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Master Thesis MSc Strategy Economics

Entrepreneurship and digitalization in developing countries

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Abstract

In this paper the relationship between the stages of economic development and entrepreneurship is examined as well as how digitalization affects total early-stage entrepreneurial activity in developing countries. Country fixed effects models with year dummy variables and one-year lagged independent variables are estimated using panel data on 104 different countries from 2001 till 2019. No evidence of a U-shaped relationship between the stages of economic development and entrepreneurship is found. A positive effect of digitalization on early-stage entrepreneurial activity is found. This effect is influenced by the country's income level and educational attainment. The effect of digitalization on entrepreneurship in middle-income countries is lower than in developing countries, which is also observed for opportunity-driven entrepreneurship. In addition, the rate of educational attainment increases the effect of digitalization on early-stage entrepreneurship. This is also found for necessity-driven entrepreneurship.

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Introduction

Ever since they gained their independency, many developing countries have been trying to boost their economies. However, after several decades most of these countries are still unable to do achieve significant economic growth and poverty remains a critical concern. Various strategies have been implemented such as export promotion and import substitution, but they did not generate the desired results (Acs & Virgill, 2010). An alternative strategy that can stimulate economic growth is to promote entrepreneurship. In developed countries entrepreneurs play an important role in the economic development of a country. Prominent entrepreneurs, like Elon Musk and Jeff Bezos, have proved with their innovative businesses that they can significantly influence a country's economic growth. In less developed countries, entrepreneurs are starting to impact the economic development too. Jack Ma, co-founder of Alibaba which is one of the largest online marketplaces in the world, is a good example. Many of these successful entrepreneurs have created their businesses using new digital technologies. These technologies can be used to help entrepreneurs in developing countries and spur the economy.

The adoption of digital technologies is known as digitalization and can create a plethora of opportunities for entrepreneurs. For instance, focusing on online consumers through your own website, online marketing or with an online presence on digital platforms can result in many potential customers. In addition, using a digital platform can lead to feedback from the digital society which is important for the success of business, especially for start-ups (Srinivasan & Venkatraman, 2018). Digital environments also generate large amounts of data that can be analyzed to determine the preferences of potential customers. This way the marketing and product portfolio can be adjusted to get a higher profit (Kraus, Palmer, Kailer, Kallinger, & Spitzer, 2018). These benefits make it easier to start a successful business and encourage entrepreneurship. Since entrepreneurship in turn stimulates economic growth, it is important to investigate the exact effects of digitalization on entrepreneurial activity. Especially for developing countries, the relationship between digitalization and entrepreneurship is essential as it may help them achieve significant economic

growth. Therefore, the research question of this paper is:

What is the effect of digitalization on entrepreneurship in developing countries?

Since digitalization is a relatively new topic, not much empirical research has been conducted on the effects of digitalization or its relationship with entrepreneurial activity. This study fills the gap in the existing body of literature by providing one. It also helps policymakers in developing countries to develop policies that can accurately stimulate entrepreneurship which will ultimately lead to economic growth.

In the following section the existing literature on entrepreneurship and digitalization are discussed, after which the hypotheses are formulated. Thereafter, the dataset is described, followed by the methodology where the models are explained. After that, the results of the different regression models are presented. This paper ends with a discussion of the results and the conclusion.

Theoretic framework

2.1 Definition of entrepreneurship

Over the last few decades, the literature about entrepreneurship has expanded dramatically. However, the concept of entrepreneurship was already introduced in the 18th century. In 1755, the economist Richard Cantillon defined entrepreneurs as people who engage in market exchanges to make a profit. In order to earn their money, entrepreneurs often act as arbitragers who bring about the equilibrium between supply and demand (Cantillon & Murphy, 2015). Cantillon was also one of the first to discuss the relationship between entrepreneurship and uncertainty and stated that entrepreneurs have to make decisions without knowing the exact outcome or the probability of the outcomes (Cantillon & Murphy, 2015). Another economist Jean-Baptiste Say proposed an alternative definition which emphasized the entrepreneurs' coordinating role in production: the entrepreneur is someone who organizes and combines the means of production into an organization (Landström & Benner, 2010). So, based on these definitions, entrepreneurs are people who manage a business, organize the means of production, and in doing so assume risk.

However, besides owning and managing a business, entrepreneurs also play an important role in creating innovations. Schumpeter (1942) states that entrepreneurs are able to turn new ideas into new products or services and commercialize them. These innovative entrepreneurs need to have the ability and the willingness to search for and create new economic opportunities. Schumpeter (1942) assumes that these opportunities are endogenous and created by the entrepreneurs themselves. However, Kirzner (1999) claims that the opportunity to innovate is created exogenously. He suggests that the role of the entrepreneur is to recognize economic opportunities before others do. So, according to Kirzner (1999) entrepreneurs do not have to introduce new products or technologically more efficient methods of production, they merely have to be more observant of economic opportunities.

Empirical studies have shown that economic opportunities are created both endogenously as exogenously. Being successful as an entrepreneur requires certain

socio-economic and personality characteristics. Shane (2000) and Koellinger (2008), for instance, show that entrepreneurs with technical backgrounds or higher educational attainment are more likely to create innovations. This suggests that some opportunities to innovate are created by the entrepreneur himself. However not all innovations depend solely on the entrepreneur's individual characteristics. Eisenhardt and Schoonhoven (1996) and Elfring and Hulsink (2003) claim that the environmental context and the availability of resources also influence the creation of innovations. Industrial clusters, for example, can lead to knowledge spillovers which provide economic opportunities and help entrepreneurs create new products, services or more efficient methods of production. So, the definition of entrepreneurship is twofold. Firstly, an entrepreneur owns and manages a business on his own account and risk. This is known as the occupational notion of entrepreneurship. Secondly, the behavioral notion of entrepreneurship refers to the ability to recognize and seize economic opportunities (Sternberg & Wennekers, 2005).

Based on this definition, three types of entrepreneurs can be distinguished. The Schumpeterian entrepreneur, the intrapreneur, and the managerial business owner. Schumpeterian entrepreneurs manage their own firms and introduce innovations that revolutionize the market. With these innovations they break down existing market structures and create new ones with new technologies, new forms of production, and new business models. This is also known as creative destruction (Fagerberg, 2013). So, the Schumpeterian entrepreneur is an entrepreneur in both the occupational and the behavioral notion of entrepreneurship as he owns and manages a firm and has the ability to seize the opportunities that are either created by himself or by his environment. Intrapreneurs, on the other hand, are only entrepreneurs in the behavioral notion. They are employed by others but take responsibility for creating innovations within the organization and in doing so risk their time and reputation. This leads to entrepreneurial ventures within a larger firm. These entrepreneurial employees can also decide to start their own firm, ultimately becoming Schumpeterian entrepreneurs (Carree & Thurik, 2010). The managerial business owners are found mostly in small firms. This group consists of shopkeepers, franchisees, and people in professional occupations. They mainly focus on earning a living and not

so much on innovating. This makes them entrepreneurs in the occupational notion only.

2.2 Benefits of entrepreneurship

Stimulating entrepreneurship is assumed to have a positive impact on a country's economy and society as a whole. The positive effect on the economy is caused by several aspects of entrepreneurship. Initial research on the relationship between entrepreneurship and job creation has shown that small firms have a disproportionately large contribution to the number of new jobs that are created (Birch, 1987; Henrekson & Johansson, 2010). However, more recent studies have called the positive effects of small firms on job creation into question. They show that young firms are responsible for the newly created jobs and not small firms (Haltiwanger, Jarmin, & Miranda, 2013). Additionally, they suggest that the quality of the jobs created by small firms is often poor as they are mostly low-wage jobs (Coad, Daunfeldt, Johansson, & Wennberg, 2014; Malchow-Møller, Schjerning, & Sørensen, 2011). The effect of startups and young firms on job creation is dynamic since many of them will exit the market within the first ten year. Most of the surviving young firms remain small and only a fraction of them continues to grow and contributes substantially to job creation. These high-growth firms make up for almost all the jobs that are lost due to the shrinking and exiting of the other startups and young businesses (Decker, Haltiwanger, Jarmin, & Miranda, 2014). So, all entrepreneurs contribute to job creation, but only the innovative entrepreneurs with high-growth firms create long-term jobs.

