beck and Demirgüç-Kunt 2006). To understand how SMEs perceive their access to finance, we included this variable in our analysis and recoded the scale into three categories: low (1–3), medium (4–6) and high importance (7–10) that are also used in the ECB analyses (European Central Bank 2018).

Product characteristics – innovativeness. The SAFE also covers questions about the innovativeness of firms. Participants were asked if they introduced a new or significantly improved product or service to the market during the past 12 months. Developing new products and services is often cost intensive and success is highly uncertain (Block 2012; Coad and Rao 2008). Innovations are often very risky for SMEs in particular, as they are too small to diversify their portfolio, which increases their risk of bankruptcy (Achleitner et al. 2011; Huyghebaert and Van de Gucht 2007; Rajan and Zingales 1995). As a consequence, it has been found that innovative SMEs face problems in particular to obtain external debt (Hall 2010; Hall and Lerner 2010; Mina et al. 2013).

Hence, equity investors such as venture capital firms, which specialize in investing in innovative small and start-up firms with a high return potential, are an alternative financing source for these high-risk firms. In general, venture capital firms have a variety of selection criteria and extensive experience to evaluate innovative start-up companies (Franke et al. 2008; Zhou et al. 2016). By using their networks and experience, venture capital firms are able to decrease information asymmetries and opportunity costs (Florida and Kenney 1988b; Hall 2010). In addition, they closely monitor the firms after their investment, and provide value-adding services. In contrast to debt providers, equity investors participate in the success

of the firm and are incentivized by higher return potentials through an exit, such as an IPO or buyout (Gompers and Lerner 2004; Hall 2010).

Industry characteristics. The SAFE dataset distinguishes between different sectors depending on the firm's main activities. The one-digit European NACE classification was the basis for the statistical stratification. In order to ensure representativeness and anonymity, the different sectors were grouped into four categories: industry, construction, trade, and other services (European Central Bank 2018). Previous research found that financing requirements differ between industries due to different asset structures and risks (Bradley et al. 1984; Coleman and Robb 2012; Degryse et al. 2012). While SMEs in the industry sector typically require more long-term capital to finance their assets with a long-term character, SMEs in the trade sector appear to require more short-term debt (Michaelas et al. 1999; Moritz et al. 2016). Service firms, however, have been found to use more internal financing sources than external financing, since their capital requirements are relatively low (Harrison et al. 2004).

Country level and macroeconomic variables

Countries. The SAFE survey (2015H1) covers a total of 39 countries, including mainly European but also non-European countries, such as China, Japan, or the United States. Our sample covers all countries where the weights could be restored with the Eurostat data, i.e. 27 European countries.[5] A number of previous studies have highlighted the importance of country differences for firm financing (e.g., Booth et al. 2001; Canton et al. 2013; Chavis et al. 2011; Daskalakis and Psillaki 2008; Demirgüç-Kunt and Levine 1999; La Porta et al. 1997). In particular, the countries' legal and financial systems affect the capital structure of firms (Beck et al. 2008; Demirgüç-Kunt and Maksimovic 1999; Fan et al. 2012; Levine 2002). This effect is even stronger for SMEs as they are more restricted in their cross-border financing activity than larger companies (Guiso et al. 2004; Jõeveer 2012). It has been found that firms in countries with more developed financial and legal systems use more external financing (Beck et al. 2008; Demirgüç-Kunt and Maksimovic 1999). In order to analyse country differences, the 27 European countries are classified based on geography (Northern, Southern, Western and Eastern Europe), their financial market system (bank-based, market-based, and former socialist countries), and the impact of the financial crisis (distressed and non-distressed countries) (Beck et al. 2008; Casey and O'Toole 2014; Demirgüç-Kunt and

[5] All 27 countries in the sample are members of the European Union (EU). Malta was excluded, since the original weights could not be restored. Moreover, the non-EU member Norway, which was part of the previous analysis by Moritz et al. (2016), was not included in our data set due to missing data.

Maksimovic 1999; Ferrando et al. 2015; Moritz et al. 2016). Furthermore, several country-specific and macroeconomic variables, which we took from sources other than the SAFE survey, are included in the analysis:

Inflation rate and volatility. The inflation rate and the inflation rate volatility of the different countries were obtained from the World Bank. We grouped the inflation rates from 2015 into three categories: deflation (rate below 0%), very low (0.0–0.5%), and low (0.5%–1%)[6]. Different previous studies have analyzed the connection between a country's inflation rate and the financing of firms (Beck et al. 2008; Demirgüç-Kunt and Maksimovic 1999; Frank and Goyal 2009; Hernández-Cánovas and Koëter-Kant 2011; Jõeveer 2013; Öztekin 2015). The results of these studies, however, vary considerably. Whereas Demirgüç-Kunt and Maksimovic (1999), Hernández-Cánovas and Koëter-Kant (2011), Bopkin (2009), and Beck et al. (2008) reported a negative effect of high levels of inflation on the use of long-term debt, other studies did not find any significant relationship between inflation rate and the firms' capital structure, or reported the inflation rate as a non-reliable factor to predict leverage (Fan et al. 2012; Frank and Goyal 2009).

Furthermore, high inflation rates and high inflation volatility in the past indicate a high uncertainty about future inflation rates (Ball 1992; Fan et al. 2012; Frank and Goyal 2009). This uncertainty is associated with higher business risks, as higher inflation rates increase the volatility of the firms' operating income. As a consequence, it has been found that inflation uncertainty negatively influences the number of firms' investments by issuing debt (Fan et al. 2012; Hatzinikolaou et al. 2002).

Tax rate. We include the total tax rate and the corporate tax rate of a country as additional variables. We grouped these into three categories: low (0–25%), medium (26–50%) and high (> 50%). Several studies analyzed the effect of taxes on corporate decision-making and in particular, on financial decision-making (e.g., Fan et al. 2012; Graham 2003). According to trade-off theory[7], firms in countries with higher tax rates appear to use more debt (Graham 2003; Miller 1977; Modigliani and Miller 1958; Myers 1984; Wu and Yue 2009). Debt has a tax advantage over equity, since interest expenses are deductible (Graham 2000).

[6] The inflation rates were all below 1% in 2015.

[7] Trade-off theory states that firms have to choose between tax advantages by using debt and the risk of bankruptcy due to high leverage (Bradley 1984; Klapper et al. 2002; Myers 1977). Hence, this theory suggests that firms aim to reach an optimal debt level (Myers 1984).

Gross Domestic Product (GDP) per capita. The World Bank provides data about countries' GDP. We categorized the GDP per capita levels (in US dollars): very low (0–20,000), low (20,001–40,000), high (40,001–60,000) and very high (> 60,000). The GDP per capita is an indicator for the economic development of a country. Various studies have found a relationship between GDP and the capital structure of firms (Bopkin 2009; Camara 2012): firms in countries with a high GDP per capita have been found to rely more on internal (e.g., retained earnings) rather than external financing (Bopkin 2009).

In addition, previous research has investigated the effect of GDP growth rate and GDP change rate on the capital structure of firms (De Jong et al. 2008; Hernández-Cánovas and Koëter-Kant 2011; Holton et al. 2014). De Jong et al. (2008) investigated how firm- and country-specific factors affect the leverage choice of firms in 42 countries worldwide. They revealed that GDP growth rate has a positive effect on a firm's debt level (De Jong et al. 2008).

Unemployment rate. We include the countries' unemployment rate as another macroeconomic variable in the cluster analysis. We grouped the unemployment rates into three categories: low (0–6%), medium (7–13%) and high (> 13%). Similar to the variable GDP per capita, the unemployment rate is an indicator for the economic development and stability of a country. Previous research has found a significant relationship between the unemployment rate and a firm's capital structure, but with mixed findings (non-significant effect or a significant positive effect on the leverage level of firms) (Camara 2012; Mokhova and Zinecker 2014).

Property rights (index). In order to provide information on the impact of the institutional environment on firms' financing decisions, we include an indicator of property rights protection, as compiled by the Heritage Foundation. Since all European countries have a property rights index of at least 30, we grouped the values into four categories based on the classification of the Heritage Foundation: very low (property rights values between 30 and 50), low (51–70), high (71–90) and very high (> 90). According to the Heritage Foundation, a property rights index of less than 30 means that the property rights are weakly protected, the court system is highly inefficient, corruption is extensive and expropriation is possible. On the contrary, a value of more than 90 implies that the government guarantees the protection of private property, the court system enforces contracts efficiently and there is neither corruption nor expropriation (Heritage Foundation 2018). Previous studies have indicated the importance of the protection of private property for the financial development of a country (Beck et al.

2003; Beck et al. 2008). Furthermore, it has been found that companies in countries with better protection of property rights use external finance to a larger extent. In particular, bank and equity finance is used more often in these countries, as better protection of property rights is necessary for financial contracts and the security of investments (Beck et al. 2008; Psillaki and Daskalakis 2009).

Economic freedom (index). The Heritage Foundation also publishes an annual economic freedom index that covers ten quantitative and qualitative factors, grouped into four broad categories of economic freedom: rule of law (property rights, freedom from corruption), limited government (fiscal freedom, government spending), regulation efficiency (labor/business/monetary freedom) and openness of markets (financial/trade/investment freedom) (Heritage Foundation 2018). Protection of property rights is one of ten factors included in the Economic Freedom index. However, additional country-specific characteristics with regard to the institutional environment are covered by this index. Each of the ten factors of economic freedom is measured on a scale of 0 to 100. The overall Economic Freedom Index is the average of the different category factors. Again, we grouped the values into categories based on the classification of the Heritage Foundation: low (index between 0–60), medium (61–70) and high (> 70). Previous research has shown that the legal and financial environment has an impact on firms' capital structure (Fan et al. 2012; La Porta et al. 1997). For instance, firms in countries with a higher level of corruption appear to be more leveraged to a greater extent as the expropriation of external equity holders is easier than it is for debt holders (Fan et al. 2012).

2.3.4. Descriptive statistics

For our research goal to identify financing patterns of SMEs in Europe, we include all firms from the SAFE survey with less than 250 employees according to the definition of the European Commission (European Commission 2005). Hence, our study includes 13,098 firms (see Tables 2-3 and 2-5). We reweighted the sample using data from Eurostat on firm size, economic activities and countries, in order to make valid statements for the overall population of SMEs in Europe. The final reweighted sample mainly consists of micro firms with less than 10 employees (93%). Meanwhile, 6% of the firms employ 10–49 people, whereas only 1% of the firms have 50–249 employees. Furthermore, approximately 90% of the companies have an annual turnover of less than EUR 2m. Regarding firm age, most of the firms (71.8%) are mature companies (≥10 years old). The majority of SMEs are from Italy (16.8%), France (13.3%), Spain (10.4%), Germany (9.7%) and the United Kingdom (7.9%). About 40% are

single-owner firms or belong to families or entrepreneurs, while only 0.2% of the companies are owned by venture capitalists or business angels. Most of the firms belong to the service (47.6%) and trade sector (27.8%). One third of the SMEs introduced a new or significantly improved product or service to the market during the past 12 months. Regarding growth expectations, around 45% of the firms expect to have moderate turnover growth in the next two to three years (0–20% per year).

Credit lines, bank overdrafts or credit card overdrafts were the external financing source that the largest share (33.9%) of firms in the sample used over the past six months. Moreover, trade credit (15.7%), bank loans (14.3%) and leasing, hire-purchase or factoring (12.5%) were important sources of external financing. The issuance of debt securities (1.2%), equity capital (1.2%), and other sources of financing, such as crowdfunding or subordinated debt instruments (1%), were used to a lesser extent. However, many firms (40.6%) in the sample had not used any external financing in the last six months. Table 2-3 provides a detailed overview of the utilization of the different sources of financing.

Table 2-3: Sample description (active cluster variables).

Source of financing	**used in the past 6 months**
Retained earnings or sale of assets	10.7%
Grants or subsidized bank loans	5.3%
Bank overdraft, credit card overdrafts, credit lines	33.9%
Bank loans	14.3%
Trade credit	15.7%
Other loans	9.6%
Debt securities issued	1.2%
Leasing, hire-purchase or factoring	12.5%
Equity	1.2%
Other sources of financing	1.0%
Factoring	2.9%
No external financing used	40.6%

Notes: N = 13,098.

2.4. Empirical analysis

2.4.1. Identifying an empirical taxonomy of SMEs in 2015

To identify an empirical taxonomy of SMEs based on different financing instruments, we perform a cluster analysis. In total, 13,098 SMEs are included in the analysis, providing a seven cluster solution ($p < 0.01$). The results of the cluster analysis are shown in Table 2-4.

Table 2-4: Cluster results.

	Clusters							
Financing instruments	**Mixed-financed (other loans)**	**Mixed-financed (retained earnings or sale of assets)**	**State-subsidized SMEs**	**Debt-financed SMEs**	**Trade-financed SMEs**	**Asset-based financed SMEs**	**Internally-financed SMEs**	**Pearson Chi²**
Retained earnings or sale of assets	7.5%	**92.8%**	12.7%	0.0%	1.0%	0.0%	0.0%	10511.2 ***
Grants or subsidized bank loans	6.2%	1.1%	**100%**	0.0%	0.3%	0.0%	0.0%	11406.4 ***
Credit line, bank overdraft or credit card overdrafts	48.5%	35.5%	56.5%	**85.7%**	45.8%	37.2%	0.0%	6038.7 ***
Bank loans	21.8%	14.6%	49.7%	35.6%	18.4%	0.0%	0.0%	2632.5 ***
Trade credit	23.7%	22.1%	29.2%	0.0%	**95.6%**	0.0%	0.0%	8453.6 ***
Other loans	**93.9%**	14.2%	0.0%	0.0%	0.5%	0.0%	0.0%	10405.3 ***
Debt securities issued	0.5%	0.4%	1.0%	0.0%	9.8%	0.0%	0.0%	1021.7 ***
Equity	0.9%	10.4%	0.0%	0.0%	0.5%	0.0%	0.0%	1074.9 ***
Leasing, hire-purchase or factoring	16.8%	20.3%	23.0%	6.9%	23.6%	**100%**	0.0%	6106.6 ***
Other	11.7%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	1413.5 ***
No external finance	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**100%**	13098.0 ***
N	1,129	1,324	602	2,481	1,382	859	5,321	
Percentage of firms	8.6%	10.1%	4.6%	18.9%	10.6%	6.6%	40.6%	
Description	Firms that use a large variety of financing instruments with focus on other loans	Firms that use a large variety of financing instruments with focus on retained earnings or sale of assets, and equity	Firms that use grants/ subsidized bank loans but also other types of debt	Firms that use different types of debt, in particular short-term debt	Firms that use mainly trade-related types of financing	Firms that mainly use asset-based related types of financing (leasing, hire-purchase or factoring)	Firms without external financing	

Cluster 1 (Mixed-financed SMEs with a focus on other loans). This cluster is characterized by the utilization of a large number of different financing instruments. However, the main focus is on "other loans", such as loans from family and friends or related companies, which were used by 93.9% of SMEs in the cluster. Short-term debt is also very important and is used by nearly half of the SMEs in the cluster (48.5%). In addition, trade credit (23.7%), bank loans (21.8%) and leasing, hire-purchase or factoring (16.8%) are relatively important, while retained earnings or sale of assets (7.5%), grants or subsidized bank loans (6.2%), and in particular equity capital (0.9%) and debt securities (0.5%), are of less importance. It is noteworthy that this is the only cluster in which other sources of financing, such as subordinated debt instruments, participating loans and crowdfunding, are of

any importance (11.7%). 1,129 SMEs (8.6% of the number of firms in the whole sample) belong to this cluster.

Cluster 2 (Mixed-financed SMEs with a focus on retained earnings or sale of assets). Firms in this group also use a great variety of financing instruments. However, the most important financing sources are retained earnings or sale of assets (92.8%). Credit lines, bank overdrafts or credit card overdrafts (35.5%), trade credit (22.1%), leasing, hire-purchase or factoring (20.3%), bank loans (14.6%), and other loans such as loans from family and friends (14.2%) are also used in this cluster. Equity capital (10.4%) is much more important than in all the other SME clusters. Debt securities (0.4%) and grants or subsidized bank loans (1.1%) are used to a small extent. 1,324 SMEs (10.1%) belong to this cluster.

Cluster 3 (State-subsidized SMEs). The state-subsidized SME cluster contains the smallest number of firms (602 SMEs, 4.6%). All firms in this cluster had used government grants or subsidized bank loans over the previous six months. In addition, short-term debt in terms of credit lines, bank overdrafts or credit card overdrafts (56.5%), and bank loans (49.7%) are important financing sources.

Cluster 4 (Debt-financed SMEs). The debt-financed SME cluster is the second largest group in the sample with 2,481 SMEs (18.9%). This cluster focuses on short-term debt (85.7%) and long-term debt (35.6%). Firms included in this group use leasing, hire-purchase or factoring to a lesser extent (6.9%).

Cluster 5 (Trade-financed SMEs). SMEs in this cluster (1,382 firms, 10.6%) focus on trade credit. 95.6% of the SMEs in this cluster use this source of financing. In addition, short-term debt is used by 45.8% of SMEs in this cluster. Furthermore, SMEs use leasing, hire-purchase or factoring (23.6%), and bank loans (18.4%). The trade-financed SME cluster is the only group where the issuance of debt securities plays a considerable role (9.8%).

Cluster 6 (Asset-based financed SMEs). The asset-based financed SME cluster is the second smallest group with 859 firms (6.6%). All SMEs in this group use leasing, hire-purchase or factoring as an external source of financing. Credit lines, bank overdrafts or credit card overdrafts (37.2%) are the only other financing source for SMEs in this cluster.

Cluster 7 (Internally-financed SMEs). The majority of firms belong to the internally-financed SME cluster (5,321 firms, 40.6%). All firms rely on internal financing and had not used any external financing instruments over the past six months.

2.4.1.1. Profiling and describing the taxonomy

According to Table 2-5, statistical tests reveal that firm-, product-, industry- and country-specific characteristics including macroeconomic variables ($p < 0.01$) affect the distribution of SMEs across clusters. In particular, country-specific characteristics are important influencing factors. We highlight and discuss the main results of the cluster characteristics in the following.

Table 2-5: Cluster comparison: firm-, and country-specific characteristics.

Variable		Categories	Total sample	N	Mixed-financed SMEs (with focus on other loans)	Mixed-financed SMEs (with focus on retained earnings/ sale of assets)	State-subsidized SMEs	Debt-financed SMEs	Trade-financed SMEs	Asset-based financed SMEs	Internally-financed SMEs	Test Statistic	
												Pearson Chi²	Cramer's V
		SMEs per cluster			8.6%	10.1%	4.6%	18.9%	10.6%	6.6%	40.6%		
Firm level													
Size													
	Number of employees	1–9 employees	93.0%		8.7%	9.7%	4.3%	19.1%	10.4%	6.1%	41.7%		
		10–49 employees	6.0%		7.9%	14.7%	8.4%	17.2%	12.5%	12.3%	27.0%		
		50–249 employees	1.0%	13,098	9.4%	21.1%	11.0%	14.8%	13.3%	11.7%	18.8%	182.5***	0.083
	Turnover	≤ € 2m	90.1%		8.7%	9.5%	4.2%	19.1%	10.1%	6.2%	42.2%		
		> € 2m– € 10m	8.0%		7.1%	14.4%	7.7%	17.2%	15.6%	9.9%	28.1%		
		> € 10m– € 50m	1.6%		9.8%	21.5%	9.8%	17.3%	13.1%	9.3%	19.2%		
		> € 50m	0.3%	13,098	12.2%	12.2%	4.9%	34.1%	7.3%	4.9%	24.4%	225.7***	0.076
Firm age		≥ 10 years	71.8%		7.7%	10.4%	4.7%	20.4%	10.2%	6.0%	40.6%		
		5 to less than 10 years	19.0%		10.1%	9.7%	4.7%	16.2%	10.6%	8.6%	40.1%		
		2 to less than 5 years	7.7%		11.9%	8.9%	3.0%	11.9%	13.6%	6.9%	43.8%		
		< 2 years	1.5%	13,098	17.2%	5.7%	7.8%	18.7%	13.0%	5.2%	32.3%	147.9***	0.061
Ownership		Public shareholders	0.6%		14.7%	16.0%	8.0%	6.7%	10.7%	10.7%	33.3%		
		Family or entrepreneurs	40.4%		7.9%	10.8%	5.4%	19.8%	11.5%	5.8%	38.9%		
		Other firms or business associates	6.3%		10.6%	13.0%	4.1%	10.6%	13.3%	8.9%	39.4%		
		Venture capital firms or business angels	0.2%		12.9%	38.7%	0.0%	12.9%	6.5%	3.2%	25.8%		

Table 2-5: Cluster comparison: firm-, and country-specific characteristics (continued).

Variable	Categories	Total sample	N	Mixed-financed SMEs (with focus on other loans)	Mixed-financed SMEs (with focus on retained earnings/ sale of assets)	State-subsidized SMEs	Debt-financed SMEs	Trade-financed SMEs	Asset-based financed SMEs	Internally-financed SMEs	Test Statistic	
											Pearson Chi²	Cramer's V
	SMEs per cluster			8.6%	10.1%	4.6%	18.9%	10.6%	6.6%	40.6%		
	One owner only	50.1%		8.9%	8.9%	3.8%	20.0%	9.4%	6.9%	42.0%		
	Other	2.4%	13,096	6.8%	11.6%	8.7%	8.7%	11.0%	5.5%	47.7%	199.4***	0.055
Growth rate p.a. (average p.a. over past 3 years)												
Employment	High growth	10.1%		11.4%	10.7%	6.8%	16.4%	15.7%	7.7%	31.5%		
	Moderate growth	23.4%		7.6%	10.1%	5.7%	18.6%	11.3%	7.6%	39.1%		
	No growth	47.1%		7.4%	10.5%	3.4%	18.6%	8.7%	6.4%	45.0%		
	Got smaller	17.9%	12,942	11.5%	9.1%	5.1%	21.8%	11.3%	5.4%	35.8%	290.7***	0.067
Turnover	High growth	15.7%		8.5%	12.5%	3.9%	16.4%	12.8%	9.0%	36.9%		
	Moderate growth	35.8%		8.7%	11.1%	5.2%	18.7%	10.4%	7.8%	38.1%		
	No growth	25.9%		6.9%	8.5%	3.5%	18.9%	8.8%	5.6%	47.8%		
	Got smaller	20.9%	12,920	10.4%	9.1%	5.2%	21.1%	11.3%	4.2%	38.6%	259.2***	0.063
Growth rate p.a. - Expectation (next 2–3 years)												
	High growth	11.5%		12.6%	13.0%	6.0%	15.9%	10.1%	6.3%	36.1%		
	Moderate growth	45.4%		8.8%	9.7%	5.3%	19.5%	11.3%	7.1%	38.3%		
	No growth	30.5%		6.4%	10.7%	3.7%	18.8%	9.4%	6.3%	44.7%		
	Get smaller	9.2%	12,761	9.8%	9.0%	2.9%	20.5%	11.2%	5.5%	41.1%	184.8***	0.059

Table 2-5: Cluster comparison: firm-, and country-specific characteristics (continued).

Variable	Categories	Total sample	N	Mixed-financed SMEs (with focus on other loans)	Mixed-financed SMEs (with focus on retained earnings/ sale of assets)	State-subsidized SMEs	Debt-financed SMEs	Trade-financed SMEs	Asset-based financed SMEs	Internally-financed SMEs	Test Statistic	
											Pearson Chi²	Cramer's V
	SMEs per cluster			8.6%	10.1%	4.6%	18.9%	10.6%	6.6%	40.6%		
Profitability												
Profit	Increased	28.7%		8.8%	11.4%	4.4%	18.5%	10.4%	7.8%	38.7%		
	Remained unchanged	38.1%		7.4%	9.4%	4.3%	18.6%	9.5%	6.8%	43.9%		
	Decreased	33.2%	13,098	9.9%	9.8%	5.1%	19.8%	11.9%	5.2%	38.5%	88.3***	0.058
Access to finance problems												
	Low	42.8%		5.3%	10.5%	3.1%	15.1%	8.3%	6.9%	50.9%		
	Medium	23.6%		7.4%	9.3%	5.2%	21.3%	11.6%	7.8%	37.3%		
	High	33.6%	12,604	14.1%	10.3%	6.6%	23.4%	12.5%	5.7%	27.6%	760.8***	0.174
Product characteristics												
	Product or service innovation	33.3%	13,098	10.7%	12.4%	6.1%	19.5%	11.3%	6.0%	33.9%	181.4***	0.118
Industry characteristics												
	Industry	10.0%		6.2%	13.4%	6.4%	18.9%	13.0%	6.4%	35.7%		
	Construction	14.6%		7.9%	9.2%	3.6%	21.2%	12.1%	6.4%	39.5%		
	Trade	27.8%		8.1%	8.9%	5.4%	19.4%	14.4%	5.6%	38.1%		
	Services	47.6%	13,098	9.6%	10.4%	4.0%	18.0%	7.3%	7.2%	43.5%	232.6***	0.077
Country level												
Inflation rate												
	Deflation	28.3%		9.8%	9.1%	4.3%	14.4%	14.9%	6.8%	40.6%		
	0 to less than 0.5%	61.4%		8.2%	11.0%	4.8%	20.7%	9.0%	6.3%	39.9%		
	≥ 0.5%	10.3%	13,098	7.8%	7.4%	3.8%	20.8%	8.1%	7.2%	44.8%	190.0***	0.085

Table 2-5: Cluster comparison: firm-, and country-specific characteristics (continued).

Variable	Categories	Total sample	N	Mixed-financed SMEs (with focus on other loans)	Mixed-financed SMEs (with focus on retained earnings/ sale of assets)	State-subsidized SMEs	Debt-financed SMEs	Trade-financed SMEs	Asset-based financed SMEs	Internally-financed SMEs	Test Statistic	
											Pearson Chi²	Cramer's V
	SMEs per cluster			8.6%	10.1%	4.6%	18.9%	10.6%	6.6%	40.6%		
Inflation volatility (standard deviation over the preceding 4 years)												
	0 to less than 0.5	2.9%		4.7%	13.7%	3.1%	16.6%	8.5%	13.5%	39.9%		
	0.5 to less than 1	30.6%		7.5%	11.9%	2.7%	22.4%	5.3%	9.1%	41.1%		
	1 to less than 1.5	50.7%		9.1%	9.0%	6.3%	18.6%	13.4%	4.2%	39.3%		
	1.5 to less than 2	11.3%		7.9%	8.4%	3.7%	13.7%	15.7%	9.0%	41.6%		
	≥ 2	4.4%	13,098	14.7%	12.1%	1.4%	13.8%	2.9%	4.9%	50.2%	597.6***	0.107
Tax payments (number per year)												
	Low	63.8%		9.0%	10.6%	3.4%	17.9%	10.3%	7.4%	41.4%		
	Medium	34.2%		8.1%	9.5%	7.1%	20.7%	11.1%	4.9%	38.7%		
	High	2.1%	13,098	5.8%	6.6%	0.7%	21.9%	9.5%	7.7%	47.8%	158.0***	0.078
Time for paying taxes (hours per year)												
	Very fast	2.1%		10.8%	17.9%	2.9%	15.4%	15.0%	6.5%	31.5%		
	Fast	50.4%		9.0%	10.9%	3.3%	18.2%	11.5%	6.4%	40.8%		
	Slow	41.7%		7.5%	9.1%	6.8%	20.3%	10.0%	7.1%	39.2%		
	Very slow	5.8%	13,098	12.4%	7.9%	1.3%	16.8%	4.6%	4.5%	52.5%	245.6***	0.079
Total tax rate												
	Low	1.7%		8.3%	15.7%	2.3%	17.0%	14.7%	5.5%	36.4%		
	Medium	44.7%		10.3%	9.8%	3.1%	15.2%	11.0%	8.7%	41.9%		
	High	53.7%	13,098	7.2%	10.2%	5.9%	22.1%	10.1%	4.8%	39.7%	268.1***	0.101

Table 2-5: Cluster comparison: firm-, and country-specific characteristics (continued).

Variable	Categories	Total sample	N	Mixed-financed SMEs (with focus on other loans)	Mixed-financed SMEs (with focus on retained earnings/ sale of assets)	State-subsidized SMEs	Debt-financed SMEs	Trade-financed SMEs	Asset-based financed SMEs	Internally-financed SMEs	Test Statistic	
											Pearson Chi²	Cramer's V
	SMEs per cluster			8.6%	10.1%	4.6%	18.9%	10.6%	6.6%	40.6%		
GDP per capita (in US-Dollar)												
	Very low	20.0%		10.7%	9.2%	2.7%	14.5%	10.1%	7.2%	45.5%		
	Low	34.8%		7.7%	8.7%	7.9%	20.2%	13.0%	4.0%	38.5%		
	High	44.1%		8.5%	11.5%	2.8%	19.9%	9.0%	8.1%	40.1%		
	Very high	1.1%	13,098	5.0%	14.2%	3.5%	21.3%	3.5%	12.8%	39.7%	391.1***	0.100
Average of annual GDP growth rate (averaged through 2011–2015)												
	Less than 0%	34.6%		7.7%	8.6%	8.0%	20.2%	13.0%	4.0%	38.4%		
	0 to less than 1%	22.9%		6.6%	11.2%	2.4%	23.6%	5.8%	6.9%	43.5%		
	1 to less than 2%	22.1%		10.0%	10.2%	2.9%	17.8%	4.6%	9.8%	44.6%		
	2 to less than 3%	18.3%		10.4%	10.5%	3.3%	13.0%	18.6%	7.2%	36.9%		
	≥ 3%	2.0%	13,098	16.1%	18.0%	1.1%	10.5%	12.7%	6.4%	35.2%	823.5***	0.125
Unemployment rate												
	Low	15.9%		10.3%	9.7%	2.7%	19.3%	4.5%	10.9%	42.6%		
	Medium	62.5%		7.9%	11.1%	5.1%	20.0%	10.9%	5.9%	39.2%		
	High	21.6%	13,098	9.5%	7.6%	4.6%	15.7%	13.9%	5.3%	43.4%	269.5***	0.101

Table 2-5: Cluster comparison: firm-, and country-specific characteristics (continued).

Variable	Categories	Total sample	N	Mixed-financed SMEs (with focus on other loans)	Mixed-financed SMEs (with focus on retained earnings/ sale of assets)	State-subsidized SMEs	Debt-financed SMEs	Trade-financed SMEs	Asset-based financed SMEs	Internally-financed SMEs	Test Statistic	
											Pearson Chi²	Cramer's V
	SMEs per cluster			8.6%	10.1%	4.6%	18.9%	10.6%	6.6%	40.6%		
Property Rights												
	Very low	9.2%		11.6%	8.4%	1.4%	14.1%	15.5%	5.4%	43.6%		
	Low	40.9%		7.8%	8.9%	7.6%	19.2%	12.0%	5.2%	39.4%		
	High	48.9%		8.8%	11.4%	2.7%	19.6%	8.6%	7.8%	41.1%		
	Very high	0.9%	13,098	5.7%	12.2%	3.3%	21.1%	4.1%	14.6%	39.0%	355.9***	0.095
Economic Freedom Index												
	Low	3.7%		7.9%	5.0%	2.5%	7.7%	30.5%	4.6%	41.8%		
	Medium	61.6%		7.5%	10.0%	5.8%	21.1%	9.8%	5.5%	40.3%		
	High	34.7%	13,098	10.7%	10.8%	2.6%	16.3%	9.8%	8.7%	41.1%	424.0***	0.127

Notes: Pearson's chi-square test and Cramer's V for categorical variables. ***p < 0.01, **p < 0.05, *p < 0.1.
The table should be read by comparing the share of SMEs per cluster and the share of SMEs in each category of passive cluster variables.

2.4.1.2. Firm level characteristics of the clusters

While larger SMEs use a great variety of financing instruments such as bank loans, trade credit, state-subsidized financing and equity, smaller SMEs tend to use more internal financing (41.7% of SMEs with 1–9 employees belong to the internally-financed cluster) and short-term bank debt (19.1% of SMEs with 1–9 employees belong to the debt-financed cluster). This result is in line with previous studies, which found that smaller firms, with their liability of smallness and legitimacy problems, face difficulties obtaining external financing (e.g., Aldrich and Auster 1986; Freeman et al. 1983; see also Kraemer-Eis et al. 2016 for an overview). In particular, banks have been found to be reluctant to lend money to smaller companies as the bankruptcy risk for these firms is higher (Degryse et al. 2012; Michaelas et al. 1999). Hence, small firms more often tend to be financed by internal sources or short-term bank debt (Beck et al. 2008; Berger and Udell 1998; Freeman et al. 1983; Huyghebaert and Van de Gucht 2007; Singh et al. 1986). In line with previous research, our cluster analysis reveals that not only size but also firm age seems to be an important determinant for financing (Chavis et al. 2011; Huyghebaert and Van de Gucht 2007; Mac an Bhaird and Lucey 2010). More mature firms use a larger number of financing sources including bank loans, equity and retained earnings, whereas younger SMEs appear to rely more on other loans (e.g., loans from family and friends), internal or state-subsidized financing. Due to higher information asymmetries resulting from the lack of track records and the absence of established relationships between capital providers and younger firms, these firms typically have problems obtaining external financing and are more likely to rely on informal financing sources (Berger and Udell 1998; Chittenden et al. 1996; Holmes and Kent 1991; Jensen and Meckling 1976).

In addition, the ownership structure of SMEs across clusters differs significantly. In particular, owner-managed SMEs appear to prefer short-term bank financing (20% of owner-managed firms belong to the debt-financed cluster), whereas family-owned firms and SMEs with more than one owner tend to use a larger variety of financing instruments. These results are in line with previous research which found a significant influence of an SME's ownership structure on its capital structure (Huyghebaert et al. 2007; Romano et al. 2001). In particular, it has been shown that owner-managed firms prefer debt and internal financing instruments over equity in order to retain control (Bathala et al. 2004; Chittenden et al. 1996; Romano et al. 2001).

Furthermore, we find that innovative SMEs appear to use short-term bank debt to a relatively large extent (19.5% of SMEs with a product or service innovation in the last 12 months belong to the debt-financed cluster). Moreover, they are comparably strongly represented in both mixed-financed clusters, which have a high utilization of retained earnings or sale of assets, equity, and other loans (such as from family and friends). They also seem to frequently use grants or state-subsidized loans (6.1% of all "innovative" SMEs belong to the state-subsidized cluster, which is higher than the share of all SMEs (4.6%) in this cluster). Innovative firms are typically associated with a higher asset intangibility and higher failure risks. In addition, information asymmetries are particularly high and result in higher agency costs (Cosh et al. 2009; Gompers and Lerner 2000). Therefore, innovative SMEs have comparatively greater difficulty obtaining external capital and especially bank debt (Achleitner et al. 2011; Huyghebaert and Van de Gucht 2007; Rajan and Zingales 1995). With regard to growth, the cluster analysis reveals that SMEs with higher past (turnover or employment) growth rates tend to use a larger variety of financing instruments and in particular trade credit, leasing or hire-purchase and factoring. Hence, they can be found more often in the trade-financed and asset-based financed clusters. Moreover, companies with high turnover growth rates are well-represented in the mixed-financed cluster with a focus on retained earnings or sale of assets, while enterprises with high employment growth rates are more often in the mixed-financed cluster with a focus on other loans as well as in the state-subsidized cluster. SMEs with high growth expectations for the future are also comparatively more often in the mixed-financed and the state-subsidized clusters. This result can be explained with previous findings, stating that high growth firms typically require more external financing, but at the same time have been found to face more difficulties acquiring external capital from formal financing sources due to their risk profile (Carpenter and Petersen 2002b; Cassar 2004).

With regard to profit development, our cluster analysis reveals that SMEs with increased profits in the past 12 months more often tend to be in the mixed-financed SME cluster (with focus on retained earnings or sale of assets). This result is not surprising as more profitable firms are more likely to retain their earnings. Hence, these firms have more internal financing at their disposal and require less external financing. This result is also in line with the pecking order theory (Myers and Majluf 1984; Myers 1984). Furthermore, we find that firms with low perceived access-to-finance problems more often tend to be internally financed, while only a relatively small fraction of these firms are state-subsidized. SMEs suffering from high perceived access to finance problems are comparatively more often in the

debt-financed, mixed-financed, state-subsidized and trade-financed clusters. This result might be explained by the fact that internally-financed firms do not seem to require external financing. On the contrary, financially constrained firms appear to follow a diversification strategy to secure the required level of financing.[8]

Comparing the industry-specific characteristics across clusters, service firms seem to focus mainly on internal financing. In addition, they are comparatively more often in the asset-based financing and mixed-financing clusters. This result is in line with previous research, which has shown that service firms typically rely more on internal financing due to their asset structure (Moritz et al. 2016). Furthermore, they are less able to provide collateral, which is required for external financing, especially bank debt. Therefore, they seem to rely more on alternative financing instruments such as asset-based financing (Chavis et al. 2011; Erramilli and Rao 1993). SMEs in the industry sector, however, tend to be more likely to be in the trade- or mixed-financed clusters with a focus on retained earnings and sale of assets. Due to their asset structure, SMEs in the industry sector require more long-term financing (golden rule of capital), but are also able to attract more debt as they can provide collateral to secure it (Degryse et al. 2012; Michaelas et al. 1999). This might be one explanation as to why SMEs in the industry sector are comparatively more often in the state-subsidized cluster, in which bank loans also play a prominent role. The cluster analysis further reveals that SMEs in the construction sector rely strongly on debt and trade-based finance. According to previous research, SMEs in the construction sector have to rely more on short-term rather than long-term debt, as banks are reluctant to provide long-term debt due to the sector's higher risks (Degryse et al. 2012; Hall et al. 2000; Jiménez and Saurina 2004). The typical assessment that the construction sector intensively uses asset-based financing (Kraemer-Eis and Lang 2012) is not confirmed by our analysis. SMEs in the trade sector use trade financing in particular. SMEs in the trade sector typically require more working capital, and hence are

[8] However, the result may – at least to some degree – also be biased by measurement and data collection. For instance, self-assessment of perceived and actual access-to-finance problems might be distorted in the sense that high-performing firms are less likely to complain about access to finance problems, while SMEs with a poor performance might be inclined to blame their problems on their access to finance situation, in order to justify their current situation (Claessens and Tziousmis 2006). Therefore, the results might be – at least in part – driven by the current business situation of the firms. With regard to our sample, SMEs in the clusters with high perceived access to finance problems in particular show decreasing profits in the past 12 months, whereas SMEs in the internally-financed cluster (where SMEs that stated low access to finance problems are comparatively strongly represented) have relatively stable profits. Moreover, the definition of access to finance problems is difficult to assess and might cause problems in firms' self-assessment (Claessens and Tziousmis 2006). Ferrando and Mulier (2015) indicate significant differences between perceived and actual financing constraints. Due to the data set, however, only the perceived access to finance problems of SMEs could be included as a passive cluster variable.

more likely to be financed by short-term debt and trade credit. (Chittenden et al. 1996; Klapper et al. 2002; Petersen and Rajan 1997).

