List of appended papers

This thesis is based on work presented in the following articles.

Paper I

Dastory, L., Schäfer, D., & Stephan, A. (2025). Funding gap for innovation and firm size: an inverted u-shape relationship. Submitted to, *Small Business Economics.*

Paper II

Dastory, L., Schäfer, D. & Stephan, A. (2025). Has the Funding Mix of German Firms Changed After Stricter Bank Regulation? Submitted to, *Industry and Innovation.*

Paper III

Dastory, L., Baum, C., Lööf, H &, Stephan., A. (2025). STEM Entrepreneurs. Submitted to, *Journal of Technology Transfer.*

Paper IV

Dastory, L. (2025). Technological change, job tasks and wages. Submitted to, *Journal of Economic Behavior& Organization.*

Abstract

This doctoral thesis consists of four papers. The two first papers are related to financial economics and the other two to labour economics. All four papers deal with microeconomics analysis of individuals and firms. Where the first two are from a firm's perspective and the two are from an individuals perspective. Moreover, all four papers underline the importance of innovation for productivity, competitiveness and economic growth.

In the first essay we use German Community Innovation Survey to identify financially constrained firms. Contrary to previous studies we find that the relationship between financial constraints and firm size is inverted u-shaped and that it is the group of medium sized firms which has the largest funding gaps. This is explained by the fact that these firms have high innovation capabilities but at the same time face high cost of capital. Furthermore, we test if financial constraints have an impact on firm productivity growth. We find negative effects from funding gaps on productivity, but only for investment in tangible capital and not for innovation investments.

The second essay investigates whether there has been a change in the productivity and funding mix of innovative Small and Medium-sized Enterprises (SMEs) post stricter bank regulations. Our result shows that the likelihood of using bank loans as a funding source has not changed for innovation investments nor for tangible investments after stricter capital regulations have been announced. On the other hand, sources such as subsidies have increased due to regulatory programs that have been implemented in the aftermath of the recent financial crisis. Furthermore, SMEs productivity has not changed post stricter bank regulations. Overall, the impact from different sources of funding on productivity is rather limited.

The third essay explores firm formation by migrants with a STEM background. The result shows that native born STEM workers have a higher probability to form firms relative to migrants. Further categorization of migrants shows that refugees are more likely to become entrepreneurs than EU-labour migrants. Overall, entrepreneurial migrants have equal or higher predicted income in comparison to native born STEM entrepreneurs.

The fourth essay analysis wage effects from changing work tasks using a tasked-based approach where workers are mapped in a two dimensional model classified by their cognitive and routine task content. The result shows clear signs of wage polarization. A switch from routine and manual tasks to non routine cognitive task yields an average wage premium of about 2-6%. More importantly, while the gap was 1-5% in the beginning of the period, it increased to 10-13% at the end of the period. The result suggest that adapting new production technology and innovations to complement analytical skills has a higher and increasing marginal productivity compared to technologies aimed to replace or complement routinized and manual work tasks. The period of this study is associated with several so-called breakthrough technologies such as, computerization, robotization, digitalization and the introduction of IT technology.

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Stockholm, June 2025 Linda Dastory

Introduction

The purpose of the study

Economic growth is one of the most important subareas of economics. Its fundamental relevance stems from the fact that economic growth leads to nation and individual prosperity. Many of the foundations of modern economics were laid by Adam Smith, thus, during this period of time the difference between rich and poor countries were likely rather small. This gap has ever since grown rapidly to levels that were probably unimaginable for economists during the 18th and 19th century (Maddison 2007, Acemoglu et al. 2002). Essentially, this disparity between nations stems from different growth levels which in turn has led to large income gap per capita and living standards across the world (Acemoglu 2012). Thus, as economic growth has the ability to increase prosperity gaps, it also has the power to close such disparities. Great examples are demonstrated by countries such as Japan, South Korea and Singapore. One may study economic growth from a variety of different aspects as economic growth and potential obstacles of economic growth are affected by a variety of different factors. One key subarea of economic growth is innovation and technological development. It is well known that technological development and innovation activity is an essential determination factor for productivity, competitiveness and economic growth. Thus, any factor that may hinder technological change and innovation may also mitigate economic growth (OECD 2024). The main purpose of the research in this thesis is to better understand how the complex processes of financing, technological change, innovation and entrepreneurship contributes to economic growth. In this respect, my work belongs to the research tradition that tries to capture, describe and analyze economic development through the lens that captures society from a micro-economic perspec-

tive. The starting point for my studies is actual companies and individuals.

