Volkswirtschaftliches Institut für Mittelstand und Handwerk an der Universität Göttingen

ifh Working Paper No. 20/2019

Digitization and Knowledge Spillover Effectiveness – Evidence from the 'German Mittelstand'

Till Proeger[a,1], Petrik Runst[a]

a Institute for Small Business Economics at the Georg-August-University Goettingen, Heinrich-Düker-Weg 6, 37073 Göttingen, Germany

Abstract:

The Knowledge Spillover Theory of Entrepreneurship (KSTE) considers determinants of knowledge diffusion as well as their impact on entrepreneurial activities and growth. Extending the KSTE, the role of incumbent firms for the broad diffusion of new knowledge has been emphasized. For those firms, the barriers to an effective flow of information are considered using the concepts of knowledge filters and absorptive capacities. Both concepts enable the derivation of institutional measures to penetrate knowledge filters and systematically increase absorptive capacities. We interpret the process of digitization as a central process of knowledge spillover in recent years and determine digitization-related knowledge filters for particular domains of firm decision-making. Using a consultant-based in-depth evaluation of 200 SMEs conducted in the context of a federal innovation program, structural drivers, firm clusters and domain-specific knowledge filters for digitization are determined. We find little evidence for structural drivers of knowledge spillover effectiveness. However, as firms are clustered according to their digitization pattern, we show that firms realize high degrees of digitization in most domains or in none, leading us to argue that domain-specific knowledge filters are weak. Rather, knowledge spillover in digitization can be considered a process with initially strong general knowledge filter and – once this filter has been penetrated – weaker subsequent domain-specific knowledge filters. Policy and managerial implications for increasing digitization-related knowledge spillovers in SMEs are discussed.

JEL: D21; D82; H41; K23; L14

Keywords: Digitization; Knowledge Filter; Knowledge Spillover Theory of Entrepreneurship; Small and Medium Enterprises

[1] Corresponding author. Till.Proeger@wiwi.uni-goettingen.de

1. Introduction

Extending the endogenous growth theory (Romer, 1986, 1994), the role of knowledge spillovers has come into the focus of researchers and policy-makers in past years, thus aiming at explaining the "missing link" (Braunerhjelm et al., 2010) between knowledge production and economic growth. This strand of discussion has been considered within the knowledge spillover theory of entrepreneurship (KSTE) (Acs et al. 2009a; Audretch & Keilbach, 2008; Audretsch, 1995, Acs et al., 2013; Ghio et al., 2015 for literature reviews). From a policy perspective, the existence and role of the barriers to effective knowledge commercialization, denoted "knowledge filters", has been investigated in order to assess and recommend strategies of penetrating those knowledge filters. This aims at fostering knowledge spillovers and thus, ultimately, increase (regional) economic competitiveness and growth (see e.g. Acs et al., 2004; Acs & Plummer, 2005; Mueller, 2006; Carlsson et al., 2009). Apart from entrepreneurial activities, i.e. the creation of new firms commercializing knowledge, the pivotal role of incumbent firms for knowledge spillover has recently been emphasized. Their ability to absorb, implement and disseminate new knowledge has been described as having a similarly high relevance for knowledge spillovers as newly founded firms (Qian & Jung, 2017). This might be particularly important for national systems of innovation characterized by a lower entrepreneurial dynamic, yet a higher ability to promote incremental innovation by smaller and long-lived SMEs (Proeger, 2018).

In the process of digitization[2], national institutional systems of innovation are challenged by the radical changes stemming from digital transformations on all societal levels (e.g. Hinings et al., 2018, Loebbecke & Picot, 2015). Digitally innovative entrepreneurial ecosystems are becoming the central source of radical innovations transforming societies and business worldwide, serving as a transfer mechanism efficiently bridging the knowledge gap from research to market adoption (Sussan & Acs, 2017). However, the ensuing broad dissemination of that knowledge leading to substantial economic gains in terms of increased competitiveness and growth requires successful knowledge spillovers to incumbent firms on a large scale. Economies unable to absorb radical digital innovations and implement them within their specific fabric of incumbent firms will fail to reap the economic benefits and ultimately loose competitiveness. Therefore, from the perspective of (regional) policy-makers aiming at establishing knowledge spillovers in the domain of digitization broadly across firms outside of those digital entrepreneurial ecosystems, incumbent firms and their specific absorptive capacities occupy a central role.

Considering previous results (e.g. Bahrat & Chaudhury, 2017), it can be assumed that incumbent SMEs – constituting a central segment of firms in most economies – are likely to be an important impediment for increasing digitization due to their lower absorptive capacity for new knowledge. We thus suggest that SMEs' reluctance to conduct digitization measures is essentially an issue of knowledge filters hampering the efficient flow of knowledge from innovative entrepreneurial sectors to SMEs. To support policy-makers in designing institutions to penetrate those knowledge filter, a more specific understanding of the different knowledge filters hampering digitization in SMEs is required. In this study, we contribute to this research goal by exploiting a novel dataset of German SMEs from the 'German Mittelstand' (De Massis et al., 2017) participating in a federal innovation program detailing their degree of digitization in different intra-firm domains. The questionnaire is used as a support mechanism by professional association of the German craft sector for the German Federal Ministry for Economic Affairs and Energy and is conducted by innovation consultants with firm representatives.

Our dataset encompasses data on 200 German SMEs of different sizes as well as market and regional backgrounds. The respective firms participated in an extensive questionnaire on all aspects of their firm's level of digitization, which includes communication with customers and B2B sales, internal firm processes, development of digital business models, degree of employee training and IT-security. Using this unique dataset, we analyze domain-specific digitization effectiveness as well as its structural drivers and interpret those patterns as a measure on the effectiveness of their penetration of domain-specific knowledge filters. Additionally, we look at the relationship between digitization effectiveness in different intra-firm domains. These analyses allow us to provide policy and managerial implication for decision-makers interested in designing institutions fostering digitization-related knowledge spillovers in SMEs.

The remainder of this paper is structured as follows. Chapter two explains the research context of this paper, chapter three explains the dataset, while the fourth chapter shows our analyses. Finally, chapter five provides a concluding discussion and policy implications of our results.

[2] While numerous definitions of digitization exist, following Loebbecke and Picot (2015), we denote digitization as the broad transformation process of an economy through digital technologies. This process has effects on all societal groups; within firms, it primarily refers to the use of new technologies such as big data analytics, machine learning, automation, a transformation of communication structures with customers and other businesses. However, it refers not only to the use of novel technologies per se, but also encompasses the various changes on workplaces, intra-firm processes and firm structures fostered by technological change.

2. Research Context

Overall, our work is positioned between the literature on the KSTE, in particular the studies investigating knowledge filter and means of their penetration and the literature on technology adoption in SMEs from the viewpoint of information systems research (IS). Combining those strands of literature, we aim at contributing primarily to the further study of knowledge filter from a policy perspective, giving policy-makers and managers implications for increasing knowledge spillovers to SMEs to increase their competitiveness.