2.4.1.3. Country-level characteristics of the clusters

Country-specific characteristics. To analyze the effect of country-specific variables on SME financing, we follow the approach of Moritz et al. (2016) and categorize the various countries according to their geographic location in Europe, their financial market system and the effect of the financial market crisis (distressed vs. non-distressed countries) (see Table 2-6). To be able to analyze country-specific effects in more detail, we included a number of macroeconomic variables in our analysis. Using Cramer's V as an indicator for the ability to explain the cluster affiliation, we find that country-specific and macroeconomic differences are more pronounced than the differences by product-, firm- and industry-specific characteristics.

Table 2-6: Cluster comparison: country-specific characteristics.

Groups of countries by region (UNSD)	Mixed-financed SMEs (with a focus on other loans)	Mixed-financed SMEs (with a focus on retained earnings/ sale of assets)	State-subsidized SMEs	Debt-financed SMEs	Trade-financed SMEs	Asset-based financed SMEs	Internally-financed SMEs	Test Statistic	
								Pearson Chi²	Cramer's V
Eastern Europe[a]	10.2%	8.8%	2.8%	15.0%	10.4%	7.1%	45.7%		
Northern Europe[b]	11.0%	12.8%	2.8%	12.6%	16.9%	7.7%	36.3%		
Southern Europe[c]	7.7%	8.6%	7.9%	20.2%	12.9%	4.1%	38.6%		
Western Europe[d]	7.6%	11.3%	2.8%	22.8%	5.1%	8.5%	42.0%		
Total sample	8.6%	10.1%	4.6%	18.9%	10.6%	6.6%	40.6%	651.7***	0.129

Notes: N = 13,068; Pearson's chi-square test and Cramer's V for categorical variables. ***p < 0.01, **p < 0.05, *p < 0.
(a) BG, CZ, HU, PL, RO, SK; [b] DK, EE, FI, IE, LT, LV, SE, UK; [c] CY, ES, GR, HR, IT, PT, SI; [d] AT, BE, DE, FR, LU, NL

Groups of bank-based, market-based and former socialist countries	Mixed-financed SMEs (with a focus on other loans)	Mixed-financed SMEs (with a focus on retained earnings/ sale of assets)	State-subsidized SMEs	Debt-financed SMEs	Trade-financed SMEs	Asset-based financed SMEs	Internally-financed SMEs	Test Statistic	
								Pearson Chi²	Cramer's V
Bank-based countries[a]	7.4%	10.3%	5.9%	21.9%	9.5%	6.1%	38.9%		
Market-based countries[b]	10.8%	10.2%	2.2%	13.6%	15.0%	7.3%	41.0%		
Former socialist countries[c]	10.7%	9.5%	2.7%	14.4%	9.9%	7.5%	45.5%		
Total sample	8.6%	10.1%	4.6%	18.9%	10.5%	6.6%	40.6%	295.2***	0.150

Notes: N = 13,068; Pearson's chi-square test and Cramer's V for categorical variables. ***p < 0.01, **p < 0.05, *p < 0.1.
[a] AT, BE, CY, DE, ES, FI, FR, GR, IE, IT, LU, PT; [b] NL, SE, UK, FI; [c] BG, CZ, EE, HR, HU, LT, LV, PL, RO, SI, SK

Table 2-6: Cluster comparison: country-specific characteristics (continued).

Groups of non-distressed vs. distressed countries	Mixed-financed SMEs (with a focus on other loans)	Mixed-financed SMEs (with a focus on retained earnings/ sale of assets)	State-subsidized SMEs	Debt-financed SMEs	Trade-financed SMEs	Asset-based financed SMEs	Internally-financed SMEs	Test Statistic	
								Pearson Chi²	Cramer's V
Non-distressed countries	9.1%	10.8%	2.8%	18.2%	9.1%	8.0%	42.0%		
Distressed countries[(a)]	7.8%	8.7%	7.9%	20.3%	13.2%	3.9%	38.2%		
Total sample	8.6%	10.1%	4.6%	18.9%	10.6%	6.6%	40.6%	325.5***	0.158

Notes: N = 13,098; Pearson's chi-square test and Cramer's V for categorical variables. ***p < 0.01, **p < 0.05, *p < 0.1.
[(a)] CY, ES, GR, IE, IT, PT, SI

Drawing on the classification by the United Nations Statistics Division (UNSD), we divided Europe into Northern Europe, Southern Europe, Eastern Europe and Western Europe. Our cluster analysis reveals that, although internally-financed SMEs have the highest percentage within each European region, SMEs in Eastern European countries seem to rely particularly on internal financing (45.7%). This result is in line with prior research (Moritz et al. 2016) and might be explained by the historically underdeveloped financial markets in Eastern European countries (Črnigoj and Mramor 2009; Klapper et al. 2002). Northern European SMEs are comparatively more often mixed-financed or trade-financed SMEs. Prior studies have found that Northern European countries have well-organized financial market systems and consequently have access to a large number of financing instruments (Demirgüç-Kunt and Maksimovic 2001; Guiso et al. 2004). Furthermore, firms in countries with well-developed financial markets have been found to use trade credit more often, as it is an attractive alternative to other, mainly bank-related, short-term debt (Demirgüç-Kunt and Maksimovic 2001; Guiso et al. 2004; Marotta 2005). Southern European SMEs, however, tend to be more likely to be in the state-subsidized cluster. This result might be explained by the aftermath of the financial market crisis, as access to finance for SMEs in countries such as Spain, Greece or Portugal was especially difficult (Ferrando and Mulier 2015) and government support programs were issued to support the economy in these countries (Casey and O'Toole 2014; Ferrando and Griesshaber 2011). Western European firms are comparatively more often in the debt-financed cluster (22.8%), which is likely to be explained by the relatively strong banking sector in these countries (Allard and Blavy 2011; Demirgüç-Kunt and Maksimovic 1999).

To delve deeper into the differences due to the prevailing financial market system, we divided the European countries included in our study into bank-based, market-based and former socialist countries. Bank-based financial systems are characterized by the dominant role of banks (Demirgüç-Kunt and Levine 1999; Levine 2002). The results of our cluster analysis are in line with previous research and show that SMEs in bank-based countries more often tend to be in the debt-financed cluster, relying mainly on bank financing (Moritz et al. 2016; Nyasha and Odhiambo 2014). In addition, SMEs in bank-based countries more often tend to be in the state-subsidized cluster, which is characterized by a high degree of financing with government grants and subsidized loans. During and in the aftermath of the recent financial crisis, banks reduced the availability of bank loans, especially for risky and small firms (Ferrando and Griesshaber 2011). Bank-based financial market systems were particularly affected by this change in lending policies and required government action to

secure financing alternatives for firms in these countries. Interestingly, this cluster is also characterized by a high degree of bank loans, which cannot easily be explained by the firm characteristics of SMEs in the state-subsidized cluster. Hence, it seems that government subsidies might provide a positive signal for other capital providers, in particular financial institutions (Beck et al. 2008; Freel 2006; Mina et al. 2013). Previous research revealed that SMEs in particular faced financing constraints during the recent economic and financial crisis (Ferrando and Griesshaber, 2011). To understand how the financial market crisis affected the financing patterns of SMEs, we divided the countries into distressed and non-distressed countries (Moritz et al. 2016). We find that SMEs in distressed countries seem to be more likely to fall into the trade-financed or state-subsidized cluster. This result is in line with previous studies that indicated an increasing utilization of alternative financing instruments in deteriorating financial markets (Casey and O'Toole 2014; Moritz et al. 2016). Furthermore, SMEs in distressed countries appear to rely more on grants or subsidized bank loans, which can be explained by financial constraints and the higher availability of subsidies (Casey and O'Toole 2014).

Macroeconomic variables. The cluster analysis further reveals that a country's inflation rate (Cramer's V = 0.085) and inflation volatility (Cramer's V = 0.107) seem to be important factors in determining the financing patterns of SMEs (see Table 2-5). SMEs in countries with a higher inflation rate tend to use less trade financing and state subsidies, but are comparatively more often in the debt-financed cluster. Previous research found that higher inflation is negatively associated with the utilization of external financing (Beck et al. 2008) but, at the same time, higher inflation rates and higher expected inflation rates seem to increase the leverage ratio of SMEs (Frank and Goyal 2009; Öztekin 2015). However, we find a contrary result: firms in countries with low inflation volatility more often tend to be in the debt-financed SME cluster. Regarding inflation volatility, we find that SMEs in countries with very high inflation volatility tend to be comparatively more often in the internally-financed or mixed-financed cluster (with a focus on other loans). This can be explained by the fact that high inflation volatility decreases the predictability of a country's future development, which in turn increases the business risk of firms. As a consequence, firms are more likely to avoid long-term debt in this uncertain environment (Ball 1992; Fan et al. 2012; Frank and Goyal 2009).

Furthermore, we find that GDP per capita (Cramer's V = 0.100) and GDP growth rates (Cramer's V = 0.125) are related to the financing of firms. Both variables provide information about the economic condition of a country (Bas et al. 2009; De Jong et al. 2008). Our cluster

analysis reveals that SMEs in countries with high GDP per capita are comparatively more often in the mixed-financed (with focus on retained earnings or sale of assets), asset-based and debt-financed clusters. Hence, SMEs in more developed and economically sound countries seem to be able to obtain financing from a larger variety of financing sources (Bas et al. 2009). In line with this finding, firms in countries with relatively high GDP growth rates appear to use a broader range of financing instruments (18.0% of SMEs in countries with an average GDP growth rate of ≥ 3% from 2011–2015 belong to the mixed-financed SME cluster with a focus on retained earnings or sale of assets), whereas SMEs in countries with lower GDP growth rates are more likely to use state subsidies. This result implies that SMEs in less well developing countries obtain more government support than SMEs in countries with high GDP growth rates.

SMEs in countries with higher tax rates are more likely to be in the debt-financed cluster (22.1% of SMEs in countries with a total tax rate of > 50% belong to the debt-financed cluster) and in the state-subsidized cluster, in which the use of bank loans is also relatively high. In contrast, SMEs in countries with lower tax rates tend to use a larger variety of financing instruments as well as trade financing. This result is in line with trade-off theory, which is based on the idea that firms have to make a trade-off decision between a positive tax effect of debt and bankruptcy risk (Miller 1977; Myers 1977). Therefore, firms in countries with higher tax rates are able to generate a higher positive tax effect and are therefore more likely to use more debt than firms in low tax rate countries (Graham 2003; Jensen and Meckling 1976; Myers 1977; Psillaki and Daskalakis 2009).

A number of European countries suffered from economic instability and high unemployment rates due to the financial and economic crisis which started in 2007. The banking system was strongly affected by these developments and firms still suffer from bank lending constraints (Casey and O'Toole 2014; Ferrando and Griesshaber 2011; O'Higgins 2012; Tanveer et al. 2012). It has been found that firms with bank lending constraints are more likely to use internal financing and alternative financing instruments, for instance trade credit (Casey and O'Toole 2014; Ferrando and Mulier 2015; Love et al. 2007). These findings are reflected in our cluster analysis, which shows that SMEs in countries with high unemployment rates (> 13%) are more likely to be in the internally-financed and trade-financed cluster.

In addition, we find that SMEs in countries with low property rights protection tend to rely strongly on internal rather than external financing. Nevertheless, trade finance and other

loans (e.g., from family and friends, a related enterprise or shareholders) also appear to be important financing instruments in these countries. Property rights protection is closely related to financial development and the effectiveness of financial contracting (Beck et al. 2003; La Porta et al.1997). Therefore, better protection of property rights is associated with better access to external financing for SMEs (Beck et al. 2008; Psillaki and Daskalakis 2009). This finding is further supported by looking at the economic freedom index. We find that SMEs in countries with higher economic freedom use a broader range of financing instruments and are consequently more likely to be in the mixed-financed clusters. In addition, our cluster analysis reveals that SMEs in countries with a very low level of economic freedom seem to be more often in the trade-financed cluster (30.5% of SMEs in countries with an economic freedom index between 50 and 60 belong to this cluster). This finding might also be due to the financial crisis and the difficulties faced by various European countries, especially Greece (Drakos 2012; Gibson et al. 2012).[9]

2.4.2. Comparison of two taxonomies of SME financing patterns

The results in the previous sections have shown that the distribution of SMEs across clusters differs significantly. In this section, we compare our cluster results, which are based on the SAFE survey 2015H1, with the cluster analysis of Moritz et al. (2016), based on the SAFE survey 2013H1, to examine the stability of the clusters over time.

Comparing the financing instruments used, both cluster analyses (SAFE survey 2013H1 and 2015H1) show similar financing patterns, in particular with regard to the trade-financed, internally-financed and state-subsidized clusters. The latter is characterized in both cluster analyses by a very high utilization of government subsidies and grants. However, bank loans and short-term bank debt, trade credit, leasing, hire-purchase and factoring are used as complements to grants or subsidized bank loans. Both cluster analyses identified a cluster of SMEs which had not used any external financing over the past six months. This internally-financed cluster is the largest group of SMEs in both cluster analyses. In addition, the trade-financed cluster in both studies is characterized by the utilization of trade credit, other short-term debt and leasing, hire-purchase and factoring. The main differences between the two cluster results are that the current cluster analysis (2015H1) contains two mixed-financed clusters, which are similar to the one mixed-financed cluster identified in the SAFE survey

[9] Greece is the sole country in the cluster comparison with an Economic Freedom Index that is less than 60. Due to the banking sector difficulties after the financial crisis, Greek firms appear to use alternative financing sources instead of bank loans and are consequently more likely to be in the trade-financed cluster (Casey and O'Toole 2014; Love et al. 2007)

2013H1, but with two different main instruments: SMEs in the one cluster rely more on retained earnings and sale of assets, whereas SMEs in the other use more loans from families, friends and business associates. In addition, we find a combined debt-financed cluster (2015H1), which includes elements of the debt-financed and flexible-debt financed cluster identified in the data of 2013. Finally, we found a new cluster in the 2015 data, in which all SMEs used leasing, hire-purchase or factoring as an external source of financing (asset-based financed cluster).

Even though the clusters changed in part, we find strong similarities regarding firm-, product-, industry- and country-specific characteristics in both cluster analyses. Both studies reveal that smaller firms are more likely to use internal financing or short-term debt (Moritz et al. 2016). Younger firms, however, more often tend to be in the mixed-financed or state-subsidized cluster. Interestingly, very young firms (< 2 years) are less likely to be in the internally-financed cluster in 2015H1 (32.3%) than they are in 2013H1 (41.8%), but there is a comparatively high proportion of young SMEs in the mixed-financed cluster with a focus on other loans in 2015H1 (17.2%). Since external financing is often not available due to high information asymmetries, and internal financing is often not sufficient, young SMEs have been found to rely on informal financing sources (e.g., loans from family and friends) (Berger and Udell 1998; Chittenden et al. 1996). However, the results are limited by the very small sample of young firms in the SAFE survey 2015H1, since only 1.5% of all SMEs belong to this age classification. This small subsample might lead to significant inconsistent results over time. Both cluster analyses reveal that single-owner companies are more likely to be in the internally-financed cluster, whereas family firms or SMEs with owner teams more often appear to be in the debt-financed cluster. Owner-managed companies are more likely to avoid a dilution of control, which might explain the high proportion of these firms in the internally-financed cluster. Even though family firms and entrepreneurial teams are also likely to avoid too much influence through external parties, they seem to be more open to a larger variety of external financing instruments but focus on low influential financing sources, in particular short-term bank debt (Bathala et al. 2004; Chittenden et al. 1996; López-Gracia and Sogorb-Mira 2008; Mac an Bhaird and Lucey 2010). Innovative SMEs are more likely to use short-term debt, state-subsidized forms of financing or a large number of financing instruments, whereas equity financing also seems to be a relevant financing instrument (2013H1 and 2015H1). As innovative SMEs are associated with a higher asset intangibility, higher risk due to fewer diversification possibilities, and higher information asymmetries, firms are more likely to be restricted to short-term debt or have to rely on alternative financing sources.

Venture capital is also an important source of financing for innovative, high-growth SMEs (Achleitner et al. 2011; Cosh et al. 2009; Gompers and Lerner 2004). The high percentage of innovative SMEs in the state-subsidized cluster might be explained by the different government support programs initiated to support these types of companies in particular. Looking at the industry sectors, both cluster analyses reveal that SMEs in the service sector rely strongly on internal financing. This result might be explained by their typically low degree of tangible assets and consequently, less necessity for external financing. In addition, these firms also have less access to bank loans due to very limited availability of collateral. Therefore, financing from turnover or bootstrapping techniques are important financing sources for these companies (Chavis et al. 2011; Klapper et al. 2002; Moritz et al. 2016; Winborg and Landström 2001). According to the two cluster analyses, SMEs in the trade sector seem to prefer trade financing and short-term debt. This result is in line with prior research, which found that SMEs in the trade sector need large amounts of working capital, which makes short-term debt and trade financing appropriate financing instruments (Hutchinson 1995; Klapper et al. 2002; Michaelas et al. 1999).

To sum up, both cluster analyses (2013H1 and 2015H1) show very similar cluster results and are surprisingly stable over time. Although our study (2015H1) reveals a seven-cluster solution in contrast to the six-cluster solution of the previous work (Moritz et al. 2016), SMEs in both cluster analyses use similar financing instruments as substitutes or complements, in particular in the trade-financed, internally-financed and state-subsidized clusters (2013H1, 2015H1). Moreover, SMEs in these clusters show very similar characteristics. However, some of the clusters identified in the two studies differ from each other. The debt-financed cluster (2015H1), for instance, seems to be a combination of the debt- and flexible-debt financed cluster found in 2013. Furthermore, we found a distinction between two mixed-financed clusters and identified a completely new asset-based financed SME cluster. However, looking at the characteristics of the SMEs in the different clusters, we find very strong similarities between both cluster analyses.

2.5. Discussion

2.5.1. Summary of main findings and contributions

We developed an empirical taxonomy of European SME financing patterns using the SAFE survey 2015H1 and identified seven financing types: mixed-financed SMEs with a focus on other loans, mixed-financed SMEs with a focus on retained earnings or sale of

assets, state-subsidized SMEs, debt-financed SMEs, trade-financed SMEs, asset-based financed SMEs, and internally-financed SMEs. The seven clusters differ according to firm-, product-, industry- and country-specific characteristics (including macroeconomic variables). Table 2-7 summarizes the main results of the cluster analysis.

Table 2-7: Cluster summary.

Cluster	Financing in cluster	Characteristics				
		Firm-specific	**Product-specific**	**Industry-specific**	**Country-specific**	**Macroeconomic variables**
Mixed-financed SMEs (with focus on other loans)	SMEs that used a large variety of instruments with a focus on other loans (94%)	More often younger micro and medium-sized firms with larger turnover; esp. single-owner firms, public shareholder, VC-financed firms or other firms/business associate as owner; more often negative past growth but high growth expectations	More innovation	More likely for service and trade sector	Esp. in Northern and Eastern European countries; more often in market-based or former socialist countries	More often low inflation rate but high volatility and high annual GDP growth rate in the past 5 years; more likely high tax rate and high economic freedom score
Mixed-financed SMEs (with focus on retained earnings or sale of assets)	SMEs that used a large variety of instruments with a focus on retained earnings or sale of assets (93%); only cluster with a noteworthy amount of equity financing (10%)	More often older, small and medium-sized firms with ownership by VCs and BAs relatively high represented; moderate to high past growth and high future growth expectations	More innovation	Most likely for industry sector	Esp. in Northern European/ Western and bank-/market-based countries; non-distressed countries	More often very high GDP per capita and annual GDP growth rate in the past 5 years; more likely medium unemployment rate, low tax rates and very high protection of property rights and high economic freedom score
State-subsidized SMEs	100% of SMEs used grants or subsidized bank loans; large use of other bank loans	More often very young and small or medium-sized firms; esp. family firms/entrepreneurial teams and public shareholders; with moderate and high employee growth in the past; high growth expectations	More innovation	Most likely for industry sector	Esp. in Southern, bank-based and distressed countries	More often low annual GDP growth rate in the past 5 years; more likely medium to high unemployment rate, medium economic freedom and low property rights index
Debt-financed SMEs	86% of SMEs used credit line/ bank overdraft/ credit card overdrafts and 36% bank loans; some used leasing/factoring	More mature micro and small firms; esp. family firms/entrepreneurial teams or single-owner firms; no growth in the past and relatively low growth expectations	Average innovation	More likely for construction and trade sector	Esp. in Western European, bank-based and distressed EU countries	More often low inflation volatility and annual GDP growth rate in the past 5 years; more likely high tax rate and high protection of property rights
Trade-financed SMEs	96% of group used trade credit and 46% credit line/bank overdraft/credit card; some used leasing/factoring, bank loans; only cluster with considerable use of debt securities	More often younger (2–5 years) and small/medium-sized firms; esp. family firms/entrepreneurial teams or other firms/business associates; high employment and turnover growth in the past; no high growth expectations	Average innovation	Most likely for trade sector	Esp. in Northern and Southern European countries; more often in market-based and distressed EU countries	More often deflation, but relatively high inflation volatility and high unemployment rate; more likely low tax rate, low protection of property rights and very low economic freedom index

Table 2-7: Cluster summary (continued).

Cluster	Financing in cluster	Characteristics				
		Firm-specific	**Product-specific**	**Industry-specific**	**Country-specific**	**Macroeconomic variables**
Asset-based financed SMEs	100% of group used leasing/factoring and 37% credit line/bank overdraft/credit card overdrafts	More mature small and medium-sized firms; more often other firms or business associates with moderate to high employee and turnover growth in the past and moderate growth expectation	Low innovation	Most likely for service sector	Esp. in Western European, non-distressed countries	More often low inflation volatility and moderate annual GDP growth rate in the past 5 years; more likely high unemployment rate and very high protection of property rights
Internally-financed SMEs	100% of group did not use any external debt	More often young micro firms; esp. single-owner firms with no growth in the past high and no growth expectations	Low innovation	Most likely for service sector	Esp. in Eastern European, former socialist countries	More often high inflation rate and volatility: low annual GDP growth rate in the past 5 years and very low GDP per capita; more likely high unemployment rate and very low protection of property rights

Our study has several implications for both theory and practice. According to the theoretical contribution, our research extends the SME finance literature in particular in three ways. First, we contribute to the literature with regard to substitutive and complementary use of different financing instruments for SMEs. While previous research focused mainly on a single financing source or a small number of financing instruments (few exceptions are Beck et al. 2008; Berger and Udell 1998; Casey and O'Toole 2014; Lawless et al. 2015; Moritz et al. 2016; Robb 2002), for instance bank loans, trade credit, or venture capital, we considered a large variety of different financing instruments (Andrieu et al. 2018; Cosh et al. 2009; Hutchinson 1995) by creating an empirical taxonomy of SME financing patterns. Second, we examine whether the empirical taxonomy of SME financing patterns found by Moritz et al. (2016) remains stable over time. The authors identified six distinct SME financing types, namely: mixed-financed SMEs, state-subsidized SMEs, debt-financed SMEs, flexible-debt-financed SMEs, trade-financed SMEs and internally-financed SMEs. Our study shows similar financing patterns which strongly indicates that specific financing instruments are often used as complements or substitutes. Third, we extend the study of Moritz et al. (2016) by adding macroeconomic variables to the dataset. Not only firm-, product-, and industry-specific variables affect the financing patterns of SMEs (e.g., Beck et al. 2008; Cosh et al. 2009; Michaelas et al.1999), but also country-specific characteristics, which we analyzed in greater depth by investigating their macroeconomic differences (e.g., Beck and Demirgüç-Kunt 2006; Chavis et al. 2011; Hernández-Cánovas and Koëter-Kant 2011).

The results of our research can help policy makers to develop and adapt government support programs. Our results reveal that several homogeneous SME financing patterns exist in Europe. They can be characterized by different firm-, product-, industry- and country-specific characteristics, and use financing instruments in different combinations as substitutes or complements.

Policy makers can benefit from these findings in several ways. The results of the cluster analysis by Moritz et al. (2016) revealed that SMEs in the state-subsidized SME cluster complement grants or subsidized bank loans with a large variety of financing instruments, but in particular with bank loans. Our study supports this finding and reveals that state-subsidized SMEs have access to bank loans, even though their specific characteristics would imply a different result. We find that SMEs in this cluster are characterized by relatively high growth rates in the past, high future growth expectations and high innovation activities, which typically make access to bank debt rather difficult. Hence, our findings support the assumption of Moritz et al. (2016) that financing by government support programs for relatively risky innovative and fast growing SMEs appears to send a positive signal to external capital providers. In addition, we also find that state subsidies seem to be used more by small and medium-sized firms and less by micro firms. Micro firms, however, are more likely to be in the internally-financed or debt-financed cluster (with a high percentage of short-term debt financing instruments). This result is also in line with the results of Moritz et al. (2016). Hence, further analyses could investigate whether this result can be explained by the specific structure of these subsidies, which does not meet the requirements of micro firms, or if micro firms simply lack the awareness of government support programs. The answer to these questions can help to give policy makers valuable information on how to further improve their programs.

Finally, the cluster analysis identifies the impact of macroeconomic variables on the financing patterns of European SMEs. By comparing Cramer's V, we find that macroeconomic differences are more pronounced than firm level characteristics with regard to European financing patterns. Therefore, policy makers should consider macroeconomic factors, such as the country's inflation volatility, the property rights or the unemployment rate, and their impact on the firms' financing.

2.5.2. Limitations and future research

Our study is subject to some limitations. First, the study is limited to the sampling technique and questions asked in the SAFE survey. For instance, the SAFE survey does not

include solo self-employed entrepreneurs, and consequently a large number of start-up firms are excluded from the research. In addition, firms are asked about their application for and usage of different financing instruments, rather than about the relative importance of each instrument for the firm. Also, SMEs are asked whether they had used the specific financing instruments during the past six months. Although the short time period offers the possibility to control for macroeconomic changes and biases over the business life cycle of the firms, longer time periods could investigate SMEs' financing patterns more comprehensively. Furthermore, the inclusion of more firm-specific variables in the analysis, particularly balance sheet data, which has been used in prior research (Ferrando and Mulier 2015), would strengthen the results of our analysis. However, due to the anonymity of the SAFE survey, matching this information to the survey data is very problematic (Ferrando and Mulier 2015).

Second, our statistical approach leads to some further limitations. Although we have controlled for different cluster analysis algorithms and similarity measures, cluster analyses are relatively sensitive to the number of variables included and variations in the dataset (Hair et al. 2010). Furthermore, the comparison of the calculated cluster analysis in our study with the analysis of Moritz et al. (2016) can only be descriptive, as there are no statistical tests for the differences and similarities between the two cluster solutions.

The limitations described above provide a number of future research areas. First, to obtain a full picture of the stability of financing patterns over time, a panel dataset of SMEs is required. Even though the ECB has introduced a (small) panel component to the survey, a complete panel dataset for all waves is not available (European Central Bank 2018). However, future research could include the different waves of the SAFE survey in the cluster analysis and use the wave number as a passive cluster variable to examine the stability of the clusters over time. Second, the relationship between financially constrained SMEs and the use of alternative financing instruments, including switching between instruments over time, would be an interesting research area. Hence, including separate categories in the research for new financing instruments, such as crowdfunding, could shed more light on the trends in SME financing. Third, future research could investigate the differences in financing of micro, small and medium-sized companies. In particular, research into the financing of micro firms and how this differs to that of larger SMEs is still scarce. As with our results, Moritz et al. (2016) also found that micro firms appear to use internal financing instruments and short-term debt more often. Lawless et al. (2015) have shown that size (measured by the number of employees) is positively related to the use of financing instruments. They found that the smaller the firms, the less likely they are to use different financing instruments. However, it

remains unclear whether the financing patterns of micro firms differ from other small or medium-sized companies, which would be an interesting research question for future studies.

3 Financing micro firms in Europe

The vast majority of firms in Europe are micro firms. Still, we know little about their financing patterns. Our paper aims to close this gap. Based on a large European firm-level dataset, we find that micro firms differ in their financing patterns from small and medium-sized companies. Our empirical results show that micro firms are more likely to use internal financing instruments, whereas they are less likely to use state subsidies, trade credit or asset-based financing instruments. Furthermore, micro firms differ from medium-sized firms by using more short-term debt (credit card overdrafts, credit lines and bank overdrafts). The implications of these findings for micro firms and policy makers are discussed.[10]

[10] This study has been published as: Masiak, C., Block, J. H., Moritz, A., Lang, F., and Kraemer-Eis, H. (2019). How do Micro Firms Differ in their Financing Patterns from Larger SMEs?. *Venture Capital*, 21(4): 301–325.

3.1. Introduction

Micro firms are an important part of the European economy (European Commission, 2016). They make up the largest share (around 93%) of non-financial companies in Europe and are important for economic development and growth; they employ around 30% of the workforce (Kraemer-Eis et al. 2016). To be able to survive and grow, these firms need access to capital (Beck and Demirgüç-Kunt 2006; Carpenter and Petersen 2002a; Lee et al. 2015). Therefore, it is important to understand the financing instruments used and required by these firms. Although prior research has investigated the financing patterns of small, medium-sized and large firms (Masiak et al. 2017; Moritz et al. 2016), little is known about the financing patterns of micro firms. This is an important oversight, as micro firms differ from other firms in a number of ways, particularly in their ownership structure, resource availability and cost structure. These characteristics directly influence the costs for obtaining external capital and, hence, the financing structure of these companies (Baas and Schrooten 2006; Binks et al. 1992; Freeman et al. 1983; Rao et al. 2008). In other words, prior research has mainly focused on either single financing instruments (e.g., Lawless et al. 2015) instead of analysing the complementary and substitutive effects of different financing instruments, for instance using trade credit complementary to bank overdrafts, or the financing patterns are rather descriptive (Masiak et al. 2017; Moritz et al. 2016) and do not include multivariate analyses.

We tap into this research gap by investigating the financing patterns of micro firms in Europe to improve our understanding about how they differ from small and medium-sized companies. To this end, we use an EU-wide dataset created from the "Survey on the access to finance of enterprises" (SAFE survey), which is conducted on behalf of the European Commission and the European Central Bank. The survey contains detailed information about a large set of financing instruments as well as firm, product, industry and country information about the 12,144 companies included.

Our results provide evidence for some of our main predictions. Micro firms are less likely to use state subsidies, trade credit or asset-based financing instruments, whereas they are more likely to use internal financing instruments. Also, micro firms differ from other medium-sized firms by relying more on short-term bank debt (credit card overdrafts, credit lines and bank overdrafts).

The contributions of our study are threefold. First, we contribute to the SME financing literature (Casey and O'Toole 2014; Lawless et al. 2015; Moritz et al. 2016), which, so far, has not analyzed the differences between micro firm financing patterns and those of larger

SMEs. Second, we contribute to the trade financing literature (McGuinness and Hogan 2016; Ogawa et al. 2013) by showing that micro firms use fewer trade financing instruments than larger SMEs. Third, we contribute to prior research on micro firms (Fleming and Goetz 2011). We find that the specific characteristics of micro firms have an influence on their financing structure and that they seem to rely more on internal rather than external financing instruments.

Improving our understanding of micro firms' financing patterns can help policy makers provide tailor-made support for these types of firms. Our results will enable better prediction and assessment of the consequences of policy changes, particularly for the financing of micro firms. Our results indicate that, in addition to facing difficulties accessing external financing in general, micro firms also encounter challenges when it comes to receiving government grants or subsidized bank loans. Given micro firms' importance to the overall economy, these issues can be seen as signals of market weakness and highlight the need for further public support for these types of companies. Moreover, as their financing patterns differ from small- and medium-sized firms, support for micro firms should be designed in a way that meets their specific needs.

The article proceeds as follows: The next section provides a short description of micro firms and a summary of prior research on micro firm financing. Section 3.3 presents our conceptual framework and derives hypotheses. Section 3.4 introduces the dataset, empirical methods and variables used in the dataset. In Section 3.5, we show the results of the regression analyses, while Section 3.6 discusses our results and highlights their implications for theory and practice.

3.2. Prior literature on micro firm financing

3.2.1. Definition and characteristics of micro firms

Although there is no universally accepted definition of micro firms, the vast majority of definitions focus either on the number of employees and/or the turnover of the firm. The European Commission defines micro firms according to the number of employees, annual turnover or the balance sheet total. According to this definition, micro firms have less than 10 employees and have an annual turnover or a balance sheet total of no more than EUR 2m (European Commission 2003).

Micro firms differ from larger firms in various ways. First, micro firms typically operate as single owner-managed firms (Ang 1992; Marwa 2014). According to previous research, the interests of single-owners of micro firms, such as their growth ambitions, the risk level they are willing to take or their desire for independence, differ from larger companies (Berger and Udell 1998; Chittenden et al. 1996; Howorth 2001). Moreover, micro firms are opaque, as they usually do not publish annual statements, and contracts with stakeholders are not publically available (Abdulsaleh and Worthington 2013; Berger and Udell 1998). Hence, information asymmetries and moral hazard problems, which are always prevalent in borrower-lender relationships, are particularly pronounced when it comes to very small firms, and agency costs are typically much higher (Ang 1992; Bruhn-Leon et al. 2012; Daskalakis et al. 2013; Heshmati 2001; Kraemer-Eis et al. 2016). Micro firms therefore need to signal their quality to gain legitimacy and credibility (Berger and Udell 1998; Khaire 2010).

3.2.2. Financing of micro firms

Research on SME financing has increased substantially over the last years (e.g., Ang et al. 2010; Daskalakis and Psillaki 2008; Hall et al. 2004; López-Gracia and Sogorb-Mira 2008). It has been shown that access to finance can be a significant growth constraint for smaller companies (e.g., Ayyagari et al. 2008; Beck and Demirgüç-Kunt 2006; Wright et al. 2015). However, most studies do not explicitly distinguish between micro, small and medium-sized firms, or do not take into account the complementary and substitutive effects of different financing instruments (exceptions are for example Beck et al. 2008; Chavis et al. 2011; Moritz et al. 2016). Despite the economic importance of micro businesses, only a very small number of researchers have investigated the financing of micro firms: Daskalakis et al. (2013) used data from Greek small and micro firms and found that these companies rely more on their own funds instead of using equity from venture capitalists (VCs) or business angels (BAs). Furthermore, Greek firms of this type appear to face a funding gap, especially with respect to long-term bank debt (Daskalakis et al. 2013). In line with these results, Lawless et al. (2015) found that European micro firms rely more heavily on internal financing rather than external financing instruments (e.g., debt, government grants or equity finance) in comparison to small or medium-sized firms. By using cluster analysis, Moritz et al. (2016) investigated the financing patterns of a large sample of European SMEs and confirmed these results. They found that micro firms are more likely to be internally-financed and less likely to be debt-financed or state-subsidized. In addition, Chavis et al. (2011) found that this trend can be seen

worldwide: being a micro firm is positively related to the use of informal finance and negatively related to the use of credit lines, bank finance, leasing and trade credit.

In addition, it has been found that European micro firms are more often rejected in the loan application process (Holton et al. 2014; Kraemer-Eis et al. 2018). These findings become even stronger during a financial crisis (Casey and O'Toole 2014). However, micro firms are still less likely to apply for alternative financing (e.g., trade credit) in comparison to small and medium-sized companies (Casey and O'Toole 2014).

Prior research has also connected microfinance and microcredits with micro firm financing (Chan and Lin 2013; Sonnekalb 2014). According to the definition of the European Commission, microcredits include amounts less than EUR 25,000 and are tailored to micro firms or self-employed people (Kraemer-Eis et al. 2018). Even though this form of financing started in developing countries (Khandelwal 2007), today, microcredits are used to support small businesses in both developing and developed countries in order to reduce access to finance constraints (e.g., Chan and Lin 2013; Forcella and Hudon 2016; Sonnekalb 2014).

3.3. Theory and hypotheses

3.3.1. Financing patterns of SMEs

To date, only a few studies have considered the substitutive and complementary use of different financing instruments (Chavis et al. 2011; Lawless et al. 2015; Masiak et al. 2017; Moritz et al. 2016). They found that smaller firms use a small number of different financing instruments (Chavis et al. 2011; Lawless et al. 2015), whereas larger firms have more diversified financing structures (Lawless et al. 2015; Moritz et al. 2016). Moritz et al. (2016) investigated the complementary and substitutive use of different financing instruments by developing an empirical taxonomy of SME financing patterns. They found that, although financing in Europe is heterogeneous, several homogeneous financing patterns exist (Moritz et al. 2016). These financing patterns are used as a basis in the following hypotheses.

3.3.2. Hypotheses

3.3.2.1. Debt financing pattern

The debt financing pattern comprises both short- and long-term debt such as credit lines, bank overdrafts, credit card overdrafts and bank loans (excluding subsidized bank loans). To be able to provide these types of debt and reduce default risks, banks need either to

use cost intensive monitoring tools (Baas and Schrooten 2006; Binks et al. 1992) or to demand collateral (Degryse et al. 2012; Hall et al. 2000; Michaelas et al., 1999). For debt providers, especially banks, intensive monitoring is typically not feasible or cost efficient. Hence, they typically prefer collateral provided by the firm (Manove et al. 2001; Ono and Uesugi 2009). However, smaller companies usually do not possess the assets required to use as collateral. As a result, banks are reluctant to provide debt to smaller companies due to higher monitoring and risk management costs. Moreover, debt providers can typically achieve economies of scale as the debt amount increases (Anderson and Khambata 1985; Saito and Villanueva 1981). Micro firms, however, often require micro loans which are – from a cost argument – less attractive for banks (Van der Graaf et al. 2016).

In addition, not only debt providers (supply-side) but also micro firms (demand-side) face higher costs when applying for debt-financing instruments. Micro firms particularly lack the resources to implement the same level of specialization as larger companies which means that financing is often just one task among many for employees or the company's owner. Hence, they need to use their limited resources to reconcile the search and application for debt financing with a range of other tasks. Consequently, the knowledge about and the incentives to use debt financing are lower for smaller firms due to higher costs. In summary, we argue that higher costs arise for both debt providers and micro firms to obtain debt-financing instruments (European Central Bank 2016; Lawless et al. 2015). Thus, we propose the following:

Hypothesis 1. *Micro firms are less likely than small and medium-sized firms to have a debt financing pattern.*

3.3.2.2. Trade financing pattern

The trade financing refers to the postponement of payments of the firm's suppliers to a later agreed date (trade credit). This short-term financing instrument has been found to be frequently used by SMEs (Huyghebaert et al. 2007). Suppliers often grant payment extensions while being less likely to engage in extensive monitoring and controlling efforts compared to banks (Wilson and Summers, 2002). The preference of smaller firms to use trade-financing instruments is also in line with the pecking-order theory: owner-managed firms appear to prefer internal over external financing, and debt over equity (López-Gracia and Sogorb-Mira 2008). In particular, short-term debt is preferred after internal financing is depleted (Holmes and Kent, 1991; Hutchinson 1995).