The two first papers of my dissertation are devoted to deepen the understanding of how the technological progress through innovation in small and medium firm is financed. The first of the two papers relates innovation capability to firm size and financial sources. The role of young firms' innovation capacities has been emphasized since their innovations generate structural changes in the economy. Thus, it should be a policy-level concern that restricted access to funding for innovation investments may hinder economic growth and job creation (European Investment Bank 2023). The main purpose of the first paper is to identify which firms have restricted access to funding and whether restricted access to funding affects a firms productivity. A deeper understanding of which firms that have restricted access to funding enables policy-makers to take more effective measures. The second paper considers whether stricter banking regulations affects the funding mix of financial sources for innovations. Many scholars consider regulatory failure to be responsible for the recent financial crisis (Acharya et al. 2012). Accordingly, in the aftermath of the financial crisis, the demand for firmer and stricter capital regulations rose sharply. In December 2010, the Basel Committee on Banking Supervision introduced new regulations, generally referred to as Basel III. Basically, Basel III tightens the definition of bank capital, defines higher liquidity requirements and increases minimum capital ratios (Cosimano & Hakura 2011). While the benefits of higher capital requirements are rather clear in terms of leverage and lowering the risk of bank defaults, there is less consensus regarding its disadvantages. One major concern is that higher capital requirements will decrease the supply of capital which in turn will increase the overall cost of capital, resulting in higher lending rates, aggravating financial restrictions and thereby mitigating overall economic activity (Baker & Wurgler 2015). As the purpose of the second

paper is to study the funding mix of firms chosen financial sources before and after stricter bank regulation, it is a backward induction indicator to study whether the supply of bank credit has been affected post stricter bank regulation. By studying the funding mix of firms pre-and post Basel III allows regulators and policy-makers to evaluate the outcome the regulation and to adjust and tailor eventual loopholes as well as take action against unwanted consequences.

My third paper relates to the two former by deepening the understanding of the link between technical progress and entrepreneurship by considering new firm formation by STEM-entrepreneurs [1]. In this study, I classify the STEM entrepreneurs into different categories depending on their geographical origin, gender and in the case of immigrants, also reason for settlement. STEM-entrepreneurs are considered to be one of the key drivers of economic growth in developed countries, as they contribute to job creation, technological innovation and productivity growth (Lofstrom et al. 2014, Green et al. 2016). Meanwhile, many OECD countries are facing a shortage of skilled workers in science and engineering. Thus, there is growing literature considering whether skilled migrants can mitigate this issue (Peri & Sparber 2009). From a policy perspective, this issue is particularly current/ up to date as most European Union countries are facing large immigration waves. Increased understanding of the importance of migrant entrepreneurs in the STEM sectors of the economy allows for better and more efficient integration policy.

My final paper analyses the importance of technological change for the continuous change of work tasks and the consequences on wages. Since the industrial revolution, the effect of technological change on the labour market has been prominent among economists. Since the late 1980's most OECD

[1]Defined as as university education in physics, chemistry, mathematics, statistics, biology, engineering or IT or a professional background as a technician or IT operator.

countries have experienced job polarization where occupations both at the bottom and top of the wage distribution have increased in comparison to the middle of the wage distribution. Thus, Sweden has not been an exception (Cortes 2016, Acemoglu & Autor 2011, Autor & Handel 2013, Goos et al. 2009, Adermon & Gustavsson 2015). Generally, this phenomena has been explained with the hypotheses known as task biased technical change (TBTC). In a nutshell TBTC states that technology acts more or less as a complement for certain tasks usually found at the top of the wage distribution and as a substitute for task usually found at in the middle of the wage distribution. Job polarization has been accompanied with wage polarization in most countries. However, as Sweden has experienced job polarization there is no research regarding wage polarization. Thus, the main purpose of the last paper is to study the effect of technological change on the wage of different task groups. Naturally, occupations differ in regards to wage, task and career opportunities. High productive, high wage jobs have a more positive effect on economic growth in comparison to low productive, low wage jobs. Technology affects labour market structure and wages. It is therefore important to understand future labour market changes that follow technical development.

The thesis is an empirical contribution to the literature and the theoretical foundations are derived from several strand of the research including both finance, entrepreneurship and the economics of innovation. The following section underpins the the theoretical framework used in this thesis.

Literature Review

A firm has essentially two available sources for investment expenditures: internal funding and external funding. In its core essence internal funding originates from retained earnings while external funding consists of various debt contracts such as bank loans, or external equity such as secondary share is-

sues. Contrary to the Modigliani-Miller theorem, capital structure matters in imperfect capital markets with presence of information asymmetry. When supplier of credit have less information regarding the quality of a certain investment, they are forced to charge a risk premium reflecting the average risk of an investment project. This creates a wedge between the cost of internal and external capital. Thus, investors are faced with a hierarchy of funding sources where funds with lower cost will be used first. Hence, internal funding will be preferred over debt and debt over equity. Generally this is referred to as the pecking order theory. Given that internal funding is finite, firms usually need to seek external funding. However, due to market imperfections firms with potentially profitable investment opportunities may not be able to acquire it. Thus, a firm is considered being financially constrained if investment is restricted by its access to internal funding and its inability to acquire sufficient external funding. Financial constraint are in particularly relevant for young and small innovative firms. The availability of external funding has been acknowledged as a significant determination factor for hampering the growth of small and medium sized firms (Jarvis 2000, Mina et al. 2013, Ferrando & Pál 2024). Moreover, small firms are associated with higher operational risk and consequently with a greater likelihood of bankruptcy. In addition the younger and smaller the firm, the shorter is their track record and the less collateral is available. This creates obstacles for debt funding (Hall & Lerner 2010, Berger & Udell 1998, 2002, Guariglia 2008).