Considering the "missing link" (Braunerhjelm et al., 2010) between knowledge production in research institutions and its effective commercialization in regional economies has extended the endogenous growth theory (Romer, 1986, 1994). This research program is pursued within the knowledge spillover theory of entrepreneurship (KSTE) (e.g. Acs et al. 2009a; Audretsch & Keilbach, 2008; Audretsch, 1995 as well as Acs et al., 2013 and Ghio et al., 2015 for literature reviews). Although extensive knowledge spillover are potentially profitable for businesses and desirable from a policy-perspective for its positive effects in terms of competitiveness and (regional) growth, there are systematic barriers to knowledge spillover, which are considered under the term "knowledge filters" in the literature (see e.g. Acs et al., 2004; Acs & Plummer, 2005; Mueller, 2006; Carlsson et al., 2009). Those knowledge filters can help explain the "knowledge paradox" (Audretsch & Keilbach, 2008), which describes the issue that there is no natural link between investments in knowledge production and increases in competitiveness and growth on a regional or national level.[3] Thus, the questions discussed in the respective studies concerns the effective penetration of knowledge filters. Overall, entrepreneurial activities by start-ups close to research institutions have been considered extensively as the most effective channel for commercializing knowledge, while incumbent firms tend to be considered as incapable of penetrating knowledge filter (Acs et al., 2013; Acs et al., 2009a; Audretsch & Keilbach, 2007; Audretsch, 1995). This tends to shift the policy focus on establishing a culture of entrepreneurship in universities and fostering start-ups that transform new knowledge to market products. However, from the perspective of (regional) policy makers aiming at increasing the overall adaptation of new knowledge across firms, the role of incumbent firms has a similarly high relevance. Qian and Jung (2017) introduce this perspective to the KSTE by showing that incumbent firms have considerable absorptive capacities (Cohen & Levinthal, 1990; Qian & Acs 2013) for new knowledge and can therefore constitute an effective complement for the penetration of knowledge filters in regional economies.

Turning to digitization, the seminal contribution on digital entrepreneurial ecosystems (DEE) by Sussan & Acs (2017) combines the established concepts of entrepreneurial and digital ecosystems and outlines future strands of research in digital entrepreneurship. While focused upon the innovative core ecosystems driving the digital transformation, their description of socially embedded open governance structures underlines the need to investigate the willingness and ability of other stakeholders such as incumbents and regulators to participate in the respective digital ecosystems (Sussan & Acs, 2017, p. 69). Our research contributes to this research domain by investigating the conditions by which non-digital incumbent SMEs can be drawn into DEE dynamics, which can be seen as a precondition for substantial economic spillovers by those DEEs to regional economies characterized by non-digital SMEs. We suggest that the effectiveness of inclusion in the dynamics of digital transformation can be operationalized using the concept of knowledge filters. We attempt to measure the extent of those knowledge filters in SMEs using the degree of intra-firm digitization in different domains as a proxy for knowledge spillover effectiveness. We suggest that this captures technological adoption, as well as human resources-related changes, process innovations and the relationship with customers.

This understanding resonates with the information systems research (IS) capability perspective on digitization in SME (see e.g. the literature review in Li et al., 2017), which advocates a holistic view of digitization combining managerial requirements (Doherty & King, 2005), the redefinition of business processes and employee training (Markus, 2004) as well as investments in human resources and organizational capabilities (Cha et al., 2015) as a set of capabilities necessary for an intra-firm digital transformation. For SMEs in particular, it is acknowledged that those transformational efforts in different domains of the firm require external impulses fostering internal reorganizations (Bharati & Chaudhury, 2015). We suggest that – from a public policy perspective – those impulses should be interpreted as knowledge spillovers and the failure to absorb spillovers in a particular domain (e.g. HR, organizational development, technology adoption, big data etc.) be seen as resulting from knowledge filters. Therefore, failure to conduct digitization in a specific domain would point to a particularly strong knowledge filter in that domain since external input has not been successfully implemented. This assumption guides our further analysis of the degree of SME-digitization and barriers to knowledge spillover and thus connects the studies on knowledge filters, digital entrepreneurial ecosystems and the IS-perspective on digitization in SMEs.

[3] Examples for determinants of knowledge filters range from geographical characteristics of a particular region (Acs et al., 2009a; Acs & Plummer, 2005), the effectiveness of national institutions (Stenholm et al., 2013, Proeger, 2018), the age of firms (Acs et al., 2009b; Carlsson et al., 2009) or social norms (Guerrero & Urbano, 2014).

To sum up, we primarily contribute to the literature on knowledge spillover, more particularly regarding incumbent SMEs in the field of digitization by providing novel evidence on incumbents' intra-firm knowledge filters. We therefore draw upon research on digital entrepreneurial ecosystems as well as the information system approach to SME digitization. This exploratory approach using a unique dataset allows us to formulate policy and managerial implications regarding the penetration of digitization-related knowledge filters.

3. Data

3.1 Questionnaire background

Our sample is gathered from a questionnaire designed for SMEs from the German craft sector that aims at determining in detail the degree of digitization in the different functional domains of a given firm. The questionnaire and its application by consultants of the craft organizations is financed by the German Federal Ministry for Economic Affairs and Energy (BMWi) and can be considered the latest push to increase digitization among craft SMEs. German chambers of craft employ "innovation consultants" for their member firms specifically trained to increase technology intensity in the respective firms. In cooperation with scientific advisors and innovation consultants from across Germany, the Center for the Digitization of the Crafts (KDH) drafted the questionnaire as a measure of analyzing the digitization of the respective firm and provide a heuristic for consultants to suggest digitization measures to the firm. The questionnaire can be used online with extensive explanation on the different questions; however, the regular approach is to conduct the questionnaire with the help of a trained innovation consultants.

Innovation consultants and – in the online version[4] – explanatory texts ensure that the index values of 5 to 1 are explained in detail, since each number is assigned to a particular degree of digitization. Therefore, the answers are not subjective ratings regarding the perceived degree of digitization. Rather, they are fairly objective measures of specific domains of digitization within a firm. Consider for instance the question regarding the analysis of customer data. A firm representative will be asked whether customer data is stored and used. An answer of "5" is chosen if data is stored centrally, analyzed centrally and used to improve the individual communication with customers. An answer of "4" is chosen if customer data is stored centrally and used in some way other, e.g. looked at by the manager once a month. The other options similarly have a strict graduation to a lower degree of digitization in the respective fields and have fairly specific descriptions for the different options. These specifications exist for all questions and are explained by the respective consultant and in the internet form. To ensure a homogeneous answering pattern, the innovation consultants have been trained prior to the introduction of the questionnaire.

