The Role of Information Communication Technology on Financial Development

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ABSTRACT

Although there is well-developed literature on the determinants of financial development, previous studies have neglected the role of Information Communication Technology (ICT). To fill this gap; this research aims to test whether ICT can be considered as a possible determinant of financial development using an annual time series data for Germany that covers the 1990-2016 period. Individuals using the internet (% of the population) and domestic credit to the private sector were used as proxies for ICT and financial development. To refrain from omitted variable bias, gross domestic product (GDP) per capita, foreign direct investment (FDI), and stock market capitalization were included in the empirical model as control variables. To investigate the statistical properties of the variables and the relationship among them, the following tests were employed: the ADF and PP unit root tests, the Johansen-Juselius co-integration test, the canonical co-integrating regression test, and the Granger causality test. Obtained empirical findings showed that ICT has a significant positive impact on financial development. Financial development is also positively and significantly affected by GDP per capita, FDI, and stock market capitalization. Moreover, the Granger causality test revealed that ICT and stock market capitalization Granger causes financial development. Obtained empirical findings imply several policy implications for Germany to improve its financial development further. To fund neglected start-up ICT firms, increase tax incentives to motivate research and development on ICT, and strengthen ICT infrastructure will help to improve the ICT, which will, in return; stimulate financial development. Germany should also further enhance its labor skills to benefit from the impact of ICT on financial development. Economic growth, FDI, and stock market capitalization should be considered to develop the financial sector as well. Policies regarding these factors are discussed in the conclusion section in detail.

Keywords: Information communication technology; Financial development; Stock market capitalization; Foreign direct investment; Economic growth; Time series analysis; Germany.

ÖZ

Finansal kalkınmanın belirleyicileri ile ilgili iyi geliştirilmiş bir literatür olmasına rağmen yapılan önceki araştırmalarda Bilgi İletişim Teknolojisi (BİT) ihmal edilmiştir. Bu boşluğu doldurmak için, bu tez Almanya'da 1990-2016 dönemini kapsayan yıllık zaman serisi verisi kullanılarak BİT'in finansal kalkınmanın olası bir belirleyicisi olarak değerlendirilmesini amaçlamaktadır. İnternet kullanan bireyler ve özel sektör için yerel krediler, BİT ve finansal gelişim için gösterge olarak kullanılmıştır. Değişkenlerin istatiksel özelliklerini ve birbirleri ile olan bağlantılarını incelemek için ADF ve PP birim kök testi, Johansen-Juselius eş-bütünleşme testi, ve Granger nedensellik testi kullanılmıştır. Elde edilen bulgular, BİT'in finansal gelişim üzerinde istatistiksel olarak anlamlı ve pozitif etkisinin olduğunu göstermiştir. Kişi başı GSYH, GYY ve borsa kapitalizasyonu, finansal gelişim üzerinde pozitif etkilere sahiptir. Elde edilen sonuçlara göre, Almanya'nın finansal gelişimini geliştirmesi için çeşitli öneriler yapılmıştır. Almanya, ekonomik büyüme, GYY ve borsa sektörünün önemini finansal sektörün gelişimi için göz önünde bulundurmalıdır.

Anahtar Kelimeler: Bilgi İşlem Teknolojisi, Finansal gelişim, Borsa kapitalizasyonu, Doğrudan yabancı yatırım, Ekonomik büyüme, Zaman serisi analizi; Almanya.

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LIST OF ABBREVAITIONS

ADF	Augmented Dickey-Fuller
CCR	Canonical Co-integrating Regression
FD	Financial Development
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
ICT	Information Communication Technology
IDC	International Data Corporation
MENA	Middle East and North Africa
OECD	The Organization for Economic Co-operation and Development
PP	Philips-Perron

Chapter 1

INTRODUCTION

The escalation of Information Communication Technology (ICT) usage globally and its penetration into almost all industries, including the financial sector, has pushed the need to study its role as a potential determinant of financial development. ICT contributes to financial development by increasing the speed of data transmission, decreasing the costs of production as information costs become relatively less, reducing the exchange cost, and increasing efficiency. Although there is vast literature on several aspects of ICT and financial development, such as the effect of ICT on economic growth and other variables, the determinants of financial development, and their role in spurring economic growth, the role of ICT on financial development has been widely neglected and remains under-investigated. Therefore, this study aims to fill this gap by explicitly investigating the role of ICT in financial development. Adding ICT as a determinant of financial development is the main contribution of the study, since previous studies have mainly focused on the role of ICT in enhancing economic growth and not development in the financial sector. The role of ICT on financial development will be examined using annual time series data for Germany that covers the period 1990 till 2016. The following variables were chosen to carry the investigation; individuals using the internet (% of the population) as a proxy for ICT, domestic credit to the private sector as proxy for financial development. To refrain from omitted variable bias, gross domestic product (GDP) per capita, foreign direct investment (FDI), and stock market capitalization will be added to the empirical model as control variables. The following tests will be employed: the ADF and PP unit root tests, the Johansen-Juselius co-integration test, the canonical co-integrating regression test, and the Granger causality test.

Financial development can be defined as "the factors, policies, and institutions that lead to effective financial intermediation and markets, and deep and broad access to capital and financial services" (Financial Development Index, 2008). According to Levine (2004), financial development is an improvement in the production of financial markets, instrument, and intermediaries. Levine (2004) describes the functions of a well-developed and efficient financial system as follows: provides information about investments and allocates capital efficiently, monitors firms and applies corporate governance, reduces the risks endured by investors, mitigates transaction costs and information asymmetry to pool savings from investors, and promotes specialization by reducing transaction costs. Another definition of financial development is the development of the private sector to spur economic growth and the reduction of the poverty levels and costs in the financial system. The reduction of costs, provision of information, monitoring of contracts, and facilitating of transactions all promote the development of financial intermediaries and financial markets (Eryilmaz, 2015). Recently, some authors have defined financial development by including the development of financial institutions, financial tools, and financial markets that stimulate investment and growth (Altay, 2017; Yurtkur, 2019).

Financial development has several substantial effects on macroeconomic fundamentals, especially economic growth. Early researchers (e.g., Schumpeter, 1912) mentioned the indirect effect of financial development on reducing poverty levels and on improving the living standards of individuals. In reference to Levine and Zervos (1998), the level of development in a financial system can be used as an indicator in assessing real growth. Moreover, at a microeconomic level, Demirguc-Kunt and Maksimovic (1996) state that the level of sophistication in financial institutions and the access to financial instruments affect the performance of firms and industries. To further understand this relationship, we have to examine the different ways financial development contributes to economic growth. As explained by Gupta (1987), financial development increases the supply of financial instruments and services, thus decreasing transaction costs. In this way, funds are transferred to the most efficient areas, which ultimately increase human and physical investments and spur economic growth. Financial development also encourages small investors and households to invest in financial instruments. An efficient financial system promotes the funding of entrepreneurs for technological development, which promotes economic growth.

Merton (1991) explains that financial development stimulates economic growth by providing an efficient system for conducting payments; allocating, pooling, and transferring of funds; diversifying risk, and managing information asymmetry problems. The development of financial markets creates stable economic growth through the efficient allocation of resources from areas of surplus to more productive ones (Ciftci, Ispir, and Yetkiner, 2017). Yurtkur (2019) illustrates the relationship between financial development and economic growth by presenting several points. First, economic growth requires more investments, and an increase in investments requires an increase in savings to fund such investments. Second, a direct relationship exists between the amount of government savings and investment rate and the economic growth rates. Third, an advanced financial system accelerates the provision of savings in a country. Fourth, the safety of the investment environment and the real rate of return affect the transfer of funds in an economy.

Two contradicting theories explain the relationship between financial development and economic growth. The first theory, also known as the supply leading view, claims that economic growth is aroused by financial development. The second theory, known as the demand following view, states that financial development is aroused by economic growth. Following the supply leading view, Schumpeter (1912) emphasizes the role of efficient banking systems in selecting and funding the optimum investments leading to growth in the economy. The supply leading view claims that financial development leads to economic growth by increasing the saving funds and the effectiveness of capital accumulation, and it has been confirmed by several researchers (Greenwood and Jovanovic, 1990; Bencivenga and Smith, 1991; Levine, 2004). By contrast, Robinson (1952) states that the financial sector is responsive and controlled by the demand in the real economic sector, consistent with the demand following view. Business entities and organizations create demand for financial services by encouraging financial intermediaries to develop their services and performance. The demand following view has been supported by many researchers, including Friedman and Schwartz (1963), Ireland (1994), and Al-Yousif (2002). Some researchers have suggested a two-way relationship between financial development and economic growth. Pardhan, Arvin, Hall, and Nair (2016) found a bi-directional causality between economic growth and financial development in a panel data series of 18 Eurozone countries in 1961–2013. Calderón and Liu (2003) examine panel data of 109 countries in the period 1960–1994 and find a bilateral causality between financial development and economic growth. According to this view, financial development and economic growth complement each other.

Information communication technology (ICT) can be defined as “the digital processing and utilization of information by the use of electronic computers. It comprises the storage, retrieval, conversion, and transmission of information” (Okauru, 2011). Another more detailed definition of ICT is as follows: “A wide range of computerized technologies that enable communication and the electronic capturing, processing, and transmission of information. These technologies include products and service such as desktop computers, laptops, hand-held devices, wired or wireless connectivity, business productivity software, data storage and security, network security, other related protocols” (Ashrafi and Murtaza, 2008). The British Computer Society defines ICT more comprehensively as “the scientific, technological and engineering disciplines and the management techniques used in information handling, processing and disseminating; their applications; computers, networking and communication and their integration with men and machines; and associated social, economic and cultural matter.” ICT can be classified into three groups: information technology, telecommunication technology, and networking technology (Nicol, 2003). A wide range of technologies can be found under these three groups, such as fixed landlines, mobile phone devices, the Internet, and computers. Many other definitions can be found to understand ICT. Majority of the researchers agree that ICT can be generally described as the technology that collects, stores, manipulates, and disseminates different forms of information.

