DIGITALISATION IN AUSTRIA: STATE OF PLAY AND REFORM NEEDS

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Executive Summary

This report provides an overview and analysis of the state of digitalisation in the Austrian economy. Austria aims to become a European Innovation Leader and digitalisation provides an important lever with which to achieve this goal.

The performance of the Austrian economy in the realm of digitalisation is mixed:

- The ICT producing sector measured in value added to GDP is small compared to the Innovation Leaders' ICT sectors. ICT exports are also below this reference group. The gap between Austria and the Innovation Leaders regarding ICT exports is increasing.
- Closer analysis reveals a more differentiated picture: The weakness is mainly due to ICT services. The ICT producing sector in Austria is small, but its exports are remarkably complex, and its patenting performance is on a par with Innovation Leader countries.
- Strengths exist in terms of industry 4.0 technologies, both with regard to their adoption in the manufacturing sector and with regard to innovation and technology development. Especially in the machinery and equipment sectors, the patent quality of non-ICT patents referencing digital technologies is high.
- The diffusion of key digital technologies in comparison to Innovation Leaders presents a heterogeneous picture. Austria scores better in categories related to Industry 4.0 and manufacturing, such as the adoption of enterprise resource planning (ERP) systems, radio-frequency identification technologies (RFID) and customer relationship management (CRM) software; but its performance is lower in the adoption of technologies such as cloud computing and social media.
- The performance in some digitalization indicators is driven by the sectoral composition of countries. After correcting for these composition effects, the performance of Austria regarding the adoption of social media improves and the performance in RFID deteriorates in comparison to the non-corrected ranking.

The overall digitalisation performance of Austria is marked by good performance in the manufacturing industries and weaknesses in the service sector:

- Austrian firms in digitally intensive sectors derive their competitive advantage from the technological content of their products, the qualified work force, product quality and the customisation of their products. The main challenges to promote further digitalisation are unexpected changes in the market environment and operative aspects related to the adoption of digital technologies.
- Austria ranks above the average of the EU-28 in many indicators for the adoption of Industry 4.0 related technologies but it is not among the leading countries in Europe. Weaknesses can be detected concerning the take-up of digitalisation in service industries. Thus, reform needs emerge with respect to policies promoting the diffusion of digital technologies.

The diffusion of digital technologies is hampered by their low adoption in microenterprises, SMEs and generally modest industrial dynamics in Austria:

- Austria has lower industry dynamics in terms of high growth firms and entry rates than Innovation Leader countries, with the notable exception of the ICT producing sector. This affects the diffusion of digital technologies. The adoption of digital technologies is generally lower in sectors with a higher SME share and faster in sectors with higher industry dynamics.
- The challenges of microenterprises and smaller enterprises regarding digitalisation are mainly related to information gaps. Entrepreneurs face uncertainty about the available technological solutions (know-what) and uncertainties about the deployment of these digital solutions (know-how). Regulation and financial factors are also important barriers mentioned by microenterprises.
- The "KMU Digital" support programme provides a good example of a low threshold programme to foster the digitalization of SMEs. Structural Reforms should address the low industry dynamics in the ICT service and ICT using sectors. Support schemes should take informational and organizational challenges of digitalisation into account.

The evidence on digitalisation and the workforce reveals:

- Austrian firms have difficulties recruiting ICT specialists. This shortage of ICT specialists can be seen at every level. At the same time, Austrians with low educational attainment have a quite distant relationship to digital technologies.
- The evidence shows that the task structure of work is changing due to digitalisation. Manual routine jobs are decreasing, and abstract non-routine jobs are increasing in importance.
- Reform needs arise regarding the promotion of ICT skills and competencies of the workforce. In the short term this calls for a reform of the criteria-based immigration system and a stronger focus on ICT in the education, training and re-training of employees. In the longer term this needs to be addressed in the education system.
- The digital infrastructure of Austrian schools shows quite some variation across school types. Notably primary and general secondary schools lag behind.

The Austrian digitalisation policy landscape is currently in a phase of reorganisation:

- Many federal policy competences related to digitalisation have been centralised in the newly formed Ministry of Digital and Economic Affairs. The Digitalisation Agency (DIA) was established in 2018 to coordinate the strategy process.
- This led to the “Digital Austria” initiative, which provides an attempt to streamline, harmonise and concentrate efforts in a fragmented policy landscape, in which different departments and layers of federal Austrian policy structure interact.

Two additional points need to be taken up by Austrian digitalisation policy in the path ahead:

- The prioritisation of policy fields should occur in a clearer and more transparent fashion, the streamlining of competences should be continued, and a quantitative benchmarking (if possible) should be considered with policy targets articulated upfront. This should eventually lead to the establishment of a monitoring and evaluation framework of Austria’s digitalisation progress.
- Addressing deficits in the broadband infrastructure should remain a priority. Especially fixed-broadband take-up rates are lagging behind those of Innovation Leaders. Since 2015, a broadband deployment promotion programme has been in place. It promotes the establishment of broadband infrastructures, particularly in under-served rural areas. An interim evaluation supports the continuation of the programme, and highlights that subsidies have, by and large, effectively contributed to the programme’s objectives. The evaluation also recommended some adjustments in the programme design with respect to a greater focus on 5G readiness and, relatedly, the establishment of a fibre optic grid.

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1. INTRODUCTION

Digitalisation is an ongoing process which affects almost all dimensions of the economy. It is an umbrella term describing a wide range of changes of economic and social activities around digital communication and digital media. Mobile and cloud computing, the Internet of Things, artificial intelligence, machine learning, and big data are not only transforming business activities, but also generating new business models, which require new firm strategies and affect innovation, consumer behaviour and society in general.

In the economic domain, ICT technologies trigger structural transformations of business interactions that go along with changes in employment relations and required skills, customer relations, value chains and economic interactions in general. The diffusion of new digital technologies affects all sectors and enterprises of the economy. However, not all firms are equally able to benefit from this. Smaller firms generally adopt new technologies associated with digitalisation later than do larger firms. This is partly explained by structural differences in firm-level resources. The use of new technologies requires appropriate skills, resources and framework conditions. Here, structural policies can promote digitalisation by supporting the creation, adoption and effective use of digital technologies and related business models.

This study analyses the process of digitalisation of the Austrian economy against the background of Austria's policy objective to become a "European Innovation Leader". However, the available evidence and indicators suggest that Austria is lagging behind comparable European countries in the diffusion of ICT and the use of digital technologies, especially in the business sector (cf. Peneder et al. 2016, OECD 2017, Gönenc - Guérard 2017).

Digitalisation is commonly perceived as a central element in a modern knowledge-based economy. Hence, a review of the state of play of digitalisation in Austria will focus on the digital transformation of production, service and innovation activities and the related policy framework. In this report structural reforms relate to public policies and policy initiatives which foster these transformations to ensure higher growth, competitiveness and employment. Above and beyond presenting an overview of digitalisation and Austria's associated policy framework, this study focuses on three specific areas for structural reform:

(1) digitalisation of manufacturing and service sectors,

(2) digitalisation of small firms, micro-enterprises and entrepreneurship, and

(3) digitalisation of the workforce.

1.1. Structure of the study

The study is structured as follows: The next chapter provides a concise overview of the state of play of digitalisation in Austria, ranging from a re-assessment of the importance of ICT producing sectors in Austria to the diffusion of digital technologies. This part will provide a discussion of the most important policy measures that support ICT production and use in Austria.

The third chapter provides an overview of the progress of the digital transformation of industry and the services sector using a survey among manufacturing firms as starting point. The associated challenges and the opportunities for structural reforms are discussed against the background of the state of play and the impact of robotization, platforms and "Industry 4.0" initiatives in manufacturing and services.

The fourth chapter analyses policies and initiatives which support entrepreneurship and digitalisation processes among small firms and micro-enterprises. In a first step, it provides a literature survey on small firms and digitalisation. It continues with a detailed analysis of the state of play of digitalisation of SMEs and industry dynamics in Austria with a focus on the adoption of digital technologies. Challenges and policy priorities for the adoption of digital technologies by microenterprises are discussed in detail. Policy initiatives are discussed in light of the underlying evidence and their potential for structural reform is assessed.

The fifth chapter provides an analysis of the impact of digitalisation on the workforce and digital skills. First, it presents evidence on ICT skills in Austria by discussing the growth rate of ICT specialists and ICT skill demand by enterprises. The chapter continues with a discussion of the digitalisation of the education system, as well as crowd and gig-working in Austria. Here, the focus lies on existing labour regulations and social security regulations. Strengths and weaknesses of the Austrian system - in comparison to those of selected Member States - are assessed. The next part of the analysis uses a task-based approach to assess current labour market developments, and to project possible future developments. The chapter continues with an analysis of past labour market and job task trends that shows how the skill structure has changed since 1995 in Austrian manufacturing and service industries. This evidence, jointly with a task forecast across sectors, provides an important basis for the discussion of existing policy initiatives and structural reform needs, which aim at ensuring high levels of employability in the age of robots and digitalisation.

The sixth and last chapter summarises the most important findings of the four main chapters of the study. It presents both the specific and the most salient general results before it summarises policy aspects of digitalisation, which are also relevant for other EU Member States.

1.2. Contribution and main insights

A number of studies on digitalisation in Austria exist (e.g. cf. Peneder et al. 2016, OECD 2017, Gönenc - Guérard 2017), that document that Austria is lagging behind comparable European countries in the diffusion of ICT and the use of digital technologies. These studies focus on diffusion and innovation in digital technologies, as well as labour market outcomes and policy issues. This report builds on the insights from these studies and goes beyond their findings by presenting novel insights:

- Using patent data and data on the complexity of exports allowed to pin down the result that the Austrian ICT producing sector is small but shows good performance in terms of technological innovation and economic performance.

- The use of the same data together with evidence from the European Manufacturing Survey and the WIFO Industry Survey allowed to show that Austria is comparably strong in adoption and innovation of Industry 4.0 technologies.

- The study provides an analyisis of digitalisation in Austrian manufacturing at the firm level, where sources of competitive advantage, challenges to digitalisation and perceived policy priorities are linked to digital intensity.

- The use of a decomposition exercise allowed to purge digital technology adoption indicators from sectoral composition effects. This led to new insights into the weaknesses of the adoption of digital technologies in Austria.
- The exercise of linking digital intensity and diffusion of digital technologies with industry dynamics and SME indicators confirmed that a faster diffusion of digital technologies is associated with industry dynamics.
- Using survey data, the report provides a first analysis of investment in digital technologies and digitalisation challenges of microenterprises. The results indicate that microenterprises are subject to information gaps and uncertainty as regards digitalization.
- The linking of indicators of the task structure of occupations with indicators of digitalisation allows confirming that the changes in the Austrian task structure of work are in fact associated with the ongoing digitalisation and automatisation.
- Finally, the report links these results to the Austrian digitalisation policy environment and is able to identify areas of priority for structural reforms to support digitalisation in Austria.

The report has particular policy relevance, as Austria's current government has made digitalisation one of its priorities. At the end of January 2019, the government presented the new digitalisation initiative "Digital Austria" and announced that "2019 will be the digitalisation year" for Austria. During this year, new approaches, solutions and structural reforms will be developed to foster the progress of digitalisation. Thus, the present report is timely and its findings will be useful for policy makers in Austria.

1.3. Methods used in this report

This report draws on a rich variety of data sets and methods to study the effects of digitalisation processes on Austria's economy. Important data sources for the international comparisons are obtained from the European Commission (e.g., the DESI dataset). These are based on the Community Survey on ICT usage in households and by individuals, and the Community Survey on ICT usage in enterprises. In addition, data from the EUKLEMS, ITU, OECD and WIOD data as well as patent statistics constructed from EPO's Patstat database were used in the report. Moreover, Austrian national data was used for the analysis of the task-based approach in chapter 5. The evidence on the digitalisation of microenterprises in chapter 4 relies on surveys conducted among Austrian enterprises.[1]

1.3.1. Comparison countries

International data were used to compare Austria's performance with other countries. The main reference countries selected for this study are the "Innovation Leader" countries identified by the European Innovation Scoreboard 2018. The Innovation Leader countries in this Study are: Sweden, Denmark, Finland, United Kingdom, the Netherlands and Luxembourg. This choice was made because catching up with the group of Innovation Leader countries is one of the goals of Austria's RTI strategy.[2]

The performance of the Innovation Leader countries can be heterogeneous for digitalisation indicators, and might even be outperformed by other Member States. For this reason, in addition, Austria's performance was benchmarked against the EU-28 average and the best performing country in the EU. Considering the geographical and cultural proximity as well as the dense economic linkages Germany has also been included in the group of comparison countries. The Scandinavian countries, Sweden, Denmark and Finland, are also included in the group of comparison countries, as these countries are often considered as role models for ambitous innovation policies. Finland and Sweden joined the EU in 1995 together with Austria and as a the small open economy Denmark is comparable to Austria regarding its economic structure.Together this allows to develop a differentiated picture to compare and assess the Austrian performance in digitalisation. Table 1-1 provides an overview of the comparison countries.

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[1] These results were kindly made available by the aws and the Austrian Economic Chambers (AWS-WKO KMU-MARKETMIND survey 2018) and Arthur D Little and the Austrian Economics Chambers (KMU Index 2018). The authors wish to thank Norbert Knoll (aws) and Alexios Seibt (Arthur D Little) for providing access to these data and unpublished results based on these, as well as helpful insights from several discussions.

[2] https://www.bmvit.gv.at/innovation/publikationen/fti_strategie.html

Table 1-1: List of comparison countries

Country	Code	Country group	Rationale of inclusion
Sweden	SE	Innovation Leader (IL)	EIS Innovation Leader 2018
Denmark	DK	Innovation Leader (IL)	EIS Innovation Leader 2018
Finland	FI	Innovation Leader (IL)	EIS Innovation Leader 2018
Netherlands	NL	Innovation Leader (IL)	EIS Innovation Leader 2018
United Kingdom	UK	Innovation Leader (IL)	EIS Innovation Leader 2018
Germany	DE	-	Neigbouring, economically connected country, shares many structural traits with Austria
Best performing country		-	Best performing country in the EU

1.3.2. Policy analysis and expert interviews

The policy analysis draws on desk research, published and unpublished sources as well as a series of expert interviews. The aim of these background interviews was to better understand constraints and opportunities related to digital transformation in Austria. The general guidelines for all interviews were:

- To better understand the role of the key players and driving factors influencing the policy environment in Austria.
- To gain better insights into the main fields that possibly need structural reforms to foster digitalisation in Austria.
- To better understand the needs, challenges and policy background for digitalisation in microenterprises.
- To better understand the labour market of ICT specialists and the skill and qualification needs of enterprises.

The selection of interview partners was driven by the thematic coverage of this report. It was important to identify discussion partners who were able to contribute different perspectives and practical experience to support a comprehensive assessment of the various aspects of digitalisation in Austria. The availability of of interview partners was partly limited by the time constraints of the project. Overall, a total of 22 in-depth interviews were carried out. The insights were especially relevant for the assessment of policy programmes, the policy environment in Austria and information about ongoing and not yet launched, new initiatives. In addition, the expert interviews provided relevant insights into the topics of digitalisation of microenterprises and ICT specialists in Austria. These helped to validate the quantitative results and were highly valuable in assessing the policy initiatives that support digitalisation in Austria. The names of the interview partners are not mentioned in the main text, but the list of interview partners is provided in appendix A.

2. STATE OF PLAY OF DIGITALISATION IN AUSTRIA

2.1. Introduction

Since the early 2000s, information and communication technologies (ICT) have continued to advance, and growing connection speeds have supported the emergence of cloud and mobile platforms that are transforming how organizations use computing resources and exploit data. The use of digital technologies has the potential to increase the efficiency and effectivity of production processes. At the same time, a slowdown in labour productivity has been observed in about 90% of OECD countries since the turn of the millennium.

To a large extent, economic performance and growth of countries is determined by innovation and technological progress (Fagerberg 2000; Krüger 2008; Verspagen 2001). New technologies are changing national industrial structures which in turn affect productivity and growth (Peneder 2002). With globalization, high-income countries' competitiveness hinges on the quality and efficiency of their products and production processes. Technological catch-up and maintaining one's position at the technological frontier, thus, is a central policy goal. However, technological diffusion and adoption is neither cost-free nor unconditional and relies heavily on substantial and well-directed efforts (Lall 2005). Moreover, absorption capacities differ between countries (Cohen - Levinthal 2000; Narula 2004).

Austria aims at becoming a European Innovation Leader, but the available evidence and indicators suggest that Austria is lagging behind comparable European Countries in the diffusion of ICT and the use of digital technologies, especially in the business sector (Peneder et al. 2016; OECD 2017). Therefore, section 2.2 provides a comprehensive and broad description of the state of play of digitalisation in Austria and benchmarks the country against important reference countries or country groups. It is split into four broad subsections. The first provides an overview and analysis of the ICT adoption (DESI) indicators and Austria's position in the different rankings if the industrial specialisation of the country is properly accounted for. The second subsection briefly compares Austria's broadband infrastructure to its European peers. The third provides an overview of the digitalisation of the Austrian business sector along several dimensions, and the fourth subsection finally examines the relation between digitalisation and productivity growth.[3]

Section 2.3 provides a general discussion of the policy environment. It includes both general policy initiatives and aspects of public policies towards digitalisation, such as broadband infrastructure and e-government. Together with the analytical and specific results of the study this provides the basis for the discussion about policy reform needs. Thus, the relevant policies are discussed by drawing on policy documents and empirical evidence.

2.2. The digital transformation in the Austria economy

2.2.1. Austria in the Digital Economy and Society Index (DESI)

Technological diffusion can be measured by the number of firms adopting new technologies and their speed of implementation. The "Digital Economy and Society Index" (DESI) commissioned by the European Commission can be used to shed light on the adoption of digital technology in EU Member States[4]. The DESI indicator is a composite indicator that consists of the weighted average of five dimensions each measured by several sub-indicators: (1) connectivity (25%), (2) human

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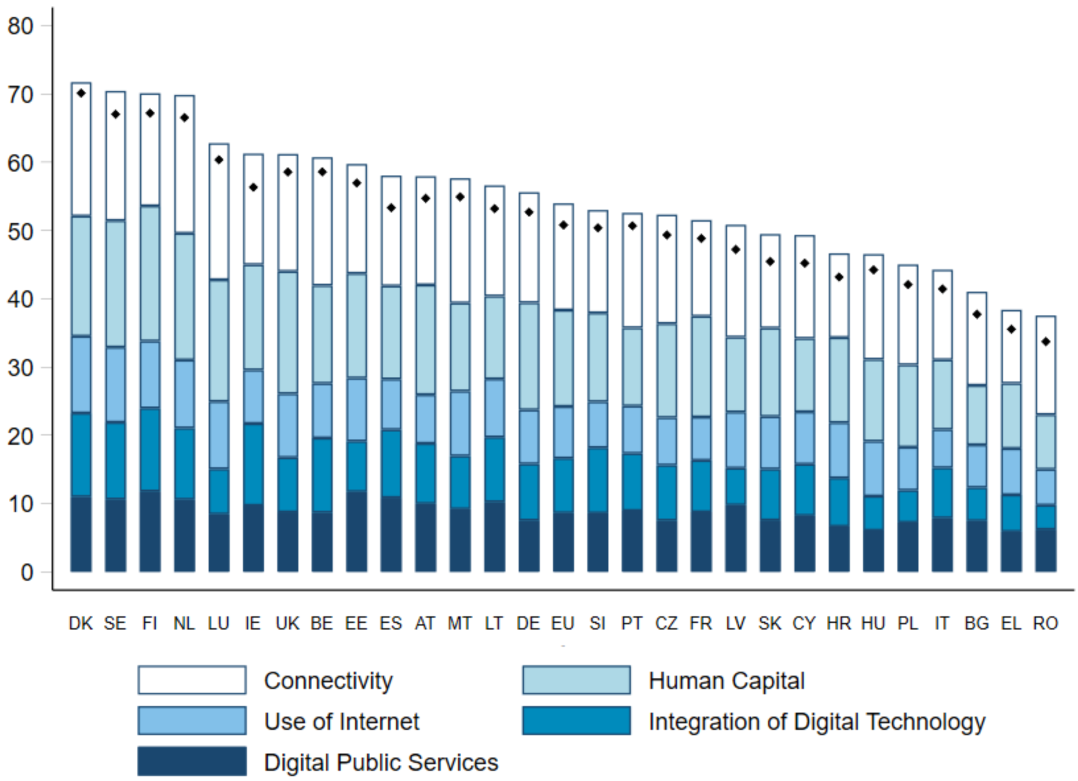
[3] The appendix to this chapter provides more details and evidence on some of the observations made in different parts of the section.

[4] https://ec.europa.eu/digital-single-market/en/desi

capital (25%), (3) use of internet (15%), (4) integration of digital technology (20%) and (5) digital public services (15%).

Figure 2-1: Digital Economy and Society Index (DESI), 2018 and 2017

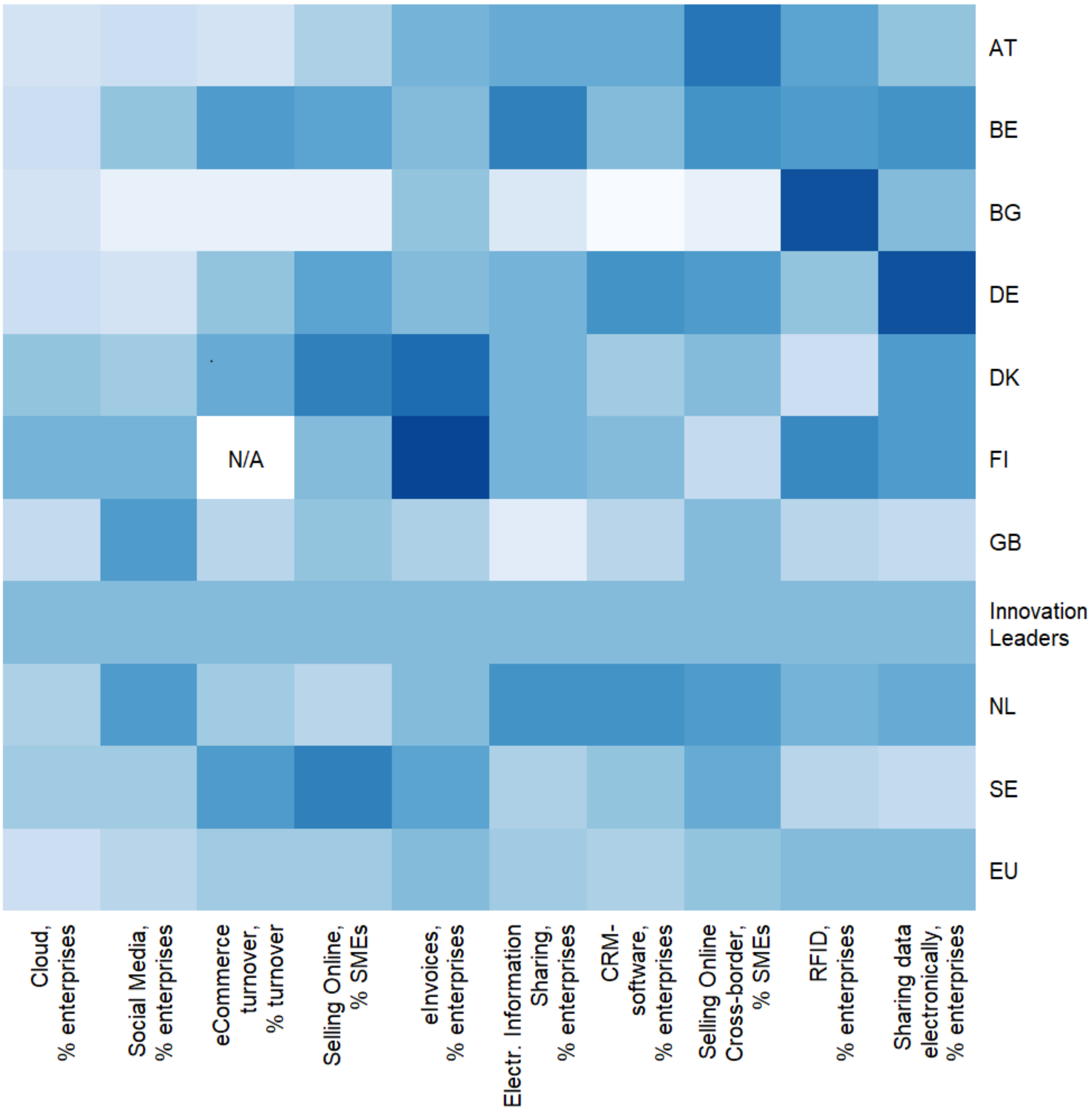


Source: European Commission, Digital Scoreboard. Note: DESI 2018 data are used to illustrate differences in the five DESI dimensions; diamonds represent the composite indicator values of the DESI 2017.

Austria has been ranking in the upper half of the EU Member States for years. In 2018, Austria was at 11th place, behind Innovation Leader countries such as Denmark, Finland and Sweden. While Austria performs well in human resources and digital public services, the other three dimensions, especially the use of internet services, are average.

To compare Austrian firms' technology adoption levels with other Member States, we focus on adoption statistics. We consider the use of cloud computing, social media, e-invoicing, electronic information sharing (e.g. ERP), Radio Frequency Identification (RFID), and eventually the percentage of small and medium-sized firms (SMEs) selling online, their percentage of turnover made from e-commerce and their percentage of cross-border online sales. In addition, customer relationship management (CRM) and electronic data sharing are included (not part of the fourth DESI dimension).

Figure 2-2: Use of digital technologies



Source: Eurostat, WIFO illustration. Note: Darker shades indicate a score above and lighter shades below the group of Innovation Leaders.

The heatmap illustrated in Figure 2-2 shows the distance of Austria's scores to the average scores of the country group of Innovation Leaders. Darker shades indicate that countries score better, and lighter shades that countries perform worse than the Innovation Leader average. The picture that emerges shows that Austria's business sector is adapting to new digital technologies relatively well. However, it is happening at a slower pace than in other innovation-intensive EU countries.

The performance is heterogeneous across technologies. With a few exceptions, the firms in the sample seem to perform better in technologies that could be interpreted as B2B rather than B2C. Austria performs well in the categories e-invoicing, electronic information sharing, the implementation of customer relationship management software, cross-border online sales and RFID. Its performance is below the Innovation Leaders in the categories cloud computing, social media use and the percentage of business turnover from e-commerce.

2.2.1.1. The effect of industry composition on ICT adoption

This heterogeneous picture of technology diffusion evokes the questions about structural characteristics. There are not only vast differences between industries but also between countries in their technology adoption. Especially the role of industrial specialisation has been linked to technology use (Van Pottelsberghe 2008). As a result, average ICT adoption statistics might mask important sectoral differences. Some countries with above-average adoption rates might perform well due to their industry composition, which may explain part of the country differences.

Table 2-1 illustrates differences between various sector groups in terms of the above-presented ICT adoption indicators in the EU28.[5] There are large differences in ICT use across sectors. Some technologies seem to be industry-neutral. For instance, in most sectors about one third or more of firms use enterprise resource planning (ERP) software, whereas other technologies such as radio frequency identification (RFID) are less common. Others seem to be sector-specific. Widespread use in manufacturing sectors can be observed for some technologies, like ERP or RFID. Other indicators, such as the percentage of firms using more than one type of social media or the use of Customer Relationship Management (CRM) software is more pronounced in service sectors like accommodation or accounting, scientific research and advertising.

To assess the extent to which industry composition affects country adoption rates of digital technologies we will disentangle country and sector effects, and "purge" aggregate ICT adoption indicators from the effect of industry composition. The results allow to differentiate between a sectoral composition effect and a genuine country-wide ICT adoption weakness. The decomposition implemented follows the literature on the aggregate relevance of sectoral differences of business R&D intensities (Van Pottelsberghe 2008; Mathieu – Van Pottelsberghe 2010; Reinstaller and Unterlass 2012).[6]

When "purging" the DESI indicators from the effect that industrial structures have on outcomes, two results are striking from an Austrian perspective:

- Austria is ranked third in the use of RFID. The new ranking based on the industry-purged RFID estimates perceives Austria at the 9th position in the EU.
- Austria gains five ranks according to the "industry-purged" ranking in terms of firms using social media ("new" rank: 12, "old" rank: 17).

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[5] The activity breakdown follows the NACE Rev. 2 groupings for enterprises with 10+ employees that is available in Eurostat's survey on ICT usage in enterprises: NACE section C10_18, C19_23, C24_25, C26_33, D35_E39, F41_43, G45_47, G47, H49_53, I55, J58_63, L68, M69_74, N77_82.

[6] The decomposition methodology and all regression results are provided in the Appendix A of this chapter.

Table 2-1: Sector-specific ICT use in the EU28 (DESI 2016/17)

Sector groups / ICT adoption indicators (Dim. 4)	Food, beverages, textiles, wood and paper	Coke, petroleum, chemical, plastics	Basic metals & fabricated metal products	Computer, machinery, motor vehicles, transport and furniture	Utilities (electricity, gas, water, waste)	Construc-tion	Wholesale trade	Retail trade	Land, water and air transpor t	Accomo-dation	Telecom., program-ming, video, publishing	Real estate activitie s	Accounting, scientific research and advertising	Travel agency, rental, security and administrative	All sectors (excl. financial activities)
% of enterprises with ERP software (2017)	34	54	46	52	43	21	41	28	25	25	49	33	34	26	34
% of enterprises using RFID technologies (2017)	6	7	6	6	8	2	5	6	6	3	3	2	2	3	4
% of enterpirses using social media (2017)	16	19	11	21	15	9	22	19	11	40	59	21	31	22	21
% of enterprises sending e-invoices (2016)	19	19	16	18	24	20	21	15	17	18	21	8	14	16	18
% of enterprises buying cloud computing services (2016)	9	12	7	11	13	9	12	11	10	15	43	17	24	16	14
% of enterprises having done electronic sales to other EU countries	9	9	6	10	2	1	11	10	8	59	12	4	5	5	9
% of enterprises selling online (at least 1% of turnover)	19	17	12	16	10	6	26	22	17	64	21	9	9	13	18
% of enterprises' total turnover from e-commerce (2017)	23	23	15	30	15	2	18	10	25	29	18	2	6	12	18
% of enterprises using CRM (2017)	27	40	32	39	36	20	41	30	24	44	62	36	41	33	33
% of enterprises sharing data electronically (2017)	16	20	17	19	16	11	28	27	19	15	20	11	12	11	18

Source: Eurostat.

In some cases, relative sector size, i.e. a country's specific industry composition, is correlated with the indicators. Table 2-2 shows the sign and significance of the coefficients of sector size. Given sector- and country-specific conditions, the share of firms using ERP, CRM and RFID is positively correlated with the sector size of manufacturing of coke and refined petroleum products, basic metals and fabricated metal products, except machinery and equipment, and manufacturing of computers, electrical and transportation equipment and repair and installation of machinery (C19-33), as well as with transportation (H49-53) and accommodation (I55). The use of cloud computing solutions, electronic information sharing or social media, larger shares of transportation and accommodation sectors are related to larger adoption rates of those technologies. Then again, simultaneously controlling for sector- and country-specific effects, larger shares of textile, wood and paper manufacturing (C10-18) or of energy sectors (D35-E39) correlate with lower usage rates of digitalisation indicators, like RFID.

In general, the size of food, wood and textile manufacturing sectors (C10-18), as well as the size of the energy and water supply industry (D35-E39), are negatively or not significantly correlated with the digitalisation indicators presented here, while the size of sectors such as the accommodation (I55) or transportation (H49-53) industry are positively related to the usage rates of most of the indicators used.