Furthermore, it has long been acknowledged that innovation activity is an essential determination factor for productivity, competitiveness and economic growth. The role of young firms' innovation capacity has been emphasized since their innovations generate structural change in the economy (Mina et al. 2013). Thus, it is of policy concern that restricted access to funding for innovation investments may hinder economic growth and job creation.

Innovation investments differ from tangible investment expenditures due to its intangible nature of the asset being created as well as due to a high degree of uncertainty (Demmou et al. 2021). Accordingly, similarly to the case of small medium-sized enterprises (SMEs), there is a lack of collateral that may be used as security for debt funding (Crouzet & Eberly 2023). These features of innovation investments make raising external funding for innovation projects more expensive in comparison to tangible investments (Hall 2010). Empirical literature confirms that firms tend to use internal funds over external funds when financing innovation projects (Hall 1989, 1992, Himmelberg & Petersen 1994, Bougheas et al. 2003, Czarnitzki & Hottenrott 2011). Overall the theoretical and empirical literature suggest that financial constraints depend not only on information asymmetries and moral hazard problems but also on other firm characteristics (Petersen & Rajan 1995, Czarnitzki 2006, Czarnitzki & Hottenrott 2009, Brown et al. 2012) such as, borrower-lender relationship (Martinelli 1997, Berger & Udell 2002) and other institutional factors (Hall 1992, Bloch 2005, Bhagat & Welch 1995).

A neglected factor in the empirical literature is the concept of innovation capability. It is hypothesized that innovation capability has an impact on financial constraints for innovation investment. This implies that a firm's capacity to generate and achieve new innovation projects, is an important determinant of financial constraints.

An additional concern that may affect the availability of external funding for innovative SMEs is the increased demand for stricter bank capital regulation. There is a view among scholars that the crisis was primarily a regulatory failure (Acharya et al. 2012). The Basel Committee on Banking Supervision has introduced a new round of regulations, generally referred to as Basel III, which seeks to seal the loophole that was exposed during the financial crisis. The Basel accord or the Basel standard is an international

regulatory framework, which applies to its member countries internationally active banks. In its core essence, Basel III increases minimum capital ratios, tightens the definition of bank capital and requires tighter liquidity requirements (Cosimano & Hakura 2011). While the benefits of higher capital requirements are rather clear in terms of lower leverage and thereby lower risk of bank defaults, there is less consensus regarding its disadvantages. One major concern is that higher capital requirements will increase the overall cost of capital and thereby increase lending rates[2] and mitigate economic activity[3] (Baker & Wurgler 2015). Theoretically higher lending rates should have a greater impact on innovative SMEs.

Moreover, the relationship between technological change and wage distribution has long been a topic of interest among economists. Scholars have generally associated technological progress to an increase in demand for skilled labour in comparison to low-skilled labour. This has been referred to as skilled bias technical change (SBTC). The shift in labour demand is caused by increased productivity which in turn pushes returns to skills above it's long run equilibrium level. Thus, there is an increase in skilled labour supply. An increase in both supply and demand for skilled labour is then expected to yield a monotonic growth in the relative amount of skilled labour. Thus, according to SBTC there is a positive relationship between employment level and wage level as wage levels should reflect higher human capital.

However, during the past decades, the labour market in most OECD countries have experienced an increasing job polarization [4]that is, an increase in employment both at the top and bottom of the wage distribution relative to employment share for occupations in the middle of the wage distribution.

[2]see Admati et al. (2013) for a detailed discussion regarding increased capital requirement and capital cost.

[3]see e.g Cummins et al. (1994), Philippon (2009), Gilchrist et al. (2013) for further discussion and evidence on how the cost of capital effects real investments.

[4]See for e.g Goos et al. (2009), David et al. (2006), Fernández-Macías (2012)

Although each country may have several specific explanations for job polarization there is a similar international pattern that indicates some common over all factors. Pioneer studies by Autor et al. (2003, 2006) and Goos & Manning (2007) has linked this phenomena to the task content of different occupations. This hypothesis is referred to as task-bias technical change (TBTC). Since the 1980s technological changes has resulted in continuous decreasing prices of computers (and other technologies) which in turn has resulted in a rapid increase of computerization and digitization of the labor market.

The task content of occupations in middle of the wage distribution tend to be routinized (for example manufacturing jobs and routine office jobs) and are therefore easy to substitute with technology. Thus, one may expect a decrease in such occupations. For occupations at the top the wage distribution (such as doctors, engineers and economists) technology is considered to be a complement. The content of these occupations cannot be replaced with technology. On the contrary technology is considered to increase the productivity of these occupations hence, it is profitable to create such jobs. Occupations at the bottom of the wage distribution (often service occupations) cannot (yet) be replaced by technology nor can technology (yet) increase the productivity of the task content considerably. Hence, occupations at the top and bottom of the wage distribution is expected to increase relative to the middle of the wage distribution. An important question that raises from job polarization is whether job polarization leads to wage polarization?

The Swedish wage structure over the past 40 years is a well studied area. A Comprehensive wage compression took place from the late 1960s to the end of 1970s with reduced wages for different educational groups, occupation, gender etc. During the 1980s the wage gaps started to increase continuously until the beginning of the 21 century. There have been relatively little changes in the wage gaps during the 21 century.