The questionnaire has six sub-domains: firm specific details, Digitization of customer & supplier relations, digitization of firm processes, development of digital business models, staff qualification in digital technologies, IT safety measures. Each sub-domain features five to ten questions with answering options of 5 (fully agree) to 1 (don't agree at all). In the domain of IT safety measures, only values of 1 (implemented) or 0 (not implemented) are allowed. From respondents' answers to all questions, an overall index value and index values for the sub-domains are constructed. The indices weigh all questions equally. Firms with more than two non-answers are excluded from the sample.

3.2 Sample description

Our sample consists of 200 firms that completed the questionnaire, of which 156 completed the questionnaire with a consultant; the other 44 firms completed the questionnaire online using the online-information for the different answer options which are congruent with the information provided by the consultants. Firms completed the questionnaire between July 2017 and May 2018. Apart from the answers to the different digitization questions, firms provided the firm age, federal state, field of business and regulatory characteristics of the field[5], the revenue and number of employees.

Let us first consider the basic structural information on the firms. Regarding the age, a share of .55 has been founded after 1980. The rest have been founded between 1900 and 1980 with firms founded after 1945 make up about .35 of the overall sample. The regional distribution is unequal across Germany with the majority of firms coming from the southern state of Baden-Wurttemberg and Bavaria with the western state of North-Rhine Westphalia and the northern Lower Saxony having substantial but lower shares. The other federal states are

[4] The online version can be accessed via: www.bedarfsanalyse-handwerk.de.

[5] The question regards the regulation of craft businesses in Germany, of which the sample mainly consists. There are two regulatory classes ("A"- & "B-Gewerke") which are primarily differentiated by the required occupation licensing for opening up a business. In the A-sector, a further qualification title is required to run a business, while in the B-Sectors, there are no entry requirements. For the analysis of digitization patterns, this differentiation should not play a substantial role and is therefore dropped from the analysis.

represented, yet with a lower overall weight in the sample. The distribution of answering firms is not connected to the degree of digitization of the respective state, but simply reflects the different financing of the firm consultants by the federal governments and craft organizations. Since we aim at determining structural drivers of knowledge spillovers in digitization, we refrain from an in-depth analysis of regional patterns, which are unlikely to yield additional results for our question.

Regarding the professional field of all businesses, our sample covers pretty accurately the overall distribution of craft firms in Germany. While we would not suggest that our results are representative of the craft sector as a whole[6], our sample firms do cover all professional fields. Diverging from the actual distribution are the size and revenue of our firms: our sample has larger firms with a higher average revenue than in the general population of firms. It can be assumed that, since participation in the questionnaire requires time by the manager or leading employees, smaller firms are less likely to participate due to the lack of resources. Table 1 gives an overview of the different sub-sectors, their representation in our sample and gives a comparison to the latest official statistical census of craft firms ("HWZ", the most recent one is from 2015).

Table 1. Representativeness of our sample

Variable	Sample	Census 2015
Professional field[7]		
Construction Sector	.16	13%
Interior Construction	.54	41%
Crafts for commercial demand	.15	14%
Car maintenance	.04	9%
Food crafts	.04	4%
Health crafts	.03	4%
Crafts for private demand	.04	15%
Number of employees		
<5	.15	.59
5-9	.22	.22
10-19	.27	.12
20-49	.23	.06
>50	.13	.02
Annual revenue (€)		
17.500-50.000	.09	.19
50.000-125.000	.04	.21
125.000-250.000	.07	.18
250.000-500.000	.16	.16
500.000-5.000.000	.63	.24
>5.000.000	.09	.03

Overall, our sample consists of younger firms concentrated in southern Germany due to a regionally higher number of consultants conducting the survey with firms and is fairly representative of all professional fields within the subsector of German crafts. Firms are larger and have a higher revenue than on average. While not fully representative, the sample is useful to analyze structural determinants of knowledge flows in the process of digitization across a broad range of professional fields. The fact that particularly younger and larger firms have answered is understandable and underlines the expectably higher absorptive capacities of those SMEs, yet is not likely to bias our results regarding market-specific knowledge filter, which should be fairly similar for all sizes of firms.

[6] Along with industrial SMEs, the German craft sector is considered the backbone of the German model of production of highly specialized SMEs with a high knowledge intensity and innovativeness. The sector yields an annual revenue of about 581 Bn. Euros, features a share of 12% of all employees, 28% of all apprentices within the dual training system and 1 Mio. firms overall (for all current numbers, see information by the German Confederation of Skilled Crafts (ZDH) on https://www.zdh.de/daten-fakten/kennzahlen-des-handwerks-2016/. Therefore, it can be considered a representative economic sector for conducting research on the structure of SMEs.

[7] The seven categories each include a number of different crafts of a very broad spectrum. Examples include: Construction Sector (masons, roofer, roadbuilder); Interior Construction (painter, plumber, carpenter, electrical machine building); Crafts for commercial demand (metalworker, cleaner, opticians); Car maintenance (vehicle builder, car mechanics, motorbike and bicycle mechanics); Food crafts (baker, butcher, confectionist); Health Crafts (opticians; hearing aid acoustician, prosthetic dentistry); Crafts for private demand (sweep, barber, clocksmith). The sample also includes a small number of non-craft SMEs, which have similar backgrounds and professional fields.

4. Results

4.1 Descriptive Results

Initially, we present a descriptive analysis of the overall answering patterns shown by firm representatives before going into detail in the analytical cluster and regression analysis. We thus determine structural answering patterns that are considered in detail afterwards.

4.1.1 Indices

We begin by presenting in table 2 the overall index values and the respective sub-indices as given by the entire sample of firms. Keep in mind that the answers (1-5) are not mere subjective ratings by respondents but fairly objective descriptions of different intra-firm processes. Respondents are explained which number to choose given their particular firm situation. This makes the indices a fairly objective measure of the intra-firm situation in the given field. Looking at the results, even on an aggregate level, there is considerable variation in the answering patterns with staff qualification ranking highest and the development of digital business models lowest. Providing digital information, implementing customer processes thus increasing sales are the most salient implemented aspects. Most firms score lower at the introduction of customer rating tools, the use of the latest technologies in their production processes and score low on specific cost models in connection to online sales, all of which are understandable when considering that the sample consists mostly of small to medium-sized craft firms, which have quite limited resources to implement digital business models.