Table 2-2: Significant correlations between digitalisation indicators and sectors

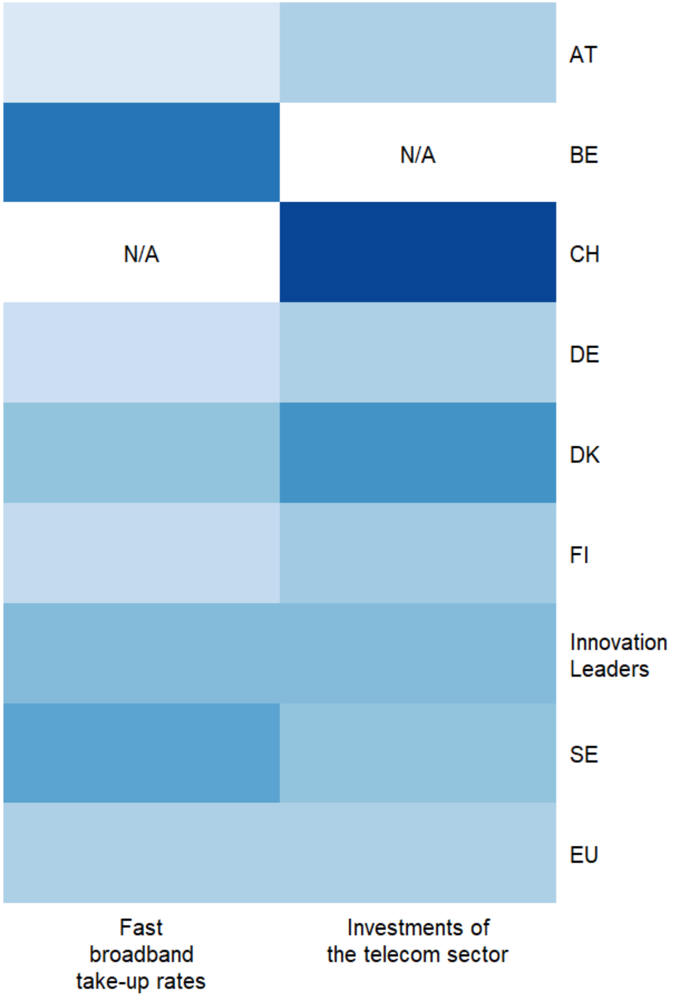
Variables	VAShare-C10-18	VAShare-C19-23	VAShare-C24-25	VAShare-C26-33	VAShare-D35-E39	VAShare-F41-43	VAShare-G45-47	VAShare-H49-53	VAShare-I55	VAShare-J58-63	VAShare-L68
ERP	---	+++	+++	+++				+++	+++	---	
RFID	--		++	+	---						
SM								+++	+++	+++	
EINV									+++		
Cloud					-			+++		+++	
CRM			++	++				+++	+++		
EIS				+	--				+		

Source: WIFO illustration. Note: The colour represents the sign of the coefficient: orange: negative, blue: positive; +/- $p < 0.1$, ++/-- $p < 0.05$, +++/--- $p < 0.01$; White elements represent coefficients insignificantly different from zero.

2.2.2. The broadband grid infrastructure

A number of studies have established positive effects of the use of broadband internet on economic outcomes, including aggregate growth, productivity and employment (Clarke – Qiang – Xu 2015; Hardy 1980; World Bank 2009; Norton 1992; Röller – Waverman 2001; Yoo 2014). To provide a picture of Austria's position in broadband related rankings, two indicators are used. First, the DESI indicator "Fast broadband take-up" that measures the percentage of households subscribing to broadband of at least 30 Mbps. This is a use-indicator, for which the availability of infrastructure is the necessary precondition (Friesenbichler 2012). The second indicator is the per capita investment into the telecom sector at the country level (Friesenbichler 2016). Austria underperforms in the broadband take-up rate. It ranks below the EU average and that of the Innovation Leaders, especially Sweden and Denmark.

Figure 2-3: Fast broadband take-up rates and per capita telecom investments



Source: DESI, ITU data, WIFO illustration. Note: Fast broadband take-up rates in 2017 in % of individuals aged 16-74). Total telecom investments p.c. mean value of the period 2005-2013.

Considering the per capita investments into the telecom sector (the mean for the period 2005-2013 is used), Austria's investment scores are close to the mean value of the EU as a whole, but lower than the Innovation Leaders. It is important to note that such rankings are not led by EU Member States in an EU-OECD-wide comparison. Non-EU countries such as Switzerland, Australia and Canada exhibit the highest per capita telecom investments, followed by Denmark and the United States.

2.2.3. Digitalisation in the Austrian business sector in international comparison

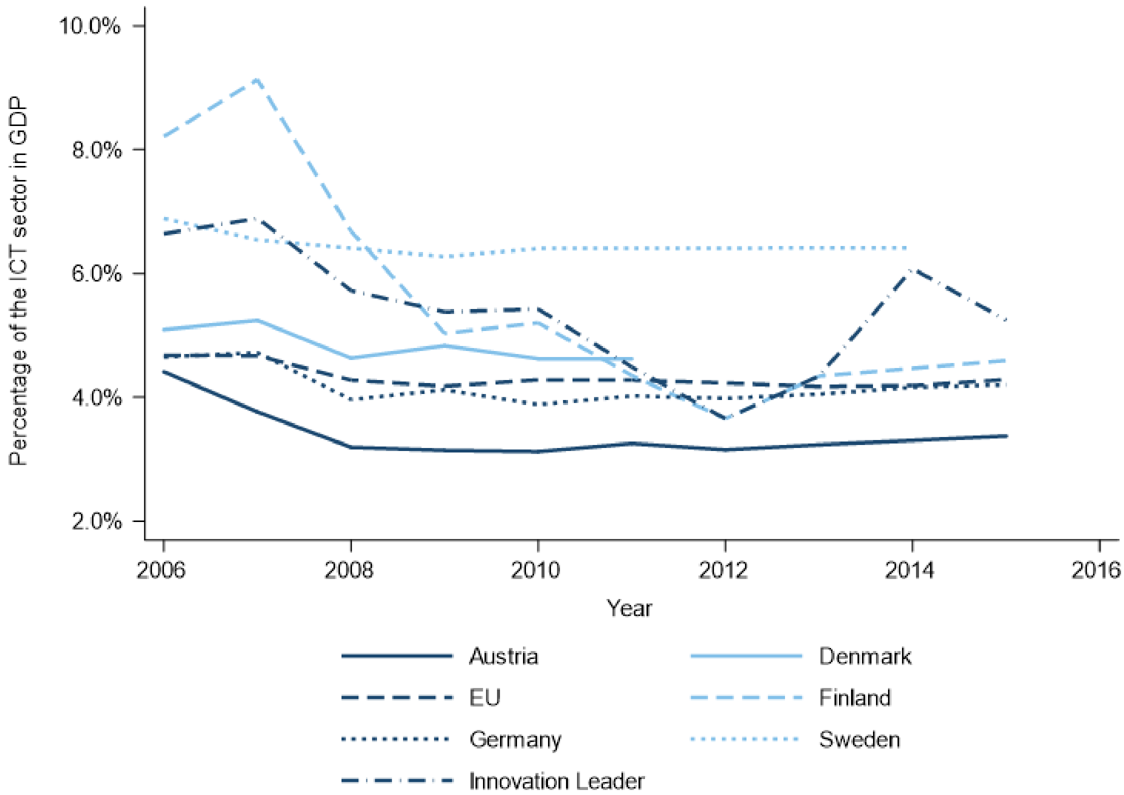
2.2.3.1. ICT-producing sectors

To assess the direct economic importance of ICT sectors in the EU Member States, first, a look at the size of these sectors is useful. Figure 2-4 illustrate the shares of the ICT producing sectors in total GDP of Austria, the EU average and the reference countries since 2006. On average, the average share of the ICT sectors in GDP ranges between 4 and 5% in the EU28 (2006: 4.7%, 2015: 4.2%) and has been rather stable for the last 10 years. Except for Finland, whose share dropped significantly from above 9% in 2009 to below the EU average in 2012, the percentages of the ICT sector have remained rather constant across EU countries.

Austria's share of the ICT sector in total GDP dropped in 2008 and since then has remained stable at slightly above 3%. Thus, Austria's share of the ICT sector is below that of Innovation Leader countries like the UK, but also clearly lower than the average share in the EU. However, a high share of ICT-producing sectors is not an exclusive characteristic of Innovation Leader countries. For instance, Hungary shows relatively high shares of ICT sectors in GDP (2015: 5.9%), which might reflect Hungary's embeddedness in innovation-intensive value chains because of foreign direct investment (Stehrer 2012; Janger et al. 2017; Lengyel - Cadil 2009).

A further breakdown of this evidence into ICT manufacturing and ICT services shows that the shares of ICT manufacturing have decreased in Innovation Leader countries for years, while simultaneously the importance of the ICT service sector has been rising. However, in Austria this cannot be observed, as the shares of the ICT service and manufacturing sectors, measured both by value added and employment, have remained stable at low levels.

Figure 2-4: Share of the ICT producing sector in GDP

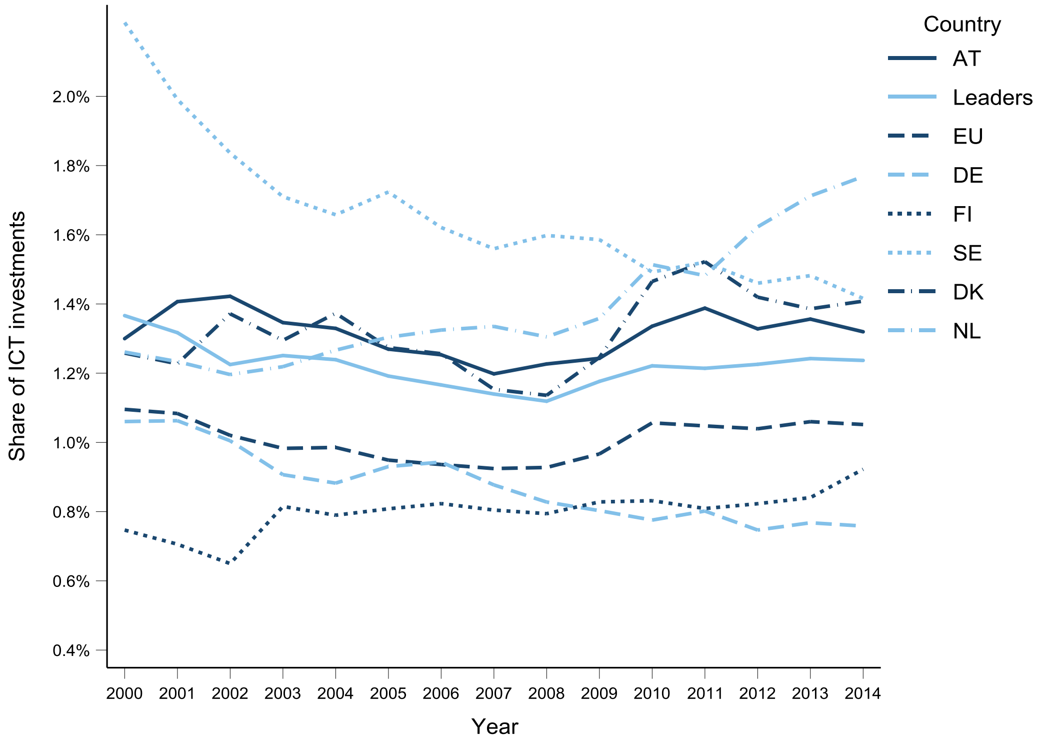


Source: Eurostat, WIFO illustration. Note: The ICT producing sector (2006 OECD definition) comprises the following industries (NACE Rev.2): (261) Manufacture of electronic components and boards, (262) Manufacture of computers and peripheral equipment, (263) Manufacture of communication equipment, (264) Manufacture of consumer electronics, (268) Manufacture of magnetic and optical media, (465) Wholesale of information and communication equipment, (582) Software publishing, (61) Telecommunications, (62) Computer programming, consultancy and related activities, (631) Data processing, hosting and related activities; web portals, (951) Repair of computers and communication equipment. VA at factor cost of ICT sector divided by VA at factor costs of all NACE sectors. To calculate the EU average missing values are replaced by three year moving averages wherever possible. Luxembourg, Netherlands, Cyprus and Ireland are not included in the EU averaged because of lack of data. The Innovation Leader average includes following countries: Sweden, Denmark, Finland, the United Kingdom (data for the Netherlands and Luxembourg are missing).

2.2.3.2. ICT investments and intermediaries of ICT-producing sectors

Declining ICT prices and improved quality of digital equipment and software has been a major source for productivity growth (Van Ark 2016). However, in most OECD countries ICT investment shares compared to GDP have been falling since the turn of the millennium. To some extent this might be due to slower growth in computers and communication equipment investments, while the share of software investments has remained stable in most OECD countries. In contrast, investments in ICT services have been growing (Van Ark 2016). The potential advantages of purchasing ICT services are the increase of business flexibility, scalability and the utilization of data capabilities, which can have a positive effect on efficiency and firm productivity.

Figure 2-5: Share of total ICT investments (% of total investments)



Source: EUKLEMS (Kirsten Jäger (The Conference Board) 2017), WIFO illustration. Note: The total ICT investments are the sum of investments in ICT equipment, software and databases and communication equipment. Data for Belgium, Croatia, Hungary, Poland, Latvia, Malta and Romania are (partially) lacking and for the calculation of the EU average only included whenever possible.

On average, ICT investment shares of total investments in the EU remained rather stable over the last years (Figure 2-5). While the Netherlands have strongly increased their ICT investments since 2011, Sweden's ICT investment share has been decreasing. In comparison, Austria's share of ICT investments in total investments is stable and clearly above the EU average, and also above the average of the Innovation Leader countries. A further breakdown[7] of ICT investment into the components of investment in computing equipment, in communications equipment and in computer software and databases shows that since the turn of the millennium investment shares in computing equipment have decreased significantly in the EU (2000:0.4%, 2014: 0.2%) and in the Innovation Leader countries (2000:0.5%, 2014: 0.3%), while Austria's investment share has always been below the EU average but above that of the Innovation Leaders.

Austria's share of investments in communications equipment of total investments (2014: 0.3%) is one of the highest in the EU and clearly above the EU average (2014: 0.2%). However, in line with most

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7 Reported in the appendix of the report.

other EU Member States the investment share in communications equipment is decreasing[8]. However, sector-level data provide some reasons for caution when interpreting these investment data. As there is a discrepancy between investment data for the telecommunications sector in Austria in the Structural Business Statistics and the EUKLEMS data, the investment in communications equipment in Austria might be overestimated. In contrast to investment in computing equipment, the average shares of investment in software and databases has been increasing over the last 15 years in the EU (2000:0.4%, 2014: 0.6%) and in Austria (from 0.6% in 2000 to 0.8% in 2014).

An analysis of the integration of the Austrian economy in value chains in industries with high or medium high digital intensity (Calvino et al. 2018) shows that Austria is not well-integrated into such value chains. If the integration is measured in terms of the value added share induced by (upstream) industries with high digital intensity in the Austrian sectors, Austria's value added shares are well below the EU28 average and far behind innovation leading countries like Sweden.

A further breakdown of these results by sector shows that the share of intermediate inputs from upstream sectors with high or medium-high digital intensity in an industry's value added has increased for most sectors in the Austrian economy over time. However, the dynamics were below the developments in the Innovation Leader countries.[9]

2.2.3.3. Trade of ICT-intensive sectors

Figure 2-6 show the export shares of high ICT-intensive sectors for Austria, some reference countries, the EU28 average and the group of Innovation Leaders. The comparison shows that Austria's export shares of high ICT-intensive sectors are comparatively modest, decreased between 2004 and 2010, and have not yet fully recovered. Since 2004 the gap between the EU28 average export shares of ICT-intensive sectors and Austria's export shares as well as between the average in Innovation Leader countries and Austria has widened.

Behind this pattern is a weakness of service exports. The Austrian performance in terms of ICT-intensive exports of goods was above average until the crisis in 2008/09. In 2008/09 Austria's export shares of ICT-intensive goods dropped to a level below the EU average (but still above the average shares of Innovation Leaders) and have stagnated since then. All Innovation Leader countries show export shares of goods in ICT-intensive sectors that have been below the EU average since 2008. In contrast, Austria's shares of service exports from ICT-intensive sectors was always below the EU average and far behind the shares of the Innovation Leader countries. While Innovation Leader countries have increased their service export shares slowly over time, Austria's share of service exports in ICT-intensive industries has stagnated since 2000, with the result of a widening gap between Austria's export shares of ICT-intensive services and those of Innovation Leader countries.

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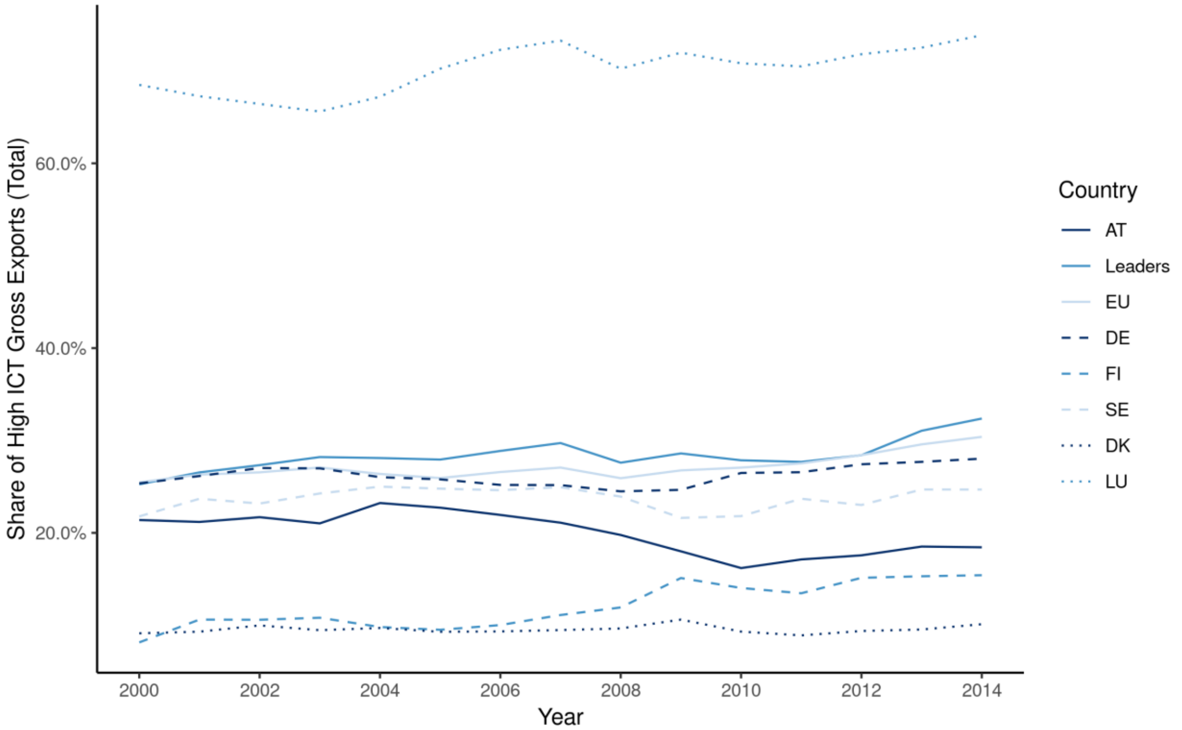
8 Spain whose shares increased to 0.4% in 2014 is an exception.

9 More detailed evidence is provided in the appendix.

Figure 2-6: Shares of exports of high ICT-intensive sectors between 2000 and 2014



Source: WIOD, WIFO calculation; Note: High ICT-intensive sectors (NACE Rev.2) include (Calvino et al. 2018): Transport equipment (29-30), Telecommunications (61), IT and other information services (62-63), Finance and insurance (64-66), Legal and accounting activities, etc. (69-71), Scientific research and development (72), Advertising and market research; other business services (73-75), Administrative and support service activities (77-82), Other service activities (94-96).

An analysis of the specific characteristics of ICT-intensive exports – relying on implicit measures of product complexity[10] – shows that compared to the EU average, the complexity of ICT-intensive products in Austria is high. Since 2011, in the EU only Germany has exported ICT-intensive products with similar or higher complexity than Austria. Especially in goods such as electronic integrated circuits, diodes, transistors, semiconductor devices and storage devices Austrian exports are characterised by high complexity scores. Thus, although Austria has a rather low export share of ICT-intensive products, the portfolio of these ICT-intensive products is remarkably complex.

2.2.3.4. ICT innovations and technological diffusion

The data on business expenditures on research and development (BERD) in ICT-intensive industries shows that while Austria is well below the Innovation Leaders and similar to or well below the EU average in manufacturing of computers and peripheral equipment and in computer programming, consultancy and related activities, it has the highest share of BERD in the manufacturing of electronic components and boards among the innovation leading countries and is well above the EU28 average.

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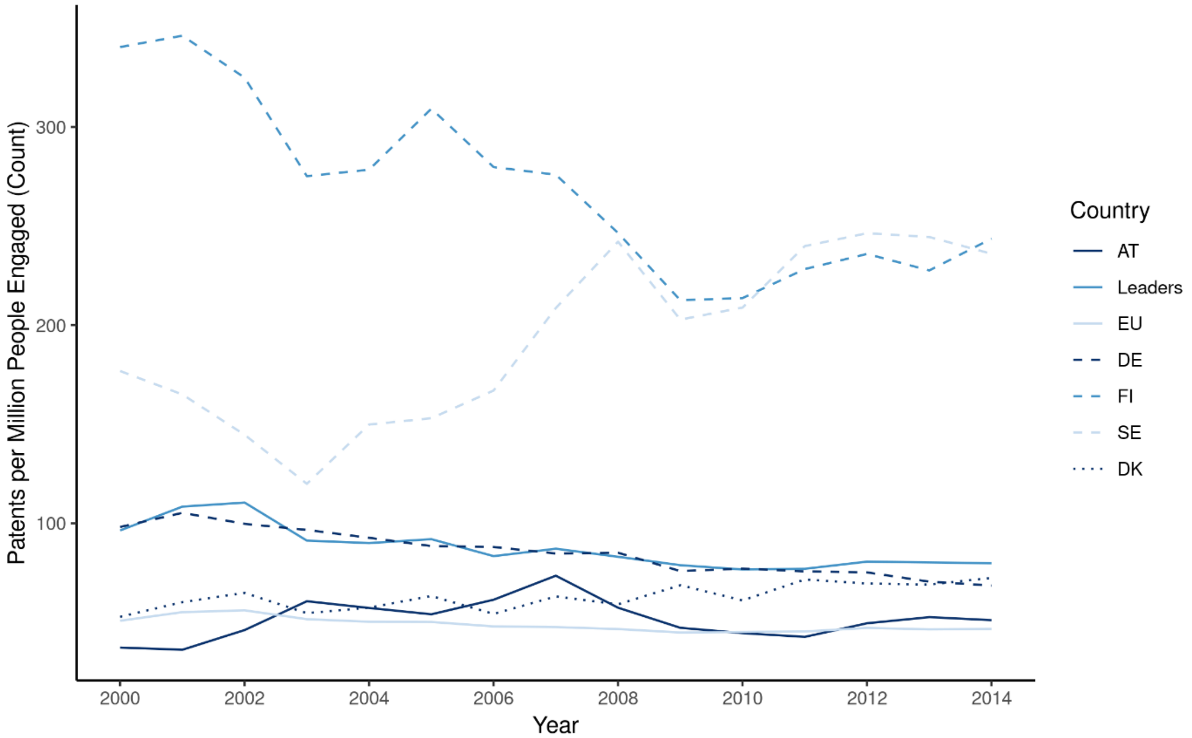
10 Details are provided in the appendix.

The share of BERD in this sector (more than 6%) is comparable to that of Malta, Ireland and Italy. This is primarily due to a few highly competitive firms acting in this sector, such as Infineon, AMS or Siemens. In contrast, Austria's share of BERD in computer programming and consultancy in total R&D expenditures is the second lowest in the EU (2015: 4.3% Austria, 2.9% Italy).[11]

Figure 2-7: Number of ICT patent applications per people engaged (in Mio.)



Source: PATSTAT, WIFO illustration. Note: ICT patents are defined following Inaba and Squicciarini, 2017. Data are missing for Luxembourg. The EU average and average of the Innovation Leaders are calculated without Luxembourg.

Looking at the output of ICT-related technology development in terms of patents filed at the European Patent Office (EPO) Figure 2-7 shows that in 2014, about 218 patents were filed by Austrian companies or inventors at the EPO, i.e. 51 patents per one million people engaged. This level of ICT patent applications per person is similar to the EU28 average. Among the Innovation Leader countries, Sweden and the Netherlands have recorded the highest numbers of filed ICT patents.

This aggregate figure may not be very informative as digital technologies cover many technological fields. A breakdown into technological subfields as proposed by Inaba and Squicciarini (2017), shows a more differentiated picture. In addition, one should distinguish between patent applications in digital technologies and patent applications in other technological fields (other than digital technology) that cite digital technology patents. While the former capture technology development mostly by ICT

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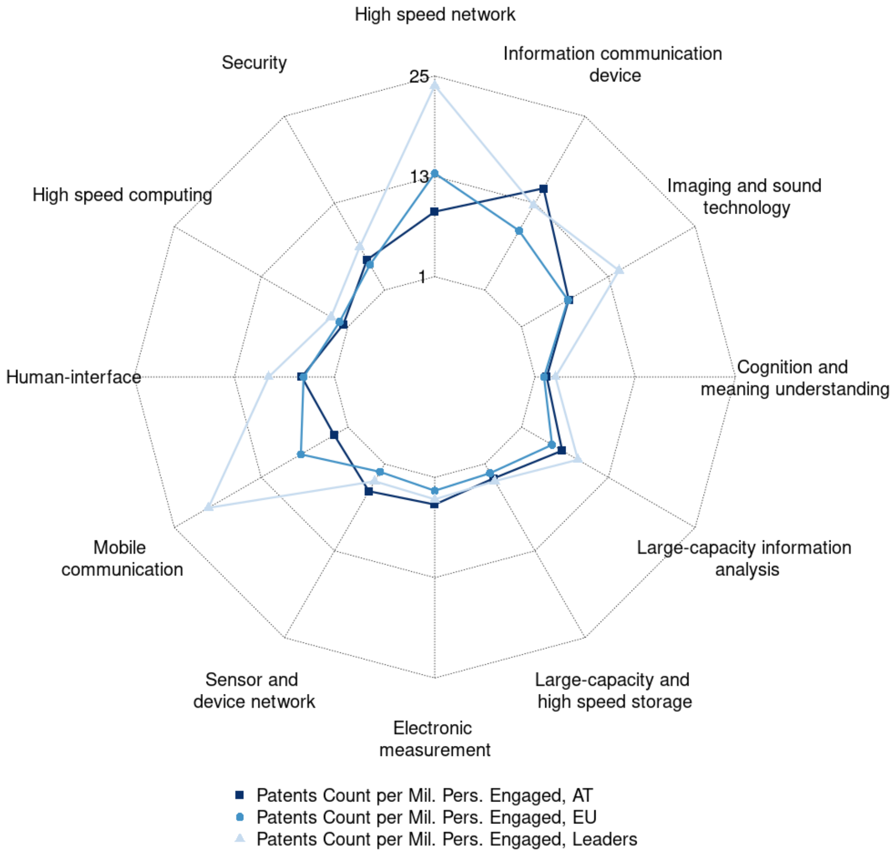
11 Details are provided in the appendix.

industries and are therefore likely to be heavily determined by industrial specialization, the latter capture the diffusion of digital technologies into other fields and measures the degree of digitalisation of technologies developed in a country.[12]

Figure 2-8: Average number of patent applications across digital technologies (per Mio. persons engaged; 2008-2014)



Source: PATSTAT, WIFO illustration. Note: ICT patents are defined following Inaba and Squicciarini, 2017. Data are missing for Luxembourg. The EU average and average of the Innovation Leaders are calculated without Luxembourg.

Figure 2-8 shows the average number of patent applications at the EPO per one million persons engaged. On average, the numbers of patents in the EU seem to be rather equally distributed across different technological fields, though a peak in information communication devices is observed. Innovation Leader countries, in contrast, have clearly specialised in high-speed networks, mobile

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12 While there is a body of literature showing that citations to other patents are prevalently included by patent examiners and should therefore not be interpreted as factual knowledge spillovers (cf. Alcácer et al. 2009, Reinstaller - Reschenhofer 2017 for a discussion) this aspect is irrelevant for the current exercise as the interest lies here in identifying inventions that use digital technologies irrespective of direct spillovers between inventors.

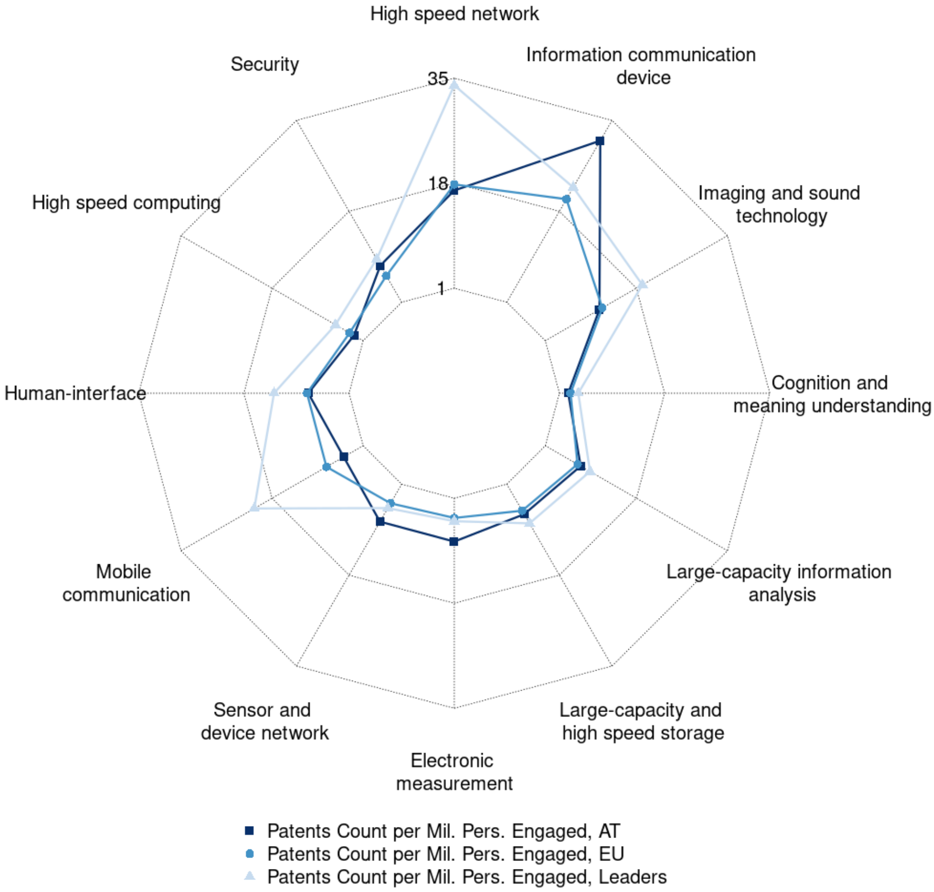
communications (partly driven by Finland) as well as in imaging and sound. In comparison, Austria's patent applications show a concentration in technologies related to information communication devices. The observed pattern remains the same if citation-weighted counts adjusting for patent quality are used instead of patent counts.

The industry-level breakdown for Austria shows that for ICT patents the highest per capita counts in any sector are observed in computer, electronic and optical products (26) and electrical equipment (27). In these two industries the number of patent filings has increased slightly over time. Another sector in which digital technologies are invented is the machinery and equipment sector (28) where patenting activities have decreased in the recent past. Other sectors with considerably more limited inventive activity in digital technologies are the transport equipment industry (29-30), other manufacturing including computer repairs (31-33), and IT and information services (62-63).

Figure 2-9 shows the average numbers of patents that cite a patent in one of the listed digital technology classes. For instance, in Innovation Leader countries per one million persons engaged approx. 35 patents listed in non-digital technology classes include citations to high-speed network patents. Peaks indicate ICT technologies that are more often referred to in other patents that do not deal with digital technologies themselves. This indicator can be interpreted as a measure of technological diffusion of new ICT technologies to other technological fields. Compared to the EU28 or the Innovation Leaders, Austria's non-ICT patents more often cite patents listed in the class "information and communication device". Non-ICT patents applied by Innovation Leader countries more often cite high-speed network, imaging and sound and mobile communication technologies. An analysis of citation-weighted patent counts shows that considering the impact of patents in terms of citations does not affect the relative position of Austria in relation to the Innovation Leaders in the technological subfields.

An industry-level breakdown of patenting in non-ICT technologies citing ICT patents reveals that patenting activities of the Austrian business sector are below the levels of Innovation Leaders. However, once patent quality is considered, the gap narrows considerably over time. In single technological domains Austria performs even better than the Innovation Leader average. This is especially true for the machinery and equipment industry. As for ICT patents, the overall patenting gap for non-ICT technologies using digital technologies is mostly driven by the lower patent intensity of the computer and electronic/optical products industry (26) compared to the Innovation Leaders. In the field of emergent digital technologies and here especially in the fields related to the Industry 4.0 paradigm, results indicate that Austrian companies intensely cite such technologies in their own non-ICT patents. This suggests they integrate such technologies in their own technology development.

Figure 2-9: Average number of non-ICT patents citing patents of different ICT technologies (per Mio. persons engaged; 2008-2014)



Source: PATSTAT, WIFO illustration. Note: ICT patents are defined following Inaba and Squicciarini, 2017. Data are missing for Luxembourg. The EU average and average of the Innovation Leaders are calculated without Luxembourg.

2.2.4. ICT and productivity

2.2.4.1. Cross country evidence

The use of digital technologies has the potential to increase the efficiency and effectivity of production processes. Therefore, a positive connection between the invention, use and adoption of digital technologies and a country's productivity is often assumed.

