Stockholm School of Economics
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Spring 2017

Determinants of European FinTech activity: 2008-2015

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Abstract

FinTech has grown substantially since the 2008 financial crisis. European FinTech investments have increased from US$ 930 million in 2008 to US$ 46 billion in 2015. However, since FinTech is a relatively new industry, little academic research on the factors that influence FinTech development has been done. Therefore, this study aims to provide more insight into determinants of the European FinTech industry, by investigating its development in 24 European countries between 2008 and 2015. We expect that the size of the financial market, the number of mobile phone subscriptions, consumer trust and institutional development positively affect FinTech, but that it is negatively affected by the soundness of the financial system, collectivism and uncertainty avoidance. Regressions provide evidence that uncertainty avoidance and soundness of the financial system affect FinTech as per our hypotheses, but that consumer confidence is negatively related to FinTech development. We did not find any significant evidence of the effect of the other variables on FinTech activity.

Keywords: FinTech, financial innovation, Europe, determinants, start-ups

The authors would like to express their thanks to Associate Professor Michael Halling for his invaluable contributions throughout the study process and the writing of this report.

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1. Introduction

This introduction provides a broad overview of the financial technology (FinTech) sector. It starts with an examination of the term 'FinTech' and the historical linkages between finance and technology, focusing especially on recent, post-2008 developments in Europe, the United States, and Asia. It is followed by a section on the relevance of FinTech and this academic paper, where the research question will also be introduced. The introduction concludes with a discussion of background information that is essential to understanding the current complexities of the FinTech environment and efforts that are underway to promoting sustainable growth of the industry.

1.1 Definition

The term 'FinTech' is coined more and more often in the news, in professional organisations, and in academia. However, there is no clear academic or professional definition of what FinTech really is. Rather, it is a portmanteau of financial services and technology that can refer to start-ups, technology companies, or even legacy providers (Garfinkel & Nicolacakis, 2016). Blake, Hughes, and Vanham (2016) describe FinTech as a broad category that refers to the innovative use of technology in the design and delivery of financial services and products, cutting across multiple business segments including advice, lending, payments, and investment management. McManus (2016) defines FinTech as an economic industry composed of companies that use technology to make financial systems more efficient. There are many more definitions of FinTech, but at the heart of all these definitions lies the intersection of finance and technology.

Shuttlewood, Volin, and Wozniak (2016) make an additional distinction between so-called disruptive and collaborative FinTech ventures. Collaborative FinTech companies are the FinTech companies that predominantly target financial institutions as their customers, whereas disruptive players enter the market to compete against those incumbents by providing financial services that until recently were only available from banks or financial advisers. However, the FinTech landscape goes beyond disruptive and collaborative start-ups: as the business model of traditional banks and other financial institutions is under threat from FinTech disruptors (Burton, 2017), they are increasingly embracing FinTech as a means for accessing new markets and improving the user experience for their customers (KPMG, 2017), and are now some of the largest FinTech investors (CB Insights, 2016). They are joined by large tech firms such as Google, Apple, and Samsung, who are keen to secure a part of the growing FinTech market for themselves (Chishti & Barberis, 2016).

The three aforementioned tech companies are, for example, entering the FinTech space with their own payment solutions, i.e. Android Pay, Apple Pay, and Samsung Pay (Pagliery, 2014). Other examples of FinTech applications include bank retail services such as Berlin-based online bank N26 (Scally, 2016) and London-based Revolut (Williams-Grut, 2017), crowdfunding platforms such as Kickstarter and Indiegogo (Payton, 2017), peer-to-peer lending platforms such as Lending Club (Barzilay, 2017), and robo-advising portfolio management companies such as US-based Wealthfront and Folio (Desai, 2016) and Netherlands-based Pritle (Finextra, 2017). What these FinTech companies all have in common is that they use internet-based technology to solve inefficiencies in the financial services market – be it through providing low-cost solutions, opening markets to previously unserviceable customers, or by offering altogether new services (McManus B. , 2016). Kashyap, Garfinkel, and Haskell (2016) estimate that by 2020, more than 20 percent of incumbents' financial services business will be at risk to FinTech companies, especially in consumer banking (up to 80 percent) and fund transfer and payments services (up to 60 percent).

1.2 Development

Finance and technology have always been intricately intertwined. Arner, Barberis, and Buckley (2015) identify three distinct phases of FinTech. The first age of FinTech, or FinTech 1.0 according to their definition, lasted from 1866 to 1967. During this time, finance became globalized through technological developments such as the telegraph, railroads, canals, and steamships. This period also saw the introduction of the first credit card in 1950 (Markham, 2002). The second age of FinTech, or FinTech 2.0, started in 1967 with the marketing of the first financial calculator by Texas Instruments and the introduction of the first automated teller machine (ATM) by Barclays in the United Kingdom (Barclays, n.d.). Arner, Barberis, and Buckley (2015) describe FinTech 2.0 as the period where financial services transitioned from an analogue to digital industry, though the prevailing expectation was still that the providers of digital banking solutions would be supervised financial institutions. FinTech 2.0 lasted from 1967 until the global financial crisis of 2008, after which public perception of banks deteriorated and "a mindset shift occurred from a retail customer perspective as to who has the resources and legitimacy to provide financial services" (Arner, Barberis, & Buckley, 2015, p. 15). At this point in time, a new group of actors applying innovative technology to financial services was created, and the third age of FinTech, i.e. FinTech 3.0, started.

FinTech has grown exponentially since the global financial crisis of 2008 (Economist, 2015). Between 2008 and 2015, global investment in financial technology has grown from US$ 930 million to approximately US$ 46 billion, depending on the specifics of the measurement method (Skan, Lumb, Masood, & Conway, 2014; Shuttlewood, Volin, & Wozniak, 2016), declining to approximately US$ 25 billion in 2016. However, global FinTech M&A deal volume stayed high at 236 transactions, more than any other single year since 2008, and total global venture capital (VC) investment in FinTech companies also grew from US$ 12.7 billion in 2015 to US$ 13.6 billion in 2016. Of total global investment in FinTech, companies in the Americas received US$ 13.5 billion across 555 deals in 2016, of which US$ 12.8 billion across 489 deals went to US FinTech companies. European FinTech companies in that year received US$ 2.2 billion across 318 deals, the majority of which went to UK and German FinTech companies. Finally, Asian FinTech companies received US$ 8.8 billion in investment across 181 transactions, though US$ 4.5 billion was attributable to one single transaction in China (KPMG, 2017). Silicon Valley, New York, London, Berlin and Hong Kong have become epicentres of FinTech activity, employing large numbers of highly skilled workers and generating substantial revenues (Kinsella, 2016).

In Europe, the FinTech landscape can roughly be divided into three regions. In Northern Europe and Western Europe, FinTech focuses primarily on bank retail services. In Southern Europe, payment solutions are more in demand, and in Central and Eastern Europe, investments tend to favour big data, cyber security, and analytical service providers (Toh, 2016). It seems that this regional divide can, to some extent, be explained by looking at the penetration of online banking: relatively speaking, more people use online banking services in North-Western Europe than in Southern Europe (Statista, u.d.). In countries where online banking and the use of internet and communication technology (ICT) is commonplace, it would therefore be likely that FinTech bank retail services face fewer entry barriers, whereas new payment solutions would help mitigate some of the time and cost inefficiencies if online banking and ICT adoption rates are low. The Asian FinTech industry can similarly be defined into four broad regions, i.e. China, India, South East Asia, and developed markets that include e.g. Singapore, Japan, Korea, and Australia (Gnirck, 2016). In many ways, the Asian FinTech market is therefore comparable to the European FinTech market: it is culturally, economically, and industrially diverse, and FinTech activity seems to be consolidated in a few epicentres. The US, in contrast, is a much more homogeneous environment.

A particular distinction between Europe and the US on the one hand and Asia on the other, is the effect of the global financial crisis on the banking sector (Gnirck, 2016). In Europe and the US, undercapitalized banks were hit hard by the financial crisis; this was much less the case in Asia. The incentive to innovate the financial markets was therefore much less urgent in Asia, and FinTech was consequently slower to establish itself as an industry (Gnirck, 2016). Development of FinTech in the US and Europe has generally also followed a more bottom-up approach, in which new market players capitalize on perceived market inefficiencies, whereas the development of FinTech in Asia is predominantly encouraged by top-down legislative initiatives (Gnirck, 2016). While the FinTech industry in Europe and the US has already matured to some extent – investment in collaborative FinTech is now growing faster than investment in disruptive FinTech (Shuttlewood, Volin, & Wozniak, 2016) and banks are among the largest FinTech investors (CB Insights, 2016) – the prospects of FinTech in Asia far exceed those of FinTech in both Europe and the US. Asia has an unbanked population of approximately 1.2 billion people, a credit gap of around US$ 300 billion, and existing banks struggle to address these issues (Hope, u.d.). A detailed further discussion of the Asian FinTech market is, however, outside the scope of this study; for further reading, please refer to Hope (u.d.), Ngai et al (2016), and KPMG (2017).

1.3 Relevance

Despite its exponential growth in recent years, FinTech is still a relatively new and unexplored industry. The subject has received some attention from academics, although these efforts have mainly focused on the application of specific technologies such as decentralized 'blockchain' networks and cryptocurrencies (Kosba, Miller, Shi, Wen, & Papamanthou, 2016), crowdfunding and peer-to-peer lending (Dushnitsky, Guerini, Piva, & Rossi-Lamastra, 2016), and payment solutions (Kim, Park, Choi, & Yeon, 2016) to name a few. However, except for Haddad & Hornuf (2016), few researchers have explicitly focused on the broader context of the FinTech environment and the factors that drive its development.

In this study, we look at the development of the FinTech industry in the European Economic Area (EEA). The European FinTech industry has gone through tremendous growth since 2008, although this growth has been concentrated in a relatively small number of countries. The aim of this study is therefore to establish a better understanding of the cultural and economic environments

in which FinTech thrives. This study builds on and extendsprior academic and professional findings, andapproaches the subject from a holistic perspective.

This study focuses on the development of FinTech in European Economic Area (EEA) member countries. The reasons for choosing this subset of countries are threefold. For one, as mentioned, Europe is a region rich in economic and cultural diversity; analysing the variety in these factors could explain why FinTech has a significant presence in some countries, but is virtually absent in others. Furthermore, as this study aims to extend existing academic research, this specific subset of countries would contribute to the comparability of our findings. Third, there are considerations for doing an analysis of EEA member countries that are more practical in nature, such as data availability and familiarity.

Finally, as the growth of FinTech is likely to continue to gain momentum – especially considering upcoming regulatory changes in Europe, such as the European Commission's second Payment Services Directive, which is discussed in section 1.4.2 – it is important to develop a complete and coherent understanding of the sector, its complexities, and the opportunities it presents. The results of this study could be of interest to investors, FinTech entrepreneurs, and legislators alike, as a better understanding the drivers of FinTech activity could make investment decisions, user targeting efforts, and policy making more effective.

1.4 Background

In this section, we set the stage by providing an introduction to background information relevant to the FinTech discussion. We start with an assessment of the importance and impact of the regulatory environment, distinguishing between rules-based regulation and principles-based regulation, to understand the regulatory challenges faced by both FinTech firms and financial security authorities and innovative solutions that have been created to overcome these challenges. The section continues with a broader discussion of past FinTech developments in the European Union and current efforts towards creating a single, integrated European playing field. The section concludes with a discussion of efforts at the national level to promote local growth of FinTech, looking especially at the creation of so-called 'hub organizations' and their role in the national FinTech environment.

1.4.1 Regulation: Rules-Based vs Principles-Based

Regulatory frameworks are important enablers of innovation. In response to the credit crisis of 2008, financial regulation has become increasingly complex and has transitioned in many ways from a light-touch 'principles-based' approach to a stricter 'rules-based' approach. Generally speaking, a principles-based approach is based on a broad set of principles of conduct set out by the financial services regulator, and it is then left to regulated parties to decide how these should be appropriately implemented. In a rules-based approach, the regulated parties have little freedom to decide on implementation, instead requiring the regulator to set out a comprehensive and more specific rule book (Newey, 2013). For a detailed discussion of rules-based regulatory regimes and principles-based regulatory regimes in the context of financial innovation, please refer to Brummer & Gorfine (2014). Financial institutions have since become subject not only to increasing political pressures, but also to EU-centric regulations and escalating requirements to produce financial, risk, and compliance data (Treleaven, 2015). As we have seen, however, global investment in FinTech has grown to almost US$ 46 billion in 2015 despite increasing regulation (KPMG, 2017).

It is clear that the evolution of FinTech poses challenges for regulators and market participants alike, particularly in balancing the potential benefits of innovation with the possible risks of new approaches (Arner, Barberis, & Buckley, 2015). Blind (2012) argues that in general, the negative effect of compliance costs of rules-based regulatory frameworks should be compared with the more dynamic effect of principles-based regulations generating additional incentives for innovative activities or, in other words, that compliance costs should be compared to the attractiveness of introducing financial services innovations to the market. Creating an appropriate regulatory framework for FinTech is challenging when technology is moving quickly and developing across many different jurisdictions, but existing financial regulatory frameworks are clearly ill-equipped to oversee dynamic and rapidly changing FinTech companies (Kiem, Weir, Potel, & Trillmich, 2016). Alastair Lukies, chairman of the United Kingdom's FinTech industry body Innovate Finance, argues that "regulatory innovation is as important as technological innovation if FinTech is to continue progressing" (Thornhill, 2016).