ICT is vital in today’s world for many reasons. First, it provides individuals, institutions, and governments with easy access to necessary information quickly and easily. Second, it helps the reduction of production costs and the increase in production efficiency. Third, it increases the efficiency in financial markets, reducing capital costs less. It also eases access to new markets and human capital through digital networking. ICT has penetrated every aspect of life, and its effect can be observed in many areas, from gross domestic product (GDP) growth to social interactions. Previous studies have mentioned the presence of a strong link between ICT and the social and economic development of countries, as ICT has been proved to enhance the GDP growth, employment rate, and productivity in many industries. According to the World Economic Forum (2013), for every 10% growth in the digital sector in a country, the GDP per capita increases by 0.75%, and the unemployment rate decreases by 1.02%. Moreover, ICT can significantly reduce information asymmetry and eliminate third-party intervention, enabling the development of small firms and entrepreneurs (Toader, Narcis, Firtescu, Roman, and Anton, 2018). ICT has transformed the lives of individuals in rural areas, especially with the rapid increase in technology use by developing countries in the past few years. According to Pramanik, Sarkar, and Kandar (2017), who examined the role of ICT in rural areas development, ICT contributed in the development of education systems, healthcare services, agriculture, and disaster management, including the forecasting and prevention of natural disasters.

ICT usage has extensively increased in recent years, and it can be seen in the recent surge of mobile cellular and broadband subscriptions and percentage of Internet users (World Bank, 2017). These developments have diffused ICT into the financial sector. This diffusion has a dramatic effect on the financial sector and its participants. ICT increases the degree of financial activity by reducing information asymmetry and increasing liquidity (Asongu and Nwachukwu, 2016). ICT enhances market transparency because of the availability of reliable data (Sepehrdoust, 2018), improves the performance of the financial sector in both developed and developing countries by increasing the efficiency of resource allocation and channeling of funds, and minimizes time and place constraints. ICT penetration reduces operation and production costs, decreases the risk endured by financial institutions and consumers, and creates demand and investment in many sectors of the economy including the financial sector (Pradhan, 2015; Bahrini and Qaffas, 2019). Financial management has also improved because of the ICT diffusion, which increases the efficiency in data reporting and financial analysis (Chauhan, 2018).

ICT has transformed the financial sector and financial services. Internet and mobile penetration provides individuals easy access to deposits, loan, and online financial transactions. Depositors also gain access to their information, thus decreasing the risk endured by financial institutions and reduces the cost and processing time (Andrianaivo and Kpodar, 2011; Wamboye et al., 2015). ICT also increases the availability of borrowers' risk profiles, so that banks and financial institutions can accurately select borrowers based on their up-to-date information, thus decreasing constraints to financial access (Asongu et al., 2016). According to Lapukeni (2015), ICT innovation has allowed the expansion and access to financial services and instruments globally, reaching individuals and areas that were isolated before the technological development era. It has demolished the need for physical bank branches, reduced the costs for both the supplier and user, and increased financial inclusion. The use of smartphones and Internet broadband has facilitated the expansion of digital financial services quickly and increased the quality of these services. Financial services have become more data integrated; that is, they are better at analyzing potential risk and return and deepening the customer–supplier relationship, thus creating financial products that fit customer needs.

The revolutionary effect of ICT on the financial market and instruments can be observed in the security market. Technology-driven stock trading has become more common recently with the introduction of electronic brokerage. This development has decreased the costs for investors by reducing the intermediary fees and encouraged more investment. Mobile trading applications have also made it easier and quicker for investors to trade securities with fewer restrictions. According to Meadow (2019), trading applications such as “Robinhood” have made access to stock markets easier and more affordable than ever. Faster transactions in the market lead to higher trade volume and more frequent price changes, therefore demanding the immediate reactions of the investors to new information (Meadow, 2019), which contributes to the efficiency of the market. The Internet has also increased the availability of information, especially financial reporting, by enabling investors to independently analyze and carefully select a suitable investment without any third-party influence. With the diffusion of ICT, companies have become more informationally exposed, providing real-time data by allowing investors to capture up-to-date information and analyze market trends accurately.

This introduction will be followed by chapter 2 which includes a review on previous literature that have examined related topics; then chapter 3 with more detail on ICT and financial development. Methodology is described in chapter 4, followed by the results in chapter 5 and finally the conclusion which includes recommendations and policies in chapter 6.

Chapter 2

LITERATURE REVIEW

Although previous literature has investigated the relationship between financial development and many other variables, some of these variables have been given more attention by the academic community. The relationship between financial development and economic growth is one of the most widely investigated topics in the financial development literature. Real GDP is the most commonly used measure for economic growth. According to Callen (2018), “GDP measures the monetary value of final goods and services—that is, those that are bought by the final user-produced in a country in a given period.” Previous literature has affirmed the presence of a positive relationship between the level of financial development and economic growth. Madsen and Ang (2016) conduct a regression analysis on 21countries from the Organization for Economic Co-operation and Development (OECD) countries from 1870 to 2009 and find a significant positive relationship between financial development and economic growth by all theoretical means (innovation, savings, and fixed investment). Okeke and Acha (2017) use time series data between 1987 and 2014 to screen the relationship between financial development and economic growth. They use the stock market capitalization ratio, the ratio of credit to the private sector, and money demand as proxies for financial development. The results indicate a significant positive relationship between GDP and all the indicators of financial development in their model. Many studies have found evidence for the effect of financial development on economic growth. Estrada, Park, and Ramayandi (2010) use several measures for financial development, including total liquid liabilities, stock market capitalization, and bank credit, and find that all these measures have a positive effect on real per capita GDP growth. Usman and Adeyemi (2017) investigate the relationship between financial development and economic growth in Nigeria using domestic credit to the private sector as a proxy for financial development. The findings suggest that the ratio of domestic credit to the private sector to the GDP has a significant positive effect on GDP growth. Some studies have found evidence of the role of GDP growth in financial development. Salem and Trabelsi (2012) claim that economic growth stimulates an efficient and stable financial sector by improving the pooling of domestic funds and the efficiency of mobilizing capital in the economy.

Some research has reported the existence of a two-way causality link between economic growth and financial development. Hassan, Sanche, and Yu (2011) confirm the two-way causality relationship between financial development and economic growth based on the results from a multivariate time series model in the period of 1980–2007. Shahbaz, Rehma, and Muzaffar (2014) examine the relationship between financial development and economic growth using time series data in Bangladesh in 1976–2012 by applying the Bayer–Hank co-integration approach and the vector error correction model Granger causality. Their results confirm that financial development spurs the real per capita GDP growth, and thus the real per capita growth affects financial development.

Many researchers have investigated the determinants of financial development because of the importance of financial development in many macroeconomic fundamentals, including economic growth, which is the ultimate aim of each fiscal and monetary policy, and financial variables. Therefore, a broad literature has emerged from this research question (Beck and Levine, 2004; Cherif and Dreger, 2016; Elsheif, 2015; Grima and Shortland, 2008; Kaushal, 2015; Law, Tan, and Azman-Saini, 2015; Roe and Siegel, 2011; Yucel, 2009). Voghouei, Azali, and Jamali (2011) gather important determinants from many studies and report many factors as potential determinants of financial development: institutional quality, legal system, government policies, trade openness, political stability, corruption, and culture. Andrianaivo and Yartey (2009) assert that the size of the capital market affects economic growth. However, governments should begin with developing and deepening their banking sector first and then move on to developing their capital market, as capital markets need a mature banking system and sufficient demand for financial instruments to function efficiently. Therefore, it can be argued that an important determinant of financial development is the presence of an efficient banking system and the demand for financial instruments. Badeeb (2015) emphasizes the importance of trade openness and provides evidence to show the positive effect of this variable on financial development. Beck and Levine (2004) claim that legal institutions significantly affect the level of financial development. Democratic structures and political stability can also alter the degree of financial development (Grima and Shortland, 2008; Roe and Siegel, 2011).

According to Cherif and Dreger (2016), openness to foreign trade is an important determinant of financial development. Their results reveal that in the case of Middle East and North Africa (MENA) countries, corruption has a significant effect on the banking sector development, stock market development, and law and order. Elsheif (2015) examines the determinants of financial development in Egypt using time series analysis in the period of 1974–2012. Financial development represented by domestic credit to the private sector is significantly positively affected by liquid liability, market capitalization, and turnover ratio. Yucel (2009) investigates the relationship among trade openness, financial development, and economic growth and find a bidirectional causality running from trade openness and economic growth to financial development in the case of Turkey. Kaushal (2015) also finds economic growth to cause financial development in India in 1991–2013. Law, Tan, and Azman-Saini (2015) conduct a study on globalization, institutional reforms, and financial development using panel data series on East Asian economies and find that both globalization and institutional reforms can lead to financial development. Using panel data from developing and industrialized countries, Baltagi, Demetriades, and Law (2009) find that both trade openness and financial openness significantly affect financial development. Although many factors have been put forward as potential determinants of financial development, only a few factors have been widely used by researchers.

Foreign direct investment (FDI) is defined as foreign expenditures made by investors to create long-term tangible control over productive assets (Dellis, 2018). Hosting countries benefit from FDI through the better utilization of resources, the creation of jobs, and the training of their labor force (Shah, 2013). FDI is considered to facilitate economic growth in direct and indirect ways through the creation of employment, the enhancement of productivity, the increase in competitiveness, and technological development. Mosiori (2014) confirms that FDI creates employment, improves the capability of production, and develops local individuals' skills through technology. Moreover, FDI promotes investments that increase production and the utilization of goods and services. FDI also creates access to global markets and foreign currencies, which are also significant for economic growth (Denisia, 2010). After the 2009 recession, FDI has become the primary foreign source of financing in developing economies. As a result, the relationship between FDI and financial development has been extensively investigated (Shah and Faiz, 2015).

Many studies have provided evidence on the effect of FDI on financial development. FDI is expected to assist financial development, as FDI inflows have become a large share of financial resource inflows (Lin and Miyamoto, 2012). FDI also eases access to funds, which can benefit local firms, therefore increasing competition in the hosting markets (Desbordes and Wei, 2017). Desbordes and Wei (2017) examine the relationship between FDI and financial development and find that FDI leads to financial sector development by funding financial markets through financial instrument trading. They conclude that financial systems must increase access to external finance to enhance FDI. According to Alfaro (2010), financial development enhances FDI in indirect ways, such as efficiently allocating capital to local firms and providing more variety for intermediate inputs in a hosting country. Otchere, Soumare, and Yourougou (2016) find a two-way causality between FDI and financial development using panel data in 1996–2009 in African countries. Their regression results reveal that FDI can promote financial market development by improving the transparency and depth of financial sectors. Soumaré and Tchana (2015) examine 29 emerging markets and discover a two-way causality between FDI and stock market development indicators. Belkhodj, Mohiuddin, and Karuranga (2017) conclude that the level of financial development has a significant effect on the FDI location choice, thus implying that multinational companies tend to choose regions with a higher financial development in which to invest. Using panel data of 92 developing countries, Munemo (2017) concludes that FDI is significantly dependent on financial sector development in host countries. Accordingly, the current study employs FDI as a potential determinant of financial development because of the documentation of the importance of FDI in financial development.