It is widely acknowledged that the use of broadband promotes dynamic growth and employment (Kretschmer 2012; Qiang – Rossotto – Kimura 2009; Reinstaller 2010, Friesenbichler 2012; see Friesenbichler 2016 for a summary in German). It reduces transaction costs and allows the launch of innovative services. These productivity-enhancing effects can be observed at the firm level, at the industry and at the macroeconomic level (Airaksinen et al. 2008). According to a World Bank study, a

10% increase in broadband penetration leads to an increase in GDP per capita of 1.2 percentage points (Qiang – Rossotto – Kimura 2009). Crandall – Lehr – Litan 2007 have estimated an increase in employment growth of 2% to 3% for the US when broadband penetration increases by 10%. In addition, broadband also has a positive impact on consumption, especially through the faster availability of information and the resulting reduction in transaction costs. For example, Greenstein – McDevitt (2012) show that the switch from switched lines to broadband connections in the USA has created between 4.8 and 6.7 billion US dollars in additional consumer surplus.

Input-output models offer an approach for quantifying the economic effects of the expansion of data grids. These show the effects in several stages. They initially consider the first-round effects arising from the construction of the infrastructure. For example, Atkinson - Castro - Ezell, 2009, calculate for the USA that investments of US$ 10 billion would directly create 64,000 jobs. For Austria a similar analysis has shown that an additional investment of one billion euros would result in additional € 1.2 billion in value added and create 14,700 jobs (Peneder et al. 2016). These first-round effects are supplemented by second- and third-round effects. Studies show that the estimated level of employment growth fluctuates considerably (Katz – Suter, 2009). However, lower transaction costs may also accelerate structural change, that can have negative effects at the regional (and the country) level. Thus, the medium to long-term effects of broadband use can be ambivalent (Firth – Mellor 2005).

At the firm level there the empirical evidence suggests, that the positive effects of broadband on productivity can only be realised when accompanied by complementary investments in organisational capital (Fabling – Grimes 2016; Andrews – Nicoletti – Timiliotis 2018). What is masked by the aggregate productivity developent is the widening performance gap between frontier firms and laggards (Andrews – Criscuolo – Gal 2016; Decker et al. 2016). This gap is not only based on frontier firms pushing the technological boundaries but is also associated with a decreasing rate of technology adoption of laggard firms (Andrews – Criscuolo – Gal 2016). Market structures might have affected this process further. Increasing survival probabilities in spite of low relative productivity are observed by (McGowan – Andrews – Millot 2017). As a result, lower competition implies less pressure to adopt to new technologies (Criscuolo – Gal – Menon 2014). The deterioration of productivity could in part be due to slow real investments in IT that no longer boost overall output per worker. Misallocation of IT investments might restrain substantial returns from ICT at the aggregate level (Byrne – Corrado 2017; Van Ark 2016; Dhyne et al. 2018).

Here, we analyse in a first step the correlation between productivity and the different digitalisation indicators used before. Fixed effects are included to control for industry and country specificities. The following regressions are estimated:

$$LabourProd_{ijt} = \alpha + \delta_j Digi_{ijt} + \beta_{ij}(I \odot J) + \beta_t T + \epsilon_{ijt}, \qquad 2\text{-}1$$

$$TFPGrowth_{ijt} = \alpha + \delta_j Digi_{ijt} + \beta_{ij}(I \odot J) + \beta_t T + \epsilon_{ijt}, \qquad 2\text{-}2$$

where *LabourProd* is the labour productivity level in sector *j*, in country *i* at time *t* and *TFPGrowth* denotes the respective annual growth rate of the total factor productivity (TFP). *T* represents time-fixed effects and $I \odot J$ are elementwise multiplications of the binary sector and country indicators controlling for sector-country specificities. Thus, differences in productivity between sectors (e.g. manufacturing vs. service sectors), between member States (new MS vs. old MS) are controlled for, but also national regulations targeting specific sectors that affect productivity are captured by the fixed effects.

Variation in time is necessary to reasonably use sector-country fixed effects. For short panels we need to use a specification that includes time-, country- and sector-specific effects separately. This is particularly relevant for the ICT adoption indicators since they cover a shorter period (2009 to 2017) and are not available in every year:

$$LabourProd_{ijt} = \alpha + \delta_j Digi_{ijt} + \beta_i I + \beta_j J + \beta_t T + \epsilon_{ijt}, \qquad 2\text{-}3$$

$$TFPGrowth_{ijt} = \alpha + \delta_j Digi_{ijt} + \beta_i I + \beta_j J + \beta_t T + \epsilon_{ijt}, \qquad 2\text{-}4$$

Table 2-3 shows the conditional correlations that have been estimated based on those four equations. While none of these results can be interpreted as causal, the inclusion of the sector-country fixed effects ensures that most fixed influences that affect the performance of a certain sector in a specific country have been filtered out. A significant and positive correlation is observed between productivity growth and the share of investments in computing equipment, the share of total ICT investments, the share of value added from ICT-producing sectors used along the value chain as well as the share of ICT-intensive sectors in total exports. However, no significant correlation between these digitalisation indicators and labour productivity levels can be observed.

By using three different fixed effects (one for each time, country and sector), average differences, for instance due to general productivity variations between sector groups, are controlled for. The share of firms using ERP, but also the share of firms using social media, buying cloud computing and sharing data electronically with their suppliers and/or customers is significantly positive associated with productivity levels. Moreover, many of the variables also show a significantly positive association with productivity growth rates, such as the share of firms using social media, cloud computing algorithms and the share of firms connected to fast-speed internet.

Table 2-3: Correlation between different digitalisation indicators and productivity measures conditional on various fixed effects

	Labour Productivity based on working hours	Labour Productivity based on persons employed	TFP growth (VA per hour worked)	TFP growth (VA per employed)	Fixed effects
Share of investments in communications equipment (% of total investments)	39.980	70,331	0.1130	0.1160	(Sector x country), Time
Share of investments in computing equipment (% of total investments)	8.703	17,725	0,2220**	0,2230**	(Sector x country), Time
Share of investments in computer software and databases (% of total investments)	-7.383	-12,682	0.0250	0.0328	(Sector x country), Time
Share of total ICT investments (% of total investments)	0.936	2,315	0,0792*	0,0850**	(Sector x country), Time
Share Intermediates from ICT-producing sectors in total Interm.	-59.900	-84,279	-0.1470	-0.1310	(Sector x country), Time
Share of value added from ICT producing sectors in total value added	-34.880	-5,685	0.2930	0,3250*	(Sector x country), Time
Share of ICT-intensive sectors in total exports	26.290	58,432	0,341**	0,3790**	(Sector x country), Time
Share of ICT-intensive sectors in total exports (VA)	40.260	80,236	0,759***	0,8520***	(Sector x country), Time
Number of patent applications across digital technologies (per Mio. persons engaged.)	-0.084	-134.6	0.0002	0.0002	(Sector x country), Time
Number of citation-weighted patent applications of different ICT technologies (per Mio. persons engaged)	-0.049	-84.3	0.0001	0.0001	(Sector x country), Time
Number of non- ICT patents citing patents of different ICT technologies (per Mio. persons engaged)	-0.062	-80.9	0.0000	0.0000	(Sector x country), Time
Number of citation-weighted non-ICT patents citing patents of different ICT technologies (per Mio. persons engaged)	-0.050	-59.7	0.0003	0.0003	(Sector x country), Time
Enterprise Resource Planning, % enterprises	0,399***	464,8*	-0.0004	-0.0004	sector, country, time
Radio Frequency Identification, % enterprises	-0.009	333.6	0.0019	0.0021	sector, country, time
Social Media, % enterprises	1,113**	1,516	0.0019	0,00203*	sector, country, time

E-Invoices, % enterprises	-0.081	152.4	-0.0014	-0.0015	sector, country, time
Cloud Computing, % enterprises	1,278**	2,021	0,00274*	0,00283*	sector, country, time
Customer Relationship Management, % enterprises	0.445	134.1	0.0002	0.0002	sector, country, time
Electronic Data Sharing, % enterprises	0,462**	753,8*	-0.0002	-0.0001	sector, country, time
Fast-speed internet connection > 100 Mb/s, % enterprises	0.016	-1,007	0,00153**	0,0015**	sector, country, time

Source: Eurostat, WIOD, PATSTAT, EUKLEMS; WIFO calculations.

2.2.4.2. Digitalisation and firm-level productivity dynamics

The evidence presented in the previous sections suggests that the Austrian business sector is trailing Innovation Leaders both in the adoption and generation of digital technologies, whereas several of these indicators are positively correlated to total factor productivity growth. This section will analyse, for the few selected indicators that are available at required levels of granularity, how the diffusion and generation of digital technologies correlate with total factor productivity growth at the firm level.

The theoretical framework draws on neo-Schumpeterian models of endogenous growth (e.g. Acemoglu et al. 2006). In these models, productivity growth depends on both the ability to catch up and the ability to innovate, with the importance of the latter increasing as the country or industry gets closer to the technological frontier. If technological knowledge can flow across countries, then productivity growth in follower industries is a function of the gap between the productivity level of an industry in a country and the world technological frontier in that specific industry. Industries lagging behind the technological frontier can promote productivity by adopting or imitating more advanced technologies available on the market. However, the closer they move to the frontier, the fewer such opportunities exist, and the development of own new technologies (innovation) becomes more important. This process implies that productivity growth at the company level is a function of productivity growth by the frontier firms in an industry, the distance of the observed company to this technological frontier as well as country-, industry- or company-specific activities that influence its productivity growth.

In a first step the analysis will assess whether companies from sectors with high or medium high digital intensity show systematic differences in firm level total factor productivity growth relative to companies from other sectors. Given the generally observed growth dynamics of digital technologies, the expectation is that companies operating in these sectors show a systematically higher total factor productivity growth.

In a second step, the analysis will assess whether companies operating in sectors where data show a strong integration into value chains with upstream industries with high or medium high digital intensity and whether companies actively developing digital technologies or technologies using digital technologies show systematic differences in productivity growth. From the sector-level analysis, we would expect that companies in sectors with a stronger integration into global value chains with industries with high digital intensity should show higher firm-level productivity growth. As the link between patenting activity and firm-level productivity is more clearly defined in this analysis, one should expect a significant association between the technological activities of companies and their total factor productivity growth.

The econometric analysis follows Arnold – Nicoletti – Scarpetta (2008). We estimate regressions using firm level data for 24 European countries for the years 2010, 2012, 2014, and 2016. The analysis will isolate potential effects for Austria to assess whether Austrian companies show a systematic advantage or disadvantage compared to companies with similar characteristics in other countries. This hints at country-specific effects on firm-level productivity growth. The firm-level data are drawn from the Amadeus (Bureau van Dijk) firm-level data base. For the current analysis, a balanced panel has been constructed, i.e. the data set consists of companies for which data for all four points in time were available.[13] These data have then been matched to company specific patent records drawn from EPO's Patstat database and sector-level evidence for the embedding of a sector in value chains comprising industries with high or medium high digital intensity measured in terms of the value added share of these sectors in sector value added and calculated from the WIOD data base.

The patent indicators as well as the value added share indicator have been presented and discussed in the previous sections of this report. The patent data represent citation-weighted company level patent stocks per employee. In one set of regressions these per capita patent stocks have been split into patents stocks of patents that are not related to ICT technologies (neither as main technological field nor as patent citing other patents from technological fields associated with digital technologies) and ICT-related patent stocks.

The estimated baseline equation examining the impact of the diffusion and generation of digital technologies has the following specification:

$$\Delta TFP_{i,s,c,t} = \alpha_0 + \alpha_1 \Delta TFP_{Fs,t} + \alpha_2 GAP_{i,s,c,t} + \alpha_2 Z_{i,s,c,t} + \alpha_4 X_{i,s,c,t} + \gamma_s + \gamma_{c,t} + +\varepsilon_{i,s,c,t} \qquad \text{2-6}$$

where $\Delta TFP_{i,s,c,t}$ denotes the total factor productivity growth of firm *i* in sector s in country *c* at time *t*, while $\Delta TFP_{Fs,t}$ stands for total factor productivity growth at the frontier defined as the 99.5 percentile of all firms in the data set active in sector s at time t across countries.[14] $GAP_{k,t}$ denotes the log difference of the TFP levels between the observed firm and the frontier in the sector in which the firm is mainly active ($\ln TFP_{i,s,c,t}$ -$\ln TFP_{Fs,t}$). The expected sign for α_1 is positive, as TFP growth in the leading industries should exert a pull effect on TFP growth on other companies in the sector across countries as the technological set grows larger and new technologies diffuse. Given its definition the

[13] While Amadeus provides a comprehensive firm level data set with detailed data on company level performance, finance and other general characteristics, it should be kept in mind, that these data are not sampled according to statistical criteria and therefore are not necessary representative of the underlying firm population in a country. This is particularly true for Austria, where the data set is heavily biased towards larger companies. The results presented here should therefore be taken as being indicative and not necessarily representing the true characteristics of the firm population in each of the countries included in the analysis.

[14] TFP and TFP growth have been calculated using a superlative index where the TFP level in a firm has been calculated as a function of firm level value added and the two input factors labour and capital. See Arnold – Nicoletti – Scarpetta (2008) for details.

expected sign of α_2 is negative, as sectors that are farther behind the technological frontier should experience higher rates of TFP growth.

Variable $Z_{i,s,c,t}$ is a placeholder for indicators capturing our variables of interest. In the first set of regressions this is a categorical variable indicating whether the observed firm is part of a sector with high or medium high digital intensity. This specification can be used to study systematic differences in firm-level total factor productivity across sector types and to identify specific effects for Austrian companies. In a second set of regressions indicators capturing either the diffusion or generation of digital technologies are used.

As an indicator for technology diffusion we use the share of value added from industries with high or medium high digital intensity in sector value added. Unfortunately, firm-level indicators are not available. To avoid biased estimates clustered standard errors are used. To capture firm-level technology generation, citation-weighted patent stocks for ICT or ICT using technologies per employee are used.

Finally, the equation includes a set of company-level control variables $X_{i,s,ct}$ such as non-ICT related patent stocks per employee to control for the general level of technological activity of a company or firm size to control for firm size effects. In addition, the regressions include sector and country-time dummies γ_s and $\gamma_{c,t}$, to control for general unobserved sector-level and country- and time-specific characteristics.

Table 2-4 presents the first set of results. Models (1) to (3) allow studying whether companies from sectors with high or medium high digital intensity systematically differ in their total factor productivity growth compared to companies from other sectors. The results show that if we do not explicitly distinguish between companies from the manufacturing and the service sector, no specific effect for these broad sector groups can be identified. However, once we distinguish between manufacturing and services a statistically significant difference emerges manufacturing companies from sectors with high or medium high digital intensity experiencing on average an annual TFP growth that is four percentage points higher than for manufacturing companies that are not part of these sectors. For the service sectors the effect is statistically not different from zero. This is partly due to the fact that almost all service sectors included in this analysis (telecommunication and knowledge intensive business services) have either high or medium high digital intensity and the categorical variable is therefore not capable of capturing significant differences.

The regression models (4) to (6) allow assessing the existence of specific and systematic effect on TFP growth for Austrian companies in sectors with high or medium high digital intensity compared to non-Austrian firms. This is examined by interacting the categorical variable on the broad sector group with the dummy variable for Austria. The overall effect for Austria then results from the linear combination of the interacted indicator with the categorical variable. This result is reported in the bottom of the regression table.

The results largely mirror those observed for the global firm population. There is only a systematic difference in firm-level performance for companies with high digital intensity in the manufacturing sector. The result would hint at an Austrian bonus, as the estimated coefficient is larger for Austrian manufacturing firms than for manufacturing firms with high or medium high digital intensity globally. However, some caution about this result is in place as the number of cases in the Austrian subsample is small (105 manufacturing companies of which 47 in H or MH sectors; 20 service companies of which all in H or MH sectors) and the interaction effect is not significant.

However, a relatively robust result that emerges from this analysis is that in the manufacturing sector companies in sector with high or medium high digital intensity show on average higher TFP growth at the company level and this is also confirmed for Austria.

Table 2-3 presents the results of an analysis of the impact of the diffusion and generation of digital technologies on firm-level total factor productivity growth. The analysis has been carried out with a standard panel fixed effect estimator and clustered standard errors to avoid biased standard errors due to the inclusion of sector-level indicators in the regression. The regression includes the share of sector-level value added from sectors with high or medium high digital intensity as a sector-level proxy for the diffusion of digital technologies, the stock of ICT patents (both ICT patents and ICT using patents) per employee, as well as an interaction effect between these two indicators to consider possible complementarities between the diffusion and creation of digital technologies. Lagged values of all these indicators are regressed upon firm-level total factor productivity growth. All regressions control for sector, time and country effects as well as firm size and the level of patenting in fields outside ICT.

Table 2-4: Firm-level TFP growth in sectors with high and medium high digital intensity

Firm level productivty growth for sectors with high digital intensity						
	Outlier robust regression - base line			Outlier robust regression - Austria		
Dependent variable: MFP growth firm	(1) All	(2) Manufacturing	(3) Telecommunication and KIBS	(4) All	(5) Manufacturing	(6) Telecommunication and KIBS
MFP growth frontier	0.134*** (0.006)	0.169*** (0.018)	0.050** (0.020)	0.134*** (0.006)	0.169*** (0.018)	0.050** (0.020)
Lagged gap to frontier	-0.114*** (0.000)	-0.180*** (0.001)	-0.073*** (0.000)	-0.114*** (0.000)	-0.180*** (0.001)	-0.073*** (0.000)
Sector with H-MH digital intensity	0.020 (0.018)	0.041*** (0.012)	0.000 .	0.02 (0.018)	0.087*** (0.011)	0.000 .
Sector with H-MH digital intensity x Austria				0.005 (0.017)	0.03 (0.026)	-0.033 (0.152)
Firm size	-0.006*** (0.000)	-0.007*** (0.000)	-0.008*** (0.001)	-0.006*** (0.000)	-0.007*** (0.000)	-0.008*** (0.001)
Constant	-0.286*** (0.015)	-0.165*** (0.025)	-0.145** (0.069)	-0.289*** (0.018)	-0.388*** (0.028)	-0.111 (0.167)
Country-time dummies	Y	Y	Y	Y	Y	Y
Sector dummies	Y	Y	Y	Y	Y	Y
Observations	599,697	174,901	53,625	599,697	174,902	53,625
Adj. R2	0.57	0.41	0.67	0.57	0.41	0.67

Total effect of being part of a sector with H-MH digital intensity on firm level multifactor productivity in Austria			
Coefficient	0.024	0.116***	-0.033
Standard error	(0.025)	(0.028)	(0.151)

Source: Amadeus (Bureau van Dijk) and OECD industry ICT classification, WIFO calculations. Note: + p<0.15, * p<0.10, ** p<0.05, *** p<0.01. Standard in brackets below coefficients.

Table 2-5: Firm-level TFP growth in sectors and the diffusion and production of digital technologies

Digitalisation and firm level productivity growth						
Fixed effect panel regression (clustered standard errors)	All countries			Austria		
Dependent variable: MFP growth firm	(1) All	(2) Manufacturing	(3) Telecommunication and KIBS	(4) All	(5) Manufacturing	(6) Telecommunication and KIBS
MFP growth frontier	0.398** (0.159)	0.580*** (0.150)	0.351* (0.188)	0.912** (0.380)	1.147** (0.423)	-2.206*** (0.263)
Lagged gap to frontier	-1.300*** (0.010)	-1.309*** (0.011)	-1.290*** (0.023)	-1.102*** (0.103)	-1.037*** (0.091)	-1.475*** (0.172)
Lagged value added share from industries with H-MH digital intensity	0.085 (0.221)	0.085 (0.233)	0.461 (0.373)	-1.75 (2.403)	-0.39 (2.286)	9.181** (3.751)
Lagged citation weighted patent stock per employee ICT/ICT using	0.716*** (0.216)	1.627** (0.625)	0.659** (0.248)	2.708 (7.367)	2.602 (8.337)	-43.962 (192.255)
Lagged value added share x ICT/lagged ICT using patent stock	1.099** (0.416)	2.858** (1.304)	0.926** (0.387)	-6.724 (8.375)	-6.536 (9.201)	0.000 .
Lagged citation weighted patent stock without ICT/ICT using per employee	0.04 (0.049)	0.053 (0.053)	-0.141 (0.241)	-1.934 (2.260)	-2.927 (2.768)	25.728** (7.950)
Firm size	-0.046*** (0.007)	-0.041*** (0.007)	-0.046*** (0.015)	-0.211 (0.184)	-0.123 (0.165)	-0.404** (0.161)
Sector dummies						
Observations	145,470	115,230	33,592	242	208	38
Adj. R2	0.67	0.68	0.66	0.79	0.79	0.92
Total effect of the lagged value added share from sectors with high digital intensity on firm level multifactor productivity						
All countries	1.184** (0.485)	2.942** (1.297)	1.387** (0.537)	-8.474 (8.259)	-6.929 (9.258)	9.180** (3.750)
Total effect of the lagged citation weighted patent stock per employee ICT/ICT on firm level multifactor productivity						
All countries	1.815*** (0.517)	4.484*** (1.574)	1.585*** (0.492)	-4.016 (13.742)	-3.933 (15.192)	-43.962 (192.254)

Source: Amadeus (Bureau van Dijk), PATSTAT (EPO), WIOD, WIFO calculations. Note: + p<0.15, * p<0.10, ** p<0.05, *** p<0.01. Clustered standard errors (cluster by sector) in brackets below coefficients.

Model (1) presents results for all firms across all countries, whereas Models (2) and (3) provide split sample analyses for manufacturing and service sector firms. Models (4) to (6) report Model (1) presents results for all firms across all countries, whereas Models (2) and (3) provide split sample analyses for manufacturing and service sector firms. Models (4) to (6) report the analysis for Austria. It should be kept in mind that, due to the inclusion of an interaction term, the total effect of both the value added share and ICT patent stocks is given by the linear combination of the estimated coefficients for the respective indicator and the interaction term. This is reported in the bottom of the regression table. The impact of ICT patent stocks on firm level MFP growth increases with higher levels of embeddedness in value chains with industries with high or medium high digital intensity.

For the global sample Models (1) through (3) confirm the positive association between the diffusion and creation of digital technologies on firm-level total factor productivity growth. For Austria no significant results can be obtained. This is however likely to be due to the small number of observations with a high variation in the relevant indicators.

2.2.5. Summary

This section has compared the performance of Austria in ICT indicators with the countries that are classified as Innovation Leaders as a reference group.

The performance with regard to the diffusion of digital technologies in Austria shows a mixed picture. Austria scores better than the group of Innovation Leaders in the categories e-invoicing, electronic information sharing, the implementation of customer relationship management software, cross-border online sales and RFID. Its performance is below the comparison group in the categories cloud computing, social media use and the percentage of business turnover from e-commerce.

The performance in digitalisation adoption indicators is not independent from sector and country effects. A statistical method was applied to control for industrial composition, and thus “purge” DESI indicators from sector effects. This led a different overall rankings and affected Austria’s position for important indicators: First, Austria is officially ranked third in the use of RFID. The new ranking based on the industry-purged RFID locates Austria at the 9^{th} position in the EU. Second, Austria gains five ranks for the indicator percentage of firms using of social media (“new” rank: 12, “old” rank: 17).

Austria also underperforms in the broadband take-up rate. It ranks below the EU-average and the Innovation Leaders, especially Sweden and Denmark. The per capita investments in the telecommunication infrastructure is close to the EU average, but below the Innovation Leader average.

ICT investment shares are at reasonably high levels, but the performance of the Austrian business sector in terms of ICT-intensive exports of goods and services is stagnating at a level clearly below the EU average. Driven by Austria’s low export shares from ICT-intensive service sectors, this leads to a widening gap between Austria’ s share of ICT-intensive exports and that of the group of Innovation Leaders. However, the portfolio of ICT-intensive products that are exported from Austria is remarkably complex and hints at high level of product quality despite low export quantities.

While in general Austria’s business expenditures on R&D (BERD) in ICT is below that of innovation leading countries (except for the share of BERD in manufacturing of electronic components and bards), and average ICT patent activities are lagging as well, Austria’s patent applications are concentrating in technologies related to information communication devices. In this field the diffusion of technology, measured by the number of non-ICT patents citing patents in ICT classes, is working better in Austria than in reference countries.

A correlation analysis has shown that a significant and positive correlation is observed between sector-level productivity growth and the share of investments in computing equipment, the share of total ICT investments, the share of value added from ICT producing sectors used along the value chain as well as the share of ICT-intensive sectors in total exports. Given that Austria does not rank very highly in many of these performance indicators one should expect negative repercussions on productivity growth in this country. An econometric analysis of firm-level MFP growth provides however a more neutral picture. It suggests that Austrian manufacturing companies in sectors with high or medium high digital intensity perform even better than their peers in the sample in terms of MFP growth, whereas no difference can be observed for the entire sample.

This indicates that despite the mixed picture on Austrian performance in aggregate digitalisation indicators, Austrian companies do not perform worse than their peers and in manufacturing they seem even to perform better. A second set of results suggest that MFP growth at the firm level is positively associated with both the creation and the diffusion of digital technologies and Austrian companies could benefit from adopting them more extensively digital technologies. On the technology creation side, indicators show that progress has been made in the past decade.

2.3. Policy framework

This section discusses Austria's policy framework of digitalisation policies. The first part will first set the stage by discussing general policy initiatives and the government programme. The remainder will then elaborate on two specific policy fields that are widely discussed in Austria: the grid infrastructure and e-government. The overall objective of this sub-chapter is to provide insights into the following guiding questions:

- What is the overall framework of Austria's ICT policies? Who are the key players? What priorities are set?
- What policies address the previously identified grid infrastructure?
- How is Austria positioned in e-government rankings? What aspects of e-government can be improved?

Methodologically, this section will discuss national policy documents. It will also use evaluation reports and complement these findings with quantitative information (e.g. from e-government rankings) and qualitative information obtained from a series of interviews which were conducted.

The objective of this subchapter is to discuss existing policy priorities and to assess the cornerstones of Austrian ICT policies. As such it provides the basis for a discussion about policy reform needs.

2.3.1. Overall policy framework and initiatives

The starting point is the current coalition agreement of Austria's government (BKA 2017). Digitalisation is considered in two ways.

- First, it is a topic on its own. It clusters "digitalisation" goals around the three larger categories: (i) modern infrastructure, (ii) the public administration and "smart regulations" for the interaction with citizens and firms, and (iii) education, the economy and security.

- Second, the thematic cross-sectional nature of the topic implies that digitalisation is considered in many sections of the government programme. This is to be expected with a cross-sectional, general purpose technology. A variety of sub-headings provides ICT-related objectives (see Table 2-6). These are "transport and infrastructure" and "agriculture and rural areas".

Table 2-6: ICT topics in the government programme

Header 1	Header 2	ICT-topic in objective
State and Europe	Public administration reform and constitution	
	Europe and foreign policy	
Order and safety	Internal security	• Closing digital security gaps in Austria and protecting citizens from the new threats of digitisation
	Integration	
	Justice	
	National defense	• Build a sophisticated cyber defense as part of a nationwide cyber strategy of the federal government
Future and society	Education	
	Science	• More effective university governance and digitisation: pioneering modern and efficient public administration
	Innovation and digitalisation	• Overall research strategy with a research, technology and innovation package and governance structure optimisation • Strengthen open innovation and social innovation • Modern infrastructure as the foundation of digitisation • Digitisation of administration and smart regulation for better service and more interaction with citizens and businesses • Digitisation of education, the economy and the security sector
	Media	• Creating fair conditions in an increasingly global digital market
	Sports	
	Art and Culture	
Fairness and justness	Family and Youth	• Use of digital media
	Women	
	Pensions	
	Health	• Expansion of digitisation and telemedicine
	Social affairs and consumer protection	
Location and sustainability	Finance and Tax	
	Industrial location and debureaucratisation	
	Employment	
	Transport and infrastructure	• New eco-efficient forms of mobility and digitisation, road safety and transport infrastructure safety
	Agriculture and rural areas	• Commitment to equal opportunities for regional living spaces - promote settlements and expand infrastructure - promote mobility
	Tourism	
	Environment	
	Energy	

Source: BKA, WIFO illustration.

Interviews were conducted to gain an additional assessment of the policy dynamics. The interview partners stressed that the ICT content of the government programme reflects the policy discussions that have been ongoing in Austria for the last few years. It was unanimously appreciated that there is a digitalisation focus in the government programme.

However, word of caution was also articulated. Public policies were perceived as important pillars steering the effects of ICT, and Austrian policies have recently increasingly been focusing on digitalisation. However, the overall ICT development is in many cases not triggered by the state or public policy, but in the meantime governed by private companies, which are typically not based in Europe. The geographical distribution of these "influencers" is highly skewed towards the USA and Asia, with China taking an increasingly strong position. As one interview partner put it, *"we live in a highly connected world and have reached a point of no return. Think of your daily shopping at a supermarket, which would not be possible without electricity and a register connected to the internet. Many people are still not aware that ICT has become a fundamental part our everyday lives. Moreover, many topics that we are discussing today are irrevocable. The discussion should not be about whether digitalisation is possible, but how we can manage it, and – in some cases – if we can manage it at all."*

Austria's ICT policies have long been criticised as fragmented. Insularly designed measures were poorly funded, and ICT policies were not a policy priority. This criticism concerned ICT-use programmes, the education system as well as supply side aspects such as broadband infrastructure (Friesenbichler 2012). To overcome coordination issues across ministries, a step was taken in the institutional architecture, and a "digitalisation ministry" bundles ICT aspects (see Box 2-1).

Box 2-1: A ministry for digital affairs

With the establishment of the Federal Ministry for Digital and Economic Affairs (bmdw) a major institutional change with respect to "digitalisation" has recently occurred. The establishment of an "ICT-ministry" answers a long call for an "ICT-coordinator", which bundles competences in Austria's fragmented competences and federal structures.

The core task of the newly established ministry is to further advance digitalisation and digital transformation in Austria. Its priorities include the improvement of existing framework conditions and the coordination and implementation of e-government solutions. The ministry leads the strategy process, comprising a policy plan for gradual implementation and the nationwide coordination. It seeks to foster a digitalisation-friendly legal framework and oversees e-government services and the digitalisation of the administration and governance system.

In addition, the ministry provides funding schemes aiming to promote the competitiveness of Austria's economy with respect to digitalisation. Yet, not all thematic aspects are organised within this ministry. For instance, the deployment of broadband infrastructures continues to be implemented by a well-established group within the Austrian Ministry for Transport, Innovation and Technology (bmvit).

Even though the changes possibly lead to a streamlining of decision making, the background interviews brought about concerns about the implementation of ICT policies. Coordination challenges are expected to remain due to split competences across a great variety of agents and a "*fuzzy policy landscape*".

With the Digitalisation Agency (DIA), another coordinating player has been installed as a national and international contact point for digitalisation measures. DIA is a networking and consulting agency, which also closely interacts with the inter-ministerial task force of the "Chief Digital Officers" (CDO). It pursues a largely strategic agenda and will not implement promotion programme.

DIA is embedded in the Austrian Research Promotion Agency (FFG), which is operationally responsible for the implementation of digitalisation measures in close interaction with the ministries bmdw and the bmvit. DIA was initially in charge of the "Digital Roadmap Austria" which the Ministry for Digital and Economic Affairs oversees.[15] It seeks to incorporate not only the ICT aspects of the government programme, but also ongoing initiatives such as "Digital Austria" (see below). It might continue the coordinating activities of the KIG (Kompetenzzentrum Internetgesellschaft – a former federal ICT agency and policy coordinator). The new agency will serve as an umbrella organisation covering all Ministries concerned, and thus expands previous efforts which were more focused on single topics.

The Digitalisation Agency has started three pilot projects in the summer 2018:

- In DIA-LOG, DIA regularly organises thematic events on current digitalisation topics (e.g. digitalisation in tourism)
- The planned Digital Innovation Hubs (DIH) will support SMEs in digitalisation projects through a network of regional digital centres. DIA will be involved in the initial phase and promotion of this new cooperation model.
- On behalf of the Federal Government, DIA invites SMEs to a moderated platform of 5G and broadband to accelerate the implementation of the infrastructure projects of the Federal Government.

The assessment of DIA by the interview partners showed a mixed picture. It was stressed that the establishment of DIA may be a step to a more efficient policy coordination. However, it is set up as a division of the Austrian Research Promotion Agency (FFG). On the one hand, this may create friction as the DIA has a strategic agenda but is embedded in an implementing agency. On the other hand, this positioning allows DIA to exploit synergies within established structures that have experience in interacting with firms.

The interview partners said that it is yet unclear what activities the organisation will effectively pursue. This concerns multiple aspects, such as the interplay with other agents. An SME focus has been announced by DIA, but it is yet unclear how DIA will interact with the "SME Digital" programme of the Austrian Economic Chambers. Even though promising steps have been taken in the right direction, the overall policy landscape is still in a formation phase and pivotal elements – especially the prioritisation of policy fields – are yet lacking. DIA could make recommendations to this end.

Eventually, one interview partner noted that DIA's future role could resemble the role of the Austrian Council for Research and Technology Development. The latter organisation was founded upon a legal

[15] See (see also a Government Report on Research and Technology 2017; https://www.bmvit.gv.at/innovation/publikationen/technologieberichte/downloads/ftb_2017.pdf.

act which clearly defines the organisation's responsibilities to oversee and quantitatively benchmark the country's research and technology strategy.