Table 2. Note: IT- Security only features the answer options 0 (not implemented) or 1 (implemented)

Indices	Degree of Implementation
Customers & Suppliers	**2.8**
Digital Information on Products & Services	3.4
Online Applications for Customer Acquisition	2.4
Customer Rating Tools	2.0
Analysis of Customer Data	3.2
Suppliers connected to IT-systems	2.9
Processes	**2.7**
IT Infrastructure up to date	3.7
Customer Processes via IT	3.6
Digital Documentation of Processes	2.6
Use of innovative Technologies	2.0
Digital Inclusion of external Resources	3.1
Analysis of Process Data	2.7
Digital Connection of Production Units	2.2
Use of Cloud Technologies	2.3
Intra-Firm Communication via mobiles Devices	2.3
Digital Coordination and Planning of Workers	2.6
Business Models	**2.3**
Increased Sales due to Digital Technologies	3,3
Digital Market Observation	2,8
Larger Breadth of Products & Services	2,4
Individual IT-Solutions for Customers	2,1
Different Cost Models due to digital Technologies	1,8
Revenue due to Online Sales	1,4
Staff Qualification	**3.0**
Staff accepts Introduction of IT	3.6
Staff has relevant IT-Competencies	3.4
Staff receives IT-Training	3.2
Digital Qualification is provided	2.7
Digital Staff Recruitment	2.8
Process Data available	2.5
Staff is training in IT-Safety measures	2.8
IT Safety	**.75**
Basic Protection for all Devices	.94
Software Products up-to-date	.82
Regular Data Backups	.86
Access Protection for all Devices	.8
Use of strong Passwords	.49
Staff is informed of IT-Risks	.6

4.1.2 Correlation of Indices

Building on those initial results, we can show the connections between the answering patterns for different intra-firm domains. Using the overall sub-index averages, we consider their correlation to determine which intra-firm processes are interconnected.

Table 3. Correlation of Indices

	Customers & Suppliers	**Processes**	**Business Models**	**Staff Qualification**	**IT Safety**
Customers & Suppliers	1				
Processes	**0,61**	1			
Business Models	**0,56**	**0,56**	1		
Staff Qualification	0,48	**0,64**	0,46	1	
IT Safety	0,19	0,24	0,08	0,30	1

Looking at table 3, there are two strong correlations, namely between Customer & Supplier relation and digitization of processes and between digitization of processes and staff qualification. Further, one can see robust correlations between the implementation of digital business models and customer & supplier relations and process digitization. This basic analysis shows us that there are strong inner connections between all subcomponents of digitization except for IT safety. Therefore, although they touch very different domains of SME firm activities and could well be optimized separately, they should be considered a coherent process within the respective firm. These initial results warrant the hypothesis that the different domains have a logical inner connection and that digitization efforts in one domain lead to the adoption of additional knowledge in different domains. Apart from these processes, IT safety is not correlated with the different aspects of digitization. Obviously, fulfilling IT safety standards does not necessarily lead to digitization efforts in the other firm domains.

4.1.3 Determinants of overall index

Further, we consider the structural firm specifics and their impact on the degree of overall digitization. We therefore run a simple correlation analysis of structural variables and each firm's overall digitization index values.

Overall, there are no effects for the regional distribution of firms, none for the main customers (private, businesses, state) and none for the age of the firm. Firms with a higher digitization value tend to be less happy about the speed of the internet connection; otherwise, there are no effects for the quality of the internet connection. Regarding the domain of firm activity, there are only weak effects: SMEs in food crafts are slightly less digitized, car maintenance and health crafts are slightly more digitized. Otherwise, there are no field-specific effects. The only stronger effects are in terms of revenue and number of employees. Here, we find the expected pattern that a higher number of employees and a higher revenue is correlated with higher index values. This effect is particularly strong for very small firms (less than 50K revenue p.a. and under 10 employees. Above that threshold, there is little variation with the exception of the highest class of revenues, which is digitized above average.

Overall, we find little evidence that specific markets or structural indicators drive knowledge spillover in digitization. This can be interpreted such that the degree of digitization depends primarily on informal factors, e.g. the individual manager's openness and interest towards digitization. This component of a firm's absorptive capacity seems to be evenly distributed across markets in our sample with only a weak market push towards digitization in two domains. To extend this analysis, we conduct a cluster analysis of different clusters digitization types within our sample.

4.2 Determinants of Digitization

4.2.1 Cluster Analysis

To take a more detailed look at firm responses, we conduct a principal component analysis, which uses the correlation of all answers to show answering patterns. First, the correlation coefficients of all answers are constructed. Based upon those correlations, answering patterns can be shown, meaning that specific questions are often answered in a similar manner. Looking into those clusters enables us to describe and interpret the respective digitization pattern. Table 4 shows the different answers and resulting four clusters along with the respective factor loadings.

Table 4. Cluster of answering patterns, resulting firm cluster and factor loadings.

Indices	Cluster # 1	2	3	4
	Factor Loadings			
Customers & Suppliers				
Digital Information on Products & Services			**-0,31**	
Online Applications for Customer Acquisition				**0,32**
Customer Rating Tools				**0,33**
Analysis of Customer Data				-0,25
Suppliers connected to IT-systems			0,20	
Processes				
Customer Processes via IT	0,23			
Digital Documentation of Processes	0,21			-0,21
Use of innovative Technologies	0,20			
Digital Inclusion of external Resources				
Analysis of Process Data	0,20			-0,24
Digital Connection of Production Units	0,23			
Use of Cloud Technologies			0,23	
Intra-Firm Communication via mobiles Devices				
Digital Coordination and Planning of Workers			0,29	
Business Models				
Customer Processes via IT				
Increased Sales due to Digital Technologies	0,20		**-0,27**	
Digital Market Observation	0,25			
Larger Breadth of Products & Services				
Individual IT-Solutions for Customers		**-0,25**		
Different Cost Models due to digital Technologies		**-0,30**		
Staff Qualification				
Revenue due to Online Sales		**-0,28**		
Staff accepts Introduction of IT		0,24		
Staff has relevant IT-Competencies		**0,33**		
Staff receives IT-Training	0,23			
Digital Qualification is provided	0,20			-0,22
Digital Staff Recruitment	0,19			
Process Data available	0,20			
IT Safety				
Staff is training in IT-Safety measures	0,19			
Basic Protection for all Devices			0,26	**0,32**
Software Products up-to-date			0,27	
Regular Data Backups			0,24	
Access Protection for all Devices				
Use of strong Passwords				**0,37**
Staff is informed of IT-Risks		0,23		
Cronbach‘s alpha	0,88	0,35	0,60	0,68

Drawing on this analysis, we can identify four distinct clusters of firms due to their respective answering patterns.

Let us first consider Cluster one, which includes firms ranking high on a number of digitization measures. They have conducted training for the employees and have increased sales due to the use of IT. This cluster includes the

most advanced SMEs in their field with regard to digitization. Knowledge spillover for those firms has been extensive and can be considered a continuous process since process data and customer processes are integrated, which makes constant improvements on the digital systems likely. Also, the increasing sales due to the improvement on the firm's digital infrastructure are likely to lead to further investment and improvements, which systematically penetrates knowledge filters in the domain of digitization. Cluster two includes firms that use digital solutions on a lower level, have trained their staff accordingly, yet do not proceed with a further integration of digital technologies. Apparently, the basic level of digitization fits their business model and further digitization would require investments and knowledge acquisition that would not compensate for the expected gains. Cluster three can be described as digitally well-connected to their suppliers and using some digital processes while not providing substantial digital information on products and services; overall, this does not lead to increased sales. We interpret this constellation as resulting from a strong and mandatory integration of the firms' processes into supplier and customer digital systems. These measures are required to conduct in the respective business, yet does not lead to increased business success since it is a basic requirement. Therefore, investments and knowledge spillover are determined by external agents, yet in this manner succeed in penetrating knowledge filter for those SMEs. Cluster four finally can be described as the minimally digitized firms, which use certain basic measures for digitally acquiring customers yet do not evaluate the respective data and fails to provide extensive training for employees. Overall, those SMEs are likely to have a simple homepage, employees are uninvolved and have a basic safety standard. Therefore, no extensive knowledge spillovers have been conducted; only very simple digital applications have been conducted, yet no digitization process within the firm has been initiated.