However, previous research has shown that suppliers can be reluctant to provide trade credit to very young and small firms due to high information asymmetries and default risks associated with smaller firms (Andrieu et al. 2018). Furthermore, even though trade credit is a flexible form of short-term debt, cost sensitive smaller firms might be reluctant to use it (at least as long as there is an alternative), as this form of financing is often rather expensive (Marotta 2005; Robb 2002; Taketa and Udell 2007). Altogether, we propose the following:

Hypothesis 2. *Micro firms are less likely than small and medium-sized firms to have a trade financing pattern.*

3.3.2.3. State-subsidized pattern

The state-subsidized financing pattern comprises grants and subsidized bank loans supported from public sources, such as guarantees or reduced interest rate loans. Prior research found that smaller firms have a lack of awareness of public funding programs (Aldrich and Auster 1986; Daskalakis et al. 2013; Öztürk and Mrkaic 2014). Furthermore, the application process is often very complex and time consuming. This overburdens the limited resources of smaller firms and, hence, they are less likely to apply for subsidized bank loans and grants (Daskalakis et al. 2013). Therefore, we propose the following:

Hypothesis 3. *Micro firms are less likely than small and medium-sized firms to have a state-subsidized pattern.*

3.3.2.4. Asset-based financing pattern

The asset-based financing pattern includes both leasing and factoring as external financing instruments. These two financing instruments have been found to be attractive financing sources for SMEs (Beck 2013; Deloof et al. 2007). However, leasing as an asset-based financing instrument is often used for specific asset-types, such as machinery, vehicles and industrial equipment, which are predominantly used by larger firms (Oxford Economics 2015). Risks for the lessor are priced into the leasing fees. Fees for smaller firms are typically higher due to higher information asymmetries and transaction costs and can thus make leasing unattractive (Eisfeldt and Rampini 2009).

Factoring, especially without recourse, has also been found to be an interesting financing alternative for SMEs, as firms can sell their outstanding invoices to a factor at a discount (Klapper 2006; Summers and Wilson 2000). Hence, factoring is not a form of lending and does not rely on the creditworthiness of the invoice seller. Instead, it is an asset-

based type of financing that relies on the debtor's creditworthiness. However, the discount charged by the invoice buyer negatively influences the return on sales, which can make factoring unattractive, particularly for smaller firms (Beck 2013; Berger and Udell 2006; Klapper 2006).

Hence, we propose that very small firms use less asset-based financing instruments (leasing and factoring) due to higher costs (Lawless et al. 2015; Oxford Economics 2015):

Hypothesis 4. *Micro firms are less likely than small and medium-sized firms to have an asset-based financing pattern.*

3.3.2.5. Internal financing pattern

The internal financing pattern refers to funds generated by the operations of the company, such as bootstrapping or profits of the firm. Overall, and in line with our previous argumentation, we expect that micro firms are altogether less likely to obtain external financing and hence are more likely to rely on internal financing instruments instead. We propose:

Hypothesis 5. *Micro firms are more likely than small and medium-sized firms to have an internal financing pattern.*

3.4. Data, methods and variables

3.4.1. Data

For our empirical analyses, we use survey data from the "Survey on the access to finance of enterprises (SAFE survey)", which has been conducted since 2009 on behalf of the European Central Bank (ECB) and the European Commission (EC). The SAFE survey is run on a semi-annual basis only by the ECB and it is carried out every two years and, since 2013, every year on a larger scale in cooperation with the EC (European Commission 2015; European Central Bank 2018). The two waves differ both by the number of questions in the survey and the number of participating countries. We use data from the EC/ECB wave conducted between April and September 2015 including a large number of European

countries and, compared to the ECB wave, a larger set of additional information (e.g., access to finance problems, firm data)[11].

The aim of the SAFE survey is to provide data on the financing conditions faced by SMEs in Europe on a regular basis. Besides questions about the firms' financing situation, the SAFE survey gathers firm-specific information such as firm size (turnover, number of employees), firm age, ownership structure, main activity (industry, trade, construction, service), growth, innovation activity and evaluation of access to finance. In line with the EU's employee threshold definition of SMEs, the SAFE survey differentiates between micro (1–9 employees), small (10–49 employees), medium-sized (50–249 employees) and large firms (≥ 250 employees). We follow this definition in our study, which was also applied by Lawless et al. (2015) and Moritz et al. (2016). In total, our sample consists of 12,144 SMEs in 27 European countries.[12]

3.4.2. Method

3.4.2.1. Cluster analysis

To construct our dependent variable, we perform a hierarchical cluster analysis to identify SME financing patterns using the SAFE survey (wave 2015HY1). Participants of the SAFE survey were asked whether they used specific financing instruments during the past six months. In total, eleven different financing instruments are included as active cluster variables in the cluster analysis[13].

We test several hierarchical cluster analysis algorithms, such as single linkage, average linkage, complete linkage, k-means and Ward's method. In line with Masiak et al. (2017) and Moritz et al. (2016), we use Ward's method and squared Euclidean distance as a measure of proximity to perform the cluster analysis, as they provide relatively homogeneous results with

[11] We included data from the EC/ECB wave from 2015 in order to check the consistency of the clusters found by Moritz et al. (2016). If we consider a newer dataset, we will face the problem of additional variations, such as macroeconomic effects, newer financing instruments or changes in the SAFE survey itself.

[12] Malta was excluded due to a large number of missing data in the survey. All other European Union countries are covered by the data set.

[13] The following financing instruments are included in the cluster analysis: (a) retained earnings or sale of assets, (b) grants or subsidised bank loans, (c) credit lines, bank overdrafts or credit card overdrafts, (d) bank loans (both short and long-term), (e) trade credit, (f) other loans (for example from family and friends, a related enterprise or shareholders), (g) leasing, hire purchase or factoring (h) debt-securities issued, (i) equity (quoted shares, unquoted shares or other forms of equity provided by the owners or external investors such as venture capital companies or business angels), (j) other sources of financing (subordinated debt instruments, participating loans, crowdfunding). In addition, we included a variable that indicated whether a company did not use any external financing in the past six months.

a low intra-cluster heterogeneity (Masiak et al. 2017; Moritz et al. 2016). Furthermore, we use the Test of Mojena and Elbow Criterion as validation tests for the number of clusters.

3.4.2.2. Regression analyses

Based on these results, we perform regression analyses using the financing patterns as dependent variables; the aim is to analyse the differences between micro and small or medium-sized firms. However, the error terms of the different equations could be correlated with each other. We address this concern by using a multivariate probit model which is similar to the approach of Zellner's method of a joint seemingly unrelated regression (Cappellari and Jenkins 2003; Zellner 1962). Since our dependent variables are dichotomously coded, we run a multivariate probit model that allows for binary dependent variables and involves a simultaneous estimation of equations for the firm's decision to use specific financing patterns. The reference group for the analysis are medium-sized firms. To check for differences between micro and small firms, we calculate a p-value test to determine whether the coefficient of micro firms equals the coefficient of small firms.

Based on separate individual logistic regression analyses for each financing pattern, we estimate a seemingly unrelated estimation, which is used to further check the robustness of our results. As an additional robustness check, we perform a multinomial logistic regression with the internally-financed cluster as the base category.

3.4.3. Variables

3.4.3.1. Dependent variables

We use five financing patterns, focusing on debt-financing, trade-financing, state-subsidized, asset-based financing and internal financing instruments as dependent variables. All dependent variables are binary coded (1 = firm belongs to the financing pattern; 0 = otherwise).

3.4.3.2. Independent and control variables

To test our hypotheses, our main independent variable is firm size, which we measure according to the number of employees. Following the definition recommended by the EU (Kraemer-Eis et al. 2018), we distinguish between micro (1–9 employees), small (10–49 employees) and medium-sized firms (50–249 employees).

Further control variables are included in our analysis based on the findings of prior research on financing patterns (e.g., Lawless et al. 2015; Masiak et al. 2017; Moritz et al. 2016). We include several dummies describing the main owner in the firm, as previous studies have found that the ownership structure significantly affects business financing (e.g., Chittenden et al. 1996; Ferrando and Griesshaber 2011). We include: *family or entrepreneurs*, *one owner only*, *public shareholders*, *other enterprises or business associates*, and *venture capital enterprises or business angels*. Furthermore, we include a variable for firm age (*age < 2*, *age 2–4*, *age 5–9*, *age > 9*), since previous research has shown that firm age affects the capital structure of companies (e.g., Chavis et al. 2011; Chittenden et al. 1996). Whereas younger firms rely more on informal financing, older firms appear to use more formal financing such as bank loans (Chavis et al. 2011).

In addition, the dummy variables *past turnover growth* (over 20% per year, less than 20% per year, no growth, got smaller) and *growth expectations* (grow substantially, grow moderately, stay the same, become smaller) are included in the analysis. It has been shown that smaller firms with high growth rates typically require more external financing in order to finance their growth objectives (Cassar 2004). The dummy variable *innovativeness* refers to a value of "1", indicating that the firm introduced a new or significantly improved product or service to the market, and a value of "0", indicating otherwise. Innovative small firms often face problems obtaining external financing, since the development of new products and services is often cost intensive and their success is highly uncertain. A lack of diversification options increases small firms' dependency on their innovation success and consequently increases their default probability, which makes them very risky for capital providers (Block 2012).

Prior research has also investigated the impact of the industry on the firm's capital structure (e.g., Bradley et al. 1984; Coleman and Robb 2012; Degryse et al. 2012). It has been found that firms in the service sector typically require less external financing than firms in other sectors, since capital requirements are often lower (Harrison et al. 2004). Firms in the industry sector typically have a large share of long-term assets (i.e., machines) and therefore require long-term financing instruments (Hall et al. 2000; Michaelas et al. 1999). To examine the effect of industry sectors, we use the four categories applied in the SAFE survey: *industry*, *construction*, *trade* and *services* (European Central Bank 2018).

In addition, the variable *access to finance problems* measures whether access to finance was indicated as an important problem for companies in the past six months on a scale from 1

to 10 (categorized as low = 1–3, medium = 4–6 and high importance = 7–10). Furthermore, we include dummy variables for the *capital positon* and *changes in turnover* (Lawless et al. 2015). We include country dummy variables in our dataset to control for country differences. Previous research highlighted the importance of institutional characteristics, particularly the system of law and the protection of property rights, on the capital structure of firms (Beck et al. 2008; Fan et al. 2012; Masiak et al. 2017). A detailed overview of all variables is provided in Table 3-1.

Table 3-1: Variable description.

Variable	Description
Dependent variables	
Financing patterns	Dichotomous variables (1 = firm uses the specific financing instruments; 0=otherwise)
Independent variables	
Micro firms	Dichotomous variable (1 = firm is a micro firm; 0 = otherwise)
Small firms	Dichotomous variable (1 = firm is a small firm; 0 = otherwise)
Medium-sized firms	Dichotomous variable (1 = firm is a medium-sized firm; 0 = otherwise)
Control variables	
Age < 2	Dichotomous variable (1 = firm is younger than 2 years; 0 = otherwise)
Age 2–4	Dichotomous variable (1 = firm is 2–4 years old; 0 = otherwise)
Age 5–9	Dichotomous variable (1 = firm is 5–9 years old; 0 = otherwise)
Age > 9	Dichotomous variable (1 = firm is older than 9 years; 0 = otherwise)
Family or entrepreneurs	Dichotomous variable (1 = family or entrepreneur owns the largest stake in the firm; 0 = otherwise)
One owner	Dichotomous variable (1 = one owner owns the largest stake in the firm; 0 = otherwise)
Public shareholder	Dichotomous variable (1 = public shareholder owns the largest stake in the firm; 0 = otherwise)
Other enterprises or business associates	Dichotomous variable (1 = other enterprises or business associates own the largest stake in the firm; 0 = otherwise)
VC/BA	Dichotomous variable (1 = venture capitalist or business angel owns the largest stake in the firm; 0 = otherwise)
Other	Dichotomous variable (1 = other owns the largest stake in the firm; 0 = otherwise)
Innovativeness	Dichotomous variable (1 = firm has introduced a new or significantly improved product or service to the market during the past 12 months; 0 = otherwise)
Profit unchanged	Dichotomous variable (1 = profit over previous 6 months remains unchanged; 0 = otherwise)
Profit increased	Dichotomous variable (1 = profit over previous 6 months increased; 0 = otherwise)
Profit decreased	Dichotomous variable (1 = profit over previous 6 months remains decreased; 0 = otherwise)
Capital position unchanged	Dichotomous variable (1 = capital over previous 6 months remains unchanged; 0 = otherwise)
Capital position increased	Dichotomous variable (1 = capital over previous 6 months increased; 0 = otherwise)
Capital position decreased	Dichotomous variable (1 = capital over previous 6 months remains decreased; 0 = otherwise)
Turnover expectation > 20%	Dichotomous variable (1 = expected turnover of the firm over the next two to three years will grow > 20%; 0=otherwise)
Turnover expectation < 20%	Dichotomous variable (1 = expected turnover of the firm over the next two to three years will grow < 20%; 0=otherwise)
Turnover expectation unchanged	Dichotomous variable (1 = expected turnover of the firm over the next two to three years will stay the same size; 0 = otherwise)
Turnover expectation become smaller	Dichotomous variable (1 = expected turnover of the firm over the next two to three years will become smaller; 0 = otherwise)
Access to finance problems	Dichotomous variable for each category: low (1–3), medium (4–6), and high importance (7–10) (access to finance has been an important problem in the past six months on a scale of 1–10, where 1 means it is not at all important)
Industry dummies	Dichotomous variable for the relevant industry (industry, trade, construction, service)

3.5. Results

3.5.1. Cluster analysis

The results of the cluster analysis are presented in Table 3-2. We found seven distinct financing patterns: *mixed-financed SMEs with a focus on other loans*, *mixed-financed SMEs with a focus on retained earnings or sale of assets*, *state-subsidized SMEs*, *debt-financed SMEs*, *trade-financed SMEs*, *asset-based financed SMEs*, and *internally-financed SMEs*[14].

Table 3-2: Cluster results.

	Clusters							
Financing instruments	**Mixed-financed (other loans)**	**Mixed-financed (retained earnings /sale of assets)**	**State-subsidized**	**Debt-financed**	**Trade-financed**	**Asset-based financed**	**Internally-financed**	**Pearson Chi²**
Retained earnings or sale of assets	20.6%	**100%**	17.4%	0.0%	4.6%	0.0%	0.0%	9354.2 ***
Grants or subsidized bank loans	1.3%	3.6%	**100%**	0.0%	1.5%	0.0%	0.0%	10949.5 ***
Credit line, bank overdraft or credit cards overdraft	48.6%	46.8%	57.5%	**82.2%**	51.7%	40.9%	0.0%	4183.2 ***
Bank loans	24.3%	26.5%	43.9%	45.2%	24.8%	0.0%	0.0%	2398.9 ***
Trade credit	30.6%	33.8%	32.0%	0.0%	**85.4%**	0.0%	0.0%	6454.8 ***
Other loans	**100%**	1.7%	0.0%	0.0%	4.4%	0.0%	0.0%	10061.7 ***
Debt securities issued	0.6%	0.6%	0.2%	0.0%	8.3%	0.0%	0.0%	750.1 ***
Equity	0.8%	1.2%	0.3%	0.0%	10.7%	0.0%	0.0%	934.6 ***
Leasing, hire-purchase or factoring	30.9%	38.6%	39.2%	15.6%	35.1%	**100%**	0.0%	4739.4 ***
Other[(a)]	1.2%	0.5%	8.5%	0.0%	5.3%	0.0%	0.0%	415.6 ***
No external finance	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**100%**	12144.0 ***
N	972	1,531	956	2,062	1,886	1,174	3,563	
Percentage of firms	8.0%	12.6%	7.9%	17.0%	15.5%	9.7%	29.3%	

Notes: N = 12,144; Pearson's chi-square test: ***p < 0.01, **p < 0.05, *p < 0.1.
a) Other financing instruments = subordinated debt instruments, participating loans, crowdfunding

The first cluster (*mixed-financed firms with a focus on other loans*) includes firms that use a large number of different financing instruments. However, the focus is on other loans such as loans from family and friends or related companies and short-term debt. It is the second smallest cluster with only 972 firms. In the second cluster (*mixed-financed firms with a focus on retained earnings or sale of assets*), firms use a great variety of financing

[14] The results are in line with Masiak et al. (2017).

instruments, but mainly rely on retained earnings or sale of assets. The cluster contains 1,531 firms (12.6%). All firms in cluster 3 (*state-subsidized firms*) use government grants or subsidized bank loans. It is the smallest cluster with 956 firms (7.9%). Furthermore, institutional debt (e.g., bank loans) is an important external financing instrument in this group. Firms in the fourth cluster (*debt-financed firms*) focus on both short-term and long-term bank debt. It is the second largest cluster, including 2,062 firms (17.0%). Cluster 5 (*trade-financed firms*) contains firms that use primarily trade credit or other short-term debt (e.g., bank overdrafts, credit lines or credit card overdrafts). 1,886 firms (15.5%) are included in this cluster. All firms in cluster 6 (*asset-based financed firms*) use leasing, hire-purchase or factoring as an external source of financing. 1,174 firms belong to this cluster (9.7%). The majority of firms, however, do not use any external financing. As a result, the seventh cluster is labelled *internally-financed*; it is the largest cluster with 3,563 firms (29.3%).

3.5.2. Regression analysis

3.5.2.1. Main results

As our dependent variables we use the different financing patterns identified in Section 3.5.1 and perform regression analyses. The results of our main model, in which we perform a multivariate probit model, are shown in Table 3-3. We report the coefficients and the standard errors in brackets. In addition, we check whether the coefficients of micro and small firms are statistically equal. Our results are unlikely to suffer from multicollinearity due to the large sample size and the variation inflation factors.

Table 3-3: Multivariate probit regression model on financing patterns.

Dependent variables	Debt financing	Trade financing	State-subsidized financing	Asset-based financing	Internal financing
Independent variables					
Firm size variables, *reference group: medium-sized firms*					
Micro firms	0.088**	-0.200***	-0.475***	-0.258***	0.617***
	(0.039)	(0.040)	(0.050)	(0.043)	(0.035)
Small firms	0.047	-0.048	-0.130***	-0.020	0.271***
	(0.037)	(0.038)	(0.044)	(0.039)	(0.034)
p-value of test (coefficients size micro = size small)	p > 0.1	p < 0.01	p < 0.01	p < 0.01	p < 0.01
Control variables					
Age variables					
Age < 2	-0.219	0.226	0.037	0.107	-0.117
	(0.180)	(0.167)	(0.203)	(0.189)	(0.153)
Age 2–4	-0.276***	0.075	-0.217**	-0.010	0.166***
	(0.070)	(0.067)	(0.094)	(0.072)	(0.055)
Age 5–9	-0.044	0.107***	-0.085**	0.012	-0.014
	(0.032)	(0.035)	(0.043)	(0.035)	(0.028)
Age > 9 (reference group)					
Ownership variables					
VC/BA	0.266	0.530***	-0.038	-0.013	-0.384*
	(0.106)	(0.174)	(0.254)	(0.181)	(0.204)
Family or entrepreneur	0.221**	-0.058	0.239*	-0.195**	-0.104
	(0.103)	(0.091)	(0.130)	(0.093)	(0.082)
Other	0.125	-0.036	0.063	-0.187*	-0.065
	(0.107)	(0.096)	(0.135)	(0.097)	(0.085)
One owner	0.241**	-0.053	0.216*	-0.186**	-0.024
	(0.103)	(0.092)	(0.131)	(0.093)	(0.082)
Other enterprises or business associates	0.044	0.040	0.438***	-0.372***	0.062
	(0.128)	(0.115)	(0.151)	(0.122)	(0.102)
Public shareholder (reference group)					
Innovativeness	-0.041	0.055*	0.159***	-0.027	-0.129***
	(0.030)	(0.031)	(0.037)	(0.034)	(0.027)
Capital position					
Improved	-0.024	-0.041	0.045	0.029	-0.004
	(0.057)	(0.058)	(0.072)	(0.066)	(0.051)
Unchanged	0.052	-0.020	-0.025	0.033	0.156***
	(0.050)	(0.052)	(0.065)	(0.060)	(0.045)
Deteriorated (reference group)					

Table 3-3: Multivariate probit regression model on financing patterns (continued).

Dependent variables	Debt financing	Trade financing	State-subsidized financing	Asset-based financing	Internal financing
Profit					
Increased	0.005	0.037	-0.060	0.061	0.012
	(0.040)	(0.041)	(0.050)	(0.045)	(0.036)
Unchanged	-0.003	-0.017	-0.059	0.004	0.091***
	(0.037)	(0.039)	(0.047)	(0.042)	(0.033)
Decreased (reference group)					
Turnover expectation					
> 20%	0.033	-0.081	0.286***	0.116	-0.120*
	(0.705)	(0.072)	(0.092)	(0.083)	(0.062)
< 20%	0.0255	-0.047	0.177**	0.131*	-0.118**
	(0.058)	(0.059)	(0.078)	(0.070)	(0.050)
Same size	0.009	-0.046	0.006	0.103	0.009
	(0.060)	(0.062)	(0.082)	(0.072)	(0.052)
Become smaller (reference group)					
Access to finance problems					
Low (1–3)	-0.282***	-0.256***	-0.353***	0.017***	0.629***
	(0.034)	(0.036)	(0.043)	(0.038)	(0.031)
Medium (4–6)	-0.057	-0.038	-0.113**	0.034	0.185***
	(0.037)	(0.039)	(0.045)	(0.043)	(0.036)
High (7–10) (reference group)					
Industry dummies	Yes	Yes	Yes	Yes	Yes
Country dummies	Yes	Yes	Yes	Yes	Yes
	Rho1	Rho2	Rho3	Rho4	
Rho/2	-0.211***				
	(0.019)				
Rho/3	-0.170***	-0.165***			
	(0.023)	(0.024)			
Rho/4	-0.418***	-0.311***	-0.115***		
	(0.016)	(0.018)	(0.021)		
Rho/5	-0.195***	-0.158***	-0.105***	-0.272***	
	(0.021)	(0.021)	(0.024)	(0.020)	
Number of observations	12,144				
Log-likelihood	-21,709.10				
Wald χ^2 (255)	3,067.34				

Notes: N = 12,144. Multivariate probit model, SEs are in parentheses. ***p < 0.01. **p < 0.05. *p < 0.1.

We find that, against our expectation, the variable *micro firms* increases the probability of having a *debt financing* pattern. The regression analysis indicates that micro firms are more likely than medium-sized firms to have *debt financing* patterns (coef. = 0.088; $p < 0.05$). Hence, we do not find support for H1. However, we do find support for H2. The regression shows that *micro firms* decreases the probability of having a *trade financing* pattern (coef. = -0.200; $p < 0.01$). In addition, micro firms are less likely than small ($p < 0.01$) and medium-

sized firms (coef. = -0.475; p < 0.01) to have *state-subsidized* financing patterns. These findings support our hypothesis H3. Furthermore, we find that micro firms are less likely than small or medium-sized firms to have *asset-based financing* patterns. Both the regression analysis (coef. = -0.258; p < 0.01) and the p-value test (p < 0.01) support Hypothesis H4. The results also reveal that micro firms are more likely than small and medium-sized firms to have *internal financing* patterns (coef. = 0.617; p < 0.01), which supports Hypothesis H5.

3.5.2.2. Other results

Beside our main results, several control variables also show significant effects. Regarding the age of firms, we find that less mature firms (ages 2–4), are less likely to have *debt financing* patterns (coef. = -0.276; p < 0.01) and are more likely to have *internal financing* patterns (coef. = -0.166; p < 0.01). In addition, we find that firms with an age of 5–9 years are more likely to have *trade financing* patterns (coef. = 0.107; p < 0.01) and less likely to have state-subsidized financing patterns (coef. = -0.085; p < 0.05).

Regarding the ownership structure of firms, we find strong significant effects. Family firms or entrepreneurs are more likely to have *debt financing* patterns (coef. = 0.221; p<0.05). Single-owner firms tend to have *debt financing* patterns (coef. = 0.241; p < 0.05) and *state-subsidized financing* patterns (coef. = 0.216; p < 0.1) more frequently, but are less likely to have *asset-based financing* patterns (coef. = -0.186; p < 0.05). Moreover, we find that innovative firms are more likely to have *trade financing* patterns (coef. = 0.055; p<0.1) and *state-subsidized financing* patterns (coef. = 0.159; p < 0.01), but are less likely to show patterns of internal financing (coef. = -0.129; p < 0.01).

3.5.2.3. Robustness checks

As a robustness check, we calculate separate logistic regressions for each of the different financing patterns and run a seemingly unrelated estimation. The results are very similar to the findings of the multivariate probit model on financing patterns (see Appendix 3-A1). As a further robustness check, we calculate a multinomial logistic regression (see Table 3-A2). The *internal financing cluster* is the base category of the regression analysis. The results show that micro firms are more likely than small or medium-sized firms to have an *internal financing* pattern than in the remaining clusters (state-subsidized, debt-financed, trade-financed, or asset-based financed cluster). Furthermore, we run additional univariate and multivariate analyses with regard to specific financing instruments (see Table 3-A3 and Table

3-A4) in order to check, whether micro firms also use single financing less often than other small or medium-sized enterprises.

3.6. Discussion

3.6.1. Discussion of main findings

The aim of our study was to investigate the particularities of micro firm financing compared to larger SMEs. Even though prior research has shown that SMEs use different financing instruments as complements or substitutes to each other (e.g., Berger and Udell 1998; Chavis et al. 2011), and that firm size has an effect on firms' financing patterns (e.g., Hall et al. 2000; Moritz et al. 2016), no prior study has separated SMEs into groups according to firm size and then conducted a detailed analysis of each group's financing patterns. Due to the high economic importance of micro firms, this is, however, an important research question. In line with prior research (e.g., Lawless et al. 2015), we find that there is a statistically significant effect of firm size on firm financing but that this effect is independent of firm age. Additionally, our results reveal that the financing patterns of micro firms differ significantly from small and medium-sized firms. In other words, micro firms use different financing instruments as substitutes and complements to those used by larger SMEs. In principal, the result are in line with previous research on SME financing, which found that particularly small firms face difficulties to obtain external financing due to the liability of smallness, legitimacy problems as well as high transaction costs and information asymmetries (e.g., Artola and Genre 2011; Berger and Udell 1998; Block et al. 2018a).

Most of our expectations about the differences in SME financing are supported by our results. However, against our expectation, we find that micro firms are more likely than medium-sized firms to have a *debt financing* pattern. Prior research has found that banks are typically reluctant to lend money to small firms, since the risk of bankruptcy for these firms is particularly high, while the collateral is low (e.g., Berger and Udell 1998). However, it needs to be considered that the debt-financed cluster is characterized by a high proportion of short-term debt (credit lines, bank overdrafts or credit card overdrafts). Prior research has shown that flexible short term-debt is especially important for micro firms, since long-term debt has been found to be either less attractive due to high costs or less favourable other financing conditions or more difficult to obtain for these firms (Hall et al. 2000; Hutchinson 1995). According to our results, smaller firms with low access-to-finance problem are less likely to be debt-financed. Hence, it appears that micro firms that suffer from financing problems

particularly rely on financing instruments such as short-term debt (bank overdrafts, credit lines, credit card overdrafts) and bank loans. Nevertheless, bank loans in the SAFE survey are not differentiated according to their duration. Hence, we do not know if micro firms more often used short-term bank loans, which are typically easier to obtain. Furthermore, micro firms are more likely to have an *internal financing* pattern. This result can be explained with previous findings that smaller firms have difficulties to obtain external financing (Berger and Udell 1998). The results indicate that these firms do not expect high turnover growth and rather have stable profits and an unchanged capital position according to the results. Interestingly, these firms have a higher probability to have low or medium access-to-finance problems. The data suggests that some firms are internally financed and do not require external financing. Nevertheless, the results have to be interpreted with caution. First, the results can be biased by measurement and data collection. For instance, the self-assessment of perceived and actual access to finance problems might be distorted, since SMEs with a poor performance might blame problems on access to finance to justify the current performance. Second, the definition of access to finance problems may be unclear to the respondents of the SAFE survey. For instance, Ferrando and Mulier (2015) show considerable differences between actual and perceived finance problems.

Whereas prior attention has considered SMEs as a homogeneous group (e.g., Beck and Demirgüç-Kunt 2006), we particularly show that micro firms are a distinct group within the large group of "SME" with specific financing patterns. While a large number of new actors and financing instruments have emerged in recent years (Block et al. 2018a), many financing instruments have not been tailored to the specific requirements of micro firms or the costs of application for these financing instruments are simply too high for micro firms.

3.6.2. Implications for theory and practice

Our results provide three main theoretical contributions. First, we contribute to the literature on SME financing that investigates the complementary and substitutive use of different financing instruments (Casey and O'Toole 2014; Chavis et al. 2011; Lawless et al. 2015; Masiak et al. 2017; Moritz et al. 2016). We add to this literature by distinguishing between different firm sizes (micro, small and medium-sized firms) and show significant differences in micro firm financing patterns in comparison to larger SMEs. In other words, the use of financing instruments differs by SME size class, which implies that the three SME segments micro, small, and medium-sized need to be differentiated. Second, we contribute to the research investigating trade financing (McGuinness and Hogan 2016; Ogawa et al. 2013;

Tsuruta 2008). Whereas previous research has found that trade credit is an important financing source for informationally opaque firms (e.g., Berger and Udell 1998; Ogawa et al. 2013, Huyghebaert et al. 2007), our study reveals that trade-financing instruments appear to be particularly relevant for larger SMEs, but not for micro firms. Third, we contribute to the micro firm literature (e.g., McKenzie and Woodruff 2017). We find that micro firms use primarily internal financing instruments or short-term debt, such as credit lines, bank overdrafts or credit card overdrafts. Moreover, micro firms use state-subsidized bank loans or grants, trade credits and asset-based financing to a lesser extent than larger SMEs.

Our findings have practical implications, particularly for policy-makers. Our results reveal that micro firms appear less likely to be financed by subsidized loans or grants, even though they are often targeted by specific support programs. However, it is unclear whether this is due to a lack of awareness of public funding programs (Daskalakis et al. 2013; Öztürk and Mrkaic 2014) or whether the programs are simply not feasible for the requirements of micro firms – e.g. due to administrative burdens. Hence, we recommend further investigation into this result, and suggest to either increase awareness of public funding programs or adapt support programs to the specific requirements of micro firms. This is particularly important, as our results indicate that the financing patterns of micro firms differ from small and medium-sized firms. In other words, a "one-size-fits-all-approach" does not appear to be promising. Whereas European institutions, for instance, distinguishes between SMEs and large firms, the SME category itself is regularly not differentiated enough. Support programs that target micro firms should be tailored specifically to those businesses' needs in order to optimize the policy intervention's impact and should be separated from more general SME support programs.

However, even though some programs designed specifically for micro firms do exist, the implied costs to apply for public support programs can be high. Hence, indirect public support programs (e.g., through portfolio guarantees for financial intermediaries) that use standard financing channels – in particular, banks, microfinance institutions and other providers of finance for micro-enterprises – are likely to be more efficient, as these mechanisms mitigate the collateral requirements for micro firms to obtain bank loans and do not require additional application processes.

Important steps in this direction were taken in the European Progress Microfinance Facility (Bruhn-Leon et al. 2012) and subsequent programs, e.g. the EU Programme for Employment and Social Innovation (EaSI Financial Instruments). The microfinance

instruments of these initiatives were successfully absorbed in the market, which is an indication of micro-enterprises' large need of external funding in general and of debt financing in particular. Even though this program is just a first step to support micro firms, the results reinforce the findings of this study and emphasize that public support mechanisms should be tailored to the specific characteristics and needs of micro firms.

3.7. Limitations and future research

Our study has some limitations, particularly regarding the dataset and the questions asked in the SAFE survey. In our analysis, we only included financing instruments that were used by firms in the past six months. This reduces distortions, for example, by macroeconomic changes. Nevertheless a longer time period or a panel dataset would help to see if our results were stable over time. Furthermore, we cannot distinguish between the relevance of financing instruments for specific types of firms and their frequency of use. In addition, the survey does not cover solo self-employed companies, which significantly limits the scope of micro firms included in our dataset. Furthermore, our study only includes firm-level data such as firm age, size and industry, and does not account for macroeconomic data or country-specific differences.

These limitations point towards interesting research areas that should be further investigated in the future. First, it has been shown that country-specific differences impact the capital structure of firms (e.g., Daskalakis and Psillaki 2008; La Porta et al. 1997). Future research could therefore add macroeconomic variables (e.g., tax rates, interest rates, protection of property rights) to the dataset, in a way that is similar to the approach chosen by Masiak et al. (2017), for instance, and run a multi-level regression to control for these variables and further investigate how these differences affect the financing patterns of micro firms. As cross-border financing is typically very difficult with low funding volumes (Wagner 2012), micro firms are likely to be affected strongly by these country-specific differences, including the countries' macroeconomic and legal environment.

Second, prior research has linked micro financing to micro firms (e.g., Chan and Lin 2013; Sonnekalb 2014). An in-depth analysis of the loan sizes used in micro firms would provide further insights into the financing patterns of these companies. This could produce additional information about how micro loans can help these firms achieve access to finance and allow for policy recommendations regarding how to structure micro loan programs.

Third, as mentioned above, a deeper analysis of the differentiation of various loan durations and, in particular, the importance of short-term debt and working capital could provide a substantial amount of relevant information that would enable a better understanding of micro firms' financing patterns and the need for policy intervention.

Fourth, high fixed costs (in absolute and relative terms in comparison to loan amounts) in providing financing for small businesses are often an important constraint. Particularly, costs to reduce asymmetric information (e.g., screening activities) are typically higher when it comes to smaller companies. Against this background, it remains to be seen whether technological developments (e.g., better data availability, internet platforms, fintechs, etc.) can reduce or even eliminate this issue in small business lending (Block et al. 2017a; Kraemer-Eis et al. 2018). This is an area that we cannot cover in this paper, but that certainly merits further research.

Fifth, the lack of collateral is a key factor limiting the access to finance of smaller companies in general and micro-enterprises in particular (Bruhn-Leon et al. 2012; Kraemer-Eis et al. 2018). This aspect is used, inter alia, as a background for deriving our hypothesis 1 further above. A deeper investigation of this issue, focusing on the lack of collateral of micro-enterprises and looking into ways to mitigate its consequences, could bring useful information for policy makers and the potential design of financial instruments.

We started this paper by stressing the importance of micro firms for the European economy. Our research generates significant new insights into small firm financing patterns, as our results reveal that different components of the SME group differ significantly with respect to their financing behavior. More research is needed to fully understand these patterns and to better support policy makers in designing appropriate interventions that deliver optimal impacts.

4 Entrepreneurial opportunities and VC financing across regions

The aim of this chapter is twofold: first, the effects of regional- and firm-level factors on the intellectual property (IP) output (i.e., patents and trademarks) of high-tech firms are analyzed. So far, little is known about how regional factors influence the IP output of high-tech firms. We combine data on 8,317 German high-tech firms with regional data and perform various regression analyses. The IP output is measured by the number of patents and trademarks granted. In particular, the receipt of venture capital and firm size have a significant effect on the IP output. With regard to regional factors, the student rate in a region is positively linked to IP output, whereas the existence of a technical university in a region has no significant effect on the IP output. Innovative firms with a high IP output typically require external financing. VC financing is particularly appropriate for financing these firms due to its risk/return structure. Hence, the distribution of venture capital (VC) investments across German regions is analyzed and the geographical determinants of these VC investments are explored in the second study. Little is known about regional determinants of governmental (GVC), independent (IVC) and corporate (CVC) VC firms, and whether these types of VC firms invest in different regions. Combining a dataset of 402 German districts, our regressions show that regions with a higher supply of human capital and knowledge creators attract a significantly higher number of GVC investments. Moreover, we find a significant difference in economically weaker regions but not a metropolitan bias. Hence, GVC firms do not invest more frequently in rural regions per se and do not prevent regional disparities more often than other types of venture capital firms. The implications of these findings for high-tech firms and regional policy are discussed.[15]

[15] This chapter has been published as: Masiak, C., Fisch, C. O., Block, J. H. (2018). What Drives the Intellectual Property Output of High-Tech Firms? Regional- and Firm-Level Factors. In: A. Presse, and O. Terzidis (Eds.). Technology Entrepreneurship. Insights in New Technology-Based Firms, Research Spin-Offs and Corporate Environments: 157–175. Heidelberg: Springer. The second study has been published as: Masiak, C., Fisch, C. O., and Block, J. H. (2020). In Which Regions do Governmental, Independent, and Corporate Venture Capital Firms Invest? An Empirical Investigation across 402 German Regions. In: Moritz, A., Block, J. H., Golla, S., and Werner, A. (Eds.). Contemporary Developments in Entrepreneurial Finance: 201–227. Heidelberg: Springer.

4.1. Introduction

Previous studies have investigated the determinants of intellectual property output (IP output) at the firm level (e.g., Galende and De la Fuente 2003; Huergo and Jaumandreu 2004; Madrid-Guijarro et al. 2009) and at the regional level (e.g., Bottazzi 2003). However, only a small number of studies have combined high-tech firm-level and relevant regional-level data in a study without using an aggregated IP output (e.g., Naz et al. 2015; Smit et al. 2015). Naz et al. (2015) emphasize the demand for the combination of firm-level data with corresponding regional data. In this study, we focus on high-tech firms because of their link to innovation (e.g., Bhattacharya and Bloch 2004; Block and Spiegel 2013; Kim and Marschke 2004). Therefore, this study initially investigates the research question: Which firm- and regional-level factors drive the IP output of high-tech SMEs?