There is a long list of politically desired goals which relate to digitalisation. This is met by a wealth of policy initiatives promoting a multitude of aspects of digitalisation. Several policy platforms and initiatives were implemented, *inter alia* aiming to facilitate the ongoing digital transformation of the economy. Since this is subject to path dependency, the following will briefly describe the "Digital Roadmap" and "Digital Austria", the most recent development.

The Federal Ministry for Digital and Economic Affairs[16] hosted the "Digital Roadmap Austria", which brought together a wide range of policy actors to discuss a multitude of policy fields[17]. More than 100 experts from all ministries, the federal states, the Association of Towns and Municipalities as well as from social partners and other organisations participated in the preparation of the Digital Roadmap. In 2017, a total of approximately 150 policy measures of all ministries were presented in one umbrella initiative (FTB 2017). The roadmap identified a wealth of challenges, existing and planned measures and activities[18]. While providing an extensive overview, it has been criticised for lacking policy priorities leading to limited effectiveness of the platform.

This led to a recent change in the policy setting. At the end of January 2019, the government announced, "Digital Austria", its new digitalisation initiative.[19] It focuses on three priorities: society, economy and public administration. The strategy lists twenty projects under the header "society" (including public services such as oesterreich.gv.at - a one-stop-shop for citizens, or digital skills). The priority "economy" contains eleven projects, such as fintech, automated mobility or artificial intelligence. There is a strong SME focus, and it also lists SME Digital to explicitly address the needs of SMEs (see SME section)[20]. The priority "public administration" includes ten projects, such as IT consolidation at the federal level, electronic funding processes or combating digital and online crime.

Hosted by DIA, "Digital Austria" involves multiple actors. These not only comprise the DIA, the Federal Minister for Transport, Innovation and Technology, the Federal Minster for Digital and Economic Affairs and the promotion agencies (AWS, FFG), but also the Chief Digital Officers (CDOs). These were appointed in each department to coordinate innovation and digitalisation issues

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[16] The new Austrian government shifted some of these competences, since 8th of January 2018 the Federal Ministry Digital and Economic affairs is responsible for digitalisation and e-government. The platform used to be owned by the Federal Chancellery and the Federal Ministry of Science, Research and Economy.

[17] See https://www.digitalroadmap.gv.at/en/ (accessed on 26 June 2018).

[18] These can be categorised under a wide range of headings: Education; Infrastructure; Research and Innovation; Business; Work and Jobs; Health, Care and Social Affairs; Environment, Energy, Agriculture and Climate Protection; Mobility and Transport; Media, Civic Courage and Culture; Integration and Inclusion; Security, Protection and Trust; Politics and Administration.

[19] See https://www.digitalaustria.gv.at/eng/ (accessed on 4 March 2019).

[20] See https://www.wko.at/Content.Node/kampagnen/KMU-digital/index.html.

between the ministries and to work on a nationwide innovation and digitalisation strategy. Also, a substantial number of industry representatives is involved.

The government announced that "2019 will be the digitalisation year". In the first half, the initiative will focus on analysing the status quo. In the second half of 2019, there will be proposals for solutions of identified issues. The implementation phases are planned for next year.[21] Also, Digital Austria is an umbrella initiative, which (at least partly) incorporates other initiatives addressing more specific topics, such as e-government or the "Digitalisierungsoffensive" ("digitalisation offensive", which is sketched below).[22]

The interview partners stressed that both Digital Austria and the CDOs are valuable contributors to the discussion and the policy dynamics. Even though improvements in the streamlining of decision takers have been made, a wealth of topics remains, which continues to reflect the challenge to prioritise policies fields. In addition, competences are not only located at the federal level, but also at the state (Bundesländer) and the municipalities, which renders policy implementation more difficult.

2.3.2. The grid infrastructure and 5G

The modest performance across a range of broadband use indicators (see Section 2.2) led the government to develop a new broadband strategy "Breitband Austria 2020" (Broadband Austria 2020; bmvit 2014a), which is the basis for a promotion programme (Master Plan Broadband Promotion[23]; bmvit 2014b) that is at the core of Austria's ICT infrastructure policies. It is well equipped with a budget that amounts to an envisaged promotion volume of one billion Euro. Therefore the programme is also known as the "Digitalisierungsmilliarde", the "digitalisation billion".[24]

The aim is to improve broadband access in Austria, especially via promoting infrastructure investments. The main target is to close the digital divide between rural and urban regions across Austria's regions (bmvit 2014a). To this end, investments in broadband infrastructure is encouraged in areas where otherwise no high speed broadband access would be offered in the foreseeable future (see Figure 2-10 and Figure 2-11 for an illustration of the urban-rural divide in Austria in fixed and mobile broadband use indicators).

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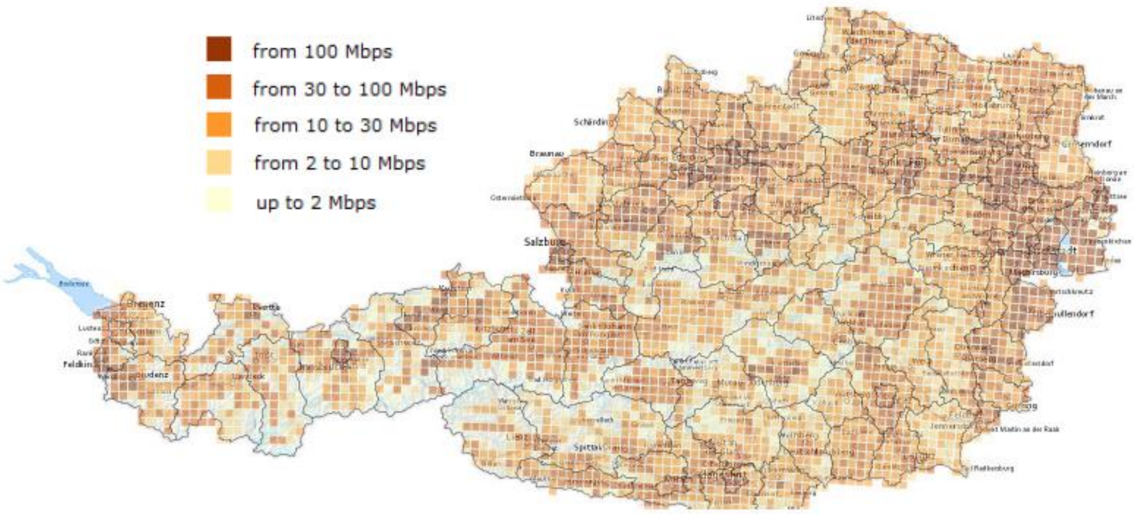
[21] See https://www.bundeskanzleramt.gv.at/-/bundeskanzler-kurz-startschuss-fur-das-digitale-amt- (accessed on 4 March 2019)

[22] See https://secure.sebastian-kurz.at/digitalisierung/1/ (accessed on 26 June 2018).

[23] https://www.bmvit.gv.at/telekommunikation/breitband/index.html (accessed on 19 October 2018).

[24] See https://www.bmvit.gv.at/telekommunikation/breitband/foerderungen/ (accessed on 26 June 2018).

Figure 2-10: Available download speed, fixed broadband access 2018



Source: Broadband Atlas https://www.breitbandatlas.info/map.php (accessed on 21 August 2018).

Given the status quo of the current coverage, the targets that the programme seeks to achieve seem ambiutous. By 2020, almost all Austrian households and companies should have access to ultra-fast broadband (>100 Mbps).[25]

Based on the Broadband Strategy 2020 and the Master Plan the bmvit launched several coordinated funding programmes since 2015; comprising the following components:

- "Access" focuses on the spatial expansion of "high-performance access networks", aiming for improved coverage
- "Backhaul" supports the strengthening of feeder networks and the connection of isolated solutions to the core networks
- "Empty conduit" facilitates the installation of empty conduits for communication networks during ongoing municipal civil engineering work

In addition, the programme "Connect" accelerates the high-quality and sustainable fibre-optic expansion to schools and SMEs.

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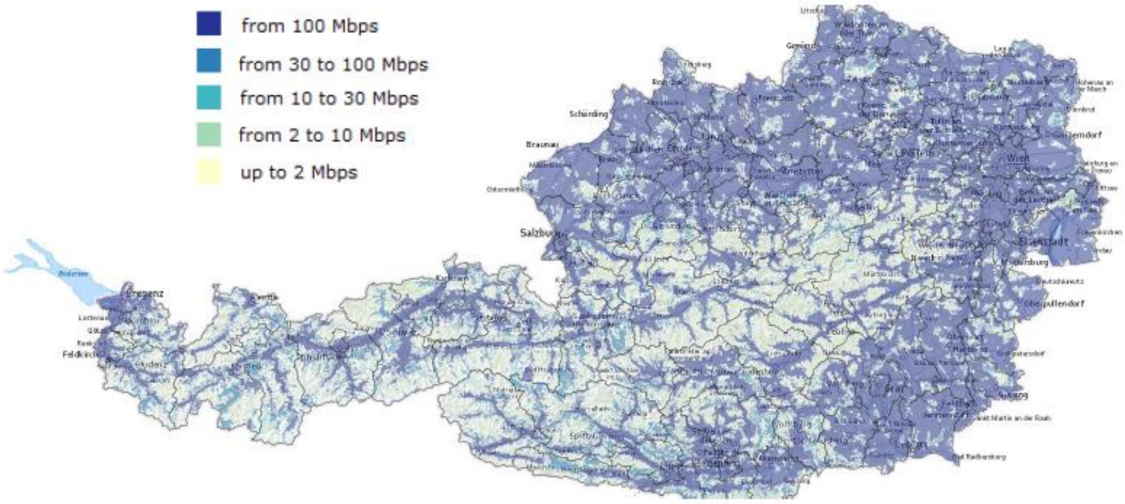
[25] https://www.bmvit.gv.at/telekommunikation/breitband/index.html (accessed on 19 October 2018).

Figure 2-11: Available download speed, mobile broadband access 2018



Source: Broadband Atlas https://www.breitbandatlas.info/map.php (accessed on 21 August 2018).

Hence, the programme addresses the difficult framework conditions that the expansion of the fibre-optic grid in Austria currently faces. There are hardly any empty conduits, an underground wiring is expensive and a wiring over the surface is typically prohibited or not desired. At the same time, both the retail price level and the demand for high bandwidths seems to be low. The copper-based network operated by the incumbent A1 is well suited for an FTTC access at rather low cost per participant. Altogether, this leads to a modest roll-out of the latest technologies (RTR 2018). The argument about low demand is also supported by evidence from two recent studies. Peneder et al (2018 forthcoming) point out that in an international comparison, Austria performs much better in terms of coverage and availability of broadband networks and connections than in terms of actual subscriptions. Furthermore, Bärenthaler-Sieber et al. (2018) show the existence of a relative bandwidth gap[26] based on small-scale raster (regular lattice) data on the supply and demand for the incumbent's (A1 Telekom) broadband lines, especially for higher bit-rate lines. Econometric analyses of these data (and other (socio-)economic indicators) show that an increase in the potential download speed leads to a disproportionate increase in this relative bandwidth gap (Bärenthaler-Sieber et al. 2018).[27] Then again, past deployments of data grids have shown a supply-push pattern, i.e. a substantial increase in demand after the roll-out of infrastructure (Friesenbichler 2012).

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[26] This relative bandwidth gap is defined as the difference between the maximum possible download rate and the average download speed in relation to the maximum possible download rate per 500x500 meter raster cell.

[27] Another indicator to measure a possible demand deficit for fast bandwidths - the so-called upgrade option to 16Mbps, the proportion of customers who could upgrade to a higher product - yields very similar results. Here, too, the influence of the maximum possible download speed on the demand deficit is positive and highly significant.

The design of the programme legally requires monitoring and evaluation. Neumann et al. (2017) conducted a first interim evaluation of the first two years (2015/2016) of the programme implementation. This evaluation is based on the strategy “Broadband Austria 2020” and provides a process analysis and an assessment of the overall efficiency and effectiveness of the activities.[28] Hence, “Broadband 2020” is perceived as a dynamic strategy concept, which should be adapted to new developments such as 5G, which is why the evaluation reflected the programme against a 5G background.

The evaluation provided a series of insights and lessons learned:

- 204 million euros[29] were allocated in the first two years (2015/16) of the programme. This might induce an estimated total of approx. €500 million investments, which would be a considerable increase in the telecommunication investments in Austria compared to previous years.
- Provided that all funded projects will be implemented in terms of investment, a total of approx. 30% of additional homes could be connected.
- The evaluation recommends a strategy of "5G-Readiness” for Austria. Such readiness should be accompanied by a bundle of measures (e.g., increases in network coverage and network density at 4G; the connection of as many mobile masts to the fibre network as possible, which also requires the general area expansion of a fibre optic network).
- Moreover, the evaluation recommends a stronger consideration of the technology promoted, since not all subsidies are conducive to the achievement of the 100 mbit/s transmission speed target. Also, the effects of the subsidies on competition should be increasingly considered.

Not only the evaluation of the broadband promotions, but also the government (see Box 2-2 below)[30] and the newly founded Digitalisation Agency (DIA) prominently discuss 5G. In addition, the interview partners have brought up several 5G related aspects. The potential of 5G is widely acknowledged. 5G currently serves as an umbrella term for multiple applications that are characterised by high data rate, reduced latency, energy saving, cost reduction, higher system capacity, and massive device connectivity. It is closely tied to the internet of thins and software-defined systems. Albeit relying on optical fibre infrastructures, 5G is likely to become a new mobile transmission standard, which will enable new, yet unknown applications and business models.

Assessing the terminology of policy documents, several interview partners mentioned that terminology such as “readiness” or “5G leaders” are eventually secondary, as long as effective deployment is facilitated. Becoming a leader will be difficult given the developments in both R&D and deployment

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[28] In this first phase of the programme, many funded projects have not become market-effective yet. A first quantitative impact assessment can only be conducted in a later phase of programme implementation.

[29] The planed budget for the first phase amounted to 293 million euros. Interview partners confirm that the full billion is expected to be paid out by 2025.

[30] Source: “Austria‘s way to become a 5G pioneer in Europe” (https://www.bmvit.gv.at/en/service/publications/downloads/5Gstrategy.pdf, accessed on 28th October 2018).

of 5G solutions in other countries. The technology experts that provided background information in interviews stressed that, given the cost of 5G, it currently seems unlikely that 5G will be rolled-out to all consumers. Target consumer of the technology are larger organisations which operate data intensive technologies. This is likely to include larger manufacturing firms, transport companies, hotels, research facilities or hospitals.

Box 2-2: The 5G strategy of the Austrian Government

In April 2018, the (Federal Ministry for Transport, Innovation and Technology (bmvit) has published the official 5G strategy of the Austrian government.

Phase 1: The first pre-commercial 5G tests are to be implemented by mid-2018.

Phase 2: By the end of 2020, the interim goal of an almost area-wide availability of ultra-fast broadband connections (100 Mbit/s). This will create the basis for a nationwide expansion of 5G. At the same time, 5G is to be launched in all state capitals.

Phase 3: By the end of 2023, 5G services are to be available on the main transport routes and by the end of 2025, the goal of an almost area-wide availability of 5G can be realised.

Currently, 5G is in a market and technology formation phase. It is yet unclear how the standard will be designed technically, whether it will be a private or a public standard or whether it will allow interoperability. It is also conceivable that the standard is not driven by telecom or mobile phone companies, but by industrial firms or groups of firms.

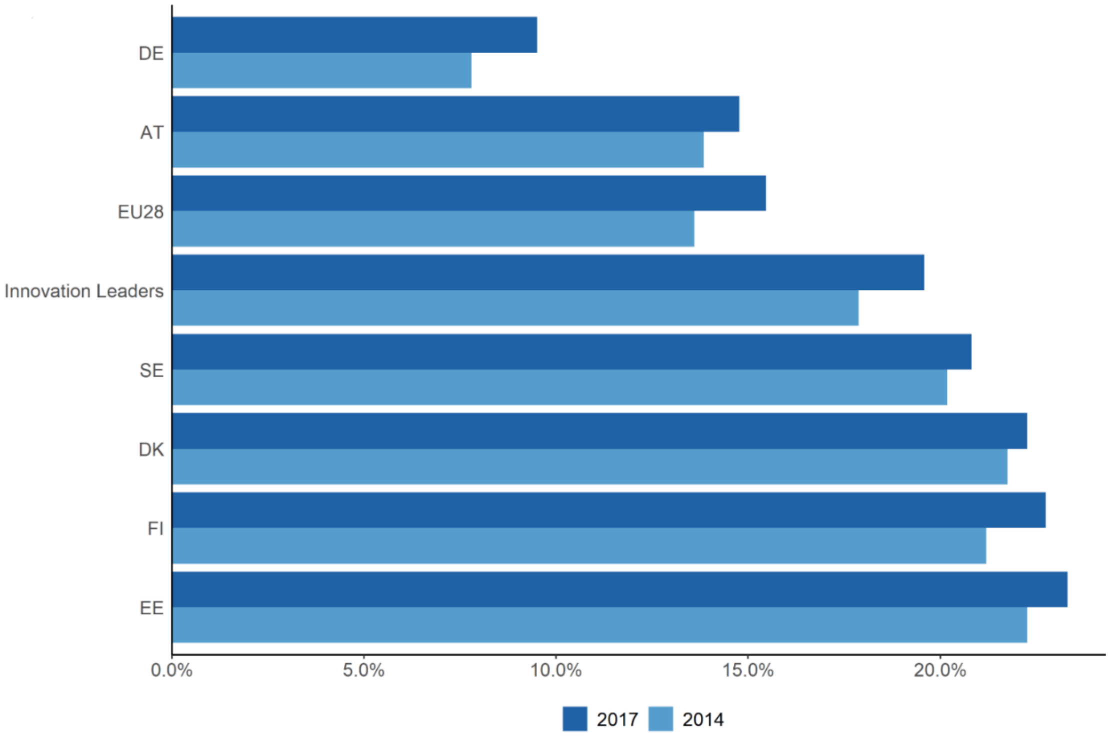
5G is closely tied to the use, and thus the auctioning, of the frequency spectrum. In Germany, industrial policy reserved a part of the frequency spectrum for industrial firms. A mobile virtual network operator (MVNO) for industry is being discussed. This is not the case for the auctioning in Austria, because Austrian industry was reportedly not aware of the opportunities or would rather cooperate with existing telecom providers.

A variety of aspects concerning the 5G deployment was mentioned that concerns not only Austria but the EU as a whole. Some interview partners expressed grave concerns about security issues which eventually concern technology ownership and industrial espionage. The operational software solutions which 5G requires are more complex than that of the regular fibre networks which are currently in use. The current solutions are mainly produced by Chinese firms. Given global competition and strategic industrial policies, both an ownership and a security question arise. Then again, a domestic or EU-wide provision of 5G would hamper free trade and thus prices and the quality (or technological content, respectively) of the solutions installed. Returning to closed markets was seen as suboptimal by all interview partners, and such steps need to be clearly justified, for instance with industrial espionage.

2.3.3. E-government

The “Digital Economy and Society Index” provides an e-government use indicator, measuring the share of people sending filled forms of public authorities over the internet within the past 12 months of the time of the survey. Recent data on e-government us shows that Austria ranks in the group of medium performers. Austria’s e-government use rate would approximately have to double to join the top performing countries Estonia and Denmark (Figure 2-12).

Figure 2-12: E-government use in 2014 and 2017 (% of individuals aged 16-74)



Source: DESI, WIFO illustration.

This led the current Austrian government to mention in its programme for the period 2017 – 2022 that it seeks to regain its leading position in e-government rankings. From a competitiveness perspective, this focus is well justified. E-government has been shown to reduce transaction costs and to facilitate several competitiveness-related aspects (see Box 2-3).

Box 2-3: E-Government and competitiveness

Friesenbichler – Strauss (2014) summarise the relationship of e-government with competitiveness. It is argued that e-government affects competitiveness through a reduction of transaction costs. Hirst – Norton (1998) emphasise that e-government affects firm-public administration relationships via three dimensions: (i) External connections between firms and the public administration. These are (ideally) improved due to more transparency about decisions and the provision of information. This includes the provision of information. (ii) Relational connections between firms and the public administration change due to organisational reforms that accompany the launch of e-government services. Often horizontal and vertical tasks are merged in the provision of e-services, so that e-government applications provide one-stop shops for firms. (ii)The organisation of bureaucracy changes also internally when services are provided online. Moreover, online services allow a timelier response and geographical flexibility.

In addition, e-government may facilitate the democratic attributes of regulatory procedures by enabling inclusiveness (e.g. OECD 2016) and enhance good governance (Andersen 2009; Shim – Eom 2009), because digital applications tend to increase the transparency of decision-making and may make corruption less likely (Pitlik et al. 2012). Srivastava and Teo (2007) analyse the relationship between e-government and competitiveness at the country level. First, they link e-government government variables to efficiency parameters, such as indicators on public resource spending or administrative efficiency. Second, the efficiency gains which e-government induces eventually increases GDP per capita. This confirms that the provision of e-government services is part of an efficient public administration and contributes to a sound business environment (Lau 2005).

Austrian policy documents often refer to a leading position of Austria in e-government rankings. Historical e-government data from the "EU Benchmark 2010" confirms this statement. In 2010, Austria indeed takes a leading position in the indicator "overall sophistication", together with Portugal, Malta and Ireland. In 2012, when a new methodology was implemented that also took into consideration e-government use and Austria was relocated to a medium position.[31] Nevertheless, the use of e-government has been increasing in Austria over the last years. This has been noted by the recently published "E-Government Monitor 2018" on the use of e-government services in Austria, Germany and Switzerland. The services analysed in the report are broadly defined and include not only the interaction with the public administration but also information searches on public websites. The report found that e-government use in Austria has been rising from 67% to 74% in the period from 2014-2018.[32]

To gain deeper insights into the policy dynamics, a series of background interviews were conducted. This information can be used to assess if the current measures are instrumental in Austria's efforts to re-take its leading position in e-government rankings.

All interview partners highlighted the existence of coordination issues. This concerns on the one hand the coordination between ministries, which is currently addressed by a variety of measures such as the DIA or the Chief Digital officers, and on the other hand the coordination across federal layers. According to our interview partners around three quarters of all administrative e-processes require cooperation between ministries and/or local authorities. Improvements in e-government effectiveness require more e-government use, which is linked to policy coherence and coordination of e-government providers and the different administrative units. Legal barriers and administrative boundaries hamper the digitalisation of certain administrative processes. In other words, processes are digitised differently by different departments and local authorities. Ideally, e-government solutions should be geared to problem situations and offered by a single source, as envisaged by the digitalisation ministry. However, the Austrian governance structure is more fragmented, and it has been observed that different local authorities implement different IT solutions. This is not a technical (ICT-related) challenge but indicates a general regulatory issue. A harmonisation of competences would require a re-allocation of competences between political agents and implementing organisations and agencies.

Nevertheless, it is important to note that there are great efforts undertaken to streamline and coordinate policy making. This particularly concerns the newly established digitalisation ministry, whose aim is

31 See https://www.digitales.oesterreich.gv.at/-/eu-benchmark-2013 (accessed on 25 October 2018).

32 See fortiss and the Iniative D21, https://www.egovernment-monitor.de/fileadmin/uploads/user_upload/studien/PDFs/191029_eGovMon2018_Final_WEB.pdf (accessed on 15 November 2018).

to coordinate and provide a wide range of e-government tools.[33] At its core is a one-stop-shop for public services, which aims to provide the ten most important administrative steps of major life events online (e.g., registration of a newly born child). In addition, public services should also be available through mobile services, thus building on an existing strength of Austria like "the high percentage of smartphone use".[34]

Technically, it seems likely that e-government use will continue to increase. One interview partner noted that recent developments in Austria, such as the Mobile Phone Signature, which allows citizens to provide evidence of their identity on the web, is likely to stimulate demand.[35] In addition, it was highlighted that e-government systems are continuously improved in terms of their usability and new functions are constantly integrated. However, complex processes with multiple players are difficult to change, which again points at policy coordination challenges.

Electronic procurement is at the heart of European policy initiatives for digitalisation and e-government. In Austria electronic procurement has been obligatory since April 2017 for selected procurement authorities such as federal ministries or the Bundesbeschaffungsgesellschaft (BBG), and since 18.10.2018 for all approximately 7,700 Austrian awarding authorities. The delay of the adoption of the latest procurement directive in Austria led to the situation that many of these authorities and many firms started late with the adoption of e-government tools. The (BBG) and the ANKOE are providing e-procurement services for authorities and firms.

2.3.4. Summary

This section focused on the cornerstones of the debate to assess the overall functioning of the policy landscape. Methodologically, policy documents were screened, and a series of background interviews were conducted. The rather aggregate perspective was chosen because a granular discussion of policies would have been beyond the scope of this study.

Austria's current government programme focuses on ICT, and there are many policy platforms and initiatives which address ICT topics. Overall, this signals policy awareness and can be regarded as a positive development. The recently established initiative "Digital Austria" provides an overview of the current challenges as well as existing and planned measures and activities. It serves as a basis for implementing the government's digitalisation strategy. Even though the initiative has streamlined topics and focuses on three broad policy areas (society, economy and public administration), a wealth of topics remains, rendering the implementation of a consistent strategy challenging. In this context, the government announced that "2019 will be the digitalisation year". In the first half, the "Digital Austria" will focus on analysing the status quo. In the second half of 2019, there will be proposals for policy solutions. The implementation phases are planned for 2020.

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33 See also the Chancellor's website: https://secure.sebastian-kurz.at/digitalisierung/1/ (accessed on 26 June 2018).

34 According to the Mobile Communications Report 2017 of the Mobile Marketing Association Austria and MindTake Research, 94 percent of all Austrians currently use a smartphone and 93 percent use the Internet regularly with their smartphone (in the 15 to 29 age group it is even 100 percent).

35 See https://www.buergerkarte.at/en/index.html (accessed on 9 October 2018).

To address coordination issues, the digitalisation ministry (Federal Ministry for Digital and Economic Affairs, bmdw) and especially the Digitalisation Agency (DIA) have been newly established. DIA is a networking and consulting agency that closely interacts with the inter-ministerial task force of the "Chief Digital Officers".

The interview partners perceived these developments as generally positive, but stress that such efforts only concern the federal level, and issues with respect to states (Bundesländer) and municipalities are likely to remain. In addition, concerns about the institutional setting of DIA were articulated. DIA is part of FFG, Austria's Research Promotion Agency, an implementing agency, but is designed to pursue a strategy-setting agenda. In this context, an interview partner suggested that DIA's future role could resemble the role of the Austrian Council for Research and Technology Development in technology policy, whose foundation resulted from a legal act which clearly defines responsibilities to oversee and quantitatively benchmark the country's research and technology strategy.

Another aspect of digitalisation that is debated in policy circles is e-government. Austria's current government programme seeks to regain the leading position in e-government rankings. The e-government rankings indicate that Austria performs well in the provision of services but has potential in the use of e-government applications. Also, in the provision of e-government there were reports of coordination issues due to split competences between different public entities at the different federal levels. Especially in e-government the co-ordination of public agents is important.

Eventually, there is a key policy field which has emerged as a priority in Austria: the broadband infrastructure. Especially fixed broadband take-up rates (DESI, 2018) and per capita investments in both fixed and mobile telecom infrastructures in Austria are comparatively low, and substantially lower than in the country group of Innovation Leaders. Since 2015, a broadband deployment promotion programme amounting to one billion Euro is in place. Hence, the programme addresses a long-standing weakness in ICT rankings and an often-cited bottleneck of digitalisation. It focuses on the establishment of broadband infrastructures and thereby closing the digital divide between urban and underserved, rural areas. An interim evaluation supports the continuation of the programme, and highlights that subsidies have, by and large, effectively contributed to the programme's objectives. The evaluation came to the following conclusions:

- A continuation of the programme.
- Some adjustments in the programme design are required, especially a greater focus on 5G readiness and, relatedly, the establishment of a fibre optic grid.

2.4. Conclusions

The analyses in this chapter have taken a bird's eye view of the digitalisation of the Austrian economy in international comparison. The results show a mixed picture.

- In terms of the diffusion of digital technologies Austria scores better than the group of Innovation Leaders in the categories e-invoicing, electronic information sharing, the implementation of customer relationship management software, cross-border online sales and RFID.
- Its performance is below the comparison group in the categories cloud computing, social media use and the percentage of business turnover from e-commerce.

- Controlling for industrial specialisation which affects the DESI rankings, Austria position changes in two important indicators:
    - is officially ranked third in the use of RFID. Yet, the new ranking based on the industry-purged RFID estimates perceives Austria at the 9th position in the EU.
    - Second, Austria would gain five ranks (from rank 17 in the official ranking to rank 12 in the industry purged one)
- Austria under-performs in the broadband take-up rate and ranks below the EU-average and the Innovation Leaders, especially Sweden and Denmark.
- The per capita investments in the telecommunication infrastructure is close to the EU average, but below the group of Innovation Leaders and the countries that lead in an EU-OECD comparison.
- Austrian ICT-intensive exports of goods and services are stagnating at a level clearly below the EU average. Driven by Austria's low export shares from ICT-intensive service sectors, this leads to a widening gap between Austria's share of ICT-intensive exports and that of the group of Innovation Leaders. However, the portfolio of ICT-intensive products that are exported from Austria is remarkably complex and hints at high level of product quality despite low export quantities
- Austria's business expenditures on R&D (BERD) in ICT is below that of innovation leading countries (except for the share of BERD in manufacturing of electronic components and bards), and average ICT patent are lower than in these countries.
- Given Austria's industrial specialisation patent applications are however concentrated in a few fields of digitalisation especially in domains related to Industry 4.0. Here, in several field and sectors Austria's performance is well above that of Innovation Leaders. Generally, the quality of technological developments has improved especially in non-ICT technologies that make use digital technologies.
- A correlation analysis has shown that for many of the indicators in which Austria is trailing the Innovation Leaders, a significant and positive correlation between sector-level productivity growth. This can potentially have negative repercussions on productivity growth in this country.
- An econometric analysis of firm-level MFP growth, however, provides a more neutral picture. Austrian companies do not perform worse than their peers and in manufacturing they seem even to perform better.
- However, the econometric analysis also suggests that Austrian companies could benefit from adopting them more extensively digital technologies.

The most important findings of this part of the analysis and lessons that can be learned from it are summarised in Table 2-7.

Table 2-7 Policy transferability table (indicators of digital transformation)

Observed Problem	Drivers	Solution taken in Austria	Lessons learnt
Diffusion of ICT technologies in Austria is below the scores of Innovation Leaders	The drivers of diffusion are soft factors such as awareness, hard factors such as the broadband infrastructure that still shows potential and structural factors like the industry composition/structure	Awareness campaigns (KMU Digital) Broadband promotion	Country- and industry-specific effects bias the diffusion indicators. "Purging" the data from such bias helps identify structural aspects which are thus relevant for policy making.

The analyses of the Austrian policy framework with regard to the digitalisation agenda show that Austria's policy landscape is currently in a formation phase. With regard to the observed weaknesses of the Austrian economy in the digital agenda, positive developments can be observed. Austria's current government programme focuses on ICT, and there are many policy platforms and initiatives which address ICT topics. The recently established initiative "Digital Austria" provides an overview of the current challenges as well as existing and planned measures and activities. To address coordination issues, the digitalisation ministry (Federal Ministry for Digital and Economic Affairs, bmdw) and especially the Digitalisation Agency (DIA) have been newly established. DIA is a networking and consulting agency that closely interacts with the inter-ministerial task force of the "Chief Digital Officers".

Nevertheless, it is yet unclear how competences and responsibilities will eventually be structured. The analysis in this chapter suggests that to improve the policy framework a number of steps should be taken:

- A continuation of the prioritisation of policy fields,
- a continuation of the streamlining of competences, and
- a - wherever possible quantitative - benchmarking of articulated targets to establish a monitoring and evaluation framework of the digitalisation progress.

Another important aspect of digitalisation is e-government.

- The e-government rankings indicate that Austria performs well in the provision of services but has potential in the use of e-government applications even though improvements related to the introduction of the "Mobile Phone Signature" have been observed.
- The analysis has revealed coordination issues due to split competences between different public entities at the different federal levels. Three quarters of the bureaucratic processes require more than one public administration agent.

- The diffusion of some e-government applications seems to have been hampered due to a lacking critical mass.

The development of the broadband grid is a key priority in Austria

- Especially fixed (and to a lesser extent mobile) broadband take-up rates and per capita investments in Austria are lower in Austria than in the country group of Innovation Leaders.
- Since 2015, a broadband deployment promotion programme amounting to one billion Euro is in place to addresses the long-standing weakness in ICT rankings and an often-cited bottleneck of digitalisation.
- An interim evaluation has supported the continuation of the programme, and highlights that subsidies have, by and large, effectively contributed to the programme’s objectives. The evaluation suggested adjustments in the programme design and to put greater focus on 5G readiness and the establishment of a fibre optic grid.