Given clear job polarization of the Swedish labour market one may expect that wages would follow the same pattern. However, it is only the relative wages of the upper half of the wage distribution that has increased during 1990s. Thus, job polarization does not necessarily follow wage polarization. Given task bias technical change there are mainly two factors that will determine relative wage changes. The first factor is whether technology is a complement or a substitute to the task content of an occupation and the second factor is the development of the labour supply.

As mentioned above technology is a complement for the task content of occupations at the top of the distribution. This fact increases this occupational groups productivity and thereby increases relative wages. Increased relative wages will in turn increase the supply of labour for this occupational group. The increased supply of labour will neutralize the increase in wages. In reality increased supply of labour will in the short run not have an affect on relative wages due to task bias technical change as this occupational groups usually requires some sort of an higher education which usually takes a couple of years to complete. In the long run relative wages will depend on whether it is the supply of labour that increases fastest or the demand for labour in this occupational group. If technical change accelerates then the demand for labour will be larger than the supply of labour hence, relative wages will increase for the this occupational group. This is referred to as the race between technological change and education (Goldin & Katz 2009, Card & DiNardo 2002).

For occupations at the bottom of the wage distribution, technology is neither a complement nor a substitute, thus wages are not directly affected by technical progress. However, the wages of this occupational group may indirectly be affected by technical progress. As the wages of the individuals at the top the wage distribution increases the demand for services may in-

crease. Increased labour demand for this occupational group may also be affected by other factors such as the taxing system. For example, in 2007 the Swedish government introduced tax deduction for household services such as cleaning, maintaining and laundry. Another example is the decrease in value added sales tax for restaurant and catering services that was introduced in 2012, which lead to an increase in employment within the restaurant industry. [5] Thus, labour supply can increase at the same rate as labour demand in this occupational group since generally service tasks do not require any higher education, hence wages are expected to be neutralized. But what happens to the relative wages of the occupations in the middle of the wage distribution that is, the routine jobs? Intuitively, one may expect that the decrease in labour demand due to technical progress would lead to a decrease in relative wages in comparison to relative wages for the occupations at the bottom of the wage distribution (service jobs). What happens to the relative wages of the routine jobs will depend on labour supply. If labour demand decreases for routine jobs and labour supply for service jobs remains constant, then our intuitive expectation would be correct, that is one may expect technical progress would lead to a decrease in relative wages for routine jobs in comparison to relative wages in services jobs. However, if labour supply increases for service occupations then theoretically relative wages for these two occupational groups could be constant. On the other hand, we may also observe the opposite. That is, that the relative average wage for routine jobs increases in comparison to service jobs despite the fact that relative wages has been constant for all individuals whom have not switched occupation. Ceteris paribus, this is because individuals with low productivity and thereby lowest wages have left the routine labour force which makes it seem like there has been an increase in relative average wages for the routine jobs.

[5] See Dillen (2015) for a detailed discussion regarding value added sales tax for restaurant and catering services

However, in reality relative wages for individuals whom have routine jobs has not changed at all [6].

Technical progress is of great importance for sustained productivity and economic growth. New innovation and services that the high-tech sector produces distinguishes an economies output from other nations and allows for capital accumulation, increased wages and productivity growth. A high level of entrepreneurship generates a strong high-tech sector. High-tech entrepreneurs are willing to take risks that the already existing high-tech enterprises will not and are capable to identifying opportunities they fail to recognize (Jorgenson et al. 2005). In turn, high-tech entrepreneurs linked to the STEM[7] profession are assumed to have a key role in the creation and adoption of scientific and technological innovation (Peri & Sparber 2009). Meanwhile, many OECD countries are experiencing a shortage of STEM (scientists and engineers) labour within high-tech fields. Thus, skilled international migrants may be able to mitigate such labour shortage faced by most developed economies.

Immigrants are considered to be highly entrepreneurial. In many developed economies migrants are over represented in business ownership in comparison to native-born (Borjas 1986, Lofstrom 2004, Clark & Drinkwater 2000, Schneider & Veugelers 2008, Fairlie & Woodruff 2010).

A vast number of studies have tried to identify the reason for the over representation of migrant entrepreneurship compared to native born. Cultural differences tied to the entrepreneurs country of origin, willingness to take risks and past work experience has been emphasized as well as joint selection benefits for entrepreneurs from the same country (Akee et al. 2013, Kerr et al. 2015). However, one of the leading hypothesis is that immigrants

[6] See Acemoglu & Autor (2011) for a detailed discussion

[7] STEM workers are defined as university education in physics and chemistry, mathematics and statistics, biology, engineering and IT, or a professional background as a technician or IT operator.

are pushed towards entrepreneurship due to discrimination on the labour market and mismatch of qualifications (Borjas 1986, Kerr & Kerr 2018).

Furthermore, the majority of the current literature studies migrant scientists and engineers as employees. The literature linking skilled migrants to entrepreneurship is rather scarce thus, the small fraction that exist has merely a focus on the U.S high-tech sector.