To address the first research questions, we use a unique dataset of high-tech firms provided by Spotfolio[16] and expand it with regional data from INKAR, as well as data on universities. Various regression analyses estimate the IP output of high-tech firms. To the best of our knowledge, we are the first to explore the whole of Germany with regard to high-tech firms at the regional level and firm level. Previous research has focused on either the regional IP output (e.g., Block and Spiegel 2013) or on specific regional factors, such as regional human capital (e.g., Naz et al. 2015). Second, we use patents and trademarks as proxies for IP output, allowing a more precise comparison of these measurements with regard to high-tech firms (Sandner and Block 2011). The results of the first study show that regional- and firm-level factors have an impact on the firm's IP output. While the existence of a technical university in a region (as opposed to no technical university in the region) has no significant effect, the student rate has a significant positive effect on the high-tech firms' IP output. With regard to internal factors (firm level), firm size and the receipt of venture capital are positively linked to the IP output. Therefore, venture capital appears to be an appropriate financing instrument for innovative high-tech firms due to its risk/return structure. Additionally, both proxies (number of patents granted and number of trademarks granted) show similar results, indicating that trademarks can be used in a similar way to patents to measure the innovation output of high-tech firms. Interestingly, firms appear to use patents and trademarks as complements rather than substitutes.

[16] Spotfolio is a German company which can be described as a matching platform and search engine. It primarily focuses on innovative high-tech firms and provides company information either from web crawling or from companies registered on the website which complete their own profiles.

In this context, both decision makers and firms are interested in financing these entrepreneurial opportunities and high-tech firms with a high IP output. In particular, venture capital (VC) is an important source of funding for high-tech and entrepreneurial firms, which has also been shown in the first study (Block et al. 2018a; Block et al. 2017b; Cumming and Zhang 2016; Gompers and Lerner 2001). To foster the development of an active VC market, European policy makers have explicitly highlighted the provision of VC in the Europe 2020 political agenda (European Commission 2011). Hence, VC has become one of the key priorities in EU politics (Da Rin et al. 2006; Guerini and Quas 2016). From a government's point of view, VC firms are important for both realizing the objectives set by Europe 2020 and spurring innovational and economic growth in Europe (Bertoni and Tykvová 2015; Colombo et al. 2016; Guerini and Quas 2016). European and national policy makers, however, want to foster not only economic growth, but also prevent regional disparities and inequalities (Bertoni and Tykvová 2015; Bottazzi et al. 2004; Tykvová 2006). However, as prior research shows, VC is not equally distributed across countries, regions, and industries (e.g., Chen et al. 2010; Cumming and MacIntosh 2003; Fritsch and Schilder 2008; Jeng and Wells 2000; Sorenson and Stuart 2001).

The majority of prior studies look at the US market (e.g., Chen et al. 2010; Elango et al. 1995; Florida and Kenney 1988a, 1988b). Thus, little is known to date about a regional VC (equity) gap for young and innovative firms in Europe (exceptions are, for instance, Lutz et al. 2013; Martin et al. 2005; Streletzki and Schulte 2013). Furthermore, prior research has primarily focused on decision-making criteria of venture capitalists at the firm level (e.g., Hall and Hofer 1993; Kirsch et al. 2009; MacMillan et al. 1985; Pierrakis and Saridakis 2017; Zhou et al. 2016), but has partially neglected both a potential regional dimension of VC firms and a differentiation between VC types. From a policy perspective, however, it is of utmost importance to develop regional clusters and to reveal regional characteristics to attract specific VC firms. Hence, the second study focuses on the regional dimension of different VC firm types and examines which VC firm types provide financing for entrepreneurial opportunities. Our second empirical study aims to differentiate between different venture capital types and addresses the following research questions: which characteristics of German regions help to explain geographical patterns in VC investment, and how do particular types of VC investors, namely governmental venture capital (GVC), independent venture capital (IVC), and corporate venture capital (CVC) firms differ in their geographical investment patterns? Do local biases exist in that particular VC firms only invest in high-tech firms located relatively close to them geographically?

Combining a dataset of 402 German regional districts ("*Kreise"*, NUTS 3-level) with a dataset of VC investments in Germany, in the second study we investigate the factors determining where VC investments occur in Germany. We distinguish between different types of VC investors: GVC, IVC, and CVC firms. Our findings show that regions with a higher technical university density and a higher student rate in the corresponding region have a significantly higher number of GVC investments. Furthermore, GVC firms appear to invest more frequently in rural areas than IVC firms. The GDP per employed person in the respective region, however, does not have a significant effect on GVC, IVC, or CVC investments.

Our study thus contributes to two particular streams of research in the innovation and VC literature: first, both trademarks and patents are proxies for IP output and appear to be influenced by similar factors. Second, by comparing different types of VC investors and their investments, we contribute to the growing literature on differences among VC investors (e.g., Colombo and Murtinu 2017; Guerini and Quas 2016; Gupta and Sapienza 1992; Pierrakis and Saridakis 2017). In particular, GVC investments have a more regional component than other types of VC firms (IVC, or CVC firms). Third, by investigating regional characteristics of VC, we contribute to the literature about geographical determinants of VC investing (e.g., Chen et al. 2010; Gupta and Sapienza 1992; Mason and Pierrakis 2013) and regional biases that may exist (e.g., Chen et al. 2010; Fritsch and Schilder 2008; Mason and Harrison 2002). While prior research has shown that spatial proximity between VC investor and portfolio company is positively linked to the likelihood of a VC investment (e.g., Chen et al. 2010; Lutz et al. 2013; Martin et al. 2005), little is known about further regional characteristics that determine VC investments. Our study contributes to this discussion on regional determinants and reveals specific regional characteristics that influence the likelihood of VC investments of specific GVC, IVC, and CVC types in a region. Finally, from a policy perspective, our research sheds light on the competitiveness and innovation potential of specific regions, and identifies important regional characteristics that attract VC investments.

The remainder of the study is organized as follows: Section 4.2 focuses on entrepreneurial opportunities across regions. This section derives hypotheses, and describes the dataset and results of the empirical multivariate analyses. Section 4.3 concentrates on the second study about VC financing across regions, provides background information on the different venture capital types, and conceptualizes the link between different types of VC firms and regional investment patterns. Furthermore, this section shows the respective multivariate analysis results. The results of both study 1 and study 2 are discussed in Section

4.4, indicating the study's implications, its limitations, and avenues for future research. The chapter closes by acknowledging limitations as well as proposing starting points for future research.

4.2. Study 1 – Entrepreneurial opportunities across regions

4.2.1. Hypotheses

4.2.1.1. Firm-level hypotheses

Venture capital

Venture capitalists use a variety of selection criteria to evaluate investments in start-ups (Franke et al. 2008). This evaluation is often thorough and aims to ensure the success of the venture capital investment. As a result, firms with particularly strong capabilities pass the evaluation process more often (Franke et al. 2008). This selection process leads to investments in technology-driven and highly innovative firms because they are characterized by a high-growth potential (Gompers and Lerner 2004). Beside the selection process, venture capital firms are permanently active in supporting activities such as the recruitment of managers, sharing experience gained from previous successful business expansions or the provision of further non-financial assistance (Block et al. 2018a; Franke et al. 2008). Hence, venture capital-financed firms should have a higher IP output than firms without venture capital support.

Second, entrepreneurs face several funding challenges at the beginning of their firm's life cycle. Venture capitalists can help firms overcome these challenges (Alexy et al. 2012). For example, venture capitalists are often part of established networks of large corporations, financial institutions, universities, and other organizations. Therefore, venture capital firms reduce several risks which high-tech firms face (e.g., reducing uncertainty by establishing relationships with suppliers or financial institutions). Due to the networks and cooperation which are established by venture capital firms, we assume that venture capital-financed firms have a higher IP output than firms which are not venture capital-financed. Hence, we hypothesize:

Hypothesis 1. *Receiving venture capital is positively linked to the IP output of high-tech firms.*

Firm size

High-tech SMEs might be particularly disadvantaged with regard to identifying collaborations and transferring knowledge due to lack of resources (e.g., De Jong and Freel 2010; Freeman et al. 1983; Singh et al. 1986). Moreover, SMEs often lack the necessary capabilities to manage and process external knowledge (Cohen and Levinthal 1990). According to Cohen and Levinthal (1990), the absorptive capacity of an organization plays a crucial role in the learning and innovation process. Absorptive capacity includes the ability to identify, comprehend, and apply external knowledge (Cohen and Levinthal 1990). Thus, firms with a larger absorptive capacity are able to learn from universities, institutions or other organizations, and can effectively use external knowledge for the development of innovations (Cohen and Levinthal 1990; Dyer and Singh 1998). SMEs often have less experience than large firms, as well as less financial resources and resources for extensive R&D investments (Block et al. 2015; Nooteboom 1994). Furthermore, the qualification of employees is essential for developing innovations.

In addition, rapid environmental changes characterize the high-tech industry, so continuous development of the skills and abilities of a firm's employees is necessary. SMEs are thus disadvantaged with regard to the development of employees' expertise. Although formalization (e.g., codified instructions or formalized procedures) within a firm might lead to inflexibility, prior research notably highlights positive effects (Jansen et al. 2005; Lin and Germain 2003). Formalization enables a codification of best practices, as well as a guideline for the knowledge process, in order to efficiently implement external knowledge in the innovation process (Jansen et al. 2005; Lin and Germain 2003). Formalization, however, appears to be more likely to occur in well-established and larger firms due to time constraints and lack of resources in smaller firms. As a result, larger firms have a higher absorptive capacity of external knowledge, higher formalization, and consequently a higher IP output. We thus argue:

Hypothesis 2. *Firm size is positively linked to the IP output of high-tech firms.*

4.2.1.2. Regional-level hypotheses

Presence of a technical university

Knowledge spillovers, intense cooperation in R&D activities and research efforts can lead to regional networks which favor the development of innovation systems (Block and Spiegel 2013; Cooke 2001). Universities are often considered as "knowledge factories" and

various possibilities exist for firms to acquire knowledge from them (e.g., publications, scientific papers, and collaboration) (Agrawal and Henderson 2002; Fisch et al. 2015; Fritsch and Schwirten 1999). Moreover, the high-tech sector itself is notably innovation-driven and has been shown to favor a close connection between universities and high-tech firms (Fritsch and Aamoucke 2013; Hellerstedt et al. 2014).

Proximity is an important factor that shapes the way in which firms profit from spillovers by universities. Previous research has indicated that spillovers are often limited to a certain geographic distance (Anselin et al. 1997; Fritsch and Schwirten 1999; Jaffe et al. 1993). A possible explanation for spatially bound knowledge spillovers is the nature of university knowledge. In general, there is a distinction between explicit (codified) and implicit (tacit) knowledge. Explicit knowledge is normally codified and can be transmitted verbally or in writing (Howells 2002; Polanyi 1962, 1966). Publications or papers are examples of explicit knowledge that are transferrable to industries (Howells 2002; Polanyi 1962, 1966). In contrast, tacit knowledge cannot be transmitted in a direct way, since it depends on experience, procedures and learned behavior (Howells 2002; Polanyi 1962, 1966). Examples of tacit knowledge, however, include students, professors, or scientists of the university, who experience or embody tacit knowledge. Face-to-face interaction and continuous personal contact become more important with regard to the transfer of tacit knowledge, which implies that spatial proximity favors knowledge spillovers (e.g., Audretsch and Lehmann 2005; Bade and Nerlinger 2000).

Due to the content-related proximity, beneficial knowledge spillover effects should arise among technical universities and high-tech firms in particular. As a result, not only the regional innovation system, but also the IP output, is improved due to knowledge spillovers between technical universities and high-tech firms. Therefore, we assume:

Hypothesis 3a. *The number of technical universities in a region is positively linked to the IP output of high-tech firms.*

Student rate

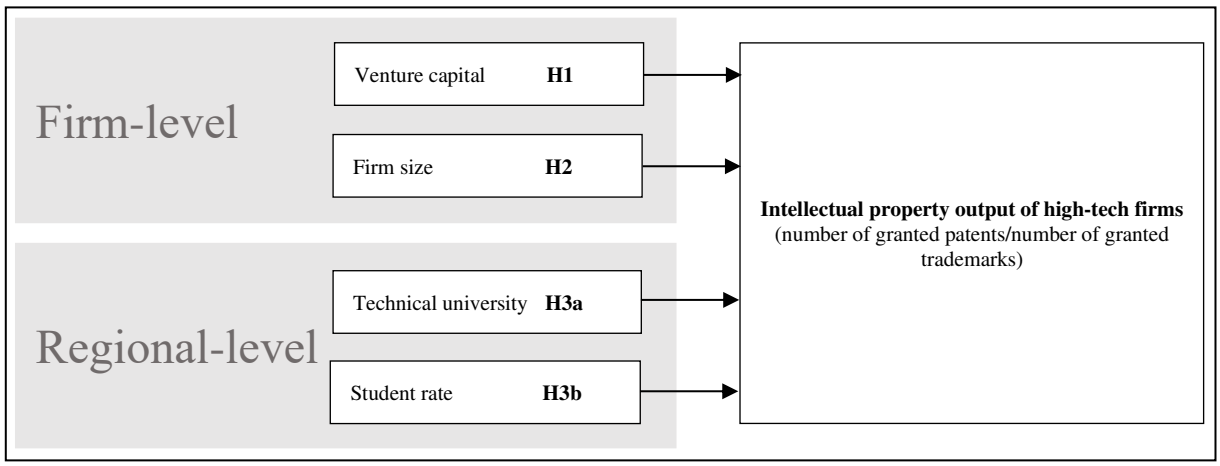
In addition, universities can contribute to regional innovativeness by producing skilled employees. The high-tech industry particularly needs employees educated to at least university level in order to stay competitive. Highly educated workers have the ability to adapt and implement new technologies more easily. They are mainly responsible for know-

how trading in a firm, since they possess the relevant knowledge (Blundell et al. 1999; Carter 1989; Vinding 2006). Combined with the general improvements in human resource management practices (e.g., job rotation, delegation of responsibility), the absorptive capacity of a firm increases and its IP output is likely to grow as a consequence (Bartel and Lichtenberg 1987; Vinding 2006).

The student rate in a region represents a potential source of highly qualified employees for the various firms. Previous research indicates that firms often recruit technical staff from local universities and this source is more important than customers, suppliers, competitors, or other organizations (Dahlstrand 1999). Prior research used the student rate as a proxy for university knowledge spillovers and tested the relationship between student rate and regional innovation output (Block and Spiegel 2013). Thus, we argue:

Hypothesis 3b. *The number of students in a region is positively linked to the IP output of high-tech firms.*

Figure 4-1: Conceptual model.



Reference: Own illustration.

4.2.2. Data

4.2.2.1. Dataset

Our dataset combines data at the firm level and regional level. At the regional level, data from 360 German districts from 2010 is included (NUTS 3-level). The NUTS classification used is a hierarchical system designed to delineate the territory of the European Union, for example for socio-economic analyses (Eurostat 2015). The NUTS 3-level includes small regions and is equivalent to the German district level ("*Kreisebene"*), including both districts ("*Kreise*") and autonomous cities ("*kreisfreie Städte*"). The Federal Office for

Building and Regional Planning in Germany provides data on the various districts. This data is complemented by data from the Gründungsatlas, which includes detailed data on German start-ups. Additionally, we use the Spotfolio database to add information about German high-tech firms. Spotfolio primarily focuses on smaller, innovative high-tech firms and provides company information either from web crawling or from companies registered on the website (self-reported).

Various definitions of high-tech sectors exist. A simplified classification is provided by Legler and Frietsch (2007): firms that exceed a 7% share of R&D expenditure in turnover belong to the high-tech sector, whereas a share of between 2.5% and 7% corresponds to medium-tech sectors. The remaining firms are classified as belonging to low-tech industries (Legler and Frietsch 2007). Spotfolio uses this approach, as well as a study by the Lower Saxony Institute for Economic Research (NIW), the Fraunhofer Institute for Systems and Innovation Research (ISI), and the Centre for European Economic Research (ZEW) to classify high-tech companies in Germany. In Spotfolio, the industries in which a firm operates are categorized by the WZ-2008 classification, the German categorization of industrial sectors by the Federal Statistical Office. The following industries are considered: manufacturing (C10–33), information and communication (J58–63), and professional, scientific and technical activities (M69–75). Most importantly, however, information about the patent applications and trademarks of the firms is also included in Spotfolio. We matched the company data to districts using zip codes. In addition, we matched this data with data on all private and public German universities or universities of applied science, which was obtained from the Higher Education Compass ("*Hochschulkompass"*).

4.2.2.2. Variables

Dependent variables

We use two different dependent variables. First, a dummy for granted patents is used as a proxy to measure the IP output of companies. Patents are an adequate and reliable proxy for innovations (Acs and Audretsch 1989; Acs et al. 2002; Block and Spiegel 2013). Second, a dummy for trademarks is used as a further proxy to measure a firm's IP output (Gotsch and Hipp 2012; Mendonça et al. 2004). Patents protect technological assets (e.g., inventions), whereas trademarks protect marketing assets (e.g., brands) (Block et al. 2015).

Independent variables

First, the variable *venture capital* refers to H1 and measures whether a company has obtained venture capital ("1" = company has received venture capital; "0" = company has not received any venture capital). The second independent variable (H2) is firm size (*small firms*). There are four types of companies depending on total assets, sales revenue and number of employees. Two of the three classifications have to apply to the relevant firm for two consecutive years. Spotfolio differentiates between micro-enterprises, small enterprises, medium-sized companies and large companies.[17]

With regard to H3a, the variable *technical university* ascertains whether a technical university is located in the respective district ("1" = at least one technical university exists; "0" = a technical university does not exist). The variable captures knowledge spillovers between technical universities and firms. We focus on technical universities rather than non-technical universities because high-tech firms benefit more from the focus on engineering and science subjects to be found at technical universities. Moreover, technical universities receive higher funds than non-technical universities in order to compete for technology transfer (Audretsch and Lehmann 2005). The *student rate* represents another important independent variable that is used to assess H3b. It measures the number of students at a university divided by the number of inhabitants in the district where the university is located. The student rate reflects human resources that might be employed in the district, and can foster knowledge spillovers to firms as well as increase the IP output of a firm. In comparison to the university variable, it includes students from universities and universities of applied science (Block and Spiegel 2013; Fritsch and Schwirten 1999). A detailed description and explanation of the variables is provided in Table 4-1.

In addition, we include several control variables that have been proven to influence IP output at the firm or regional level. Even though the majority of studies have focused on the relationship between regional factors and the regional innovation output, some regional factors appear to have a direct effect on a firm's innovation output (Srholec 2010). First, the variable *start-up rate* measures the number of start-ups divided by the number of inhabitants and is consequently a proxy for entrepreneurship (Block et al. 2013). Although it has been used as a proxy for regional innovation output in previous research (Block and Spiegel 2013), it can be argued that the start-up rate influences the IP output of a firm as well. According to Almeida and Kogut (1997), small firms are able to exploit new technologies in local small

[17] We included small firms and grouped medium-sized and large firms together as the reference group.

firm networks better than large firms. Therefore, a high number of small firms in a German district should positively influence the IP output of a firm. Furthermore, *GDP per employed person* and *household income* both reflect the economic environment in the relevant district, whereas the *unemployment rate* and *R&D employee rate* characterize the labor market in the specific region (e.g., Block and Spiegel 2013; Florida et al. 2008; Naz et al. 2015). In addition, *R&D subsidies* measures the loans granted by the German Development Bank divided by the number of inhabitants. Subsidies, such as R&D subsidies, lead to an increase in firms' innovation activities (Almus and Czarnitzki 2003).

Prior research shows the positive impact of various industries on the IP output of individual firms (e.g., Klenow 1996; Santarelli and Piergiovanni 1996). An additional firm-specific variable refers to the *fixed assets* of a company. Since the Spotfolio database does not include a firm's turnover, the variable *fixed assets* is used as a proxy for its capital. Table 4-1 explains and describes the variables used in more detail.

Table 4-1: Variable description.

Variable	Description
Firm characteristics	
Venture Capital	Dichotomous variable (1 = firm has received venture capital; 0 = firm has not received venture capital)
Small firms	Dichotomous variable (1 = firm is a small firm; 0 = firm is not a small firm)
Medium-sized/Large firms	Dichotomous variable (1 = firm is a medium-sized/large firm; 0 = firm is not a medium-sized/large firm)
Log (fixed assets)	Logarithmized fixed assets of a firm
Log (Patents)	Logarithmized granted patents of a firm
Log (Trademarks)	Logarithmized granted trademarks of a firm
Patents (0/1)	Dichotomous variable (1 = firm holds at least one granted patent; 0 = firm does not hold any granted patent)
Trademarks (0/1)	Dichotomous variable (1 = firm holds at least one granted trademark; 0 = firm does not hold any granted trademark)
Patents (count)	Number of granted patents based on applicant firm
Trademarks (count)	Number of granted trademarks based on applicant firm
Main area	Dummy variable for the relevant industry based on the WZ-2008 industry classification (Manufacturing; information and communication; professional, scientific and technical; other)
Regional characteristics	
Technical University	Dichotomous variable (1 = at least one technical university exists in the specific German district; 0 = a technical university does not exist in the specific German district)
Student rate	Measures the number of students which are enrolled at a university divided by inhabitants (in 1,000)
Start-up rate	Number of start-ups divided by inhabitants (in 10,000)
GDP/employed person	Gross domestic product per employed person in €1,000 (in the specific district)
Household income	Household income per inhabitant in € (in the specific district)
R&D employee rate	Number of R&D employees divided by total employees (in 1,000)
R&D subsidy	Granted long-term loans by the KfW Bankengruppe to encourage innovation (in €1,000) divided by inhabitants (in the specific district)
Unemployment rate	Number of unemployed people in the region divided by employed people (in the specific district)

Data source: Eurostat (2010); Federal Office for Building and Regional Planning (2015); Gotsch and Hipp (2012); Hochschulkompass (2015); Mendonça et al. (2004); Naz et al. (2015); Spotfolio (2016).

4.2.2.3. Descriptive statistics

To enable a better understanding of the data and variables used, descriptive statistics are displayed in Table 4-2. In total, our final dataset contains 8,317 high-tech firms in Germany, which are mostly small firms (approx. 92%). On average, each firm possesses 1.35 patents and only 0.45 trademarks. With regard to the dependent variables, the average number of technical universities is 0.25 per district, and an average of 0.01 firms received venture capital. The dataset mainly consists of small firms.

Figure 4-A1 (see Appendix) shows the geographic distribution of firms in the dataset. In total, 360 districts are included in the regression analyses. The majority of firms (in this dataset) are located in Western and Southern Germany, whereas some districts in Eastern Germany are not included in the further analyses. Figure 4-A1 also depicts the distribution of technical universities. Some technical universities are located in districts with a high number of high-tech firms.

Table 4-2: Descriptive statistics.

Variable	Mean	SD	Min.	Max.
Firm characteristics				
VC	0.01	-	0	1
Small firms	0.92	-	0	1
Medium-sized/Large firms	0.08	-	0	1
Log (fixed assets)	10.49	2.57	0	18.66
Log (Patents)	0.15	0.58	0	6.93
Log (Trademarks)	0.14	0.45	0	4.72
Patents (count)	1.35	19.64	0	1,021
Trademarks (count)	0.45	3.13	0	111
Patents (0/1)	0.09	-	0	1
Trademarks (0/1)	0.12	-	0	1
Main area				
Manufacturing	0.60	-	0	1
Information	0.33	-	0	1
Professional	0.07	-	0	1
Others	0.00	-	0	1
Regional characteristics				
Technical university	0.25	0.43	0	1
Student rate	0.03	0.05	0	0.35
Start-up rate	0.26	0.06	0.09	0.47
GDP/employed person	0.03	0.02	0.01	0.10
Household income	1.70	0.28	1.23	3.11
R&D employee rate	0.13	0.13	0.00	0.94
R&D subsidy	0.18	0.21	0	1.37
Unemployment rate	0.07	0.03	0.02	0.17

Notes: N = 8,317 firms.

4.2.2.4. Multivariate analyses

Method

We use several types of regression that are estimated using Stata. First, a logistic regression was conducted with the dependent variable *patents (0/1)* ("1" = firm holds a patent; "0" = firm does not hold a patent), as well as the variable *trademarks (0/1)* ("1" = firm holds a trademark; "0" = firm does not hold a trademark). Second, we performed negative binomial regressions. The dependent variables are the number of patents granted (*patents*) and the number of trademarks granted (*trademarks*). In general, both Poisson regression and negative binomial regression are appropriate for data with a count-character, such as the number of patents or trademarks (Cameron and Trivedi 1998; Chatterjee and Simonoff 2013). The negative binomial regression, however, is more appropriate than a Poisson regression for a

dataset with possible overdispersion (Cameron and Trivedi 1998), which is usually the case for patent data (e.g., Fisch et al. 2016).

Results

We use patents and trademarks as the dependent variables. Both variables are dummy variables and measure whether a company has at least one patent or trademark (coded as 1) or not (coded as 0). The results of our analyses are displayed in Table 4-3. H1 states that the receipt of venture capital is positively linked to the IP output of high-tech firms. To assess this hypothesis, Model 1 shows the results of a logistic regression with patents (0/1) as the dependent variable, and indicates that the variable *venture capital* ($p < 0.01$) is statistically significant. Thus, H1 is strongly supported by the data. With regard to H2, the empirical results indicate that being a *small firm* ($p < 0.01$) decreases the likelihood of holding a patent or trademark. In other words, the IP output increases with the size of the firm. H3a addresses the knowledge spillover effects of technical universities. It is hypothesized that firms should have a higher IP output if a technical university is located in the same region as the firm. Our results (Model 1) do not show a significant effect and hence do not support H3a. H3b refers to the impact of the student rate in a region on the IP output of high-tech firms. *Student rate* ($p < 0.05$) shows a significant effect on the IP output. H3b is consequently supported by our results. Beside the hypotheses tested, some control variables show significant effects as well. It is noteworthy that the independent variables *patents* and *trademarks* show significant results. The variable *log (trademarks)* ($p < 0.01$) has a significant positive effect on the probability of holding a patent. Moreover, the variable *GDP per employed person* ($p < 0.05$) and *household income* ($p < 0.05$) show statistically significant results.

The second model shows the logistic regression results for *trademarks (0/1)* as the dependent variable, which is used as an additional measurement for IP output in the regression analyses. Overall, the results are very similar to Model 1. Model 2 (Table 4-3) shows that the variable *venture capital* ($p < 0.01$) is significantly positive. The variable *student rate* ($p < 0.10$) has a positive impact on the likelihood of having a trademark as well. Moreover, *technical university* is not statistically significant, while being a small firm has a significantly negative effect on holding a trademark. The results of the logistic regression analysis using *trademarks (0/1)* as the dependent variable substantiate the previous results. In addition, two control variables show a significant effect. The variables *household income* ($p < 0.10$) and *patents* ($p < 0.01$) increase the firm's probability of holding a trademark.

Furthermore, negative binomial regressions are performed to check the robustness of the main models. The number of patents and trademarks granted are used as dependent variables. The results of the negative binomial regression are presented in Table 4-3 (Model 3 and 4) and underline the robustness of the logistic regression analyses. H1, H2, and H3b are supported by the robustness checks (Model 3), whereas H3a is not supported by the results. The non-finding of H3a is consistent across all models (Model 1–4). While *student rate* positively influences the number of patents and trademarks, Model 4 does not show a significant result.

Table 4-3: Logistic regression (Model 1 and 2) and negative binomial regression models (Model 3 and 4).

Variable	Model 1	Model 2	Model 3	Model 4
Dependent variable	**Patents (0/1)**	**Trademarks (0/1)**	**Patents (count)**	**Trademarks (count)**
Firm characteristics				
VC	1.459 (0.325) ***	1.326 (0.252) ***	1.543 (0.353) ***	0.891 (0.200) ***
Small firms	-1.357 (0.105) ***	-0.859 (0.124) ***	-2.795 (0.266) ***	-1.706 (0.243) ***
Log (fixed assets)	-0.033 (0.016) **	0.013 (0.016)	-0.061 (0.029) **	-0.019 (0.021)
Log (Patents)		1.289 (0.080) ***		1.085 (0.075) ***
Log (Trademarks)	1.719 (0.110) ***		2.057 (0.167) ***	
Regional characteristics				
Technical university	0.092 (0.131)	0.107 (0.125)	0.013 (0.226)	0.155 (0.173)
Student rate	2.237 (0.915) **	1.515 (0.802) *	2.701 (1.591) *	0.563 (0.989)
Start-up rate	-1.140 (0.766)	-0.686 (0.740)	-1.746 (1.215)	0.273 (1.042)
GDP/employed person	-8.993 (4.028) **	-4.417 (4.011)	-14.29 (7.494) **	-1.558 (5.341)
Household income	0.305 (0.131) **	0.310 (0.170) *	0.218 (0.289)	-0.277 (0.253)
R&D employee rate	0.257 (0.288)	-0.146 (0.324)	1.730 (0.694) **	-0.128 (0.452)
R&D subsidy	0.134 (0.213)	0.284 (0.284)	0.581 (0.473)	0.040 (0.452)
Unemployment rate	-2.509 (1.796)	2.552 (1.742)	-2.345 (3.924)	-1.461 (3.275)
Main area (dummies)	Yes	Yes	Yes	Yes
Pseudo log-likelihood	-1,754.44	-2,503.62	-4,008.74	-4,442.30
Wald Chi-squared	722.07 ***	463.24 ***	505.04 ***	465.14 ***

Notes: N = 8,317 firms. Coefficients, standard errors (clustered at regional level) in parentheses. ***p < 0.01. **p < 0.05. *p < 0.1.

4.3. Study 2 – VC financing across regions

4.3.1. Conceptual framework and hypotheses

4.3.1.1. Characteristics of GVC, IVC, and CVC firms

Prior research on VC has shown that VC firms have a positive effect on portfolio firms' performance with regard to economic performance (e.g., Colombo and Murtinu 2017; Croce et al. 2013), innovation output (e.g., Bertoni and Tykvová 2015), and exit rates (e.g., Giot and Schwienbacher 2007). Furthermore, the different VC firms (GVC, IVC, and CVC firms) contribute and add value not only to the investee, but also foster regional development. For instance, VC firms provide financial resources to the investee (Bertoni et al. 2013; Colombo and Murtinu 2017). In particular, young and innovative firms have a lack of financial resources due to market failures (Hall and Lerner 2010). Moreover, portfolio firms benefit from the certification effect of VC firms to external partners or financial providers (Colombo et al. 2016; Guerini and Quas 2016) and the network partners of the investor (Fried and

Hisrich 1995). High-tech firms, for instance, increasingly innovate in networks instead of on their own. Moreover, VC firms support their portfolio firms by providing added value, since the investees usually lack internal expertise (De Clercq et al. 2006). Also, VC firms monitor their portfolio firms in order to guarantee the success of entrepreneurial firms (Gompers 1995; Wang and Zhou 2004). Besides the contribution to the portfolio firms, VC firms in regions foster and support the economic development in those regions (e.g., Florida and Kenney 1988a).

Due to the ownership and governance structures, however, the several types of VC firms differ significantly in terms of their primary objectives, the provision of added value to the portfolio company, and their regional focus (Bertoni and Tykvová 2015; Colombo and Murtinu 2017; Guerini and Quas 2016; Luukkonen et al. 2013). Hence, the investment patterns of the different VC firms may considerably differ from each other. We explicitly distinguish between independent venture capitalists, governmental venture capitalists, and corporate venture capitalists in our study, and consider their expected geographical investment patterns. IVC firms are typically organized as limited partnerships, in which the investment process is run by an independent management company that has no direct connection to the ultimate investor (Bertoni and Tykvová 2015; Colombo and Murtinu 2017). An independent venture capitalist's primary objective is to generate financial returns, part of which are received by the general partners of the VC firm (Bertoni and Tykvová 2015; Colombo and Murtinu 2017; Sahlman 1990). Beside the financial support, IVC firms provide value-adding services to the portfolio company (Luukkonen et al. 2013). Since independent venture capitalists are especially interested in high financial returns, IVC firms have strong incentives to actively support the portfolio company. For instance, independent venture capitalists provide the portfolio company with unique contacts to qualified workers and potential suppliers or customers (Bertoni and Tykvová 2015; Luukkonen et al. 2013).

GVC firms are normally not organized as limited partnerships and the management company is not independent of the government (Bertoni and Tykvová 2015; Cumming and MacIntosh 2006). Prior research generally distinguishes between three different governmental funds: funds-of-funds, hybrid funds, and direct public funds (Colombo et al. 2016). A typical example of a VC funds-of-funds construct is the European Investment Fund (EIF), which invests in other investment funds instead of directly investing in a portfolio company (e.g., Pan-European Venture Capital Fund(s)-of-Funds program). Governmental venture capitalists may involve private investors in order to co-invest in funds (hybrid funds). The German *High-Tech Gründerfonds* fund includes, for instance, not only investors such as the German Federal

Ministry of Economics and Technology, but also industrial groups, and is hence classified as a hybrid fund. Furthermore, direct public funds contain solely direct investments in portfolio companies by GVC firms (Colombo et al. 2016).

GVC firms possess objectives and value-added services that differ from those of other types of VC firms. Whereas independent venture capitalists often have a focus on purely financial objectives, governmental venture capitalists' objectives are not limited to financial returns and are broader in nature (Bertoni and Tykvová 2015; Minola et al. 2017). First, governments regularly establish GVC funds to respond to equity gaps in the market, since private equity firms cannot meet all the demand of young and innovative firms (Luukkonen et al. 2013). GVC firms foster a crowding-in effect on the development of the entire VC market to correct market failures (Brander et al. 2015; Colombo et al., 2016). Second, the objectives of GVC firms are characterized by the entity that established them (Bertoni and Tykvová 2015; Colombo et al. 2016). In other words, positive externalities for the whole of society complement the financial objectives, namely economically and regional development objectives (Colombo et al. 2016). In particular, peripheral regions that lack economic growth or are characterized by a high unemployment rate may benefit from governmental investments, and are explicitly mentioned in the agenda of GVC firms (Colombo et al. 2016).

Furthermore, the time-horizon of GVC investments is oriented towards the long- rather than the short-term. Therefore, the period until the exit from a portfolio company is typically longer for GVC firms than it is for other types of VC firms (Sahlman 1990). Moreover, governmental venture capitalists are able to add value to the investee, in particular by providing unique relationships to universities or public institutions (Pierrakis and Saridakis 2017). Nevertheless, prior research has indicated that GVC funds contribute to the portfolio company to a lesser extent than those of IVC funds, especially regarding the development of business ideas, professionalization, and exit orientation (Luukkonen et al. 2013). Reasons for the lower value-added activities of GVC firms might be the higher number of portfolio firms per manager, and the minority stakes in the portfolio companies that lead to lower control and involvement by GVC firms (Cumming and MacIntosh 2007; Schaefer and Schilder 2009).

CVC firms are typically investment vehicles owned by an established, non-financial company (Colombo and Murtinu 2017). The parent company provides not only capital but also additional tangible or intangible resources to the portfolio company (Colombo and Murtinu 2017; Gompers and Lerner 2000; Rossi et al. 2017). In return, the corporate venture capitalist receives shares from the portfolio company. However, CVC firms differ, in several

respects from other VC types. First, CVC firms' objectives do not normally focus purely on financial returns, which is typically a minor motivator for a CVC investment. The majority of CVC programs seek a window on technology that is related to the core business of the parent company, or complements the parent company's products (Dushnitsky and Lenox 2005). In other words, the CVC firms aim to source knowledge and learn about new technologies and consequently enhance the innovativeness of the parent company (Wadhwa et al. 2016; Yang et al. 2014). Second, the capabilities of corporate venture capitalists differ considerably from other types of venture capitalists. CVC firms are able to provide specialized knowledge from the parent company to the portfolio company, such as complementary competencies, distribution channels, or production capacity. Moreover, portfolio companies may benefit from the specialized and industry-specific network partners of the parent company (Colombo and Murtinu 2017). However, CVC firms represent an ancillary activity of a parent company. Hence, the capabilities and skills for supporting the portfolio company and the quality of value-enhancement activities of CVC firms are limited (Colombo and Murtinu 2017).

4.3.1.2. Regional development focus of GVC firms

These findings from prior literature appear to indicate that GVC firms in particular have varying objectives, ranging from the development of young industries, to supporting regional development and job creation by setting up regional funds (e.g., Luukkonen et al. 2013). Hence, the financial objectives are less pronounced in GVC than in IVC or CVC firms. Independent venture capitalists, for instance, often have specific incentive structures that focus on performance-linked bonuses (Leleux and Surlemont 2003). Governmental venture capitalists, however, consider investments that have a lower return but generate social payoffs, regional development and lead to job creation (Colombo and Murtinu 2017; Colombo et al. 2016). Furthermore, GVC firms aim to reduce VC investment disparities and foster the development of peripheral regions. Therefore, we expect that GVC firms invest more frequently in economically weak and rural regions than other VC types, and formulate the following hypotheses:

Hypothesis 4. *GVC firms invest more often in regions with a low population density than a) IVC and b) CVC firms.*

Hypothesis 5. *GVC firms invest more often in regions with a low GDP per employed person than a) IVC and b) CVC firms.*

4.3.1.3. Network partners of GVC firms

Knowledge spillovers, intense cooperation in R&D activities, and research efforts can lead to regional networks which favor the development of regional innovation systems (Block and Spiegel 2013; Cooke 2001). Universities are often considered as "knowledge suppliers", and various possibilities exist for firms to acquire knowledge from universities (Agrawal and Henderson 2002; Fisch et al. 2015). In particular, universities can be seen as regional suppliers of knowledge in two respects: first, universities include both explicit (codified) and implicit (tacit) knowledge. Whereas explicit knowledge is normally codified and can be transmitted verbally or in writing, implicit knowledge cannot be transmitted in a direct way, since it depends on experience, procedures and learned behavior (Howells 2002; Polanyi 1962). Universities produce and transfer this knowledge (knowledge spillovers) to a region that can be a source of entrepreneurial opportunities (Baptista and Swann 1998). Second, universities contribute to regional innovativeness and entrepreneurship by producing skilled employees. Highly educated workers have the ability to adapt and implement new technologies more easily. They are mainly responsible for know-how trading in a firm, since they possess the relevant knowledge (Blundell et al. 1999; Vinding 2006).

Spatial proximity is an important factor that shapes the way in which firms and VCs profit from universities' knowledge. Previous research has indicated that knowledge spillovers are often limited to a certain geographic distance (Anselin et al. 1997). In particular, the tacit component of university knowledge spillovers requires face-to-face interaction and continuous personal contact (Audretsch and Lehmann 2005). Furthermore, prior research indicates that firms often recruit technical staff from local universities, and this source is more important than customers, suppliers, competitors or other organizations (Dahlstrand 1999). Hence, spatial proximity favors both knowledge spillovers of universities and the recruitment of highly educated staff (e.g., Audretsch and Lehmann 2005). We argue that knowledge spillovers of technical universities create entrepreneurial opportunities in a region, and consequently attract VC firms to invest in these districts. A technical university plays a more important role in the context of high-tech firms and VC in particular, since the focus of a technical university is on engineering and science subjects. Therefore, both knowledge spillovers and (innovative) entrepreneurial opportunities may be spatially linked to the proximity of a technical university (Audretsch and Lehmann 2005). However, due to the different characteristics of GVC, IVC, and CVC firms, we expect that VC firms differ in the usage of network partners such as technical universities. Whereas independent and corporate venture capitalists provide added value to the portfolio company by having contacts to

qualified workforce, alliance partners, suppliers, or specialized knowledge, GVC firms especially have network partners in public institutions and interact more frequently with these public actors (Bertoni and Tykvová 2015; Colombo and Murtinu 2017; Perrakis and Saridakis 2017).