Arner, Barberis, and Buckley (2015) argue against too-early or too-rigid regulation, instead proposing an approach that balances the view of each party and is proportionate to their obligations. Regulators, they argue, need to review the best approaches to support FinTech and adjust their methods, i.e. rules-based or principles-based, towards regulation accordingly. With respect to

FinTech, in circumstances where innovation is offering potential benefits to markets and customers, but is not yet well understood, favouring a principles-based approach would seem to maximize the benefits and minimize applicable negative trade-offs as the new innovation develops (Brummer & Gorfine, 2014). A discussion of FinTech would therefore, in short, be meaningless without also discussing the regulatory environment.

The considerable growth of FinTech has created an urgent need for reliable, secure, and agile regulatory solutions (Kehoe, Dalton, & Smith, 2015). Regulation and technology (RegTech) now seem to go through a similar development as FinTech. The authors define RegTech, or Regulatory Technology, as having four key characteristics: agility, speed, integration, and analytics. According to Kehoe, Dalton, and Smith, "RegTech will help firms to automate the more mundane compliance tasks and reduce operational risks associated with meeting compliance and reporting obligations [in the short term]. In the longer term, [RegTech] will empower compliance functions to make informed risk choices based on data provided insight about the compliance risks it faces and how it mitigates and manages those risks" (Kehoe, Dalton, & Smith, 2015, p. 3).

Gulamhuseinwala, Roy, and Viljoen (2015) attribute three main benefits to RegTech. First, it supports innovation through the identification of technologies that help firms better manage regulatory requirements and helps the regulator to fulfil its objectives of protecting consumers, promoting effective competition and confirming market integrity. Second, it supports firms to develop advanced data analytics capabilities, and finally, it reduces the cost of compliance through the simplification and standardization of compliance processes. A detailed discussion of RegTech is beyond the scope of this study; for further reading, refer to Gulamhuseinwala, Roy, and Viljoen (2015) and Kehoe, Dalton, and Smith (2015).

In response to the challenges posed by the current regulatory frameworks, some governments are experimenting with so-called regulatory sandbox programmes (Financial Conduct Authority, 2017). In a regulatory sandbox, companies work alongside a regulator when testing a FinTech product or service. This gives the firms the ability to test a new product or business model with a limited launch, without going through the full regulatory process (Colchester & Witkowski, 2016). The United Kingdom's Financial Conduct Authority (FCA) was the first financial services regulator to propose such a regulatory sandbox. The sandbox programme is built on three pillars:

acknowledgement that firms requiring authorisation have had to incur significant costs before they can meaningfully explore consumer appetite or whether there are significant risks posed to customers; concern over interpretation of established regulation; and ensuring that the sandbox's safe space for firms does not transfer risks from firms to consumers (Woolard, 2016). The FCA will only consider those propositions that demonstrate a prospective direct or indirect consumer benefit. It requires every sandbox firm to agree on upfront testing parameters and customer safeguards, and to have a fair exit strategy for consumers (Financial Conduct Authority, 2017).

Financial regulators across the world have shown significant interest in the FCA's regulatory sandbox programme. Australia, Abu Dhabi, Hong Kong and Singapore have launched similar programmes or announced their intention to do so, and a bill that closely mirrors the FCA's regulatory sandbox has recently been introduced to the United States' House of Representatives (Witkowski, 2016). In addition, the FCA has signed numerous co-operation agreements with other countries' FSAs to enable regulators to share information about financial services innovation in their own markets, including regulatory issues and emerging trends (Global FinTech Hubs Federation, 2016). The European Commission has also expressed its admiration of the United Kingdom's FCA, though introducing a EU-wide approach would be challenging because financial regulation and supervision generally remains at the national level (Shaw, 2016). The following section will therefore further elaborate on EC/EU efforts aimed at creating a unified FinTech market environment, as well as Member State initiatives at the national level.

1.4.2 FinTech and the European Commission's Digital Single Market

The groundwork for what could be called Europe's digital economy was laid in 2000, when the European Commission (EC) issued its first directive[1] on the taking up, pursuit of and prudential supervision of the business of electronic money institutions (European Parliament, Council of the European Union, 2009). In 2007, it was followed by a directive[2] on payment services in the internal market, which was updated in 2015. The initial Payment Services Directive (PSD) of 2007 resulted in the establishment of the Single Euro Payments Area (SEPA), and the updated Payment Services Directive 2 (PSD2) now aims to develop a common market for electronic payments, facilitate new types of payment services, and enhance customer protection and security (European Parliament,

[1] Directive 2000/46/EC (now 2009/110/EC)
[2] Directive 2007/64/EC

Council of the European Union, 2015). Interestingly, PSD2 has already resulted in an estimated four percent premium on the value of FinTech firms (Smart Money People, 2016)

PSD2 effectively requires financial institutions to provide third parties with access to their customers' account information in order to improve banking services for businesses and consumers. According to KPMG (2017), the PSD2 will be a significant game changer for the banking and finance industry. Together with a general commitment to open banking by governments and regulators, KPMG foresees that PSD2 is going to put European FinTech in a global spotlight, likely bringing with it increased investor interest in complementary technologies such as data and analytics. Especially investments in cross-industry platforms are likely to generate significant investor attention, and it may also create opportunities for niche FinTech companies that can provide specialized offerings based on the open data mandated by PSD2 (KPMG, 2017).

PSD2 fits into the Digital Single Market (DSM) strategy that the European Commission adopted on 6 May 2015. As of yet, the digital market of the European Union consists of 28 individual marketplaces instead of a single unified one. This theoretically means, for example, that a digital financial service provider has to set up and obtain regulatory approval in every individual Member State. Unsurprisingly, this creates significant compliance costs that make effective competition by new players virtually impossible (Bucak, 2015). The EC has therefore identified the completion of the Digital Single Market (DSM) as one of its ten political priorities, and it estimates that the DSM could raise European GDP by at least four percent by 2020 and generate up to €250 billion of additional growth (European Policy Centre, 2010)

The strategy is built on three pillars: better access for consumers and businesses to digital goods and services across Europe, creating the right conditions and a level playing field for digital networks and innovative services to flourish, and maximising the growth potential of the digital economy (European Commission, 2017). Part of the Digital Single Market strategy is for the European Commission to develop a comprehensive strategy on FinTech. The EC is therefore setting up a Financial Technology Task Force (FTTF) which brings together services responsible for financial regulation and for the Digital Single Market, along with competition and consumer protection policy (European Commission, 2016). The aim of the FTTF is to formulate policy-oriented recommendations for 'laying down the right conditions to support innovation and for a future-proof environment to emerge' (Viola, 2016). Results are not yet available, but are expected in the course of 2017.

1.4.3 Government initiatives and public-private partnerships

Deloitte's Hub Review (2016) highlights the importance of government support at the national level for the creation of a thriving FinTech industry. Even though the United Kingdom is already one of the global leaders in FinTech, the UK government is committed to further developing its FinTech sector. In 2014, it commissioned EY to produce a report to consider the UK environment for FinTech compared to that in other leading FinTech hubs to highlight where it needs to improve, drawing on the best practices of other FinTech leaders (HM Treasury, 2016). EY's conclusions confirmed that the UK has a particularly good policy environment for FinTech, with the most supportive regulatory regime, and the firm acknowledged the Financial Conduct Authority as one of the most progressive regulatory bodies in the world when it comes to FinTech (Gulamhuseinwala & Kotecha, 2016).

Whereas the government of the United Kingdom is proactively searching for new FinTech opportunities, other countries take a different approach. The German government, for example, is much more conservative than its British counterpart. BaFIN, the German Federal Financial Supervisory Authority, has limited regulatory initiatives specifically aimed at engagement with, and support of, FinTech companies, and regulation is still a complex, lengthy, and expensive process (Gulamhuseinwala & Kotecha, 2016). The Swedish government, on the other hand, has recently founded a new public fund-of-funds that only invests in private venture capital funds with the aim of improving the success of early-stage growth companies (Bolund, 2016). And across Europe, many countries are waiting for the Payment Services Directive 2 and new initiatives within the Capital Markets Union.

In short, different governments take different approaches towards FinTech. McQuinn, Guo, and Castro (2016) nonetheless recommend ten policy principles: supporting FinTech transformation; working to ensure that regulations encourage innovation in financial services; removing duplicate regulations in financial services; regulating FinTech at the national level; using regulatory enforcement actions to incentivize FinTech companies to protect consumers; creating tech-neutral rules for FinTech; creating a level playing field between incumbents and new entrants; promoting cybersecurity in FinTech; supporting standards development and financial data interoperability; and promoting international harmonization of laws affecting the financial services sector. According to the authors, these principles should increase innovation in financial services and capture its full benefits for consumers, businesses, and investors.

The growth of FinTech has led to the establishment of many so-called 'hub organizations' or industry bodies that represent the interests of the local FinTech community. The purpose of these organizations is often to act as a single access point to the full financial services and technology ecosystems. Examples of such hub organizations include Britain's Innovate Finance, the Netherlands' Holland FinTech, Belgium's Eggsplore and Switzerland's Swiss Finance + Technology Association (Deloitte & All Street Research, 2016). Interestingly, Sweden, which received 18 percent of all private placements in FinTech companies across Europe in the past five years (Invest Stockholm, 2015) and has the highest number of FinTech investments per capita (Northmill, 2016) does not have a hub organization, although there are plans for starting one in the first quarter of 2017 (Sörensen & Bucher, 2016).

Some of these hubs are collaborative efforts between FinTech entrepreneurs, large banks, investors, corporates, regulators, and governments, whereas others are primarily industry bodies, investment vehicles, or loose associations with varying degrees of professionalism. The common purpose for most of these organizations is, however, to help and nurture financial services focused tech start-ups including those in the FinTech space, but also those in related areas such as insurance and regulation (Sörensen & Bucher, 2016). Whether these hub organizations are successful in doing so is unclear. London's FinTech sector is by far the largest in the world both in terms of the number of FinTech companies and total investments, receiving more than US$ 1.5 billion of VC funding in 2015, and Innovate Finance is a strong industry body well-connected to the Financial Conduct Authority and the British government. Sweden, on the other hand, does not have a FinTech association but its FinTech sector performs excellent nonetheless.

In its latest Hub Review, Deloitte (2016) reviews a sample of FinTech hubs across Europe, Asia, Africa and the Americas to assess their potential based on three indices, i.e. the World Bank Doing Business Index, the Global Innovation Index, and the Global Financial Centres index. The best performing hub according to these metrics is indeed Innovate Finance in London, followed by FinTech hubs in Singapore, New York, Hong Kong, and Silicon Valley. Deloitte concludes that strong government support at the early stage of ecosystem formation is essential and that once a hub is established, government support, a culture of innovation and collaboration, progressive regulations, and strong financial services and private investors contribute to both the growth of FinTech hubs and the FinTech sector in general.

2. Literature review of determinants of FinTech activity

In this section, we discuss some of the known determinants of FinTech activity, e.g. those identified by Haddad and Hornuf (2016), as well as those determinants we hypothesise to be related to the development of FinTech. We discuss market traits, including capital market development, institutional development, and soundness of the financial system, as well as nonfinancial traits including trust in the financial system and cultural characteristics. As a technical characteristic, we also look at mobile phone adoption rates.

2.1 Development of the capital market

There are several ways in which a well-developed capital market can positively affect venture capital investments. A well-developed financial market reduces information and transaction costs. This improves capital allocation, lowers the external costs of finance and enables more entrepreneurs to find external financing (Rajan & Zingales, 1998; Beck, Levine, & Loayza, 2000; Wurgler, 2000).

An active stock market also encourages entrepreneurship because it makes it easier for investors to exit the portfolio company through an initial public offering (IPO). Black and Gilson (1999) argue that the exit of a portfolio company has three functions. First, it allows the Limited Partners (LPs) to evaluate the General Partners' (GPs) skill and provide information on with whom to invest their funds in the future. Second, LPs need the information to compare the results to other investments and decide whether to invest and if so, how much. Last, an exit allows LPs to withdraw their funds from less successful portfolio companies and invest these in more profitable ventures.

The exit of a portfolio company is therefore essential, but can be done both through an IPO and the sale of the portfolio company. However, in most cases an IPO is most efficient as the entrepreneur does not only receive cash, but is also returned much of the control he had previously ceded to the venture capitalist. Through a wholesale of the company, the entrepreneur would receive similar financial gains but would lose all control. An IPO is therefore preferable because it allows the founder to regain control of the firm. As the availability of an IPO exit depends on the size and development of the capital market, stock market activity is an important determinant of venture activity. Empirically, there is a significant correlation between the number of venture-backed IPOs and capital contributions in the subsequent year. Nahata, Hazarika and Tandon (2014)

find that a one-standard deviation increase in stock market development increases the likelihood of a successful VC exit by 9.4% to 11.4%, both through IPOs and acquisitions.