Entrepreneurship is also considered a driving force of innovations. Because of their characteristics, such as being able to recognize and seize opportunities, entrepreneurs are more likely to bring new products and processes to the market. They are also more inclined to create disruptive innovations than the incumbent firms. Disruptive innovations are innovations that gradually undermine the position of existing business models through the exploitation of new markets or niches (Fagerberg, 2013). These disruptions often originate in markets that are overlooked by incum-

bents such as low-end markets or new markets. Because most entrepreneurs operate from small businesses they benefit from certain small firm innovative advantages. For instance, small firms have less bureaucracy and shorter lines of communication compared to large firms, since small businesses are mostly flat organizations without levels between management and staff level employees. This shortens the decision-making process and enables small firms to develop and implement ideas more quickly (S. Parker, 2011). In addition, small businesses have greater incentive to innovate. They have an incentive to overcome entry barriers and the competition since they want to operate in the market and gain market share. Finally, entrepreneurs are not hindered by the replacement effect from which large firms suffer. Large businesses often have sizable investments in existing technologies which makes them unwilling to introduce new products because it will cannibalize their current offerings. Small firms do not have such investments making them more likely to innovate and introduce new products (S. Parker, 2011).

With the creation of innovations entrepreneurs drive change and enable new markets to be developed. Another way entrepreneurship increases economic growth is through taxes. As entrepreneurship leads to more firms, more jobs, and higher earnings, it raises the national income and also increases the government's tax revenue. Entrepreneurs can contribute to society in other ways as well. They meet the needs of society and improve the quality of life, while still being able to turn a profit. For example, Entrepreneurs who decide to use solar power provide long-term benefits to society by producing green energy (Hitt, Ireland, Sirmon, & Trahms, 2011). So, entrepreneurship can improve the standard of living and create wealth, not only for the entrepreneurs, but also for society.

2.3 Entrepreneurship in developing countries

Since entrepreneurship is positively related to economic growth, it can help developing countries to boost their economies. Developing countries have had a difficult and turbulent history that is still visible today. During the mid 1900s, many colonies in Africa, Asia, and the Caribbean gained their independence and began looking for

development strategies to stimulate their economies. The two most popular forms of industrial policy were import substitution and export promotion. Import substitution is the process of industrialization by producing goods for the country's domestic market that were previously imported (Acs & Virgill, 2010). The idea is that these countries need to protect their infant economies by manufacturing the same advanced products as developed countries to avoid continuously producing low value goods (Bruton, 1998)). This policy requires strong government intervention and market distorting tools such as high tariffs, overvalued exchange rates, and production subsidies to domestic producers. This eventually leads to inefficiencies in industries and bureaucracy which do not stimulate productive entrepreneurship nor economic growth (Acs & Virgill, 2010).

After several Asian countries, such as Singapore and South Korea, successfully industrialized their economies through international trade, policymakers accepted international trade as a means of economic development and started to promote export (Krugman, 1995). This is supported by the data on Asian manufactured exports which shows that there is a significant association between exports and economic growth (Balassa, 1988). One of the reasons for this positive association is because international trade grants access to overseas markets but also opens up the domestic market for foreign companies. This leads to domestic producers being exposed to larger, more competitive markets, which encourages productivity improvements and stimulates more efficient use of resources (Bhagwati, 2004). Economic development through trade also requires the production of increasingly more complex products for export. This means that countries need to shift their production to goods that are associated with high productivity. However, the ability to switch to more complex products is limited by human capital factors (Hausmann, Hwang, & Rodrik, 2007). This in one the reasons why, with the exception of some countries in East Asia, export promotion has not led to significant economic development in developing countries.

Because neither of these industrial strategies have led to the desired economic growth, countries have begun to examine the role of entrepreneurship in development. Since economic development implies a process of structural transformations,

the entrepreneur as the main creator of new products, services, production processes, business models, new markets, and new skills, seems to be the right person for this change (Brinkman, 1995). Entrepreneurship is also essential for development because entrepreneurs take advantage of the gaps left by incomplete and underdeveloped markets. Empirical evidence suggests that there is a strong association between entrepreneurship and economic growth as studies have found that regional differences in economic growth are correlated with the levels of entrepreneurship in those areas (Acs & Virgill, 2010). These findings have stimulated many countries to eliminate barriers to entrepreneurship and other market failures in order to perfect their markets. However, more needs to be done to assist in the growth of entrepreneurship and economic development.

To develop policies that accurately stimulate entrepreneurship, it is important for policymakers to know what the exact determinants are of entrepreneurial activity. Research regarding those determinants is divided into three levels: micro, meso, and macro level. These levels correspond with the individual entrepreneur, the sector or industry, and the national economy, respectively. Research on the micro level focuses primarily on personal factors, such as psychological traits, formal education, and previous work experience. Studies at the meso level of entrepreneurship often examine market-specific determinants of entrepreneurship, like profit opportunities and opportunities for entry and exit. The macro perspective focuses on national factors such as technological, economic and cultural variables (Verheul, Wennekers, Audretsch, & Thurik, 2002).

2.4 Digitalization

A potential determinant of entrepreneurship and relatively new topic in economic literature is digitalization. Digitalization is the process of adopting and using digital technologies to modify a business model and providing value-producing opportunities (Gray & Rumpe, 2015). There are three elements of digital technologies that can be distinguished: digital artifacts, digital platforms, and digital infrastructure. A digital artifact is a digital component, application, or media content that is part of

a new product and offers a specific functionality to the user (Kallinikos, Aaltonen, & Marton, 2013). Since the introduction of the internet and the development of computer programs and apps, there is an increasing number of products where the information can be separated from its related physical device. Because of this decoupling, digital artifacts have been gradually integrated into a wide range of products and services which in turn has resulted in numerous opportunities for entrepreneurs in different industries (Lusch & Nambisan, 2015). Nowadays digital artifacts are not only found in smartphones and laptops but also in home appliances, toys, and cars, like the infotainment system in a Tesla car or a thermostats. So, digital artifacts can be either stand-alone hard- or software components on a device or part of a broader ecosystem that operates on a digital platform (Nambisan, 2017).

A digital platform can be defined as a business model that uses digital technologies to connect complementors and end-users in an interactive ecosystem (McIntyre & Srinivasan, 2017; G. Parker, Alstyne, & Choudary, 2016). Complementors are third parties that provide complementary offerings, including digital artifacts. For example, Apple's iOS and Google's Android platform allow apps developed by third parties to run on their smartphones. This way digital platforms provide opportunities for entrepreneurs that involves developing complementary products and services (Zahra & Nambisan, 2011). It also enables new businesses to focus on creating and improving their product while offsetting their production, marketing, and distribution capabilities. This makes digital platforms attractive options for entrepreneurs (Nambisan, 2017).

Thirdly, digital infrastructures are defined as digital technology tools and systems that offer communication, collaboration, and computing capabilities to support innovation and entrepreneurship (Nambisan, 2017). Such digital infrastructures enable more people to engage in all stages of the entrepreneurial process (Aldrich, 2014). For example, crowdfunding and crowdsourcing allow entrepreneurs to acquire resources like capital and ideas from potential customers and investors all over the world (Kim & Hann, 2013). Similarly, cloud computing, digital makerspaces, and data analytics have made it possible for startups to cost-effectively create and test new ideas before putting them on the market (Hatch, 2013).

So, digital technologies induce entrepreneurial opportunities in terms of the outcome and the process. While digital artifacts and platforms form part of the new venture idea, digital infrastructures support the entrepreneurial process. Especially the supporting role of digital infrastructures is important for developing countries as it gives their entrepreneurs the opportunity to gather the required knowledge and capital to start a business. Since most of the developing countries do not yet have the appropriate policies in place to adequately stimulate this kind of entrepreneurship, it is more useful to investigate this group of countries than developed countries where policymakers have already taken this into account. Also, the literature regarding entrepreneurship in developed countries is already quite extensive, while additional research of developed countries is more likely to generate new insights. Therefore, the following research question will be examined:

What is the effect of digitalization on entrepreneurship in developing countries?