Furthermore, the student rate in a region represents a potential source of highly qualified employees for the various firms, and is used as a proxy for university knowledge spillovers (Block and Spiegel 2013; Dahlstrand 1999). In particular, GVC fund managers have a positive attitude towards academic entrepreneurship (Colombo et al. 2016). For instance, Knockaert et al. (2010) find that the availability of public funding in a VC firm's capital positively affects the investment manager's attitude towards an academic spin-off investment. Hence, we hypothesize:

Hypothesis 6. *GVC firms invest more often in regions with a technical university than a) IVC and b) CVC firms.*

Hypothesis 7. *GVC firms invest more often in regions with a high student rate than a) IVC and b) CVC firms.*

4.3.1.4. Local bias of VC investments

Prior research has shown that the geographical distance between the investor's location and the portfolio company has an influence on the VC investment patterns, also known as local bias (e.g., Cumming and Dai 2010). Two different explanations can account for a local bias of VC firms' investment patterns (Sorenson and Stuart 2001): first, VC firms identify and appraise investment targets in the pre-investment phase. As obtaining information regarding high-quality investment opportunities is time-consuming, VC firms typically rely on their own networks (Sorenson and Stuart 2001). Since networks tend to cluster in both geographic and social spaces, networks affect the location bias of investment activities (Sorenson and Stuart 2001). Beside the identification of investment opportunities, opportunity appraisal is essential for VC firms due to asymmetric information between investor and investee (Lutz et al. 2013). Using deep networks in an industry or a geographic area, VC firms are better able to evaluate the information regarding the quality of an investment opportunity (Sorenson and Stuart 2001). Furthermore, VC firms prefer investing in firms following recommendations from close contacts, such as from entrepreneurs that the VC previously financed (Fried and Hisrich 1995). The establishment of network contacts for both the identification and appraisal

of investment opportunities are likely to decline considerably as the geographic distance increases.

Second, VC firms monitor and advise portfolio companies in the post-investment phase. Venture capitalists actively monitor their investee to mitigate asymmetric information (Gompers 1995; Trester 1998). Furthermore, venture capital represents smart capital. In other words, VC firms provide value-added services to the portfolio company, such as financial expertise or advice on strategic and operational issues (Sapienza 1992). Both monitoring and value-added services include a geographical distance dimension (Sorenson and Stuart 2001). While monitoring requires regular visits to company operations, active assistance is easier by interacting frequently with the management at the portfolio company's location. Therefore, both monitoring and advising in the post-investment phase are more affordable as the geographical distance between investor and investee is shorter. Although all VC firms have to identify and appraise investment opportunities as well as monitor and advise their portfolio companies, we argue that the several VC types differ from each other. In particular, GVC firms are often tailored to a specific federal state, such as *MBG Mittelständische Beteiligungsgesellschaft Baden-Württemberg GmbH* or *Bayern Kapital GmbH*. These GVC firms, for instance, explicitly mention their sole concentration of investments in Baden-Wuerttemberg and Bavaria respectively. Furthermore, GVC firms are shaped by economic and regional development objectives of the entity that established the GVC firm (Bertoni and Tykvová 2015; Colombo et al. 2016). Hence, the focus of investments in relation to the spatial proximity of regions and districts of the entity is obvious. On the contrary, IVC and CVC firms concentrate on high financial returns and complementary or new technologies (Wadhwa et al. 2016), and hence are more likely to have a broader investment pattern. Thus, we hypothesize:

Hypothesis 8. *The local bias of VC investments – the geographical distance between the investor's location and the portfolio company – is more pronounced for GVC firms than for a) IVC and b) CVC firms.*

4.3.2. Data, variables

4.3.2.1. Dataset

For our empirical analysis, we used 402 regional German districts (NUTS 3-level) as our unit of observation. The NUTS classification is a hierarchical system designed to delineate the territory of the European Union, for example for socio-economic analyses

(Eurostat 2015). The NUTS 3-level includes small regions and is equivalent to the German district level ("*Kreisebene*") including both districts ("*Kreise*") and autonomous cities ("*kreisfreie Städte*").

We collected data for these districts from various data sources. Data about the VC investments is obtained from Spotfolio, which is a German business matching platform that primarily focuses on innovative high-tech firms in Germany. According to Legler and Frietsch (2007), firms that exceed a 7% share of R&D expenditure in turnover belong to the high-tech sector, whereas a share of between 2.5% and 7% corresponds to medium-tech sectors. The remaining firms are classified as belonging to low-tech industries (Legler and Frietsch 2007). Beside this approach, Spotfolio uses the WZ Code to classify high-tech companies in Germany. Therefore, specific firm data is available about German high-tech firms with regard to VC investments and different types of VC firms (government/corporate/independent VC firms). We aggregated the firm-level VC investments to a regional-level sample of 402 German districts ("*Kreise*") and autonomous cities ("*kreisfreie Städte*"). We assigned the VC investments to the districts by using the zip codes of the firm's headquarters.

Furthermore, we included regional data from four additional data sources: (1) Federal Office for Building and Regional Planning (BBSR) (2) Gründungsatlas, (3) Higher Education Compass and (4) European Patent Office (EPO). The INKAR[18] database of the Federal Office for Building and Regional Planning (BBSR) covers several regional characteristics regarding education, employment and industry at the district level. Entrepreneurship data is obtained from the Gründungsatlas, whereas the Higher Education Compass includes a list of all private and public German universities or universities of applied sciences. Moreover, we obtained information regarding regional patents from the European Patent Office by matching the regional code (NUTS 3-level) with the district code. As a result, our database covers a comprehensive list of VC-financed high-tech firms and regional data in Germany.

4.3.2.2. Variables

Dependent variables

Since we investigate the geographical investment patterns of different VC investors (GVC, IVC, CVC), we calculate three dependent variables for each investor type, namely *number of GVC investments*, *number of IVC investments*, and *number of CVC investments*

[18] INKAR = Indicators, Maps and Graphics on Spatial and Urban Monitoring

between 2011 and 2015 in the corresponding German district. For further robustness checks, we use the natural logarithm of the different dependent variables because the number of VC investments per district is highly skewed.

Independent and control variables

First, we measure the supply of entrepreneurs by using the start-up rate per district. The variable *start-up rate* measures the mean value of the number of start-ups between 2006 and 2010 divided by the number of inhabitants, and is consequently a proxy for entrepreneurship (Block et al. 2013). Second, we include a dummy variable (*technical university dummy*), indicating whether a technical university or technical university of applied sciences exists in the respective district (coded as "1") or not (coded as "0"). This variable ascertains knowledge spillovers between technical universities and VC firms. We focus on technical universities because high-tech firms benefit more from technical universities focused on engineering or science subjects. In addition, technical universities receive higher funds than non-technical universities in order to compete for technology transfer (Audretsch and Lehmann 2005). Third, we include the *population density* to measure the degree of urbanization in a German district. The variable *population density* measures the mean value (2011–2015) of the number of inhabitants divided by km² in the respective district. VC firms might prefer a short distance to network partners and a better infrastructure for monitoring reasons. Fourth, we include the *number of VC firms* by calculating the natural logarithm of the number of VC investors' headquarters and branch offices per district. Prior research has shown that the spatial proximity between VC investor and portfolio company impacts the likelihood of a VC investment (Lutz et al. 2013).

As control variables, we include a variety of explanatory variables based on prior research on VC financing. We use the *student rate* as an indicator for human resources and firm-university knowledge spillover (Block and Spiegel 2013; Fritsch and Schwirten 1999). The variable s*tudent rate* measures how many students are enrolled at a university or university of applied science divided by the number of inhabitants between 2011 and 2015 in that particular district. Furthermore, we measure the innovativeness of the regions by aggregating the mean value of *number of patents granted* (2011–2015) in the respective German district. Since the variable is highly skewed, we use the natural logarithm to reduce the skewness of that variable. Moreover, the variable *GDP per employed person* (in Euros) refers to the economic situation in the respective German district (Porter 2003). In addition, industry variables are calculated as the number of firms in the particular industry divided by

the total number of firms in the respective district (Block and Spiegel 2013). Table 4-4 provides detailed explanations of our variables.

Table 4-4: Variable descriptions.

Variable	Coding
Dependent variables	
Number of GVC investments	Number of GVC investments per German district (2011–2015)
Log (number of GVC investments)	Natural logarithm (number of GVC investments + 1)
Number of IVC investments	Number of IVC investments per German district (2011–2015)
Log (number of IVC investments)	Natural logarithm (number of IVC investments + 1)
Number of CVC investments	Number of CVC investments per German district (2011–2015)
Log (number of CVC investments)	Natural logarithm (number of CVC investments + 1)
Independent variables	
Population density	Number of inhabitants divided by km² (in 1,000) per district
GDP per employed person	Gross domestic product per employed people in € 1,000
Technical university (dummy)	Dichotomous variable (1 = at least one technical university/university of applied science exists in the corresponding German district; 0 = otherwise)
Students rate	Number of students enrolled at a university divided by inhabitants (in 1,000)
Log (number of VC firms)	Natural logarithm (Number of venture capital firms + 1) in a district
Control variables	
Start-up rate	Mean value of number of start-ups divided by employed people (in 1,000) per district from 2006–2010.
Number of patents granted/ log (number of patents granted)	Number of patents granted (EPO) from 2011–2015
Industry variables	Firms per industry divided by all firms (in a district)

Data source: European Patent Office (2018); Eurostat (2010); Federal Office for Building and Regional Planning (2015); Gotsch and Hipp (2012); Hochschulkompass (2015); Spotfolio (2016).

4.3.2.3. Descriptive statistics

The descriptive statistics apply to 402 regional districts in Germany. There are, on average, 2.05 VC investments per district in the years 2011–2015. The highest numbers can be found in *Berlin* (352 VC investments), *Munich* (123 VC investments) and *Hamburg* (47 VC investments). Furthermore, there are, on average, 1.07 IVC investments, .75 GVC investments, and .23 CVC investments per district between 2011 and 2015. The majority of governmental venture capitalists invest in *Berlin* (101 GVC investments), *Munich* (44 GVC investments) and *Hamburg* (24 GVC investments), whereas a large amount of IVC investments between 2011 and 2015 take place in *Berlin* (214 IVC investments), *Munich* (62 IVC investments), and *Cologne* (19 IVC investments). In addition, corporate venture capitalists invested in particular in *Berlin* (37 CVC investments), *Munich* (17 CVC investments), and *Stuttgart* (6 CVC investments). In addition, each district has on average 9.18 start-ups per 1,000 inhabitants between 2006 and 2010, while there is less than one technical university or technical university of applied science per district. Furthermore, there

are, on average, .54 VC firms per district (*number of VC firms*) and 518 people live per km² in each German district.

With regard to our control variables, the following results are noteworthy: the districts in our sample hold an average of 192.91 patents. However, the distribution is highly skewed: the kurtosis is 199.36 (skewness is 12.79). Concerning the student rate, we observe that on average the *student rate* (students enrolled at a university divided by inhabitants) is 32.6 per district between 2010 and 2014. Table 4-5 shows the corresponding descriptive statistics.

Table 4-5: Descriptive statistics.

	Variables	Mean	SD	Min	Max	Skewness	Kurtosis
1	Number of GVC investments	0.75	5.74	0	101	14.62	241.92
2	Log (number of GVC investments)	0.17	0.52	0	4.62	4.38	27.07
3	Number of IVC investments	1.07	11.21	0	214	17.52	327.21
4	Log (number of IVC investments)	0.17	0.55	0	5.37	4.81	33.86
5	Number of CVC investments	0.23	2.09	0	37	15.01	250.67
6	Log (number of CVC investments)	0.07	0.33	0	3.64	6.76	58.47
7	Population density	5.18	6.77	0.37	45.32	2.29	9.00
8	GDP/per employed person	61.50	11.16	44.95	127.8	2.20	11.51
9	Technical university (dummy)	0.06	-	0	1	3.63	14.15
10	Students rate	3.26	6.37	0	50.78	3.16	15.85
11	Number of VC firms	0.54	3.56	0	51	11.94	157.48
12	Log (number of VC firms)	0.16	0.48	0	3.95	4.32	26.36
13	Start-up rate	9.18	2.07	3.27	17.21	0.63	3.62
14	Number of patents granted	192.91	690.66	0	11679	12.79	199.36
15	Log (number of patents granted)	4.06	1.51	0	9.37	-0.3	3.34
16	Mining sector	0.00	0.00	0	0.01	5.01	43.75
17	Manufacturing sector	0.07	0.02	0.03	0.20	0.81	4.90
18	Energy sector	0.02	0.02	0.00	0.13	2.33	10.00
19	Transport sector	0.03	0.01	0.01	0.10	1.38	6.39

Notes: N = 402 districts. SD = Standard deviation.

Table 4-6 shows the correlations and variance inflation factors (VIFs), indicating that the problem of multicollinearity is unlikely to arise in our regression models.

Table 4-6: Correlations and variance inflation factors.

	Variables	1	2	3	4	5	6	7	8	9	10	VIF
1	Population density											2.28
2	GDP/per employed person	0.36*										1.87
3	Technical university (dummy)	0.30*	0.11*									1.15
4	Students rate	0.46*	0.13*	0.27*								1.74
5	Log (number of VC firms)	0.49*	0.38*	0.17*	0.22*							1.51
6	Start-up rate	-0.14*	-0.25*	-0.02*	-0.32*	0.03*						1.53
7	Log (number of patents granted)	0.42*	0.59*	0.20*	0.20*	0.38*	0.59*					2.09
8	Mining sector intensity	-0.34*	-0.11*	-0.10*	-0.24*	-0.18*	-0.11*	-0.15*				1.26
9	Manufacturing sector intensity	-0.48*	-0.20*	-0.21*	-0.39*	-0.33*	-0.20*	0.02*	-0.33*			1.90
10	Energy sector intensity	-0.40*	-0.04*	-0.14*	-0.26*	-0.20*	-0.04*	-0.11*	-0.20*	0.23*		1.42
11	Transport sector intensity	0.03*	0.01*	0.00*	-0.07*	0.05*	0.01*	-0.17*	0.05*	-0.09*	-0.13*	1.10

Notes: N = 402 districts. VIF = Variance inflation factor, estimated for Model 5; * Coefficients are significant at a 5% level.

Furthermore, Figures 4-A2, 4-A3, 4-A4 and 4-A5 (see Appendix) show the geographic distribution of VC investments in Germany in the years 2011–2015. The maps apply to 96 districts ("*Raumordnungsregionen*") in Germany. A high number of VC investments with more than 20 VC investments in 2011–2015 exists, for example, in *Berlin*, *Munich*, *Hamburg*, *Cologne*, *Stuttgart*, and *Aachen*. However, several districts do not show any VC investments (e.g., *Bielefeld*, *Bremen-Umland*, *Landshut*, *Main-Rhön, Siegen*). Figures 4-A2–4-A4 depict the geographic distribution of GVC, IVC, and CVC investments in the years 2011–2015. In general, a large number of both GVC and IVC investments take place in metropolitan areas, such as *Berlin*, *Munich*, *Hamburg* and *Cologne/Dusseldorf*. The number of CVC investments, however, is geographically concentrated in *Berlin* and *Munich*. In total, only a few districts exist with CVC investments.

4.3.3. Results

4.3.3.1. Method

The variables that capture the *number of VC investments (GVC, IVC, and CVC investments)* have a count-data character, i.e., the outcome is a non-negative integer variable. Moreover, a large number of districts does not have any VC investment at all. To address both the count-data character and the excess zeros of our dependent variable, we use a zero-inflated negative binomial regression. The highly significant Vuong statistic supports our approach. We estimate three zero-inflated negative binomial regressions (Table 4-7): Model 1 includes all GVC investments, whereas models 2–3 include IVC and CVC investments respectively. We conduct a seemingly unrelated estimation and a coefficient difference test to check across models for significant differences between the several VC investor types. As a robustness

check, we estimate a seemingly unrelated regression (Table 4-8) using the natural logarithm of *number of GVC investments*, *number of IVC investments*, and *number of CVC investments,* since the distribution of each dependent variable is highly skewed. Again, to assess the varying impact of regional determinants on the different VC types, we report the results of coefficient difference tests (Table 4-8). We run a seemingly unrelated regression analysis, since the error terms of the different equations could be correlated with each other (Zellner 1962).

4.3.3.2. Multivariate results

Table 4-7 displays the results of seemingly unrelated estimation based on three zero-inflated negative binomial regressions. H4 states that GVC firms invest more frequently in regions with a low population density than IVC and CVC firms, whereas H5 addresses the investments in economically weak regions. Using the number of GVC investments as the dependent variable (Model 1), the variable *population density* shows a significant negative effect ($p < 0.10$), whereas the variable *GDP per employed person* is insignificant. Moreover, the coefficient difference test (Model 7) reveals that the effects of *population density* on GVC, IVC, and CVC investments differ significantly from each other ($p < 0.05$). In particular, *population density* has a stronger effect ($p < 0.05$) on GVC than on IVC investments (Model 4). Thus, our results support H4a but we do not find support for H4b. Although there is no statistically significant difference (Model 7) between the effects of *GDP per employed person* on GVC, IVC, and CVC investments, the effects of *GDP per employed person* on GVC and CVC investments ($p < 0.05$) differ significantly from each other (Model 5). Hence, H5b is supported by our data, whereas H5a is not. H6 states that GVC firms invest more often in districts in which a technical university is located than IVC or CVC firms. Our results only show a significant coefficient difference ($p < 0.05$) between GVC and IVC firms (Model 4), and hence support H6a but not H6b. Furthermore, H7 refers to the positive effect of the *student rate* on VC investments in a district. The effect is significantly higher ($p < 0.01$) for GVC firms than for CVC firms (Model 5), and for IVC than for CVC firms (Model 6). As a result, the data clearly supports our H7b but not H7a. Moreover, H8 posits that the local bias of VC investments is more pronounced for GVC firms than for IVC and CVC firms. The coefficient difference tests indicates that GVC firms invest more frequently in geographically nearby portfolio companies than IVC firms ($p < 0.05$; Model 4), and thus supports H8a.

A number of control variables show significant results. Using the *number of GVC investments* (Model 1) as dependent variable, both the *start-up rate* ($p < 0.01$) and *log*

(number of patents granted) ($p < 0.01$) show significant results. In addition, Model 5 reveals that the effect of the start-up rate on VC investments is higher for GVC than for CVC investments ($p < 0.01$). However, the results do not show a significant difference of the effect of patents in a region on the investment behavior of the several VC types (Model 7).

Table 4-7: Zero-inflated negative binomial regressions on VC investments at the district level.

Model	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
Dependent variable	**Number of GVC investments**	**Number of IVC investments**	**Number of CVC investments**	**Diff. (1) v (2)**	**Diff. (1) v (3)**	**Diff. (2) v (3)**	**Diff. (1) v (2) v (3)**
Independent variables							
H4: Population density	-0.103***	-0.020	-0.120***	**		**	**
	(0.027)	(0.028)	(0.043)				
H5: GDP per employed person	-0.010	0.011	0.004		**	*	
	(0.012)	(0.011)	(0.011)				
H6: Technical university (dummy)	1.483***	0.307	2.045*	**			**
	(0.550)	(0.398)	(1.195)				
H7: Students rate	0.054**	0.009	-0.143**		***	**	***
	(0.023)	(0.031)	(0.068)				
H8: Log (number of GVC firms)	0.679***			**			*
	(0.079)						
H8: Log (number of IVC firms)		0.534***		**			*
		(0.042)					
H8: Log (number of CVC firms)			0.386***	**			*
			(0.073)				
Control variables							
Start-up rate	0.038***	0.033***	0.017**		***	**	***
	(0.011)	(0.010)	(0.008)				
Log (number of patents granted)	0.057***	0.060***	0.012				
	(0.018)	(0.016)	(0.013)				
Industry variables	Yes	Yes	Yes				
Years	2011–2015	2011–2015	2011–2015				
Observations	402	402	402				

Notes: Seemingly unrelated estimation based on a zero-inflated negative binomial regression, (SE) are in parentheses. Diff. = Coefficient difference test. ***p < 0.01. **p < 0.05. *p < 0.1.

Moreover, we conduct a seemingly unrelated regression as a robustness check of the main models, to test for differences between VC investor types (Table 4-8). The majority of our results are confirmed by the robustness check. According to Model 4–7, various effects show a statistically significant difference between the effects of the regional determinants on VC investments of different VC types (GVC, IVC, and CVC). In particular, the results (Model 7) indicate that the effects of the different VC types regarding *student rate*, *log (number of GVC firms)*, *log (number of IVC firms)*, *log (number of CVC firms)*, *start-up rate*, and *log (number of granted patents)* differ significantly from each other. Moreover, the variable *technical university* has a stronger effect on GVC investments than on IVC or CVC investments ($p < 0.10$) in a German district (Model 4–5). In addition, the coefficients of the *student rate* regarding GVC and CVC investments are statistically different from each other ($p < 0.01$). We also find support for a significantly stronger positive effect of the corresponding number of VC firms on the number of GVC investments (Model 4 and Model 5).

Table 4-8: Seemingly unrelated regression on VC investments at the district level.

Model	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
Dependent variable	**Log (number of GVC investments)**	**Log (number of IVC investments)**	**Log (number of CVC investments)**	**Diff. (1) v (2)**	**Diff. (1) v (3)**	**Diff. (2) v (3)**	**Diff. (1) v (2) v (3)**
Independent variables							
H4: Population density	0.004	0.005	0.006**				
	(0.004)	(0.004)	(0.003)				
H5: GDP per employed person	0.004**	0.003*	0.004**				
	(0.002)	(0.002)	(0.002)				
H6: Technical university (dummy)	0.175**	0.040	0.054	*	*		
	(0.083)	(0.075)	(0.062)				
H7: Students rate	0.016***	0.015***	0.001		***	***	***
	(0.004)	(0.003)	(0.003)				
H8: Log (number of GVC firms)	0.679***			*	***	*	**
	(0.079)						
H8: Log (number of IVC firms)		0.534***		*	***	*	**
		(0.042)					
H8: Log (number of CVC firms)			0.386***	*	***	*	**
			(0.073)				
Control variables							
Start-up rate	0.038***	0.033***	0.017**		**	*	*
	(0.011)	(0.010)	(0.008)				
Log (number of patents granted)	0.057***	0.060***	0.012		***	***	***
	(0.018)	(0.016)	(0.013)				
Industry variables	Yes	Yes	Yes				
Years	2011–2015	2011–2015	2011–2015				
Observations	402	402	402				

Notes: Seemingly unrelated regression, (SE) are in parentheses. Diff. = Coefficient difference test. *** p < 0.01. **p < 0.05. *p < 0.1.

4.4. Discussion

4.4.1. Discussion of study 1

With regard to entrepreneurial opportunities and IP output, we find a positive effect of venture capital on the IP output of high-tech firms, which is in line with our hypothesis (H1). This finding confirms previous results: for example, Kortum and Lerner (2000) underline the positive effect of venture capital activity within an industry on the patenting rate of a firm. However, it can be argued that venture capital does not necessarily induce IP output. The selection process of venture capital-financed firms itself might be responsible for the fact that these firms hold more patents or trademarks than others (Engel and Keilbach 2007; Florida and Kenney 1988a). We address this in the last section of this paper, as it poses a limitation to the generalizability of our results.

The empirical results indicate that being a small firm decreases the likelihood of holding a patent or trademark. In other words, the IP output increases with the size of the firm. The results confirm the theoretical argumentation that SMEs face problems such as the liability of newness, a lower degree of absorptive capacity, and consequently a lower IP output compared to larger firms. This is in line with previous results (e.g., Arundel and Kabla 1998; Henderson and Cockburn 1996; Kleinknecht 1989; Naz et al. 2015).

Although prior research indicates that universities are a key element in regional innovation systems (e.g., Cooke et al. 1997), our results do not show an effect on a firm's IP output. A possible explanation lies in the use of the dependent variables (*patents* and *trademarks*). According to Acs et al. (2002), patents might underrepresent research spillovers and other proxies might be more appropriate for the measurement of university knowledge spillovers. The dataset might be another reason for the insignificant results. On the one hand, the number of firms in the various technical university districts is relatively low (see Figure 4-A1), which might lead to an underrepresentation of spillover effects. On the other hand, the focus on the German district level is very specific and limits the research spillover effects of technical universities. It is unlikely that there are no spillover effects whatsoever to other German districts near the actual district of the technical university. Anselin et al. (1997) find empirical evidence that university spillovers on innovation extend over approximately 80 kilometers. Therefore, technical universities might have an impact on neighboring districts that have not been considered in our analyses.

Interestingly, the *student rate* shows a significant effect on the IP output. In contrast to the variable *technical university*, the variable *student rate* refers to all German universities and universities of applied science. This might explain the difference between the results. Previous studies indicate a positive relationship between the student rate and the regional innovation output (Block and Spiegel 2013). It appears that the regional variable *student rate* has a direct impact on a firm's IP output. Naz et al. (2015) use the variable *graduates per employee* instead of *student rate*, but the results do not show any significant effect on a firm's innovation output. They argue that students might migrate to other regions after graduation. This contradicts the results presented in this study. Our significant finding shows that the regional *student rate* has a direct impact on the firm's IP output. Thus, firms seem to be able to hire highly skilled workers from universities and translate their human capital into an increase in IP output.

Furthermore, firms often favor both patents and trademarks instead of using only one of the protection rights. This is consistent with previous research, which points out that trademarks and patents are often used in conjunction (e.g., Thomä and Bizer 2013). Previous research has also indicated that firms' motives for obtaining trademarks and patents overlap, but also differ in several respects. In particular, SMEs file trademarks due to protection, marketing, and exchange motives (Block et al. 2015). According to Block et al. (2015), the latter includes increased negotiating power with regard to external shareholders, such as investors. Marketing motives refer to the increase of brand equity or corporate image, while protection refers to the prevention of imitations and free riding (Block et al. 2015). Both protection and exchange motives play an important role when filing patents (Blind et al. 2006). Additionally, blocking and strategic motives play an important role when filing patents. While protection, reputation and blockade motives are relatively independent of firm size, exchange motives tend to be less important for small firms than large ones (Blind et al. 2006).

4.4.2. Discussion of study 2

With regard to VC financing across regions, our empirical results indicate significant differences between VC investor types. This finding is in line with arguments put forward in previous research, showing that governmental, independent, and corporate venture capitalists differ in terms of investment objectives, and possess different skills and network partners (e.g., Colombo and Murtinu 2017; Guerini and Quas 2016; Luukkonen et al. 2013). Although

all VC types (GVC, IVC, and CVC firms) invest more frequently in regions in which the VC firm is located, GVC firms appear to be especially influenced by regional characteristics.

Population density (H4) shows a significant negative effect on GVC and CVC investments, which is in line with the objectives of governmental and corporate venture capitalists. In particular, GVC firms regularly consider social payoffs and regional development as a key priority instead of high financial returns (Colombo et al. 2016). Hence, an investment focus on metropolitan areas is less pronounced for GVC than for IVC firms. Also, CVC firms' objectives are not purely of a financial nature, but rather focus on new or complementary technologies with regard to the parent firm's products (Wadhwa et al. 2016; Yang et al. 2014). Interestingly, the variable *population density* has a negative but insignificant effect on the number of IVC investments. A possible explanation lies in the construction of our independent variable (*population density*), which considers solely the number of inhabitants per km². However, we also measure urban districts/metropolitan areas with two further variables as an additional robustness check. First, we construct a dichotomous variable based on the German statistical office that considers 237 German districts as metropolitan areas. Second, we use the INKAR database, which labels a district as an independent city if the population density is greater than 150 inhabitants per km². Both the dichotomous variable and the additional population density measure show either a non-significant or a significant negative effect on IVC investments in the corresponding district. Hence, urban districts/metropolitan areas do not have a higher market attractiveness for IVC firms per se. Coordination between several actors in the system at the regional level is essential (Harding 2000), as well as, among other factors, a high potential of VC investment opportunities and (syndication) network partners (e.g., Powell et al. 2002; Sorenson and Stuart 2001).

Prior research has shown that VC is not equally distributed across regions (e.g., Cumming and MacIntosh 2003; Fritsch and Schilder 2008; Sorenson and Stuart 2001), and policy makers want to prevent these regional disparities (Bottazzi et al. 2004). GVC firms, however, do not invest more frequently in economically weak regions (measured by GDP per employed person) than IVC or CVC firms. Hence, H5 is not supported by our results. A possible explanation may be a lack of high-tech firms with entrepreneurial opportunities in these regions for not only IVC and CVC but also GVC firms. This explanation is supported by our first study, since high-tech firms are more likely to be located in metropolitan rather than rural areas. VC firms require entrepreneurs who exploit and commercialize innovative and entrepreneurial opportunities. In other words, VC firms need regions with a supply of

entrepreneurs. Although GVC firms often consider job creation and employment growth as one of their key objectives (e.g., Colombo et al. 2016), governmental venture capitalists require potential start-ups in order to invest.

In terms of universities, prior research has shown that universities are a key element in regional innovation systems (e.g., Cooke et al. 1997) and act as network partners to VC firms (e.g., Powell et al. 2002). Our results support the theoretical argumentation that technical universities possess tacit and codified knowledge that leads to locally bound knowledge spillovers (Audretsch and Lehmann 2005), and consequently to a higher number of entrepreneurial opportunities and a higher VC investment in the corresponding district. Interestingly, the existence of a technical university in a district has a positive effect on GVC investments in the corresponding German district and consequently supports H6. This finding is in line with previous research, which argues that GVC firms can add value to portfolio firms by providing and using connections to public institutions or universities (Bertoni and Tykvová 2015). In particular, GVC firms interact more frequently with technical universities that are often players in an innovation system. The results support the findings of Pierrakis and Saridakis (2017), who find that the more publicly dependent a fund is, the more it interacts with the knowledge creation community (e.g., universities, regional R&D institutes, companies of technology parks) in a regional innovation system. Also, the *student rate* positively influences GVC investments per German district. This is in line with previous research, which argues that GVC fund managers have a positive attitude towards academic entrepreneurship and academic spin-off investments (e.g., Colombo et al. 2016; Knockaert et al. 2010). Therefore, our results support H7.

Furthermore, prior research has investigated the link between the spatial proximity of a VC investor and a portfolio company, and the likelihood of a VC investment (e.g., Gompers 1995; Jääskeäinen and Maula 2014; Mason and Harrison 2002). Two lines of argument may explain this phenomenon. On the one hand, network contacts for the identification and appraisal of investment opportunities in the preinvestment phase are likely to decline over distance. On the other hand, VC firms monitor and add value to the portfolio company in the postinvestment phase, which is typically more affordable when the geographic distance between VC investor and investee is shorter (Sorenson and Stuart 2001). Although it has been argued that the spatial proximity between VC firm and portfolio company is less pronounced in denser infrastructures such as Germany (Fritsch and Schilder 2008), our results are in line with Lutz et al. (2013). Even in dense infrastructures, the geographic distance between VC firm and portfolio company positively influences the probability of a VC investment, and

more importantly, this effect appears to be independent of the VC investor type. A possible explanation for the local bias of VC investments in denser infrastructures may be that VC firms unconsciously decide to invest in close portfolio companies, or asymmetric information and a lack of networks exist that lead to investments near the VC firm's location (e.g., Lutz et al. 2013; Zacharakis and Meyer 1998). Additionally, it is noteworthy that the local bias effect is stronger for GVC firms than for IVC or CVC firms, and hence supports H8. Whereas independent and corporate venture capitalists want to have either high financial returns or a window for new technologies, governmental venture capitalists often have objectives that require investments in specific districts.

Furthermore, VC firms require investment opportunities, or in other words, entrepreneurs who successfully exploit and commercialize entrepreneurial opportunities are needed by VC firms. Our results show a significant relationship between the start-up rate and VC investments in the corresponding district. In addition, the coefficients of the effect differ significantly according to VC type. A possible explanation of the significant differences lies in the construction of our independent variable (*start-up rate*). IVC and CVC firms often invest in high-tech industries (e.g., Colombo et al. 2010), but our variable includes all industries/sectors and consequently does not distinguish between low-tech and high-tech start-ups. GVC firms, however, might be more willing to invest in less innovative portfolio firms than other VC types.

4.4.3. Implications for theory and practice

The results have not only theoretical but also practical implications for managers and policy makers. In particular, we contribute to different research streams in VC literature. First, our study adds to the growing literature distinguishing between VC investor types (e.g., Colombo and Murtinu 2017; Guerini and Quas 2016; Gupta and Sapienza 1992). GVC, IVC, and CVC firms possess various objectives, skills and acquaintances, and consequently invest in different regions (e.g., Colombo and Murtinu 2017; Guerini and Quas 2016; Luukkonen et al. 2013). GVC firms, for instance, invest more often in regions where a technical university exists. GVC firms often provide unique relationships to universities or public institutions as an added value (Bertoni and Tykvová 2015), and consequently prefer investing in these regions. Nevertheless, a local bias exists for all VC types. In other words, GVC, IVC, and CVC firms are more likely to invest in regions in which the VC firm's headquarters or district office is located. This effect, however, is more pronounced for GVC firms than for IVC or CVC firms.

Second, our study contributes to the literature about geographical determinants of VC investments (e.g., Chen et al. 2010; Gupta and Sapienza 1992; Mason and Pierrakis 2013). Whereas prior research has especially focused on regional biases of VC and VC clusters (e.g., Chen et al. 2010; Fritsch and Schilder 2008; Mason and Harrison 2002), little is known about regional characteristics that influence the likelihood of regional VC investments. We confirm that a local bias exists in the sense that VC firms invest in portfolio firms located near the investor. Moreover, technical universities appear to attract regional VC investments, whereas a metropolitan bias does not exist. Hence, knowledge spillovers of universities appear to exist in the context of VC investments. However, a region requires an entrepreneurial and VC ecosystem in order to attract regional VC investments. A high population density (metropolitan area) itself is not sufficient, but rather a complex regional ecosystem, including innovative start-ups, qualified employees, and a well-developed infrastructure (e.g., Colombo et al. 2010; Harding 2000; Lutz et al. 2013).

The results of these studies have practical implications for both managers and regional development policies. First, both trademark and patent registrations reflect the innovation activity of high-tech firms. Policy makers can use these indicators in order to examine the success of innovation subsidies or policy instruments. Nevertheless, as indicated by Flikkema et al. (2014), policies have to regulate the possible misuse of subsidies. Firms might apply for trademarks, which are relatively cheap in comparison to patent applications, in order to signal innovations instead of actually developing innovations. Additionally, the IP output tends to depend more on firm-specific factors than on region-specific factors. Political initiatives should focus slightly more on firm-specific measurements in order to improve the IP output of firms. Nonetheless, the indirect effects of regional factors should not be completely disregarded (Naz et al. 2015). Second, our results are useful for managers of high-tech firms. Locations with a high student density appear to improve the IP output. If smaller firms have a lack of resources, it may help if they are located in regions with a high student density, as this allows them to hire highly educated employees more easily. The recruitment of highly-skilled workers may be especially important for firms with financial constraints, since the geographical proximity may help smaller firms to employ students more readily. Another implication for managers refers to venture capital, as our results indicate that the ambition to receive venture capital could increase the IP output of high-tech firms. Although it remains unclear whether the ex-ante selection process of venture capital firms or the ex-post monitoring process and network effects of venture capitalists are responsible for the increase of IP output, firms obviously benefit from venture capital. In addition, managers can use

trademark and patent applications in order to review innovation activities in their industry and compare their own company with other firms (benchmarking studies).

Third, we find a strong pattern of spatial concentration in venture capital. Prior research suggests that VC firms often invest in portfolio companies which are located close by (e.g., Powell et al. 2002; Sorenson and Stuart 2001). Although Germany has a dense economy and infrastructure, the geographic distance between investor and investee remains crucial. On the one hand, entrepreneurs should choose the location of their firm carefully. If entrepreneurs consider VC as a source of financing, a relatively close geographical distance of the venture's location to a venture capital cluster may increase the probability of a VC investment (Lutz et al. 2013; Martin et al. 2005). On the other hand, regional policy makers may attract VC firms to their region to foster the regional development of innovative start-ups and regional economic growth. Also, regional policy makers may consider GVC and CVC firms as an instrument for reducing regional disparities, since it appears that GVC and CVC firms are more likely than IVC firms to invest in rural areas.

4.4.4. Limitations and future research

The research is not without its limitations. Regarding the first study, the measurement of the dependent variables poses a limitation. Although trademark variables and especially patent variables are established as a proxy for innovation output in the literature (e.g., Acs and Audretsch 1989; Block and Spiegel 2013; Gotsch and Hipp 2012; Mendonça et al. 2004), the proxy may under represent university research spillovers or further spillover effects (Acs et al. 2002; Mendonça et al. 2004). Therefore further analyses, such as a multi-level regression, should test these effects.

Furthermore, there is a potential causality problem with regard to venture capital. While we assume that the receipt of venture capital leads to a higher IP output of firms due to the network and knowledge spillover effects of venture capital firms, it can also be argued that firms are selected by venture capital firms because they are notably innovative (Engel and Keilbach 2007; Florida and Kenney 1988a). Therefore, the reason for the IP output of venture-capital financed high-tech firms cannot be properly explained (Engel and Keilbach 2007). Either high-tech firms have a higher IP output because they receive venture capital, or firms are selected by venture capital firms due to their patents and trademarks. Therefore, the selection process of venture capital firms might be the main reason for the high IP output rather than the support, for instance the knowledge spillover effects or the established networks of the venture capital firms.

Future research could complement and expand the current research project. By using the existing Spotfolio data, multi-level regression models could form an additional robustness check in order to explore the effects of different variables at the firm and regional level on the IP output of high-tech firms. The firm level and regional level are two hierarchical levels in the sample which may not be completely independent of each other (Aguinis et al. 2013). Moreover, while this study highlights knowledge spillovers between universities, venture capital firms, and high-tech firms, future research could focus on differences between industries. The differences between low- and high-tech sectors have only received a cursory examination with regard to IP output. The focus has been on either high-tech or low-tech companies rather than including both industries (e.g., Sáenz et al. 2009). A more comprehensive analysis could, for example, look into the effects of human capital and knowledge spillovers. Universities of applied science focus on teaching rather than research, whereas technical universities have their core competencies in engineering and science. The consequences have not been analyzed in detail with regard to the type of innovations. The same applies to venture capital and its spillover effects on product or process innovations. Venture capital might be more effective in specific industries or might depend on the type of innovations.