Another way in which an active stock market encourages venture capitalists is through traditional and well-developed financial institutions establishing accelerators and incubators. In turn, these offer funds and other forms of support to newly established companies (Haddad & Hornuf, The Emergence of the Global Fintech Market: Economic and Technological Determinants, 2016). In this way, the traditional financial sector does not directly financially support start-ups, but creates an environment in which entrepreneurs have better access to funds. Furthermore, a large financial sector offers FinTech companies in particular with more opportunities for disruption. In a small financial market, there are fewer existing business models that can be changed through innovation. A well-developed capital market therefore includes more chances for entrepreneurship.

We predict that the development of the capital market positively affects FinTech activity. Following Haddad and Hornuf (2016), we will use the natural logarithm of GDP per capita as a proxy of capital market development.

2.2 Mobile phone subscriptions

Mobile phone subscriptions will function as a proxy for the availability of the latest technology. High internet penetration and a large number of mobile phone subscriptions allow more consumers to be reached by FinTech companies, which increases chances for entrepreneurs to succeed. Technical advancements are necessary because they provide start-ups with the basics to build their business on (Arend, 1999). Without technological changes, start-ups would be unable to disrupt the traditional financial system. For instance, they have allowed for faster payment services, have cut transaction costs of banking and they improve the sharing of information through f.i. Blockchain (Haddad & Hornuf, The Emergence of the Global Fintech Market: Economic and Technological Determinants, 2016). Even though mobile payment systems were initially offered in emerging markets, innovations in developed markets are catching up. Hardware- and app-based systems such as Square and PayPal and the growing usage of mobile wallets drive an accelerating growth of non-bank mobile payments (Ernst & Young, 2014).

We predict that more mobile subscriptions positively affect FinTech activity.

2.3 Soundness of financial system

The fragility of the financial system during the 2008 crisis has attributed to the surge in FinTech activity through several mechanisms. First, banks have become more risk adverse and more hesitant to lend to small firms. FinTech start-ups can take advantage of this funding gap left by large traditional institutions through for instance P2P-lending and crowdfunding (Haddad & Hornuf, The Emergence of the Global Fintech Market: Economic and Technological Determinants, 2016). Second, many experienced employees of major financial institutions lost their jobs. Many of them became entrepreneurs, which increased the supply of investment opportunities for venture capital funds. Third, the crisis led to more stringent regulation for financial institutions, whereas FinTech often falls outside of the scope of financial regulation and has thereby become more attractive to investors. Related to this, Cumming and Schwienbacher (2016) find that FinTech companies have raised significant funds since the financial crisis. This pattern is especially noticeable in countries without a financial centre. In these countries, there is a less pronounced enforcement of banking rules, which reduces compliance costs. This makes it less expensive for both investors and entrepreneurs to take on risks, which positively affects the formation of start-ups. In countries with major financial centres there is a stronger enforcement due to the economies of scale of prudential supervision.

In line with amongst others Cumming and Schwienbacher (2016), we hypothesize that the more sound the banking sector is, the less FinTech activity there will be.

2.4 Trust

The financial crisis has not only attributed to the rise of FinTech through the mechanisms discussed above, but also through consumer trust. Consumers lost their trust in the traditional banking system during the financial crisis. Newly established FinTech companies are at an advantage because they are not associated with the financial crisis and therefore do not suffer from consumers' distrust (Cumming & Schwienbacher, 2016). FinTech companies offer not only more attractive technology and lower transaction fees, but also more trust and transparency (Menat, 2016).

Whereas soundness of the financial system reflects the trust that business executives have in banks, we will model consumer confidence using the amounts of state aid used by national

governments to resolve financial issues brought on by the 2008 financial crisis. We have attempted to obtain data that directly reflects consumer confidence. As data directly reflecting consumer confidence was unattainable and it is beyond the scope of this study to generate it ourselves, we use State aid as a proxy, since it affects consumer confidence through news coverage and the financial situation in the country. A higher amount of state aid is correlated both to a larger volume of news coverage and a more negative view on the state of the national economies. Furthermore, we believe that used state aid is in direct relationship to other inherent financial problems such as e.g. stock market developments, which literature has found also negatively influences consumer sentiment. Otoo (1999) and Jansen and Nahuis (2003) have shown that there is a strong positive correlation between stock market developments and consumer confidence in Japan and 11 European countries. Furthermore, interest rates and the dollar exchange rate significantly affect consumer sentiment (Vuchelen, 2004).

A mathematical model based on over 2,000 news stories about the economy in Michigan between 1978 and 1988 was found to predict the University of Michigan's Index of Consumer Sentiment very accurately (Tims, Fam, & Freeman, 1989). News media affect consumers' perceptions of the economy through three channels. First, media convey professional opinions and the latest news on the economy to consumers. Second, the greater the volume of news about the economy, the likelier it is for consumers to update their expectations about the economy. High news coverage is especially common during and just after recessions, which implies that this channel is countercyclical. Last, both the tone and the volume of economic reporting convey a signal to consumers. The volume of coverage itself already implies a decline in sentiment (Doms & Morin, 2004). Media exposure during the 2008-2009 worldwide economic crisis strongly affected expectations regarding the future development of the national economic situation, but did not affect personal expectations. People believed that their personal finances would not be endangered, even though they did expect the national economy to worsen (Boomgaarden, van Spanje, Vliegenthart, & de Vreese, 2011).

We expect that a decline in consumer trust, operationalised as higher state aid, will positively affect FinTech activity.

2.5 Cultural traits

National culture is found to affect both venture capital activity and a country's financial system. Anglo-Saxon countries such as the U.K. and the U.S. have a financial system that is mostly stock-based, whereas Continental Europe and Japan have markets that rely more on banks. After controlling for legal environment, it is found that countries with higher uncertainty avoidance tend to have bank-based systems. Culture may therefore be an important determinant of a country's financial system (Kwok & Tadesse, 2006).

Dushnitsky et al. (2016) look into country-level determinants of four crowdfunding platforms – Donation, Reward, Lending and Equity. They find that the legal environment and cultural factors do not affect creation of crowdfunding platforms as a whole, but that they are significant when looking into the effects on the four crowdfunding model separately. The Lending platform stands out from the other three in two ways. First, strength of legal rights positively affects the creation of Lending platforms, even though its effect is negative on the creation of Donation and Equity platforms. Furthermore, there are more Lending platforms in countries that emphasize feminine values such as cooperation and helping others. The extent to which a culture is more community-oriented as opposed to individualistic therefore influences which rewards investors seek and how many Lending platforms there are in a country.

Li and Zahra (2012) look into the importance of countries' cultural traits with regards to VC activity. They find that high levels of uncertainty avoidance and collectivism weaken the positive effect of formal institutions on venture capital. Venture capital is well-suited to fund young entrepreneurial start-ups (Hellmann & Puri, 2000). However, venture capital funding is faced with transaction problems due to higher than average uncertainty and information asymmetry (Li & Zahra, 2012). Formal institutions, defined as 'a set of political, economic and contractual rules that regulate individual behaviour and shape human interaction', can provide the appropriate incentives for investors to overcome high transaction and opportunity costs. For instance, it has been shown that VC activity depends on government initiatives, favourable fiscal and legal environments (Armour & Cumming, 2006; Nahata, Hazarika, & Tandon, 2014), quality of regulatory policies (Jeng, 2000) and corporate tax policies (Da Rin & Nicodano, 2006).

However, cultural settings affect the influence that formal institutions have on VC activity. In an uncertainty-avoiding society, entrepreneurs have a lower tolerance for risk-taking, are faced with higher opportunity costs and are less likely to respond to incentives offered by formal institutions. Collectivism can result in entrepreneurs relying more on their existing, informal network for deal flow and exclude new venture capitalists from making investments. Therefore, similar formal institutional regulations and policies in different societies can lead to dissimilar economic outcomes as they are affected by cultural values and norms.

We hypothesize that countries with lower levels of uncertainty avoidance have a larger FinTech industry. We also predict that countries that are more collectivist have a smaller FinTech industry.

2.6 Institutional development

The institutional framework implemented by administrative regulations is essential for the analysis of regulation and innovation (Blind, 2012). However, FinTech operates in a legal and regulatory environment that was designed with other types of financial institutions in mind; the consequent non-fit results in ambiguity within decision-making authorities and potentially no or inconsistent rulings from supervisory bodies (De Jonge & Van der Zee, 2016). Regardless, FinTech is one of the most important factors that determine the attractiveness and investor appetite for FinTech companies. While it would therefore be interesting to measure the effect of regulation on the development of FinTech across countries and over time, it is difficult to find a reliable proxy of the extent to which FinTech has been integrated in regulation because the majority of countries in the sample, with exception of f.i. regulatory sandboxes in the United Kingdom and, to some extent, Switzerland (Werder, 2016), do not have regulation that is specifically aimed at promoting FinTech. Most countries instead prefer novel cooperative approaches between the FinTech companies and financial supervisory authorities within the existing regulatory frameworks. Additionally, it seems that most countries are waiting for the European Commission to publish the Payment Services Directive 2 before introducing legislative changes. Ultimately, it was therefore decided not to include a proxy for FinTech-specific regulation in the regression models. Instead, the institutional development used in the models refers to the overall, non-FinTech specific development and pertain to e.g. political stability, rule of law and the absence of corruption.

Effective political and economical institutions have been found to be essential in enforcing the complex contracts that are used in VC transactions (North, 1990). Even though formal institutions do not necessarily reflect their efficiency, they are able to enable or contain VC activity in a country. For instance, a country in which the bureaucracy has the expertise and skill to govern without being faced with policy changes or disruptions by the government, offers better political environment for investor. On the other hand, institutions can hinder VC activity through corruption and reduced efficiency, which can raise the costs of doing business and introduce uncertainty and instability into the political process (Bergara, Henisz, & Spiller, 1998).

We expect that institutional development positively affects FinTech activity.

3. Methodology

In this section, we will describe our methodology. To this aim, we will first discuss how we have operationalised our independent and dependent variables and where we have retrieved the data. We will continue by discussing the controlling independent variables and our reasons for including these in our analysis. We conclude with a description of the regression methods and validations tests that have been used in this study.

3.1 Data and sample

Our main data source is SDC Platinum's VentureXpert, which provides the most complete coverage of venture capital activity in the world (Li & Zahra, 2012). However, commercial databases are known to provide inadequate coverage of VC investments outside of the USA because they overrepresent investments by independent investors and underrepresent especially governmental investments (Bertoni, Massimo, & Quas, 2015). As we have been unable to complement the dataset with other sources, it is important to keep in mind the limitations of the dataset when interpreting the results. We retrieved the data used in our analysis on 1 February 2017. Our observation period starts on 1 January 2007 and ends on 31 December 2015. The total dataset comprises observations from 9 years, but our independent variables are lagged by one year. We therefore have 8 years' worth of observations for each variable: our independent variables span from 2007 to 2014 and our dependent variables from 2008 to 2015. We identify 116 start-ups in total for the relevant sample period. To analyse the determinants that affect FinTech start-up formation, we collapsed the information into a panel dataset that consists of 192 observations for an 8-year period across 24 European countries. Data on FinTech and VC activity come from VentureXpert. The other variables are obtained from various data sources, including surveys. Most of the variables have been used in earlier research on VC or FinTech activity. Only of the variables Trust and Hubs we have not found any earlier operationalisation in research.

3.2 Variables

3.2.1 Dependent variables

We use two measures to capture FinTech. The first is the *number of FinTech start-ups*, and the second is the *amount of investments* in the FinTech sector, in thousands of US$. We use two different measures for several reasons. First, our independent variables may have different effects on our two measures. For instance, the presence of a hub may directly encourage the funding of existing start-ups but have no effect on the formation of new start-ups. We directly use these two variables in our control regressions. However, we transform the number of start-ups and the amount of investments using annual VC investments and the active population to arrive at three benchmarked variables. Our main dependent variables are *FinTech investments as percentage of VC investments*, *FinTech investments per capita* and *number of start-ups per capita*, which constitute our main dependent variables. Because the amounts of investments and number of start-ups reflect different dimensions of FinTech activity, comparing the variables' coefficients and significance could therefore provide interesting insights into the relationships between the determinants and different measures of FinTech activity. Furthermore, the VentureXpert database is incomplete and does not accurately represent VC activity. The measures therefore serve as robustness checks. By using both investments amounts and number of start-ups, we follow the same method as Li and Zahra (2012). By benchmarking the variables, we consider FinTech's prominence compared to countries' VC sectors and the size of their population. Through this, we implicitly control for population, VC activity and the size of the financial market.

3.2.2 Independent variables

Development of the capital market

It has been shown that there is a high correlation between real income and the size of the country's capital market as the expansion of an economy will drive demand for financial services. To satisfy this increase in demand, financial institutions will grow and become more sophisticated. (Yartey, 2008). To examine how the development of the capital market affects FinTech activity, we will therefore use real income as a proxy for the size of the financial market. We measure this variable by using the natural logarithm of GDP per capita in US$, which we retrieved from the World Development Indicators.

Mobile phone subscriptions

To test the effect of the availability of the latest technology on FinTech activity, we use mobile telephone subscriptions, using data from the World Development Indicators. The variable measures the annual number of post-paid and prepaid telephone subscriptions per country per 100 inhabitants.