Recent research shows that immigrant entrepreneurs have clear motivations for starting a firm in comparison to native born. Moreover, the probability of conducting R&D and innovation is higher among immigrants and there is a higher likelihood for an immigrant-owned firm to file for patent in comparison to native-owned firms (Brown et al. 2018, 2019).

In order to understand the role of immigrants in high-tech entrepreneurship an important first step is to explore and explain firm formation by migrants.

The research approach

The prime objective of my study is to capture, measure and better understand the economic processes that leads to increased productivity and higher wages. A main challenge is to find representative data to apply on appropriate empirical methodologies, and to build the research on relevant theoretical frameworks.

The aim of the first paper is to better identify financially constrained firms as a function of innovation capability and firm size and to test whether financial constraints have an impact on firms' productivity. Measuring financial constraints in R&D investment has been an empirical challenge for researchers as most empirical studies have limited access to data. Thus, scholars have provided ambiguous results regarding R&D investments and finan-

cial constraints [8]. Traditionally, investment models have used investment sensitivity to cash-flow where such sensitivity has been considered to indirectly reflect a firms lack of access to the credit market [9]. Such investment models suffers from problems of not being able to distinguish demand shocks from cash-flow shocks. Moreover, the fundamental concept of whether cash-flow sensitivity is a adequate measure of financial constraint has been addressed by many scholars (see (Kaplan & Zingales 1997, 2000, Cleary 1999, Fazzari et al. 2000, Alti 2003, Moyen 2004) were (among others) it has been argued that dividend and accounting policies which mainly have an aim to mitigate moral hazard problems may determine free cash flow levels (Dhanani 2005, D'souza & Saxena 1999, Yoon & Starks 1995, Lie 2000). Furthermore, R&D spending tends to be smoothed over time which makes it difficult to measure the effect of cash flow fluctuations in one period on investments in the next period. Thus, more recent studies have tried a different approach were they focus on firms access to external funding through studying credit requests. However, such approach suffers from selection bias as firms whom don't expect to receive funding don't apply for it. [10]

The recent increase and availability for comprehensive innovation survey data has allowed researchers to apply more direct measures of identification of financially constrained firms. If a firm responds that innovation projects was not implemented or hampered due to lack of funding it is regarded as an indication of financial constraints. Hajivassiliou & Savignac (2008) and Hottenrott & Peters (2012) apply such direct survey-based methodology where they also account for simultaneous financial decisions.

Thus, the empirical approach in the first paper is designed to manage the above mentioned methodological problems when measuring financial con-

[8] see Hall (2002, 2008, 2010) for excellent literature review.

[9] See for example Fazzari et al. (1988), Schiantarelli (1996), Bond & Van Reenen (2007), Bloom et al. (2007) for literature review

[10] see for example Czarnitzki & Hottenrott (2011), Czarnitzki (2006), Piga & Atzeni (2007)

straints. In the first two papers I use German data from the Mannheim innovation panel data provided by the Centre for European Economic Research (ZEW). The database is a survey base containing important information regarding new products, improved products, services and expenditures for innovation. Such rich survey data allows for direct measure of financial constraints.

However, one major issue with the use of survey data is the concern of the respondents to questionnaires may provide biased answers if they expect the results to have policy relevance. For example, the owners of firms may overemphasize the relevance of the financial constraints they face in the hopes of inducing the government to implement measures aimed at increasing the availability of financing. Although one cannot eliminate this problem completely when using survey data it is possible to approximate the veracity of the respondents answers. In order to mitigate problem of bias answers, an additional survey question is used in which each firm is asked if their firm did not implement innovation projects due to lack of financial resources. I find a positive correlation between financial constraints and no implementation. Thus, there is correspondence between the hypothetical question and real decisions. According to Hall (2010) the ideal way of identifying financial constraints on investment is to actually give a firm additional cash exogenously, and observe what the cash is used for. However, the lack of true experiments and resources of this kind leaves researchers with the next best option namely offering hypothetical funding through survey data. Thus, the financial constraint variable is an ordinal categorical variable derived from two survey questions, I therefore use an ordinal probit model to estimate financial constraints. As mentioned in the theoretical framework innovation capacity is one of the determination factors for financial constraint. Naturally, one may argue that there may be a reversed causality or even a two

way causality. However, this is not very likely in this setup. As we are using survey data where past variables are used to capture innovation capability, financial constraints is measured using the ideal test which is the firms current response. Thus, if it is assumed that innovation capability is predetermined, it is exogenous to financial constraint.

Furthermore, firms decision on their level of investment accrues simultaneously as other expenditures are determined such as, dividends payment, debt payment or capital investments. That is investment in innovation and R&D is in competition with other uses of funds. I take this into account by using Roodman's conditional mixed process (CMP) when estimating financial constraints by using Roodman's conditional mixed process (CMP). The CMP model has several advantages. First, it is a seemingly unrelated regression (SUR) estimator, which allows several equations to be estimated simultaneously using a system approach in which the error terms are allowed to be correlated. Taking such correlation into account mitigates the omitted variable bias. Furthermore, it is a flexible model for which the dependent variable may be binary, censored, interval, or continuous, and it also allows each equation to vary by observations. Moreover, in order to estimate the effect of financial constraint on firms productivity I estimate a firms total productivity as a function of financial constraints, firm size and controls. The variable financial constraint is lagged one period which allows us to make the assumption that financial constraint is predetermined and not affected by current productivity.