With regard to the second study, we consider 402 districts of Germany as our unit of observation. However, several variables, such as *technical university*, may have an effect on VC investments in neighboring districts. In other words, a variable that measures the exact location of VC firms (number of GVC, IVC, and CVC firms) or technical universities and a corresponding distance (in km) may be more accurate than matching the location of VC firms or universities to the respective German district. Prior research has shown that, for example, university spillovers on innovation extend over approximately 80 kilometers (Anselin et al. 1997). As a result, the technical university of Munich (TUM), for example, may have spillover effects to German districts that do not only belong to the district of the technical university itself (district *Munich*), but also to other districts such as *Starnberg*, *Dachau*, *Freising*, *Erding*, or *Ebersberg*. In addition, it remains unclear whether our finding that GVC and IVC firms invest in innovative regions is based on a selection or treatment effect. In other words, we cannot unequivocally ascertain whether VC firms select innovative regions for their investment patterns, or whether VC firms encourage firms to actively innovate. Fifth, we have not explicitly considered syndication effects of VC investments. Prior research has shown that a spatial proximity effect exists between venture capital investors and investees in

Germany (e.g., Lutz et al. 2013), but syndication networks expand the radius of VC investments (e.g., Sorenson and Stuart 2001).

In addition, our independent variable *technical university* does not consider non-technical universities or universities of applied sciences that have prominent faculties with a focus on natural sciences, biotechnology or similar areas. Future research may match the faculty footprint with the industries of the firms to analyze knowledge spillovers in a region. Finally, we consider the number of investments rather than the investment sum as our dependent variable. Although this measurement has been used in previous research (e.g., Powell et al. 2002), it might lead to a bias effect of VC investments in Germany. As a result, future research could investigate the investment sum and test regional determinants on the VC patterns of different VC firms.

5 ICO financing for entrepreneurial opportunities

We apply time series analysis to investigate the market cycles of Initial Coin Offerings (ICOs) as well as bitcoin and Ether. Our results show that shocks to ICO volumes are persistent and that shocks in bitcoin and Ether prices have a substantial and positive effect on these volumes – with the effect of bitcoin shocks being of shorter duration than that of Ether shocks. Moreover, higher ICO volumes cause lower bitcoin and Ether prices. Finally, bitcoin shocks positively influence Ether but not the other way round. Our study has implications for financial practice, in particular for cryptocurrency investors and entrepreneurial firms conducting ICOs.[19]

[19] The study in this Chapter has been published as: Masiak, C., Block, J. H., Masiak, T., Neuenkirch, M., and Pielen, K. N. (2019). Initial Coin Offerings (ICOs): Market Cycles and Relationship with Bitcoin and Ether. *Small Business Economics*. https://doi.org/10.1007/s11187-019-00176-3.

5.1. Introduction

Cryptocurrencies are digital currencies that rely on distributed ledger technology (DLT)[20]. They emerged with the invention of the first cryptocurrency, Bitcoin, introduced by Nakamato in 2008 (Nakamoto 2008). Bitcoin is based on cryptographic proof and allows transactions between two untrusted parties without an additional intermediary (e.g., clearing house). Whereas Bitcoin is based on a proof-of-work blockchain[21], Ether as the second most important cryptocurrency in terms of market capitalization intends to implement a proof-of-stake[22] blockchain (Catalini and Gans 2017). Cryptocurrencies, such as bitcoin or Ether[23], have gained momentum since 2017 and a hype has emerged around them. The market capitalization of cryptocurrencies has sky-rocketed and public awareness has considerably grown. Bitcoin prices reached a peak of approximately 19,361 USD per bitcoin in December 2017. This hype, together with the diffusion of blockchain technology, has furthered Initial Coin Offerings (ICOs) as a new financing instrument for entrepreneurial firms with DLT-based business models. In ICOs[24], ventures raise capital by selling tokens to a number of investors (the "crowd") in exchange for cryptocurrencies (e.g., bitcoin or Ether) or fiat (e.g., USD, EUR) (Fisch 2019).

Typically, DLT-based ventures create their own cryptocurrency and distribute it among investors against bitcoin or Ether in an ICO. According to CoinSchedule, more than $12.0 billion has been raised in 767 ICO campaigns since 2016, highlighting the relevance of ICOs for the proliferation of entrepreneurial finance. We expect to see market cycles, as well as evidence of persistence, in that past ICO volumes influence subsequent ones. Such an effect would be in line with the research on Initial Public Offerings (IPOs) (e.g., Lowry and Schwert 2002). Most ICOs are token-based[25] and require the investor to exchange cryptocurrencies such as bitcoin and Ether for tokens. Hence, we expect bitcoin or Ether prices to be a leading indicator for subsequent ICO volumes. In this context, our study

[20] Blockchain is the most frequently used type of distributed ledger technology. Specifically, it is a decentralized, public transaction ledger.

[21] The validity of the public ledger is based on "mining". In other words, computer power is needed to verify and extend the transaction logs over time (Catalini and Gans 2017).

[22] The validity of the public ledger will have a deterministic basis in the future. Another difference between Bitcoin and Ethereum is the script language. Ethereum uses the script language Solidity that allows computations within the blockchain, whereas Bitcoin is only able to conduct multi-signature functions. Ethereum therefore allows more complicated procedures. (Hosp 2018)

[23] Bitcoin (with a capital "B") refers to the concept of the first decentralized currency based on a blockchain, whereas bitcoin represents the cryptocurrency itself (currency unit) (Hosp 2018). Similarly, Ethereum means the open source platform that is based on blockchain technology, while Ether refers to the cryptocurrency (currency unit) (Hosp 2018).

[24] An ICO is sometimes referred to as either a "crowdsale" or "token sale" (Fisch 2019).

[25] Tokens represent a specific asset or utility that is based on a DLT. Tokens can represent any assets that are fungible and tradeable, such as commodities or any other cryptocurrencies (Hosp 2018).

examines the following interrelated research questions: first, to what extent are ICO volumes persistent? Second, to what degree do bitcoin and Ether prices influence ICO volumes and vice versa?

To address our research questions, we collect a dataset that covers ICO volumes, bitcoin and Ether prices over a period of 68 weeks from January 2017 to April 2018. Our data sources are CoinSchedule (https://www.coinschedule.com/) for ICOs and CoinMarketCap (https://coinmarketcap.com) for bitcoin and Ether prices in USD. To test our predictions, we apply a recursively identified vector autoregression (VAR) model to the three time series under consideration. Our results show that shocks to ICO volumes are indeed persistent and that shocks in bitcoin and Ether prices have a substantial and positive effect on ICO volumes – with the effect of bitcoin shocks on ICO volumes being of shorter duration than the effect of Ether. Moreover, higher ICO volumes cause lower Ether and bitcoin prices. Finally, bitcoin shocks positively influence Ether but not the other way round, supporting the notion that bitcoin is the dominant cryptocurrency. Our results are robust when considering the number of ICOs rather than ICO volumes.

Our study contributes to the small but growing entrepreneurial finance literature on ICOs and cryptocurrencies (e.g., Adhami et al. 2018; Amsden and Schweizer 2018; Cheah and Fry 2015; Fisch 2019). It also contributes to the literature on the funding dynamics in crowd-based venture financing (Hornuf and Schwienbacher 2018; Vismara 2018, Cumming and Hornuf 2018). Our results have implications for financial practice, particularly for entrepreneurial firms seeking to conduct an ICO. Such firms can see from our results that market timing is an important factor determining the success of an ICO, and that not only past ICO volumes matter in this regard, but also that bitcoin and Ether prices have substantial effects.

The remainder of the chapter is organized as follows: Section 5.2 provides background information on ICOs and cryptocurrencies. Section 5.3 introduces the data employed and explains the econometric methodology. Section 5.4 presents and discusses the empirical results, while Section 5.5 concludes with the chapter's implications, its limitations, and avenues for future research.

5.2. Context and theoretical background

5.2.1. Blockchain technology

A blockchain consists of a chain of blocks of transaction data and represents a decentralized, public transaction ledger. According to Iansiti and Lakhani (2017), the technology is based on five basic principles: first, each party in the blockchain has access to the entire database and its transaction history. Hence, a *distributed ledger* exists in which no single party is able to control all the information, but rather every party can directly verify and view the transaction records of the other parties. An intermediary (e.g., a clearinghouse) is consequently unnecessary. Second, communication is based on *peer-to-peer transactions* instead of central nodes. Information is stored and forwarded to each node. Third, transactions are *transparent* and *pseudonymous*. The entire transaction records are visible to the public. Each blockchain user, however, receives an identifier (alphanumeric address). If a user shares identity with others, everyone can read the history of his/her transactions on the public blockchain. Fourth, blockchain technology is characterized by *irreversibility*. A blockchain consists of a chain in which each block is incorporated into the subsequent one and an alteration of the transaction record is not possible. Fifth, a blockchain is based on *computational logic*. In other words, by using algorithms, users can trigger transactions between nodes.

Blockchain technology enables various application opportunities and different types of transactions. Finance and accounting, for instance, is one specific experimentation field for blockchain technology. By using this technology, firms' accounting records can be audited automatically without disclosing the identity of the entities involved (Iansiti and Lakhani 2017). Cryptocurrencies, such as bitcoin and Ether, are an additional application of blockchain technology itself and are described in more detail in the next section.

5.2.2. Cryptocurrencies

Cryptocurrencies are digital currencies and applications of DLT, in which all rules and regulations are programmed in a cryptographic algorithm. The vast majority of cryptocurrencies are based on a peer-to-peer network and a blockchain, where all transactions are recorded and validated as a ledger. Similar to gold, Euro, US dollar, Japanese yen or any further fiat currency, cryptocurrencies can be used to buy or sell products and services. In the case of cryptocurrencies, the value is simply based on supply and demand, and is not

influenced by government and/or central banks. Furthermore, cryptocurrency users can transfer a value without intermediaries or geographic limitations.

Bitcoin and Ether are one of the most important cryptocurrencies as of 2018 (in terms of market capitalization) and represent a widely accepted medium of value exchange (Fisch 2019). The invention of Bitcoin resulted in the creation of further coins such as Ripple, IOTA, and EOS. Currently, more than 1,500 different coins exist that are also traded and listed on websites (see coinmarketcap.com for a comprehensive list of coins and the respective market cap, price and circulating supply).

5.2.3. ICOs

A universally accepted definition of an ICO does not yet exist (e.g., Fisch 2019). Therefore, we provide a broad definition of an ICO that covers its main characteristics and enables it to be distinguished from other financial instruments in the entrepreneurial finance literature. In an ICO, DLT-based ventures generally raise capital by selling tokens (rather than shares, as in an IPO) to investors in exchange for cryptocurrencies (e.g., bitcoin or Ether) or fiat (e.g., Euro, Dollar) (Fisch 2019). Tokens represent an asset or utility that is based on DLT. There are different types of tokens, namely currency tokens, equity tokens, utility tokens, and reward tokens. Currency tokens or coins are digital tokens, which were initially introduced with Bitcoin in 2008 by Satoshi Nakamoto. They refer to a digital medium of exchange (Fisch 2019). Equity tokens (or security tokens) represent ownership rights to an asset (e.g., company stock). In line with the Howey test[26], equity tokens fall under the regulatory scope of the US SEC, since they are categorized as securities under securities law. Utility tokens (also known as app coins or app tokens) provide users with a specific utility, such as a product or service (similar to reward-based crowdfunding) (Fisch 2019). They allow investors to fund the development of a blockchain project and gain access to the specific service or product in the future. Since utility tokens are not considered as securities according to the Howey test, these tokens do not fall under the securities law and are consequently not regulated yet. Furthermore, reputation (or reward) tokens also exist. These tokens give a reward to users who are active on a particular platform. For instance, users who publish content on certain social networks, such as Steemit, earn rewards for their contributions.

Regardless of the type of token used, the common link between all past and future ICOs is that buyers of tokens generally speculate that their value will increase, and that they will be able to secure or sell them in secondary markets. Moreover, it is worth mentioning that tokens

[26] The Howey test determines whether certain transactions are securities (BitTrust 2017).

often do not have a counter-value at the time of the ICO. The technological nature of blockchain technology means that ICOs are not applicable to every entrepreneurial firm or venture (Fisch 2019). Hence, investors face both high information asymmetries and a high risk of investment failure.

Since the ICO market is relatively unregulated and different token types exist, ICO campaigns differ substantially from each other. Nevertheless, the main actors in every ICO campaign are the venture/entrepreneurial firm (capital seekers) that initiates an ICO campaign, investors (the crowd), trading exchanges (intermediaries), and contributors (e.g., external participants that work for the ICO campaign). An ICO campaign typically contains three stages, which can last several months and have specific incentives for investors (Benedetti and Kostovetsky 2018).

Pre-ICO phase. A venture/entrepreneurial firm intends to run an ICO campaign. In preparation, the firm usually publishes a white paper and launches a website to inform potential investors about the ICO campaign (Fisch 2019). A white paper is an (electronic) document that provides the key information about the ICO campaign and is similar to a business plan (Fisch 2019). However, white papers are published voluntarily and are not subject to particular standards or specific guidelines. Whereas some white papers contain detailed information about the technology, others simply focus on financing aspects, the project team or the product/service itself. Furthermore, the entrepreneurial firm normally announces an advisory board (to signal the quality of the ICO project) and hires experts (e.g., marketing experts, legal advisors) for conducting the ICO campaign, in exchange for either capital or a considerable number of tokens. In particular, smaller firms with a lack of finance and resources tend to purchase external expertise in order to indicate their quality commitment to potential investors and to differentiate their ICO from other campaigns.

In order to test market acceptance, firms conducting an ICO often offer *private sales* or *pre-sales*. Private discussions or pitches from the venture/entrepreneurial firm to potential investors, create interest in the ICO campaign and a willingness to invest (in a private sale) before the actual start of the ICO. At this stage, investors are usually able to invest fiat instead of cryptocurrencies (e.g. bitcoin or Ether), which simplifies the process for both investors and capital seekers, since they do not need to change fiat to cryptocurrencies. In the case of a public *pre-sale*, firms conducting an ICO also try to gauge the market acceptance of their ICO, as well as the smoothness of the ICO process (e.g., transfer of cryptocurrency investments to the accounts of the venture). In general, investors use trading exchanges, such

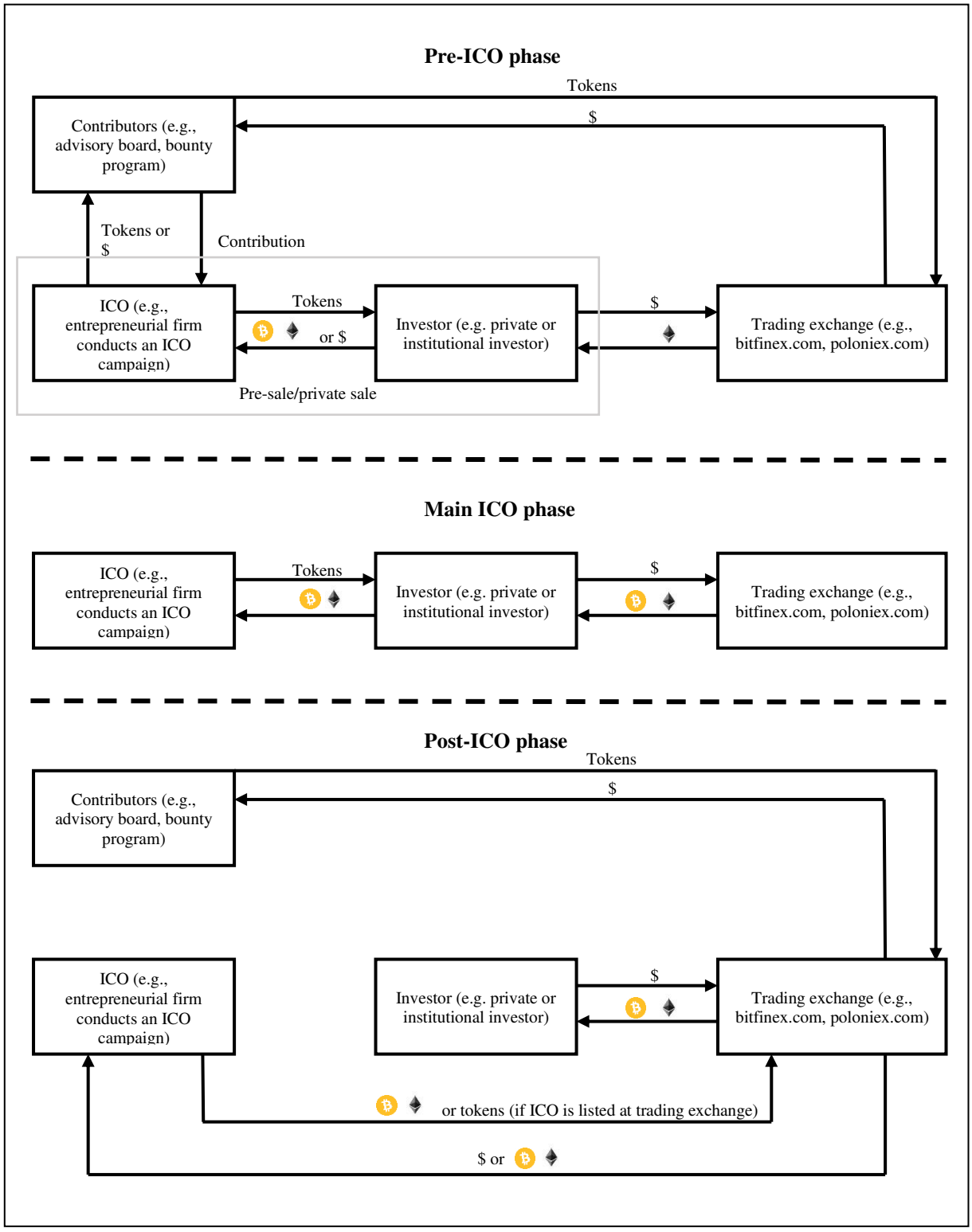
as bitfinex.com, to exchange fiat (e.g., dollars or Euros) for cryptocurrencies (mostly Ether) in order to invest in the ICO. Investors in the *private sale* or *pre-sale* phase typically receive discounts on the token price.

Main ICO phase. To promote the ICO campaign, the venture usually provides bonus schemes for ICO investors. As a result, early investors in the main ICO phase receive more tokens for the same token price. In order to receive tokens, potential private or institutional investors typically have to invest cryptocurrencies. Some investors already possess a considerable amount of cryptocurrencies. If not, these investors generally use trading exchanges, such as bitfinex.com, to exchange fiat (e.g., dollars or Euros) for cryptocurrencies in order to invest in an ICO campaign. Interestingly, the venture itself can decide the duration of the ICO campaign and can also extend the time for collecting money.

Post-ICO phase. After an ICO campaign, several actors (investors, venture/entrepreneurial firm, contributors) aim to exchange tokens for fiat, and transactions involving tokens, fiat, and cryptocurrencies rise significantly. In particular, an entrepreneurial firm or venture that has conducted an ICO needs fiat in order to make investments and develop the product or service based on blockchain technology.[27] Trading exchanges offer the opportunity to change tokens to fiat or other cryptocurrencies. In order to trade tokens, the ICOs have to be listed on the trading exchange which typically takes time (often several months). Besides the ICO firms, investors will aim to increase the value of the tokens they receive and will sell them if their value rises considerably. The same is true for contributors to an ICO campaign. In particular, smaller ventures have a lack of resources and often do not have specialists to conduct an ICO campaign for them. Hence, such experts are hired for an ICO campaign and are normally paid in tokens. Moreover, the majority of ICO campaigns include an advisory board. The members are typically rewarded with tokens and signal the technical and economic expertise of the corresponding ICO campaign. As is the case with investors, the contributors will typically sell the tokens after the ICO campaign if their value rises sharply. Figure 5-1 summarizes the ICO process including the key actors and steps involved.

[27] However, ventures are often not able to directly sell all their tokens. To signal the integrity of the ICO campaign, ventures typically lock a certain number of tokens for the team of the venture (for approximately 6–24 months). Furthermore, ventures need a business bank account that allows the transfer of fiat to cryptocurrency transactions, since a large number of banks do not accommodate businesses that wish to trade in cryptocurrencies. In other words, the authorization procedure takes time and ventures are often not able to directly exchange cryptocurrencies for the required fiat money.

Figure 5-1: Mechanism of ICO campaigns.



Reference: Own illustration.

5.2.4. Related Literature

Although ICOs have achieved remarkable success by raising more than $11.3 billion since 2016, little has been published in peer-reviewed work to date on ICO mechanisms and dynamics. Adhami et al. (2018) have analyzed the determinants of ICO success using a hand-collected dataset from 253 ICO campaigns. In particular, the publicly available code source of the ICO, pre-sale of tokens, and the offering of tokens that allow investors to access a specific service positively influence the success of an ICO. Fisch (2019) analyzed 423 ICOs between 2016 and 2018. He found that high-quality source codes and technical white papers have a positive effect on the amount raised in an ICO. According to the analysis of Amsden and Schweizer (2018), venture quality (e.g., large ICO team size) positively influences an ICO's success, whereas venture uncertainty (e.g., short white papers, not being on social media channels such as Telegram or Github) has a negative effect on ICO success. Further working papers, such as Conley (2017), Enyi and Le (2017), Venegas (2017) and Yadav (2017), do not analyze empirical data but rather focus on the legal nature of cryptocurrencies and ICOs, or a theoretical analysis of token types. Hence, the majority of working papers to date have primarily focused on either technical descriptions of ICO campaigns or the determinants of success by analyzing single project characteristics.

The two streams of literature most closely related to our study deal with market cycles of cryptocurrencies and IPOs. With regard to cryptocurrencies, Brauneis and Mestel (2018) find that bitcoin is the most efficient cryptocurrency by virtue of being the least predictable. Using vector autoregression and impulse response results, Urquhart (2018) shows that the attention received by bitcoin is influenced by both the volatility and volume realized the previous day. Applying different GARCH models, Katsiampa (2017) reveals that the bitcoin market is highly speculative and the optimal model for predicting bitcoin prices is the AR-CGARCH. Urquhart (2017) finds price clustering in bitcoin at round numbers. Furthermore, Corbet et al. (2018) show that cryptocurrencies are interconnected, but disconnected from other financial markets such as the S&P500 or gold.

Not only similar terminology ("Initial Coin Offering" vs. "Initial Public Offering") but also similar characteristics (e.g., trading on exchanges) of ICOs and IPOs show how closely these financing instruments are related (Fisch 2019). However, two main differences exist between ICOs and IPOs (Benedetti and Kostovetsky 2018): first, investors are able to buy shares in a company in an IPO, whereas ICO investors purchase a different asset (tokens). Second, ICO campaigns typically take place in the early stage of a venture's life cycle, while

IPOs are normally reserved for later stages or are used as an exit strategy. Nevertheless, both financing instruments are normally traded on secondary markets and it is unclear whether market cycles of IPOs and bubbles can be also found in ICOs. With regard to IPOs, prior research has used time series analyses to evaluate their market cycles, timing, and equity returns (e.g., Lowry 2003). According to Lowry and Schwert (2002), high IPO returns on the first day lead to high IPO activity over about six months. In other words, more firms go public once they see other firms obtaining high initial returns. Yung et al. (2008) argue that positive shocks lead to more firms going public. IPOs issued during "hot" quarters, for instance, are more likely to delist than those in cold quarters. Subsequent research finds similar results: IPO volume is sensitive to contemporaneous IPOs, and if firms in a particular industry go public, this is indicative of the overall growth prospects of the specific industry and affects IPO market cycles (e.g., Benveniste et al. 2003). Furthermore, some prior studies use VAR models to identify market cycles of IPOs. Lowry et al. (2010) show that initial IPO returns fluctuate considerably over time and are significantly higher during hot IPO markets. Using a VAR model, Doidge et al. (2017) reveal a considerable decline in publicly listed companies in the US in 2010 compared to 1975.

Whereas market cycles of both IPOs and cryptocurrencies have been analyzed, to date no research exists about the market cycles of ICOs and how these interact with cryptocurrencies such as bitcoin and Ether.

5.3. Data and econometric methodology

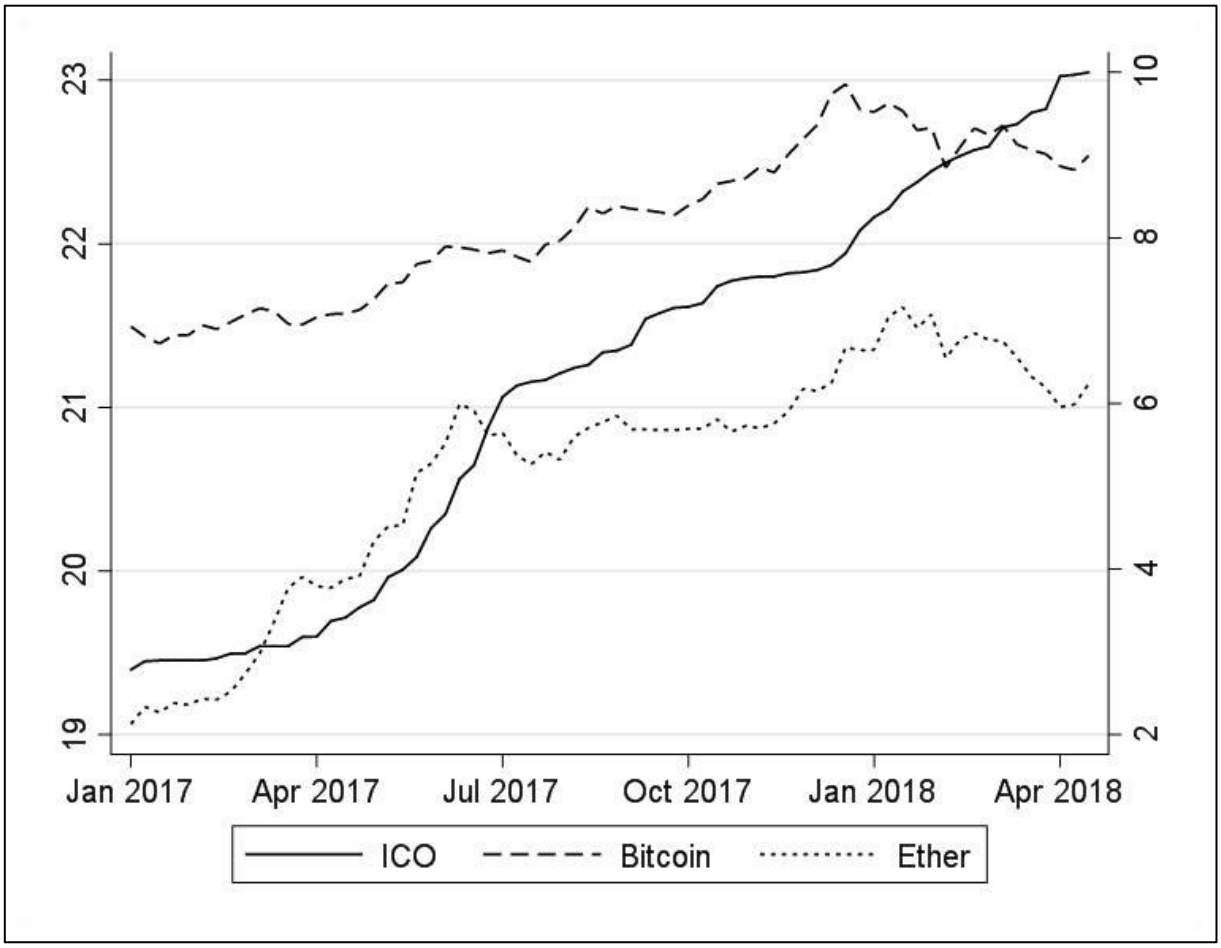
5.3.1. Data

Our dataset covers 68 weekly observations for the period from 2 January 2017 to 16 April 2018, and consists of three variables: (i) the cumulative amount raised in ICO campaigns, (ii) the price of bitcoin, and (iii) the price of Ether. All three variables are measured in logs. We use two different data sources. First, CoinSchedule provides a comprehensive list of ICOs, and has been used in a previous article (Fisch 2019). Beside the amount raised in the ICO in USD, CoinSchedule includes information about the date of the ICO and the website of the corresponding ICO campaign. Second, CoinMarketCap provides information on daily bitcoin and Ether prices in USD. As we have permission to access Application Program Interface (API) calls, we can retrieve daily bitcoin and Ether prices.

Figure 5-2 shows the evolution of these variables over time and Table 5-A1 in the Appendix displays descriptive statistics. All three variables exhibit a clear upward trend. The

strongest average growth rate can be found for Ether (6.55% per week), followed by the ICO indicator (5.93% per week), and bitcoin (4.42% per week).

Figure 5-2: ICO, bitcoin, and Ether over time.

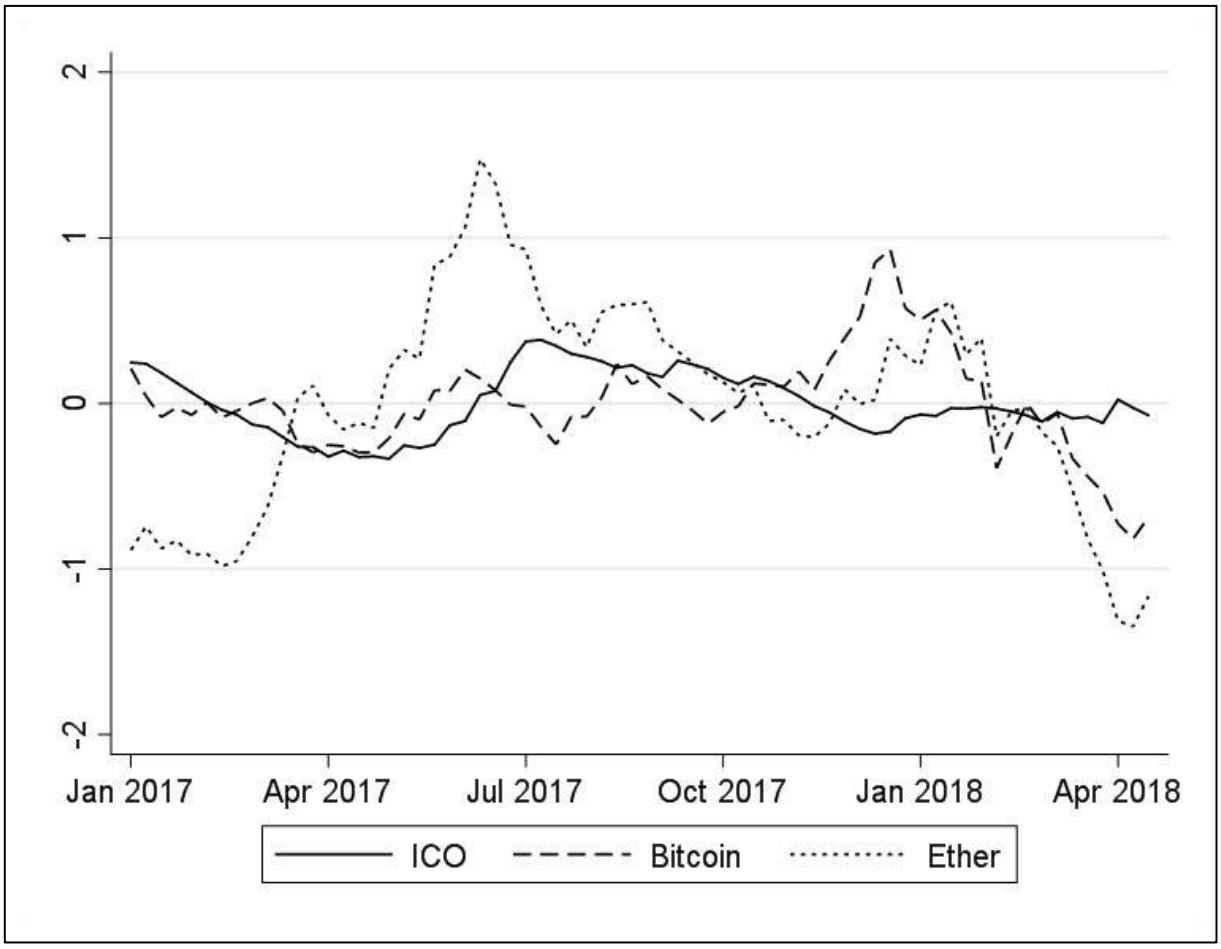


Notes: Figure 5-2 shows the amount raised in ICO campaigns (left axis) as well as the prices of bitcoin and Ether (both on right axis). All variables are in logs.

To avoid spurious relationships between the variables in the empirical analysis below, we remove the linear deterministic trends. In addition, we test for non-stationarity of the de-trended series with the help of an Augmented Dickey-Fuller (1979) test. The null hypothesis of non-stationarity can be rejected for all three variables at the 5% significance level.[28] Figure 5-3 shows the evolution of the de-trended variables over time.

[28] The test statistics are –2.48 (ICO), –2.16 (bitcoin), and –2.33 (Ether). The critical value is –1.95. Lag length selection (three lags) is based on the Schwert (1989) rule.

Figure 5-3: ICO raised, bitcoin price, and Ether price over time.



Notes: Figure 5-3 shows the amount raised in ICO campaigns as well as the prices of bitcoin and Ether. All variables are in logs and linearly de-trended.

Ether is the most volatile series with a standard deviation of 0.64, followed by bitcoin (0.31) and ICO (0.19). Indeed, we observe stronger booms (e.g., in June 2017 and January 2018) and busts (e.g., in April 2018) in Ether than in bitcoin or ICOs. The correlation between pairs is found to be the strongest in the two cryptocurrencies ($\rho = 0.46$), followed by ICO and Ether ($\rho = 0.17$), and ICO and bitcoin ($\rho = 0.04$). Hence, it appears that the relation between the two cryptocurrencies and the ICO indicator is, at best, rather modest. However, it remains to be seen whether these bivariate contemporaneous relationships hold in a multivariate VAR model that also incorporates dynamics in the connections across variables.

5.3.2. Econometric Methodology

Our empirical strategy builds on a linear VAR model (Sims 1980), which can be written in its reduced form as follows:

$$X_t = \delta + \sum_{i=1}^{p} \boldsymbol{A}_i X_{t-i} + U_t \quad (1)$$

X_t is the 3×1 vector of endogenous variables including the linearly de-trended variables for (i) the amount raised in ICO campaigns (in logs), (ii) bitcoin prices (in logs), and (iii) Ether prices (in logs). δ is the 3×1 vector of intercepts, U_t is the 3×1 vector of non-structural error terms, and the $\boldsymbol{A}_i$ are 3×3 parameter matrices. Both the Bayesian information criterion and the Hannan Quinn information criterion favor a lag length of 1 for the three-variable VAR model. However, the residuals of the Ether equation exhibit significant autocorrelation at the 5% level. Hence, a VAR(1) is not able to sufficiently capture the dynamics in the system. In contrast, the use of two lags eliminates serial correlation in the error terms of all equations at the 5% level.

One problem with the least-squares estimation of Eq. (1) is the potential correlation in the error terms across equations. Without a proper transformation of the reduced-form VAR we are not able to identify the effects of changes, say, in bitcoin on ICOs, as typically the other variable co-moves with changes in bitcoin. Hence, to identify the effect of pure shocks in one variable on the other variables in the system, we have to transform the reduced-form VAR into a structural VAR. To do so, we impose a recursive identification scheme that orthogonalizes the residuals and transforms these into true innovations, which are uncorrelated to each other.

A Cholesky decomposition of this nature exists for each regular variance-covariance matrix Σ_{UU} and relies on a lower triangular matrix P, for which $\Sigma_{UU} = PP'$ holds. Using this triangular matrix, the moving average representation[29] of Eq. (1) can be transformed as follows:

$$X_t = \mu + U_t - \sum_{i=1}^{\infty} \boldsymbol{B}_i U_{t-i} \tag{2}$$

$$X_t = \mu + PP^{-1}U_t - \sum_{i=1}^{\infty} \boldsymbol{B}_i PP^{-1}U_{t-i} \tag{3}$$

Defining $\boldsymbol{\theta}_i = \boldsymbol{B}_i P$, $\boldsymbol{\theta}_0 = P$, and $W_t = P^{-1}U_t$, we can simplify Eq. (3) as follows:

$$X_t = \mu + \boldsymbol{\theta}_0 W_t - \sum_{i=1}^{\infty} \boldsymbol{\theta}_i W_{t-i} \tag{4}$$

Since P has no non-zero entries above its main diagonal, the transformed contemporaneous residuals of the three equations are no longer correlated with each other, and represent true innovations or shocks.

This kind of identification scheme obviously requires assumptions on the instantaneous relationships across the three variables. We propose to order ICOs first, followed by bitcoin

[29] Every stable VAR of order p can be rewritten as a vector moving average model of order infinity, that is, the weighted sum of all residuals.

and Ether. This implies, first, that shocks to ICOs can have a contemporaneous effect on the other two variables, whereas the opposite effect is ruled out. Second, shocks to bitcoin can directly move Ether prices, but not vice versa. The theoretical idea is that investors who engage in ICOs are driven by "longer-term" considerations, at least compared to buying and selling cryptocurrencies. Hence, ICOs are the slowest-moving variable and only affected by shocks to the cryptocurrencies with a time lag. Bitcoin is considered the benchmark cryptocurrency, which is why we order it before Ether and allow for a contemporaneous reaction of Ether to shocks in bitcoin.[30]

5.4. Empirical results

5.4.1. Results of VAR model and granger causality tests

We start our discussion of the results with the least squares estimates of Eq. (1) in Table 5-1.

Table 5-1: Estimates of VAR model.

	1: ICO	**2: Bitcoin**	**3: Ether**
ICO_{t-1}	**0.940**	**-0.801**	-0.770
	(0.122)	**(0.354)**	(0.506)
ICO_{t-2}	-0.046	**0.735**	0.456
	(0.116)	**(0.337)**	(0.482)
$Bitcoin_{t-1}$	-0.008	**1.070**	0.119
	(0.050)	**(0.144)**	(0.205)
$Bitcoin_{t-2}$	-0.003	-0.156	-0.065
	(0.049)	(0.141)	(0.201)
$Ether_{t-1}$	0.014	-0.123	**0.965**
	(0.036)	(0.104)	**(0.149)**
$Ether_{t-2}$	0.041	0.165	0.023
	(0.036)	(0.105)	(0.150)
Constant	-0.007	-0.014	-0.008
	(0.006)	(0.017)	(0.024)
R^2	0.941	0.825	0.908
Portmanteau: $Chi^2(6)$	6.70	7.11	11.93

Notes: Table 5-1 shows the coefficients (with standard errors in parentheses) for the estimation of Eq. (1) using least squares. Coefficients in bold are significant at the 5% level. Line "Portmanteau" shows statistics for a test of the null hypothesis of no serial correlation. Number of observations: 68.