Soundness of financial system

We measure the soundness of the financial system using data from The Global Competitiveness Index. The GCI uses the World Economic Forum's annual Executive Opinion Survey, which annually surveys nearly 15,000 top global business executives in 141 economies. The purpose of the GCI is to capture countries' competitiveness and productivity (Haddad & Hornuf, 2016). The business executives work at small- and medium-sized enterprises and large companies, from various sectors of activity, from all regions of the economies. The survey was administered through a combination of face-to-face or telephone interviews, mailed paper forms and online surveys. Despite that the data comes from a survey and is therefore relatively subjective, it has the advantage that it reflects how the financial system is perceived by professionals from different substrata of the economy and how the banks are believed to affect doing business.

We use the responses to the question 'How do you assess the soundness of banks?', with answers on a scale from 1 to 7 (1 = *extremely low – banks may require capitalization* and 7 = *extremely high – banks are generally healthy with sound balance sheets*) at the year-country level (Browne, Battista, Geiger, & Gutknecht, 2014).

Trust

Data on state aid, which is our operationalisation of trust, has been obtained from the European Commission and refers to crisis state aid, consisting of recapitalisations and guarantees granted to financial institutions. Recapitalisation shows amounts of capital, including liquidation aid and excluding aid repayments. Guarantees are the guarantees on liabilities of banks. The data may not necessarily include all Member States' state aid to banks, as governments may have financially assisted institutions under conditions that do not constitute state aid (European Commission, 2016). Both variables are reported in billions of euros.

Cultural traits

We use measures of uncertainty avoidance and collectivism to examine the effect of national culture on entrepreneurship and FinTech activity. Uncertainty avoidance and collectivism are two of the six cultural dimensions defined by Geert Hofstede. A dimension "is an aspect of a culture that can be measured relative to other cultures" (Hofstede G. , 2011). After these dimensions were initially defined mostly through surveys on IBM employees in the 1970s, six replications took place between 1990 and 2002 involving 14 countries. We directly use the Hofstede measure for uncertainty avoidance. We calculate collectivism as 100 minus the Hofstede measure for individualism since the scores for all measure range from 0 to 100. For instance, a country with a Hofstede score for individualism of 46 would be assigned a collectivism score of 54.

Uncertainty avoidance is defined as "the degree to which the members of a society feel uncomfortable with uncertainty and ambiguity" and is not the same as risk avoidance. Uncertainty avoiding cultures will try to minimise ambiguity by strict rules, behavioural codes and disapproval in deviant opinions. Collectivism refers to the "degree to which people in a society are integrated into groups". In these cultures people are integrated into cohesive groups, often with extended families that continue protecting them in exchange for unquestioning loyalty. (Hofstede G. , 2011). The Hofstede measures have been criticized and there have been suggestions that the number of dimensions should be extended. Moreover, it is important to note that these dimensions are only constructs and do not actually 'exist'. They do not consider complexities and the changing circumstances of an increasingly globalized world (Hofstede G. , 2011). Specifically, there is evidence that the uncertainty avoidance-construct is in fact invalid, using data from Germany and France (Schmitz & Weber, 2014). The GLOBE study, in which 17,000 middle managers in 961 organisations were surveyed, developed nine cultural dimensions. Even though there are several discrepancies between the results of Hofstede's research and the GLOBE study, the most substantial differences were found to be the uncertainty avoidance-measure (Venaik & Brewer, 2008). However, despite the shortcomings of the Hofstede measures, the measures are still frequently cited by researchers in studies on international business, innovation and entrepreneurship. Furthermore, as there is currently no better measure of national cultural differences, Hofstede provides us with the best proxies for cultural dimensions. Because cultural values are relatively stable over time, we treat these as time-invariant (Li & Zahra, 2012).

Institutional development

To account for the effect of governance and regulation on FinTech activity, we use the variable institutional development (Li & Zahra, 2012). Data has been retrieved from the 2016 Worldwide Governance Indicators. Institutional development has been calculated as the simple mean of six other aggregates, being 'Voice and Accountability', 'Political Stability and Absence of Violence/Terrorism', 'Government Effectiveness', 'Regulatory Quality', 'Rule of Law' and 'Control of Corruption'[3]. Estimates range from -2.5 (*weak governance performance*) to +2.5 (*strong governance performance*).

3.2.3 Controlling independent variables

Availability and adoption of ICT

We have included the variable mobile phone subscription as a proxy for the availability of latest technology. However, we included two more variables to control for the extent to which a country is an early adopter of new technology. 'Availability of ICT' reflects the question 'In your country, to what extent are the latest technologies available?', with answers ranging from 1 (not available at all) to 7 (widely available). 'Business adoption of ICT' refers to 'In your country, to what extent do businesses adopt new technology?' with a similar scale (1=not at all, 7=adopt extensively). We use these two variables to complement the number of mobile phone subscriptions per 100 inhabitants. Availability of ICT and Business adoption of ICT show correlations of only -0.11 and 0.14 with mobile phone subscriptions. Summary statistics shows that the countries with the highest number of mobile phone subscriptions (e.g. Lithuania, Italy, Luxembourg) are countries with relatively little FinTech activity. Despite mobile phone subscriptions being used in earlier research, we suspect that this variable may not necessarily be appropriate in this paper. One reason could be

[3] Voice and Accountability: Reflects perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media. Political Stability and Absence of Violence/Terrorism: Political Stability and Absence of Violence/Terrorism measures perceptions of the likelihood of political instability and/or politically-motivated violence, including terrorism. Government Effectiveness: Reflects perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies. Regulatory Quality: Reflects perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development. Rule of Law: Reflects perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence. Control of Corruption: Reflects perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests.

that the use of mobile telephones in Europe has been long-established and may not be a very suitable proxy for the availability of the latest technology, which it could be in developing markets where there are relatively few mobile phone subscriptions. We therefore add these two additional ICT measures as robustness checks.

Active population

We control for a country's population and labour market by including the active population, defined as the total population in millions of people, between the ages 15 and 64. Data has been retrieved from the World Development Indicators. We take the log of active population to make interpretation of the results easier.

Hubs and public-private partnerships

Deloitte's Hub Review (2016) served as the starting point for gathering data about local FinTech hub organizations. To complete the sample, data from the Global FinTech Hubs Federation (2016) was used, as well as additional Internet sources for establishing the founding years of specific hub organizations.

The majority of FinTech hubs was founded only recently, while some countries do not seem to have a coherent approach towards FinTech or a representative FinTech organisation at all; however, most countries that have a significant FinTech sector also have a strong FinTech hub. This variable is operationalized as a dummy variable. The variable is 1 starting the year of foundation. An overview of the founding dates of the national hubs can be found in Table 1.

It is important to note that there is not one definition of a hub. Several are initiatives started by governments, whereas others are purely commercial. Some governments still encourage FinTech activity without a hub being present. The lack of a hub therefore does not automatically mean that the industry and government are not actively trying to stimulate the FinTech sector, whereas the presence of a hub does not necessarily reflect continuous and effective efforts to boost FinTech. However, given the lack of previous research and the difficulty of comparing other means of FinTech-stimulating measures, the foundation of hubs provides the best means of establishing to what extent FinTech is supported nationally.

Table 1: Foundation dates of government hubs in Europa

Year	Countries[4]
2008	Luxembourg
2009	Denmark
2010	-
2011	Estonia
2012	-
2013	-
2014	Germany, Netherlands, United Kingdom
2015[5]	Belgium, France, Ireland, Latvia, Norway, Poland, Portugal, Switzerland
2016[6]	Czech Republic, Hungary, Spain

Venture Capital (VC) activity

To control for the overall VC investment climate in a country, we include the variable Venture Capital activity. This allows us to separate variation in FinTech activity from variation in overall VC activity and look into whether a country's FinTech sector is successful as a result of its already strong VC sector, or is relatively stronger. Data on VC investments has also been retrieved from VentureXpert and pertains to VC investments excluding FinTech, over the same time period and in the same countries in thousands of US$.

3.3 Regression and estimation methods

We report results for the following linear regression model:

$$
\begin{aligned}
FinTech\ activity_{i,t} \\
&= \beta_0 + \beta_1\ capital\ market_{i,t-1} + \beta_2\ mobile\ phone\ subscriptions_{i,t-1} \\
&+ \beta_3\ soundness\ of\ financial\ system_{i,t-1} + \beta_4\ trust_{i,t-1} + \beta_5\ culture_{i,t-1} \\
&+ \beta_6\ institutional\ development_{i,t-1} + \beta_7\ ICT_{i,t-1} + \beta_8\ active\ population_{i,t-1} \\
&+ \beta_9\ hubs_{i,t-1} + \beta_{10}\ VC\ activity_{i,t-1}
\end{aligned}
$$

[4] Austria, Bulgaria, Croatia, Finland, Italy, Lithuania, Norway and Sweden currently do not have FinTech-specific government hubs.
[5] Fall outside of the time-period used in our sample.
[6] Fall outside of the time-period used in our sample.

where FinTech activity is activity in country i and year t and the independent variables have a one-year time lag.

We test three dependent variables in our main regressions: FinTech investments as percentage of VC investments, FinTech investments per capita and number of start-ups per capita. For each of these three dependent variables we run three regressions: one with all independent variables, a smaller model without institutional development and an even smaller model without institutional development (Institutions) and business adoption of ICT (Business ICT), which is discussed in more detail in section 4.1.3.

Breusch-Pagan LM tests for the nine models have provided no evidence of significant differences across countries, which leads us to use normal OLS instead of random effects. Even though the fixed effects allow us to control for time-invariant characteristics so that we can assess the net effect of the predictors on the dependent variables, they will by definition exclude uncertainty avoidance and collectivism because these are time-invariant. We therefore primarily use normal OLS because it allows us to include cultural values and explicitly test for their effects, and we compare the results to fixed effects models to control for all time-invariant characteristics. Furthermore, as the data is incomplete and does not accurately reflect FinTech activity in Europe, the fixed effects model therefore also serves as a robustness check for the OLS model.

Teste for time-fixed effects were insignificant, which leads us to not incorporate these in our regressions. In addition, tests for heteroscedasticity using the Modified Wald-statistic for both the OLS and the fixed effects models were significant for all regressions ($p < .001$). We therefore use robust standard errors in all OLS and fixed effects models.

4. Empirical results

In this section, we introduce the results of our analysis of European FinTech activity. We start with a subsection on descriptive statistics, in which we describe the statistical properties of the dependent and independent variables. We subsequently perform univariate analyses of the independent variables to assess their individual relationships with the dependent variables. In the final subsection, we perform multivariate regression analyses to test whether the hypotheses we have introduced earlier will be rejected or not and to answer the research question: what are the determinants of European FinTech activity? The results of our analyses will be further discussed and placed in a wider context in section 5, Conclusion and discussion.

4.1 Descriptive statistics

4.1.1 Non-normalised dependent variables

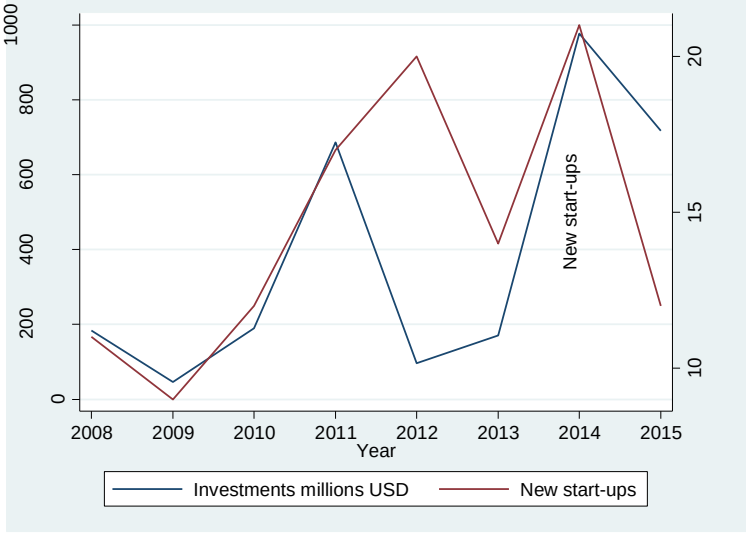
Figure 1 shows that FinTech activity has grown considerably over time, as the number of start-ups founded in 2014 (21) was approximately twice as high as in 2008 (11) and 2009 (9). The year 2012 showed a decline in investments despite its large number of new start-ups. In 2013 and 2015 we observe drops of the FinTech start-up formations and amount of investments compared to the previous years. It is however unclear what has caused these declines, as numerous reports including that of KPMG (2017) make no mention of such a decline, but rather point towards an increase in overall FinTech activity both in investments and the number of companies founded. However, KPMG (2017) does mention the existence of outliers, i.e. single firms that receive a disproportionately large number of investments, and it is possible that our sample does not include these firms. Possible other explanations could include market uncertainty over the Cypriote and Greek debt crisis in 2013 and 2015, although the variation can most likely be attributed simply to the limited number of firms and investments in our sample.

Appendix 1, which displays summary statistics of the annual number of FinTech start-ups and investments for each country, shows that the level of FinTech activity varies substantially across countries. As expected, Germany (44) and the United Kingdom (31) have the highest number of FinTech start-ups, followed at considerable distance by France (10). However, with a correlation of 0.40 there seems to be only a moderate direct relationship between the number of start-ups and the total investments. This is reflected by the United Kingdom, which has 15.5 times

the number of start-ups of Denmark, but only over three times the amount of investments. Especially Western European countries show much FinTech activity, representing 84.5% of the number of start-ups and 79.5% of total investments. Second are the Nordics, which have only 3.4% of the number of companies but a disproportionate 19% of total investments (Appendix 7).