Table 2-8 provides a summary of the issues that have been identified in the analysis of the Austrian policy framework related to digitalisation and highlights important lessons for other European member states.

Table 2-8: Policy transferability table (policy framework)

Observed Problem	Drivers	Solution taken in Austria	Lessons learnt
Policy coordination and harmonisation of initiatives	A wealth of policy fields is discussed and the eventual policy focus is often unclear. The policy players at different levels of Austria's subsidiarity pursue different policies. This is a general problem in federal structures. One result is that the critical mass required for the diffusion of certain applications is lacking or that e-gov services are sub optimally designed	Coordinating institutions were established (Digitalisation Agency, Ministry for Digital Affairs), but these mainly focus on the federal level. It is unclear to what extent states and municipalities can be effectively involved.	The next steps should comprise a prioritisation of policy fields, a continuation of the streamlining of competences, and (where possible quantitative) benchmarking of articulated targets to establish a monitoring and evaluation framework.
Publicly open data grids with sufficient quality (poor deployment of fastest technologies) Perceived under-investment into broadband grids	Externalities (market failure) and uncertainty about demand and future technology	Public co-investments (Broadband Austria 2020), i.e. investment subsidies of a total of €1bn Euros for all layers of the grid architecture	Evaluation report recommends continuation but suggests a fibre-optic focus and 5G readiness. More generally, the organisation of such critical infrastructures for "ultra fast broadband" is unclear (public or private).

3. DIGITAL TRANSFORMATION OF MANUFACTURING AND THE SERVICES SECTOR

The digital transformation and the adoption of information and communication technology is considered to be one of the main drivers productivity growth. Digitalisation does not only affect the efficiency of production; it also allows firms to combine a more flexible production in small batches with the cost advantages of mass production. In addition, digitalisation enables firms to create new services and business models and facilitates the organization of spatially distributed production in global value chains. This chapter looks at the diffusion of digital production technologies at the sector level and then discusses the drivers, obstacles and specific competencies of Austria in industrial digitalisation.

Given the evidence that Austria lags behind the Innovation Leaders in the adoption of digital technologies the first part of this chapter uses data from the WIFO Industry Survey to develop an understanding on how manufacturing companies in Austria perceive digitalisation and Industry 4.0. The analysis sheds light on the role these factors play for competitiveness and what challenges Austrian companies perceive in relation to their development and adoption. The analysis shows that in some instances there are systematic differences firms in industries with high and low digital intensity.

The second part of the chapter analyses the up-take of Industry 4.0 technologies and digital platforms by Austrian firms as a specific case studies. Industry 4.0 adoption is discussed using data from the European Manufacturing Survey, whereas the adoption and use of digital platforms by Austrian firms is based on data from Statistics Austria provided by the European Surveys on ICT Usage Enterprises. These data allow on the one hand monitoring the evolution of e-commerce and platform use in Austria. On the other hand, it is possible to shed light on the demand side – the readiness of Austrian consumers to use platforms – with data from the Eurobarometer surveys and Eurostat statistics on ICT use in households. Especially for the B2C segments of the service sectors the digitalisation of households is also important.

The final part of the chapter will provide an overview on the policy landscape in Austria with regard to measures targeting the development and adoption of digital technologies. It draws on publicly available documents as well as several expert interviews.

3.1. Challenges and impacts of digitalisation perceived by Austrian manufacturing companies in sectors with high or medium high digital intensity

3.1.1. Introduction

The evidence in the previous section shows that the Austrian business sector lags behind Innovation Leaders with regard to ICT investment, the value-added share from sectors with high digital intensity, and their patenting activities in ICT technologies or in technologies that draw on ICT technologies. Given that the diffusion and production of digital technology is an important driver of competitiveness and productivity growth (cf. OECD 2015), the question arises whether Austrian companies active in industries with high digital intensity perceive competitive disadvantages, specific challenges or constraints resulting from the Austrian policies more heavily than companies in other sectors. This question will be examined in this section data from the WIFO Industry Survey carried out in 2016 (see Box 3-1). This survey focuses on manufacturing firms.

Box 3-1:The WIFO Industry Survey

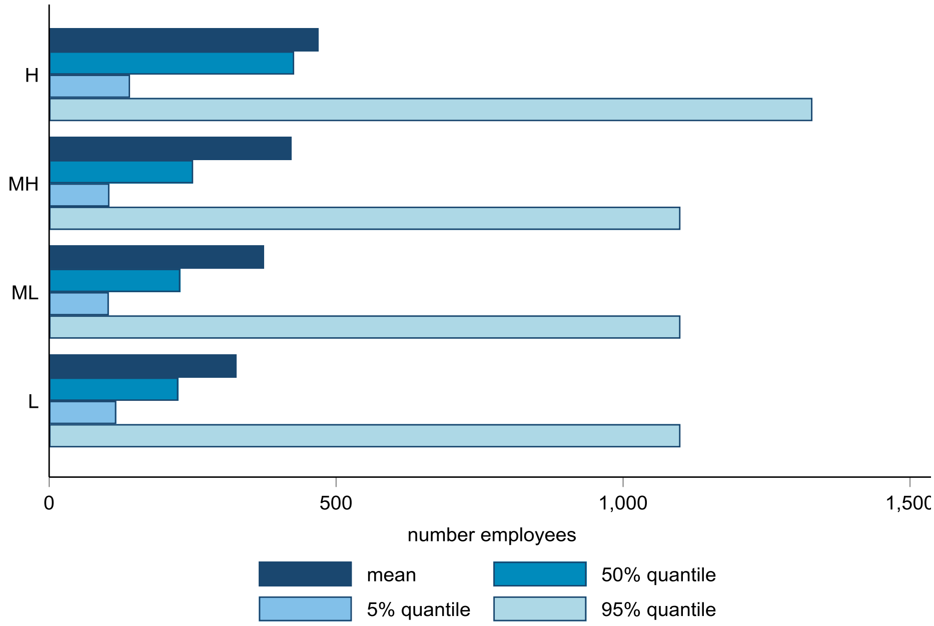
In 2016 the Austrian Institute for Economic Research (WIFO) carried out a survey to gather information about the past, current and future strategies of Austrian manufacturing firms. The focus was on product, sourcing and market strategies, as well as changes in positioning in global value chains and core competencies. A set of questions explored the respondent's perceptions of as well as priorities for industrial policies in Austria to support companies' competence building and international competitiveness. Other questions addressed challenges and consequences of digitalisation and Industry 4.0 for the companies (Hölzl et al. 2017). It is planned to repeat this survey every three years. The 2016 survey was conducted between June and September 2016. The adjusted gross sample included all firms of the NACE2 segment C ("Manufacturing") which reported more than 250 employees in the Herold database, which made for a sample of 498 firms. This list was augmented by a sample of manufacturing firms which reported between 100 and 250 employees, and which were mentioned in the publication "Hidden Champions" (Advantage Austria 2015). The adjusted gross sample comprised 1005 Austrian manufacturing firms, of which 323 responded to the questionnaire. This resulting net sample of the 2016 survey covered companies employing about one sixth of the total workforce in the Austrian Manufacturing sector in 2016 (629.000 persons).

With its broad coverage of manufacturing companies in Austria, the WIFO Industry Survey can be used to evaluate systematic differences in company characteristics as well as response patterns on issues related to digitalisation and Industry 4.0 adoption using the OECD classification of digital-intensive sectors. This section will first characterise the sample. It will then present evidence on how the perception of competitive strengths and important competitive factors differs for companies across sector groups with different digital intensity. It will proceed with evidence related to the challenges and consequences companies across sector groups perceive in relation to digitalisation and the adoption of Industry 4.0 technologies. Finally, it will present evidence on the policy priorities to support competitiveness and digitalisation, as well as the administrative burden perceived by Austrian manufacturing companies across sector groups.

3.1.2. Characteristics of the sample by digital intensity of the sector

Around 8.3% of the companies surveyed in the WIFO Industry Survey can be attributed to sectors with high digital intensity, and another 48.4% can be attributed to sectors with medium-high digital intensity (H-MH) totalling jointly 183 observations. The remaining 139 observations in the sample can be attributed to the sectors with medium low or low digital intensity (ML-L). Thus, in the sample there is a slight prevalence of companies in sectors with high or medium high digital intensity.

Figure 3-1: Company size by digital intensity of sector

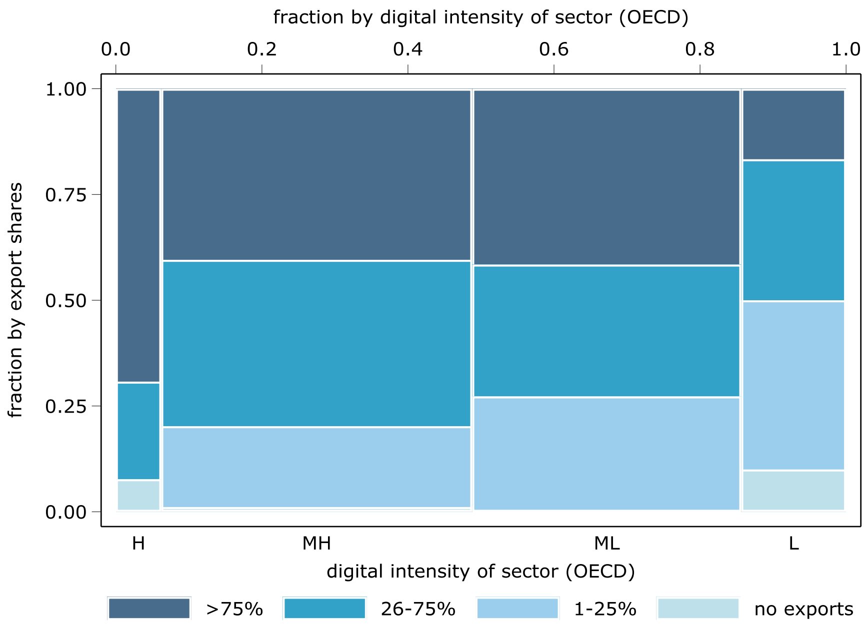


Source: WIFO Industry Survey 2016, WIFO calculations. Note: Digital intensity: H .. high, MH .. medium high, ML .. medium low, L .. low.

The size distribution of companies in the four subgroups plotted in Figure 3-1 shows that companies tend to be larger in the sectors with high or medium high digital intensity. Slightly less than half of the sample consists of companies that employ less than 250 staff (group shares for H-MH: 41%; ML-L: 54%), whereas on the upper end of the scale about 16% of the surveyed companies employ more than thousand persons (group shares for H-MH: 70%; ML-L: 55%). Especially companies in the sector with high digital intensity tend to be larger not just in the average, but also in the lower and upper parts of the size distribution. In the analysis of the response patterns of to the questions examined in this report company size should therefore be accounted for, as this may play an important role in observed differences across sector groups.

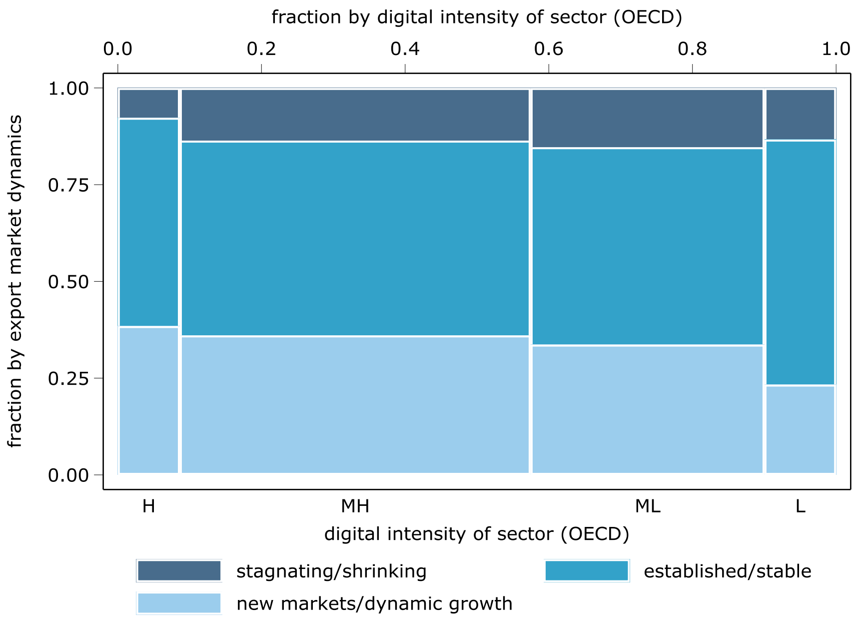
Figure 3-2 shows that the export shares are significantly higher for companies in sectors with high digital intensity. Companies in sectors with medium high digital intensity tend to have higher export shares but the differences to companies in the other sector groups are small. Figure 3-2 shows also the high export orientation of Austrian manufacturing firms. Considering the export market dynamics in which the companies were active in the five years before the survey, Figure 3-3 shows less marked differences between sector groups. The figure presents the aggregated response pattern to a question in the survey where companies have been asked to indicate whether in the respondents' opinion the international markets in which their company has been active in the past five years have developed dynamically, in a stable way, stagnated or declined. While there seems to be an indication that sectors with high or medium high digital intensity have newer or dynamically growing markets, this difference, however, is statistically not significant.

Figure 3-2: Export shares by digital intensity of sector



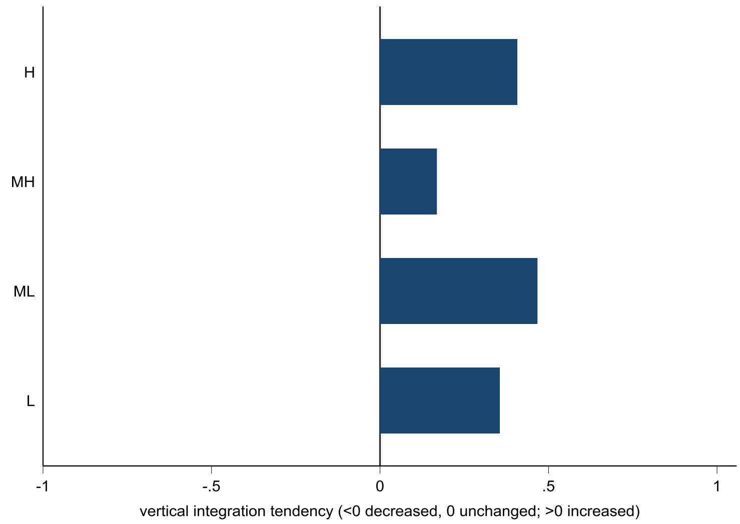
Source: WIFO Industry Survey 2016, WIFO calculations.

Figure 3-3: Export market dynamics by digital intensity of sector



Source: WIFO Industry Survey 2016, WIFO calculations.

Figure 3-4: Development of vertical integration by digital intensity of sector

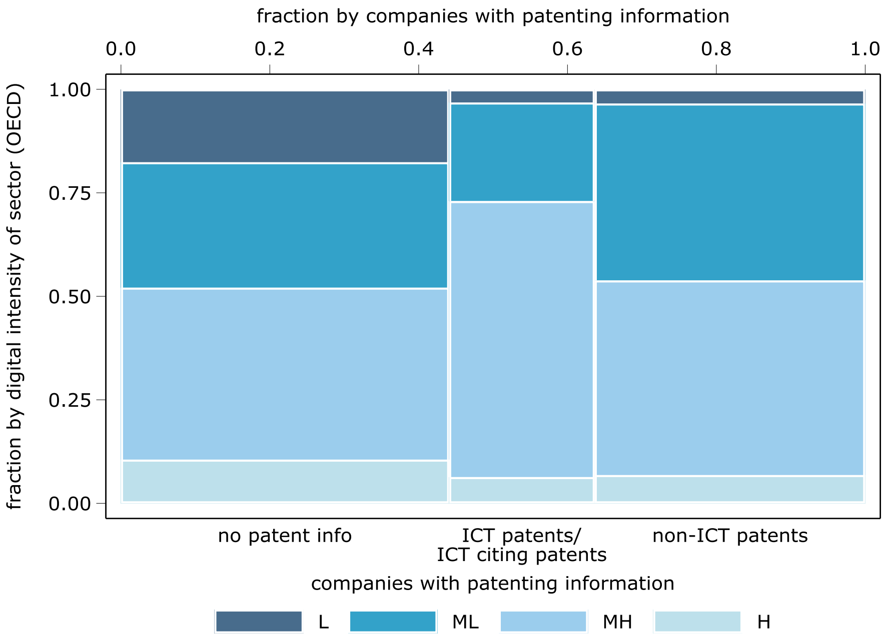


Source: WIFO Industry Survey 2016, WIFO calculations.

Figure 3-4 shows that vertical integration has increased in the Austrian manufacturing sector the five years prior to the execution of the survey. In the figure, responses have been normalised in such a way that a maximum of one would indicate that all companies indicated that their vertical integration had increased, whereas a score of minus one would result if vertical integration had decreased for all companies. The general tendency towards increased vertical integration has been more tamed for companies in sectors with medium-high digital intensity, whereas companies in sectors with high digital intensity do not differ in their development from sectors with medium-low or low digital intensity. The tendency to increase vertical integration is related to the need to control supply chains in technologically more complex products to ensure quality and protect intellectual property.

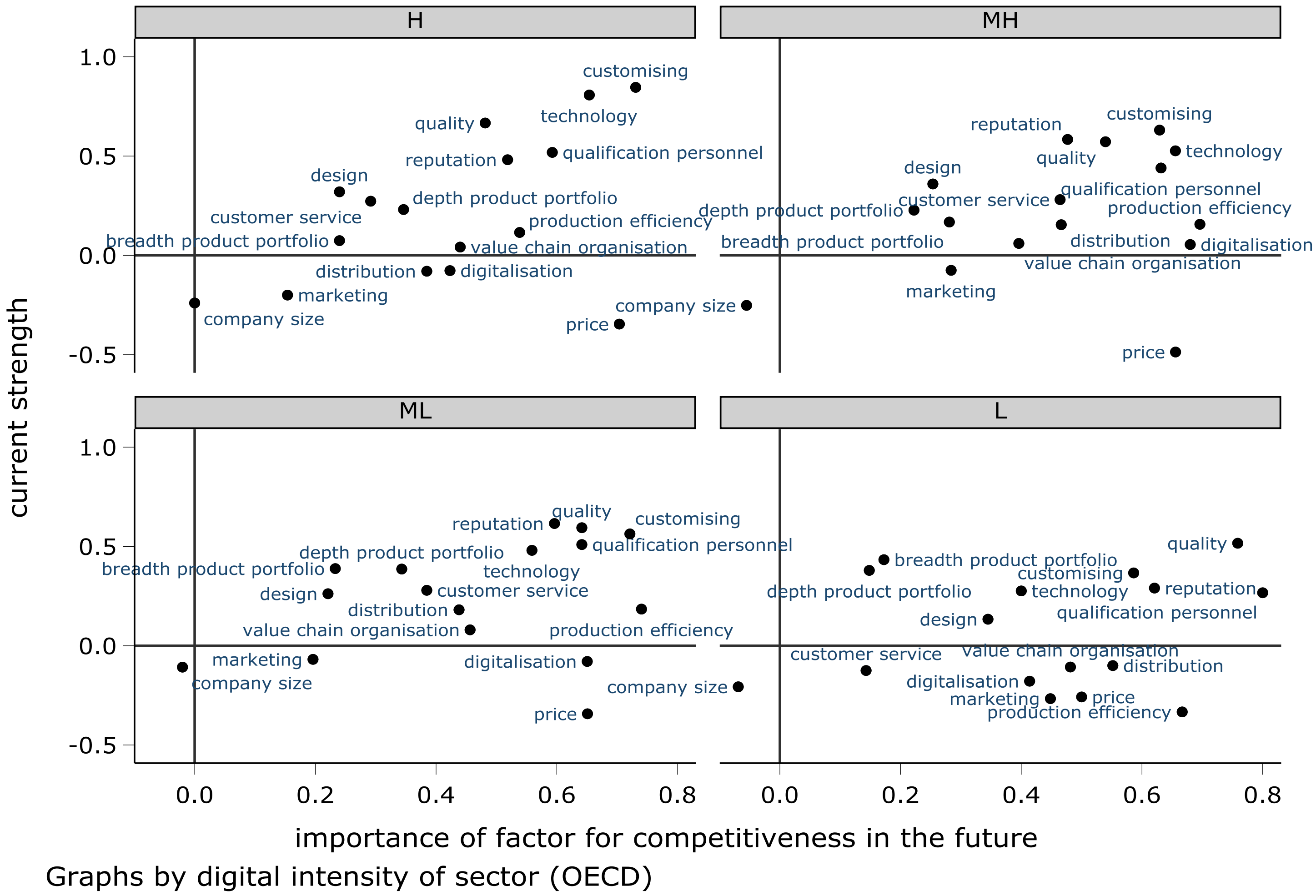
Figure 3-5 finally shows that activities in ICT patents or non-ICT patents using ICT technologies are strongly concentrated in the medium-high digital intensity sector group. This mirrors the sectoral results presented in the previous subsection. Unreported results show that companies that have such patents in their portfolio are more active in dynamic markets and have higher export shares on average than companies that don't. However, the overall response patterns concerning consequences and challenges of digitalisation, the self-assessment of competitive advantages and policy priorities of companies in high or medium high digital intensity industries do not differ qualitatively from each other industries. For this reason, in what follows only results concerning these broader industry groupings will be reported.

Figure 3-5: Patenting activity by digital intensity of sector



Source: WIFO Industry Survey 2016, PATSTAT, Amadeus (Bureau van Dijk), WIFO calculations.

Figure 3-6: Self-assessment of perceived current competitive strengths and their importance for the future by digital intensity of sector



Source: WIFO Industry Survey 2016, WIFO calculations.

3.1.3. Self-assessment regarding competitive strengths and weaknesses by their digital intensity of the industry

The WIFO Industry Survey asked large Austrian manufacturing companies to provide a self-assessment of their current competitive strengths and to provide a judgement whether the importance of these competitive factors will increase or decrease in the future. Respondents were asked to provide their judgment both of their competitive strengths and their importance in the future on a four-part Likert-type scale. To obtain an overall picture the scores were balanced and normalised across respondents in each subgroup to range between a maximum of one and a minimum of minus one. Respondents were asked to provide an assessment of the following competitive factors: technological content of products, product quality, product design, breadth of the product portfolio (i.e. the number of different product lines catering to different needs of customers in a specific market they are active in capturing horizontal diversification), product depth (i.e. the number of product variants catering to different market segments in a market catering to a specific customer need in a given market), the reputation of their trademark and customer goodwill, price, the qualification of the work force, the company size, the efficiency of production processes, digitalisation (e.g. logistics, production, distribution), customising, marketing distribution, organisation of the value chain, and customer service.

Figure 3-5 plots the scores for the two questions obtained in this way against one another in a scatter plot for each sector group. The vertical axis shows scores balanced across respondents for the self-assessed current competitive strengths, whereas the horizontal axis shows the balanced score for the importance of these factors in the future. The reference lines split the figure into four quadrants. The right quadrants are of interest. The upper right quadrant indicates the factors where companies identify their current strengths and which of these they consider to be of increasing importance in the future. The lower right quadrant in turn shows factors with increasing importance in which companies perceive a competitive disadvantage.

In their self-assessment, Austrian manufacturing firms tend to view themselves as being in advantage relative to their competitors in most of the indicated fields. The most important factor in which Austrian manufacturing firms in sectors with high or medium-high digital intensity see themselves in disadvantage with regard to their main competitors is price. Factors where companies see themselves in a slight disadvantage (on balance) are company size, marketing and distribution. The judgement concerning digitalisation is neutral. Here, Austrian companies tend to see themselves as on par with their main competitors. Given the previous results from the sector level analysis this is a quite striking result.

Among the factors that companies in sectors with high and medium-high digital intensity consider to be of increasing importance for their competitiveness in the future figure price, their capability to customise products, the technological content of their products and the qualification of their personnel next to production efficiency. Digitalisation is considered as a factor with increasing importance especially by companies in the sectors with medium-high digital intensity.

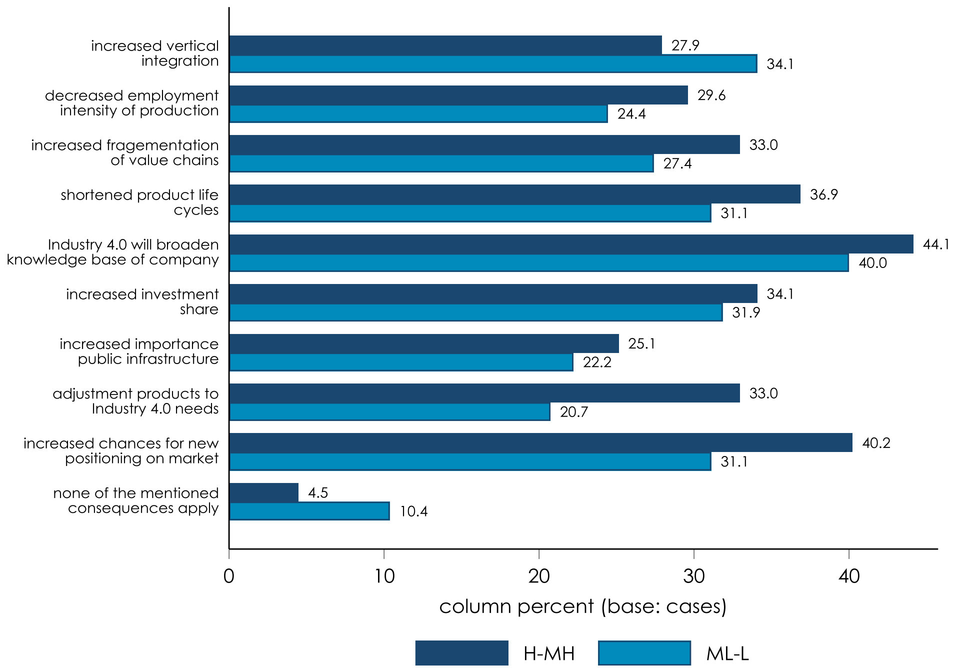
The examination of the internal correlation structure of the response patterns for the current competitive strengths by means of a factor analysis reveals that there are three clusters of closely related responses. This means that across companies the response patterns on the items in this cluster positively correlate. The first cluster shows that responses referring to strengths related to the technological content of companies' products is closely related to responses referring to strengths in product quality, the qualification of the personnel, and customising. The second cluster shows that self-assessed current strengths related to the efficiency of production, digitalisation, distribution and the organisation of value chains. This points at the likely role digitalisation is playing inside companies. It seems to be viewed as an instrument to increase the efficiency of production by improving the organisation of the company's value chain especially with regard to downstream activities. The third cluster reflects strengths in the breadth and depth of the product portfolio to company size. This may be taken as an indication that larger companies are more likely to base their competitive advantage on the design of their product portfolio.

An analogous analysis for the competitive factors that in the self-assessment of companies are likely to play a more important role in the future reveal a high correlation in the response patterns for the need to increase the efficiency of production and digitalisation. This is consistent with the internal correlation structure of response patterns for current strengths and indicates that companies implicitly relate the increased importance of digitalisation in the future to the increase in importance of production efficiency. The link to the organisation of the value chain and downstream activities is less pronounced, however.

3.1.4. Consequences and expected challenges of Industry 4.0 and digitalisation

In the WIFO Industry Survey companies have been asked to assess the expected consequences, as well as the expected impact of digitalisation and Industry 4.0 developments on their company. With regard to the expected consequences companies were asked about the impact on the vertical integration and employment intensity of production, the fragmentation of value chains, the duration of product life cycles, the impact of Industry 4.0 on the companies' knowledge base, the investment share, the importance of public infrastructure, the need to adapt products to fit Industry 4.0 specifications, and companies' chances to reposition themselves on the market. The question was multiple choice, and the respondents could cross all items they considered to apply to their company.

Figure 3-7: Expected consequences of digitalisation and Industry 4.0 by digital intensity of sector



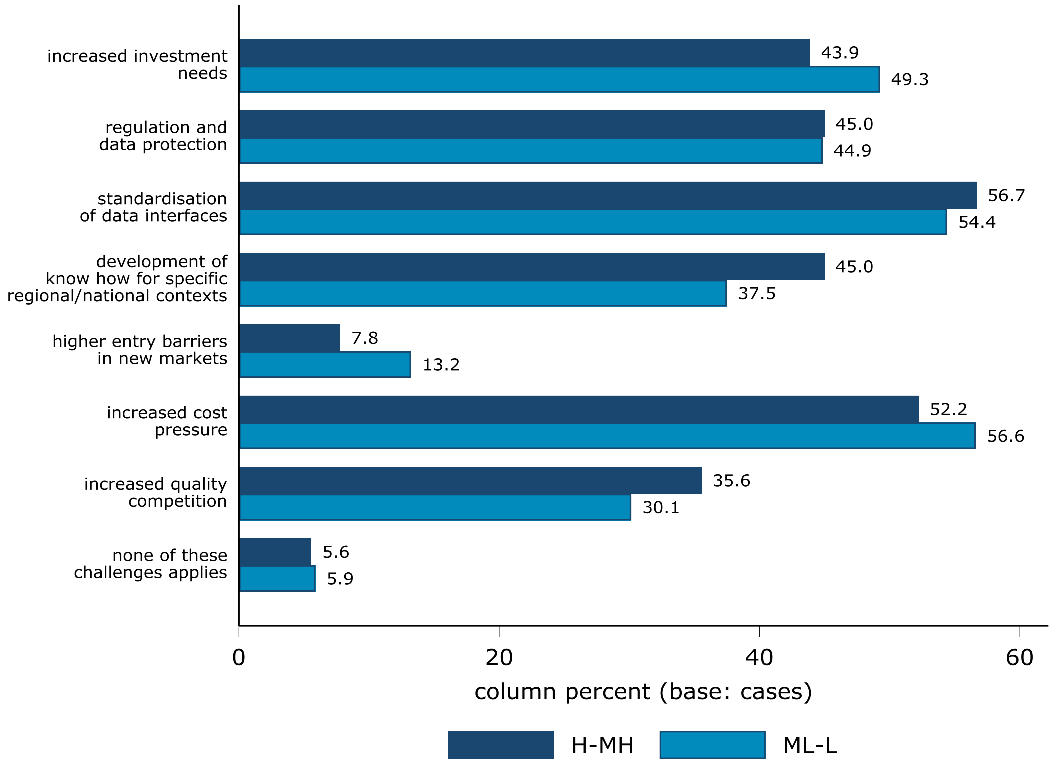
Source: WIFO Industry Survey 2016, WIFO calculations.

For better readability Figure 3-7 summarises the principal results for combined H-MH and ML-L sector groups. It shows that companies in the sectors with high digital intensity indicate that digitalisation and Industry 4.0 are likely to increase the fragmentation of their value chains. At the same time product life cycles will shorten. Increased digitalisation and Industry 4.0 require to broad the knowledge base and an adaption of products to accommodate new technical specifications. Companies indicate however also that they see increasing digitalisation and Industry 4.0 as a chance to reposition themselves on the market.

The examination of the internal correlation structure of the response patterns by means of a factor analysis reveals that responses cluster for the impact on the vertical integration and the employment intensity of production, the fragmentation of value chains, the duration of product life cycles, and increased investment needs. This indicates that respondents consider these items to be jointly relevant. It is interesting to observe that companies seem to view the issues of the fragmentation of value chains on the one hand, and of increased vertical integration on the other hand as being closely related. This gives some indications on the possible reason for the increased vertical integration in Austrian industry observed earlier. It seems to be a reaction to the increased fragmentation of value chains, possibly to better control own production processes and protect intellectual property.

Similarly, responses for the impact of Industry 4.0 on the companies' knowledge base, the importance of public infrastructure, the need to adapt products to fit Industry 4.0 specifications, and companies' chances to reposition themselves on the market are closely related. So, this cluster of responses seems to capture rather perceived opportunities as opposed to the first cluster that seems to capture perceived threats.

Figure 3-8: Expected challenges of digitalisation and Industry 4.0 by digital intensity of sector



Source: WIFO Industry Survey 2016, WIFO calculations.

Companies were also asked to assess the expected challenges related to increasing digitalisation and Industry 4.0 related developments. The answer categories covered the following items: the need to increase investments, regulations and data protection, standardisation of data interfaces, the need to increase companies' know-how in the national or regional context, higher entry barriers into new markets, higher cost pressure, harder quality competition or no challenge related to any of these fields. The question was multiple choice, and the respondents could tick all items they considered to apply to their company.

Figure 3-8 summarises the response to this question. For better readability it condenses the results for the H-MH and ML-L sector groups. It shows that for companies in the sectors with high or medium-high digital intensity the standardisation of data interfaces, issues with regulations and data protection, the need to increase companies' know-how in the national or regional context as well as increased cost pressure were the items most frequently mentioned by the respondents. Even though the figure hints at some differences in the response patterns across sector groups, econometric tests show that these are statistically not significant. Austrian manufacturing companies in sectors with high and medium-high digital intensity seem not to differ systematically in their perception of challenges related to digitalisation and Industry 4.0 from companies in other sectors with lower digital intensity.