Before looking at the relationship between digitalization and entrepreneurship, the effect of entrepreneurial activity on economic growth will be further investigated. The effect that entrepreneurship has on economic growth differs depending on the stage of economic development of a country. Porter, Sachs, and McArthur (2002) identify three stages of economic development: (1) factor-driven stage, (2) efficiency-driven stage, and (3) innovation-driven stage; with two transitions between these stages. Factor-driven economies are the least developed economies and production here is based primarily on agriculture, natural resources and unskilled labor (Wennekers, Wennekers, Thurik, & Reynolds, 2005). Still, the rates of self-employment are relatively high at this stage as most of the small manufacturing and service firms are owned by individual entrepreneurs and managerial business owners (Acs, Desai, & Hessels, 2008). When countries move to the second stage, the efficiency-driven stage, production becomes more capital intensive and the efficiency and skill of the workforce become more important. At this stage, the number of entrepreneurs decreases as the economy develops. A reason for this is the higher return to employees relative to entrepreneurs as capital stocks increase. This makes it more attractive to become a wage worker (Acs et al., 2008). The innovation-driven stage is driven primarily by knowledge and the creation and commercialization of new ideas. This

stage is marked by an increase in entrepreneurial activity that is due to the fact that the share of manufacturing in the economy decreases and services become more important (Wennekers et al., 2005). So, the level of entrepreneurship is high in the factor-driven stage, decreases in the efficiency-driven stage, and increases again when a country moves to the innovation-driven stage. This suggests a U-shaped relationship between the level of entrepreneurship and economic development. The first hypothesis will test whether this U-shaped relationship can indeed be observed:

Hypothesis 1: There is a U-shaped relationship between entrepreneurship, measured by Total early-stage Entrepreneurial Activity, and economic development, measured by GDP per capita

The main goal of this paper is to find out what the impact of digitalization is on the level of entrepreneurship. There are not many empirical studies on the effects of digitalization, but theory suggests that there is a positive relationship since digital technologies can provide several opportunities for entrepreneurs. The fact that worldwide billions of people have access to the internet grants small entrepreneurial businesses the ability to connect with numerous potential consumers. The customers also do not have to be near. Call center, for example, are often based in low-income countries like India or Brazil, while their customers are located in Europe or North America. They can be reach consumers through their own website, several forms of online marketing, or with an online presence on digital platforms. Because a high user base on an online platform can generate tremendous network effects, choosing the right platform can result in a large group of potential customers, participants adopting a provided technology, and feedback from the digital society which can be important for the success of business, especially in the launching phase (Srinivasan & Venkatraman, 2018). Additionally, digital environments where consumers and firms interact, yield businesses with a considerable amount of data. This information can be used to analyze what potential customers are looking for and businesses can adjust their marketing and product portfolio accordingly. This gives digital entrepreneurs a major advantage over non-digital entrepreneurs who do not have access to this kind of information (Kraus et al., 2018). Other advantages of digital technologies are the easier communication with suppliers, the availability of global

delivery services, and the reduction of paperwork that all contributes to increasing online sales (Bieron, 2015).

With digitalization, entrepreneurial processes have also become less bounded. New digital infrastructures, such as 3D printing and digital makerspaces, enable firms to quickly create, modify, and recreate product ideas and business models, while things like cloud computing and mobile networking give entrepreneurs the ability to rapidly and easily enhance their capabilities and performance at low costs. This way digital infrastructures allow entrepreneurs to work in their own non-linear manner giving them the opportunity to create their own entrepreneurial processes (Brynjolfsson & Saunders, 2009; Ries, 2011). These benefits of digital technologies are likely to affect the number of entrepreneurs and the way they conduct their business in a positive way. The second hypothesis will therefore be:

Hypothesis 2: Digitalization positively affects the level of entrepreneurship, measured by Total early-stage Entrepreneurial Activity, in developing countries

Although digitalization is expected to have a positive effect on the total level of entrepreneurship, there might be certain entrepreneurs who benefit more from it than others. Not all entrepreneurs are the same which means that they have different reasons to start their own business. An entrepreneur's motive can be classified as either opportunity- or necessity-driven (Acs, 2006). These are also known as pull and push motives. In the literature mostly pull motives are reported since many of these studies are conducted in developed countries where entrepreneurship is primarily opportunity driven. One of the pull motives to start a business is autonomy. People value their freedom and therefore prefer to be independent so they can work on their own terms. This is one of the most cited pull factors for starting a business (Gelderen & Jansen, 2006; Kolvereid, 1996). Another reason is monetary. When wage workers earn less than their self-employed colleagues, they are likely to switch to self-employment (Hessels, Gelderen, & Thurik, 2008). The Schumpeterian entrepreneurs often detect economic opportunities or find solutions to certain problems and choose to start their own business (Carree & Thurik, 2010). Finally, being an entrepreneur can give one a certain status which incentivizes to become an entrepreneur (Hessels et al., 2008).

However, individuals can also be pushed into entrepreneurship. Necessity motives occur when unemployment or the threat of it forces people into self-employment. Push motives play a large role in developing countries where social safety nets are nonexistent, and unemployment often means going hungry (Thurik, Carree, Stel, & Audretsch, 2007). Necessity-driven entrepreneurs are therefore not the ones bringing the innovation and economic growth as they often lack the knowledge, skills, and resources to do so. For this reason, the adoption of digital technologies is unlikely to benefit them as much as it will opportunity-driven entrepreneurs. Therefore, the third hypothesis is:

Hypothesis 3: Digitalization has a positive effect on the level of opportunity-driven entrepreneurship, while it does not affect the number of necessity-driven entrepreneurs

Data

To examine the relationship between digitalization and entrepreneurship, a panel dataset is created by combining data from the Global Entrepreneurship Monitor (GEM), the World Economic Forum, the World Bank, and the national statistics bureaus of several countries. The GEM gathers information specifically related to entrepreneurs, while the databases of the World Economic Forum, the World Bank, and the national statistics bureaus contain country-level data about various subjects such a countries' institutions, innovations, infrastructure, and more. The data withdrawn from these databases is all country-level data from 2001 till 2019 of 104 different countries. The countries included in the dataset are all categorized based on their stage of economic development. This division into factor-, efficiency-, and innovation-driven countries is based on the list published by the United Nations (UN). Since the UN issues a new list every year, the categorization of a country varies over time. This has been accounted for in the dataset by adjusting the categorization for each year. An overview of the countries included in the dataset can be found in Table A1 in Appendix A as well as their stage of economic development in the last year that they are observed.

As measurement for the level of entrepreneurship in a country, the Total early-stage Entrepreneurial Activity (TEA) is used. This index represents the percentage of adults (18-64-year-old) in the population who are either a nascent entrepreneur or an owner-manager of a new business (GEM, 2020a). In addition, the percentage of opportunity and necessity driven entrepreneurship is included in the dataset which will be used as dependent variables to test the third hypothesis. While opportunity driven entrepreneurs start their own firm in order to take advantage of a business opportunity, necessity driven entrepreneurs pursue self-employment to avoid unemployment (GEM, 2020b). Digitalization might affect these necessity- and opportunity-driven entrepreneurs differently. To measure digitalization several variables can be considered. The simplest one is the number of individuals with access to the internet as a percentage of the population. However, internet access does not fully represent digitalization, since it does not include the integration of

digital technologies in businesses or the skills needed to take advantage of the possibilities offered by a digital society. An alternative measurement of digitalization is technological readiness which is measured by the World Economic Forum. Technological readiness measures the agility with which a country adopts new productivity-enhancing technologies by looking at the availability of ICT and other technologies in an economy. It also takes into account the rate by which these new technologies are adopted (Schwab, 2006). So, technological readiness measures digitalization more accurately than internet access, however some aspects are still not taken into consideration.

To get a more precise measurement of digitalization, a new variable is be created based on the Euler-Hermes Enabling Digitalization Index. This variable takes into account several other conditions necessary for companies to adopt digital technologies successfully. It is based on five components: regulation, knowledge, connectivity, infrastructure, and size. The level of regulatory performance is assessed using the Ease of Doing Business indicator from the World Bank. The knowledge component consists of higher education and training scores as well as the innovation score developed by the World Economic Forum. For connectivity, four indicators are used: the number of people using internet as a percentage of the population, mobile phone and fixed phones lines subscriptions, and the number of secure servers per 100 people (Islam, Dib, & Subran, 2018). Infrastructure is measured through the infrastructure variable used in the Global Competitiveness Index from the World Economic Forum. This measures the quality and extension of transport infrastructure as well as utility infrastructure such as electricity and telephone networks (Islam et al., 2018). The size is determined by the number of internet users and the GDP (Islam et al., 2018). The combination of these indicators results in an index that accurately depict the level of digitalization in a country.

To control for other factors that simultaneously affect entrepreneurship, several control variables are included. The first control variable is GDP per capita, which is an indicator of a country's economic growth. This is measured in two ways: a continuous variable which is used to determine if there is a U-shaped relationship between entrepreneurship and economic development and a categorical variable,

Income, which is used to test the second and third hypothesis. The income variable consists of three groups: low, middle, and high income. A country has a low income if its GDP per capita lies between 0 and $4,045$ dollar, a middle income if it is between 4045 and $12,535$ dollar, and a country's income is considered high when it exceeds $12,535$ dollar per capita (Serajuddin & Hamadeh, 2020).

Demographic characteristics are captured by including primary and upper secondary educational attainment, the labor participation rate of women, and the population density. Educational attainment is included because studies have shown that enrollment in higher education has a positive effect on early-stage entrepreneurship (Uhlaner & Thurik, 2010). The primary and upper secondary education levels are chosen because they are well-documented, also in developing countries. So, there are enough observations in the dataset. Additionally, the labor participation rate of women is added. Because women are less likely to become entrepreneurs compared to men, a higher labor participation rate of women implies that there may be a lower overall business ownership rate in the labor force (Acs, Arenius, Hay, & Minniti, 2005). The population density is important because the level of entrepreneurship may vary between rural regions and urban areas. Thinly populated areas have a relatively large number of small retail stores and workshops while in urban areas smaller businesses are being outperformed by large companies that benefit from economies of scale (Wennekers, Thurik, Stel, & Noorderhaven, 2007). However, networks and other supply side factors in urban areas can induce entrepreneurship in many service industries (Audretsch & Keilbach, 2004).