Appendix 1 shows that there are four countries for which no start-ups and investments are reported: Czech Republic, Luxembourg, Netherlands and Norway. The lack of observations for especially the Netherlands is puzzling, given its reputation as an attractive FinTech market: perhaps the most successful Dutch FinTech company, Adyen, is already valued at more than US$ 2.3 billion after its latest fundraiser (Cookson, 2015). This also confirms that the dataset is incomplete and further research is warranted. To remedy the limitations of our dataset to some extent, it is possible not to look at the data on the individual country level, but rather to aggregate it on a regional level. Indeed, doing so brings our data more in line with that found in other reports.

Figure 1: Total number of start-ups and investments per year in US$



4.1.2 Normalised dependent variables

In our main regressions, we use benchmarked dependent variables to control for any effects that are more related to the size of the population in a country or overall VC activity rather than the particular strength of the VC industry as a whole. We look at the FinTech investments as a proportion of all VC investments; FinTech investments per capita; and number of companies founded per capita.

Table 2: Means for all normalised dependent variables, per year

Year	Mean value		
	FinTech investments as % of VC	FinTech investments per capita	Number of start-ups per capita
2008	5.3%	310	0.07
2009	0.6%	46	0.04
2010	7.8%	214	0.01
2011	6.0%	6554	0.08
2012	1.8%	172	0.03
2013	1.8%	344	0.04
2014	11.3%	1499	0.06
2015	3.4%	1009	0.02

Similar to the total number of start-ups and investments, the benchmarked dependent variables vary substantially. FinTech investments as percentage of VC varies between 0.6% and 11.3%. The variable does not show a clear pattern and has large year-on-year-difference. For instance, in 2012 and 2013 FinTech constituted 1.8% of all VC investments, but 11.3% in 2014. These large discrepancies can be due to substantial variation in not only FinTech investments, but also in its benchmark, VC activity (see Figure 1).

FinTech investments and number of start-ups per capita also vary considerably. However, as active population is very stable in the countries, this variation is mostly due to fluctuations in the non-normalised dependent variables. FinTech investments per capita show a wide range from US$ 46 to US$ 6554, whereas the number of start-ups per capita shows less fluctuations and remains between 0.02 and 0.08.

There is a moderate correlation of 0.49 between FinTech investments as percentage of total VC activity, and FinTech investments per capita, which is not unexpected because they have the same numerator. In contrast, there is little correlation between the benchmarked dependent variables otherwise.

4.1.3 Independent variables

The independent variables show clear but very different trends over time. The number of mobile phone subscriptions and the two ICT-measures related to the availability and adoption of new technology increase between 2008 and 2014. In contrast, the soundness of the financial system sharply decreases from 6.2 to 5.0. The other measures GDP per capita, institutional development and active population remain stable, as can be seen in Table 3. Guarantees and recapitalisations are still 0 in 2007 and reach a peak in resp. 2008 and 2009. They have both nearly decreased to zero in 2014. Institutional development shows high correlations with other variables, such as the log of GDP (0.88) and uncertainty avoidance (-0.61), in Appendix 4. To control for multicollinearity, we also run regressions in which we will exclude institutional development. Furthermore, the ICT measures are highly correlated with each other. Besides institutional development, we also exclude the business adoption of ICT from a set of regressions because this variable shows a higher correlation with other independent variables than the availability of ICT.

Table 3: Means for all independent variables, per year

Year	Mean value[7]										
	GDP per capita	Mobile	Soundness	Institutions	Availability ICT	Business ICT	Active population	Government hubs	Recapitalisations	Guarantees	VC activity
2007	40,255	118.4	6.2	1.2	4.8	5.2	13.2	0	0.0	0.0	71,368
2008	39,984	122.6	6.3	1.2	5.3	5.3	13.2	1	5.2	16.7	151,396
2009	37,859	122.5	6.2	1.2	5.6	5.4	13.2	2	3.6	34.7	51,672
2010	38,545	123.5	5.3	1.2	5.8	5.4	13.3	2	3.9	32.0	90,664
2011	39,018	127.9	5.0	1.2	5.9	5.4	13.2	3	1.3	22.0	73,364
2012	38,800	130.6	5.2	1.2	6.0	5.4	13.2	3	2.4	17.8	113,745
2013	38,856	128.5	5.1	1.2	5.9	5.4	13.2	3	0.6	12.6	196,392
2014	39,458	127.4	5.0	1.2	5.8	5.3	13.2	6	0.2	5.9	268,003

[7] Collectivism and uncertainty avoidance are excluded from this table because they are time-invariant. Their mean values are 36.8 and 62.2 respectively.

4.2 Univariate analysis: scatter plots and t-tests

To get a general sense of the relationships between the normalised dependent variables and our independent variables, we include a number of scatter plots. In addition, we use t-tests to further test our hypotheses and the relationships that have been implied by the scatter plots. We use one-sided t-tests for our main variables of interest because we have clear hypotheses with regards to the sign. However, since we have no clear expectations for our controlling independent variables, we have used two-sided t-tests for these. We have two sets of subsamples: in the first the subsets were created based on the median of the independent variable; in the second the splits were set at the 1st and 3rd quartile of the independent variable or alternatively at a clear visual separation. In this section, we highlight the most interesting scatter plots and t-tests only. For a complete overview of the t-tests that are significant at $p < 0.10$, please refer to Table 4.

We find that especially scatter plots with the variables uncertainty avoidance and soundness of financial institutions show distinct patterns. When looking at FinTech as a proportion of total VC investments versus soundness of financial institutions (Figure 2), we see that investments in FinTech generally tend to be higher when soundness of financial institutions is moderate to high. What this could imply is that there are inefficiencies in countries with relatively well-functioning financial institutions, creating market opportunities for the solutions and services provided by FinTech start-ups. Corrected for outliers, these findings appear to be corroborated when examining the number of FinTech start-ups per capita for each region (Figure 3).

Three of the ten t-tests that are significant at a 95%-confidence interval relate to soundness, and support our hypothesis that a financial system that is more sound will have less FinTech activity, even though the scatter plots suggest the opposite, positive, relationship. The relationship between soundness and specifically the proportion of FinTech investments is significant at a 10% level regardless of whether we split the sample at its median or the quartiles. When splitting by the 3rd quartile, the difference will be the largest as the 18 countries that are the least sound will have on average 4.3 times more FinTech investments percentage-wise than the six soundest countries[8]. In the least sound countries, FinTech investments will constitute 7.34% of all VC investments, compared to 1.28% in the financially soundest quartile. If therefore seems that the countries that are financially sound and have a more active FinTech industry are only outliers, and that less sound

[8] Finland, France, Luxembourg, Norway, Sweden, Switzerland

countries in fact enjoy more FinTech activity. Furthermore, the six least sound countries will have 0.0805 start-ups per capita, whereas the soundest 16 will on average have 0.0353 ($p < .05$), shown in Figure 3.

Figure 2: FinTech as a proportion of total VC investments versus soundness of financial institutions

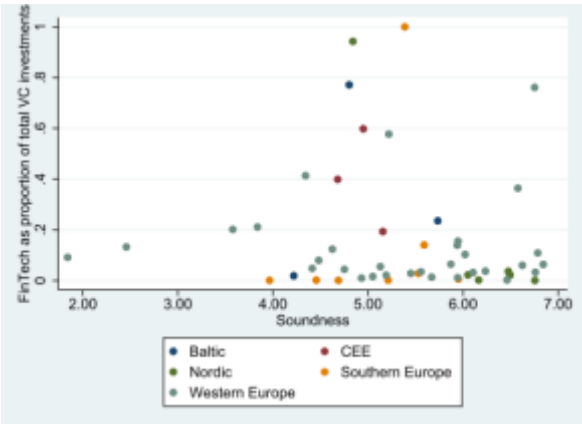
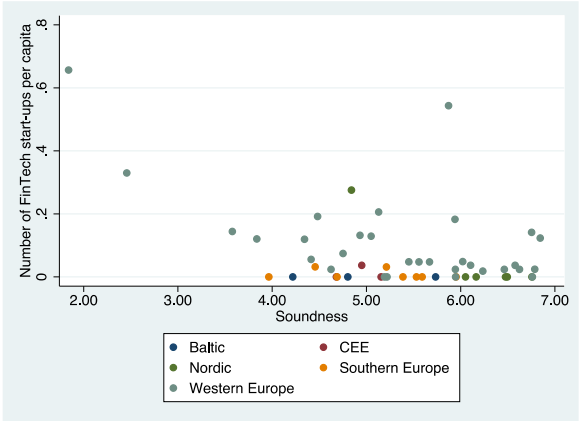


Figure 3: FinTech start-ups per capita versus soundness of financial institutions



Similarly, we have looked at uncertainty avoidance as a measure of risk appetite within a region given the inherent uncertainties and unknowns of FinTech. What is interesting to see is that while proportional investment in FinTech (Figure 4) does not appear to be related to uncertainty avoidance, the number of FinTech start-ups per capita (Figure 5) appears to indicate that FinTech investments are proportionally higher in regions where uncertainty avoidance is lower, i.e. predominantly in North-Western Europe. This seems to correspond with our hypothesis that FinTech activity is driven in part by a cultural element. Indeed, EY corroborates these findings: the countries with the highest FinTech adoption rates all score low to very low on uncertainty avoidance (EY, 2016; Itim International, 2017). EY (2016) also finds that only a minority of people that do not use FinTech solutions do so because of a lack of trust.

Figure 4: FinTech as a proportion of total VC investments versus uncertainty avoidance

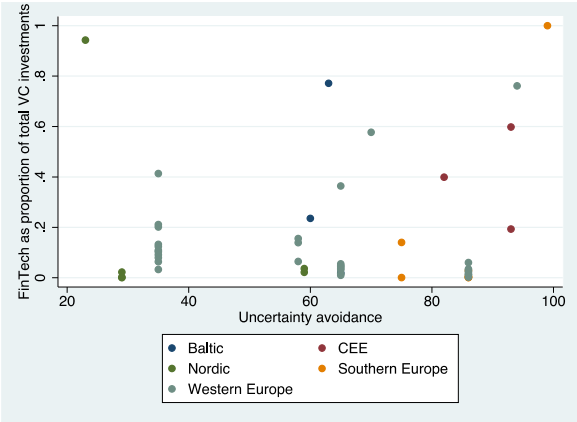
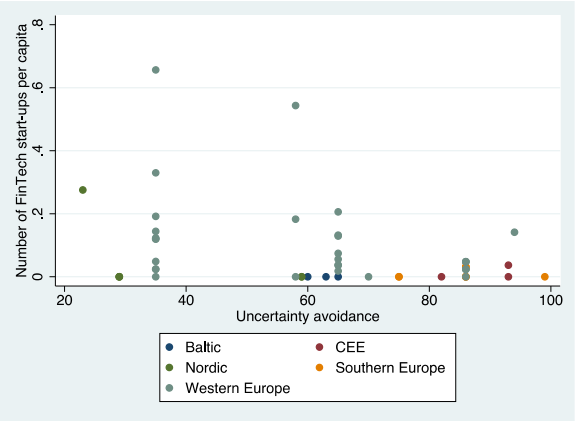


Figure 5: FinTech start-ups per capita versus uncertainty avoidance



Uncertainty avoidance, together with soundness, is one of two variables that shows the highest number of statistically significant t-tests. Countries that are more uncertainty avoidant, either by running a t-test with the median or the split at score 43, have far less FinTech activity, which is most obviously reflected by the pattern in Figure 5. The four countries[9] with an uncertainty avoidance score below 43 – a point at which there is a clear division - have FinTech investments per capita of US$ 6144, whereas the others have an average investment of US$ 155 ($p < .01$). The countries that are less uncertainty avoiding also have nearly three times the number of start-ups as the remaining countries. This difference is even bigger when using the median score of 68 to split the samples. The twelve countries with a measure lower than 68 have 4.5 times the number of start-ups per capita as the most uncertainty avoiding countries ($p < .01$) (see Figure 5). Collectivism shows a similar trend, as the most individualist countries have FinTech investments per capita of US$ 2202 and the most collectivist countries have US$ 104 average FinTech investments.

The appetite for FinTech solutions and services also tends to be driven by younger, digitally literate and higher-income customers concentrated in high-development urban areas (EY, 2016). These findings correspond with the information included in Figure 6 and Figure 7, which look at the proportional investment in FinTech and the number of FinTech start-ups per capita against the availability of ICT. The relationship appears to be more pronounced in Figure 7; a possible explanation could be that high availability of ICT promotes the creation of technology-intensive start-ups, but does not necessarily influence the funding these companies receive.