Market capitalization is defined as the total market value of firms' outstanding shares and is commonly used to measure the size of a firm (Chen, 2018). Market capitalization is determined by the changes in the volumes and price indexes in the market. Therefore, stock market activities heavily influence market capitalization. This variable has been widely used as an indicator for measuring stock market depth and efficiency (Mishkin and Eakins, 2012). The largest share of market capitalization research is dedicated to its effect on economic growth. The stock market plays a vital role in channeling and mobilizing surplus funds through financial intermediaries toward productive investment, thus promoting economic growth (Caporale, Guglielmo, and Soliman, 2004). Shahbazet al. (2008) uses annual time series in 1971–2006 to investigate the relationship between market capitalization and economic growth and finds a strong positive relationship between them. Cavenaile, Gengenbac, and Palm (2011) find a significant positive effect of market capitalization on economic growth for Malaysia, Mexico, Nigeria, the Philippines, and Thailand in the 1997–2007 period. Prats and Sandoval (2016) prove the presence of a causal link between market capitalization and economic growth for six Eastern European countries (Slovakia, Poland, Hungary, Bulgaria, Czech Republic, and Romania). Nordin and Nordin (2016) test the effect of stock market capitalization on real GDP per capita in the Malaysian economy and find that an increase of 1% in stock market capitalization leads to a 0.23% increase in the real GDP per capita. Moreover, approximately 27% of the variation in the real GDP growth is reflected by stock market capitalization. Qamruzzaman and Wei (2018) observe a statistically significant relationship between market capitalization and GDP per capita. They find that stock market development leads to sustainable economic growth by promoting access to financial institutions, diversification of financial assets, efficient capital allocation, and long-term capital in the market.

A strong relationship exists between market capitalization and the financial sector. Market capitalization can be used to measure the financial performance of an economy because of the fact that market capitalization has been proved to perform the functions of an efficient financial system, such as increasing liquidity, promoting investment, facilitating the exchange of goods and services, and mobilizing and pooling of funds (Dokmen, Aysu, and Bayramoglu, 2015). It also reflects the flow of funds in an economy and the efficiency of resource allocation from areas of surplus to areas lacking in sufficient resources. The low market capitalization caused by the inefficiency of stock market development disables the efficient flow of funds and increases costs, hindering the development of the financial system (Mishkin, 2004). Long-term patterns in stock market capitalization have been used to measure financial development and financial market efficiency (Levine and Zervos, 1996).

Stock market capitalization is used as a measure of stock market development in many studies that assume the size of the stock market to be usually linked to its performance. Garcia and Liu (1999) find a link between the development of financial intermediaries and market capitalization using a sample of 15 developed countries in 1980–1995. Following the framework of Levine and Zervos (1998), Caporale, Guglielmo, and Soliman (2004) investigate the causality among market capitalization, financial development, and economic growth in seven countries. Their results indicate the existence of causality between stock market capitalization and banking sector deposits and of domestic credit to the private sector in some countries but not in others. According to the authors, when adding stock market capitalization to the regression with financial development, a strong causality is found between stock market capitalization and economic growth. This result emphasizes the importance of a developed stock market in creating a well-functioning financial sector. Conversely, Tang (2006) observes that the relationship between market capitalization and financial development is only significant in developed countries. Aduda, Masila, and Onsongo (2012) find a significant relationship between stock market capitalization as a proxy for stock market development and domestic savings as a proxy for financial development using data from the Nairobi Stock Exchange market.

Chapter 3

THE EFFECT OF ICT ON FINANCIAL DEVELOPMENT

The main role of financial intermediation is the transfer of financial funds from depositors to borrowers in an economy. The introduction of ICT has altered the nature of financial intermediation through the creation of new financial assets and the improvement of investment and risk management (Genberg, 2009). Awulatu (2012) claims that financial intermediaries who adopt ICT have produced more revenue, increased quality and efficiency as well as produced more profit that others. ICT is important for financial intermediaries as it reduces information asymmetry enabling financial institutions to obtain information on the risk profiles of their borrower. When this type of information becomes available financial intermediaries can select their borrowers more efficiently (Asongu et al., 2016). According to Kuroda (2016), ICT-driven financial intermediation has increased the efficiency of capital allocation, therefore providing funds to investments with the highest productivity and revenue. Adjei (2018) investigated the role of ICT on the performance of financial intermediaries and found a statistically significant relationship between ICT tools like; ATM's, telephone and internet services, and interbank fund transfer; and financial intermediaries performance. He also stated that financial intermediaries have to make sure that they apply ICT efficiently by implementing adequate machines and skilled employee in order to minimize users' costs and customer time to transact. This will increase both customer satisfaction and market share of these financial intermediaries in the financial market. According to the findings of Sassi and Goaieda (2013), a significant positive relationship exists between ICT proxies and economic expansion.

Financial access is one of the leading indicators of financial development and can be defined as the availability of financial services without the existence of price and non-price obstacles (World Bank, 2008). Limited financial outreach and inclusiveness hinders direct access of households and firms to formal financial services. Financial systems have to be able to provide saving, transaction, payments, and risk diversifying products to a large scope of participants. Otherwise excluded individuals and firms will have to rely on just their own capital and resources which will create social and income inequality as well a slower economic growth rate (Rajan and Zingales, 2003). With access to financial products and services, the low income people will have access to safe money savings in banks and investments via financial institutions, preventing the concentration of monetary power with a small number of individuals; this also prepares the low income individuals for any risk of an economic shock. Moreover, financial access also enhances the participation by all parties, increasing the value of the entire national financial system, and making monetary policies more effective (Kelkar, 2010).

Financial access can be enhanced by the diffusion of ICT. ICT plays an important role in enhancing financial access since it encourages financial institutions in order to boost the access of credit to individual firms and households. “Information technology networks have dramatically boosted the reach of traditional financial institutions and processes” and financial markets have recently become globally integrated, which means that one financial market in a country can easily influence another financial market in another country (Claude, 2016). Financial institutions nowadays require technological tools like high broadband networks and complex data bases to compete; this is why ICT has become essential for the operation of any financial sector. Financial institutions are also using social media channels to reach their customers and to gather data useful in competing and innovating (Claude, 2016). The widespread use of mobile phones and internet services can be used for diffusing financial services to the unbanked individuals. It also adds flexibility and ease to financial users eliminating time and place constraints. To facilitate financial access in rural and unreached areas the implementation of a technological framework is necessary ensuring the delivery of financial services to the largest possible population in a transparent and effective way with an adequate economic cost (Ramswaroop, 2017). Bahsin (2015) claimed that apart from providing access for financial institution services, ICT can facilitate utility payments like electricity and water bills, mobile subscriptions etc. with the help of online payments. Given the strong link between financial development and financial access, the contribution of ICT to financial access is expected to enhance financial development

ICT has proved to be an effective player in the development of the financial service sector. Technology-driven financial services or e-finance describes the availability of financial services via electronic communications (Information Age, 2018). Electronic financial services are enhancing financial inclusion in remote areas that have very restricted financial access to the formal financial sector. E-finance services have improved the penetration of general accounts such as; bank, credit, savings, and mobile wallets accounts. Switching from cash transactions to online money transactions increases both efficiency and speed of transactions while decreasing costs of money transfer. Security is an essential feature of e-finance service since remittances before were subject to theft. Online financial services also enhance transparency by reducing the risk of information leakage with the help of digital records. Digital records of customers' transactions can also be used for credit scores, which improve mobile digital borrowing (World Bank Development Group, 2014). ICT enhances services like financial trading, financial reporting, and financial transactions. ICT also provides investors with immediate information which help in decision making. Financial reporting also becomes automated and can easily be accessed by traders. Instead of using checking account ICT driven financial services can now conduct money transactions quickly and easily (Novison, 2017).

According to a report conducted by McKinsey Global Institute (2016), technology-driven financial services are proven to promote financial services in remote areas. The introduction of electronic financial services has created stable financial development and economic expansion through the efficient mobilization of domestic resources, an increase in national saving, and boosting of governmental revenues. Another study by MIT and Georgetown University (2015) found that mobile money services have pulled out 2% of the Kenyan population from poverty, which was approximately close to 194,000 households. The USAID organization provided 20% of public school teachers in Liberia with digital salary payments. This technology reduced the costs by 61% and reduced the time in retrieving salaries by 98% (USAID, 2019). The contribution of ICT to the financial services will have positive effects on financial development. According to study conducted by Susanto, Chang and Ha (2016), using a survey on 301 smartphone users subscribed to online financial services, online financial services have a significant impact on the users perceived trust, satisfaction and usefulness. Another study by Nath and Liu (2017) using panel data for 49 countries stated that ICT has a significant positive effect on the performance of six types of services including financial services, insurance services and business services.

Financial management is defined as the process of planning, controlling and organizing financial funds in order to achieve a certain goal or objective. Financial management is vital for financial development in which it helps in resource allocation decisions, measuring inputs and outputs, integrating budgeting and accounting and investment decisions (Olowofela, Adebowale and Adejonwo, 2018). Financial management can promote efficiency in the financial sector by increasing the efficiency of institutional decisions and practices. The integration of ICT can further enhance the efficiency of financial management, resulting in a more developed financial system. ICT is a common tool used in coordinating and organizing the operations of many financial institutions, enhancing financial management. ICT is useful in managing budgets, monitoring cash flows, managing risk, monitoring compliances, financial reporting, and investment decision making (Oz, 2009). In addition to other benefits, the diffusion of ICT in risk and asset management has increased the feasible scale of providing financial products and services and increased their distribution capacity through lower infrastructure costs (Aghion, 2008).

ICT allows financial institutions to efficiently maximize their production, communicate faster both internally and externally, and obtain electronic records and data quickly and easily. Moreover, ICT integrated financial management also improves accounting systems, financial risk management, cost management, and financing and budgeting strategies. ICT is effective in reducing operational costs by using computerized technologies instead of low-value labor reducing the unit cost of transactions. ICT also promotes effective decision making using information processing, data mining, and econometrics and statistics. Efficient decision making reduces costs and risk of errors, therefore increasing revenues which serve the financial market as a whole (Kirmani, Wani and Saif, 2015). Godwin (2016) claimed that technological financial management supports transaction monitoring, online applications, risk analysis, data screening and aggregation, financial modeling, scenario analysis, enhancing internal organizational culture and engaging with customers. In 2017 alone, the international Financial Management Software market size was rounded to 4.36$ billion and is expected to grow by 11.7% from 2018 to 2025. Adesola (2013) conducted a regression analysis to investigate the impact of ICT on the operation and management of banks in Nigeria, taking into account the speed and efficiency of operations, service delivery, employee's performance, and the bank profits. The results indicate that ICT has a positive impact on all their dependent variable, which confirms the importance of ICT in financial management. Binuyo and Aregbesola (2014) investigated the effect of ICT on the performance of financial institutions in South Africa during the period of 1990 to 2012 using dynamic panel data and an orthogonal transformation method. Their results confirm the results of Adesola (2013) and therefor, further validates that ICT promotes better financial performance.