Most of the variation in the three variables can be explained by their lagged value(s). Solely in the case of bitcoin, we detect a statistically significant, albeit offsetting, influence of lagged values on the ICO indicator. Granger causality tests, that is, tests for joint exclusion of

[30] Note that the results presented in Section 5.4 are qualitatively similar when applying other recursive schemes. To conserve space, we focus on the results of the theoretically most reasonable scheme, and can provide all other results on request.

both lags for any one variable from the equation of another variable, indicate that we find a simple Granger causal relationship from Ether to ICO ($F(2,59) = 10.11$) at the 1% level. Two other Granger causal relationships can be found at the 10% level, as lagged values of the ICO indicator significantly predict both bitcoin prices ($F(2,59) = 2.56$) and Ether prices ($F(2,59) = 3.04$).

However, as already stated in Section 5.2, such an analysis of the reduced-form of Eq. (1) neglects contemporaneous relations across the variables. Indeed, we find non-zero bivariate correlations in the residuals of Eq. (1). In the case of bitcoin and Ether, the conditional correlation is quite substantial ($\rho = 0.59$). The correlations between ICO and bitcoin ($\rho = –0.20$), and ICO and Ether ($\rho = –0.11$), also indicate that we cannot interpret the residuals as true shocks to any of these variables. Consequently, we rely on the Cholesky decomposition and the MA representation in Eq. (4) to demonstrate what happens when a shock to one of the variables transmits through the system on impact and for the 26 weeks thereafter.

5.4.2. Impulse response functions

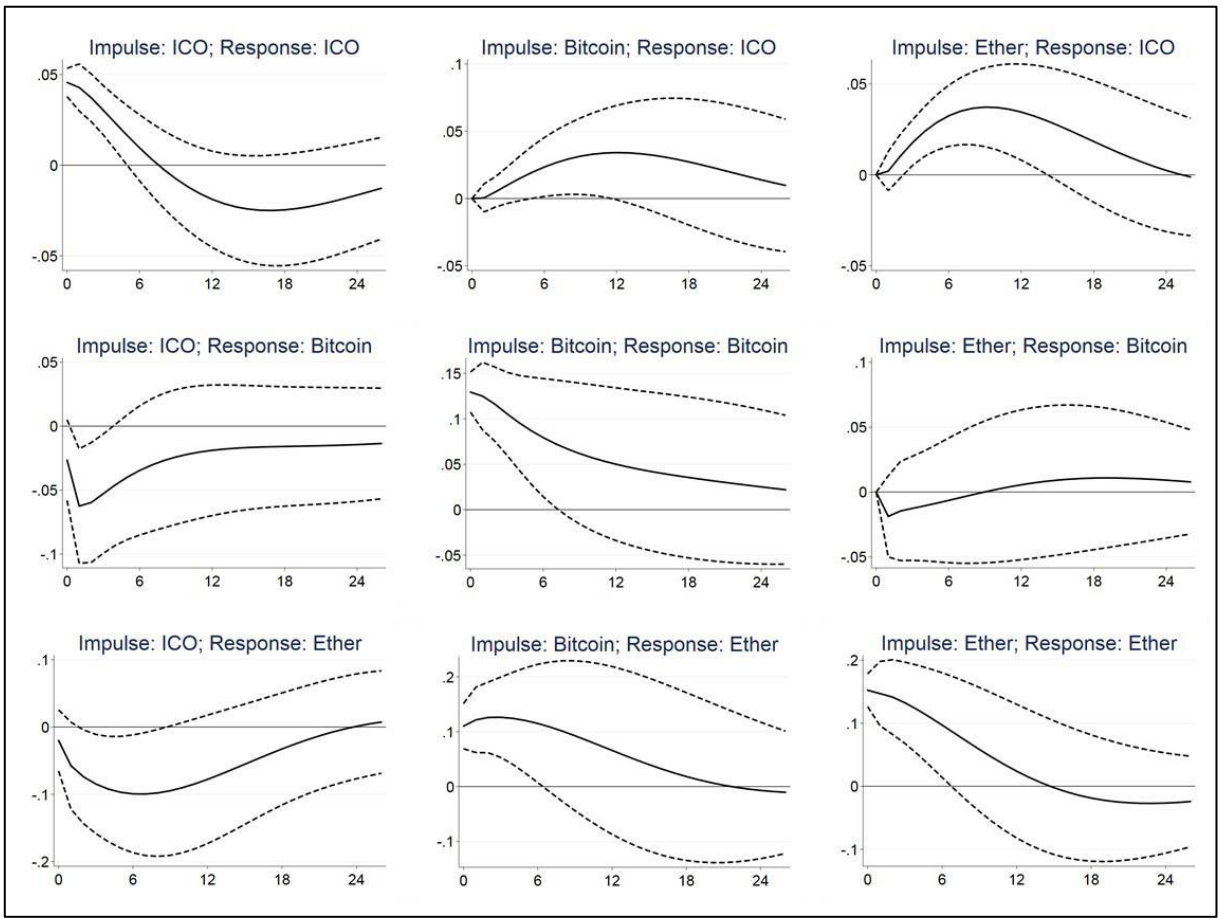
Figure 5-4 shows the impulse responses functions (solid lines) alongside the 95% confidence bands (dashed lines). As indicated by the impulse responses on the main diagonal, shocks to any of the three variables are persistent, implying that a bullish (bearish) market remains bullish (bearish) for four weeks in the case of ICOs, seven weeks in the case of bitcoin, and six weeks in the case of Ether.

The effects of ICO shocks on both cryptocurrencies are negative, which is in line with the mechanism of ICOs. Both firms conducting an ICO and the remaining actors in an ICO campaign (e.g., contributors, entrepreneurial firms) normally aim to sell tokens in secondary markets afterwards, in order to receive fiat. Thus, a shock in an ICO leads to a decline in cryptocurrency prices. We observe a significant compression of bitcoin prices one to three weeks after the shock, with a maximum effect of 6.2 percentage points (pp) after one week. The negative reaction of Ether becomes significant after two weeks, and remains so until eight weeks after the shock. Here, the maximum contraction of 10 pp is found after seven weeks. To put these figures into perspective, we need to account for the size of the shock to the ICO indicator, which amounts to 4.6 bps. Hence, shocks to the ICO indicator lead to reactions of more than twice the size in the case of Ether and of roughly one-and-a-half times the size in the case of bitcoin.

Turning to the reaction of ICOs to the cryptocurrencies, we observe a positive and significant reaction to shocks in both variables. Innovations in Ether have a highly significant and pronounced effect on ICOs after three to 14 weeks, with a peak effect of 3.7 pp after nine weeks. In contrast, shocks to bitcoin only trigger a significant response five to eleven weeks after the event, with a maximum increase of 3.4 pp after eleven weeks. When we account for the size of the shocks (12.9 pp for bitcoin and 15.2 for Ether), we can see that their effect on ICOs is only roughly a quarter of the original size. Hence, innovations in ICOs tend to drive change in cryptocurrencies rather than the other way round.

Finally, we take a closer look at the relationship between the two cryptocurrencies. In line with the idea that bitcoin is the benchmark, we detect no significant effects of shocks in Ether prices on bitcoin prices at any horizon under consideration. In contrast, shocks to bitcoin exert a significant positive effect on Ether, from impact until six weeks later. The peak effect of 12.6 pp is found after three weeks and amounts to roughly one standard deviation in the triggering variable.

Figure 5-4: Impulse responses of VAR model.



Notes: Figure 5-4 shows the impulse responses (solid lines, in percentage points) to a one standard deviation shock in the ICO indicator (left panel), bitcoin prices (middle panel), and Ether prices (right panel) alongside the corresponding 95% confidence bands (dashed lines). Cholesky decomposition is based on the following ordering: (i) ICO, (ii) bitcoin, and (iii) Ether.

5.4.3. Robustness tests

5.4.3.1. Impulse response functions

As part of our robustness tests, we replace the indicator for the cumulative amount of money raised (volume) in ICO campaigns by the cumulative number of successfully completed ICO campaigns (also linearly de-trended). As with our baseline model, we also estimate a VAR(2) model and obtain the impulse responses based on the same recursive ordering. Figure 5-A1 in the Appendix shows the results. In the following discussion, we focus on the dynamic relationships between the cryptocurrencies and the ICO indicator.

We no longer detect a negative response of Ether after shocks to the ICO indicator. Similarly, there is no positive reaction to bitcoin shocks in terms of the number of successful ICO campaigns. The only two results that carry over from the baseline model are the negative response of bitcoin to ICO shocks and the positive reaction of ICOs to Ether shocks. Hence, it

appears that the total amount of money raised in ICO campaigns is the better indicator for explaining the dynamic relationship between ICOs and the two cryptocurrencies.

5.4.3.2. OLS regression analyses applied to ICO success

As an additional robustness test, we estimate various OLS regressions with the amount raised (log) as the dependent variable (see Table 5-A2). While Model 1 includes industry, country and year dummies, Model 2 implements additional control variables regarding the hype surrounding an ICO campaign. For instance, media attention during the ICO campaign or social media activities such as Reddit followers are included as control variables. The variables bitcoin price and Ether price are added stepwise in Model 3 and Model 4. In total, each model contains 318 ICOs. In particular, the hype variables in Model 2 (Twitter, Telegram, Reddit follower, Google Trends) considerably influence the ICO volumes, as indicated by the increase in R^2 from Model 1 to Model 2. Also, the inclusion of bitcoin and Ether prices slightly increase R^2 from Model 2 to Model 3 and Model 4. In line with our previous results, bitcoin prices significantly increases the ICO volume (amount raised in an ICO campaign) ($p < 0.10$). Furthermore, Ether prices have a significant effect on ICO volumes ($p < 0.01$) as well.

5.5. Discussion

5.5.1. Main findings and implications

Our study is the first to identify market cycles in and shocks to ICOs and cryptocurrencies, and is closely related to a set of papers that uses VAR models to analyze market cycles of cryptocurrencies and IPOs (e.g., Doidge et al. 2017; Lowry et al. 2010). In our VAR model, we use amounts raised by ICO campaigns, and bitcoin and Ether prices between January 2017 and April 2018. Our main results are as follows: first, we find evidence that a bullish (bearish) market in the case of ICOs remains bullish (bearish) for approximately four weeks, whereas shocks to bitcoin and Ether prices are persistent for seven and six weeks respectively. Hence, a hype in one ICO positively influences subsequent ICOs, which is in line with the respective IPO literature (e.g., Lowry and Schwert 2002). Furthermore, the impact of bitcoin and Ether prices on the subsequent prices (of bitcoin and Ether) are relatively short-lived. Second, the effect of ICO shocks on both bitcoin and Ether prices are negative. According to the mechanism of ICO campaigns (Figure 5-1), investors, contributors, and the actual venture conducting the ICO typically aim to exchange tokens for

cryptocurrencies and, in particular, fiat money in the post-ICO phase. A shock to ICOs therefore negatively influences cryptocurrency prices. Moreover, shocks to ICOs have a stronger and more persistent effect on Ether than on bitcoin. An explanation for this phenomenon may be related to the fact that the vast majority of tokens generated for ICO campaigns are based on the Ethereum platform. In other words, investors require Ether rather than bitcoin to invest in ICOs. Third, innovations in either Ether or bitcoin positively influence ICOs three to 14 weeks after the shock. This may be an indication for the hype surrounding the entire cryptocurrency and ICO sphere and spillover effects of cryptocurrencies on ICOs. Prior literature on financing (e.g., crowdfunding and IPO, or secondary markets), for instance, found a significant effect of media content on the stock market (e.g., Gurun and Butler 2012; Tetlock 2007). The media and news hype surrounding cryptocurrencies (e.g., "*ICOs: The New Gold Rush*", "*Bitcoin rally continues as futures forecast even higher prices*") may thus have a positive effect on ICOs. In particular, high prices and success stories of bitcoin investors may attract the attention of further potential investors. In fact, media attention to bitcoin measured with data from Google Trends is influenced by the volatility and volume realized the previous day (Urquhart 2018). Additionally, the current crypto and ICO market may be driven by irrational herding behavior. As with crowdfunding, an ICO is considerably publicized in media channels, which may lead to social contagion processes. Hence, investors may simply follow others without considering all the facts or their own experience (e.g., Moritz 2015; Simonsohn and Ariely 2008). However, innovations in ICOs are generally seen to drive change in cryptocurrencies than the reverse. Finally, shocks to bitcoin prices influence Ether prices more strongly than the other way round. Bitcoin, as the first and leading cryptocurrency in terms of market capitalization, thus partly determines Ether prices. In summary, market cycles of ICOs, bitcoin and Ether are seen to exist and interact with one another.

Our results are relevant for cryptocurrency investors and blockchain-based ventures seeking to obtain entrepreneurial finance through an ICO. First, market timing matters when planning an ICO campaign. Entrepreneurial firms intending to conduct an ICO should be aware of the spillover and hype effects, and use this knowledge to choose the optimum time to launch their ICO campaign. The decision to kick off during hot ICO and cryptocurrency markets will most probably lead to higher volumes in the respective ICO campaign. Second, the interplay between cryptocurrencies and ICOs is of particular relevance for cryptocurrency investors. After a successful ICO campaign, such as the ICO of Telegram that collected approximately 1.7 billion USD, prices in cryptocurrencies may decrease considerably.

Investors should therefore be aware of blockbuster ICOs when looking to buy or sell cryptocurrencies.

5.5.2. Limitations and future research

Future research could further improve our understanding of this new emerging financing instrument and help to mitigate imbalances in financing for innovative entrepreneurial firms by relying on the limitations of this study. First, the study primarily focuses on different market cycles (ICOs, bitcoin, Ether) due to the connection of ICOs to cryptocurrencies, but neglects exogenous variables (e.g., specific ICO campaign characteristics) to an extent. Hence, future research might further investigate characteristics of ICO campaigns. Second, since ICOs are a type of crowdsale and have specific mechanisms that are linked to crowdfunding (Fisch et al. 2019), different mechanisms explored in crowdfunding could be transferred to ICO research. As with crowdfunding (e.g., Block et al. 2018b), for instance, ventures regularly post updates during an ICO campaign. However, little is known about the effects of these updates in social media channels (e.g., Reddit, Steemit, Telegram) and blogs of the venture on the success of ICO campaigns. Furthermore, prior research has applied signaling theory to crowdfunding (e.g., Ahlers et al. 2015; Block et al. 2018b). Since high information asymmetries exist between a venture and ICO investors, future research could investigate whether signaling theory is also applicable to ICOs and how ventures are able to signal quality to ICO investors. In particular, do specific instruments of ICO campaigns, such as a white paper or technical paper, positively influence the amount raised in an ICO campaign? Third, the number of ICO campaigns has risen sharply since 2018. Hence, future research might look into the robustness of the results by analyzing future ICO campaigns, since both new datasets and ICO listing websites are available (e.g., ICO bench). Fourth, media articles regularly report on blockchain, cryptocurrencies and the hype surrounding ICOs. Whereas media attention appears to have no significant influence on returns in cryptocurrencies (e.g., Urquhart 2018), ICO campaigns may significantly benefit from media attention. Finally, the majority of ICO campaigns are traded on trading exchanges such as bitfinex. Whereas this study analyzes the effect of market cycles of ICOs, bitcoin, and Ether on the volume of ICOs in a campaign, future research could investigate the effect of such market cycles on the current returns and volatilities after trading begins on trading exchanges.

6 Conclusion

This chapter provides a conclusion to the dissertation. Section 6.1 summarizes the main results of the previous chapters, while Section 6.2 highlights the implications for theory and practice. The dissertation concludes with the main limitations and avenues for future research in Section 6.3.

6.1. Summary of main findings

The first research topic addressed in this dissertation refers to the financing of micro, small and medium-sized firms. These studies reveal that European SMEs use different financing instruments as complements or substitutes to each other. By applying a cluster analysis, the results of Chapter 2 show that European SME financing is heterogeneous. However, different homogeneous financing patterns exist. In total, the chapter identifies seven distinct SME financing types based on the various financing instruments of the SAFE survey: mixed-financed SMEs with a focus on other loans, mixed-financed SMEs with a focus on retained earnings or sale of assets, state-subsidized SMEs, debt-financed SMEs, trade-financed SMEs, asset-based financed SMEs, and internally-financed SMEs. Moreover, the various financing patterns can be profiled according to firm-, product-, and country-specific characteristics, as well as macroeconomic variables (e.g., inflation rate, GDP per capita, unemployment rate, property rights index).

The findings of Chapter 2 are related to the results of Chapter 3, which reveal that financing patterns of European micro firms differ substantially from those of other small and medium-sized enterprises. In particular, micro firms are more likely to use internal financing instruments, and are less likely to use state subsidies, trade credit or asset-based financing instruments. In addition, medium-sized firms use short-term debt to a lesser extent than micro firms. Flexible short term-debt may be especially important for micro firms, since long-term debt has been found to be either less attractive due to high costs or less favourable, and other financing conditions are more difficult to obtain for these firms (Hall et al. 2000; Hutchinson 1995).

The second research topic is related to entrepreneurial opportunities and the financing of innovative and entrepreneurial firms. Chapter 4 initially combines data from 8,317 high-tech firms with regional data and includes both the number of patents and trademarks granted

as a measure of IP output. The results of the dissertation indicate that venture capital has a positive effect on the IP output (measured as patents/trademarks) of high-tech firms, whereas being a small firm decreases the likelihood of holding a patent or trademark. Furthermore, the student rate of a region shows a significantly positive effect on the IP output. Also, high-tech firms tend to favor both patents and trademarks instead of using only one of these protection rights. Whereas the first part of Chapter 4 reveals firm- and regional-level determinants for the IP output of high-tech firms, the second part of Chapter 4 considers VC as a specific financing instrument for these entrepreneurial opportunities and innovative firms.

Due to asymmetric information, agency conflicts, insufficient collateral, and high transaction costs for capital providers (e.g., Popov and Udell 2012; Ryan et al. 2014; Sogorb-Mira 2005), entrepreneurs and innovative firms regularly suffer from a lack of finance, which limits both their growth and survival rate. The second part of Chapter 4 consequently investigates VC that is particularly appropriate for these firms. Analyzing the distribution of VC investments across 402 German districts, the regressions reveal significant differences between VC investor types (GVC, CVC, and IVC firms). GVC, IVC, and CVC venture capitalists differ regarding their investment objectives and possess different skills and network partners (e.g., Colombo and Murtinu 2017; Guerini and Quas 2016). GVC firms regularly consider social payoffs and regional development as key priorities (Colombo et al. 2016), and can add value to portfolio firms by providing and using connections to public institutions or universities (Bertoni and Tykvová 2015). This study finds that regions with a higher supply of human capital and knowledge creators attract a significantly higher number of GVC investments. Moreover, this study shows significant differences in economically weaker regions but not a metropolitan bias. Although all VC types (GVC, IVC, and CVC firms) invest more frequently in regions in which the VC firm itself is located, GVC firms appear to be especially influenced by regional characteristics.

Finally, Chapter 5 focuses on ICOs as an emerging financing instrument that is especially interesting for innovative and entrepreneurial firms with a business model based on DLT. Using a VAR model and three different time series, namely the amounts raised by ICO campaigns, and bitcoin and Ether prices between January 2017 and April 2018, this study finds evidence that a bullish (bearish) ICO market remains bullish (bearish) over a period of approximately four weeks. Also, shocks to bitcoin and Ether prices are persistent (seven weeks in the case of bitcoin; and six weeks in the case of Ether). Furthermore, shocks to ICOs have a negative influence on both bitcoin and Ether prices, while shocks to Ether or bitcoin positively influence ICOs. Lastly, shocks to bitcoin prices particularly influence Ether prices

but not the other way round. The theoretical and practical implications of the findings are discussed in detail in the following section.

6.2. Theoretical and practical implications

6.2.1. Implications for theory

The main theoretical contribution of the dissertation with regard to the financing of SMEs and entrepreneurial opportunities can be divided into three areas.

SME and entrepreneurial financing literature (Chapters 2, 3, and 5). This dissertation has several implications with regard to SME (including micro firms) financing literature. First, the findings contribute to the literature on substitutive and complementary use of different financing instruments for SMEs. Whereas prior research mainly considered a single financing source or a small number of financing instruments, such as bank loans, trade credit, or venture capital (Andrieu et al. 2018; Cosh et al. 2009; Hutchinson 1995), this dissertation focuses on a large variety of different financing instruments by creating an empirical taxonomy of SME financing patterns. These patterns are in line with the SME financing patterns found by Moritz et al. (2016), providing an initial indication as to their stability. Accordingly, we have seen that specific financing instruments are often used by European SMEs as complements or substitutes. Second, the dissertation contributes to cross-country research, the financing patterns of SMEs are not only affected by firm-, product-, and industry-specific variables (e.g., Beck et al. 2008; Cosh et al. 2009; Michaelas et al.1999) but also by country-specific ones (e.g., Chavis et al. 2011; Hernández-Cánovas and Koëter-Kant 2011). Such variables include country's geography, financial market system and the degree of financial market integration in the EU, and macroeconomic variables, such as the countries' tax system, GDP growth and inflation rate (Moritz 2015). Third, the findings of the dissertation contribute to the financing literature of micro firms (e.g., Andrieu et al. 2018; Ang et al. 2010; Daskalakis et al. 2013). The utilization of financing instruments differs considerably in European micro firms compared to larger firms, which implies that SME segments need to be differentiated with regard to financing. Fourth, the dissertation contributes to the evolving literature on ICOs (e.g., Adhami et al. 2018; Amsden and Schweizer 2018; Fisch 2019). By empirically analyzing ICO campaigns using VAR models, the dissertation reveals that shocks to both cryptocurrencies and past ICOs have a positive influence on the amount raised in subsequent ICO campaigns.

Market imperfections and failures (Chapters 3 and 4). Prior research reveals access to access-to-finance problems as a substantial growth constraint for micro, small and medium-sized enterprises (e.g., Beck and Demirgüç-Kunt 2006). First, this dissertation confirms that European micro firms in particular use internal financing instruments or short-term debt, such as credit lines, bank overdrafts, or credit card overdrafts. Moreover, micro firms use state-subsidized bank loans or grants, and asset-based financing to a lesser extent than larger SMEs. Although previous research has found that trade credit is an important financing source for informationally opaque firms (e.g., Berger and Udell 1998; Huyghebaert et al. 2007; Ogawa et al. 2013), trade-financing instruments tend to be particularly relevant for small and medium-sized firms, but not for micro firms. Second, innovative entrepreneurs/SMEs in particular often suffer from financial constraints. Even though this dissertation confirms an uneven distribution of VC investments across regions, there is a strong connection to VC types' financing patterns (e.g., Colombo and Murtinu 2017; Guerini and Quas 2016; Luukkonen et al. 2013). GVC firms, for instance, are more likely to invest in rural regions than CVC or IVC firms. This dissertation confirms considerable differences between VC types based on their ownership and governance structures, leading us to conclude the existence of specific VC investment patterns. In particular, innovative start-ups and SMEs in rural areas might face difficulties attracting certain types of VC. To put it another way, specific VC types, such as GVC firms that also have the objective to support regional development, are more likely to invest in rural regions.

Regional clusters and regional development (Chapter 4). This dissertation further contributes to the literature on regional clusters and regional development (e.g., Chen et al. 2010; Fritsch and Schilder 2008; Mason and Harrison 2002). On the one hand, the dissertation confirms that a local bias exists, meaning that VC firms prefer to invest in regions where their own headquarters or district offices are located. On the other hand, it is noteworthy that this "home bias" exists for all VC types (GVC, ICV, and CVC firms), even though GVC is more regional. Technical universities appear to attract regional VC investments, whereas a metropolitan bias does not exist. In conclusion, this dissertation has shown that a region requires an entrepreneurial and VC ecosystem to attract regional VC investments. A high population density (metropolitan area) itself is not sufficient to attract VC investment but a complex regional ecosystem is required, including, among others, innovative start-ups with a high IP output, qualified employees and a well-developed infrastructure (e.g., Colombo et al. 2010; Harding 2000; Lutz et al. 2013).

6.2.2. Implications for practice

Policy makers. The dissertation's results are important for political decision-makers in particular with regard to SME financing and regional development. First, considerable differences in financing patterns exist in European countries. Whereas SMEs in Germany or Italy especially focus on bank credit, SMEs in Ireland or the United Kingdom make a particularly frequent usage of trade credit. Therefore, a "one size fits all" approach does not appear to be promising. In other words, EU programs for financing SMEs need to be tailored to specific country characteristics.

Furthermore, little attention has been devoted to financing of micro firms in Europe, as institutions often consider SMEs as a homogeneous group. The results, however, show that micro firms in particular are a specific group within SMEs with their own characteristic financing patterns. The results imply that policy makers should consider micro firms as a separate group with specific characteristics and financing needs that differ from those of other small and medium-sized firms. Whereas a large number of new actors and financing instruments have emerged in recent years (Block et al. 2018a), many financing instruments have not been tailored to the specific requirements of micro firms, or the costs of application for these financing instruments are simply too high. A possible alternative is indirect governmental subsidy programs that provide guarantees for financial intermediaries, and consequently reduce the default risk with regard to traditional financing instruments, such as bank credit, for risky firms. An example of such an indirect governmental support program at the EU level is the European Progress Microfinance Facility. Funded by the European Investment Bank and the European Commission, and managed by the European Investment Fund in the 2007–2013 programming period, the "PROGRESS" facilitates micro credits (less than 25,000 EUR) for entrepreneurs and micro firms. "PROGRESS" funding, however, does not go directly to these firms. The EC, EIB, and EIF either undertake guarantees or support micro-credit providers. Another such program, the EU Programme for Employment and Social Innovation, has a similar financing structure and one of its aims is to increase the availability and accessibility of microfinance for micro firms.

Second, the results of the dissertation are of particular interest for regional development and innovation policies. Policy makers try to evaluate the success of innovation subsidies and policy instruments. Both trademarks and patent registrations are signals of high-tech firms and are potential indicators for their IP and innovation output. As the dissertation indicates that the IP output tends to depend more on firm-specific factors than on region-specific factors,

political initiatives should consequently focus more on firm-specific measures in order to improve the IP output of firms in a region. Nevertheless, the indirect effect of regional factors should not be completely disregarded (Naz et al. 2015) and is directly related to the activities of VCs in a regional context.

The results have shown that VC firms often invest in portfolio companies which are located close to their own offices. Despite the dense economy and infrastructure in Germany, the geographic distance between investor and portfolio company remains crucial (Lutz et al. 2013). Hence, a home bias effect exists regarding VC investments. To foster regional development of innovative start-ups and regional economic growth, regional policy makers may wish to actively try to attract VC firms to their region to reduce regional disparities. The several types of VC firms differ significantly with regard to their primary objectives and regional focus orientation due to their ownership and governance structure (e.g., Bertoni and Tykvová 2015; Colombo and Murtinu 2017; Guerini and Quas 2016; Luukkonen et al. 2013). In particular, GVC and CVC appear to be an important instrument for investments in rural areas and hence policy makers may actively support and foster GVC and CVC investments to improve the development of economically weaker regions.

Innovative small firms. The dissertation also provides more general implications for SMEs and in particular innovative small firms.

First, the regional availability of a university or locations with a high student rate have a positive effect on the regional IP output of high-tech firms according to Chapter 4. Smaller firms that regularly lack resources (e.g., financial resources) may consider setting up in a region with a higher student rate, as this allows them to hire highly educated employees more easily, profit from knowledge spillovers, and increase their IP output. Universities, for instance, produce and transfer both explicit and implicit knowledge that can be a source of entrepreneurial opportunities and innovativeness (Audretsch et al. 2005; Feldman et al. 2002). Implicit (tacit) knowledge includes, for instance, students and scientists of the university, who experience or embody knowledge. High-tech firms may profit from being located near a university and a high student rate, as face-to-face interactions and personal contact imply spatial proximity (e.g., Audretsch and Lehmann 2005; Bade and Nerlinger 2000). Furthermore, as both trademarks and patents are proxies for innovation (Fisch 2016), managers can use trademark and patent applications in order to review innovation activities in their industry and create benchmark studies of their own company.

Second, innovative small firms often have a lack of (external) financing. This dissertation particularly focuses on two specific financing instruments (VC and ICO) and provides valuable implications for this specific group within SMEs. On the one hand, we have highlighted the investment patterns of GVC, IVC, and CVC firms and underlined the importance of the locational choice for innovative small firms. The geographic distance between investor and portfolio company is essential even in dense economies and infrastructures such as in Germany. The finding implies that entrepreneurs should select their firm's location choice with care. In other words, entrepreneurs may have a higher probability of obtaining VC as a source of financing if their firm is geographically close to a venture capital cluster (Lutz et al. 2013; Martin et al. 2005). Furthermore, entrepreneurs and innovative firms may consider the different objectives and the regional focus orientation of the several VC firms to increase the probability of a VC investment. In particular, GVC and CVC firms are more likely to invest in rural areas. Moreover, GVC firms often invest in regions with a high student rate or a technical university.

Chapter 5 reveals valuable findings about ICOs, a new financing instrument that is of particular interest to high-risk innovative ventures. As seen in Chapter 5, managers of such entrepreneurial firms who intend to conduct an ICO campaign should be aware of the timing of their campaign. On the one hand, high bitcoin and Ether prices have a positive effect on the amount raised in ICO campaigns. On the other hand, a hype in ICOs positively influences subsequent ICO campaigns. Therefore, it is advisable to watch the cryptocurrency and ICO market carefully before launching one's own ICO campaign.

6.3. Limitations and avenues for future research

The dissertation has several limitations that, however, can offer guidance for future research. First, there are limitations as to the data and method used in Chapters 2 and 3. The dataset used was obtained from the SAFE survey and consequently does not include solo self-employed entrepreneurs. Hence, a large number of start-ups and micro firms are excluded from the analyses. Moreover, micro, small, and medium-sized enterprises were asked about specific financing instruments used during the previous six months. Although this short time period allows us to control for macroeconomic changes and biases over the business life cycle of the firms, longer time periods could investigate the enterprises' financing patterns more comprehensively. For instance, Andrieu et al. (2018) used SAFE survey data from 2009 and 2014, and employed a baseline binary probit model. By using the application success of trade credit and bank credit as dependent variables, they showed that firm-, industry- and country-

level variables determine the application process for trade and bank credits. Future research could either use the relatively small panel dataset of the SAFE survey or use other datasets, such as the relatively new EIB Group survey on Investment and Investment Finance (EIBIS). The EIBIS survey is a completely new dataset that covers qualitative and quantitative information on investment activities by SMEs and large enterprises. It is especially appropriate for analyzing financing patterns of European SMEs, since it is designed to build a panel dataset and is representative at the EU level, country level, and industry level. Furthermore, the EIBIS survey includes additional variables such as the investment sum, amount of the credit, and balance sheet data.

Additionally, the inclusion of both further firm-specific variables in the analysis, such as balance sheet data, which has been used in prior research (Ferrando and Mulier 2015), and additional financing instruments, would strengthen the results of our analysis. In particular, emerging financing instruments such as crowdfunding, corporate venture capital, governmental venture capital, social venture capital, venture debt (Block et al. 2018a) and ICOs are not included in the survey. According to Fisch (2019), the amount of capital raised by ICOs has increased considerably since 2017 and is an alternative financing instrument for firms with high information asymmetries and specific DLT-based business models. Hence, future research might include these emerging financing instruments to analyze the complementary and substitutive effects among traditional and new financing instruments.

Second, Chapter 4 uses districts of Germany as the unit of observation. The district level, however, may lead to a bias of several variables. Variables such as the location of the technical university or the location of VC firms may also have an effect on neighboring districts. In other words, a variable that measures a specific radius (in km) around a technical university, for instance, may be more accurate than matching universities to the district in which they are located. As university spillovers on innovation extend over approximately 80 kilometers (Anselin et al. 1997), the technical university of Munich (TUM), for example, may have spillover effects to German districts that do not belong solely to the district of the technical university itself (district *Munich*), but also to other districts such as *Starnberg*, *Dachau*, *Freising*, *Erding*, or *Ebersberg*. Hence, future research could use alternative distant measures as a robustness check. Moreover, the independent variable *technical university* in Chapter 4 does not consider non-technical universities or non-technical universities of applied sciences that have leading faculties with a focus on areas related to natural sciences or technology. To counter this limitation, future research could link the universities' (or universities of applied sciences') faculty footprint, in order to the respective firms' industries

to further investigate knowledge spillover effects. A further important limitation of Chapter 4 is that the effect of VC firms on the regional IP output and the effect of regional patenting activities on regional VC investments may be based on a selection or treatment effect. The effects cannot be entirely separated. For instance, VC firms may select innovative regions for their investment patterns, or VC firms may foster firms in order to actively innovate. Hence, future research could further investigate the causal relationship between VC investments and IP output.

Third, Chapter 4 uses patents and trademarks to measure the intellectual property output (and consequently as a proxy for innovation output). Both trademarks and patents are an established and frequently used variable in innovation literature (e.g., Fisch 2016; Godinho and Ferreira 2012). Trademarks protect marketing assets, whereas patents primarily focus on the protection of technological assets (Block et al. 2015), but not all technological inventions are patentable, or SMEs may not be able to file trademarks and patents due to high application costs (Fisch 2016). Moreover, several additional intellectual protection rights exist, such as design (patents) or copyrights, which are not included in the analyses. Furthermore, a large number of smaller firms do not use any intellectual property rights at all and rather focus on IP protection through secrecy or use lead time advantages or complementary sales and services (Fisch 2016; Thomä and Bizer 2013). As a result, future research might extend the dissertation by including additional IP output measures to validate the robustness of the findings.

Fourth, prior research has shown that geographic distance plays an important role in VC investments, but VC syndication networks considerably reduce the spatial proximity effect with regard to VC firms' investment patterns (e.g., Lutz et al. 2013; Sorenson and Stuart 2001). Although Chapter 4 considered the geographic location of GVC, CVC, and IVC firms, the effects of syndication links between different VC firms and joint investments on the regional VC investment patterns remain unclear and open avenues for future research. Furthermore, Chapter 4 analyzes the direct effects of regional determinants (e.g., existence of a technical university) on the financing patterns of GVC, IVC, and CVC firms. Future research, however, could also investigate the interplay between different regional determinants on regional VC investments. For instance, geographical accessibility may positively moderate the effect of regional patenting activities or the existence of regional technical universities on regional VC investments. According to Sorenson and Stuart (2001), the proximity between VC firm and portfolio company plays an important role both in the pre-investment and post-investment phase. Moreover, VC firms often profit from better

geographical accessibility in the sense that a well-developed transport infrastructure is available. Little is known, however, about whether an interplay between geographical accessibility and regional knowledge exists. Hence, future research might investigate the moderation effects of regional determinants on VC investment patterns.

Finally, Chapter 5 focuses on market cycles of ICOs and the effects of cryptocurrencies on the amount raised in ICO campaigns. Whereas these endogenous variables revealed that whether market cycles similar to those of IPOs do exist, future research could include exogenous variables (e.g., specific ICO campaign characteristics) in the VAR model to further disentangle the dynamics and mechanisms of ICO campaigns and determine the success factors of an ICO. Moreover, the number of ICOs has considerably risen since the beginning of 2018. Therefore, future research could also replicate the results of Chapter 5 and check for the robustness of the effects found.

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Appendix

Appendix Chapter 2

Table 2-A1: Number of SMEs in the SAFE survey by country.

Country		Number of SMEs	In percent
Austria	AT	185	1.4
Belgium	BE	329	2.5
Bulgaria	BG	182	1.4
Cyprus	CY	27	0.2
Czech Republic	CZ	575	4.4
Germany	DE	1,275	9.7
Denmark	DK	123	0.9
Estonia	EE	36	0.3
Spain	ES	1,367	10.4
Finland	FI	135	1.0
France	FR	1,743	13.3
Greece	GR	406	3.1
Croatia	HR	85	0.6
Hungary	HU	289	2.2
Ireland	IE	88	0.7
Italy	IT	2,197	16.8
Lithuania	LT	88	0.7
Luxembourg	LU	18	0.1
Latvia	LV	56	0.4
Netherlands	NL	598	4.6
Poland	PL	864	6.6
Portugal	PT	452	3.5
Romania	RO	253	1.9
Sweden	SE	386	2.9
Slovenia	SI	74	0.6
Slovakia	SK	228	1.7
United Kingdom	UK	1,038	7.9
Total		13,098	100

Figure 2-A1: Excerpt SAFE survey (2015H1).[31]

SECTION 1: GENERAL CHARACTERISTICS OF THE ENTERPRISE (*DEMOGRAPHIC PART, COMMON*)

D2. NEW RESPONDENTS: How would you characterise your enterprise? Is it...
D2. PANEL MEMBERS: Can you confirm that your enterprise is <*STATE ANSWER FROM PREVIOUS WAVE*>? [READ IF NECESSARY: **If not, what is the correct category?]**

[ONLY ONE ANSWER IS POSSIBLE]

- a branch of another enterprise [READ IF NECESSARY: branches are controlled by a parent company and are not separate legal entities] 5
- an autonomous profit-oriented enterprise, making independent **financial** decisions [READ IF NECESSARY: in the sense of making independent management decisions; this includes partnerships and cooperatives] 2
- a non-profit enterprise [READ IF NECESSARY: foundation, association, semi-government] 3
  [DK/NA] 9

D2A. NEW RESPONDENTS: In which country is the parent company of your enterprise located? D2A. PANEL MEMBERS: Can you confirm that the parent company of your enterprise is located in *STATE ANSWER FROM PREVIOUS WAVE*>? [READ IF NECESSARY: If not, what is the correct country?]

D1. How many people does your enterprise currently employ either full or part-time at all its locations <*in your country*>? Please do not include unpaid family workers and freelancers working regularly for your enterprise.

[READ IF NECESSARY: Full-time and part-time employees should each count as one employee. Employees working less than 12 hours per week are to be excluded.]
[ONLY ONE ANSWER IS POSSIBLE]
NUMERICAL ANSWER [1-999999] [DK/NA]

D1_rec. [IF NA/DK → ASK ABOUT APPROXIMATE NUMBER IN BRACKETS – ONLY ONE ANSWER IS POSSIBLE → IF STILL NA/DK → STOP INTERVIEW → INTERVIEW NOT VALID]
What is the approximate number?

- from 1 employee to 9 employees 1
- from 10 employees to 49 employees 2
- from 50 employees to 249 employees 3
- 250 employees or more 4
- [DK/NA] 9

[31] The entire questionnaire of the SAFE survey is available at: https://www.ecb.europa.eu/stats/ecb_surveys/safe/html/index.en.html. Accessed 01 August 2018.