The analysis of the internal correlation structure of the response patterns by means of a factor analysis reveals that there are three clusters of closely related responses (see Figure B-54 in the appendix to this chapter). The first cluster groups responses related to the standardisation of data interfaces and possible issues with regulations and data protection. Companies see clearly challenges related to the adoption of these technologies here that fall in the technical and regulatory spheres and have a more operative character related to the implementation of new digital technologies. The second cluster groups related responses on increased investment needs and increasing cost pressure, and the third cluster indicates that respondents implicitly see the need to increase companies' know-how in the national or regional context, higher entry barriers into new markets and harder quality competition as related. This cluster therefore captures perceived challenges related to changes in the competitive environment of firms.

3.1.5. Perceptions on policy priorities to support competitiveness

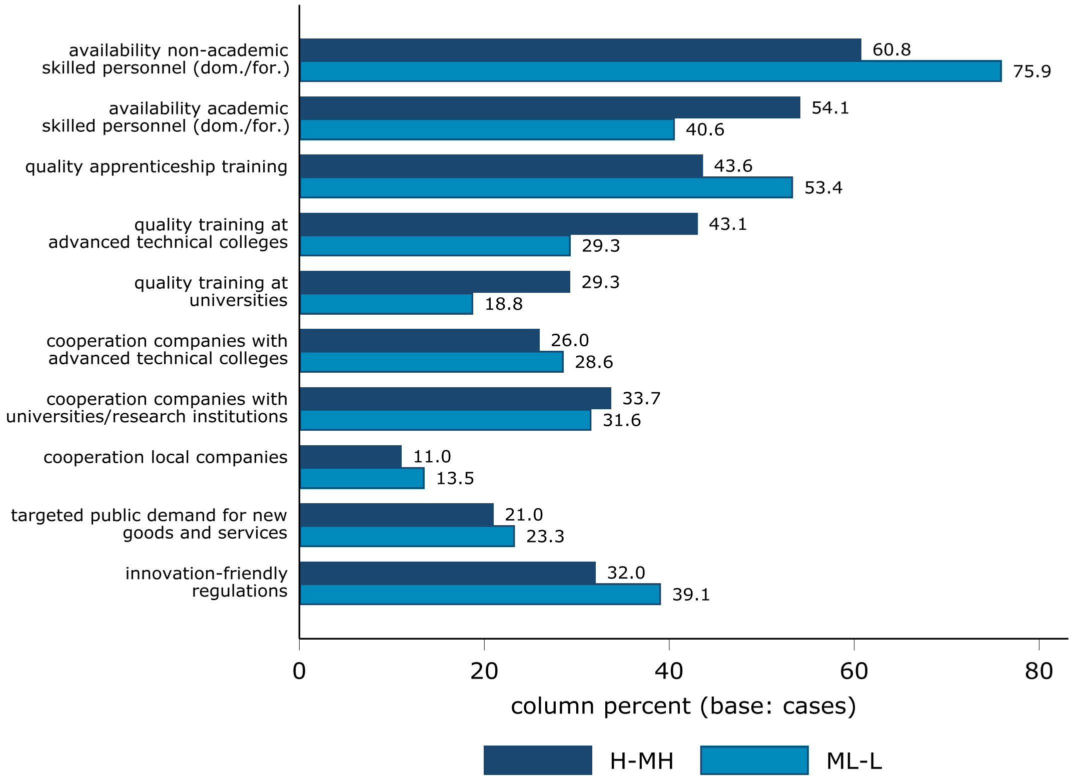
3.1.5.1. Factors for competence building

In the WIFO Industry survey companies were asked to indicate in which fields of public policy improvements would be needed to best support the development of competences at the company level. The respondents were given the choice between ten different policy fields and one open category in which they could indicate areas not directly covered by the question. The policy fields covered in the question concerned the availability of non-academic and academic specialists (domestic and foreign), the quality of apprenticeship training, the training at technical colleges and universities, the cooperation between companies and technical colleges, universities and research institutes as well as local companies, and finally public procurement as well as regulations and norms supporting innovation. The question allowed for multiple choices by the respondents.

Figure 3-9 summarises the response to this question. For better readability it condenses the results for the H-MH and ML-L sector groups (see Figure B-50 in the appendix to this chapter for a full break-down). Companies in sectors with high and medium-high consider the availability of skilled personnel in the different categories as being of importance for their own competence building. While the availability of skilled personnel is considered by all surveyed manufacturing firms as being an important area of improvement to support their own competence building, companies in industries with high and medium-high digital intensity put higher emphasis on the availability of personnel with academic training and the quality of the training at technical colleges. Companies in sectors with low digital intensity in turn put higher emphasis on the availability of non-academic personnel and the quality of apprenticeship training. Econometric tests show that the observed differences in these categories between the different industry groups are also statistically significant. This suggests that companies in sectors with high digital intensity tend to require personnel with general education whereas companies in sectors with lower digital intensity require more heavily skill-based education. General academic education typically is one that enables people to develop more generic and interdisciplinary problem-solving approaches, whereas skill-based education is more focused on the execution of specific activities in more narrowly circumscribed technical and professional domains. Krueger and Kumar (2004) tried to explain differentials in productivity growth between the US and European countries through the different focus of the respective education systems on general (US) and skill-based education (European countries).

Improvements in other policy domains seem to be of subordinate importance for the competence building of Austrian manufacturing companies and response patterns do also not significantly differ across industry groups.

Figure 3-9: Key location factors to improve the competence base of Austrian manufacturing companies



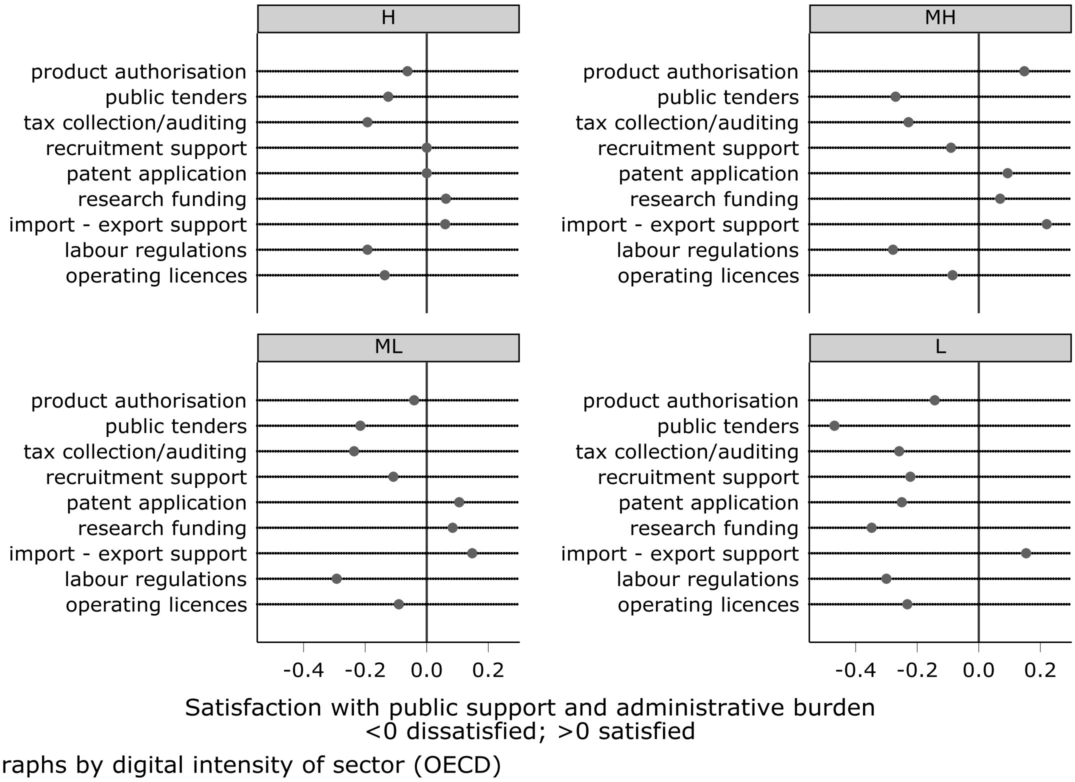
Source: WIFO Industry Survey 2016, WIFO calculations.

Looking at the internal correlation structure between response patterns by means of a factor analysis reveals that respondents highlighting the importance of the availability of academic specialists at the same time underscore also the importance of improvements in the quality of education both at technical colleges and universities. Consistently with this finding, respondents pointing at the importance of the availability of non-academic specialist at the same time also stress the importance of the quality of apprenticeship training.

3.1.5.2. Satisfaction with public administration support

Companies were asked about their satisfaction with administrative procedures and public support measures. Respondents could indicate their satisfaction with specific procedures or measures on a Likert-type scale with which they could express their satisfaction or dissatisfaction. Figure 3-10 presents the related results. Drawing on practice from business tendency surveys, favourable and unfavourable replies have been balanced over all respondents in each subgroup and normalised by the maximum possible score each item in the question could obtain if all respondents in the subgroup had chosen the same extreme value on the scale. With this normalisation the maximum score in case of total satisfaction in a subgroup would be 1, and in case of total dissatisfaction -1. The question has covered the following administrative procedures and public support measures: product authorisation processes, public tender procedures, tax collection and tax auditing, the public support to recruit personnel (for instance through the public job placement agency AMS, or subsidies to employ long-term unemployed persons, etc), import and export support (through guarantees), research and development funding, patent application procedures, work safety and work time regulations, and procedures to obtain operating licenses for new plants.

Figure 3-10: Satisfaction of Austrian manufacturing companies with administrative procedures and support measures by digital intensity of sector



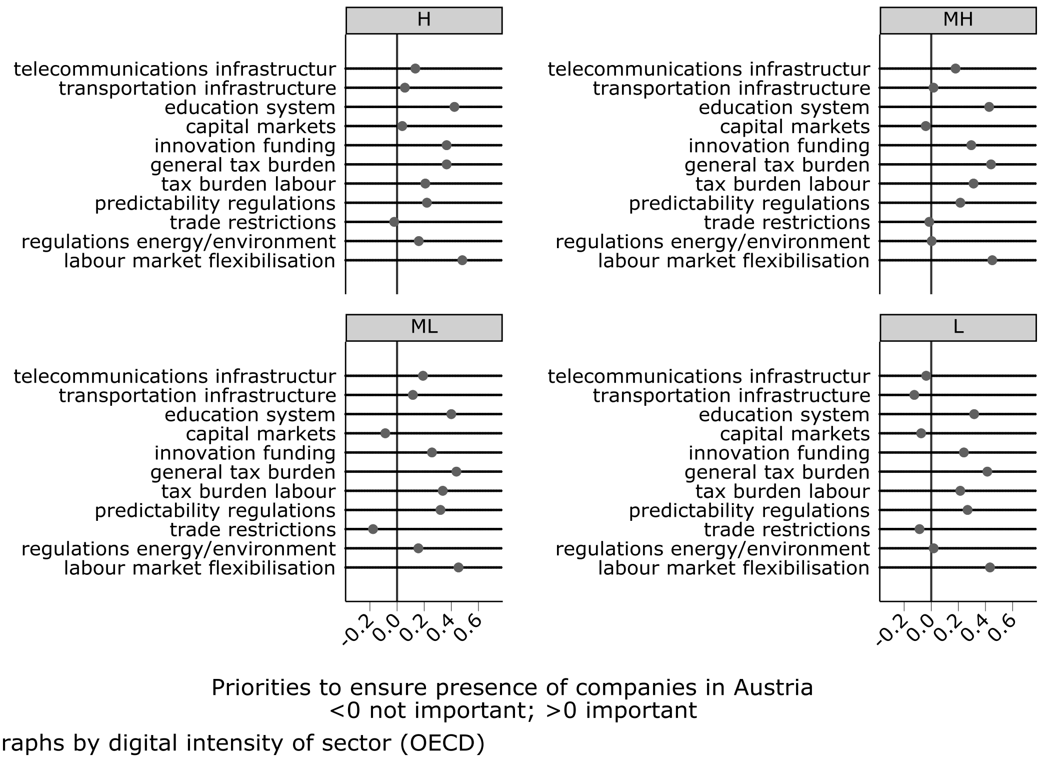
Source: WIFO Industry Survey 2016, WIFO calculations.

The response patterns are relatively similar across sector groups, with companies being generally relatively satisfied with or having a neutral attitude towards research and development funding, import and export support, and patent application procedures. For all other domains of administrative procedures and public support measures in Austria companies tend to be on balance relatively dissatisfied. For sectors with high and medium-high digital intensity particularly labour regulations, tax collection and auditing as well as public tender procedures are the domains where companies are most dissatisfied. Concerning public support measures and administrative procedures one can observe only minor difference in perceptions between companies in sectors with high and sectors with low digital intensity.

3.1.5.3. Priorities for structural policies

Finally, companies have been asked about where they see priorities for policy to support their competitiveness. As in the question concerning the satisfaction or dissatisfaction of companies with administrative procedures and public support measures, respondents could indicate their priorities on a Likert-type scale which were balanced and normalised across respondents in each subgroup to range between a maximum of one and a minimum of minus one. Figure 3-11 presents the related results.

Figure 3-11: Priorities for structural policy interventions to ensure sustained competitiveness for Austrian manufacturing companies by digital intensity of sector



Source: WIFO Industry Survey 2016, WIFO calculations.

The question has covered the following policy domains: public investments into the telecommunication infrastructure, public investments in the transport infrastructure, improvements of the education system, strengthening of capital markets, expansion of innovation funding, a general reduction of the tax burden, a reduction of the tax burden on labour with an increase of taxes on other factors, improvement of the predictability of regulations, a reduction of trade restrictions, a relaxation of regulations concerning energy and environment and an increase of the flexibility of labour law.

The results show that again there is no strong or systematic difference in the response patterns between the different industry groups. Companies do not consider a strengthening of capital markets or reductions of trade restrictions as particularly important, whereas they tend to see on balance all other domains as being important policy areas where improvements are necessary to support competitiveness. Interestingly, for companies with high or medium-high digital intensity higher investments into the telecommunications infrastructure do not figure among the most important domains. So, despite the observation that Austria suffers from an underinvestment in the development of modern telecommunications infrastructure, this seems not to be perceived as a major constraint for large manufacturing companies. Their responses closely follow the pattern observed also in other sector groups. Highest priority across industry groups is given to the education system, the flexibilization of labour laws and a reduction of the general tax burden.

3.1.6. Summary

Despite the evidence from sector-level data showing that the Austrian business sector lags behind Innovation Leaders both in the adoption and generation of digital technologies, Austrian companies active in industries with high digital intensity do not perceive competitive disadvantages arising from digitalisation. Rather, they tend to see themselves on par with their principal competitors or only mildly at a disadvantage. On the other hand, digitalisation is commonly perceived as a competitive factor with increasing importance that presents some challenges related to changes in the competitive environment and to operative issues related to the adoption of digital technologies such as the standardisation of data interfaces or data protection.

The results also indicate that companies link digitalisation implicitly to production efficiency and the organisation (possibly optimisation) of value chains. As the surveyed companies see their competitive strengths in the technological content of their products, product quality and their capability to customise their products, this is likely to offset potential disadvantages arising from lower use of digital technologies and therefore also shape perceptions about the implications and challenges related to digitalisation.

An important aspect emerging from the survey is related to the priorities for structural policies companies in sectors with high or medium high digital intensity perceive as opposed to companies in sectors with lower digital intensity. The supply of skilled personnel with academic training as well as the quality of education at technical colleges and universities is a high priority for these companies, whereas companies with low digital intensity put more emphasis on skill-specific training and the supply of skilled personnel with non-academic, professional training.

Another aspect of interest related to structural policies is that while indicators show that there is a general issue with underinvestment in Austria regarding telecommunications infrastructure and more specifically high-speed internet, Austrian manufacturing companies seem not perceive this as a major constraint for their competitiveness. While they see this aspect of structural policy as being important it is overshadowed by the emphasis given to improvements of the education system, the flexibilization of the labour market and a general reduction of the tax burden. This outcome may however be biased by the average company size of the respondents to this survey. The perceptions may also strongly differ depending on the location of the company. As larger companies typically also settle in the proximity of larger agglomerations.

3.2. The up-take of Industry 4.0 technologies and digital platforms in the Austrian business sector

3.2.1. Industry 4.0

The vision of a fully automated, scalable and flexible production is the basic idea of Industry 4.0 (I4.0). Key components are robots, enterprise planning systems (ERP), automated warehouse systems, etc. Moreover, 3D printing is sometimes also discussed under the I4.0 heading. Industry 4.0 will allow a highly flexible and at the same time highly efficient production which makes it possible to produce individualized products under the economic conditions of a mass producer (Lichtblau et al. 2015).

One of the rare data sources on Industry 4.0 is the data from the European Manufacturing Survey (EMS) 2015. The EMS is a firm-level survey that investigates product, process, service and organisational innovation in European manufacturing. EMS is organized by a consortium co-ordinated by the Fraunhofer Institute for Systems and Innovation Research (ISI).[36] Drawing on these data, the next section looks at the diffusion of individual I4.0 technologies in Austria. The sample includes 231 manufacturing firms with 20 or more employees.

3.2.1.1. Automation

In this section we present evidence on the extent Austrian firms already use different I4.0 technologies.

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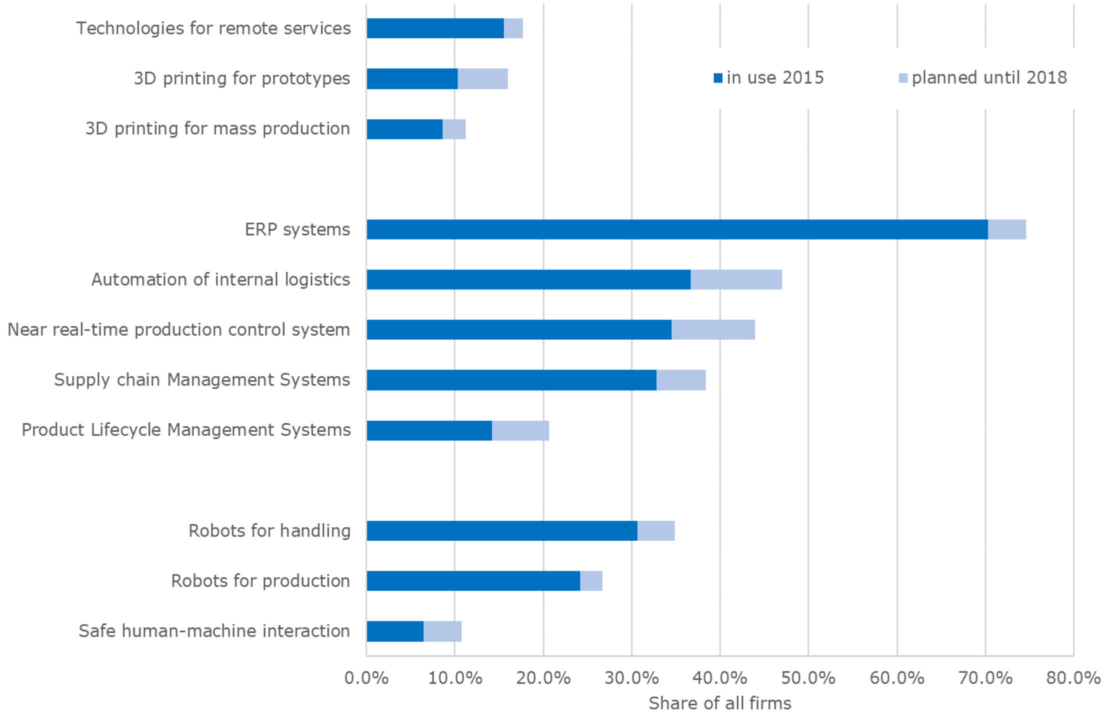
[36] http://www.isi.fhg.de/i/projekte/survey_pi.htm

Figure 3-12 shows considerable differences between the technologies. While enterprise resource planning (ERP) and automated internal logistics are already used by many firms with 20 or more employees, technologies for providing remote services (for example by augmented reality) or 3D printing are only in the first stages of their diffusion. [37]

Figure 3-12: Share of firms which use different Industry 4.0 technologies, 2015 and plans until 2018, Austria



Source: European Manufacturing Survey, AIT calculations.

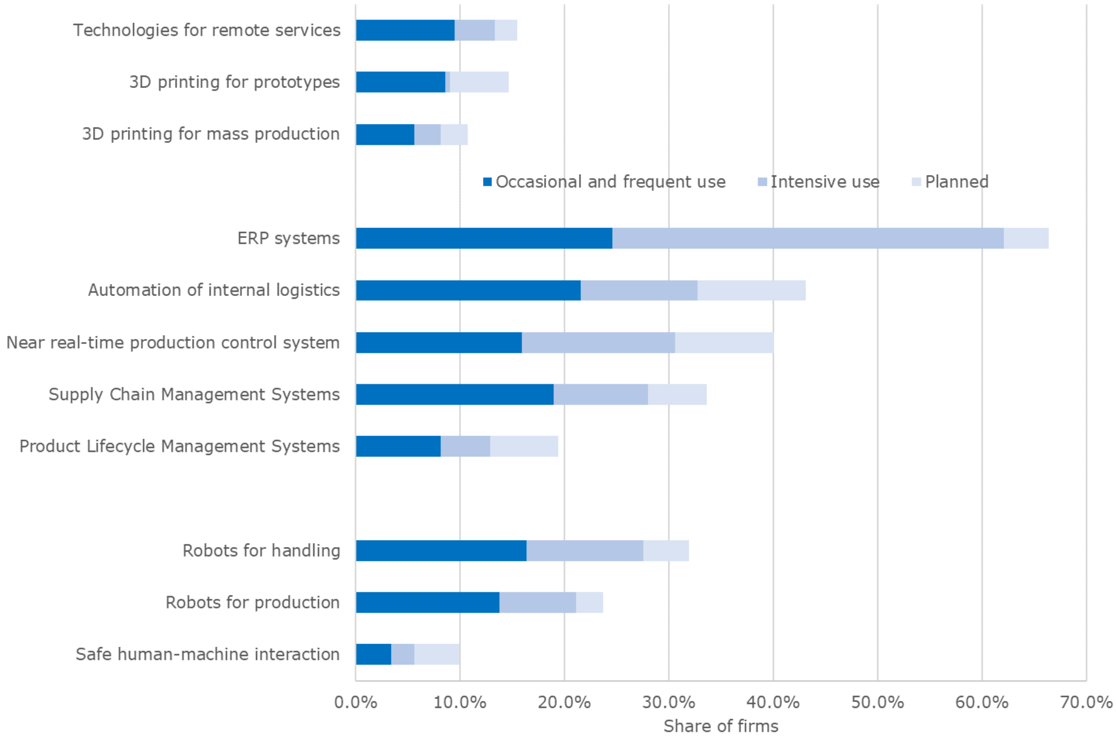
The shares of firms which plan to introduce these technologies until 2018 show that some technologies have a huge potential for further diffusion, while other seem to have reached saturation. Examples for the latter are robots in production and ERP systems, while an example for technologies with a high potential is 3D printing for prototypes. 3D printing for mass production, in contrast, still seems to be a technology which has not reached a sufficient degree of productivity so only a few firms consider to introduce it.

Figure 3-13 presents a different perspective on the diffusion of different I4.0 technologies. Firms were asked to judge is the intensity of use of a certain technology on a 3 items scale (occasionally, regular, intensive).

There are only very few firms which already use 3D printing intensively. In contrast, to ERP systems have a high degree of diffusion and are used intensively by the majority of firms. Robots are used by less than 30 percent of all firms, but there is a considerable share which uses them intensively. This confirms that ERP, automated logistics, and production control systems are already usable tools within Industry 4.0, while the first three technologies have not yet reached this stage of maturity.

[37] We provide international comparisons for ERP and supply chain management systems in the next section.

Figure 3-13: Intensity of use of different Industry 4.0 technologies, 2015 and plans until 2018, Austria

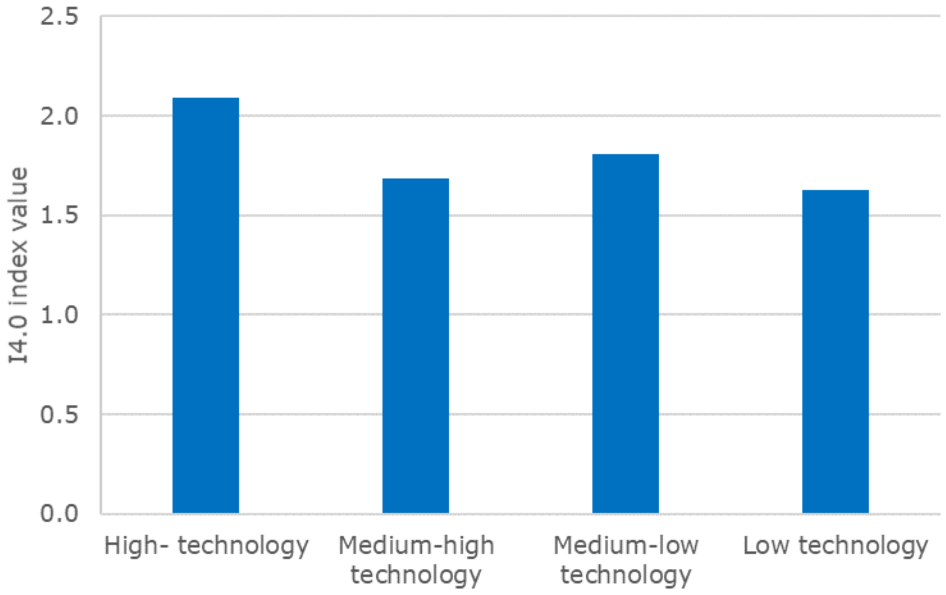


Source: European Manufacturing Survey, AIT calculations.

To compare the usage of I4.0 technologies across sectors and size classes, we aggregated the technologies to an I4.0 index (see appendix for details). The index can take a value between 0 and 5, and a higher value indicates that the firm is closer to full I4.0 implementation. The index assigns a higher weight to the most advanced technologies – cyber-physical systems. The result is shown in Figure 3-14.

We first look at differences between sectors. High technology firms reveal the highest index values, while low technology firms are assigned the lowest values. However, except for high-technology firms, all values are in the range between 1.63 and 1.83 which indicates that sectoral differences are rather small. Thus, I4.0 also finds wide application in medium- and low-technology firms, which is not surprising given the complex production processes in the wood, paper, textiles, glass, or metal industry. This result shows that Industry 4.0 is not only relevant for high technology firms but also well-suited for many of Austria's medium-tech manufacturing industries. We find also confirmation in interviews for this finding; one interview partner observes that I4.0 which has been developed for the fabrication of metal products diffuses to the wood industry. There seems to be a trickle-down effect from high technology to lower technology intensity. Moreover, the result also shows that a measure of technology intensity based on R&D intensity may be less appropriate to capture differences between sectors when it comes of Industry 4.0.

Figure 3-14: Industry 4.0 index and sectoral technology intensity, Austria 2015



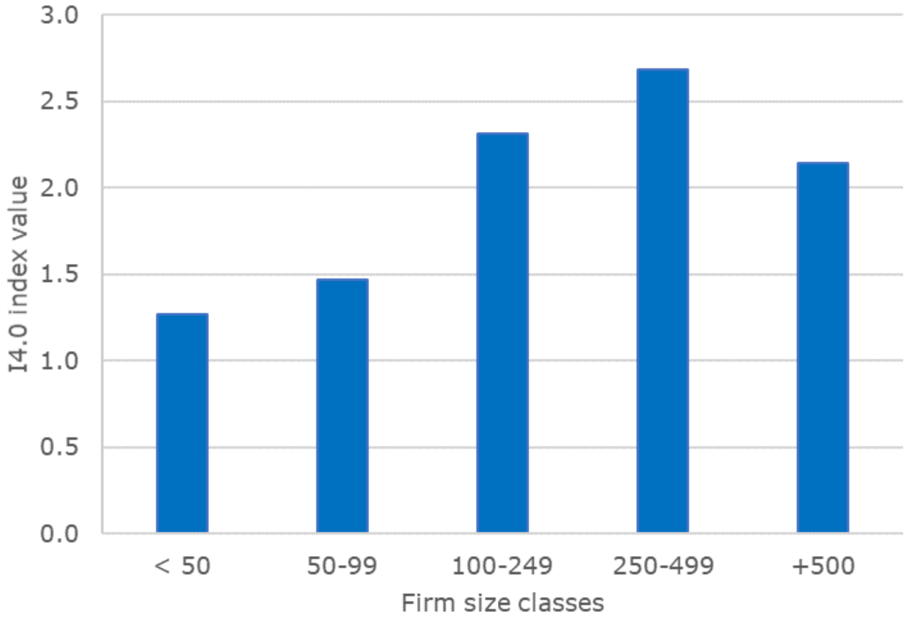
Source: European Manufacturing Survey, AIT calculations.

Another important determinant of I4.0 use is the position of the firm in the supply chain. The data show that suppliers of intermediate goods have higher I4.0 index values compared to producers of final products. This can be explained by the requirements of industrial clients to introduce supply chain management technologies to their suppliers.

We see much larger differences between firms of various size classes (see Figure 3-15 below). Small firms with less than 50 employees reveal only an index value of 1.27, while firms with 250 to 499 employees reach an index value of 2.68. A closer inspection of the data shows that the smaller firms have lower index values in all four sectoral groups depicted above, so the differences cannot be explained by a different sectoral affiliation of smaller or larger firms. Moreover, the data also indicate that large firms use these technologies more intense, although differences between size classes are smaller than in the I4.0 index.

This points to obstacles for small firms in the diffusion of Industry 4.0. One of these obstacles may be the costs associated with a modernisation of production equipment combined with a long machine life of production equipment in many sectors. Large firms can introduce I4.0 gradually, without changing the whole production process. Moreover, large, multi-product firms may see more potential for the application of Industry 4.0 than small firms with only a few products and one principal line of production.

Figure 3-15: Industry 4.0 index for firms in different size classes, Austria 2015



Source: European Manufacturing Survey, AIT calculations

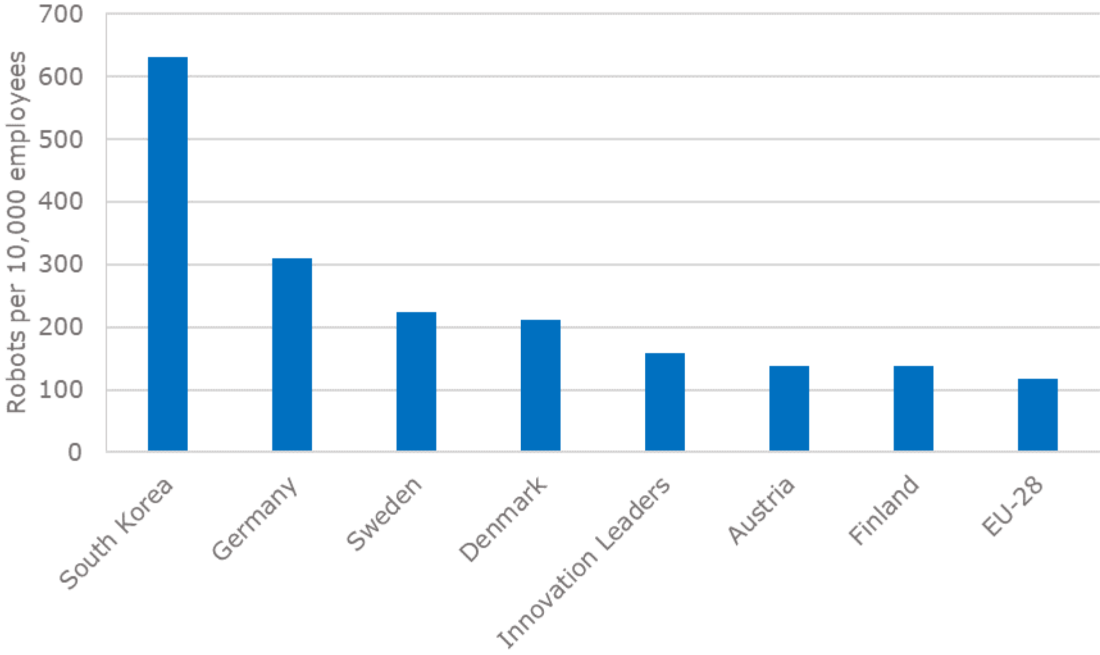
The EMS data allow limited comparisons between countries. The I4.0 index takes quite similar values for Germany, Switzerland and Austria so differences in the diffusion of these technologies between the three countries are small (Dachs – Kinkel – Jäger 2017). More comparison countries are available if we look at specific technologies. Industrial robots, as part of advanced production technologies, are a key enabling technology to improve the competitiveness of European manufacturing. We have already presented evidence the diffusion of robots above; however, there is also data on robot use provided by the International Robotics Federation (IFR) that allows international comparisons.

We compare the diffusion of industrial robots in the manufacturing sectors of different countries in Figure 3-16. IFR constructs this data by collecting information on robot sales from almost all suppliers of industrial robots in the world.