Essentially, productivity is defined as the ratio between output and input. Generally, there is two ways to estimate productivity, single factor productivity (SFP) and total factor productivity (TFP). The definition of SPF is the ratio between volume of output (measured as value added) to the factor of production that is being measured such as labour or capital. However, when

the proportion of factors is in production is changed SFP yield a bias estimate of the contribution made by the factor measured. For example if capital to labour ratio increases labour productivity may be overestimated and capital productivity underestimated. A shift in production technology can lead to an increase in labour productivity and a decrease in capital productivity. Thus, the increase of labour productivity is not a reflection of substitution of one factor by another factor. Since SPF is affected by the composition of changes in inputs SPF does not measure changes capacity of productivity Majumder (2004). Total factor productivity tries to evade problems that arise when estimating SFP. Total factor productivity measures an increase in total output that is not caused by an increase in total input. TFP is defined as the ratio of total output (generally measured as value added) to a weighted sum of production inputs. How to estimate total factor productivity has been a key issue in applied economics Kathuria et al. (2012). The fundamental issue stems from the fact that there is a positive correlation between unobserved productivity shocks and observed input levels. When a firm is subject to a productivity shock it tends to respond with an increase in output by increasing input. Thus, a negative shocks has the opposite effect. Various methods has been proposed to handle this issue. They may be categorized into three categories, fixed effect (FE) model, instrumental variables (IV) and control functions. To the latter category belongs Olley & Pakes (1992) proposal of using investment levels as a proxy for productivity estimated using a two-step procedure designed to manage the endogeneity problem. Olley & Pakes (1992) approach was further developed by Levinsohn & Petrin (2003) and Ackerberg et al. (2015). However, all three approaches suffer from identification problems. Olley & Pakes (1992) and Levinsohn & Petrin (2003) both assume that firms have the ability to adjust inputs immediately at no cost. Ackerberg et al. (2015) approach works only if the free variables in the in the model demon-

strate variability independently of the proxy variable. If this condition is not fulfilled the coefficients of the model would be perfectly collinear in the first step of the estimation and thereby not identifiable. To overcome these problems Wooldridge (2009)[11] proposes a method where the two-step estimation process is replaced with generalized method of moments (GMM). Using the GMM-method the two equations have the same dependent variable but with different set of instruments. Wooldridge (2009) approach overcomes potential identification issues. Moreover, it yields robust standard errors accounting for serial correlation and heteroskedasticity. Thus, in order to estimate the effect of financial constraint on firms productivity I estimate a firms total productivity using the the Wooldridge (2009) approach.

In the second paper I once again use the Mannheim innovation panel data to analyze how the mix of funding sources has changed after the introduction of Basel III. Once again the problem of using survey data arises. For the second paper I use survey questions that ask about a firms past behaviour. Questions regarding a firms past behaviour mitigates the issue of providing bias answers however, it does not eliminate the fact that a firm can provide untrue answers. I employ Roodman's (2011) conditional mixed process (CMP) to estimate the probability of a firm using bank loan as a funding source pre and post Basel III. In this context, the modelling of financing choices allowing for correlations between equations reflects the fact that there might be unobserved determinants of funding decisions that are captured in the model.

In the two remaining papers I use universal register information on all actual firms in Sweden and all individuals on the labour market, both employers and employees. The richest data sources is the Swedish data provided by Statistics Sweden. Today, Sweden has among the extensive data information in the world for analyzing micro-foundation for technical change, innovation,

[11] See Wooldridge (2009) for a detailed discussion

entrepreneurship, productivity, wages and growth. The objective of the third paper is to explore and explain firm formation by migrants with a STEM background, defined as university education in physics,chemistry, mathematics, statistics, biology, engineering or IT or a professional background as a technician or IT operator. I use the codes from the SSYK scheme to classify individuals as STEM. Having data in reason for settlement allows for further categorization of STEM individuals, namely. Native-born, Non-EU migrants (labor market/economic migration), EU migrants (labor market/economic migration), and Refugee (forced) migrants. Such categorization of STEM individuals mitigates the issue of self-selection and bias interpretation of the estimation results. Labour-migrants can be considered as a self selected group while refugee-migrants is considered to be a random group of individuals. Despite of STEM-categorization there is the issue of endogeneity that my data set or chosen methodology can account for. For example, STEM-individuals may be pushed towards entrepreneurship because of discrimination or their wages may be affected by discrimination. Furthermore, STEM-income is defined as the ratio of monthly earnings to median monthly wage earnings. Hence, dividend payout is not accounted for as this data was not available at the time. Instead it is assumed that all firms no matter of the founder is profit maximizing and behaves the same way.