From a knowledge-spillover perspective, it can be suggested that the first cluster has successfully coped with knowledge filter and has achieved a level of low marginal costs of acquiring additional digitization knowledge which also yields considerable additional revenue. The second and fourth cluster have acquired a basic level of digitization-relevant knowledge, have implemented that knowledge in the respective business processes yet have ceased to acquire additional knowledge since the additional costs of penetrating the respective knowledge filters is not justified by additional revenue. Finally, the third cluster considers knowledge spillover in digitization as a requirement by customers and suppliers yet does not systematically adapt digital solutions based on self-interest. Thus, from a policy-perspective aiming at increasing the positive effects of digitization among SMEs, the first cluster can be seen as a benchmark for the other firms where knowledge filters cease to be a substantial issue hindering the implementation of new technologies. By contrast, the other three clusters are hampered by knowledge filter making the adaptation of technologies and digital processes excessively difficult and costly to entrepreneurs. Therefore, specific institutional support mechanisms should be devised to cope with those knowledge filters. To gain a more profound understanding of firm characteristics within the clusters, we run two regression analyses.

4.2.2 Determinants of digitization and cluster assignment

Using a simple OLS regression, we first consider which firm characteristics go along with higher values in the overall digitization index and in the respective sub-indices. We can thus determine the role of structural firm features for the successful implementation of digital technologies and processes. Table 5 presents the regression results.

Table 5. Note: p-values in parentheses * p < 0.10, ** p < 0.05, *** p < 0.01

	(1) Overall	(2) Customers	(3) Processes	(4) Business Model	(5) Staff	(6) Safety
Regulatory class A	**-0.417****	**-0.496****	**-0.363***	-0.339	**-0.448****	-0.00645
	(0.023)	(0.019)	(0.079)	(0.119)	(0.049)	(0.923)
Regulatory class B	**-0.488***	-0.175	**-0.525***	**-0.504***	**-0.593***	-0.0474
	(0.054)	(0.547)	(0.067)	(0.096)	(0.060)	(0.599)
No. Employees	-0.000252	-0.0000442	0.000199	-0.000514	-0.000599	0.0000889
	(0.783)	(0.967)	(0.847)	(0.636)	(0.599)	(0.765)
Age	0.00187	**0.00365***	-0.000482	0.00304	0.00245	0.0000764
	(0.317)	(0.090)	(0.819)	(0.172)	(0.293)	(0.905)
Revenue below 17.000€	-	-	-	-	-	-
Revenue up to 50.000€	0.901	-0.151	0.977	0.530	**1.892*****	0.0255
	(0.121)	(0.820)	(0.137)	(0.440)	(0.009)	(0.887)
Revenue 250.000-500.000€	0.691	-0.105	0.693	0.422	**1.573****	-0.00254
	(0.142)	(0.799)	(0.313)	(0.260)	(0.005)	(0.633)
Revenue 500.000-5.000.000€	**1.204****	0.387	1.119*	0.912	**2.228*****	0.0734
	(0.199)	(0.865)	(0.254)	(0.507)	(0.020)	(0.988)
Revenue above 5.000.000€	**1.375****	0.498	**1.393****	0.831	**2.526*****	0.127
	(0.022)	(0.521)	(0.060)	(0.143)	(0.001)	(0.649)
Construction Sector	-	-	-	-	-	-
Interior Construction	0.0617	0.225	0.0612	0.148	-0.0975	0.0307
	(0.680)	(0.192)	(0.717)	(0.401)	(0.601)	(0.535)
Crafts for comm. demand	-0.0444	-0.0976	0.0222	-0.308	0.0950	0.00509
	(0.836)	(0.693)	(0.927)	(0.227)	(0.722)	(0.945)
Car maintenance	0.297	0.374	0.214	**0.642***	0.0438	-0.120
	(0.361)	(0.318)	(0.560)	(0.096)	(0.914)	(0.268)
Food crafts	-0.233	-0.288	-0.265	-0.151	-0.193	-0.0258
	(0.477)	(0.445)	(0.475)	(0.700)	(0.636)	(0.800)
Health crafts	0.291	**0.799***	0.426	-0.0419	-0.0755	-0.107
	(0.413)	(0.052)	(0.289)	(0.921)	(0.864)	(0.370)
Crafts for private demand	**0.459***	**0.973*****	0.302	0.184	**0.618***	0.0266
	(0.092)	(0.002)	(0.326)	(0.568)	(0.069)	(0.800)
Constant	-1.681	-4.403	2.989	-4.097	-3.395	1.535
	(0.656)	(0.312)	(0.484)	(0.362)	(0.471)	(0.238)
Observations	220	220	220	220	219	175
r2	0.129	0.133	0.117	0.139	0.154	0.0783

Using non-craft firms as the comparison, we find that craft firms of both regulatory classes reach lower degrees of digitization for most indices. Further, higher firm revenues goes along with higher the degrees of digitization. However, firms with low revenue reach higher levels of staff qualification. Looking at the different sectors covered in our sample, there is little evidence for systematic digitization-related effects of those sectors. Crafts for private demand tend to reach higher values with regard to customer digitization and staff qualification. Similarly, the health crafts, which also have a lot of direct customer contact tend to score higher in customer-related digitization. Car maintenance features higher values with regard to a digital business model, which be traced back to strong (mandatory) digital linkages between industrial producers and car mechanics. Apart from those few effects, there is little evidence for structural drivers of digitization effectiveness with firm size being the only strong determinant of digitization effectiveness.

Therefore, we extend the analysis by looking at the determinants of cluster assignment in our sample. Again, we run a simple OLS regression to show which firm characteristic makes assignment to the four clusters more likely. Table 6 presents the results.