Furthermore, the unemployment rate as a percentage of the population is added. A high unemployment rate suggests that there is a lack of business opportunities. This will discourage nascent entrepreneurs (Wennekers et al., 2007). To account for income disparity, the GINI coefficient is included. When income is not equally distributed, people at the lower end of the income distribution can be pushed to enter self-employment. Income disparity can also lead to a more differentiated demand which creates opportunities for entrepreneurs (Wennekers et al., 2007). Lastly, the real interest rate which functions as a proxy for the cost of capital is included. The reason for this is that higher interest rates may have a negative effect on business

ownership and entrepreneurship (S. Parker, 2004).

Descriptive statistics of these variables are shown in Table 3.1 and give an impression of the data structure. The dataset contains data of 104 countries over a time span of 19 years, but there are only 925 observations in the dataset. The reason for this is that in many countries the required variables are only recorded in some of these years and in extreme cases just once. Especially for developing countries is it difficult to find sufficient data. This means that this panel dataset is unbalanced. The table also shows that the values of the digitalization and technological readiness variables lie between 1 and 100. This is because these variables are scores that integrate several aspects necessary for digitalization to be successful. Digitalization consists of the beforementioned regulation, knowledge, connectivity, infrastructure, and size components, while technological readiness incorporates indicators on the availability of latest technologies, firm-level technology absorption, foreign direct investment and tech transfer, individuals using the internet, fixed broadband internet subscriptions, international internet bandwidth, and mobile broadband subscriptions (Schwab, 2018). The two variables measuring GDP per capita are also shown. The continuous variable is named GDP per capita, while income indicates the categorical variable.

Table 3.1: Descriptive statistics

Variable	Obs.	Mean	Std. Dev.	Min.	Max.
TEA	925	11.430	7.480	1.478	41.457
TEA opportunity	925	7.904	5.091	0.810	31.615
TEA necessity	925	2.934	2.791	0.094	16.450
Digitalization	925	15.131	17.626	1.000	100.000
Tech. readiness	925	59.995	20.434	1.000	100.000
GDP per capita	925	23595.030	21657.240	243.902	118823.600
Income	925	1.959	0.889	1	3
Upper secondary	925	60.156	20.817	2.805	96.308
Primary	925	89.524	13.258	32.504	100.000
Female labor participation	925	50.894	12.077	12.052	83.372
Population density	925	245.188	867.525	2.527	7714.702
Unemployment	925	8.099	5.558	0.091	33.761
Gini coefficient	925	37.810	8.697	23.700	64.800
Real interest rate	925	5.096	7.952	-18.122	52.437

Table 3.2 depicts the correlations between the variables that will be used in the regressions. The third, fourth, and fifth column show moderately strong negative correlation between the entrepreneurship measures and the two measurements of digitalization, Digitalization, Technological readiness. This is unexpected since a positive relationship between entrepreneurship and digitalization is expected. Furthermore, there seems to be a strong positive correlation between GDP per capita and the variables that measure digitalization. This positive association suggests that developed countries are more prone to adopt new digital technologies or digitalization spurs economic growth. The correlations between opportunity-driven TEA and necessity-driven TEA and between primary and secondary education attainment are also strong positive. Because these correlations are around 0.7 and 0.8, respectively, there may be multicollinearity which can lead to biased estimators. To prevent this, the regressions will also be run with only one of the variables.

Table 3.2: Correlation matrix

	Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	TEA	1													
2	TEA opportunity	0.926*	1												
3	TEA necessity	0.835*	0.731*	1											
4	Digitalization	-0.329*	-0.234*	-0.467*	1										
5	Tech. readiness	-0.481*	-0.394*	-0.611*	0.744*	1									
6	GDP per capita	-0.398*	-0.295*	-0.535*	0.647*	0.766*	1								
7	Income	-0.468*	-0.374*	-0.593*	0.772*	0.797*	0.843*	1							
8	Upper secondary	-0.448*	-0.417*	-0.517*	0.508*	0.631*	0.519*	0.565*	1						
9	Primary	-0.588*	-0.538*	-0.616*	0.490*	0.657*	0.536*	0.621*	0.808*	1					
10	Female labor participation	0.260*	0.280*	0.154*	0.285*	0.251*	0.269*	0.231*	0.211*	0.039	1				
11	Population density	-0.103*	-0.081*	-0.102*	0.069*	0.142*	0.096*	0.134*	0.021	-0.013	0.015	1			
12	Unemployment	-0.180*	-0.235*	0.001	-0.239*	-0.126*	-0.235*	0.191*	-0.080*	-0.007	-0.317*	-0.097*	1		
13	Gini coefficient	0.461*	0.392*	0.498*	-0.436*	-0.459*	-0.455*	-0.515*	-0.452*	-0.527*	-0.019	0.071*	0.180*	1	
14	Real interest rate	0.153*	0.149*	0.271*	-0.184*	-0.149*	-0.190*	-0.202*	-0.224*	-0.262*	0.126*	-0.006	0.055	0.254*	1

* $p < 0.05$

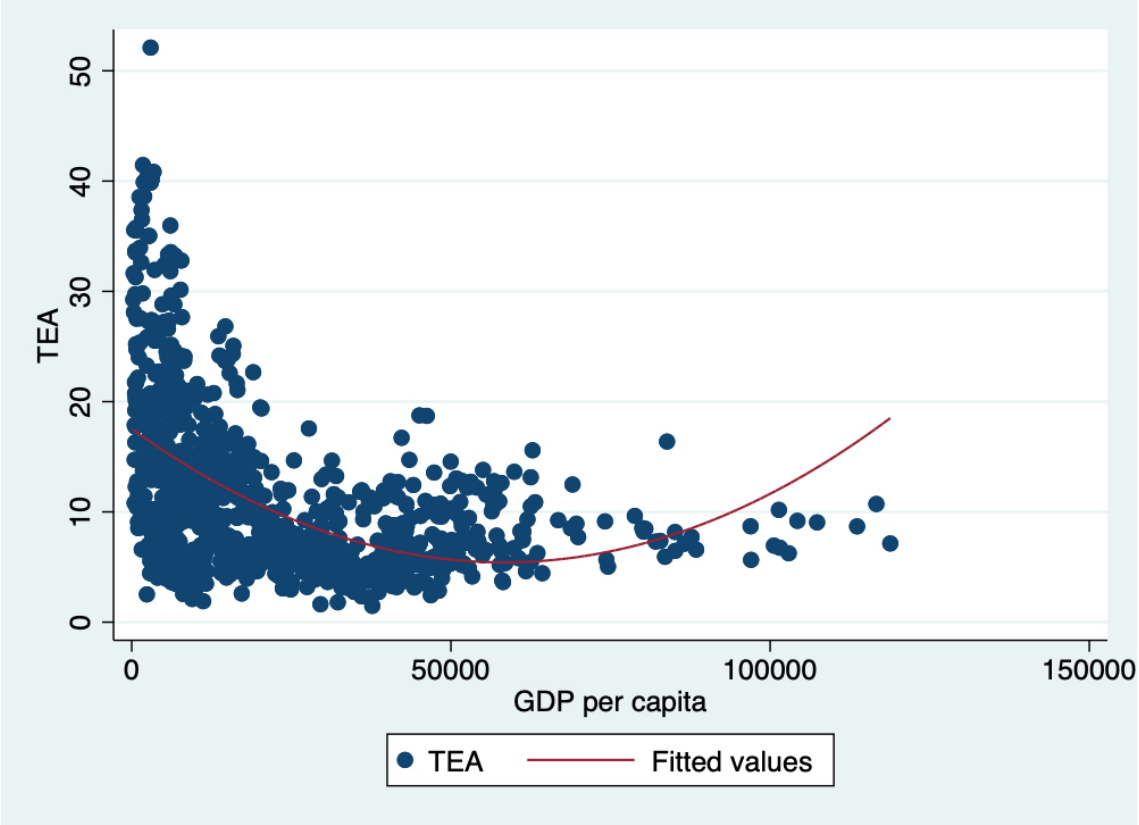

Figure 3.1: *Scatter plot of Total early-stage Entrepreneurial Activity and GDP per capita*

Figure 3.1 illustrates the relationship between TEA and GDP per capita. Since GDP is a measurement of economic growth this graph shows a simplified picture of the relationship between entrepreneurship and economic growth. The fitted values in the figure suggest that there is a U-shaped relation between the variables. However, more formal testing needs to be conducted to be sure.