Chapter 4

DATA AND METHODOLOGY

4.1 Sample Selection

We choose Germany as our sample for several reasons. Germany's economy is considered the largest in Europe and the fourth largest in the world, making it the most economically influential member of the European Union. Its well-functioning financial sector and trade openness have enhanced long-term investment and a wide range of services offered by its financial sector. Germany is striving to be number one in digital technology in Europe by advancing in ICT and software, robot and sensor technology, and intelligent systems. Germany's ICT market is also one of the largest in the world. Germany has successfully employed ICT in different sectors of its economy, strengthening the production of its industries, and enhancing its nation's leadership. These factors make Germany an ideal candidate for investigating the effect of ICT on financial development.

In 2017, Germany recorded 160 billion Euros as its ICT market turnover, making it the fifth largest ICT market in the world (Germany Trade and Investment, 2019). According to the European IT Observatory, investing in ICT equipment and services boosted the IT market to grow faster than the GDP growth rate in 2016 by 3.3%. Germany succeeded in becoming Western Europe's largest software market with an approximate turnover of 23 billion Euros and a growth rate of 6.3% in 2017. Moreover, Germany owns a large ICT sector workforce, with one million ICT professionals active in the industry. With its highly qualified labor force and massive investment ability, Germany continues to compete strongly and globally in the technology industry (Althaus, Matos and Sharma, 2018).

Germany is the fourth largest FinTech market in the world, with 700 German companies listed in the FinTech market sector (Ernst and Young, 2018). Financial intermediaries such as banks and insurance companies have supported corporate start-up programs to create new FinTech companies in the German market. The survey of Ernst and Young suggests that over half the population of Germany prefers using digital financial services available through third parties over traditional banking. The amount invested in FinTech companies by financial institutions reached 541 million Euros in 2017 (Ernst and Young, 2018).

Today, data are the most valuable asset in the finance sector. According to the International Data Corporation (IDC) for the European Commission, Germany accounts for more than one quarter of the data market volume in Europe, and its value is estimated to grow to 430 billion in 2020. Germany has successfully employed data technology in several industries in the economy, such as the health sector, financial sector, automobile manufacturing, intelligent power grids, and transportation systems. Cloud computing services are widely used by companies that have undergone recent digital transformation. According to the IDC, two out of three companies in Germany implemented cloud services in 2016.

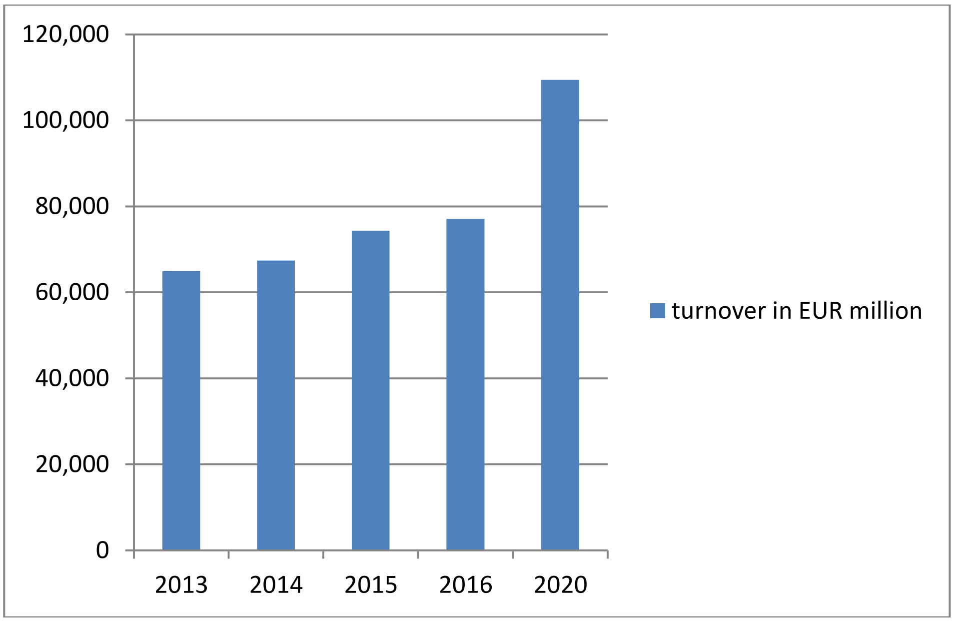

Figure 4.1: The German Data Economy 2013 – 2020
Source: IDC/European Commission 2017

4.2 Type and Source of Data

The data used in this study are annual data covering the period of 1991–2016 in Germany. Owing to the unavailability of data for the ICT proxy variable, 2016 is the last year this research examines. The dependent variable is financial development (FD), which is measured by domestic credit to the private sector as a percentage of the GDP. The independent variables are GDP in constant 2010 US dollars, foreign direct investment (FDI) net inflows, and market capitalization of listed domestic companies (STOCK) as a percentage of the GDP, and individuals using the Internet as a percentage of the population (INT). Data were collected from the World Bank development indicators (2019) online database. To observe the growth effect, all series were converted to their logarithmic form.

4.2.1 Definition of the variables

The dependent variable in the model is domestic credit to the private sector, which is implemented as a proxy for financial development. Internet penetration, which represents the ICT, GDP, FI, and market capitalization variables, is used to test the possible determinants of financial development. The following is the list of the dependent and independent variables used in this model and their brief definitions.

Domestic credit to the private sector is defined as any financial resource provided by financial corporations to the private sector. It can be in the form of loans, non-equity securities, or any type of trade credits that hold a claim for repayment (IMF, 2018). Domestic credit to the private sector (as a percentage of the GDP) measures the efficiency of the financial sector in performing its main role of transferring deposits to credits, and therefore, it can be used in measuring the degree of financial development in an economy (Asongo, 2012). Puatwoe and Piabuo (2017) use domestic credit to the private sector as a proxy for financial development in their article. Domestic credit to the private sector is the dependent variable in this model and is expected to be determined by the GDP, FDI, ICT, and stock market capitalization.

GDP refers to the market value of final products and services within a country in a given period (Johnston and Williamson, 2019). It is used to measure the value added from the production and the income earned from the production of goods and services in a certain period (OECD, 2019). Many studies have used this variable as a measure of economic growth. For example, Bogoviz and Lobova (2017) use the GDP in constant 2010 USD to measure the digitization and Internet effect on the

Russian economy. GDP is expected to positively affect the dependent variable of financial development consistent with the study of Okeke and Acha (2017).

FDI flows record the cross-border transaction values coming from direct investment for a given period. Financial flows can be in the form of equity transactions, earnings from reinvestment, and debt transactions (OECD, 2019). This model uses FDI net inflows as a percentage of the GDP to reflect the new investments inflows minus the outflows from a foreign investment divided by the GDP in an economy. Desbordes and Wei (2017) also use FDI as a percentage of the GDP in investigating the relationship between FDI and financial development and reveal that FDI significantly affects financial development. Therefore, FDI is predicted to have a significant positive effect on financial development.

Market capitalization is the share price multiplied by the number of shares outstanding for listed domestic companies. Market capitalization data were gathered from the end-of-year values and converted to US dollars using foreign exchange rates at the end of the year (World Federation of Exchanges database, 2016). The market capitalization of listed domestic companies as a percentage of the GDP was used in this model consistent with the study of Qamruzzaman and Wei (2018). Stock market capitalization is expected to positively affect financial development as previously found by Qamruzzaman and Wei (2018).

In our model, we used individuals using the Internet as a percentage of the population as a proxy for ICT. The data included individuals that used the Internet in the past three months using a computer, mobile device, and digital TV. Chinn and Fairlie (2006) employ both the Internet and mobile penetration to measure ICT in their model. Chinn and Fairlie (2006) find that as the banking sector development is associated with technology penetration rates, ICT positively affects financial development.

4.3 Methodology

This study includes five stages of analysis for the methodology part. The first stage was the descriptive statistics analysis, which summarizes the data set of coefficients. The second stage is employing the Augmented Dickey-Fuller (ADF) and the Philips-Perron (PP) unit root tests to test the integration order of the variables in the model. The third analysis conducted was the Co-integration analysis using the Johansen and Juselius co-integration test to test the possibility of a long-run equilibrium relationship among variables. After proving the existence of a long-run equilibrium relationship among variables, the CCR method was employed to estimate the long run coefficients of the independent variables. The fifth and final stage was the Granger causality test to test the causality direction among variables.

To measure the relationship between the variables of FD, GDP, FDI, INT and STOCK, the following model can be used:

$$FD= f(GDP, FDI, INT, STOCK) \quad (1)$$

This implies that FD is a function of GDP, FDI, INT, and STOCK in Germany. However, to capture growth impacts, variables are converted to logarithmic (LOG) form. The model can be written as follows:

$$LFD_t = \beta_0 + \beta_1 \, LGDP_t + \beta_2 \, LFDI_t + \beta_3 \, LINT_t + \beta_4 \, LSTOCK + \varepsilon_t \quad (2)$$

Indicating that at period t, LFD is the natural log of domestic credit to private sector; LGDP is the natural log of the real income in constant 2010 USD; LFDI is the natural log for foreign direct investment; LINT is the natural log for internet users as percentage of population, and LSTOCK is the natural log for market capitalization for listed companies. The ε represents the error term and the β_1, β_2, β_3 and β_4 coefficients reflect the elasticity of the GDP, FDI, INT and STOCK variables in the long term.