Table 6. Note: p-values in parentheses * p < 0.10, ** p < 0.05, *** p < 0.01

	(1) Cluster 1	(2) Cluster 2	(3) Cluster 3	(4) Cluster 4
Regulatory class A	-0.780 (0.489)	-0.537 (0.492)	-0.261 (0.668)	0.576 (0.271)
Regulatory class B	-0.906 (0.545)	-0.804 (0.442)	-0.506 (0.533)	**1.784**** (0.012)
No. Employees	0.000901 (0.863)	-0.000668 (0.853)	0.00168 (0.551)	-0.00150 (0.535)
Age	-0.0133 (0.225)	-0.00569 (0.460)	-0.000241 (0.968)	0.00286 (0.578)
Revenue *50.000-125.000€*	-	-	-	-
Revenue *125.000-250.000€*	1.816 (0.309)	0.145 (0.907)	**-2.658***** (0.007)	0.132 (0.874)
Revenue 250.000-500.000€	0.383 (0.813)	1.134 (0.322)	**-1.945**** (0.031)	-0.0530 (0.945)
Revenue 500.000-5.000.000€	1.117 (0.423)	0.724 (0.460)	**-1.675**** (0.030)	0.248 (0.704)
Revenue above 5.000.000€	0.676 (0.673)	1.102 (0.338)	-1.303 (0.147)	0.671 (0.382)
Construction Sector	-	-	-	-
Interior Construction	0.789 (0.295)	-0.0526 (0.919)	0.484 (0.232)	-0.295 (0.396)
Crafts for comm. demand	0.230 (0.850)	0.501 (0.555)	0.382 (0.562)	-0.922 (0.106)
Car maintenance	-2.630 (0.211)	-2.242 (0.125)	0.246 (0.827)	-0.986 (0.311)
Food crafts	0.683 (0.663)	0.328 (0.764)	-0.144 (0.866)	0.810 (0.269)
Health crafts	0.155 (0.942)	**-2.605*** (0.081)	0.786 (0.495)	-1.630 (0.101)
Crafts for private demand	0.993 (0.556)	-0.145 (0.901)	0.823 (0.367)	0.804 (0.305)
Observations	108	108	108	108
r2	0.0824	0.123	0.141	0.168
F	0.596	0.798	0.936	1.152

Looking at the results for cluster one, we find the interesting result that there are no structural drivers for assignment to cluster one. Thus, the most successfully digitized firms are not limited to specific sizes, revenue categories or sectors, as could be interpreted from the regression on the drivers of high index values. While it can be shown that larger firms with higher revenues tend to have higher index values, the assignment to cluster one, however, is not more likely for those firms. In essence, this means that there are no structural determinants for knowledge spillover effectiveness in our sample of SMEs and that other factors determine which firms reach extensive knowledge spillover. Looking at cluster two, a similar result applies. Apart from a (weak) significant result for health crafts, no structural determinants for the respective digitization pattern (low level of digitization, effective training of staff and no increasing digitization efforts) can be shown. Assignment to cluster three (mandatory use of digital systems without positive revenue-effects) is primarily determined by firm revenue: the higher the value, the less likely the assignment to this cluster. Therefore, SMEs with a basic level of digitization determined by suppliers and customers are smaller and are likely dependent on few large firms. Implementing digital technologies can be seen as a prerequisite for cooperation, rather than a strategic measure for increasing revenue. Finally, cluster four (minimally digitized) is characterized by craft firms in the second regulatory class, which tend to be smaller with lower levels of formal training. However, there is no effect of lower revenue, meaning that lower degrees of digitization are not primarily an issue of lacking resources in very small firms. Rather, the competitive environment or lower levels of formal training might be an issue to those firms, systematically restricting knowledge spillover.

5. Discussion and conclusion

How can these results of digitization patterns in SMEs representing the 'German Mittelstand' be interpreted from a knowledge spillover perspective? We suggest that digitization in firms should be considered as a knowledge-spillover problem. The technologies and processes involved have great potential for increasing productivity and revenue, but are also associated with considerable knowledge filters, particularly for SMEs with limited staff trained in IT-systems and its applications. Acquiring specific information, making informed business decisions, implementing, evaluating and improving digital business models are regularly out of reach for SMEs. Therefore, both state and corporate decision-makers aiming at improving the overall adoption of digital technologies to improve growth or business opportunities require specific policy instruments capable of penetrating knowledge filters for digitization in SMEs. To design those policy instruments, we need to learn more about absorptive capacities in SMEs, how knowledge filters work and how they can be penetrated in the domain of digitization. Our sample allows us to contribute to this research goal by showing in detail the digitization patterns for all relevant intra-firm domains in a sample of SMEs and combine those patterns with structural information on the firms. Running the analyses, we find three main results that can be used to inform our view of digitization-related knowledge spillover in SMEs.

First, there is a high correlation of the different aspects of intra-firm digitization, whereby firms have either digitized in most of the different domains or in very few to none. The aspect of IT security is an exception, meaning that firms can achieve a very low level of digitization yet perform well on the measures of IT safety; this finding could in part be explained by regulatory safety requirements. We interpret this tendency of all-or-nothing digitization as resulting from the specific structure of knowledge filter in the domain of SMEs. To SMEs, implementing the initial digital technology or process, i.e. penetrating the knowledge filter in a particular domain, can be considered quite effortful and costly. Implementing further digitization measures in turn is fostered by the already existing technologies that provide easy interfaces for different firm domains. For an example, consider the introduction of cloud storage of firm data for a firm. Once a cloud platform has been established, using that platform to record working hours or bills and using tablets to store data while working at a client becomes fairly simple. Once this system has been established, providing interfaces for customer relationships again is not a large step to take, even for small firms. Therefore, we suggest that digitization has very high initial costs in terms of acquiring the knowledge to apply digital technologies, but ever decreasing marginal costs of realizing efficiency gains in additional intra-firm domains. Our results for the five intra-firm domains support this interpretation.

Second, while our sample covers quite diverse occupations, markets and firm sizes, structural factors only play a small role in determining the degree of digitization of a given SME. Although it could be assumed that working in particular sectors or having certain characteristics would foster digitization in general or at least in particular domains, this result can only be shown weakly for a very limited number of sectors and for the level of revenues with regard to staff qualification. Although we have substantial variance in the levels of digitization, it becomes obvious that digitization in SMEs is not a direct consequence of certain structural features or logically limited to specific markets but depends on other entrepreneurial characteristics.

Third, when clustering firms according to their degree of digitization, we confirm that the "benchmark firms" with high levels of digitization in most domains not only occur in specific markets or have specific sizes. Rather, they can be found in all markets, have different revenue classes and number of employees. Therefore, while larger firms have higher index values, among the most digitally advanced firms in our sample, firm size does not matter. For the other three clusters with lower degrees of digitization, some structural specifications can be found that point to specific sizes and markets as making a particular cluster assignment more likely. However, the structural drivers are again rather broad, since cluster two features all but one sector, cluster three primarily smaller firms and cluster four firms of a particular regulatory class encompassing a large number of sectors. Therefore, we suggest that the knowledge spillover effectiveness in SME-digitization overall is not driven by structural characteristics. Obviously, this is a positive result for policy-makers aiming at increasing productivity and growth across sectors, since it cannot be shown that digitization remains unattainable in specific domains of the economy. Rather, the right entrepreneurial qualities such as innovative motivation, openness to technology, alertness or – as a partial substitute – supportive institutional structures are decisive and can be used by SMEs across a very broad spectrum of markets and sizes.