Methodology

First the shape of the relationship between entrepreneurship and economic development is tested. To find out if this relationship is U-shaped, TEA is regressed on GDP per capita and the squared root of GDP per capita since the GDP indicates a country's economic development:

$$TEA = \beta_0 + \beta_1 GDP + \beta_2 GDP^2 \tag{1}$$

There are three conditions that have to be met before a U-shaped relationship can be assumed. Firstly, β_2 has to be positive and statistically significant. Secondly, the slope must be sufficiently steep at both ends of the data range. This can be examined by entering a value from the low end of the data range and one from the high end. If there is a U-shaped relationship, the value from the high end of the data range is positive and significant while the value for the low end is negative and statistically significant. Thirdly, the turning point needs to be within the data range. To test this, the first derivative of Equation 1 needs to be set to zero which leads to the turning point being at $-\beta_1/2\beta_2$ (Haans et al., 2016). When these three conditions are met, it can be concluded that there is a U-shaped relationship between entrepreneurship and the stages of economic development.

To examine the effect of digitalization on entrepreneurship, a country fixed effects model is used. By applying country fixed effects, the within-country variation is used to control for all time-invariant variables. So, all unobservable characteristics of a country that may influence early-stage entrepreneurial activity are eliminated. Besides traits that are specific for a country, there are also seasonalities and trends that affect all countries at the same time. To eliminate these effects time dummy variables are included in the regression. Since digitalization is difficult to measure both the digitalization and technological readiness variable are used as dependent variable. In addition, the aforementioned control variables are added to the model to reduce endogeneity. The natural logarithm of the variables is used to control for outliers and to deal with skewed data. Since the rate of digitalization is not expected to have an immediate effect on the number of entrepreneurs in a country, the

explanatory variable and the control variables are lagged by one year to get a more accurate estimation of the relationship between digitalization and entrepreneurship. Because the level of economic development may act as a moderator and affect the relationship between digitalization and entrepreneurial activity, GDP per capita is also included in an interaction term with digitalization. It is likely that educational attainment also influences the relationship of TEA and digitalization so another interaction term with digitalization and upper secondary educational attainment is added to the regression. This results in the following model:

$$\begin{aligned} lnTEA_{i,t} =& \beta_0 + \beta_1 ln(Digitalization)_{i,t-1} + \beta_2 ln(Digitalization)_{i,t-1} \times ln(Income)_{i,t-1} \\ &+ \beta_3 ln(Digitalization)_{i,t-1} \times ln(Upper\ secondary)_{i,t-1} + \beta_4 ln(Income)_{i,t-1} \\ &+ \beta_5 ln(Upper\ secondary)_{i,t-1} + \beta_6 ln(Primary)_{i,t-1} + \beta_7 ln(F.\ labor\ participation)_{i,t-1} \\ &+ \beta_8 ln(Population\ density)_{i,t-1} + \beta_9 ln(Unemployment)_{i,t-1} \\ &+ \beta_{10} ln(GINI\ coefficient)_{i,t-1} + \beta_{11} (Real\ interest\ rate)_{i,t-1} + T_t + \varepsilon \end{aligned} \tag{2}$$

$i = 1,...,n$ refers to the relevant country and $t = 1,...,T$ indicates the appropriate year.

Results

First, hypothesis 1 is tested which states that there is a U-shaped relationship between entrepreneurship and economic development. This is done by running several regressions with both the GDP per capita and GDP per capita squared as explanatory variables. The results of these regressions are shown in Table 5.1. Column 1 shows the results of a pooled OLS regression which serves as a baseline. In the second model country fixed effects are included, while in model 3 time dummy variables are added as well. In the pooled OLS model the coefficients of GDP per capita and GDP per capita squared are both significant at a significance level of 0.01, but GDP per capita is negative while GDP per capita squared is positive. The positive and statistically significant β_2 estimate corresponds with a U-shaped relationship between TEA and GDP per capita. However, in the fixed effects models the signs of these variables are flipped and GDP per capita is positive, while GDP per capita squared is negative. This suggest that there is inverted U-shaped relationship between entrepreneurship and economic development. However, the coefficients are extremely close to zero which makes it difficult to draw any conclusion.

Table 5.1: Results of OLS and fixed effects models estimating a U-shape relationship between entrepreneurship and economic development

	DV = TEA		
Variables	(1)	(2)	(3)
GDP per capita	-0.0004***	0.0002***	0.0002**
	(-14.380)	(3.988)	(2.515)
GDP per capita squared	$3.30e^{-9}$***	$-1.18e^{-9}$***	$-1.09e^{-9}$
	(10.730)	(-2.700)	(-2.131)
Constant	17.220***	8.388***	10.180***
	(33.200)	(12.340)	(12.010)
Observations	925	925	925
Country fixed effects	NO	YES	YES
Time fixed effects	NO	NO	YES
Adjusted R^2	0.251	0.027	0.112

*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$. t-values in parentheses.

The second condition that has to be met is that the slope must be sufficiently steep at both ends of the data range. This is tested by entering the minimum and maximum values of GDP per capita and GDP per capita squared into the first order conditions of the regression models from Table 3. Using the pooled OLS model gives us the following estimates:

$$TEA'(GDP_{min}) = -0.0004 + 2 \times 3.30e^{-9} \times 243.9015 = -0.0004 \tag{3}$$

$$TEA'(GDP_{max}) = -0.0004 + 2 \times 3.30e^{-9} \times 118823.6000 = 0.0004 \tag{4}$$

The equations shows that entering the minimum value of GDP per capita results in a negative value and using the maximum gives us a positive value. This suggests that there is U-shaped relationship between TEA and GDP per capita. However, when Model 3 is used, which includes both the country and the time fixed effects, the results are different:

$$TEA'(GDP_{min}) = 0.0002 + 2 \times -1.09e^{-9} \times 243.9015 = 0.0002 \tag{5}$$

$$TEA'(GDP_{max}) = 0.0002 + 2 \times -1.09e^{-9} \times 118823.6000 = -0.0001 \tag{6}$$

These results imply that there is an inverted U-shaped relationship between entrepreneurship and economic development since the minimum value of GDP per capita gives us a positive value while the maximum results in a negative value. Since the values of all four equations are again very close to zero, the functional form cannot be determined yet. Next, the third condition is analyzed. The requirement states that the turning point must be within the data range. This is calculated by setting the derivative of the regressions to zero resulting in the turning point being at $-\beta_1/2\beta_2$. For the pooled OLS model this results in a turning point at 58860.935, while the turning point of the fixed effects model is at 75773.136. These are both well within the data range since the minimum is 243.902 and maximum is 118823.600.

Based on these results and the fact that the fixed effects model is the most accurate and less biased model, it cannot be concluded that there is a U-shaped

relationship between entrepreneurship and economic development. The reason for this is that the $mathrm\beta_2$ in the fixed effects model is not positive. Also, the slope is not sufficiently steep at the ends of the data range which makes it unlikely that there is a U-shaped relationship between TEA and GDP per capita. A possible explanation for this is that GDP per capita is not an accurate measurement of economic development. GDP per capita measures the average income of the population, but when the income is unequally distributed an increase in GDP per capita does not necessarily mean that the situation of all people improves. Moreover, by using GDP per capita as measurement only the monetary aspect of economic development is taken into account. However, social factors such as education, health, and leisure also play a role. Using a variable that captures all these factors may yield different results.

Next, the second hypothesis is examined which predicts that digitalization positively affects early-stage entrepreneurial activity in developing countries. To test this hypothesis, the country fixed effects models without lagged independent variables are used first. The results of the regressions are presented in Table 5.2. In model 1 the coefficient of digitalization is small and positive, but it is not statistically significant at a 10% significance level. Also, none oft the control variables are significant, expect unemployment. In the second model interaction terms between digitalization and income are added to see if there is a moderating effect of income on the relationship between digitalization and early-stage entrepreneurial activity. The results show that again none of the coefficients are statistically significant, expect unemployment. Also, the interaction terms are not significant. The third specification of the model includes an interaction term between upper secondary education and digitalization. This tests if there is a moderating effect of educational attainment on the relationship between digitalization and entrepreneurship. The coefficients of digitalization and the interaction term are both statistically significant. Because digitalization is negative, it suggests that digitalization has a negative impact on entrepreneurial activity when upper secondary education attainment is low. However, the positive interaction term between upper secondary education and digitalization indicates that when the rate of upper secondary education attainment is high, digi-

talization will have a positive effect on entrepreneurship. This relationship can also be seen in the fourth model where all the interaction terms from the previous models are included.