4.3.1 Descriptive statistics

Descriptive statistics present us with preliminary information on the distribution of the data (Fisher and Marshall, 2009). The mean provides the average value of the series, while the median expresses the middle value with the values arranged from smallest to largest. The median is less sensitive to outliers than the means since it only reflects the center of the distribution. The Max and Min represent the maximum and minimum values of the series. The standard deviation reflects the dispersion in the series while the skewness measures the degree of asymmetry in the distribution. A general rule is if the skewness is smaller than -1 or larger than 1 then the distribution is considered highly skewed; if the skewness is a value between -1 and -0.5 or between 0.5 and 1 then it is skewed to the left or right respectively. If the skewness is between -0.5 and 0, then it is assumed that the data is symmetrically distributed. Kurtosis is a measure used to test whether the distribution of the series is peaked or flat. When the kurtosis value is above three this means the distribution is peaked compared to the normal, and if the kurtosis value is less than three, the distribution is flat compared to the normal. The Jarque-Bera is a statistical test for normality and which measures the deviation of the series skewness and kurtosis from the normal distribution. The Jarque Bera is usually run before running statistical tests; like the t-test and F-test which assume a normal distribution; to confirm normality. Overall a large JB value indicates that the data set is not normally distributed while a JB value of zero means the data is normally distributed (Yazici and Yolacan, 2007). Testing for normality is important because many econometric tests assume the normality of the variables. The Jarque-Bera test equation is as follows:

$$JB = n\,[(\sqrt{b_1})2 / 6 + (b_2 - 3)2 / 24] \qquad (3)$$

Where n represents the size of the sample, $\sqrt{b_1}$ is the skewness coefficient and b_2 is the kurtosis coefficient. The null hypothesis states that the series is normally distributed, and therefore the null hypothesis of a normal distribution is rejected when a small probability value is found in the results.

4.3.2 Unit root test

The unit root is an important stochastic property of a variable which influences its behavior greatly. Unit root is known as a stochastic trend or systematic pattern in a time series sometimes referred to as a random walk with a drift (Campbell and Perron, 1991). The presence of a unit root leads to systematic and unpredictable patterns in time series data. Non-stationary variables have varying variance and mean, and the covariance varies depending on the time lag. Stationary at level is represented by I (0) while stationary at first difference is represented by I (1) and is called integrated at order one. Unit root can be explained by the following simple formula:

$$y_t = \alpha y_{t-1} + u_t \qquad (4)$$

Where (α) represents the stationary of the series. When $\alpha<1$ the series is considered stationary and when $\alpha=1$ the series is nonstationary.

The behavior of a variable is affected by whether it’s stationary or not. The existence of a unit root is what causes time series data to be non-stationary. If the series is proven to be stationary, it is considered to have limited variance which is independent of time and are temporarily affected by shocks. Non-stationary series have an infinite variance, are independent of time and endure permanent effects from any shock. Non-stationary series can be called random walks and are therefore difficult to forecast. Presence of a unit root is a problem for two main reasons. The first problem is spurious inference, meaning if two variables trend over time, the regression of one of them on the other will show a high R^2 even if there is no relationship between them. The second problem is standard assumptions in regression parameters become no longer valid. For instance, t-ratios will no longer follow a t-distribution and therefore the hypothesis cannot be undertaken. For time series data, prior to any other analysis, the series must be first examined to see whether they are stationary or not. Time series data can sometimes have trends or seasonal effects; therefore a unit root test is applied to test the integration properties and stationarity of the time series.

Dickey-Fuller (DF) (1981) is one of the most widely used unit root test which aims to determine the order of integration of the variables. The DF unit root test has been proven to show some biases and therefore the Augmented Dickey and Fuller was introduced to ensure that the error terms are uncorrelated. The Augmented Dickey-Fuller test has three specifications shown in the formulas below. The first specification Equation 5) both the trend and intercept are eliminated. The second specification (Equation 6) only the intercept is eliminated and the third and final specification (Equation 7) both the trend and the intercept are included.

$$\Delta Y_t = \gamma Yt\ -1 + \alpha \sum \Delta Y_{t-1} + \varepsilon_t \quad (5)$$

$$\Delta Y_t = \beta_1 + \gamma Y_{t-1} + \alpha \sum \Delta Y_{t-1} + \varepsilon_t \quad (6)$$

$$\Delta Y_t = \beta_1 + \beta_{2t} + \gamma Y_{t-1} + \alpha \sum \Delta Y_{t-1} + \varepsilon_t \quad (7)$$

Note that Y represents the variable, t represents the time index, Δ is the differencing operator, ε represents the residual term with constant variance and zero mean, α is the intercept representing the drift, and the parameters estimated are β1, β2, γ, and α.

An issue when implementing the ADF test is the specification of the lag length of p. When the probability value is small, the serial correlation remaining in the error terms the test becomes biased. When the p value is large, the test becomes less powerful. Both the Dicky-Fuller and the ADF share the same hypothesis testing and the same critical values. The null hypothesis is H_0: $\gamma = 1$, meaning the series contains a unit root and therefore it is non-stationary, and is expressed as I(1), alternative hypothesis is, H_1: $\gamma < 1$ meaning the series has no unit root and is stationary, I(0).

The other unit root test commonly used is the Phillips and Perron (1988) test which was introduced as a substitutable non-parametric method to deal with serial correlation. The PP test changes the ratio of the coefficients so that the test statistic is no longer affected by the serial correlation. Similar to the ADF test the PP tests the hypothesis that the series have unit root while the alternative rejects the existence of a unit root and claims stationary., but differs in that it has no lagged difference terms. In cases of high serial correlation, it is better to use the PP test over the ADF test. The PP test has two advantages over the ADF tests. One, the PP tests are insensitive to heteroscedasticity in the residual term in general forms. Two, users don't need to specify the lag length for the regression. The regression of the Phillips and Perron (1988) test is as follows:

$$y_t = \tilde{a}_0 + \tilde{a}_1 y_{t-1} - \tilde{a}_2 [\, t - \frac{T}{2}] + u_t \qquad (8)$$

Note that Y represents the dependent variable; α is the intercept; t is the trend; and u_t $_{is}$ the error term.

4.3.3 Co-integration analysis

Based on previous economic studies, nonstationary variables usually have a long-run equilibrium relationship; therefore the Johansen co-integration test (Johansen, 1998) is employed to check for convergence in long-run equilibrium series. Using the Johansen trace test, we can identify how many co-integrating vectors there are. A minimum of one co-integrating vector must to prove co-integration between variables. The Johansen (1988) methodology implements a way to find the number of co-integrating vectors between the dependent and independent variables. The equation below illustrates the Johansen method based on the VAR model:

$y_t = \mu + A_1 y_{t-1} + \cdots + A_p\, y_t{-}p + \varepsilon_t$ (for t = 1, ... , T) (9)

The vector y_t, y_{t-1} and y_{t-p} represent the level and lagged values of P variables I(1) in the model. A1 and Ap represent the coefficient matrices of (PXP) dimensions; the intercept vector is represented by μ and the error term by εt.

The number of lagged values is controlled by the assumption of no auto correlation error. Rank A reveals the co-integrating equations number estimated if the Eigen (λ_i) values are statistically significant (Johansen and Juselius, 1990). The formula below represents the estimated trace statistics (λtrace):

$\lambda trace = -T \sum \ln(1 - \lambda i)\ ,\ i = r + 1, \ldots , n - 1$ (10)

The following are the null hypotheses;

H0: $v = 0$ and H1: $v \geq 1$

H0: $v \leq 1$ and H1: $v \geq 2$

H0: $v \leq 2$ and H1: $v \geq 3$

H0: $v \leq 3$ and H1: $v \geq 4$

4.3.4 Long run coefficients

To measure the long run coefficients among variables the canonical co-integrating regression is employed. The canonical co-integrating regression model (CCR) method was developed by Park (1992). The CCR transforms the correlated variables in the long run with the error term to remove any long run serial correlation and endogeneity in the error terms. The CCR can also be used to test co-integrating vectors with integrated process of I(1). Moreover, the CCR is a single equation regression model which can apply multivariate regressions without modifying or losing efficiency (Park, 1992). According to Adom (2015), the CCR estimator can be measured in the following equation:

$$\hat{O}CCR = (\sum^{T}_{t=1} Z_t{*}Z_t{*}^{1})^{-1} \sum^{T}_{t=1} Z_t{*}\, y_t{*} \qquad (11)$$

4.3.5 Granger causality test

After employing the Johansen co-integration test to examine the long-run relationship between the series variables, the direction of causality between variables must be examined as well. The Granger (1969) causality test is undertaken to reveal the direction of these relationships. Based on the Granger causality test let us assume that in order for variable X to "Granger cause" variable Y, the forecast of Y must change by the past values of variable X and the past variables of variable Y, compared to doing nothing (Granger, 1969). Granger causality is split into unidirectional and bi-directional causality, where unidirectional causality exists from X to Y when X causes Y but doesn't cause X and bi-directional causality is when X causes Y and Y causes X as well. If neither X causes B nor B causes X, then a mutual reaction exists in between the variables.

The VAR Granger/Block Exogeneity Wald test is employed to test for casual relationship among the variables. The Chi-square (Wald) statistics is implemented to examine the collective significance of all the lagged variables in every equation in the model.

$$\ln Y_t = \sum^{n}_{i=1} \alpha_i \ln X_{t-I} + \sum^{n}_{j=1} \beta_j \ln Y_{t-j} + u_{1t} \quad (12)$$

$$\ln X_t = \sum^{n}_{n=1} \lambda_i \ln X_{t-I} + \sum^{n}_{j=1} \delta_j \ln Y_{t-j} + u_{2t} \quad (13)$$

Where X (independent variable) and Y (dependent variable) are the estimated variables; while φi and θi are the error correction terms representing the coefficients for ECTt−1; and Δ illustrates the first difference of variables. When φi is statistically significant it is assumed that variable X Granger causes variable Y, and when θi is statistically significant it is assumed that variable Y Granger causes variable X. The F statistics combines the null hypothesis which is αi =ςi = 0 and the t-statistics examines the significance of the error correction coefficient.

Chapter 5

EMPIRICAL FINDINGS

Several tests were employed to select the best model to describe the effect of ICT diffusion on financial development. The tables below present the test results and the findings of the descriptive statistics, unit root test, co-integration test, long-run coefficients, and Granger causality test.

5.1 Descriptive Statistics

Before analyzing the data set, the descriptive statistics were checked. Table 5.1 reports the descriptive statistics of the time series variables in their logarithmic form.