Figure 2-A1: Excerpt SAFE survey (2015H1) (continued).

D3. What is the main activity of your enterprise?

[ONLY ONE ANSWER IS POSSIBLE]

- construction 2
- industry [READ IF NECESSARY: it includes manufacturing, mining and electricity, gas and water supply] 12
- wholesale or retail trade 4
- transport 5
- agriculture [STOP INTERVIEW → INTERVIEW NOT VALID] 8
- public administration [STOP INTERVIEW → INTERVIEW NOT VALID] 9
- financial services [STOP INTERVIEW → INTERVIEW NOT VALID] 10
- other services to businesses or persons [READ IF NECESSARY: for example, hotels and restaurants, IT services] 13
- [READ IF NECESSARY: If none of these, please specify.]
- [DK/NA] [STOP INTERVIEW → INTERVIEW NOT VALID] 99

D6. NEW RESPONDENTS: Who owns the largest stake in your enterprise?

D6. PANEL MEMBERS: Can you confirm that the largest stake in your enterprise is still owned by <STATE ANSWER FROM PREVIOUS WAVE>? [READ IF NECESSARY: If not, what is the correct category?]

- one owner only, that is yourself or another natural person 5
- family or entrepreneurs [READ IF NECESSARY: more than one owner] 2
- other enterprises or business associates 3
- public shareholders, as your enterprise is listed on the stock market 1
- venture capital enterprises or business angels [READ IF NECESSARY: individual investors providing capital or know-how to young innovative enterprises] 4
- other 7
  [DK/NA] 9

D4. What was the annual turnover of your enterprise in 2014? [READ IF NECESSARY: Please include all locations of your enterprises, both *<in your country>* and abroad.]

[ONLY ONE ANSWER IS POSSIBLE]
[For non-euro area countries, the amounts in euro will be converted to national currency.]

- up to €500,000 5
- more than €500,000 and up to €1 million 6
- more than €1 million and up to €2 million 7
- more than €2 million and up to €10 million 2
- more than €10 million and up to €50 million 3
- more than €50 million 4
  [DK/NA] 9

Appendix Chapter 3

Table 3-A1: Seemingly unrelated logistic regression estimation on financing patterns.

Dependent variables	Debt financing	Trade financing	State-subsidized financing	Asset-based financing	Internal financing
Independent variables					
Firm size variables					
Micro firms	0.179***	-0.387***	-0.969***	-0.478***	1.124***
	(0.068)	(0.074)	(0.010)	(0.088)	(0.061)
Small firms	0.082	-0.088	-0.254***	-0.005	0.522***
	(0.066)	(0.067)	(0.083)	(0.077)	(0.059)
Medium-sized firms (reference group)					
p-value of test (coefficients size micro = size small)	p > 0.1	p < 0.01	p < 0.01	p < 0.01	p < 0.01
Control variables					
Age variables					
Age < 2	-0.457	0.443	0.148	0.272	-0.173
	(0.332)	(0.281)	(0.390)	(0.351)	(0.286)
Age 2–4	-0.533***	0.164	-0.476**	0.052	0.279***
	(0.132)	(0.116)	(0.195)	(0.142)	(0.093)
Age 5–9	-0.086	0.200***	-0.161*	-0.008	-0.035
	(0.057)	(0.067)	(0.085)	(0.065)	(0.050)
Age > 9 (reference group)					
Ownership variables					
VC/BA	0.475	0.986***	-0.062	-0.031	-0.623*
	(0.363)	(0.274)	(0.498)	(0.348)	(0.347)
Family or entrepreneur	0.427**	-0.070	0.419	-0.331*	-0.174
	(0.193)	(0.169)	(0.262)	(0.175)	(0.151)
Other	0.075	0.125	0.777***	-0.668***	0.149
	(0.241)	(0.211)	(0.299)	(0.244)	(0.182)
One owner	0.459**	-0.060	0.375	-0.334*	-0.045
	(0.193)	(0.170)	(0.265)	(0.176)	(0.154)
Other enterprises or business associates	0.240	-0.038	0.075	-0.332*	-0.095
	(0.201)	(0.177)	(0.274)	(0.184)	(0.157)
Public shareholder (reference group)					
Innovativeness	-0.067	0.101*	0.307***	-0.050	-0.221***
	(0.053)	(0.056)	(0.073)	(0.068)	(0.047)

Table 3-A1: Seemingly unrelated logistic regression estimation on financing patterns (continued).

Dependent variables	Debt financing	Trade financing	State-subsidized financing	Asset-based financing	Internal financing
Capital position					
Improved	-0.047	-0.089	0.113	0.038	-0.036
	(0.097)	(0.106)	(0.145)	(0.131)	(0.090)
Unchanged	0.098	-0.054	-0.015	0.072	0.239***
	(0.087)	(0.093)	(0.130)	(0.121)	(0.079)
Deteriorated (reference group)					
Profit					
Increased	0.010	0.075	-0.121	0.110	0.001
	(0.070)	(0.075)	(0.100)	(0.089)	(0.062)
Unchanged	-0.182	-0.032	-0.129	0.028	0.147***
	(0.064)	(0.070)	(0.093)	(0.085)	(0.056)
Decreased (reference group)					
Turnover expectation					
> 20%	0.059	-0.144	0.596***	0.203	-0.213*
	(0.124)	(0.130)	(0.183)	(0.170)	(0.107)
< 20%	0.050	-0.078	0.353**	0.232*	-0:223**
	(0.100)	(0.107)	(0.158)	(0.140)	(0.086)
Same size	0.021	-0.071	0.015	0.182	-0.004
	(0.104)	(0.112)	(0.167)	(0.147)	(0.088)
Become smaller (reference group)					
Access to finance problems					
Low (1–3)	-0.515***	-0.463***	-0.700***	0.083	1.108***
	(0.060)	(0.064)	(0.086)	(0.076)	(0.054)
Medium (4–6)	-0.009	-0.055	-0.198**	0.077	0.358***
	(0.063)	(0.068)	(0.087)	(0.087)	(0.062)
High (7–10) (reference group)					
Industry dummies	Yes	Yes	Yes	Yes	Yes
Country dummies	Yes	Yes	Yes	Yes	Yes
Number of observations	12,144	12,144	12,144	12,144	12,144
Log-likelihood	-5,331.51	-4,788.80	-3,037.67	-3,676.07	-6,587.03
Pseudo-R^2	0.036	0.087	0.093	0.047	0.104

Notes: Seemingly unrelated logistic regression estimation, SEs are in parentheses. ***p < 0.01. **p < 0.05. *p < 0.1.

Table 3-A2: Multinomial logistic regression on financing patterns.

Dependent variables	Debt financing	Trade financing	State-subsidized financing	Asset-based financing	Internal financing
Independent variables					
Firm size variables					
Micro firms	-0.668***	-1.172***	-1.743***	-1.216***	Base category
	(0.081)	(0.086)	(0.111)	(0.098)	
Small firms	-0.338***	-0.498***	-0.653***	-0.403***	
	(0.080)	(0.815)	(0.096)	(0.088)	
Medium-sized firms (reference group)					
Control variables					
Age variables					
Age < 2	-0.266	0.489	0.251	0.345	
	(0.386)	(0.348)	(0.444)	(0.417)	
Ages 2–4	-0.640***	-0.049	-0.648***	-0.148	
	(0.143)	(0.133)	(0.208)	(0.153)	
Age 5–9	-0.052	0.197***	-0.124	0.012	
	(0.066)	(0.074)	(0.093)	(0.076)	
Age > 9 (reference group)					
Ownership variables					
VC/BA	0.933**	1.249***	0.496	0.470	
	(0.471)	(0.416)	(0.595)	(0.463)	
Family or entrepreneur	0.519**	0.094	0.530*	-0.147	
	(0.221)	(0.196)	(0.287)	(0.205)	
Other	-0.020	0.022	0.606*	-0.690**	
	(0.272)	(0.243)	(0.329)	(0.273)	
One owner	0.452**	0.005	0.389	-0.244	
	(0.221)	(0.197)	(0.289)	(0.205)	
Other enterprises or business associates	0.291	0.052	0.143	-0.214	
	(0.229)	(0.205)	(0.299)	(0.214)	
Public shareholder (reference group)					
Innovativeness	0.108*	0.258***	0.458***	0.119	
	(0.063)	(0.065)	(0.081)	(0.076)	
Capital position					
Improved	-0.009	-0.038	0.149	0.066	
	(0.118)	(0.122)	(0.159)	(0.148)	
Unchanged	-0.088	-0.230**	-0.193	-0.107	
	(0.104)	(0.108)	(0.143)	(0.134)	
Deteriorated (reference group)					
Profit					
Increased	0.009	0.062	-0.113	0.098	
	(0.083)	(0.087)	(0.109)	(0.100)	
Unchanged	-0.112	-0.137*	-0.230**	-0.075	
	(0.075)	(0.081)	(0.102)	(0.094)	
Decreased (reference group)					

Table 3-A2: Multinomial logistic regression on financing patterns (continued).

Dependent variables	Debt financing	Trade financing	State-subsidized financing	Asset-based financing	Internal financing
Turnover expectation					
> 20%	0.210	0.035	0.701***	0.340*	
	(0.144)	(0.148)	(0.199)	(0.185)	
< 20%	0.203*	0.099	0.493***	0.375**	
	(0.116)	(0.121)	(0.170)	(0.153)	
Same size	0.025	-0.055	0.015	0.178	
	(0.119)	(0.126)	(0.180)	(0.159)	
Become smaller (reference group)					
Access to finance problems					
Low (1–3)	-1.192***	-1.196***	-1.463***	-0.719***	
	(0.071)	(0.076)	(0.096)	(0.087)	
Medium (4–6)	-0.276***	-0.325***	-0.457***	-0.208**	
	(0.0783)	(0.084)	(0.100)	(0.100)	
High (7–10) (reference group)					
Industry dummies	Yes	Yes	Yes	Yes	
Country dummies	Yes	Yes	Yes	Yes	
Number of observations	12,144				
Log-likelihood	-20,412.98				
Pseudo-R^2	0.086				

Notes: Multinomial logistic regression, SEs are in parentheses. ***p < 0.01. **p < 0.05. *p < 0.1.

Table 3-A3: Univariate analysis of different financing instruments.

Financing instruments	Micro firms	Small firms	Medium-sized firms	Pearson Chi²
Bank loans	14%	21%	27%	***
Bank overdrafts	34%	41%	48%	***
Trade credit	17%	23%	28%	***
Leasing	12%	26%	36%	***
Retained earnings	10%	16%	24%	***
No external financing	41%	27%	18%	***
Number of observations	12,144			

Notes: Pearson's Chi² Test: ***p < 0.01; **p < 0.05; *p < 0.1.

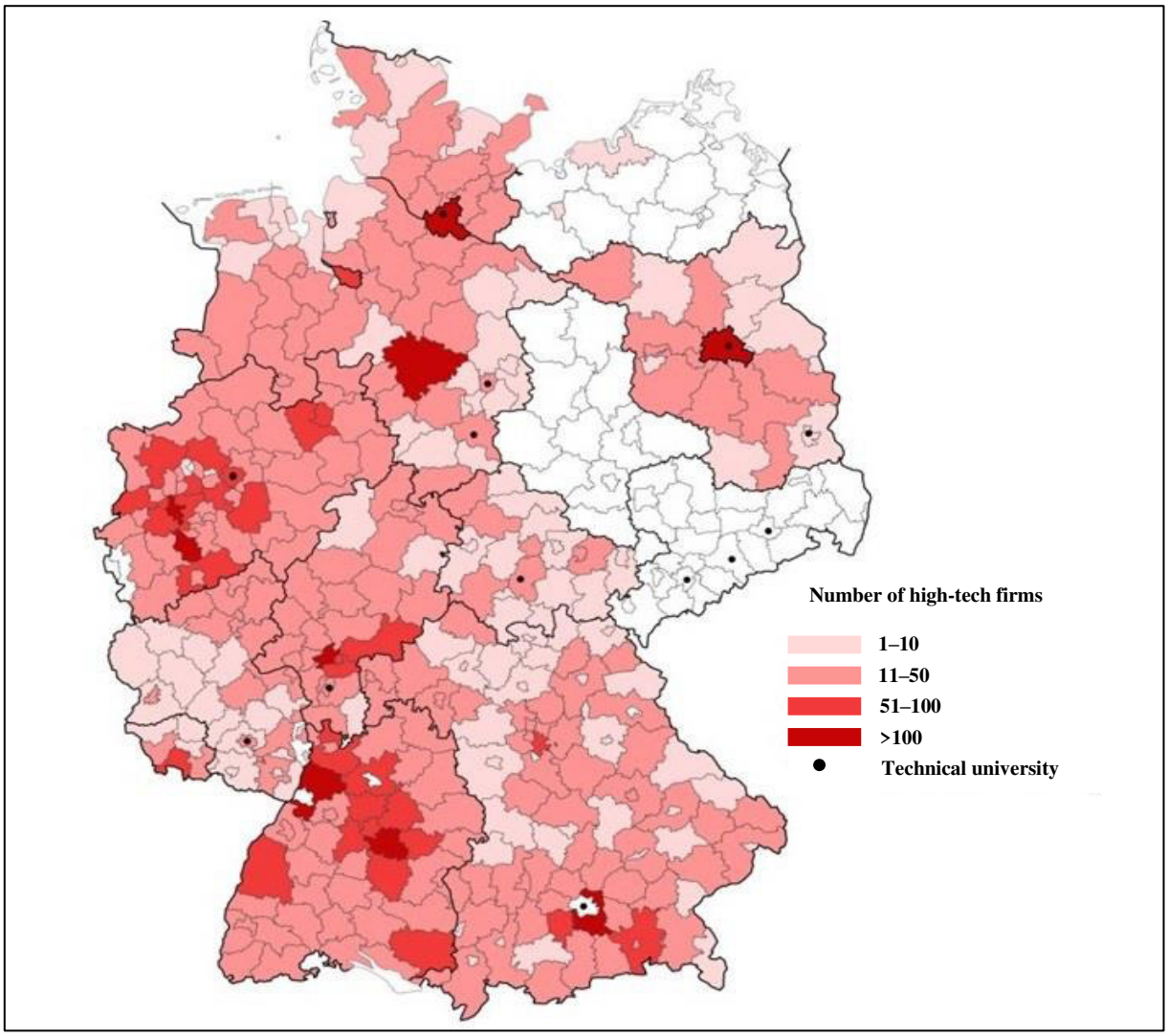
Table 3-A4: Multivariate analysis on different financing instruments.

Dependent variables	**Bank loans**	**Bank overdrafts**	**Trade credit**	**Leasing**	**Retained earnings**	**No external financing**
Firm size variables, *reference group: medium-sized firms*						
Micro firms	0.374***	0.514***	0.472***	0.262***	0.424***	3.076***
	(0.025)	(0.028)	(0.031)	(0.017)	(0.030)	(0.187)
Small firms	0.629***	0.691***	0.736***	0.627***	0.630***	1.686***
	(0.037)	(0.035)	(0.044)	(0.034)	(0.039)	(0.100)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	12,144	12,144	12,144	12,144	12,144	12,144

Notes: Logistic regressions, SEs are in parentheses. ***p < 0.01. **p < 0.05. *p < 0.1.

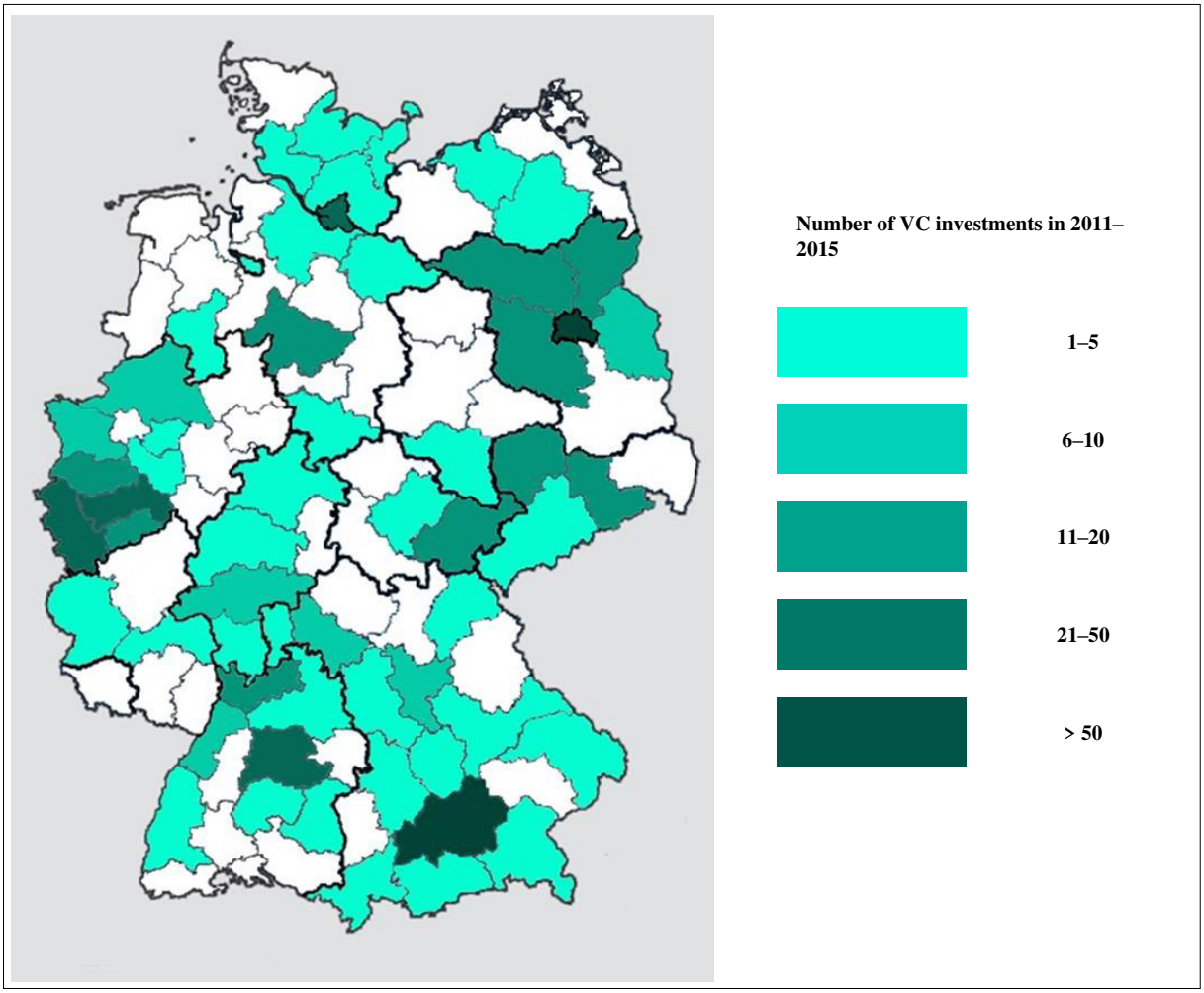
Appendix Chapter 4

Figure 4-A1: Distribution of high-tech firms in the dataset.



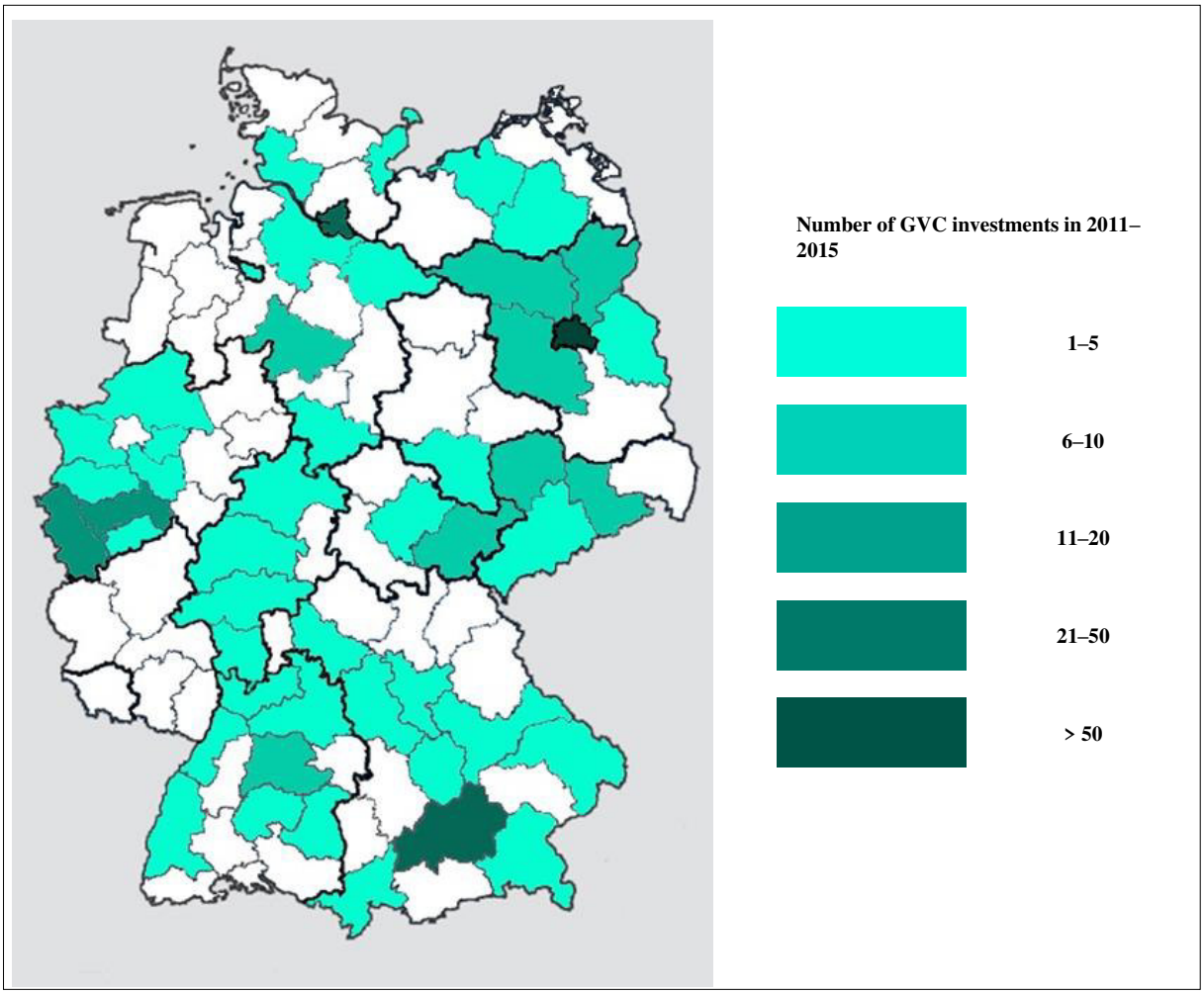
Notes: N = 360 regions, reference: own illustration based on Spotfolio (2016).

Figure 4-A2: Number of VC investments in 2011–2015.



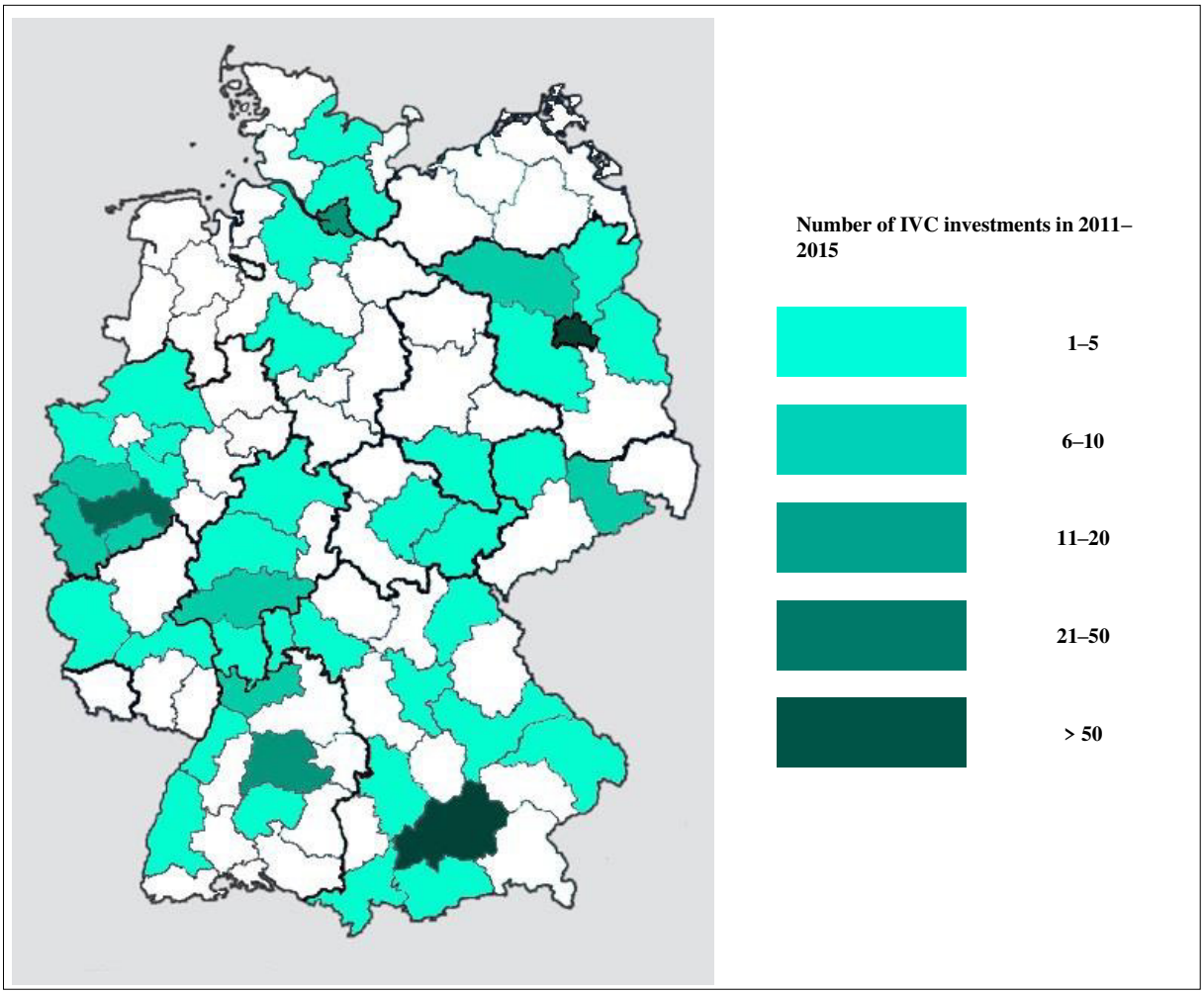
Notes: N = 96 districts (Raumordnungsregionen), reference: own illustration based on Spotfolio (2016).

Figure 4-A3: Number of GVC investments in 2011–2015.



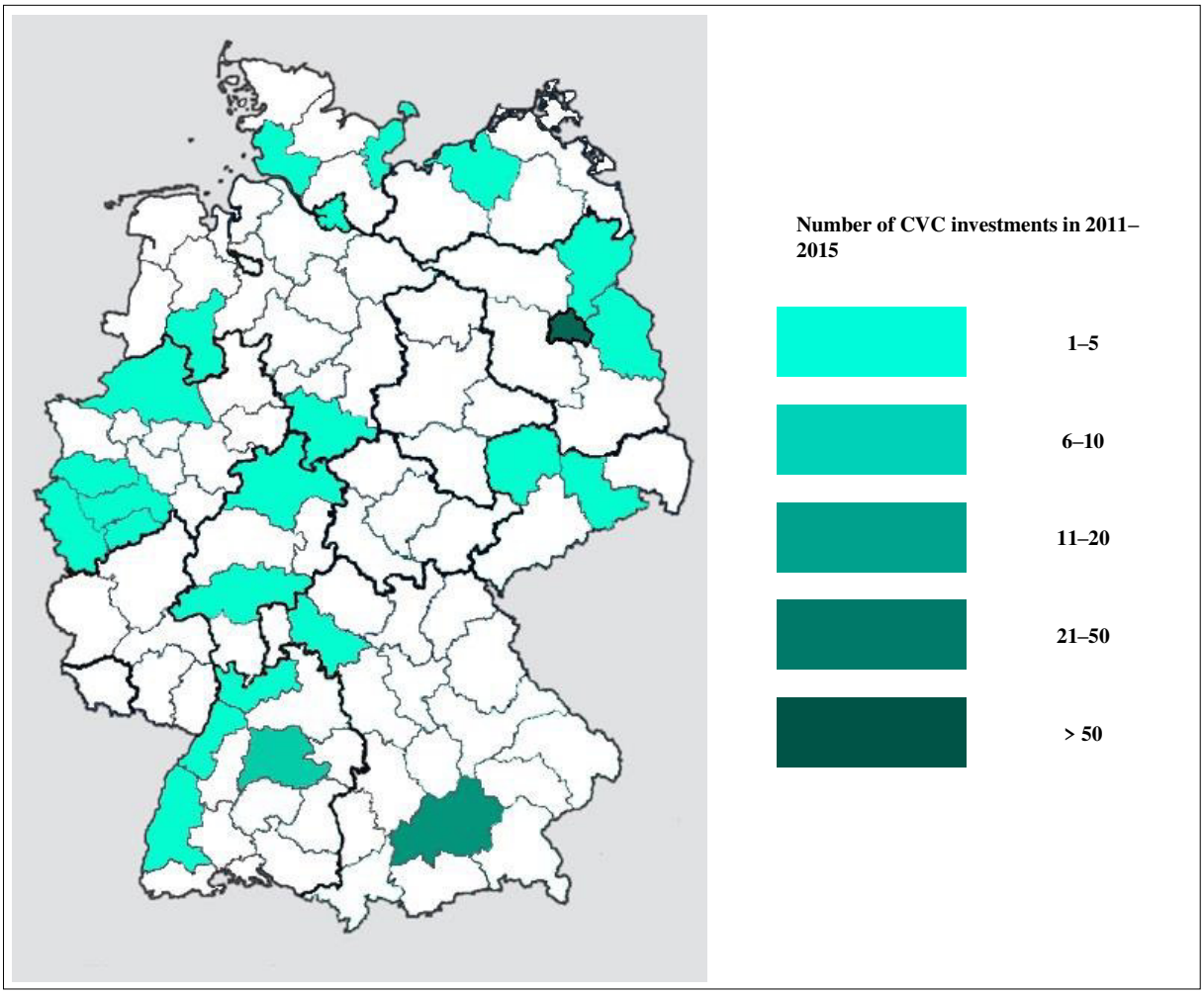
Notes: N = 96 districts (Raumordnungsregionen), reference: own illustration based on Spotfolio (2016).

Figure 4-A4: Number of IVC investments in 2011–2015.



Notes: N = 96 districts (Raumordnungsregionen), reference: own illustration based on Spotfolio (2016).

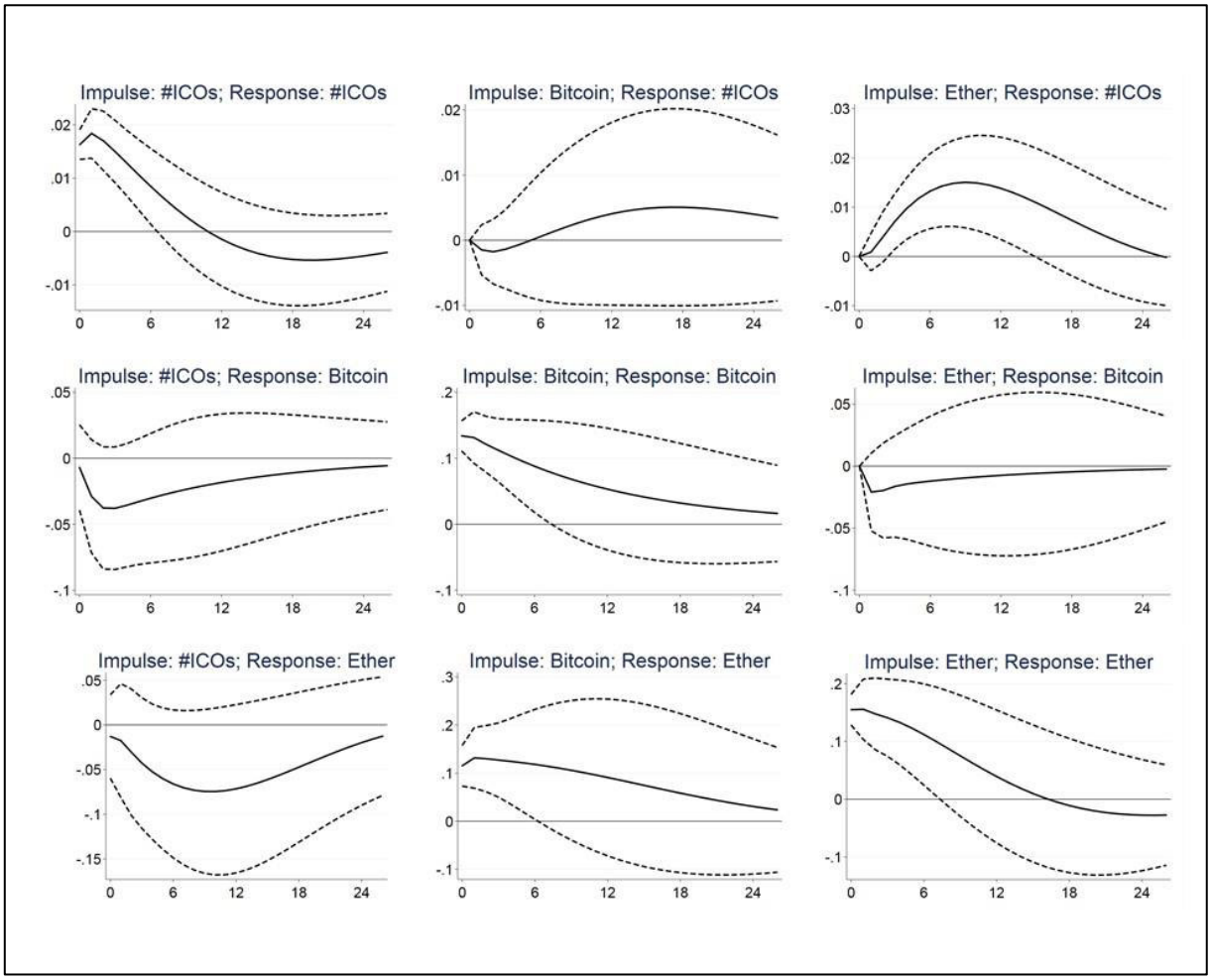
Figure 4-A5: Number of CVC investments in 2011–2015.



Notes: N = 96 districts (Raumordnungsregionen), reference: own illustration based on Spotfolio (2016).

Appendix Chapter 5

Figure 5-A1: Impulse responses of VAR model.



Notes: Figure 5-A1 shows the impulse responses (solid lines, in percentage points) to one standard deviation shock in the ICO indicator (left panel), bitcoin prices (middle panel), and Ether prices (right panel) alongside the corresponding 95% confidence bands (dashed lines). Cholesky decomposition is based on the following ordering: (i) #ICOs, (ii) bitcoin, and (iii) Ether.

Table 5-A1: Descriptive statistics.

	ICO	**Bitcoin**	**Ether**
Level			
Mean	21.13	8.20	5.21
Standard deviation	1.19	0.93	1.44
Minimum	19.40	6.72	2.13
Maximum	23.05	9.86	7.16
Correlation with ICO	1	0.931	0.898
Correlation with bitcoin	0.931	1	0.913
Correlation with Ether	0.898	0.913	1
Deterministic trend	0.059	0.066	0.044
De-Trended			
Mean	0	0	0
Standard deviation	0.191	0.315	0.636
Minimum	-0.334	-0.817	-1.348
Maximum	0.384	0.929	1.476
Correlation with ICO	1	0.045	0.174
Correlation with bitcoin	0.045	1	0.456
Correlation with Ether	0.174	0.456	1
Unit root test	-2.48	-2.16	-2.33

Notes: The upper part of Table 5-A1 displays descriptive statistics for the amount raised in ICO campaigns as well as the prices of bitcoin and Ether in log-levels, whereas the lower part provides the corresponding statistics for the linearly de-trended series. All deterministic trends are significant at the 1% level and all unit root tests (with three lags; lag length selection based on Schwert's (1989) rule) are significant at the 5% level.

Table 5-A2: OLS regression analysis on ICO volume.

Model	**Model (1)**	**Model (2)**	**Model (3)**	**Model (4)**
Dependent variable	**Log (total amount raised)**	**Log (total amount raised)**	**Log (total amount raised)**	**Log (total amount raised)**
Control variables				
Industry: Finance	-0.159	0.129	0.156	0.171
	(0.222)	(0.184)	(0.186)	(0.184)
Industry: Infrastructure	0.259	0.366*	0.425	0.473**
	(0.255)	(0.215)	(0.218)	(0.217)
Industry: Entertainment	-0.437*	0.062	0.098	0.110
	(0.239)	(0.204)	(0.206)	(0.205)
Year: 2017	1.929***	1.098***	0.988***	0.746**
	(0.388)	(0.309)	(0.325)	(0.345)
Year: 2018	2.621***	1.435***	0.948*	-0.082
	(0.467)	(0.410)	(0.535)	(0.672)
Location: US	0.283	0.056	0.037	0.057
	(0.201)	(0.162)	(0.160)	(0.159)
Location: Europe	0.437**	0.323*	0.309*	0.303*
	(0.195)	(0.174)	(0.175)	(0.172)
Twitter (dummy)		0.354	0.329	0.366
		(0.289)	(0.293)	(0.297)
Telegram (dummy)		0.748***	0.694***	0.653***
		(0.206)	(0.212)	(0.213)
Reddit follower		0.157***	0.156***	0.155***
		(0.031)	(0.031)	(0.031)
Google trends		0.485***	0.468***	0.447***
		(0.092)	(0.092)	(0.090)
Independent variables				
Bitcoin price			0.437*	
			(0.260)	
Ether price				0.176***
				(0.064)
Observations	318	318	318	318
R^2	0.250	0.420	0.425	0.433

Notes: Table 5-A2 shows an OLS regression on ICO volumes. *Twitter* and *Telegram* dummies measure the existence of a Twitter or Telegram account during the ICO campaign. *Reddit follower* includes the specific number of Reddit followers during the ICO campaign. *Google trends* is a variable that includes a real-time daily index of the volume of queries that users enter into Google. *Bitcoin price* and *Ether price* measure the respective mean value price of the cryptocurrency (30 days before the ICO until the actual start of the ICO). Robust standard errors (SE) are in parentheses. ***p < 0.01. **p < 0.05. *p < 0.1.