Since it is expected that it takes time before the adoption of digitalization affects early-stage entrepreneurial activity these models are also estimated with lagged independent variables. In Table 5.3, the results of these regressions are shown. In the first specification of the model, the coefficient of digitalization is small but positive and statistically significant at a 5% significance level. This suggests that digitalization has a positive effect on entrepreneurship, all other things being equal. The results of model 2 show the interaction term of digitalization and middle income is negative and statistically significant, while digitalization and the interaction between digitalization and high income are not significant. This indicates that the effect of digitalization on entrepreneurial activity in middle-income countries is significantly lower than in low-income countries, ceteris paribus. However, seems to be no significant effect of digitalization on entrepreneurship in low-income countries since the coefficient of digitalization is not significant. An explanation the effect of digitalization on entrepreneurial activity being smaller in middle-income countries than in low-income countries is that most middle-income countries are in the efficiency-driven stage of economic development. In this stage production is more capital intensive and becoming a wage worker is more attractive than working as entrepreneur because of the higher return to employees relative to entrepreneurs (Acs et al., 2008). This effect might outweigh the positive effect that digitalization has on early-stage entrepreneurial activity.

The third regression includes the interaction term between upper secondary education attainment and digitalization. The results of this regression are similar to the outcome of model 3 in Table 5.2 since the coefficient of digitalization is negative and statistically significant, while the interaction term is positive and significant at a 1% significance level. This means that digitalization has a negative effect on early-stage entrepreneurial activity when the rate of upper secondary educational attainment is low, ceteris paribus. However, when upper secondary education increases, the effect of digitalization on entrepreneurship becomes less negative and even positive if upper

secondary educational attainment is high enough, all other things being equal. The reason for this could be that the adoption of digital technologies creates economic opportunities which can only be seized by people with the appropriate knowledge and skill. People that do not finish upper secondary education most likely do not possess the ability to gain these capabilities.

In Model 4 the previous models are combined, and all the interaction terms are added. The estimated coefficients of digitalization, the interactions terms of digitalization and middle income and between digitalization and upper secondary education, as well as the variables income and upper secondary education are statistically significant at a 1% significance level. The negative coefficient of digitalization indicates that the adoption of digital technologies has a negative effect on entrepreneurial activity in low-income countries where upper secondary education attainment is low, ceteris paribus. Since the interaction term of digitalization and middle income is negative and significant, the effect of digitalization on entrepreneurship is smaller in middle-income countries with low upper secondary educational attainment rates compared to low-income countries where upper secondary education is low, all other things being equal. Furthermore, based on the literature, it is expected that the effect of digitalization on entrepreneurship is larger in high-income countries compared to developing countries, but as the interaction term is not significant this cannot be concluded. Finally, the positive interaction term between upper secondary education and digitalization means that the negative effect of digitalization on entrepreneurship in low-income countries with low rates of upper secondary educational attainment becomes less negative as upper secondary education increases, ceteris paribus. So, the adoption of digital technologies seems to positively affect early-stage entrepreneurial activity as long as upper secondary educational attainment is sufficiently high.

Table 5.2: Results of fixed effects models estimating the relationship between digitalization and entrepreneurship

	DV = ln(TEA)			
Variables	(1)	(2)	(3)	(4)
ln(Digitalization)	0.058	0.088	-0.352***	-0.404***
	(0.025)	(0.034)	(0.128)	(0.145)
ln(Digitalization) × Middle income)		-0.113		-0.179
		(0.112)		(0.116)
ln(Digitalization) × High income		0.053		-0.011
		(0.040)		(0.049)
ln(Digitalization) × ln(Upper secondary)			0.074**	0.089**
			(0.032)	(0.040)
Income (base category: low income)				
Middle income	0.108	-0.160	0.110*	-0.359
	(0.067)	(0.300)	(0.066)	(0.312)
High income	0.096	0.183	0.062	-0.013
	(0.110)	(0.143)	(0.110)	(0.167)
ln(Upper secondary)	-0.279	-0.161	0.068	0.203
	(0.220)	(0.231)	(0.264)	(0.282)
ln(Primary	0.242	0.173	0.204	0.054
	(0.531)	(0.538)	(0.529)	(0.538)
ln(Female labor participation)	0.078	0.044	-0.046	-0.054
	(0.456)	(0.457)	(0.457)	(0.457)
ln(Population density)	-0.205	-0.089	0.178	0.211
	(0.443)	(0.453)	(0.470)	(0.470)
ln(Unemployment)	-0.113*	-0.132**	-0.110*	-0.119*
	(0.065)	(0.066)	(0.064)	(0.066)
ln(GINI coefficient)	0.334	0.252	0.176	0.201
	(0.367)	(0.376)	(0.371)	(0.375)
Real interest rate	-0.004	-0.003	-0.004	-0.003
	(0.004)	(0.004)	(0.004)	(0.004)
Constant	1.603	1.279	-0.248	-0.291
	(3.700)	(3.717)	(3.765)	(3.765)
Observations	925	925	925	925
Time fixed effects	YES	YES	YES	YES
Adjusted R^2	0.246	0.251	0.256	0.260
AIC	122.9	123.5	118.5	119.6

*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$. Robust standard error in parentheses.

Table 5.3: Results of fixed effects models with lagged independent variables estimating the relationship between digitalization and entrepreneurship

	DV = ln(TEA)			
Variables	(1)	(2)	(3)	(4)
$\ln(\text{Digitalization})_{t-1}$	0.048**	0.039	-0.662***	-1.024***
	(0.061)	(0.063)	(0.254)	(0.289)
$\ln(\text{Digitalization})_{t-1} \times \text{Middle income}_{t-1}$		-0.269**		-0.439***
		(0.136)		(0.141)
$\ln(\text{Digitalization})_{t-1} \times \text{High income}_{t-1}$		0.023		0.213
		(0.105)		(0.114)
$\ln(\text{Digitalization})_{t-1} \times \ln(\text{Upper secondary})_{t-1}$			0.191***	0.278***
			(0.066)	(0.074)
Income_{t-1} (base category: low income)				
Middle income	-0.067	-0.768**	-0.094	-1.268***
	(0.073)	(0.365)	(0.073)	(0.382)
High income	-0.045	-0.176	-0.137	-0.731**
	(0.114)	(0.249)	(0.117)	(0.285)
$\ln(\text{Upper secondary})_{t-1}$	0.055	0.150	0.844**	1.222***
	(0.285)	(0.295)	(0.393)	(0.406)
$\ln(\text{Primary})_{t-1}$	-0.703	-0.884	-0.271	-0.332
	(0.704)	(0.707)	(0.712)	(0.708)
$\ln(\text{Female labor participation})_{t-1}$	0.505	0.551	0.482	0.522
	(0.500)	(0.499)	(0.494)	(0.488)
$\ln(\text{Population density})_{t-1}$	-0.654	-0.701	-0.564	-0.377
	(0.578)	(0.590)	(0.573)	(0.584)
$\ln(\text{Unemployment})_{t-1}$	-0.035	-0.054	-0.044	-0.070
	(0.078)	(0.078)	(0.077)	(0.077)
$\ln(\text{GINI coefficient})_{t-1}$	0.284	0.347	0.007	0.046
	(0.435)	(0.437)	(0.441)	(0.436)
$\text{Real interest rate}_{t-1}$	0.001	0.003	0.001	0.004
	(0.004)	(0.004)	(0.004)	(0.004)
Constant	5.066	5.270	0.885	-1.586
	(4.627)	(4.639)	(4.799)	(4.895)
Observations	810	810	810	810
Time fixed effects	YES	YES	YES	YES
Adjusted R^2	0.355	0.363	0.372	0.391
AIC	15.93	14.88	7.899	-0.218

*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$. Robust standard error in parentheses.

To examine if digitalization affects opportunity-driven and necessity-driven entrepreneurs differently, again country fixed effects models with year dummy variables and lagged control variables are used. The results are shown in Tables 5.4 and 5.5. In Table 5.4 opportunity-driven TEA is used as dependent variable. The results in model 1 show that digitalization is positive and significant at a 5% significance level. It is also the only coefficient that is statistically significant. This model suggests that, all other things being equal, digitalization has a significant positive on opportunity-driven entrepreneurship. When the interaction terms between digitalization and income level are included in the second model, digitalization is again positive and significant at 5%. This indicate that digitalization positively affects opportunity-driven early-stage entrepreneurial activity in low-income countries, ceteris paribus. In addition, the interaction terms with middle income and high income are both negative, but only the interaction with middle income is statistically significant. This means that all other things being equal, the effect of digitalization on opportunity-driven entrepreneurship is smaller in middle-income countries compared to low-income countries. The explanation that most middle-income countries are in the efficiency-driven stage of economic development in which working as employee is more attractive than becoming an entrepreneur applies here too.