[9] Denmark, Ireland, Sweden and the UK

Figure 6: FinTech as a proportion of total VC investments versus availability of ICT

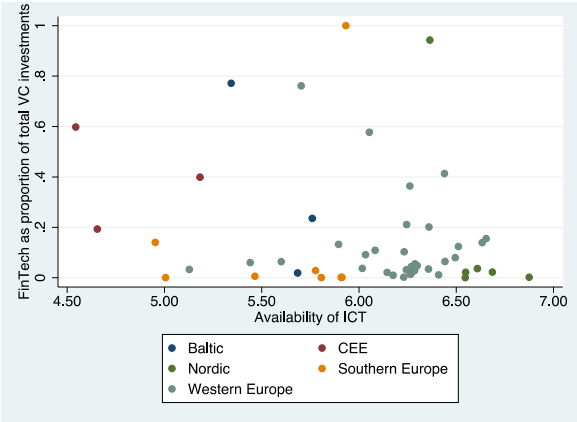
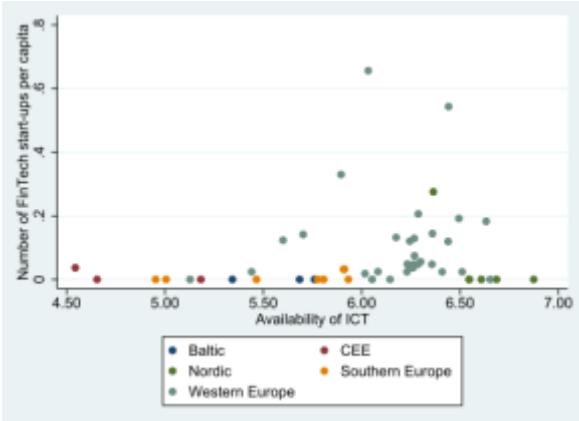


Figure 7: FinTech start-ups per capita versus availability of ICT



Indeed, when looking at business adoption of ICT, the hypothesis that a more developed technological business environment improves the FinTech ecosystem appears to be reaffirmed, and this effect also seems less pronounced in terms of the relative investment in FinTech companies (Figure 8) than in terms of the number of FinTech start-ups per capita (Figure 9).

Figure 8: FinTech as a proportion of total VC investments versus business adoption of ICT

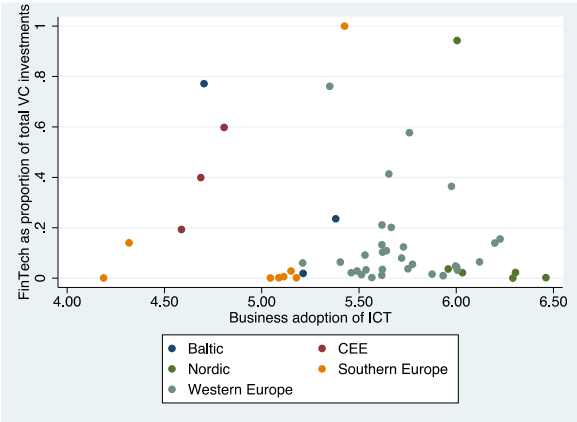
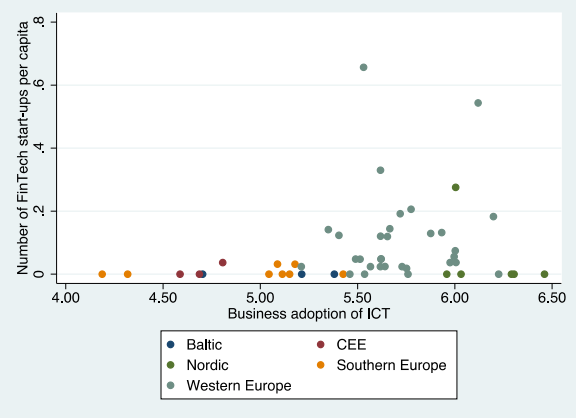


Figure 9: FinTech start-ups per capita versus business adoption of ICT



Even though a clear pattern is shown in especially Figure 9, t-tests have not shown a significant relation between business adoption of ICT and any measure of FinTech activity. In contrast, t-tests do show that the six countries with the highest availability of ICT have an annual

FinTech investment per capita of US$ 4074. In the remaining 18 countries, investments constitute only US$ 179 ($p < .05$). No significant results were found on the relationship between the availability of ICT and resp. proportional FinTech investments (Figure 6) and amount of start-ups per capita (Figure 7).

Finally, we examine the relative investment in FinTech and the number of FinTech start-ups per capita respectively against institutional development (Figure 10 and Figure 11). There appears to be a positive relationship between institutional development and FinTech activity, and this relationship is again more pronounced in terms of the number of FinTech start-ups per capita. This could indicate that the right support structures and a positive regulatory and institutional environment play an important role in the development of a FinTech sector.

Figure 10: FinTech as a proportion of total VC investments versus institutional development

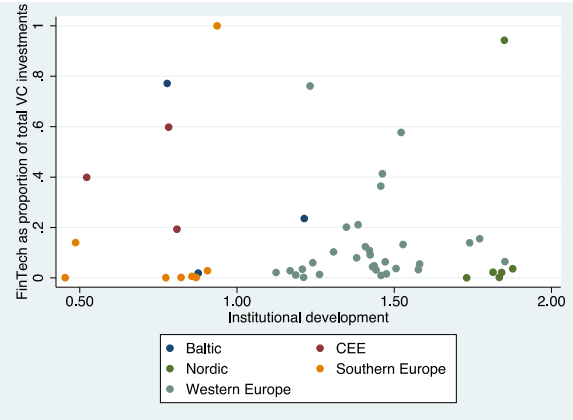
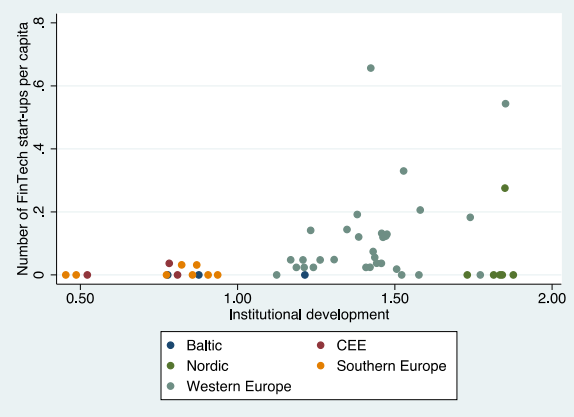


Figure 11: FinTech start-ups per capita versus institutional development



T-tests confirm that countries with higher levels of institutional development, higher recapitalisations and higher guarantees also show more FinTech activity. For instance, the twelve countries with the most developed institutions have FinTech investments per capita of US$ 3353, compared with US$ 419 for the least developed countries ($p < .10$). These countries also have twice as many start-ups per capita as the least developed countries: 0.0622 versus 0.0310 ($p < .10$). The twelve countries with the highest total recapitalisations have a FinTech investment per capita of US$ 2210, compared with Fintech investments of US$ 96 for the countries with the least recapitalisations ($p < .10$). A similar pattern is found when considering guarantees. In the twelve

countries with the highest guarantees, 6% of total investments constitutes FinTech investments, compared to 2.8% for the countries with the lowest amounts of guarantees.

However, despite the significant relations between on one hand institutional development and state aid, and on the other hand FinTech activity, there can be other related factors that truly affect FinTech that work through institutional development and state aid. For instance, a country can have a large FinTech industry because it has a large financial sector with a well-developed regulatory framework, which in turn could result in higher institutional development, recapitalisations and guarantees, though the latter are not the factors that directly affect FinTech activity.

Of the controlling variables, subsamples by the availability of ICT, the size of the active population and VC activity significantly affect FinTech activity. A smaller active population results in more start-ups per capita ($p < .05$), as does more VC activity ($p < .10$).

Generally, the scatterplots also show noticeable patterns when specifically considering different regions. The soundness of financial institutions, the availability of ICT, the business adoption of ICT, and institutional development are highest in North-Western Europe, while uncertainty avoidance is lowest. This is reflected by the t-tests, which show that North-Western Europe[10] has an average of 0.0630 start-ups per capita, whereas Southern European has only 0.0139 ($p < .05$).

It is noticeable, however, that the univariate tests do not show significant relationships between FinTech and development of the capital market, mobile phone subscriptions and business adoption of ICT[11]. The insignificance of mobile phone subscriptions and significance of availability of ICT seems to confirm our suspicion that mobile phone subscriptions is an inappropriate variable because in Europe it is no longer a suitable proxy for the latest technology. The univariate tests therefore provide further evidence for our use of the two controlling ICT-measures.

[10] In both sets of subsamples, we have included a variable that is not used in our regressions, namely Northern vs. Southern Europe. Northern Europe includes 16 countries that in the scatter plots above are grouped in Western Europe or the Baltic or Nordic regions. Southern Europe includes the eight countries from Southern Europe and CEE.
[11] The independent variable hubs has not been used in the univariate analysis because this is a dummy-variable

Table 4: Results for the t-tests with significance results p < .10. Subsample denotes how the sample has been split. Mean value below and above split show the mean values in the two subsamples. P-value is one-sided in the case of main independent variables of interest, one-sided for the controlling variables.

Independent variable	Dependent variable	Subsample	Mean value below split	Mean value above split	P-value
Soundness	FinTech investments as % of VC	Median	0.0631	0.0251	0.0378*
		Quartile 1	0.0734	0.0343	0.0564
		Quartile 3	0.0545	0.0128	0.0456*
	Number of start-ups per capita	Quartile 1	0.0805	0.0353	0.0229*
Recapitalisations	FinTech investments as % of VC	Median	0.0240	0.0642	0.0297*
	FinTech investments per capita	Median	96	2210	0.0963
	Number of start-ups per capita	Median	0.0325	0.0607	0.0759
Guarantees	FinTech investments as % of VC	Median	0.0274	0.0607	0.0598
Collectivism	FinTech investments per capita	Median	2202	104	0.0980
Uncertainty avoidance	FinTech investments as % of VC	Split at 43	0.0791	0.0371	0.0716
	FinTech investments per capita	Median	2224	81	0.0932
		Split at 43	6144	155	0.0028*
	Number of start-ups per capita	Median	0.0761	0.0171	0.0012*
		Split at 43	0.1033	0.0352	0.0047*
Institutions	FinTech investments per capita	Median	105	2200	0.0983
		Quartile 3	419	3353	0.0585
	Number of start-ups per capita	Median	0.0310	0.0622	0.0558
Availability ICT	FinTech investments per capita	Quartile 3	179	4074	0.0370*
Active population	Number of start-ups per capita	Median	0.0701	0.0232	0.0165*
VC activity	Number of start-ups per capita	Median	0.0304	0.0629	0.0973
Northern vs. Southern Europe	Number of start-ups per capita	-	0.0139	0.0630	0.0178*

* $p < 0.05$

Even though the univariate tests are generally in line with our hypotheses, it is important to keep in mind that the economic magnitude can be limited. For instance, the largest mean number of FinTech start-ups per capita is 0.1033, when splitting the sample using an uncertainty avoidance score of 43. However, in a country with an active population of 10 million this is a mean number of start-ups of only just over 1. Similarly, even though FinTech investments as proportion of VC activity of one subsample can be 2.5 times as large as the other subsample, the mean value does not exceed 7.34% of all VC activity and is therefore quite modest. In contrast, the annual FinTech investments per capita are of a larger magnitude and the difference with the mean value of the other sub sample can be much larger.

Regardless, the information does appear to correspond to some extent with existing research, such as Haddad and Hornuf (2016), as well as our initial hypotheses. The t-tests particularly support our hypotheses that financial soundness and uncertainty avoidance negatively affect FinTech, whereas state aid and institutional development affect FinTech positively. However, while it is tempting to draw conclusions based on these observations, the univariate tests also highlight the limitations of the dataset. The sample size appears to be too small to be able to inference a direct causal relationship between either investments in FinTech as a proportion of total venture capital (VC) investment or the number of FinTech start-ups per capita, and any of the included independent variables. In addition, there are outliers that might distort an interpretation of the analytical results. To control for these other factors, we run regressions in section 4.3 in which we include a number of controlling variables.

4.3 Multivariate analysis: regressions

In this section, we discuss the results of our regressions with benchmarked and non-benchmarked variables. Each regression has been run using both OLS and fixed effects. We discuss the OLS regressions using benchmarked variables in more detail, as they control for VC activity and population size, but still allow us to include cultural traits. These regressions are therefore particularly suited to answer our research question.

In our nine models using both OLS and fixed effects, we find eight significant results at a 95% confidence interval (see Table 5). The OLS estimation method only provides significant results for uncertainty avoidance. An increase of 1 point in the Hofstede measures for uncertainty avoidance decreases the number of start-ups per capita by 0.0011 or 0.0015, depending on the exact model used (see Table 5). In the dataset, the median active population is 5.9 million, which corresponds to a change in the number of start-ups for a country with a median-sized population between 0.0065 and 0.0089 per 1 point in the Hofstede measure. For this to result in one start-up less when compared to an otherwise completely similar country, the Hofstede scores would have to be 113 to 154 points higher. However, as the Hofstede scores range from 0 to 100, the variable's explanatory power is limited. Furthermore, uncertainty avoidance is not significant in the first model, where institutional development is included in the independent variables. This implies that some of the effect of uncertainty avoidance on the FinTech effect is in fact due to institutional development, which given the variables' correlation of -0.61 is not unlikely. Regardless, it is in line with our hypothesis and corresponds to the trend shown in the scatterplot in Figure 5.