Table 5.1: Descriptive Statistics (Log values):

	LFD	LGDP	LFDI	LINT	LSTOCK
Mean	-0.3375	28.7836	0.0399	2.7922	4.6858
Median	-0.3097	28.7869	0.5055	4.0235	4.7801
Maximum	-0.2243	28.9611	2.5429	4.4958	5.9329
Minimum	-0.6276	28.5743	-3.9423	-2.0723	3.1150
Std. Dev.	0.1012	0.10832	1.2865	2.1468	0.4523
Skewness	-1.1249	-0.16241	-1.0450	-1.0505	-0.8624
Kurtosis	3.6302	1.96187	4.7009	2.6010	8.2558
Jarque-Bera	6.1419	1.33113	8.1691	5.1455	34.423
Probability	0.0463	0.51398	0.0168	0.0763	0.0000

Table 5.1 shows the descriptive statistics of the logarithmic form of the variables to transform the skewed variables into a normally distributed form and the exponential trends into linear trends. The series of LGDP and LINT shows a noticeable difference between their mean and median, indicating that the sample may not be normally distributed, as the median is a robust measure that is less sensitive to outliers than the mean, which captures the average value. The minimum and maximum show the smallest and largest values in each series illustrating the range of values. The standard deviation measures the dispersion in the series, as shown in Table 5.1. LINT (percentage of Internet users) has the highest standard deviation. Therefore, this series has the largest spread, whereas LFD (financial development proxy) has the smallest spread.

Moreover, Table 5.1 indicates that all series are negatively skewed and have a long negative tail but that LFD has the highest skewness; therefore, this variable is the most asymmetrical. Kurtosis measures whether the distribution of the series is peaked or flat. A value of 3 or above indicates that the distribution has a peak to it, whereas a value closer to 0 indicates that the distribution is flat. According to the results in Table 5.1, LSTOCK has the highest peak in its distribution, followed by LFDI and LFD. The Jarque–Bera test is a test for normality. It tests whether the skewness and kurtosis match the normal distribution. Statistical tests such as the F test and T test assume normality. Therefore, the Jarque–Bera test is first run to confirm normality (Glen, 2016). The null hypothesis is that the series is normally distributed and can be rejected by a small value of probability, and the alternative hypothesis states that the series is not normally distributed. The null hypothesis can be rejected at a 1% interval for LSTOCK, indicating that the series is not normally distributed. Rejecting the null hypothesis at the 5% interval but not at the 1% interval is possible for both LFDI and LFD. However, according to the probability values, the null hypothesis cannot be rejected for LGDP and LINT, indicating that their series is normally distributed.

5.2 Unit root test results

The Augmented Dickey Fuller (1981) and the Philips-Perron (1988) unit root tests have been employed to examine the order of integration of the selected variables. The null hypothesis is; there is a unit root problem and the variables are non-stationary and the alternative hypothesis assumes no unit root problem and the variables are therefore stationary. Table 5.2 reveals the results of the ADF and PP unit root tests, indicating that we fail to reject the null hypothesis for all variables at level meaning they are all non-stationary. However, as shown in the table the null hypothesis can be rejected when taking the first difference since the values become significant. This means that the variables have a unit root problem at their level however become stationary at the first difference.

Table 5.2: ADF and PP Unit Root Tests

Statistics (Level)	LFD	Lag	LGDP	Lag	LFDI	Lag	LINT	Lag	LSTOCK	Lag
τ_T (ADF)	-2.116	(0)	-2.639	(2)	-2.639	(0)	-1.080	(1)	-2.826	(1)
τ_μ (ADF)	-2.159	(0)	-0.277	(2)	-2.421	(0)	-3.226	(1)	-2.856	(1)
τ_T (PP)	-2.068	(1)	-3.962	(4)	-2.578	(1)	-1.219	(1)	-3.722	(0)
τ_μ (PP)	-2.044	(2)	-1.024	(4)	-2.284	(2)	-1.650	(1)	-2.560	(3)

Statistics (First Diff)	LFD	Lag	LGDP	Lag	LFDI	Lag	LINT	Lag	LSTOCK	Lag
τ_T (ADF)	-6.035*	(0)	-5.770*	(1)	-6.692*	(0)	-4.641*	(0)	-5.632*	(1)
τ_μ (ADF)	-5.991*	(0)	-5.928*	(1)	-6.791*	(0)	-4.479*	(8)	-5.752*	(1)
τ_T (PP)	-8.729*	(9)	-5.400*	(1)	-7.320*	(3)	-4.668*	(2)	-8.348*	(4)
τ_μ (PP)	-6.516*	(5)	-5.568*	(1)	-7.286*	(3)	-2.389	(1)	-8.491*	(4)

Note that τ_T illustrates the most general model representing a trend and a drift; while τ_μ is a model that has a drift but no trend and τ is the model with neither a drift nor trend making it the most restricted. The values in brackets represent the lag lengths employed in the ADF test to erase serial correlation in the residual terms. On the other hand, the other values in brackets used in the PP test illustrate the Newy-West Bandwith. The unit root tests ADF and PP were both conducted beginning with the most general model till the least specific model by removing trend the intercept and trend in all models. Moreover, since the variables are integrated at the first difference, a co-integration analysis is necessary to examine the long-run relationship between variables.

5.3 Co-integration Analysis

To test the long-run equilibrium relationship among variables the Johansen (1988) co-integration test is undertaken in reference to Johansen and Juselius (1990). The null hypothesis is that there is no co-integration among the series meaning a long run relationship does not exist. The alternative hypothesis states that the number of co-integration is less than or equal to one. The third hypothesis is the number of co-integrating vectors is two at the most, the fourth hypothesis is that the number of co-integrating vectors is three at the most and the final hypothesis is that the number of co- integrating vector is four at the most. Referring to the results in table 5.3, the null hypothesis of there being no co-integrating vector among the variables can be rejected at the 5% level since the 5% critical value 68.52 is less than the trace statistics value 73.30. This means that there is at least one co-integrating vector in the model and a long-run equilibrium relationship can be found between the variables in the model.

Table 5.3: Co-Integration Results

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	5 Percent Critical Value	1 Percent Critical Value
None *	0.693	73.304	68.52	76.07
At most 1	0.622	43.756	47.21	54.46
At most 2	0.422	19.382	29.68	35.65
At most 3	0.202	5.646	15.41	20.04
At most 4	.0.000	0.000	3.76	6.65

Note: * donates rejection of hypothesis at 5% significance level and ** donates the rejection of hypothesis at 1% significance level.

5.4 Estimation of long run coefficients

The Johansen co-integration test results reveal that the variables are co-integrated and have a long-run equilibrium relationship. Therefore, the long-run coefficients between the coefficients must be measured using the canonical co-integrating regression (CCR) method. As shown in Table 5.3, the relationships between the independent variables (GDP, FDI, Internet penetration, and market capitalization) and the dependent variable of financial development (represented by domestic credit to the private sector) are all statistically significant in the long run at a 0.01 significance level.

According to the CCR results, when the GDP increases by 1%, the domestic credit to the private sector increases by 1.48%. This result confirms the previous finding of Bensalem and Trabelsi (2012) that economic growth stimulates an efficient financial sector by improving the pooling of domestic funds and the efficiency of mobilizing capital in the economy. Recently, Okeke and Acha (2017) also find that the GDP has a significant positive effect on the ratio of credit to the private sector, which is the proxy variable for financial development used in their time series model. Moreover, our finding suggests that an increase in FDI by 1% is met by an increase in domestic credit to the private sector by 0.015%. This finding is consistent with that of Desbordes and Wei (2017), who investigate the relationship between FDI and financial development and find that FDI significantly leads to development in the financial sector. The Internet penetration variable has a significant positive effect on financial development, indicating that a 1% increase in Internet penetration increases domestic credit to the private sector by 0.065%. This finding confirms the result of Adjei (2018), who examines the role of ICT in the performance of financial intermediaries and finds a statistically significant relationship between ICT tools (e.g., ATM, telephone, and Internet services) and financial intermediary performance. The stock market capitalization factor indicates a positive long-run and significant effect on domestic credit to the private sector, implying that a 1% increase in stock market capitalization leads to a 0.09% increase in domestic credit to the private sector. Dokmen, Aysu, and Bayramoglu (2015) assert this finding in their study by stating that market capitalization improves the performance of financial systems in increasing liquidity, mobilizing savings, and pooling funds. The long-run cointegrating equation is expressed as follows:

LFD= 1.48(LGDP) + 0.015(LFDI) + 0.065(LINT) + 0.091(LSTOCK). (14)

Table 5.4: Long Run Coefficients

Variable	Coefficient	Std. Error	t-statistic	Prob.
LGDP	1.4808	0.1353	10.944	0.0000
LFDI	0.0154	0.0029	-5.2939	0.0001
LINT	0.0659	0.0028	23.038	0.0000
LSTOCK	0.0919	0.0038	24.110	0.0000
C	-43.2281	3.8707	-11.168	0.0000
TREND	-0.0273	0.0017	-15.420	0.0000

5.5 Causality analysis

After examining the long-run equilibrium relationship among the variables and estimating the long-run coefficients, the Granger causality test (1988) was employed to reveal the direction of the relationship among the variables. Table 5.4 reveals the findings of the Granger causality tests (1988) based on the block exogeneity Wald (1943) test. The null hypothesis of the test implies that no causality runs from the independent variable to the dependent variable. The overall chi-square and probability reveal that all the variables combined have a long-run uni-directional causality relationship with financial development at a 10% level. According to the results in Table 5.4, the null hypothesis can be rejected at 5% for the causality running from LINT, which is the Internet usage variable, toward LFD, which is the financial development proxy. Therefore, a unidirectional causality exists from Internet usage to financial development. The Granger causality test results of Kurihara (2005) find that the lagged values of the ICT variable can partially explain the variation in the performance of financial institutions. Stock market capitalization (LSTOCK) is also proved to have a causality running toward the financial development proxy (LFD) with the ability to reject the null hypothesis at a 1% interval. This result is consistent with the finding of Caporale, Howells, and Soliman (2004), who examine the causality among stock market development, financial development, and economic growth in a sample of seven countries, namely, Argentina, Chile, Greece, Korea, Malaysia, the Philippines, and Portugal. They observe the causality between market capitalization and the financial development proxies, namely, bank deposits and domestic credit in the case of Malaysia. Therefore, significant uni-directional causality runs from Internet penetration and stock market capitalization to financial development (Int, Stock → FD).