The fourth paper examines four classifications of work tasks: non-routine cognitive (NRC), routine cognitive (RC), non-routine manual (NRM), and routine manual (RM). Using a fixed-effects model, the study estimates relative wage changes across these task groups over time while controlling for a comprehensive set of employee and firm characteristics. However, estimating wage distributions in this framework may introduce selection bias. For an individual's wage to be observed in the analysis, the individual must switch task groups. Those who change task groups may possess specific characteris-

tics that are not representative of the broader labor force, potentially skewing results. Despite this self-selection issue, the findings reveal a substantial increase in the wage premium associated with transitioning to NRC tasks from other parts of the labor market over the analyzed period. Even when holding individual characteristics constant, the marginal wage gaps for such shifts grew significantly during the time frame studied.

Over all, my empirical approach is primarily panel data analysis. There are several advantages using panel data, including that it allows the user to account for heterogeneity across the individual units. It also allows the user to deal with time-invariant omitted variables, and panel data are less likely to have problems with auto-correlation and multicollinearity as time series data do (see Baltagi (2008)).

Conclusions

In the first part of this thesis the link between innovation capability, firm size and financial constraints is investigated. The results show that relationship between firm size and financial constraints is inverse U-shaped were medium sized firms [12] are the most constrained firms.

There may be several explanations for this result. As outlined in the theoretical framework the demand for innovation funding depends on a firms' innovation capability that is, a firms capacity to generate and achieve new innovation projects thus, the higher innovation capability, the higher is the demand for innovation funding. Accordingly, medium sized firms may have a higher innovation capability and thereby a higher funding need then their smaller counterparts. At the same time medium sized firms may also face higher marginal cost of capital in comparison to larger firms. Furthermore, there seems to be a larger amount of unpursued tangible investment oppor-

[12] Medium sized firms are defined as firms with 50-249 employees.

tunities which could be an indication that tangible investment projects are facing more financially constraints. However, a possible explanation is that we do not control for the size of the investment project. Thus, tangible investments may on average be large and therefore require a larger amount of debt and hence, affect the probability of receiving debt funding. Finally, our results show that, funding gaps for tangible investments reduce productivity of firms while we do not find this adverse effect on productivity from funding gaps for innovation investments.

These results allows for better and more precise policy suggestions. If one of the driving factors for financial constraints is in fact innovation capability, then innovation capability itself should be used as criteria for policy action. An efficient financial market where innovative SMEs have access to external funding for a reasonable price may be crucial. Lending technologies are an important link between government policies, financial structures and credit availability for SMEs. The financial institutional structure of a country determines the feasibility and profitability of different lending technologies to be developed and used to fund SMEs. Government policy can create conditions and incentives for the creation of lending technologies aimed at benefiting SMEs with high innovation capability such increasing access to modern lending technologies such as mezzanine financing, venture capital and business angels (Berger & Udell 2006). Commercial banks could be encouraged to increase credit supply to innovative SMEs and increase transparency in their lending process through a governmental regulatory framework. In order to mitigate the uncertainty and high risk that is associated with investments in innovation the government can increase loan guarantee and/or equity guarantee programs (Vasilescu 2014). The loan guarantee programs should also include tangible investments as the results show that funding gaps for tangible investments have an adverse effect on productivity. Ultimately deteri-

oration in productivity of firms can mitigate competitiveness and economic growth. Thus, many of the above mentioned suggestions should be applied to medium sized firms with funding gaps for tangible investments.

Furthermore, Hottenrott & Peters (2012) are the first ones to introduce the concept of innovation capability. Thus, this relatively new concept is rather unexplored in the literature of financial constraints. Moreover, to the best of my knowledge, this paper is the first one to relate financial constraint to innovation capability and firm size while also distinguishing tangible investments from intangible investments. It is also the first paper that derives the financial constraint variable from innovation capability and relates it to a firms productivity. This paper makes an original contribution to the literature on financial constraint and innovation.

The second part of this thesis investigates whether there has been a change in the funding mix of firms for tangible and innovation investments post implementation of Basel III. In its core essence Basel III tightens the definition of bank capital, defines higher liquidity requirements and increases minimum capital ratio. While the benefits of higher capital requirements are rather clear in terms of leverage and lowering the risk of bank defaults, there is less consensus regarding its disadvantages. One major concern is that higher capital requirements will decrease the overall supply of capital [13], resulting in higher lending rates aggravating financial restrictions and thereby mitigating overall economic activity. Moreover, German SMEs account for approximately 99.6 % of all German firms and occupy about 59.4% of the labour force[14]. Thus, German SMEs are often referred to as the backbone of German economy. The financial structure of German SMEs differ from their international counterparts as they have a notably low equity ratio [15] making them dependent on

[13] See Admati et al. (2013) for a detailed discussion regarding increased capital requirement and capital cost

[14] *Institut for Mittelstandsforschung* (n.d.)