In the third model the interaction term between is digitalization and upper secondary education is included. The results show that none of the estimated coefficients are significant at a 5% significance level. This implies that digitalization does not significantly affect opportunity-driven entrepreneurship in countries with a low upper secondary education attainment rate, all other things being equal. The results of the fourth model where all interaction terms are included shows that the digitalization coefficient is not significant at a 10% significance level and neither is the interaction term between digitalization and high income. The other two interaction terms are statistically significant. This means that the effect of digitalization on opportunity-driven entrepreneurship is smaller in middle-income countries with low rates of upper secondary educational attainment compared to low-income countries with low upper secondary education rates, ceteris paribus. Also, when upper secondary education increases the effect of digitalization on opportunity-driven en-

trepreneurship increases in low-income countries with low rates of upper secondary education attainment, all other things being equal.

In Table 5.5 the results are shown of the regressions run with necessity-driven entrepreneurship as response variable. Model 1 indicates that digitalization has a significant positive effect on necessity-driven entrepreneurship, all other things being equal. In the second model the coefficients of digitalization and the interaction terms are not statistically significant at a 10% significance level. In model 3 the estimated coefficient of the explanatory variable is positive as is the interaction term with upper secondary education. Both estimates are also statistically significant at a 1% significance level. So, digitalization has a negative effect on necessity-driven early-stage entrepreneurial activity when the rate of upper secondary educational attainment is low, all other things being equal. However, when the upper secondary education increases, the effect of digitalization on entrepreneurship becomes less negative and may even become positive, ceteris paribus. This is also observed in the fourth model. So, the results are not in line with the third hypothesis which states that digitalization has a positive effect on the level of opportunity-driven entrepreneurship, while it does not affect the number of necessity-driven entrepreneurs. The findings indicate that digitalization positively affects both opportunity-driven and necessity-driven entrepreneurship. However, necessity-driven entrepreneurship is only stimulated by digitalization when the population is sufficiently educated and has at least finished upper secondary education. A possible explanation for this is that people that complete secondary education have the capabilities to gain the knowledge and skill to start their own business and provide a useful product or service to customers, while people without education do not. Another reason could be that necessity-driven TEA only measures the number of registered new businesses, while people who do not finish secondary education often end up in unreported employment.

Table 5.4: Results of fixed effects models with lagged independent variables estimating the relationship between digitalization and opportunity-driven entrepreneurship

	DV = ln(TEA opportunity)			
Variables	(1)	(2)	(3)	(4)
$\ln(\text{Digitalization})_{t-1}$	0.137**	0.121**	-0.178	-0.345
	(0.056)	(0.057)	(0.235)	(0.265)
$\ln(\text{Digitalization})_{t-1} \times \text{Middle income}_{t-1}$		-0.292**		-0.373***
		(0.124)		(0.123)
$\ln(\text{Digitalization})_{t-1} \times \text{High income}_{t-1})$		0.070		0.037
		(0.095)		(0.086)
$\ln(\text{Digitalization})_{t-1} \times \ln(\text{Upper secondary})_{t-1}$			0.090	0.138**
			(0.059)	(0.069)
Income_{t-1} (base category: low income)				
Middle income	0.029	-0.737**	0.113*	-0.875***
	(0.067)	(0.333)	(0.067)	(0.334)
High income	0.090	-0.139	0.070	-0.130
	(0.104)	(0.227)	(0.112)	(0.224)
$\ln(\text{Upper secondary})_{t-1}$	0.222	0.291	0.622*	0.947**
	(0.260)	(0.269)	(0.369)	(0.386)
$\ln(\text{Primary})_{t-1}$	-0.960	-1.147*	-0.826	-1.003
	(0.643)	(0.645)	(0.666)	(0.662)
$\ln(\text{Female labor participation})_{t-1}$	0.093	0.137	0.068	0.169
	(0.457)	(0.454)	(0.473)	(0.470)
$\ln(\text{Population density})_{t-1}$	-0.234	-0.228	0.752	0.743
	(0.528)	(0.537)	(0.489)	(0.510)
$\ln(\text{Unemployment})_{t-1}$	-0.031	-0.049	0.040	0.029
	(0.071)	(0.071)	(0.068)	(0.069)
$\ln(\text{GINI coefficient})_{t-1}$	0.305	0.389	-0.121	-0.071
	(0.398)	(0.399)	(0.412)	(0.408)
$\text{Real interest rate}_{t-1}$	0.002	0.004	0.003	0.005
	(0.004)	(0.004)	(0.004)	(0.004)
Constant	5.161	5.153	0.237	-0.685
	(4.226)	(4.228)	(4.215)	(4.348)
Observations	810	810	810	810
Time fixed effects	YES	YES	YES	YES
Adjusted R^2	0.403	0.414	0.299	0.319
AIC	-53.32	-56.06	-24.18	-31.10

*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$. Robust standard error in parentheses.

Table 5.5: Results of fixed effects models with lagged independent variables estimating the relationship between digitalization and necessity-driven entrepreneurship

	DV = ln(TEA necessity)			
Variables	(1)	(2)	(3)	(4)
$\ln(\text{Digitalization})_{t-1}$	0.141**	0.086	-1.115***	-1.408***
	(0.063)	(0.067)	(0.342)	(0.392)
$\ln(\text{Digitalization})_{t-1} \times \text{Middle income}_{t-1}$		0.276		0.091
		(0.176)		(0.191)
$\ln(\text{Digitalization})_{t-1} \times \text{High income}_{t-1})$		0.236		0.313
		(0.110)		(0.155)
$\ln(\text{Digitalization})_{t-1} \times \ln(\text{Upper secondary})_{t-1}$			0.285***	0.352***
			(0.089)	(0.100)
Income_{t-1} (base category: low income)				
Middle income	0.067	0.827*	-0.053	0.139
	(0.098)	(0.472)	(0.098)	(0.517)
High income	0.018	0.541**	-0.143	-0.754*
	(0.161)	(0.273)	(0.158)	(0.387)
$\ln(\text{Upper secondary})_{t-1}$	-0.249	-0.132	1.172**	1.170**
	(0.401)	(0.416)	(0.529)	(0.550)
$\ln(\text{Primary})_{t-1}$	-0.347	-0.047	0.319	0.602
	(0.972)	(0.976)	(0.960)	(0.960)
$\ln(\text{Female labor participation})_{t-1}$	0.559	0.368	0.023	-0.045
	(0.703)	(0.703)	(0.666)	(0.662)
$\ln(\text{Population density})_{t-1}$	0.996	0.482	-0.959	-0.503
	(0.723)	(0.762)	(0.772)	(0.791)
$\ln(\text{Unemployment})_{t-1}$	0.311***	0.266***	0.161	0.181*
	(0.100)	(0.103)	(0.104)	(0.104)
$\ln(\text{GINI coefficient})_{t-1}$	0.343	0.118	0.215	0.214
	(0.602)	(0.605)	(0.594)	(0.590)
$\text{Real interest rate}_{t-1}$	0.008	0.006	0.005	0.005
	(0.005)	(0.005)	(0.005)	(0.005)
Constant	-4.932	-3.066	-2.584	-5.789
	(6.137)	(6.166)	(6.466)	(6.633)
Observations	810	810	810	810
Time fixed effects	YES	YES	YES	YES
Adjusted R^2	0.108	0.124	0.277	0.291
AIC	279.9	276.9	235.8	232.0

*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$. Robust standard error in parentheses.

5.1 Robustness checks

The first hypothesis examines if there is a U-shaped relationship between early-stage entrepreneurial activity and economic development. To make sure that there is no misspecification of the functional form, other forms are tested by including variables with a higher power. None of these coefficients are significant at a significance level of 5%. So, testing for a U-shaped relation is justified. To test this relationship fixed effects models are used. However, an alternative method to estimate a causal relationship is random effects. The advantage of a random effects model is that time invariant variables can be estimated, which is impossible in a fixed effects model. It also accounts for serial correlation in the error term and is able to combine within and between variation which leads to a more accurate estimation of the coefficients. However, for these estimates to be unbiased the correlation between the explanatory variable and the error term has to be zero. This is often not the case. To test whether a fixed effects or random effects model is appropriate the Hausman test is performed. This is done for all models used to answer hypothesis 1, 2, and 3. In all tests the null hypothesis that there are no systematic differences between the random effects coefficients and fixed effects coefficients are rejected. This means that a fixed effects model is more appropriate to use. To account for possible multicollinearity between primary and upper secondary educational attainment all regressions are also run without the primary education variable included. This does not change the sign or significance of any of the other variables included in the model. For this reason, primary education remains in the models as control variable. Besides the digitalization variable, the effect of of digitalization is also examined using technological readiness as regressor. The results are depicted in Table A.2 in the Appendix and they show slightly different results. It appears that income and educational attainment do not to have a significant influence on the relationship between technological readiness and early-stage entrepreneurial activity. However, since technological readiness does not incorporate all factors related to digitalization, it cannot be considered an accurate measurement.