The results in Table 5.4 also reveal that a significant unidirectional causality runs from financial development to economic growth, given that the null hypothesis can be rejected at a 1% interval for the causality running from LFD to LGDP. Hassan, Sanchez, and Yu (2011) and Shahbaz, Rehman, and Muzaffar (2014) imply the existence of a bi-directional causality relationship between financial development and GDP using the Granger causality test. However, according to the findings in Table 5.4, only uni-directional causality relationship running from financial development toward GDP is found, confirming the theory of the supply leading view (Schumpeter, 1912; Greenwood and Jovanovic, 1990; Bencivenga and Smith, 1991; Levine, 2004). The supply leading view suggests that developed financial systems improve capital accumulation and fund allocation, leading to economic growth. DLFDI also has a unidirectional causality toward LGDP, rejecting the null hypothesis at a 10% interval. Therefore, FDI has a causality running toward economic growth. Baig, Kira, and Bilal (2016) conduct a Granger test that indicates that FDI and GDP cause a unidirectional causality in the case of Nepal, confirming the results in Table 5.4. According to the results, stock market capitalization also has a unidirectional causality running toward economic growth, rejecting the null hypothesis at a 5% interval of the LSTOCK causality toward LGDP. Mamun (2018) reveals bidirectional causality between stock market capitalization and economic growth, emphasizing the importance of market capitalization in economic growth. Therefore, based on the obtained result, we claim that financial development, FDI, and stock market capitalization have a significant uni-directional causality running toward the GDP (FD, FDI, Stock → GDP). The overall chi-square and probability also show that the independent variables have long-run uni-directional causality toward the GDP at a 1% interval.

Table 5.5: Granger Causality Test Results

Dependent variable	D(LFD)	D(LGDP)	D(LFDI)	D(LINT)	D(LSTOCK)	OVERALL Chi-square (prob.)
D(LFD)	-	2.437 (0.118)	2.370 (0.123)	8.388** (0.003)	11.760 * (0.000)	13.546 ***(0.008)
D(LGDP)	22.913* (0.000)	-	6.716*** (0.009)	6.103 (0.013)	10.445** (0.001)	56.141 *(0.000)
D(LFDI)	0.735 (0.391)	0.057 (0.810)	-	1.928 (0.165)	0.766 (0.3813)	2.832 (0.586)
D(LINT)	0.040 (0.840)	0.313 (0.575)	0.148 (0.699)	-	0.302 (0.582)	0.604 (0.962)
D(LSTOCK)	0.146 (0.701)	0.861 (0.353)	0.510 (0.475)	5.316 (0.021)	-	8.377 (0.078)

Note: *, ** and *** denote rejection of the hypothesis at 1%, 5% and 10% respectively.

Moreover, the results in Table 5.5 also indicates a significant one way causality runs from the independent variable economic growth towards the dependent variable financial development, given that the null hypothesis can be rejected with 1% interval for the causality running from (LFD) to (LGDP). Hassan, Sanchez, and Yu (2011) and Shahbaz, Rehman and Muzaffar (2014) have both implied the presence of a bi-directional causality relationship between financial development and GDP using the Granger causality test, however referring to the findings of Table 5.5 only one direction causality relationship running from financial development towards GDP has been found confirming the theory of the supply leading view; Schumpeter (1912) Greenwood and Jovanovic (1990), Bencivenga and Smith (1991) and Levine (2004). The supply leading view suggests that developed financial systems improve capital accumulation and fund allocation leading to economic growth. (DLFDI) also has a one way causality towards (LGDP) with rejecting the null at a 10% interval, meaning that (FDI) or foreign direct investment does have causality running towards growth in the economy. Baig, Kira, and Bilal (2016) conducted a Granger test that indicates that FDI and GDP in the case of Nepal cause a unidirectional causality confirming the results in Table 5.5. According to the results, stock market capitalization also has a unidirectional causality running towards economic growth with the rejection of the null at 5% interval of the (LSTOCK) causality towards (LGDP). Previously, Mamun (2018) revealed a two direction causality running between economic growth and stock market capitalization asserting the importance of market capitalization in economic growth. Hence based on the obtained result, we claim that financial development, foreign direct investment, and stock market capitalization have a significant uni-directional causality running towards GDP (FD, FDI, Stock → GDP). The overall Chi-square and probability also show that over all, the independent variables have long run uni-directional causality towards GDP at a 1% interval.

Chapter 6

CONCLUSION

The wide expansion and dissemination of data information are due to the rapid spread of the Internet, mobile devices, and social media networks. ICT assists financial institutions in efficiently allocating resources and funds with the least transactional costs possible, thus resulting in faster economic growth. ICT is effective in reducing information asymmetry, providing financial institutions with information regarding their borrowers and customers and increasing the financial access of households and institutions (Asongu, 2016). Mobile and Internet penetration enables financial services to reach previously excluded groups. It also reduces operating, transaction, and physical costs by eliminating the need for physical branches (Andrianaivo and Kpodar, 2011). The diffusion of ICT has allowed individuals to finance new ventures with less financial intermediaries. It has also created more competition among banks and financial institutions, creating more newly innovated online financial services with relatively low prices (Novinson, 2017). Germany is a live example of how ICT diffusion can transform the economy along with different sectors, including the financial sector. Germany has the fifth largest ICT market and is the fourth largest FinTech industry in the world. This digital transformation is a result of the heavy investments made in financing start-up technology companies that enhance FinTech services. By using ICT, Germany has developed several industries in its economy, including the financial sector. Financial intermediaries are now employing FinTech services and cloud computing services to their traditional financial services, thus increasing efficiency, speed, and revenue. In 2017 alone, Germany earned over 160 billion Euros from the ICT industry, and its ICT labor force reached one million skillful and trained employees, making Germany one of the leading countries in the ICT industry (Germany Trade and Investment, 2019).

An abundance of previous research has examined the various possible determinants of financial development, but most of them have neglected the recent role of ICT in the changing nature of the financial world. Furthermore, the relationship between ICT and economic growth has been extensively studied, whereas the relationship between ICT and financial sector development has not yet been examined in detail. Therefore, this study aims to examine the relationship between ICT and financial sector development using time series data from Germany in the period of 1990–2016. Domestic credit to the private sector was used as a proxy for financial development (FD), which is the dependent variable in this model, and the ICT variable was represented by Internet users as a percentage of the population (INT). The other independent variables were foreign direct investment net inflows (FDI) and the market capitalization of listed domestic companies (STOCK) in the current USD.

This study included five tests to examine the relationships among the variables. The descriptive statistics summarized the properties of the data set, the augmented Dickey–Fuller and the Philips–Perron unit root tests were used to test the order of integration of the variables in the model; the Johansen and Juselius cointegration tests were employed to examine the long-run equilibrium relationship among the variables; and the long-run coefficients were estimated by the CCR method. The Granger causality test investigated the causality direction among the variables. The results from the CCR method, which measures the long-run coefficients, revealed that the null hypothesis could be rejected at the 1% level for all variables and that a significant positive relationship exists between the dependent variable (FD) and all the independent variables in the model.

Specifically, a 1% increase in GDP will lead to a 1.48% increase in domestic credit to the private sector, a 1% increase in FDI will lead to a 0.015%, increase in domestic credit to the private sector, a 1% increase in Internet user will lead to a 0.065% increase in domestic credit to the private sector, and a 1% increase in stock market capitalization will lead to a 0.091% increase in domestic credit to the private sector. The Granger causality test results revealed that both Internet users and stock market capitalization have a causality running toward financial development. Moreover, financial development, foreign direct investment, and stock market capitalization all Granger caused the GDP.

We argue that not enough studies have included ICT as a determinant of financial development. However, for the other variables, the empirical findings of this study are compatible with those of previous literature. This study also provides new findings confirming the importance of ICT in the development of the financial sector. The CCR results revealed that a 1% increase in the GDP causes a 1.48% increase in financial development. This result is consistent with that of Okeke and Acha (2017), who also find that GDP has a significant positive effect on financial development. FDI was the second determinant of financial development investigated. The results showed that a 1% increase in FDI is met by a 0.015% increase in financial development and that causality exists from FDI to the GDP. Desbordes and Wei (2017) investigate the effect of FDI on financial development and find a significant positive effect similar to our results. Baig, Kiran, and Bilal (2016) conduct a Granger causality test and also observe the causality from FDI to the GDP, confirming our results. Stock market capitalization was the third determinant of financial development examined. Our results revealed that a 1% increase in stock market capitalization leads to a 0.09% increase in domestic credit to the private sector. The results of the Granger causality test revealed that stock market capitalization has the causality toward both financial development and GDP. Therefore, stock market capitalization affects both financial development and the GDP. The CCR results of Dokmen, Aysu, and Bayramoglu (2015) are compatible with our results, thus confirming their claim that market capitalization increases liquidity, mobilization of saving, and pooling of funds. Caporale, Howell, and Soliman (2004) find causality results identical to ours when testing the causality between domestic credit to the private sector and stock market capitalization. The addition of ICT as a determinant of financial development is the contribution of this study, given that most studies have focused on the importance of ICT in spurring economic growth and not financial development specifically. When testing the long-run coefficients between financial development and IC, we found that a 1% increase in Internet penetration increases domestic credit to the private sector by 0.065%. The Granger causality test revealed a causality running from the Internet usage variable toward the financial development proxy, thus confirming our hypothesis. Sassi and Goaieda (2013) investigate the effect of financial development on economic growth using ICT in the financial sector in MENA countries. They find evidence of ICT penetration having a significant positive effect on both economic growth and financial development, consistent with our results.

Different policies and recommendations can be derived from the results of this study. As causality from the GDP to financial development is found, and the CCR results indicate positive relationships among the mentioned variables, financial development is further enhanced as economic growth increases. Economic growth enhances efficiency in the pooling of funds and the mobilizing of capital, thus leading to financial development (Bensalem and Trabelsi, 2012). Governments seeking financial development must promote economic growth to create a better environment for financial institutions. Several policies and recommendations can be made from examining Germanys' economic growth. Germanys' recent economic boost has been a result of strong investment in data, construction, and machinery in addition to efficient private consumption. According to the economic analyst Utermöhl (2019), further tax cuts and monetary and social benefits must be employed to further boost private consumption in Germany. In a report on Reuters, Germany's Economy Minister Peter Altmaier stated the need to end international trade conflicts smoothly and sustainably for all economies to profit.

According to our results, FDI has a significant positive effect on financial development and causality toward economic growth. Therefore, allowing and encouraging FDI inflow results in economic growth and better financial institutions. Opening capital markets and welcoming foreign bank participation by expanding cross-border borrowing or foreign entry to local banking markedly enhance the efficiency in financial institutions, liquidity regulations, risk diversification, and investment and growth opportunities (Cetorelli and Goldberg, 2011). Germany has its strengths and weaknesses in attracting FDI. Its reliable infrastructure and industrial sectors, stable legal institution, and highly skilled workforce increase Germanys FDI inflows. However, some aspects, such as the increasing tax rates and its strict labor laws, discourage foreign investment (Santander, 2019). The German foreign economic law still holds restrictions on private direct investment for reasons such as national security, foreign exchange, and foreign policies. Therefore, to further develop the German financial sector, FDI inflows must be facilitated further by decreasing tax rates and loosening labor laws.