However, uncertainty avoidance does not affect the proportionate FinTech investments or FinTech investments per capita. Furthermore, it is insignificant in the control OLS and fixed effects models with total FinTech investments and number of start-ups as dependent variables (see Appendices 9 and 10). Similarly, despite univariate analyses implying a negative relationship between soundness and number of start-ups per capita, soundness is not significant in any of the OLS regressions. This is especially surprising given that t-tests showed significant differences in FinTech investments as percentage of VC activity and number of start-ups per capita, when split by soundness ($p < .05$).

T-tests also showed that countries with higher recapitalisations had significantly more FinTech activity in all three measures. However, this is not reflected in the OLS regression results. The independent variables whose t-tests implied a relationship with FinTech at a p-level between

.05 and .10, guarantees, collectivism and institutions, are not significant. Of the controlling independent variables, active population showed a negative relationship and availability of ICT a positive relationship. Even though both were significant at $p < 0.05$, neither of these are significant in the OLS regressions and their coefficients' sign vary per regression.

The fixed effects regressions show significant results for the dependent variables soundness, recapitalisations and guarantees (see Table 5). Soundness of financial institutions negatively affects the number of start-ups per capita, which is in line with our expectations and the results of the t-tests. However, contrary to uncertainty avoidance, the coefficient of this independent variable is relatively large. In a country of 5.9 million people, one point difference on the soundness scale, which ranges from zero to seven, results in 0.12 fewer start-ups per capita. In the regressions on the total number of start-ups per capita, soundness is also significant in two of the FE models, with coefficients of -0.2540 and -0.2480 ($p < .05$).

Table 5: Significant results for OLS and fixed effects with robust standard errors at p < 0.05, using benchmarked dependent variables

Method	Independent variable	Dependent variable	Coefficient	Model[12]
OLS	Uncertainty avoidance	Number of start-ups per capita	-0.0011*	2
			-0.0015*	3
FE	Soundness	Number of start-ups per capita	-0.0201*	3
	Recapitalisations	FinTech investments as % of VC	-0.0015*	1
			-0.0015*	2
	Guarantees	FinTech investments as % of VC	-0.0004*	1
			-0.0004*	2
			-0.0004*	3

* $p < 0.05$

[12] Model 1: complete model, including institutions and business ICT. Model 2 excludes institutions, model 3 excludes institutions and business ICT

Table 1: Overview of OLS regression results on normalised variables, with robust standard errors. Effects of all independent variables on the normalised variables. For detailed tables of other regressions, please refer to Appendices 6-8.

	OLS								
	FinTech investments as % of VC			FinTech investments per capita			Number of start-ups per capita		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Log of GDP per capita	-0.0404	-0.0244	-0.0177	-579	-1390	-1248	-0.0153	-0.0032	0.0077
Mobile	-0.0005	-0.0005	-0.0006	-70	-70	-72	-0.0003	-0.0003	-0.0004
Collectivism	-0.0005	-0.0005	-0.0005	-14	-11	-9	0.0005	0.0005	0.0006
Uncertainty avoidance	0.0001	0.0000	-0.0002	-93	-84	-89	-0.0010	-0.0011*	-0.0015*
Soundness	-0.0117	-0.0103	-0.0071	-217	-285	-215	-0.0247	-0.0236	-0.0183
Recapitalisations	-0.0001	-0.0002	-0.0002	-11	-7	-7	-0.0021	-0.0022	-0.0022
Guarantees	-0.0002	-0.0002	-0.0002	-3	-2	-3	0.0005	0.0005	0.0004
Institutions	0.0580			-2945			0.0441		
Availability ICT	-0.0050	-0.0062	0.0101	-81	-12	338	-0.0379	-0.0390	-0.0122
Business ICT	0.0086	0.0332		1977	712		0.0355	0.0544	
Log of active population	0.0169	0.0158	0.0151						
Hubs	0.0585	0.0614	0.0589	8405	8190	8156	-0.0199	-0.0166	-0.0193
VC activity				-0.0011	-0.0010	-0.0010	0.0000	0.0000	0.0000
Constant	0.4850	0.2690	0.2900	16,554	27,590	28,021	0.394	0.229	0.262
N	192	192	192	192	192	192	192	192	192
R^2	0.0416	0.0387	0.0357	0.0832	0.0819	0.0817	0.0945	0.0924	0.0823

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Recapitalisations and guarantees negatively affect FinTech investments as a percentage of total VC investments. Every billion euro of recapitalisation by the state decreases the percentage of FinTech investments by 0.15%, whereas every billion euro guarantee decreases it by 0.04%. With mean values for recapitalisations of € 2.2 billion and guarantees of € 17.7 billion, the average effects are only 0.33% and 0.71%. The two state aid measures are insignificant in the regressions on the non-benchmarked variables. Recapitalisations and guarantees were also significant in the univariate tests, but with the opposite, positive, sign. The t-tests, in line with our hypothesis, showed that higher recapitalisations and guarantees result in more FinTech, which we argue is through a decline in consumer confidence in the traditional financial industry. In contrast, the regressions show a negative relation between state aid and FinTech. A possible explanation is that state aid affects consumer confidence in FinTech companies in addition to the traditional financial industry. Even though general VC activity may still decrease in the case of more state aid, FinTech decreases more proportionately.

In our regressions on the non-benchmarked variables, the only variable of interest that significantly affects the total FinTech investments and number of start-ups is soundness of financial institutions, with coefficients of -0.2540 ($p < 0.05$) and -0.2480 ($p < 0.05$) (see Appendix 9). In contrast, in the OLS regression, the controlling variables log of active population, availability of ICT, business adoption of ICT and VC activity are significant. It is interesting that the mobile subscription rate does not influence FinTech, even though the controlling ICT variables significantly affect the number of start-ups. However, the availability of ICT negatively affects the number of start-ups, with coefficients of -0.4880 ($p < 0.01$) and -0.4940 ($p < 0.01$), while business adoption of ICT positively affects start-ups, with larger coefficients of 0.9760 ($p < 0.01$) and 1.0860 ($p < 0.01$). It is also noticeable that the economic magnitude of these variables seems rather large. An increase of 1 point on business adoption of ICT variable will already result in an extra start-up. However, business adoption of ICT and availability of ICT have a strong correlation of 0.87. The positive effect on start-ups of a higher score of business adoption of ICT is therefore likely to be offset by a higher score of the availability of ICT and its subsequent negative effect on FinTech activity.

There is no evidence in any of the regressions that the presence of a FinTech hub affects FinTech activity, nor are there are significant results for the main variables log of GDP per capita, mobile subscription rate, collectivism or institutional development.

The results of the regressions correspond to the relations as implied by the univariate tests to a limited extent. Although most of the significant results pertain to the controlling variables, we find evidence that uncertainty avoidance and the soundness of financial institutions negatively affect FinTech activity. OLS regressions using benchmarked variables show that uncertainty avoidance negatively affects the number of start-ups per capita, in line with academic literature. The fixed effects regressions show that soundness negatively affects the number of start-ups per capita, which is also in line with our hypothesis.

Even though all tests show a significant effect of state aid on FinTech, the regressions show that this relation is negative, whereas the t-tests imply a positive relationship. In the fixed effects regressions, recapitalisations and guarantees negatively affect FinTech investments, which is contrary to our hypothesis. An explanation could be that more state aid does not increase, but actually decreases consumer confidence in new, 'risky' FinTech start-ups, and that this effect is stronger for FinTech than for traditional financial firms.

When looking at the effect on non-benchmarked FinTech activity, only the variable of interest soundness is significant, and it negatively affects the total number of start-ups. The controlling variables availability and business adoption of ICT, log of active population and VC activity also affect the number of start-ups, but not in an economically meaningful way.

5. Conclusion and discussion

The aim of this study was to investigate which variables affect FinTech activity in Europe. When only looking at our benchmarked dependent variables, we find that uncertainty avoidance and soundness of the financial system negatively affect FinTech, as we initially expected. Countries that have a higher tolerance for risk may provide a better breeding ground for FinTech activity as it is more common for entrepreneurs and capital providers to make risky investments in FinTech start-ups. Less financially sound countries also have a more vibrant FinTech industry. Even though the exact channel through which this works is not clear, possible reasons are that financial regulation is less strictly enforced or that the country was hit harder in the 2008 crisis, which resulted in a funding gap left by large financial institutions. Contrary to our hypothesis, higher state aid negatively influences FinTech activity. Higher state aid could have decreased consumer confidence in the entire financial industry without excluding the FinTech start-ups, as we had theorised. None of the other variables of interest significantly affect FinTech activity.

The links between cultural traits, soundness of financial institutions and venture capital activity have been researched in earlier papers. This report provides further support to the existing literature and adds value in that we look specifically into the effect of these variables on the FinTech industry. Our findings contradict our hypothesis on the positive effect of consumer trust on FinTech. However, academic literature on this link is limited, and even the operationalisation of the measure 'consumer confidence' is not well established.

Furthermore, it is important to note that our limited dataset makes it difficult to generalise our results. Not only are some of our independent variables, such as consumer confidence, imperfect proxies, but our measures for FinTech activity are also incomplete. However, because the results of our study confirm earlier academic research despite the shortcomings of the dataset, the results may nonetheless be of use to entrepreneurs and regulators.

Further research could examine the exact channels through which the soundness of the financial system and state aid negatively influence FinTech. It could also incorporate other proxies for size of the financial market and institutional development, since earlier research has provided evidence of their effect on FinTech but this study has not showed similar results. Moreover, future research might focus on the effects Brexit might have on not only FinTech in the UK, but also in continental Europe, and how these effects relate to the determinants that have been examined up until this point.

5.1 Effects of Brexit

This section will further highlight some of the greater uncertainties surrounding Brexit, and its effects on FinTech. To start, there is the question of passporting, i.e. that a financial institution can operate throughout most of Europe when it has offices in a single European Union member state (Finch, 2016; Ford, 2017). Perhaps even more important for the United Kingdom's FinTech sector is the freedom of movement of people, as the sector is highly reliant on foreign talent (Taylor, 2017). For example, more than 30 percent of the people employed in the UK FinTech sector are not British citizens (Arnold, 2016). Whilst it is still too early to speculate how exactly a British exit from the European Union is going to look like, the uncertainty this creates in the industry should not be underestimated.

Among other items, the issues of passporting and freedom of movement create significant market uncertainties among investors. Even though this information is not new, it is noteworthy that Brexit is already affecting the UK FinTech sector. VC investments in German FinTech companies have started to exceed those in UK FinTech companies (KPMG, 2016), and overall VC funding for UK FinTech companies has fallen by more than a quarter whereas the sector was hoping for 50 percent to 100 percent growth rates (KPMG, 2016). Additionally, the funding that did happen was predominantly follow-on funding for momentum companies; there was little new funding (Arnold, 2016). According to Innovate Finance, 30 FinTech start-ups have had their funding postponed or cancelled by investors since the end of June, creating significant cash flow problems (Arnold, 2016). However, whether any FinTech firms are actually contemplating leaving the UK for continental Europe is unclear (Andreasyan, 2016). At the time of this study, no case studies or other data are available to support any such claims.

Meanwhile, the German federal state of Hesse, the country's financial hub, is actively trying to capitalize on the post-Brexit uncertainty surrounding the UK financial industry, for example by proposing to loosen the employment law which would enable banks to easily fire high-earning executives in a bid to make Frankfurt a more attractive alternative to London (Barnes, 2016). Similar initiatives are underway in the Netherlands (Van der Zee, 2017), France (Cecil & Kyle, 2017), Ireland (Hilliard, 2016), and numerous other European Union member states. While it is unclear to what extent Britain's exit from the European Union will impact its FinTech sector, these initiatives highlight that many countries in continental Europe are keen to establish themselves as viable alternative destinations for FinTech companies.

5.2 Future development of FinTech

Based on our research results, how do we see European FinTech industry developing? The answer to that question is complicated. Our research results seem to indicate that FinTech thrives in environments where people are more willing to take risks – and not just the entrepreneurs and investors, but importantly, also the users of FinTech solutions – and where there are financial market inefficiencies. However, a lot also depends on governments' willingness to enact legislation that benefits the development of FinTech. Without such legislation, it will be difficult for many FinTech firms to create the necessary scale to truly challenge incumbent financial institutions.

Despite Brexit, the United Kingdom will therefore likely remain the European FinTech leader for the foreseeable future. Its financial markets regulator, the Financial Conduct Authority, is decidedly pro-FinTech and at the forefront of regulatory innovation. However, other countries are catching up. In the Netherlands, the Dutch National Bank and the Netherlands Authority for the Financial Markets, the local financial markets regulator, have begun exploring similar legislative sandboxes (De Nederlandsche Bank, 2016), as has the Federal Council of the Swiss government (Werder, 2016). The Second European Payment Services Directive, or PSD2, is also set to provide an additional impulse to the development of the European FinTech scene.

We think that it will not be too long before FinTech solutions move beyond a small set of early-adopters and become mainstream, their development and adoption in part spurred on by significant investments from well-known incumbent financial institutions. FinTech will move beyond the esoteric to become part of people's daily lives across the European continent and beyond. Like the telegraph, railroads, canals, and steamships in the nineteenth century, or the credit card, ATM and financial calculator in the twentieth century, internet-based financial technology is set to dramatically change the financial industry in the twenty-first century.