[15] The overall average equity ratio is 25% for all firms and 20% for SMEs. Their international

debt funding (Nelles & Klusemann 2003, Behr & Guettler 2007). Given relatively high debt ratios, German SMEs have high costs of capital and have been assigned non-investment grade ratings (Schindele & Szczesny 2016). Thus, the second part of this thesis investigates if the funding mix, and in particular the use of bank loans, has changed post stricter bank regulation. The result shows that the likelihood of using bank loan as a funding source has not changed post stricter bank regulation for neither tangible investments nor for innovation investments. However, a change in the funding mix of the firms is observed as the probability of using sources such as equity, mezzanine capital and overdraft has decreased while the probability of using subsidies has significantly increased. Moreover, strong evidence is found that not only is firm size an important determinant of the funding mix but also firm age and firm type,

These result do not indicate that the cost of bank loans has not changed. However, the change in the funding mix can partly be explained by the implementation of various subsidy programs that was implemented by the German government and the European commission. The EU program, Horizon 2020 was implemented in 2014 with nearly 80 billion euros available for SME innovation investments. This was followed by several subsidy programs such as the GRW (Gemeinschaftsaufgabe Verbesserung der regionalen Wirtschaftsstruktur), KMU-innovation (Kleine und mittlere Unternehmen) and ZIM (Zentrales Innovationsprogramm Mittelstand) which was implemented by the German government to stimulate SME funding [16]. url

To the best of my knowledge this paper is the first paper to take a backward induction approach using survey data to study the funding mix and in particular the likelihood of bank loan use due to stricter bank regulation. Although we can not show causality between stricter bank regulation and

counterparts rely on 50% equity ratio

[16] *bundesministerium für bildung und forschung* (n.d.)

changes in the funding mix of firms one can statistically ensure that although the funding mix of firms has changed the likelihood of using bank loans has not changed. We add to post regulatory research by concentrating on firm side and mapping potential changes in SMEs financial funding. Thus, the main results of these two first papers in this thesis yield a better identification of financially constrained firms, which in turn allows for more precise and improved policy suggestions.

The third part of the thesis explores firm formation by migrants with a STEM background. Uniquely, the study distinguishes between: (i) labour migrants and refugee migrants, (ii) individuals migrating within the common European labour market, (iii) migrants high- and low-educated in STEM backgrounds, and (iv) entrepreneurs' genders. Labour migrants can broadly be characterized as self–selected and refugee migrants as randomly selected. Such characterization mitigates the problem of selection bias. The result shows that migrants are less likely to form their own business, but those who are entrepreneurs earn income at least as large as that of their native-born counterparts. From a policy perspective, this study contributes to an increased understanding of the importance of migrant entrepreneurs in STEM sectors of the economy, which are widely held to be a driver of welfare and growth in developed countries. Importantly, we document that refugee entrepreneurs are as productive as other STEM entrepreneurs when we use total earnings as a proxy for their productivity.

There is relatively little research that quantifies the behaviour of highly-skilled migrant entrepreneurs vis-à-vis their native-born counterparts due to lack of comprehensive data or representative large samples. Thus, the third part of this thesis fills this gap and contributes to the literature on migration and entrepreneurship and provides a better grandstand for sharper policy advice.

The fourth part of this thesis aims to gain a deeper understanding of the implications of technical change for the labour market by exploiting data that allows for identifying both skills, work tasks and occupations for the universe of workers in a panel data setting. The result shows clear signs of wage polarization which are in line with previous literature suggest an average wage premium of about 4-8% when switching to non-routine cognitive tasks from other occupational tasks. More importantly, while the gap was 3-5% in the beginning of the period, it increased to 10-17% at the end of the period. The result suggest that adapting new production technology and innovations to complement analytical skills has a higher and increasing marginal productivity compared to technologies aimed to replace or complement routinized and manual work tasks. The main contribution of the task approach is that it relaxes the implicit equivalence between workers education, skills and their jobs task [17]. The implication of this view is that the workers are not paid according to their skills, but for the productivity or market value of a task that is performed with a certain skill. This market value changes sometimes very radically by technological development.

It is difficult to predict how the Swedish labour market and wage structure will be affected by technical change in the long run. At present, we know very little about how labour supply, job mobility and unemployment for different groups has changed as a result of increased computerization and digitization. According to Piketty (2015) the size of wealth has grown relative to income size in Europe during the past decades. If equity ownership continues to be more unequally distributed than income, this trend may lead to sharply increased social gaps. A possible explanation for the rapid asset growth is technical change. Karabarbounis & Neiman (2013) show that income share gained from labour in the corporate sector has decreased severely

[17] See (Autor & Handel 2013)

since the beginning of 1980s in most countries and industries, and that these changes coincide with falling prices of technology. According to Brynjolfsson & McAfee (2014) and Brynjolfsson et al. (2014) this trend will continue if technology keeps replacing labour to a large extent. However, the authors do point out that if the complementary effects of technical change turns out to be more dominating then this trend will mitigate. The authors predict that innovators and entrepreneurs will have the largest income share in the future. Technological development, in the short to medium run, will most likely lead to growing wage gaps. Meanwhile, it is important to remember that technological development is fundamentally something positive, as it leads to increased wealth. Increased public investments as well as increased public services such as education, health care and pensions may help dealing with the challenges that are accompanied with technical development.

It is clear that not only Sweden but the whole world is facing great challenges as well as great opportunities given that we exploit the potential of technology. It is therefore important to understand future labour market changes that follow technical development which in turn requires more knowledge and research about both historical changes of technical development and changes that are happening in the near future. It is vital that institutions and policy makers whom are responsible for monitoring socioeconomic development increase their focus on how technical development such as digitization and artificial intelligence will affect the labour market. Thus, further research on these issues are of great importance.

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