Stock market capitalization has a significant positive effect on financial development and shows the causality toward financial development and the GDP. Increasing the efficiency and size of the stock market spurs financial development and economic growth. However, governments must enforce financial policies and regulations to ensure efficiency and transparency in the transfer of funds; otherwise, an increase in stock market capitalization will add vulnerability to the financial sector (Dokmen, Aysu, and Bayramoglu, 2015). German investors are still considered cautious toward the stock market in comparison with other Western countries. According to the OECD (2018), only 11% of household assets in Germany are shares and equity investment. Therefore, policy makers should work on eliminating barriers to liquidity in the German stock market to encourage and boost the confidence of investors in the market. The German government should promote the development of the financial sector performance in allocating capital and providing liquidity by removing taxing and legal obstacles (Dokmen, 2015).

According to our result, the percentage of Internet users has a significant positive effect and causality on financial development. Improving the ICT infrastructure can increase the development and innovation of the financial sector by increasing competition among financial institutions (Bahrini and Qaffas, 2015). Based on the result, several recommendations on ICT can be made. Governments and regulatory institutions must build and develop their ICT infrastructure to increase Internet and mobile penetration. Therefore, governments and institutions should promote Internet and mobile-based services by introducing e-government and e-commerce and by updating and developing the ICT infrastructure. The data processing transparency should especially be improved by increasing data protection on the Internet to reduce the chances of fraud, especially in financial transactions and services. Governments and regulatory institutions should stimulate ICT diffusion in the private sector by adopting policies, such as tax reduction, subsidies, and development of private–public partnerships to develop an ICT infrastructure.

As a leading economy, Germany has already done so much to improve its ICT. For example, the German Federal Government implemented a plan in 2016 to double the volume of its capital venture in an attempt to close the funding scheme gaps and to enhance ICT usage and innovation in the business sector. Although there have been many improvements, given the importance and competitive nature of ICT, there is still much to do even for such a developed country. The German government must work on liberalizing the operations of individuals, services, and capital to efficiently utilize online financial activities under free competition and with data protection. Moreover, the German government should provide better infrastructure and access for individuals and businesses to online goods and services and create a safe environment for digital data networks to enable the financial sector to maximize its growth potential and benefit from the ICT diffusion (Eurostat, 2019).

In a report conducted by the Commission of Experts for Research and Innovation in Germany (Expertenkom-mission Forschung und Innovation, EFI), several recommendations were presented on how the Federal Government in Germany could improve its ICT sector. The EFI suggests increasing tax incentives for research and development purposes and funding start-up ICT projects, especially in the weak regions of East and West Germany. The EFI also states that the start-up dynamics in Germany remain inadequate, as some promising innovators lack government support, especially among women and migrants. The Federal Government must also provide access to funds for the ICT and innovation sector. Dynamic start-ups are affected by funding gaps; therefore, the government must provide venture capital markets that fund start-up and young technology-based entrepreneurs. Germany has an aging society and workers with migrant backgrounds in its labor market. Therefore, it must create adequate conditions for educating and training specialists, young innovators, and women. As the world is becoming more digitalized each day, the demand increases for qualified specialists and entrepreneurs not only in the ICT sector but in all industries in the economy (BMBF, 2018). ICT is penetrating the financial sector rapidly because of the wide dispersion of mobile and Internet usage not only in Germany but globally. Therefore, governments must employ the correct mechanism to fully optimize the benefits of this diffusion.

This study has some limitations. First, the data sample was only taken from 1990–2016 because of the lack of data on the Internet users as a percentage of the population variable. As a sample of 26 years is considered small, future researchers should consider a larger data set. Second, using Internet users as an indicator of ICT is reasonable, but the accuracy of the measure remains unclear. The reason is that the number of Internet subscribers is used to estimate the number of Internet users who may use the same subscriber’s connection (Jensen and Mahan, 2008). Aside from measuring the number of Internet users, the skill level of Internet users must also be measured because not all users have ICT skills and abilities. Available and reliable data on ICT diffusion and infrastructure are lacking. Nevertheless, future researchers can expand the measure of ICT infrastructure by combining variables, such as Internet users, mobile phone subscription, number of computers, fixed phone lines, and TV sets, among others.

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APPENDIX

E-views Output

ADF and PP Unit Root Tests

Statistics (Level)	lnFD	lag	lnGDP	lag	lnFDI	lag	lnINT	lag	lnSTOCK	lag
τ_T (ADF)	-2.116	(0)	-2.639	(2)	-2.639	(0)	-1.080	(1)	-2.826	(1)
τ_μ (ADF)	-2.159	(0)	-0.277	(2)	-2.421	(0)	-3.226	(1)	-2.856	(1)
τ_T (PP)	-2.068	(1)	-3.962	(4)	-2.578	(1)	-1.219	(1)	-3.722	(0)
τ_μ (PP)	-2.044	(2)	-1.024	(4)	-2.284	(2)	-1.650	(1)	-2.560	(3)
Statistics (First Difference)	**lnFD**	**lag**	**lnGDP**	**lag**	**lnFDI**	**lag**	**lnINT**	**lag**	**lnSTOCK**	**lag**
τ_T (ADF)	-6.035*	(0)	-5.770*	(1)	-6.692*	(0)	-4.641*	(0)	-5.632*	(1)
τ_μ (ADF)	-5.991*	(0)	-5.928*	(1)	-6.791*	(0)	-4.479*	(8)	-5.752*	(1)
τ_T (PP)	-8.729*	(9)	-5.400*	(1)	-7.320*	(3)	-4.668*	(2)	-8.348*	(4)
τ_μ (PP)	-6.516*	(5)	-5.568*	(1)	-7.286*	(3)	-2.389	(1)	-8.491*	(4)

Note:
τ_T represents the most general model with a drift and trend; τ_μ is the model with a drift and without trend; τ is the most restricted model without a drift and trend. Numbers in brackets are lag lengths used in ADF test to remove serial correlation in the residuals. When using PP test, numbers in brackets represent Newey-West Bandwith (as determined by Bartlett-Kernel). Both in ADF and PP tests, unit root tests were performed from the most general to the least specific model by eliminating trend and intercept across the models. * denotes rejection of the null hypothesis at the 1 percent level.

Cointegration test

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	5 Percent Critical Value	1 Percent Critical Value
None *	0.693315	73.30490	68.52	76.07
At most 1	0.622794	43.75652	47.21	54.46
At most 2	0.422736	19.38245	29.68	35.65
At most 3	0.202151	5.646053	15.41	20.04
At most 4	6.79E-06	0.000170	3.76	6.65

Trace test indicates 1 cointegrating equation(s) at the 5% level
Trace test indicates no cointegration at the 1% level
*(**) denotes rejection of the hypothesis at the 5%(1%) level

Long run coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LGDP	1.480857	0.135311	10.94410	0.0000
LFDI	0.015485	0.002925	-5.293900	0.0001
LINT	0.065995	0.002865	23.03837	0.0000
LSTOCK	0.091961	0.003814	24.11005	0.0000
C	-43.22810	3.870712	-11.16800	0.0000
@TREND	-0.027322	0.001772	-15.42035	0.0000

R-squared	0.700250	Mean dependent var	-0.326619
Adjusted R-squared	0.606578	S.D. dependent var	0.096938
S.E. of regression	0.060803	Sum squared resid	0.059152
Long-run variance	3.93E-05		

Causality Results

Dependent variable: D(LFD)

Excluded	Chi-sq	df	Prob.
D(LGDP)	2.437559	1	0.1185
D(LFDI)	2.370884	1	0.1236
D(LINT)	8.388112	1	0.0038
D(LSTOCK)	11.76023	1	0.0006
All	13.54698	4	0.0089

Dependent variable: D(LGDP)

Excluded	Chi-sq	df	Prob.
D(LFD)	22.91334	1	0.0000
D(LFDI)	6.716719	1	0.0096
D(LINT)	6.103639	1	0.0135
D(LSTOCK)	10.44593	1	0.0012
All	56.14150	4	0.0000

Dependent variable: D(LFDI)

Excluded	Chi-sq	df	Prob.
D(LFD)	0.735206	1	0.3912
D(LGDP)	0.057637	1	0.8103
D(LINT)	1.928109	1	0.1650
D(LSTOCK)	0.766544	1	0.3813
All	2.832392	4	0.5863

Dependent variable: D(LINT)

Excluded	Chi-sq	df	Prob.
D(LFD)	0.040731	1	0.8401
D(LGDP)	0.313039	1	0.5758
D(LFDI)	0.148610	1	0.6999
D(LSTOCK)	0.302413	1	0.5824
All	0.604921	4	0.9625

Dependent variable: D(LSTOCK)

Excluded	Chi-sq	df	Prob.
D(LFD)	0.146889	1	0.7015
D(LGDP)	0.861648	1	0.3533
D(LFDI)	0.510170	1	0.4751
D(LINT)	5.316519	1	0.0211
All	8.377956	4	0.0787

Descriptive Statistics

Log values:

	LFD	LGDP	LFDI	LINT	LSTOCK
Mean	-0.337511	28.78363	0.039915	2.792258	4.685868
Median	-0.309763	28.78692	0.505579	4.023564	4.780192
Maximum	-0.224302	28.96119	2.542984	4.495881	5.932903
Minimum	-0.627644	28.57439	-3.942380	-2.072329	3.115075
Std. Dev.	0.101272	0.108321	1.286551	2.146830	0.452336
Skewness	-1.124973	-0.162419	-1.045011	-1.050550	-0.862433
Kurtosis	3.630277	1.961871	4.700962	2.601048	8.255823
Jarque-Bera	6.141940	1.331135	8.169144	5.145507	34.42369
Probability	0.046376	0.513982	0.016830	0.076325	0.000000

Original values:

	FD	FDI	GDP	INT	STOCK
Mean	0.716946	1.742597	3.18E+12	46.00331	119.0423
Median	0.733621	1.603198	3.18E+12	55.90000	119.1272
Maximum	0.799074	12.71756	3.78E+12	89.64710	377.2480
Minimum	0.533848	-0.725184	2.57E+12	0.125892	22.53511
Std. Dev.	0.068740	2.432568	3.42E+11	35.78695	59.35999
Skewness	-0.934254	3.489246	-0.014204	-0.191814	2.992735
Kurtosis	3.049440	16.65271	1.926827	1.302709	14.65191
Jarque-Bera	3.930484	264.4829	1.296571	3.406461	193.0420
Probability	0.140122	0.000000	0.522941	0.182094	0.000000