Discussion & conclusion

In this paper, the relationship of digitalization and entrepreneurship is analyzed. First, the relation between entrepreneurial activity and economic development is further investigated. Previous studies have argued that there is U-shaped relationship between entrepreneurship and the stages of economic development where entrepreneurship is high during the factor-driven stage, decreases in the efficiency-driven stage, and rises again in the innovation-driven stage. To determine if such a U-shaped relationship indeed exists, three conditions have to be met: the estimated β_2 has to be positive and statistically significant, the slope of the function must be sufficiently steep at both ends of the data range, and the turning point needs to be within the data range. This is tested using a fixed effects model. The results show that β_2 is negative and statistically significant, but extremely close to zero. When the slope of the function is measured at the minimum and maximum of the data range it is not sufficiently steep. Also, because the measured value at the high end of the data range is negative and the value at the low end is positive which is not in accordance with a U-shaped relationship, the second condition is not met. The third requirement that the turning point lies well within the data range is met. However, since the first two conditions are not satisfied, it cannot be conclude that there is a U-shaped relationship between entrepreneurship and economic development.

The second hypothesis that is tested states that digitalization positively affects the level of entrepreneurship in developing countries. This is tested with country fixed effects models that include year dummy variables and one year lagged independent variables. The results show that overall, there is a positive association between digitalization and TEA. However, there are two factors that influence the relationship between digitalization and entrepreneurship. The outcomes of the regressions indicate that the effect of digitalization on entrepreneurial activity in middle-income countries is significantly lower than in low-income countries. This can be explained by the fact that most middle-income countries are in the efficiency-driven stage of economic development. In this stage, production is more capital intensive and becoming as a wage worker is more attractive than being self-employed because of the

higher return to employees relative to entrepreneurs. When this effect outweighs the positive effect that digitalization has on early-stage entrepreneurial activity the rate of entrepreneurship will decrease. Another aspect that influences the effects of digitalization is educational attainment. The findings demonstrate that digitalization has a negative effect on early-stage entrepreneurial activity when upper secondary education is low. However, as the rate of upper secondary educational attainment increases, the effect of digitalization on entrepreneurship becomes less negative and eventually even positive. A possible explanation is that the adoption of digital technologies creates economic opportunities which can only be seized by people with the proper knowledge and skills. People that do not finish upper secondary education most likely do not possess the abilities to gain these skills. So, depending on the country's stage of economic development and the education level of the population, digitalization may increase the early-stage entrepreneurial activity in developing countries.

In the third hypothesis it is expected that digitalization has a positive effect on the level of opportunity-driven entrepreneurship, while it does not affect the number of necessity-driven entrepreneurs. This hypothesis is not supported by the results of the regressions models. The findings show that digitalization positively affects both opportunity-driven and necessity-driven entrepreneurship. However, necessity-driven entrepreneurship is only stimulated by digitalization when the rate of upper secondary educational attainment is sufficiently high. A reason for this is that people that complete secondary education have the knowledge and skill to start their own business and provide a useful product or service to customers, while people without education do not. Another possibility is that people who do not finish secondary education end up in unreported employment which is not included in GEM's necessity-driven TEA variable.

So, to efficiently stimulate entrepreneurship in developing countries, the adoption of digital technologies has to be promoted by the government and policymakers. However, to take advantage of the economic opportunities created by digitalization people need to have a certain skills and cognitive abilities. For people to learn these abilities it is important that they reach a certain level of education. Therefore,

education attainment has to be promoted first, before digitalization can be used to stimulate entrepreneurship in developing countries.

There are several limitations to this study. A serious limitation of this study is the relatively small number of observations used to estimate the models. This is due to the limited data available for developing countries. When a dataset with more observations is used, it is also possible to apply models that include two- or three-year lagged variables. This can create a better understanding of how education affects the relationship between digitalization and entrepreneurship since it takes several years before children finish school and are old enough to start their own business. Another limitation is that GDP per capita is used as measurement of economic development. However, GDP per capita measures only the monetary aspect of economic development while other aspects such as education, health, and leisure that influence economic development are not taken into account. Using a variable that captures all these factors may provide evidence that there is a U-shaped relationship between the level of entrepreneurial activity and economic development.

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Appendix

Table A.1: List of countries categorized by stage of economic development

Factor-driven	Transition from factor- to efficiency-driven	Efficiency-driven	Transition from efficiency- to innovation-driven	Innovation-driven
Bangladesh	Algeria	Belize	Argentina	Australia
Burkina Faso	Angola	Bulgaria	Barbados	Austria
Cameroon	Botswana	China	Bolivia	Belgium
Ethiopia	Iran	Colombia	Bosnia and Herzegovina	Canada
Ghana	Kazakhstan	Dominican Republic	Brazil	Cyprus
India	Libya	Ecuador	Chile	Czech Republic
Madagascar	Philippines	Egypt	Costa Rica	Denmark
Malawi	Saudi Arabia	El Salvador	Croatia	Estonia
Nigeria	Syria	Georgia	Hungary	Finland
Pakistan	Venezuela	Guatemala	Latvia	France
Palestine	Vietnam	Indonesia	Lebanon	Germany
Senegal		Jamaica	Lithuania	Greece
Uganda		Jordan	Malaysia	Hong Kong
Zambia		Jordan	Mexico	Iceland
		Montenegro	Panama	Ireland
		Morocco	Poland	Israel
		Namibia	Romania	Italy
		North Macedonia	Russia	Japan
		Peru	Suriname	Luxembourg
		Serbia	Turkey	Netherlands
		South Africa	Uruguay	New Zealand
		Thailand		Norway
		Tunisia		Portugal
				Puerto Rico
				Qatar
				Singapore
				Slovakia
				Slovenia
				South Korea
				Spain
				Sweden
				Switzerland
				Trinidad and Tobago
				United Arab Emirates
				United Kingdom
				United States

Table A.2: Results of fixed effects models with lagged independent variables estimating the relationship between technological readiness and entrepreneurship

	DV = ln(TEA)			
Variables	(1)	(2)	(3)	(4)
$\ln(\text{Tech. readiness})_{t-1}$	0.379***	0.373	-0.866	-0.808
	(0.113)	(0.136)	(0.919)	(0.992)
$\ln(\text{Tech. readiness})_{t-1} \times \text{Middle income}_{t-1}$		-0.352		-0.400
		(0.270)		(0.273)
$\ln(\text{Tech. readiness})_{t-1} \times \text{High income}_{t-1}$		0.185		0.037
		(0.248)		(0.276)
$\ln(\text{Tech. readiness})_{t-1} \times \ln(\text{Upper secondary})_{t-1}$			0.321	0.316
			(0.235)	(0.263)
Income_{t-1} (base category: low income)				
Middle income	0.087	-0.118	0.097	-0.144
	(0.066)	(0.179)	(0.066)	(0.180)
High income	0.084	0.055	0.085	-0.012
	(0.113)	(0.174)	(0.113)	(0.182)
$\ln(\text{Upper secondary})_{t-1}$	0.182	0.262	0.393	0.455
	(0.292)	(0.296)	(0.330)	(0.336)
$\ln(\text{Primary})_{t-1}$	-0.171	-0.233	0.016	-0.057
	(0.664)	(0.665)	(0.678)	(0.681)
$\ln(\text{Female labor participation})_{t-1}$	0.959*	0.990*	0.902*	0.997*
	(0.522)	(0.536)	(0.523)	(0.535)
$\ln(\text{Population density})_{t-1}$	1.487***	1.316***	1.382***	1.256***
	(0.440)	(0.452)	(0.446)	(0.454)
$\ln(\text{Unemployment})_{t-1}$	0.029	0.028	0.021	0.026
	(0.076)	(0.076)	(0.076)	(0.076)
$\ln(\text{GINI coefficient})_{t-1}$	-0.089	-0.105	-0.094	-0.099
	(0.441)	(0.440)	(0.440)	(0.440)
$\text{Real interest rate}_{t-1}$	-0.000	0.001	0.001	0.002
	(0.004)	(0.004)	(0.004)	(0.004)
Constant	-7.658*	-6.989*	-8.638**	-8.301*
	(4.122)	(4.161)	(4.178)	(4.299)
Observations	810	810	810	810
Time fixed effects	YES	YES	YES	YES
Adjusted R^2	0.198	0.205	0.202	0.208
AIC	64.28	64.93	64.13	65.25

*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$. Robust standard error in parentheses.