How can these results be used from a policy-perspective? We find that SMEs across markets can achieve high levels of digitization and yield the respective increases in productivity, competitiveness and growth. Therefore, institutionalized support aimed at penetrating knowledge filter for digitization measures should not be limited to specific sectors or firm sizes but should be open to the full spectrum of SME activity. While sector-specific measures in terms of production technology are certainly necessary, it should be pointed out that the initial knowledge filter for SMEs appear to be fairly similar across sectors. This makes sense, when considering that incumbent SME entrepreneurs of all sectors face the same costs and efforts when obtaining information about, e.g. cloud platforms and their potential applications to the firm. The initial knowledge filter for starting digitization

measures for intra-firm processes are likely to be fairly homogeneous across sectors. Only when turning to specific production technologies and processes, there will be considerable differences. Further, when considering the strong internal linkages between digitization in different intra-firm domains, it is likely that initial degree of digitization is likely to lead to further measures in the future. While this threshold is not reached in any case, as illustrated in cluster two to four in our sample, we suggest that the internal linkages between the different domains make a steadily increasing degree of digitization more likely once a firm commences. Therefore, from the perspective of knowledge filter, policies should be devised such that the initial knowledge filter is penetrated in an easily accessible domain that does not require profound intra-firm changes. Rather, smaller measures with a weaker knowledge filter should be incentivized, trusting that the internal linkages of digital structures will increase the likelihood of an endogenous systematic increase in digitization.

Those measures should be constructed broadly, thus applying to very different SMEs in different sectors, penetrating knowledge filters that are weak in the first place and occur in all SMEs. Sticking to the example mentioned above, have policy-makers foster the introduction of simple cloud-based applications that measure working time and expenses by all employees as an introductory measure penetrating the initial knowledge filter of understanding and coping with the complexity and sheer amount of digital technologies and solution. Our results suggest that the initial adoption will make subsequent digitization measures more likely since the marginal costs of penetrating knowledge filter in further domains, i.e. conducting additional digital innovations, are likely to decrease with each measure. We argue that this kind of digitization policy – understood from a knowledge spillover perspective – can foster broad learning and knowledge absorption by SMEs across sectors. Conversely, our results imply that large-scale industrial policy approaches might not be the most effective means of increasing digitization in SMEs. Instead of fostering the absorption of specific, capital-intensive technologies (e.g. due to a prominent role in the public discussion) or supporting individual tech champions, broad, cross-sector support for low threshold measures is favourable. The decision-maker implementing those policies might range from federal regulators designing support schemes for SMEs to chambers of industry and commerce, trade associations, innovation managers focused on particular regions or managers of larger firms aiming at fostering innovative digitization in their supplier and customer networks.

Turning to the research perspective, we contribute to the general understanding of knowledge spillovers and further the research on institutions helping to penetrate knowledge filters for incumbents. It has been argued (Qian & Jung, 2017; Proeger, 2018) that incumbent firms and their specific absorptive capacities should not be omitted in the analysis of knowledge filters due to their ubiquitous role in modern industrial economies. While high-tech innovativeness certainly is primarily fostered by entrepreneurial activities that play a central role in providing the missing link between R&D and growth, many highly innovative (regional) economies draw their innovative performance from incumbent SMEs successfully conducting knowledge spillover, transferring R&D into marketable products. Digitization is a prime example for this process of providing the link between high-tech products to broad, large-scale productivity increasing applications across the economy. Therefore, both our understanding of absorptive capacities in incumbent firms, the processes and difficulties in fostering knowledge spillover to those firms as well as institutional support structures are of vital importance to policy-makers trying to turn R&D into growth. We therefore emphasize that the study of digitization and knowledge filter in SMEs should be furthered to provide policy-makers with insight on how to design appropriate policy instruments.

6. References

Acs, Z.J., Audretsch, D.B., Braunerhjelm, P., Carlsson, B., 2004. The missing link: The knowledge filter and endogenous growth (discussion paper). Stockholm: Center.

Acs, Z.J., Audretsch, D.B., Lehman, E.E., Licht, G. 2016. National Systems of Entrepreneurship. Small Business Economics 46(4), 527-535.

Acs, Z.J., Audretsch, D.B., Lehmann, E.E., 2013. The knowledge spillover theory of entrepreneurship. Small Business Economics 41 (4), 757-774.

Acs, Z.J., Braunerhjelm, P., Audretsch, D.B., Carlsson, B., 2009a. The knowledge spillover theory of entrepreneurship. Small Business Economics 32 (1), 15-30.

Acs, Z.J., Plummer, L.A., 2005. Penetrating the 'knowledge filter' in regional economies. The Annals of Regional Science 39 (3), 439-456.

Acs, Z.J., Plummer, L.A., Sutter, R., 2009b. Penetrating the knowledge filter in "rust belt" economies. The Annals of Regional Science 43 (4), 989-1012.

Akerlof, G.A., 1970. "The market for "lemons": Quality uncertainty and the market mechanism". The Quarterly Journal of Economics 84 (3), 488-500.

Audretsch, D. B., Keilbach, M., Lehmann, E.E. (Eds.), 2006. Entrepreneurship and economic growth. Oxford: Oxford University Press.

Audretsch, D.B., 1995. Innovation and industry evolution. MIT Press, Cambridge, Mass.

Audretsch, D.B., Caiazza, R. 2016. Technology transfer and entrepreneurship: cross-national analysis. Journal of Technology Transfer 41(6), 1247-1259.

Audretsch, D.B., Keilbach, M., 2007. The theory of knowledge spillover entrepreneurship. Journal of Management studies 44 (7), 1243-1254.

Audretsch, D.B., Keilbach, M., 2008. Resolving the knowledge paradox: Knowledge-spillover entrepreneurship and economic growth. Research Policy 37 (10), 1697-1705.