Austria has an average position in the comparison countries with respect to the use of industrial robots. Twice as many robots are used in Germany (the best performer in the EU) and Sweden per 10,000 employees in manufacturing compared to Austria, and four times as many in Korea. The graph also shows that the gap between Austria and the EU-28 is significantly smaller than in other digitalisation indicators.

One important reason why Austria is not one of the leading countries in robotics is the industry structure. The share of manufacturing value added of the automotive industry, the most important use sector of industrial robots by far, is lower in Austria than in the countries with the highest penetration of robots per employees.

Figure 3-16: Installed industrial robots per 10,000 employees in manufacturing, 2016



Source: International Federation of Robotics (IFR)[38], AIT calculations.

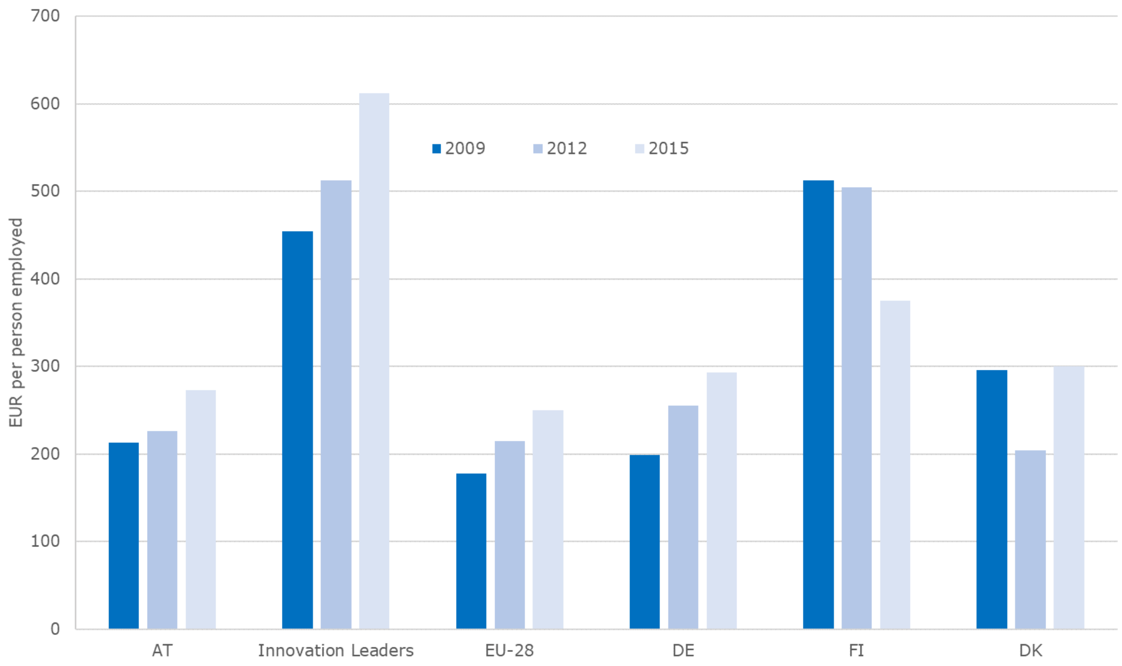
New production equipment, however, is only one part of automation. A major push towards more automation in many firms, in particular service firms, comes from software. Software can be used to codify the knowledge of experts into rules which can be applied automatically. Thus, software can make people more productive, by facilitating communication and providing more and more recent data for decision-making. Examples are enterprise resource planning and management information systems.

Data on investment in software is collected by national statistical agencies in co-operation with Eurostat. However, for unknown reasons, Eurostat only publishes data on software investment in manufacturing. Figure 3-17 compares software investment per person employed in Austria with the corresponding values for Innovation Leaders, the EU-28, Germany, Finland and Denmark. We have excluded the best performing country – the Netherlands – because their value (1,822 EUR per person employed in 2015) would distort the axis units of the figure and make the values for the other countries unreadable.

Austrian manufacturing reveals roughly a similar investment intensity as Germany, but lags behind the Innovation Leaders aggregate (consisting of DK, DE, LU, FI) and Finland (see Figure 3-17). However, compared to Finland, where software intensity decreases over time, Austria shows a clear upward trend over the years where data is available.

[38] https://ifr.org/ifr-press-releases/news/robot-density-rises-globally

Figure 3-17: Software investments in EUR per person employed, manufacturing, 2009, 2012, 2015

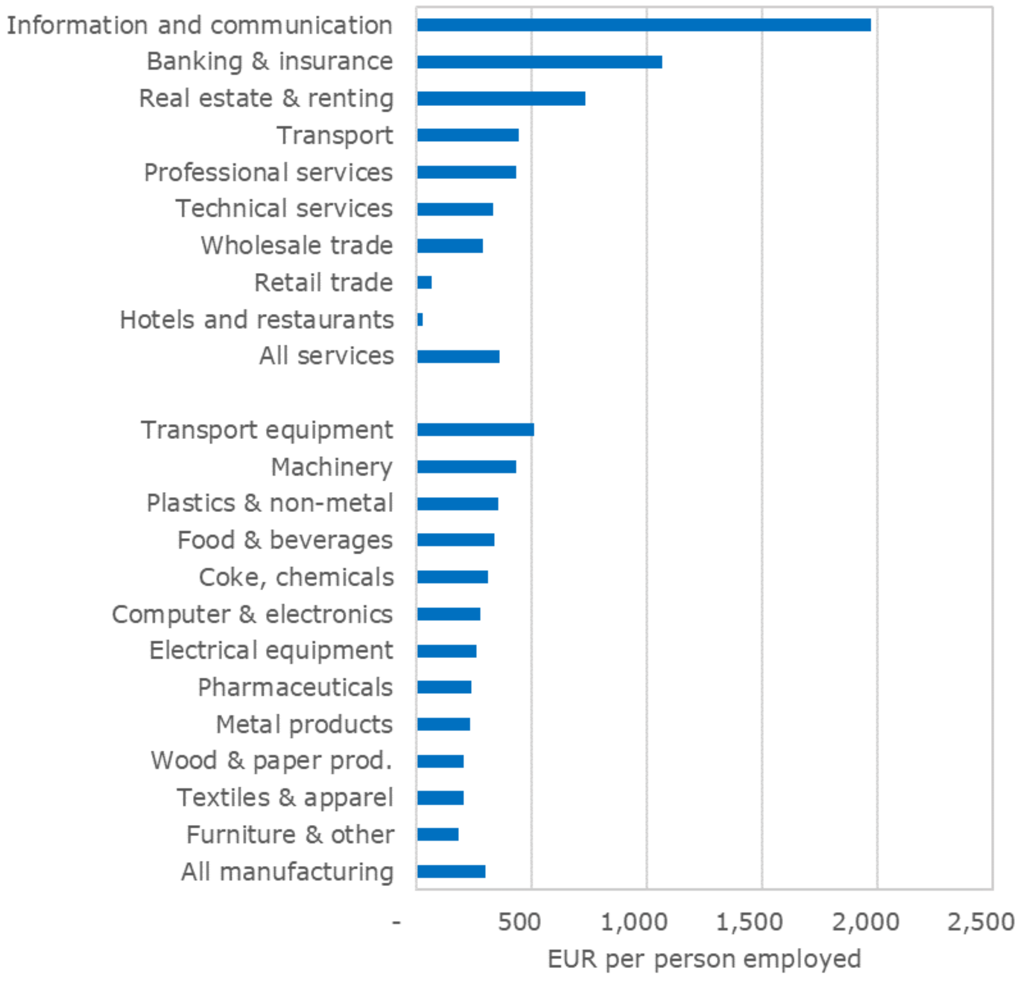


Source: Eurostat, AIT calculations. Note: data for Sweden not available.

There is no data for service industries available from Eurostat that allows international comparisons; however, we can employ national data from Austria to investigate software intensity in services. This data shown in the Figure 3-18 below clearly indicate the importance of software investments for Austrian service industries: 74% of all software investments are in service sectors, compared to 20% in manufacturing (which is also roughly the share of manufacturing on total employment). Mining, construction and utilities account for the reminder.

Overall software intensity is higher in services than in manufacturing (362 vs. 301 EUR per person employed). The most software-intensive sectors are found in services which indicates the importance of software as a production factor in these sectors: information and communication, banking and insurance and renting and real estate spend most on software relative to employment. Information and communication spend more than 1,900 EUR per employee on software, compared to 363 for all service sectors. Telecommunications, as part of information and communication services, even reveals a software intensity of 7,282 EUR per employee.

Figure 3-18: Software investments in EUR per person employed, various sectors of the Austrian economy, 2016



Source: Statistics Austria, AIT calculations.

Software investment in banking and insurance amounts to about 1,000 EUR per person employed, so this is another highly capital-intensive sector. However, banking and insurance is considerably more personnel-intensive than information and communication, so ICT is not the sole decisive factor of production in this industry. Together, these two industries account for one third of all software investments in the Austrian enterprise sector and we can assume that competitiveness and productivity growth crucially depend on software in these sectors. Other software-intensive services are real estate and renting and transport. In contrast, there are some personnel-intensive services such as retail trade and hotels and restaurants, where software investment intensity is only a small fraction of the values of the sectors.

In manufacturing, the sectors using software most intensively are the producers of transport equipment and machinery, but none of these sectors comes even close to the intensities of the most software-intensive service sectors. It may be that some software investments of manufacturing firms are embodied in equipment and not recorded as separate software investments. This may explain why software accounts for only 2.6% of all investments in manufacturing, while the corresponding value for banking and insurance is 7.3% and even 15.6% in information and communication. Overall, the service share in total investment is similar in manufacturing and services.

Even if we account for such a bias, is seems fair to assume that software is more relevant for competitiveness in large parts of the service sector compared to manufacturing. Exceptions are retail trade and tourism.

The relevance of software for services also becomes clear when we relate software investments to total personnel cost. Not surprisingly, the highest value can be found in telecommunications, where the relationship between software investment and personnel cost is 1:10 compared to 1:184 for manufacturing and 1:103 for total services. Other sectors which a low software/personnel cost ratio, and thus software-intensive relative to personnel-intensity, are renting, media, information services, and auxiliary transport services, which includes logistics (but not transport itself). The sectors with the highest software/personnel cost ratio include construction, tourism, employment activities and security and investigation activities.

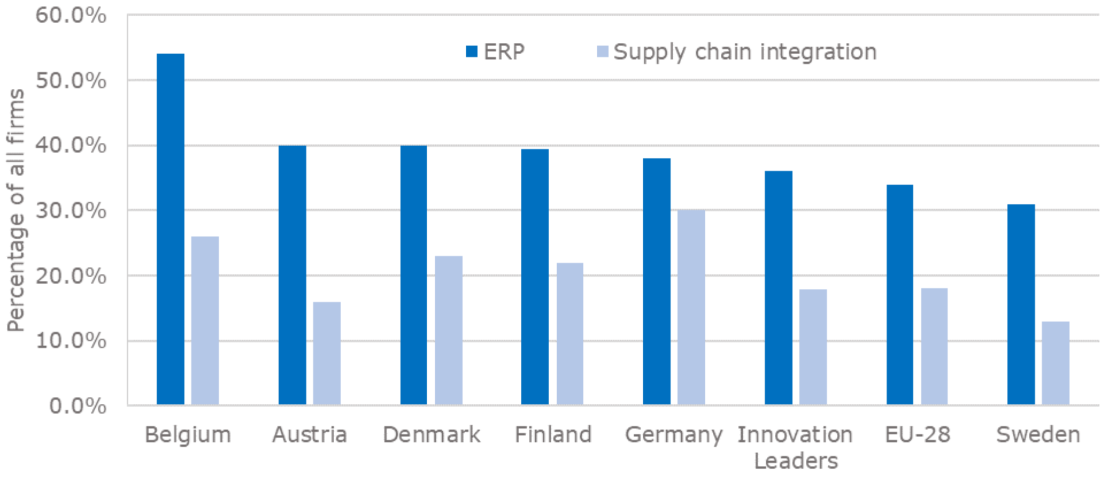
3.2.1.2. The impact of digitalisation on the integration of value chains

Information and communication technologies facilitate the internal organization of different stages of production as well as spatially distributed production in global value chains. There are several technologies that can support a tighter integration within and between firms. Internally, firms utilize enterprise resource planning (ERP) systems – software packages that collect information, facilitate the flow of information between different departments and facilitate the management of various business processes. Typical processes represented in ERP are accounting, human resources, production, or project management. To include external relations, ERP can be further enlarged to include also the processes of suppliers and customers. The integration of these upstream and downstream processes is a central idea in the current discussion on automation in firms, including Industry 4.0 and the Internet of Things (OECD 2017).

Figure 3-19 shows that ERP systems have found wide diffusion in European economies in the last years in Belgium and the Netherlands, Lithuania and Spain. Austria – with a share of 40% - is in the Top group of countries in terms of ERP is used and one level with Germany and the Innovation Leaders. In contrast, Austrian firms rank only average compared to firms from other European countries if we look at value chain integration measured by the share of firms which maintain automatic linkages of their business processes to those of their suppliers and/or customers. Here, Austria is considerably lagging behind Germany (the best performer), but also the lnnovation Leaders.

The EU28 average of both indicators is quite similar to the EU15 average (not reported in the figure); this indicates that differences between Western, Central and Eastern EU member states are quite small. Diffusion rates across EU members are particularly small among large firms with 250 and more persons employed.

Figure 3-19: Share of enterprises that use ERP systems and automatic linkages of their business processes to those of their suppliers and/or customers, 2017



Source: Eurostat, AIT calculations.

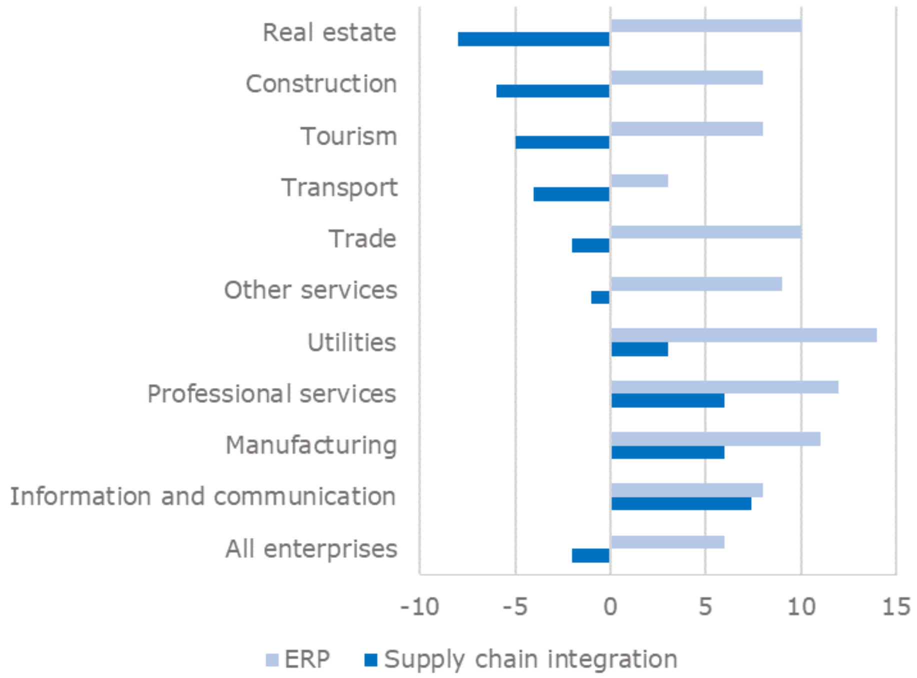
Below the country level, there are some sectoral differences in the diffusion of the two technologies. Manufacturing firms use ERP more frequently than service firms in most countries. In value chain integration, such differences do not appear.

We will investigate these differences in Figure 3-20 in more detail. It shows the differences in diffusion rate of ERP and supply chain integration between Austria and the countries of the European Union for various sectors including service sectors. At first, it becomes clear that the differences between Austria and the EU28 can be related to a slower diffusion of supply chain integration in services and construction. Austrian firms in real estate, tourism, transport and trade utilize these technologies considerably less often than do their counterparts in other EU countries.

In contrast, manufacturing and information and communication services, professional services and utilities are above the EU average. Austria is among the Top 5 countries in value chain integration in the European Union if we only consider manufacturing firms. This points to the close ties of Austrian firms with German and CEE companies in a central European manufacturing core (Stehrer – Stöllinger 2015). One explanation for at least some of the differences is international competitive pressure to adapt these technologies, which is larger in sectors open to international trade.

We also see some sectoral differences in the diffusion of ERP. Again, manufacturing is one of the leading sectors, Austria is among the Top 5 countries in the EU. Sectoral differences are smaller here and there is no sector which is below EU average. This indicates that the efficient organization of internal processes with ICT is a priority for all firms, regardless of international linkages.

Figure 3-20: Differences between Austria and the EU28 in the share of enterprises automatic linkages of their business processes to those of their suppliers and/or customers and ERP, 2017



Source: Eurostat, AIT calculations.

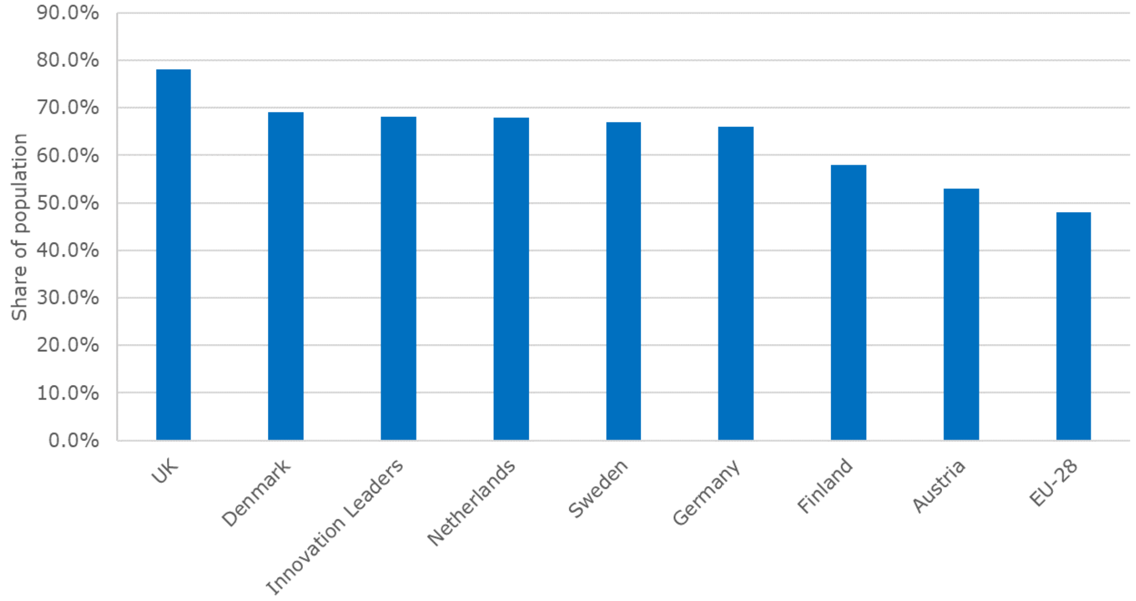
3.2.2. Platforms

Platforms are Internet-based intermediaries that facilitate transactions between suppliers and users of goods and services. Platforms are characterized by very low marginal costs for access and production of services, strong network economies of scale, and often high switching costs between platforms (McAfee – Brynjolfsson 2017). Moreover, platforms claim to improve access to unused or underutilized resources (apartments, cars, etc).

These characteristics explain the strong growth of the platform economy (or sharing economy). For some authors, such as Kenney and Zysman (2016), platforms are the determining organizational form of a future economy: ".... if the industrial revolution is organized around the factory, today's changes are organized around these digital platforms, loosely defined."

Recent data suggest that platforms have gained widespread diffusion among consumers in Austria; 42% of Internet users in Austria use online marketplaces at least once a week, which is a high value compared to other European countries (Eurobarometer 2017). According to data collected by Eurostat for 2016, 53% of all Austrians bought on-line in the last three months (see below). This is lower than in the comparison countries, but nevertheless higher than the EU average. These figures suggest that there is a demand for e-commerce in Austria from the consumer’s side.

Figure 3-21: Share of individuals who bought over the Internet in the last three months, 2016

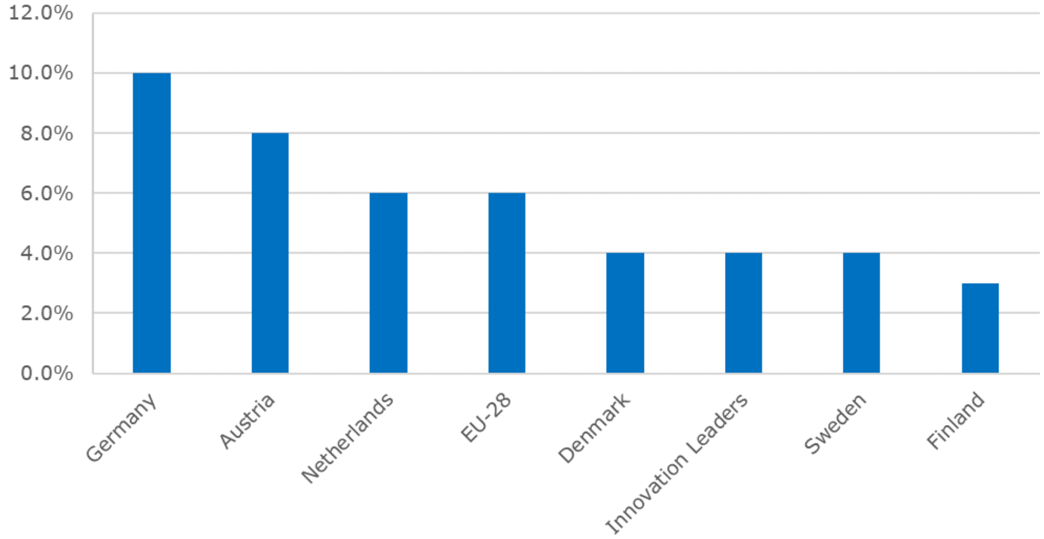


Source: Eurostat.

Austria – together with Germany, Ireland, Slovenia, Belgium and Lithuania – is also among the leading countries in Europe and the Innovation Leaders in terms of the adaptation of internet-enabled platforms (Figure 3-22 below). Eight percent of all Austrian firms use internet platforms for the sale of their goods and services, compared to 10% in Germany and six percent across all EU countries (which is considerably biased by the high value of Germany).

A closer look at the data reveals three important facts about platform diffusion in Austria: first, platforms are not the preferred form of sales over the internet. 14% of all enterprises use own websites or apps, compared to 8% which use platforms see Figure 3-22). So, websites and apps, and not platforms are the most common type of e-commerce in the Austrian enterprise sector. EDI-type systems are used by 6.7% of all firms. EDI (Electronic data interchange) exists in various standards since the 1970s.

Figure 3-22: Share of enterprises with 10 or more employees which sell via online platforms, 2016

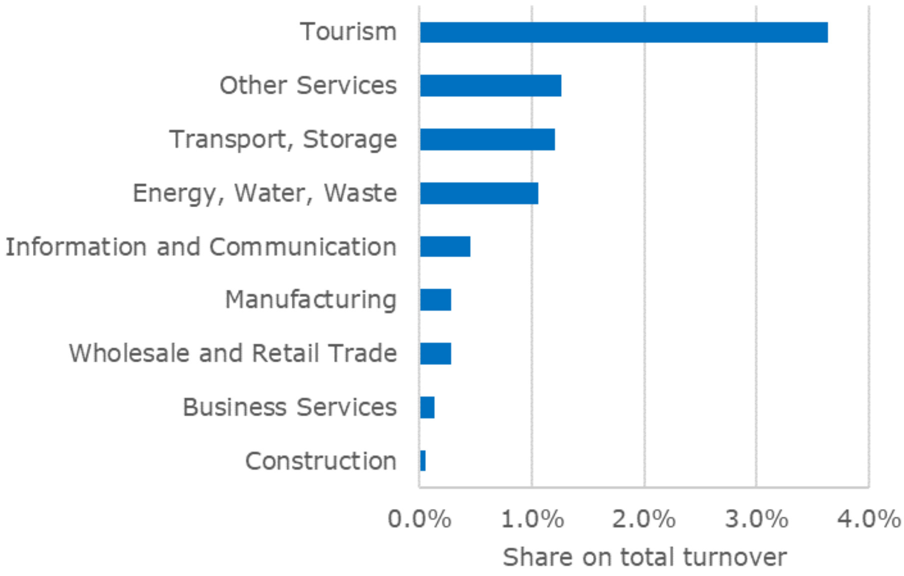


Source: Eurostat.

Second, the diffusion of platforms in the Austrian economy is highly sector-specific (see Figure 3-23 below). Tourism is the leading sector with a share of 22% of all firms. This is probably due to the success of reservation platforms such as AMADEUS, google flights, or booking.com in the tourism industry. A second important use sector are utilities and information and communication services. Construction and some services in particular seem to lag behind. The share of firms in construction which use platforms (4.3%) is quite below total economy average of eight percent.

Tourism is also the sector which generates the highest share of turnover with platforms. Sales generated over platforms account for 3.5% of total turnover of tourism firms, compared to a share of 1 – 1.3% in utilities, transport and storage and other services. Sales over platforms account for 1.1% of total turnover in manufacturing. So the economic significance of platforms in manufacturing is still below the significance platforms have for the total economy.

Figure 3-23: Share of firms with 10 or more employees which sell over online platforms, 2016, Austria.

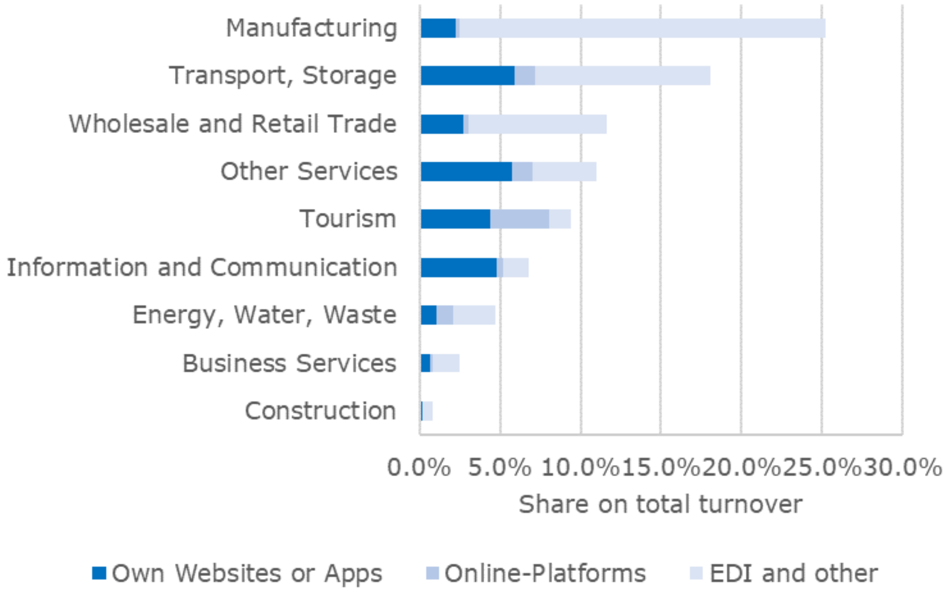


Source: Statistics Austria, IKT-Einsatz in Unternehmen 2017.

This picture, however, changes if we consider other forms of e-commerce – including webpages, apps and EDI – in addition to platforms (see Figure 3-24). Manufacturing firms already generate a quarter of their revenues (42 bn EUR in total) over electronic media. This is more turnover than in services in absolute terms (34 bn EUR) in in relative terms (10% of total turnover). Another sector which already relies to a considerable degree on electronic media for selling is transport and storage, again mainly over EDI. The share of turnover generated by electronic means is 18% in transport. We also find a considerable role of EDI for e-commerce in wholesale and retail trade which generates 22 bn EUR or 11.6% of total sales over electronic media.

Altogether, platforms have only a limited economic relevance for Austrian firms, compared to well-established EDI solutions in manufacturing, transport and trade. The only exception is tourism, where a considerable share of firms already uses platforms and generate 3.6% of their turnover over platforms.

Figure 3-24: Sales over various electronic media as a share of total turnover of the sector, 2016



Source: Statistics Austria, IKT-Einsatz in Unternehmen 2017.

In some sectors, it seems that firms have not yet found viable applications for platforms, but change happens even in these sectors. The Box 3-2 below describes wastebox, a platform for waste management in construction. The case of wastebox exemplifies some obstacles to platform development: first, the platform will likely cannibalize some of the old business of the company; second, it required considerable financial means, as was eventually organized as a separate entity from the parent company. It is therefore no surprise that the platform has been initiated by one of the largest firms in the sector. Third, wastebox is basically the application of the established idea of a platform in a new industry; this indicates that one possible bottleneck to bring about innovation is not technology, but ideas and blueprints to apply technology in new contexts. Unlike in other industries, where change came from outside, change was initiated by one of the largest firms in the industry, which may be explained by the lack of appeal of the industry to start-up entrepreneurs.

Box 3-2: Platform innovation in the waste management industry: wastebox

wastebox is a platform that makes it very easy for construction companies to order a dump truck that carries away construction waste. It was developed by Saubermacher AG, a leading private Austrian waste disposal and recycling company. Saubermacher offers full service in disposal and recycling of hazardous and hazard-free waste.

The innovation of wastebox was to use a proven business idea (platform) from a completely different industry context and apply it in the waste disposal industry. Waste disposal is a quite fragmented business. In Austria there are around 300 companies with the largest having around 35 trucks. Most of the companies compete locally. The two-sided nature of platform markets required wastebox to be attractive to both the supply and the demand side of the market. For the customers the relevant new feature is real-time information and the flexibility in ordering the services as well as massive time and thus cost savings. For the waste disposal firms it allows to organize their work more efficiently and to have a higher volume of transports.

Wastebox is also open for other companies in the industry. Currently, around 55 enterprises in the waste disposal business with around 240 trucks use wastebox. Thus, the platform has some potential to cannibalize the returns of its founding firm, which caused some resistance to change from inside the company. However, the management saw a big potential in an open platform. Additionally, closed systems were regarded as likely to fail. This is why the development required substantial strategic and financial support from the top management. Moreover, wastebox was incorporated as an independent firm, and the parent company did carefully check that the establishment of wastebox did not cause bad feelings within the enterprise, especially with the staff of the more traditional business segments of Saubermacher AG.

Wastebox is highly scalable compared to traditional waste removal, as it uses the available resources of all waste disposal firms and does not require the setup of a new fleet of trucks. wastebox is also conceived to be run in a franchising model in foreign countries. wastebox is successfully running in Austria, started in Germany and is on the way to be launched also in France and UK with the partnership of the French transnational company Veolia, that is also active in waste management and transport services. The example of wastebox shows that new digital business models such as platforms can also be used to provide innovative solutions to industries that are often considered to be traditional.

https://www.wastebox.biz/en/

https://www.saubermacher.at

3.3. Outlook

Digital technologies find frequent application in the Austrian enterprise sector. Diffusion rates in Austria, however, are however lower if compared to the Innovation Leaders but seem to be above EU average. There are two areas where Austria currently lags behind in terms of digitalisation: service sectors and small firms. This may point to obstacles for the exploitation of digitalisation.

So far, possible effects of digitalisation on productivity growth are hardly visible in Austria. Total factor productivity growth remains flat since 2001, and TFP grows even slower than in Germany and the EU (Weyerstraß 2018). There are several possible reasons for this. Results presented in this chapter suggest that the gap in the integration of the Austrian business sector in value chains with industries with high digital content is likely to play a role in this development.

While investment has accelerated in recent years compared to the early 2010s (Stöllinger 2016; Statistics Austria 2018) in Austria, the diffusion of Industry 4.0 and other technologies is not yet visible in aggregated investment. Investment cycles are long in many sectors, and firms see no reason to exchange their production equipment. The generally low level of ICT investment is however likely to hold back productivity growth.

A strong impetus for the introduction of these technologies comes from the embeddedness of Austrian firms in global value chains and foreign customers who require that their suppliers connect to these networks. The results from the WIFO Industry Survey show that digitalisation as considered as a competitive factor jointly with different aspects related to the organization of value chains. In this context however, interviews with industry experts as all as the result from the WIFO Industry survey provide no indication that the Austrian manufacturing sector has any has serious deficits in Industry 4.0.

There is more reason to worry in service industries than in the internationally exposed manufacturing sector. While data here is still scarce the indicators presented here confirm that service industries in Austria are lagging in digitalisation compared to the EU28. An example is value-chain integration. This holds particularly for tourism, transport, trade and construction. This may be explained by a lower exposure of service firms to international competition.