Appendix

Appendix 1. Summary statistics for number of companies and investments, per country

Country	Total value	
	Number of companies	Investments (Thousand $)
Austria	2	10,198
Belgium	1	23,197
Bulgaria	1	-
Croatia	1	-
Czech Republic	0	-
Denmark	2	562,236
Estonia	1	1,790
Finland	2	4,563
France	10	108,009
Germany	44	422,911
Hungary	0	500
Ireland	5	28,778
Italy	1	23,668
Latvia	1	6,193
Lithuania	0	540
Luxembourg	0	-
Netherlands	0	-
Norway	0	-
Poland	5	4,554
Portugal	0	4,477
Spain	4	13,069
Sweden	0	17,454
Switzerland	5	41,745
United Kingdom	31	1,795,451

Appendix 2. Means for all independent variables, per country

Country	Mean value											
	GDP per capita	Mobile	Collectivism	Uncertainty avoidance	Soundness	Institutions	Availability ICT	Business ICT	Population	Recapitalisations	Guarantees	VC activity
Austria	47,347	144.3	45	70	5.9	1.6	6.1	5.9	5.7	1.5	9.1	4,378
Belgium	44,437	109.4	25	94	5.3	1.3	6.1	5.5	7.2	2.6	29.4	23,815
Bulgaria	6,982	139.6	70	85	4.9	0.2	4.0	3.9	5.0	0.0	0.0	436
Croatia	13,887	111.1	67	80	5.4	0.4	4.7	4.4	2.9	0.0	0.0	-
Czech Republic	19,993	127.0	42	74	5.8	0.9	5.2	5.3	7.3	0.0	0.0	18,537
Denmark	58,413	123.1	26	23	5.6	1.8	6.3	6.0	3.6	1.3	24.8	41,851
Estonia	16,224	140.6	40	60	5.8	1.1	5.7	5.4	0.9	0.0	0.0	2,839
Finland	46,783	144.8	37	59	6.5	1.9	6.6	6.0	3.5	0.0	0.0	52,623
France	41,140	94.5	29	86	5.9	1.2	6.1	5.5	41.8	3.1	50.1	526,631
Germany	42,760	117.1	33	65	5.4	1.5	6.2	5.9	53.9	8.0	41.9	762,737
Hungary	13,414	117.0	20	82	5.1	0.7	5.0	4.9	6.8	0.0	0.0	812
Ireland	49,648	109.0	30	35	4.0	1.5	5.6	5.5	3.1	7.8	112.8	116,641
Italy	35,678	154.6	24	75	5.3	0.5	4.8	4.3	38.8	1.0	25.0	99,863
Latvia	12,764	113.7	30	63	4.9	0.7	4.8	4.6	1.4	0.1	0.1	653
Lithuania	13,220	156.7	40	65	5.2	0.7	5.1	5.0	2.1	0.0	0.0	4,383
Luxembourg	103,745	146.0	40	70	6.3	1.7	5.8	5.6	0.4	0.3	1.4	8,138
Netherlands	50,680	118.6	20	53	5.7	1.7	6.2	5.6	11.1	2.9	17.8	106,961
Norway	88,959	113.2	31	50	6.4	1.7	6.4	6.0	3.3	0.0	0.0	12,357
Poland	12,779	129.3	40	93	5.1	0.8	4.3	4.5	27.1	0.0	0.0	2,887
Portugal	22,075	117.7	73	99	5.3	1.0	5.7	5.4	7.0	1.6	6.8	13,797
Spain	30,615	109.7	49	86	5.6	0.9	5.5	5.0	31.5	7.7	36.3	233,988
Sweden	52,454	118.4	29	29	6.3	1.8	6.6	6.3	6.1	0.1	6.8	269,098
Switzerland	74,733	125.2	32	58	6.2	1.8	6.4	6.2	5.3	1.2	0.0	48,318
United Kingdom	39,592	123.4	11	35	5.1	1.4	6.3	5.6	41.4	12.5	62.8	698,062

Appendix 3. Summary statistics for all variables

Variable	Summary statistics				
	Observations	Mean	Std. Dev.	Min	Max
Number of companies	192	0.6	1.6	0	11
Investments	192	15,986	80,021	-	819,361
FinTech investments as % of VC	192	4.7%	14.9%	0%	100%
FinTech investments per capita	192	1,269	11,238	-	154,283
Number of start-ups per capita	192	0.05	0.13	0	1.10
GDP per capita	192	39,097	24,717	6,625	110,001
Mobile subscriptions per 100 people	192	125.2	17.7	89.0	172.3
Collectivism	192	36.8	15.2	11.0	73.0
Uncertainty avoidance	192	66.2	20.6	23.0	99.0
Soundness	192	5.5	0.9	1.4	6.9
Institutions	192	1.2	0.5	0.1	1.9
Availability of ICT	192	5.6	0.9	2.7	6.9
Business adoption of ICT	192	5.3	0.7	3.5	6.5
Active population	192	13.2	15.7	0.3	54.6
Recapitalisations	192	2.2	6.8	0	49.4
Guarantees	192	17.7	40.3	0	284.3
VC activity	192	127,075	318,014	0	2,647,037

Appendix 4. Correlation matrix of independent variables

	Correlation												
	GDP per capita	Mobile	Collectivism	Uncertainty avoidance	Soundness	Institutions	Availability ICT	Business ICT	Population	Hubs	Recapitalisations	Guarantees	VC activity
GDP per capita	1												
Mobile	-0.10	1											
Collectivism	-0.46	0.11	1										
Uncertainty avoidance	-0.47	-0.02	0.52	1									
Soundness	0.32	0.05	-0.03	-0.06	1								
Institutions	0.88	-0.08	-0.46	-0.61	0.33	1							
Availability ICT	0.71	-0.11	-0.37	-0.45	0.09	0.79	1						
Business ICT	0.77	-0.14	-0.38	-0.55	0.29	0.91	0.87	1					
Population	0.07	-0.17	-0.27	0.15	-0.07	-0.09	0.04	-0.06	1				
Hubs	0.26	0.25	-0.09	-0.25	0.01	0.28	0.19	0.19	-0.14	1			
Recapitalisations	0.12	-0.15	-0.15	-0.12	-0.01	0.09	0.14	0.11	0.31	-0.08	1		
Guarantees	0.19	-0.24	-0.24	-0.21	-0.14	0.13	0.17	0.13	0.29	-0.12	0.49	1	
VC activity	0.17	-0.21	-0.25	-0.15	-0.08	0.15	0.23	0.18	0.56	0.06	0.19	0.13	1

Appendix 5. Correlation matrix of dependent variables

	Correlation				
	Investments	Number of companies	FinTech investments as % of VC	FinTech investments per capita	Number of start-ups per capita
Investments	1				
Number of companies	0.40	1			
FinTech investments as % of VC	0.44	0.14	1		
FinTech investments per capita	0.61	0.08	0.49	1	
Number of start-ups per capita	0.13	0.36	0.10	0.14	1

Appendix 6. Summary statistics for benchmarked dependent variables, per country

Country	Mean value		
	FinTech investments as % of VC	FinTech investments per capita	Number of start-ups per capita
Austria	7.5%	222	0.04
Belgium	9.5%	410	0.02
Bulgaria	0.0%	0	0.03
Croatia	0.0%	0	0.04
Czech Republic	0.0%	0	0.00
Denmark	12.0%	19362	0.07
Estonia	2.9%	259	0.14
Finland	1.1%	163	0.07
France	2.3%	323	0.03
Germany	8.2%	984	0.10
Hungary	5.0%	9	0.00
Ireland	4.9%	1186	0.20
Italy	2.3%	76	0.00
Latvia	9.6%	587	0.09
Lithuania	0.2%	34	0.00
Luxembourg	0.0%	0	0.00
Netherlands	0.0%	0	0.00
Norway	0.0%	0	0.00
Poland	9.9%	21	0.02
Portugal	12.5%	80	0.00
Spain	1.0%	52	0.02
Sweden	0.4%	355	0.00
Switzerland	6.1%	949	0.11
United Kingdom	18.4%	5374	0.09

Appendix 7. Overview of number of companies and investments, per region[13]

Region	Total value			
	Number of companies	As percentage of total	Investments (Thousands $)	As percentage of total
Western Europe	98	84.5%	2,430,289	79.2%
Southern Europe	5	4.3%	41,214	1.3%
Nordics	4	3.4%	584,253	19.0%
CEE	7	6.0%	5,054	0.2%
Baltic	2	1.7%	8,522	0.3%
Total	116	100%	3,069,332	100%

[13] Western Europe: Austria, Belgium, France, Germany, Ireland, Luxembourg, Netherlands, Switzerland, United Kingdom. Southern Europe: Italy, Portugal, Spain. Nordic: Denmark, Finland, Norway, Sweden. CEE: Bulgaria, Croatia, Czech Republic, Hungary, Poland. Baltic: Estonia, Latvia, Lithuania.

Appendix 8. Overview of fixed effects regression results on normalised variables, with robust standard errors. Effects of all independent variables on the normalised variables.

	Fixed effects								
	FinTech investments as % of VC			FinTech investments per capita			Number of start-ups per capita		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Log of GDP per capita	-0.0847	-0.0807	-0.0754	1138	-346	-167	0.1100	0.0515	0.0512
Mobile	-0.0006	-0.0006	-0.0007	-115	-117	-139	-0.0010	-0.0011	-0.0011
Soundness	0.0126	0.0127	0.0129	255	199	264	-0.0178	-0.0200	-0.0201*
Recapitalisations	-0.0015*	-0.0015*	-0.0014	-33	-32	-28	-0.0026	-0.0025	-0.0025
Guarantees	-0.0004*	-0.0004*	-0.0004*	-10	-10	-9	0.0003	0.0003	0.0003
Institutions	0.0078			-2902			-0.1140		
Availability ICT	0.0141	0.0143	0.0176	166	116	1144	-0.0184	-0.0204	-0.0224
Business ICT	0.0131	0.0134		4631	4513		-0.0042	-0.0088	
Log of active population	-0.4120	-0.4120	-0.3840						
Hubs	0.0564	0.0566	0.0572	7748	7670	7998	-0.0533	-0.0564	-0.0570
VC activity				-0.0012	-0.0012	-0.0015	0.0000	0.0000	0.0000
Constant	1.545	1.508	1.463	-20,140	-6,787	12,044	-0.599	-0.0741	-0.111
N	192	192	192	192	192	192	192	192	192
R^2	0.0083	0.0084	0.0084	0.0417	0.0421	0.0471	0.0052	0.0278	0.0306

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Appendix 9. Overview of OLS regression results on non-normalised variables, with robust standard errors. Effects of all independent variables on the non-normalised variables.

	OLS					
	FinTech investments			Number of start-ups		
	(1)	(2)	(3)	(4)	(5)	(6)
Log of GDP per capita	-12202	-16988	-17091	-0.3280	-0.2560	-0.0392
Mobile	-70	-74	-73	0.0064	0.0065	0.0038
Collectivism	-240	-213	-213	0.0021	0.0017	0.0037
Uncertainty avoidance	-1060	-1016	-1013	0.0008	0.0002	-0.0059
Soundness	-3851	-4240	-4291	-0.2540*	-0.2480*	-0.1430
Recapitalisations	-646	-630	-630	-0.0025	-0.0028	-0.0022
Guarantees	-83	-80	-80	0.0067	0.0067	0.0060
Institutions	-17278			0.2590		
Availability ICT	5521	5882	5629	-0.4880**	-0.4940**	0.0411
Business ICT	6821	-515		0.9760**	1.0860**	
Log of active population	16547*	16839*	16851*	0.3110**	0.3070**	0.282*
Hubs	58335	57437	57477	0.3410	0.3540	0.2710
VC activity	0	0	0	0.0000***	0.0000***	0.0000***
Constant	164169	228562*	228238*	0.6410	-0.3240	0.3590
N	192	192	192	192	192	192
R^2	0.2366	0.2357	0.2357	0.5378	0.5373	0.5082

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Appendix 10. Overview of fixed effects regression results on non-normalised variables, with robust standard errors. Effects of all independent variables on the non-normalised variables.

	Fixed effects					
	FinTech investments			Number of start-ups		
	(1)	(2)	(3)	(4)	(5)	(6)
Log of GDP per capita	2569	7805	13775	1.6840	1.3880	1.4920
Mobile	-572	-566	-646	-0.0036	-0.0040	-0.0054
Soundness	2644	2837	3035	-0.2590	-0.2700	-0.2670
Recapitalisations	-1867	-1872	-1853	-0.0233	-0.0231	-0.0227
Guarantees	-189	-189	-189	0.0074	0.0075	0.0075
Institutions	10123			-0.5730		
Availability ICT	9995	10176	13784	-0.2480	-0.2580	-0.1950
Business ICT	14181	14574		0.2770	0.2550	
Log of active population	130675	131011	161104	1.8630	1.8440	2.3700
Hubs	51686	51957	52822	-0.1220	-0.1370	-0.1220
VC activity	0.0232*	0.0232*	0	0.0000	0.0000	0.0000
Constant	-342348	-390117	-441599	-18.0800	-15.3800	-16.2800
N	192	192	192	192	192	192
R^2	0.0712	0.0702	0.0645	0.3027	0.3115	0.2931

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

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