Braunerhjelm, P., Acs, Z.J., Audretsch, D.B., Carlsson, B., 2010. The missing link: Knowledge diffusion and entrepreneurship in endogenous growth. Small Business Economics 34 (2), 105-125.
Busemeyer, M.R., Schlicht-Schmälzle, R., 2014. Partisan power, economic coordination and variations in vocational training systems in Europe. European Journal of Industrial Relations 20(1), 55-71.
Cappelli, R., Czarnitzki, D., Kraft, K., 2014. Sources of spillovers for imitation and innovation. Research Policy 43(1), 115-120.
Carlsson, B., Acs, Z.J., Audretsch, D.B., Braunerhjelm, P., 2009. Knowledge creation, entrepreneurship, and economic growth: A historical review. Industrial and Corporate Change 18 (6), 1193-1229.
Cohen, W.M., Levinthal, D.A., 1990. Absorptive capacity: A new perspective on learning and innovation. Administrative Science Quarterly 35, 128-152.
De Massis, A., Audretsch, D., Uhlaner, L., Kammerlander, N., 2017. Innovation with limited Resources: Management Lessons from the German Mittelstand. Journal of Product Innovation Management, doi: 10.1111/jpim.12373.
Driffield, N., Love, J. H., Yang, Y., 2014. Technology sourcing and reverse productivity spillovers in the multinational enterprise: global or regional phenomenon? British Journal of Management 25, 24-41.
Driffield, N., Love, J.H., 2005. Who gains from whom? Spillovers, competition and technology sourcing in the foreign-owned sector of UK manufacturing. Scottish Journal of Political Economy 52(5), 663-686.
EFI, 2016. Research, innovation and technological performance in Germany - EFI Report 2016, edited by Commission of Experts for Research and Innovation (EFI), Berlin.
Eisenhardt, K., 1989. Theories from case study research. The Academy of Management Review 14 (4), 532-550.
Eisenhardt, K., Graebner, M.E., 2007. Theory building from cases: Opportunities and challenges. Academy of Management Journal 50 (1), 25-32.
Feser, D., Proeger, T., 2017. Asymmetric information as a barrier to knowledge spillovers in expert markets. International Entrepreneurship and Management Journal 13(1), 211-232.
Fredriksen, K., Runst, P., 2016. Masterful Meisters? Quality Effects of the Deregulation of the German Crafts Sector. Ifh working papers.
Ghio, N., Guerini, M., Lehmann, E.E., Rossi-Lamastra, C., 2015. The emergence of the knowledge spillover theory of entrepreneurship. Small Business Economics 44 (1), 1-18.
Glaser, B.G., 1965. The constant comparative method of qualitative analysis. Social Problems 12 (4), 436-445.
Glaser, B.G., Strauss, A.L., 2008. The discovery of grounded theory: Strategies for qualitative research. Recording for the Blind & Dyslexic, Princeton, NJ.
Guerrero, M., Urbano, D., 2014. Academics' start-up intentions and knowledge filters: An individual perspective of the knowledge spillover theory of entrepreneurship. Small Business Economics 43 (1), 57-74.
Hayter, C.S., 2013. Conceptualizing knowledge-based entrepreneurship networks: Perspectives from the literature. Small Business Economics 41 (4), 899-911.
Hernandez, B.J. 2016. The German Model and Dual System: A Skills Initiative for the US? Working Paper. International Conference on Studies in Humanities and Social Sciences (SHSS-2016) May 24-25, 2016 Paris (France). doi: 10.17758/ERPUB.EA0516038
Huggins, R., Johnston, A., Thompson, P., 2012. Network Capital, Social Capital and Knowledge Flow: How the Nature of Inter-organizational Networks Impacts on Innovation. Industry & Innovation 19 (3), 203-232.
Huggins, R., Thompson, P., 2015. Entrepreneurship, innovation and regional growth: a network theory. Small Business Economics 45 (1), 103-128.
Jensen, M.B., Johnson, B., Lorenz, E., Lundvall, B.Å., 2007. Forms of knowledge and modes of innovation. Research Policy 36 (5), 680-693.
Lassnigg, L., 2016. Apprenticeship policies in comparative perspective. ET-structures, employment relationship, export. Sociological Series Working Paper No. 114, Institute for Advanced Studies, Vienna.
Loebbecke, C.; Picot, A. (2015) Reflections on Societal and Business Model Transformation Arising from Digitization and Big Data Analytics: A research agenda. Journal of Strategic Information Systems 24 (3), 149-157
Maennig, W., Ölschlaeger, M., 2011. Innovative Milieux and Regional Competitiveness: The Role of Associations and Chambers of Commerce and Industry in Germany, Regional Studies 45 (4), 441-452,
Maennig, W., Ölschlaeger, M., Schmidt-Trenz, H.J., 2015. Organisations and regional innovative capability: the case of the chambers of commerce and industry in Germany. Environment and Planning C: Government and Policy 33(4), 811-827.
Mayring, P., 2004. Qualitative content analysis, in: Flick, U., Kardoff, E. von, Steinke, I. (Eds), A Companion to Qualitative Research, vol. 1. Sage, London, pp. 266-269.
Mueller, K. 2016. Economic Effects of Deregulation - Using the Example of the Revised Trade and Crafts Code 2004. Ifh working papers.
Mueller, P., 2006. Exploring the knowledge filter: How entrepreneurship and university-industry relationships drive economic growth. Research Policy 35 (10), 1499-1508.
Proeger, T. 2018. Knowledge Spillovers and Absorptive Capacity - Institutional Evidence from the 'German Mittelstand'. Journal of the Knowledge Economy, doi: 10.1007/s13132-018-0539-8.
Qian, H., Jung, H., 2017. Solving the knowledge filter puzzle: absorptive capacity, entrepreneurship and regional development. Small Business Economics, 1(48), 99-114.
Qian, H., Zoltan J. Acs, Z.J., 2013. An absorptive capacity theory of knowledge spillover entrepreneurship. Small Business Economics, 1-13.
Rammer, C., Czarnitzki, D., Spielkamp, A., 2009. Innovation success of non-R&D-performers: substituting technology by management in SMEs. Small Business Economics 33 (1), 35-58.
Romer, P.M., 1986. Retruns and long-run growth. Journal of Political Economy 94 (5), 1002-1037.
Romer, P.M., 1994. The origins of endogenous growth. Journal of Economic Perspectives 8 (1), 3-22.
Schiller, D., Diez, J.R., 2010. Local embeddedness of knowledge spillover agents: Empirical evidence from German star scientists. Papers in Regional Science 89 (2), 275-294.
Schmidt, S., 2015. Balancing the spatial localisation 'tilt': Knowledge spillovers in processes of knowledge-intensive services. Geoforum 65, 374-386.
Shu, C., Liu, C., Gao, S., Shanley, M., 2014. The Knowledge Spillover Theory of Entrepreneurship in Alliances. Entrepreneurship Theory and Practice 38 (4), 913-940.
Soskice, D.W., & Hall, P.A., 2001. Varieties of Capitalism: The Institutional Foundations of Comparative Advantage. Oxford: Oxford University Press.

Soskice, D.W., Hall, P.A., 2001. Varieties of capitalism: The institutional foundations of comparative advantage. Oxford: Oxford University Press.

Stenholm, P., Acs, Z.J., Wuebker, R., 2013. Exploring country-level institutional arrangements on the rate and type of entrepreneurial activity. Journal of Business Venturing 28 (1), 176-193.

Thomae, J., 2017. DUI mode learning and barriers to innovation - A case from Germany, in: Research Policy 46 (7), 2017, S. 1327-1339

Yang, H., Steensma, H.K., 2014. When do firms rely on their knowledge spillover recipients for guidance in exploring unfamiliar knowledge? Research Policy 43 (9), 1496-1507.