A take-away from expert interviews is the observation that Austrian manufacturing firms are struggling with the development of service offerings that complement their physical products and accompanying organisational change. New business models are often necessary to bring out the full effects of new technologies. This observation may point to a more general weakness of the Austrian innovation system towards service innovation, even though companies tend to be satisfied with the innovation support system in Austria. Another possible cause is the much-lamented lack of skilled personnel by companies, especially in industries with high or medium high digital intensity. The development of new service offerings complementing companies' products and technologies require the knowledge of a broad spectrum of ICT technologies which in turn requires personnel that capable of working in multidisciplinary teams and whose knowledge spans different technological domains.

While the results point at several difficulties the Austrian business sector faces regarding digitalisation, generally, the position of Austria in the upper half of the European Union, but not in the frontrunner group in many indicators, is not necessarily a disadvantage. Firstly, it has to be considered that a lot of the technologies are still in an early, premature state. Later generations of Industry 4.0 equipment, 3D printers or applications of artificial intelligence will be much more capable than the technology available today. Delayed technology adoption may therefore convey competitive advantages at a later stage, if companies are aware of the possibility to leapfrog competitors and build up the related capabilities in time. Second, as pointed out by Teece (2018), there is a value capture problem for innovators in the digital economy, which indicates that the economic benefits of digital technologies are not necessarily enjoyed by the frontrunners. There are no entry barriers in digital technologies such as cumulativeness of the knowledge base[39], the relevant technologies seem to be available to everyone, and become cheaper and more powerful every year.

Despite the observed gaps in the adoption of digital technologies, the outlook for digitalisation in the Austrian enterprise sector is therefore cautiously optimistic, and there is some reason to expect rising diffusion rates for these technologies. Digitalisation will increasingly find application in all sectors, including traditional low-technology sectors, as some examples already suggest.

3.4. Policy analysis

The main players in the area of digitalisation at the federal level are the Austrian Federal Ministry of Transport, Innovation and Technology (bmvit) and the Austrian Federal Ministry for Digital and Economic Affairs (bmdw). The bmvit provides around 185 million EUR a year for funding of R&D in field of Industry 4.0, (bmvit 2016). In addition, bmdw supports digitalisation (for example in creative industries or manufacturing services) and applications of Industry 4.0 in various initiatives. In addition, the Austrian Federal Cancellery was leading e-government activities at the federal level until the end of 2017, when competences moved to the bmdw. This move, however, is still not operational, because a re-organisation of the bmdw which would account for this change has been delayed due to the Austrian Presidency. The federal ministries are supported by agencies, most important the Forschungsförderungsgesellschaft (FFG, Austrian Research Promotion Agency), the Austria Wirtschaftsservice (aws) and the Digitalisierungsagentur (DIA).

Distributed competences for digitalisation are, in the end, a result of the multifaceted character of digitalisation which touches many fields of public activity. They are not regarded as a shortcoming by interview partners. The Austrian government is also aware of the co-ordination effort, and has installed an informal round of the Chief Digital Officers (CDOs) of each ministry as a co-ordination body. A further step towards co-ordination is expected from the Digitalisierungsagentur, which will host the CDO round and is expected to play a larger part in co-ordinating digitalisation efforts of various players in the future.

In terms of funding, policy initiatives to foster digitalisation in the Austrian business sector have a clear focus on fostering R&D and innovation. A large part of this funding for digitalisation is distributed through the programmes of the Forschungsförderungsgesellschaft (FFG) which emerged as the main funding body in the topic at the federal level in recent years. The FFG organizes various support initiatives on behalf of Austrian ministries and public funds. In its 2017 annual report (p. 23), the FFG states that every second Euro of financial support granted goes into

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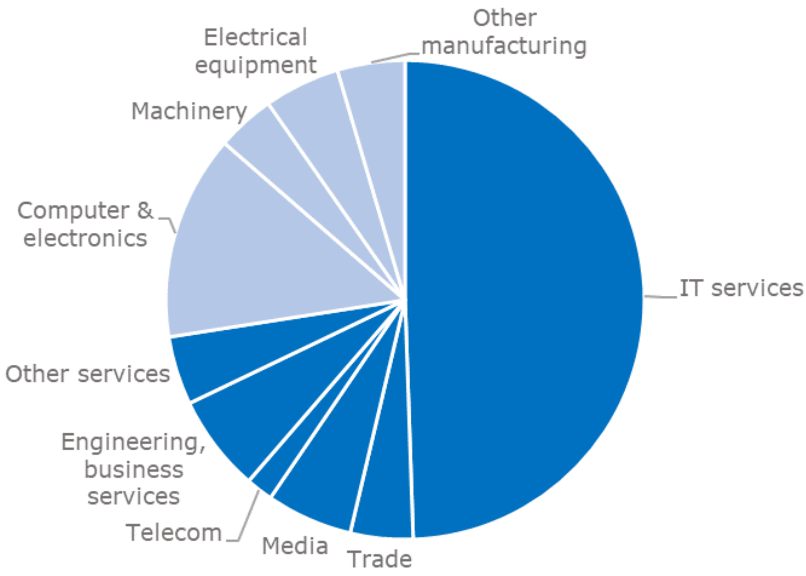
[39] Here, an exception may be the availability of large data sets for the development of artificial intelligence, where US and maybe also Chinese companies seems to enjoy an advantage compared to European firms.

digitalisation, and this amounts to around 230 Mio EUR for 2017. Compared to 2016, financial support granted increased by eight percent.

Financial support is concentrated in two FFG programmes, ICT and production technologies, which together account for 248 Mio. EUR in 2017. While production technologies are clearly focused on the manufacturing sector, the ICT programme has a much broader sectoral coverage which gives interesting insights into the generic nature of information and communication technologies (see Figure 3-25 below).

We see that around three fourths of the total funding (or 95 of 137 Mio. EUR average 2015-17) go to service firms, in particular IT service firms in the software and information service industry. Trade, media, engineering and business services are other important recipients. In manufacturing, the largest beneficiary is the computer and components industry, but also machinery has its share on financial support for ICT projects. Altogether, the ICT sector – including ICT manufacturing and services – on average received 87 Mio. EUR in the years 2015-17 from the ICT programme, which is around two thirds of all means. The remainder is equally distributed between other manufacturing and other service sectors.

Figure 3-25: Distribution of financial support in the ICT programme of the FFG among sectors, average 2015-17



Source: Austrian Research Promotion Agency (FFG), AIT calculations.

In addition to the general programme, there are some targeted programmes in the area of ICT carried out by the FFG. "Produktion der Zukunft" was started in 2012 by FFG on behalf of the Austrian Federal Ministry of Transport, Innovation and Technology (bmvit) to support R&D for production technologies in Austria, so this programme is targeted to manufacturing. The difference to the ICT and production technology programme described above is that "Produktion der Zukunft" wants to set thematic priorities and support relevant research topic. Examples are robotics, new materials such as smart textiles, bio-based industry etc. Moreover, the programme wants to encourage co-operation between science and industry by supporting co-operative R&D projects. In the last five years, the programme supported 1500 projects with over 500 Mio. EUR.

Finally, Silicon Austria aims to increase the visibility of Austria as a location for ICT research world-wide. A main goal of the project is the creation of Silicon Austria Labs, a research centre focusing on microelectronics and electronics-based systems, which should evolve into a focal point for such activities in Austria. The network of science and industry conducts cutting-edge research and lays the foundation for novel products and processes made in Austria. Other activities include the instalment of endowed professorships and pilot factories. The founding of Silicon Austria Labs is currently underway.

Another important source for financial support of R&D and innovation in ICT in Austria is the European Commission and H2020. From the start of H2020 in 2014 until mid- 2018, Austrian enterprises received 84.8 Mio. EUR from the Information and Communication Technologies and another 16.3 Mio. EUR from the Advanced manufacturing and processing programme, both part of H2020 Pillar II, Industrial Leadership. This is a considerable amount, even compared with national funding. If we divide it by the number of years (4.5) the average annual contribution from the two H2020 programmes for Austrian enterprises amounts 22.5 Mio EUR, compared to an average amount for the last three years of 45.8 Mio. EUR from the ICT programme of the FFG. In total Austrian organisations received 147.5 Mio. EUR from ICT from the ICT programme and 22.1 Mio. EUR from the Advanced Manufacturing programme. In ICT, the share of Austrian organisations on the total funding allocated (14.3%) is higher than Austria's share on total funding of H2020, which indicates that ICT is one of the focus areas of Austria in H2020.

bmvit is also in charge of telecommunications. Given the importance of connectivity, the expansion of mobile and wired broadband connections is therefore an important precondition for the widespread dissemination of Industry 4.0. The Austrian broadband infrastructure will be upgraded with the means of the “Breitbandmilliarde” an investment programme to develop rural areas with fast Internet and modernize existing infrastructure. The goal is to achieve transmission rates of at least 100 Mbit / s almost everywhere by 2020. The upcoming 5th generation (5G) mobile network will deliver much faster wireless Internet connections. For 2018, the first auction of frequencies for future 5G services by the Broadcasting and Telecommunications Regulatory Authority RTR was initially planned for autumn 2018 but has been rescheduled to February 2019. The effectiveness of these measures are discussed elsewhere in this report.

bmvit, together with industrial associations and the social partners, has also established "Verein Industrie 4.0", an association which informs companies, research organizations, politics and the media about new developments in Industry 4.0 and promotes the diffusion of use cases and best practices. Verein Industrie 4.0 is also an important forum of exchange on digitalisation between the social partners. There is a high degree of commitment among industrial associations and trade unions in Austria that digitalisation is inevitable, and to block it is no solution to possible employment losses. Public fora like the Verein Industrie 4.0 contribute to such a mutual understanding of the need for digitalisation and are an important factor that facilitates change. In addition, bmvit also promotes the dissemination of I4.0 with two pilot factories funded in 2017, and with endowed professorships.

The Federal Ministry for Digital and Economic Affairs (bmdw) supports applications of Industry 4.0 in various initiatives. An example is KMU Digital, a consulting and qualification program together with the Austrian Federal Economic Chamber. The aws has established a focus on digitization and Industry 4.0 in the Austrian ERP Fund where companies can be funded with loans for such projects. Small and medium-sized firms are the preferred beneficiaries of the ERP fund. Moreover, aws also supports technology development and entrepreneurship related to digitalisation in various programmes which guarantees, venture capital or loans. Finally, through the Smart and Digital Services Initiative (SDS-I), the bmdw promotes projects in all industries leading to the development of new services. Within SDS-I, one recent focus is on Industry 4.0 and Blockchain.

A new player besides FFG and aws is the Digitalisierungsagentur (DIA) currently established under the roof of FFG. The aim of DIA is to improve awareness for all fields of digitalisation, identify best practices in a wide sense, and foster co-ordination between the actors at federal and regional level. A focus of DIA’s activities will be small and medium-sized enterprises. So, DIA will mainly be active in areas which have been the focus of the Verein Industrie 4.0, the Austrian Economic Chambers, trade unions other associations. DIA, however, will not act as a funding agency for digitalisation. It is still too early to see where DIA will make the strongest impact. We will know more early next year when DIA will has finished their initial assessment of needs.

Given the quality improvements we see in Austrian ICT patenting activities, measures targeting R&D&I activities seem to be aligned with the dynamics of technology development in Austria in these fields. There is a broad spectrum of measures which cover a large number of potential market failures such that little funding gaps are left. This finding is also supported by the interview partners in funding bodies, who see only little room for new funding initiatives in the field of R&D&I and ICT.

Segments where more public support is required are the development of human resources (education system), awareness and the diffusion of best practices, and the development of business models based on Industry 4.0 and accompanying services. The Austrian promotion system is very much focused on technology, leaving non-technological innovation and service innovation aside. So, firms that want to develop services based on Industry 4.0 may find less support than firms with an engineering project. Given that many observers expect major economic benefits from services that are based on data collected with Industry 4.0, this may be a policy obstacle for future innovation. Innovation hubs and innovation bootcamps are two recent initiatives that aim at this gap. AT:net is another programme with a strong focus on diffusion and application of digital technologies, but faced some obstacles from the transfer of competences from the Federal Chancellery to the bmdw.

Strengthening this part of innovation policy while avoiding deadweight losses will be an important part of future initiatives. Another important area which the public support system may neglect is that of policies targeting the causes for the slow diffusion of digital technologies in the Austrian business sector.

What emerges as factors that are likely to have an important impact is on the one hand company size. The results on Industry 4.0 and digital platforms adoption show that smaller companies seem to systematically find it more difficult to invest and adopt such technologies. There is a multitude of potential causes related to company size that may affect the diffusion of digital technologies. The difficulties of small and micro-enterprises in the adoption of digital technologies is discussed in chapter 4. On the other hand, qualified labour supply both in the required quantities as well as the required quality is an important issue which companies in sectors with high digital intensity identify as a high priority for structural policies. The Austrian education systems seems to find it difficult not only to provide enough people with ICT skills but also seems to find it difficult to convey ICT skills with a certain technological breadth needed to develop and deploy modern digital technologies.

3.5. Conclusions

The analyses in this chapter have provided further firm-level evidence for the adoption deficits in some digitalisation technologies which are generally considered to be important drivers of future competitiveness. However, the results provide a nuanced picture.

Keeping in mind that companies from sectors with high or medium-to-high digital intensity included in the sample tend to be larger and have a larger export share than companies in other sector groups, a first set of results shows that

- Austrian manufacturing companies active in industries with high digital intensity do not perceive competitive disadvantages arising from digitalisation even though digitalisation is commonly perceived as a competitive factor with increasing importance.
- Austrian companies link digitalisation to production efficiency and the optimisation of value chains.
- The competitive strengths of Austrian companies lie in the technological content of their products, product quality and their capability to customise their products, and this is likely to offset potential disadvantages arising from lower use of digital technologies
- Manufacturing companies perceive challenges from digitalisation related to changes in their competitive environment and operative aspects related to the adoption of digital technologies such as the standardisation of data interfaces or data protection
- Sectors with high or medium high digital intensity perceive the supply of skilled personnel with academic training as well as the quality of education at technical colleges and universities as a high priority for structural policies
- Large Austrian manufacturing companies perceive the underinvestment in Austria regarding telecommunications infrastructure as an important but not major constraint for competitiveness. This aspect of structural policy as being important it is overshadowed by the emphasis given to improvements of the education system, the flexibilisation of the labour market and a general reduction of the tax burden.

With regard to the adoption of digital technologies the results in this chapter show that

- Austrian is not among the leading countries in Europe, but above the average of EU-28 Member States in many indicators for the adoption of Industry 4.0 related technologies and for digital platforms.

- Digital technologies have found frequent application in high- and medium-technology industries and are now diffusing into low-technology sectors as well.
- Services seems to lag behind, however data availability is limited.
- Despite gaps in the adoption of digital technologies, the Austrian business sector has the potential of making good progress towards digitalisation.

The analysis of the policy landscape related to technology policy shows that

- Public support for R&D and innovation towards digitalisation is available from different sources, including financial support, community building and creating awareness for best-practices.
- Moreover, there is some indication that public support schemes are biased towards technological innovation, leaving important issues of diffusion policies related to non-technological organizational aspects and the development of new business models aside.
- New initiatives should focus on human resources and these areas.

An overall assessment of this evidence therefore leads to the conclusion that while there are important gaps in the adoption of digital technologies and ICT investment, the Austrian business sector had the potential of making good progress towards a successful digitalisation of its operations. Some significant obstacles seem to hold back this process, and the availability of skilled personnel seems to be the most important factor here. Table 3-1 summarises the lessons that can be learned for other EU Member States.

Table 3-1: Policy transferability table

Policy domain	Observed problem	Drivers	Solutions taken in AT	Lessons learnt for EU Member states
Technology development	R&D in ICT industries was lagging behind other countries	Lack of funding for R&D in ICT; uncertainty regarding technology trends and future needs; ICT research should gain more visibility	Support for R&D in digital production technologies in bottom-up and top-down programmes, for example "Produktion der Zukunft", a funding scheme for R&D in selected topics/ technologies related to digitalisation. The programme has spurred R&D activities in Austria and set important priorities	Funding of R&D in ICT needs a mix of bottom-up funding and setting of priorities over financial incentives to reduce uncertainty.
Technology diffusion	Slower diffusion of digital technologies in SMEs compared to other EU countries	Lack of financial means, lack of knowledge about potential application areas, lack of qualified staff	Support for investment in Industrie 4.0 technologies for SMEs and firms in disadvantaged regions. aws Industrie 4.0 supports investment in equipment but also in the necessary skills and consulting for the introduction. The programme addresses not only investment needs, but also investment in complementary skills	Digitalisation needs investment in equipment, but also in the complementing skills.
Awareness	Firms, in particular SMEs, need examples of successful digitalisation which help them to identify areas of application.	Digitalisation needs a broad consensus among stakeholders; moreover, it needs blueprints and best practices that help firms to find applications	Verein Industrie 4.0 as platform for exchange over Industrie 4.0 and use cases. The Platform meets a need for exchange over Industrie 4.0 topics; moreover, the small size of the country is helping to reach all relevant actors	Digitalisation also needs the diffusion of use cases and blueprints of potential application areas to overcome uncertainty of firms.

4. MICROENTERPRISES, SMALL BUSINESS AND DIGITALISATION

4.1. Introduction

Digitalisation in the SME sector is associated with the adoption of digital technologies, the digitalisation of business practices and the adoption of new (digital) business models. The available evidence suggests that especially smaller firms and micro-enterprises that are not active in ICT-intensive sectors are lagging behind in the adoption of digital technologies, business practices and business models (e.g. Saam – Viete – Schiel 2016). Smaller enterprises seem to have deficits in IT competencies and skills, as well as data security concerns, and are afraid that the costs of digital investment will be higher than the benefits. This suggests that policies and structural reforms that remove barriers to the adoption of digital technologies and digital business tools, as well as provide and increase investment in IT competencies, are relevant to increase the potential of the digital transformation for both smaller businesses and society. In this section we concentrate on the barriers to digitalisation in very small businesses, especially micro-enterprises and barriers to digital entrepreneurship in Austria.

The chapter is organized as follows: first, a short overview of the literature on SMEs and the adoption of digital technologies is presented. Next, patterns of start-up dynamics and high-growth firms in ICT-producing and ICT-using sectors are discussed in European comparison and evidence on adoption of digital technologies in Austrian SMEs is presented. Together, this provides a clear picture of the state of play of digitalisation in the Austrian SME sector in a comparative perspective and allows to discuss barriers to digitalisation in small enterprises and industry dynamics. Then we present evidence on digitalisation and investment of microenterprises in Austria, which allows to pin down investment needs and challenges of microenterprises and young enterprises compared to larger and older firms. This section is followed by a more qualitative discussion and assessment of the state of play of microenterprises that focuses on information needs, presents industry cases and discusses policy initiatives that aim at fostering the digitalisation of the SME sector and that focus on awareness-raising, financing and reforms that affect entry regulations. The section closes with a summary and an assessment of policy initiatives and remaining structural reform needs.

4.2. Challenges and opportunities for digitalisation in small enterprises

4.2.1. Small and new enterprises and digitalisation

Entrepreneurship and SMEs are considered by many researchers and policy makers to be an engine of structural change and employment growth. SMEs have received attention because it is widely recognized that small and medium-sized enterprises (SMEs) represent a sizeable share in overall business activity, and in fact most firms are SMEs. Several studies show that the importance of SMEs has grown during the last 30 years (Stenkula 2006).

However, from a conceptual perspective the re-emergence of entrepreneurship and SMEs is closely related to the structural change towards a knowledge-based and digitalised economy (e.g. Sussan – Acs 2017, Thurik – Stam – Audretsch 2013): increasing shares of services in employment, production and technical change, and globalisation have led to a situation where small and medium-sized enterprises have more opportunities than ever. However, competition is often intense for small firms. Many small and microenterprises are small suppliers on competitive markets and are often unable to influence their prices or to build up entry barriers. Small enterprises usually have scarce resources in the form of financial resources, management and a limited in-house knowledge base. However, smallness does not only come with disadvantages. The organizational structures of SMEs tend to be more organic and informal compared to larger firms. This provides a central element in flexibility of processes. However, the adaptation of SMEs to new circumstances does not only rely on internal flexibility (e.g. Rothwell 1989) but also on processes of entry and exit. Nevertheless, there is evidence that small firms, especially entrepreneurial start-ups are drivers of innovation and new technologies. New technologies often lead to new markets due to technological disruption. Here new firms are often the ones that are best able to use the new technologies. Many of the digital giants of today were founded a few decades ago as very small new firms. And there is now abundant evidence that the adoption of modern information and communication technologies has (on average) a positive effect on the competitiveness and productivity of companies. Research shows a significant link between investment in ICT (measured as ICT capital or use) and productivity at the firm level (Greenan – Mairesse 2000, Black – Lynch 2001, Bresnahan – Brynjolfsson – Hitt 2002, Brynjolfsson – Hitt 2003; Arvanitis 2005, Hempell, 2005 see Cardona – Kretschmer – Strobel 2013 for a survey). However, for SMEs and new firms, the liability of smallness and the liability of newness also need to be taken into account. This refers to the fact that the exit probability decreases with size and age (e.g. Sutton 1997, Haltiwanger – Jarmin – Miranda 2013) and suggests that specific mechanisms often inhibit small firms in exploiting their growth potential. These liabilities are also relevant when it comes to the fostering and the adoption of digital technologies and business practices for small enterprises. For small enterprises investment into digitalisation may pose more challenges than for larger firms, as most SMEs have low management capacities and are now able to set up digitalisation strategies. But, at the same time the adoption and utilization of ICT can serve for many smaller firms as a strategic weapon for securing and developing competitive advantages, especially if digitalisation lowers economies of scale or increases the reach of markets.

4.2.2. Digitalisation and economies of scale and scope

The recent evidence for the US and Europe shows increasing productivity gaps between leading enterprises and other enterprises (Andrews – Criscuolo – Gal 2016, Berlingieri et al. 2017). This process has been described for the US as the emergence of superstar firms (e.g. Autor et al. 2017). Information technology and digitalisation seem to be an important driving force in this process, as they benefit significantly more form the new technologies than smaller firms (Bessen 2018). Seen from the perspective of leading enterprises, digitalisation increases scale economies.

This seems at first counterintuitive as the basic elements of information technology – low cost computing power, pre-packaged software, networking hardware, cloud processing solutions, enterprise information software, e-commerce software – are readily available to both small and large firms without high development costs. Information technology should therefore primarily be a force to level the playing field between large and leading firms and smaller competitors by lowering the costs of communication with customers and suppliers and by providing better control and governance of the value chain and overall reducing scale economies by facilitating more flexible forms of production and service provision.

However, it would be wrong to put all forms of digitalisation into the same basket. Off-the-shelf e-commerce solutions and word processors are not likely to generate substantial competitive advantage and scale economies. The integration of readily available information technology into the organization of firms requires not only technological but also organizational transformations. Moreover, generating a competitive advantage often requires developing cutting-edge IT systems. It is now well known that in some sectors the increased digitalisation led to large economies of scale. In banking, fixed IT development costs and network effects contribute to economies of scale (e.g. Hughes – Mester 2013). These network effects are also clearly visible in online advertising, where large firms like Google and Facebook control important “platforms” that give them a substantial competitive advantage, suggesting that scale economies and the network effects of proprietary systems may give rise to “winner-take-most” markets. This creates substantial entry and growth barriers for smaller enterprises. In European competition policy circles, new approaches to secure competition in digital markets are under discussion.

However, there is more to digitalisation and SMEs than the concentration side that especially affects highly ICT-intensive market segments. The ongoing digitalisation lowers economies of scale in many applications, providing benefits to smaller firms. Digitalisation can lower economies of scale and the costs of serving large markets. The availability of e-commerce solutions together with online payment systems generally does not provide a substantial competitive advantage for firms using these, but might provide enough competitive advantage over firms not using these systems. In fact, many studies show a positive impact of ICT capital and broadband infrastructure on productivity, also in smaller firms (Biagi 2013).

4.2.3. Challenges and potentials of digitalisation

The smallness of SMEs created adoption challenges. Many SMEs in sectors far away from ICT – especially in craft and retail trade are lagging behind in the adoption and use of information technology. Some observers speak of a digital divide between large and small enterprises (cf. Arendt 2008), but also between the production of goods and the provision of services. Adoption barriers of digital applications (such as e-commerce) are less due to access to information technologies than to a lack of knowledge, training of entrepreneurs and employees. In fact, many studies on the adoption of ICT in small enterprises show that the most important determinant of ICT adoption is the skill level of the entrepreneur and the employees. Especially for micro-enterprises the adoption decision is centred around the person of the entrepreneur and the business's workforce (e.g. Barba-Sanches et al. 2007).

This is especially relevant as there is a complementarity between information technology and organizational and human capital. This hypothesis was first formulated by Milgrom and Roberts (1990) and states that information technology only becomes productive when coupled with investment in organizational change and human skills. The available evidence supports that the investment of digitalisation per se may have a low impact on productivity, and that only the complementary change in firm organisation and human capital make it possible to reap the productivity gains. This is especially relevant for smaller firms. The need to invest in human capital and ICT skills and to adapt the (often informal) organisational structure requires much more investment than physical investment in hardware and software. In fact, many SMEs mention, as barriers to ICT adoption, that digital technologies are unsuitable for the type of business, missing ICT skills of owners and employees and the cost of developing and maintaining ICT systems.

The opportunities and potentials of digitalisation for SMEs are primarily:

(i) Access to larger markets (Aspelund – Moen 2004; Hamill – Gregory 1997; Simpson – Docherty 2004).

(ii) Increased efficiency via networked interaction along the value chain with customers (e.g. CRM) and suppliers.

(iii) Coordinated internal activities of enterprises by using Enterprise-Resource-Planning (ERP) solutions.

(iv) Cloud computing allows firms to rescale their IT Infrastructure to their actual needs.

(v) The use of digital technologies and digital solutions (virtual prototyping, network-aided design, 3-D printing, RDIF (Radar Data Interchange Format) tags, etc) can drive innovation in SMEs (Higon 2011, Hall – Lotti – Mairesse 2014).

4.2.4. Summary

The literature on SMEs and the digitalisation survey clearly indicate that small and very small enterprises can gain a competitive edge from information technology, but also that information technology does not lead to an automatic reduction of the minimum efficient scale of operations in all markets. In some instances, the competitive advantage of cutting-edge IT systems can create massive economies of scale so that the competitive process may even lead to the emergence of highly concentrated markets populated by a few "superstar firms".

However, in general there are opportunities for smaller enterprises. The advantage of flexibility of SMEs is hampered by missing managerial and organizational resources, that are often needed to implement ambitious digital transformation strategies. Such strategies are often needed, as there is a strong complementarity between ICT investments, organizational capital and skills. This increases the need for skills and financial resources for implementing comprehensive digital projects that increase productivity. The costs of investment and reorganization required by digital transformations, as well as the missing know-how and skills of entrepreneurs, are often mentioned as important barriers to digital adoption by smaller firms.

New and young firms are especially important for digitalisation and for reaping the gains of the associated productivity, as new and young firms are often considered to be the carriers of new technologies and business models. A number of studies show that disruptive technological and economic change opens up opportunities for new firms, which do not need to change their organizational structure, and which need not re-train their workforce, but can begin from scratch.

4.3. A bird's eye view of micro-enterprises, SMEs and industrial dynamics and digitalisation

4.3.1. Indicators of small firm presence

Generally, the SME segment in Austria is regarded to be strong (cf. SBA Fact sheet 2017). However, a recent study suggests that also in Austria smaller firms struggle with the adaptation of their business models, products and services, business practices and processes to the requirements and opportunities of the digital world (Arthur D Little 2017).

The figures for Austria compared to the EU average show that in 2016 99.7% of Austrian enterprises were SMEs compared to 99.8% in the EU28.[40] They employed 68.7% of persons employed and generated 62.0% of value added, which is slightly more than in the EU28. Most SMEs are very small: 87.3% were micro-enterprises (0 – 9 persons employed), accounting for 25.6% of persons employed and 18.7% of value added. Here, the Austrian numbers are lower than the EU28 numbers, which show that 93% of all firms in the EU28 countries were micro-enterprises. In comparison to the EU28 Austria has a larger share of small and medium-sized enterprises. Small enterprises (10 – 49 employees) accounted for 10.7% of enterprises, 24.1% of persons employed and 20.6% of value added.

In the present study, two shares of small firm presence in the economy (or to be more precise in an industry) are used:

- the SME share, defined as the share of the number of SMEs (0 to 249 employees) over the number of all enterprises in percent; the data source is the SME database for the SME performance review.[41]

- the microenterprise share, defined as the share of the number microenterprises (0 to 9 employees) over the number of all enterprises in percent; this is also based on the SME database for the SME Performance Review.

4.3.2. Indicators of Industry dynamics

Small firms provide much employment and are responsible for a sizeable share of employment, output and value added, however, the entry of new firms and especially the presence of a few fast-

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[40] The analysis is based on the European classification system of small and medium sized enterprises. Enterprises employing 1 to 9 employees are called micro enterprises, enterprises employing 10 to 49 employees are called small enterprises, enterprises employing 50 to 249 are called medium sized enterprises and, finally, enterprises employing more than 250 employees are called large enterprises.

[41] Available at: https://ec.europa.eu/growth/smes/business-friendly-environment/performance-review_en. Details on the data presents DIWecon (2017).

growing firms is driving the growth of employment and also productivity (e.g. Coad et al. 2014, Hölzl 2014). Thus, industry dynamics indicators are included. These reallocation processes are relevant for digitalisation, as new firms are often carriers of new technologies and new business models. In this section, we analyse whether ICT-producing, and ICT-intensive sectors have higher entry rates, a higher HGF share and a larger share of smaller enterprises than other industries and whether the Austrian performance in these sectors is on par with the countries of comparison.

In the economic literature, firm entry, firm growth but also firm exit are considered to be important drivers of the reallocation of resources within and across industries. Especially start-ups and industry turbulence are recognized as important drivers of the structural change that underlies much of long-run growth processes. New and young firms are often considered the carriers of new technologies and new business practices. Firm entry and firm exit as well as shares of high growth firms are linked to productivity growth at the industry level (Foster – Haltiwanger – Syverson 2008; Foster – Haltiwanger – Krizan 2006; Bravo-Biosca 2010). More productive firms reduce the importance of less productive firms unless there are frictions to reallocation, such as barriers to entry and barriers to growth.[42] For this reason, recent research has emphasized resource misallocation as an important source of productivity differentials. This research has established that cross-country differences in productivity may be linked to the heterogeneity in firm performance and growth (Andrews – Cigano 2014, Bartelsman – Haltwanger – Scarpetta 2013, Hsieh – Klenow 2009). This suggests that differences in high-growth firm presence may be related to differences in the ability of economies to direct resources to the most productive firms. It is well known that high-growth firms contribute disproportionately to employment generation. There is ample evidence for a large number of European Countries (e.g. Storey 1994, Anyadike-Danes et al. 2009, Henrekson – Johansson 2010) that a small number of fast-growing firms create a large share of jobs, while most firms do not grow at all. There is some evidence that the presence of high-growth firms is also associated with higher productivity growth, innovation and exports (Coad et al. 2014, Hölzl 2015). The available evidence also shows that HGFs are distributed across all sectors in the economy (e.g. Anyadike-Danes et al. 2009, Daunfeldt – Johansson – Halvarsson 2015). Hölzl (2011) and the FTB (2016) present evidence for Austria and show that Austria ranks below the European average in both the entry of new firms and the presence of high-growth firms.

In the present report we use the following indicators for industry dynamics:

- the entry rate defined as the number of new enterprises in time *t* divided by the number of active enterprises in time *t*, reported as percentage. This corresponds to the birth rate (V97020) in the business demography database provided by Eurostat in its structural business statistics. We supplemented the number of active enterprises by using structural business statistics by size class from Eurostat as well as the number of enterprises taken from the database of the SME Performance Review.

- the turnover rate defined as the entry rate plus the exit rate. It is an indicator of business churn. It corresponds to the indicator of business churn (V9715) in the business demography database provided by Eurostat in its structural business statistics. We supplemented the number of active enterprises by using structural business statistics by size class from Eurostat as well as the number of enterprises taken from the database of the SME performance review.

- Sometimes the exit rate is also used in the report. It is needed to construct the turnover rate. It is based on the death rate (V97030) in the business demography database of Eurostat and defined as the number of exits over the number of active enterprises.

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42 An important strand of the reallocation literature discusses institutional frictions to firm growth and reallocation, which affect firm entry and exit decisions and may inhibit industrial reallocation and negatively impact aggregate growth (Restuccia - Rogerson 2013; Restuccia - Rogerson 2008).

- The high-growth firm share (HGF share) is defined as the number of HGFs over the number of active enterprises. In this report we identify HGFs using the European definition which defines those firms as HGFs that have an annualized growth rate of 10% or more over a three-year period and had more than 10 employees at the beginning of the period. The enterprise share is calculated as the ratio of HGFs to the number of firms with more than 10 employees at the end of the period. The number of HGFs are taken from the business demography database. The number of firms with more than 10 employees was supplemented from the structural business statistics by size class from Eurostat as well as the number of enterprises taken from the database of the SME performance review.[43]

4.3.3. Relationships between industry dynamics indicators and small firm shares

Before analysing the relationship between digitalisation and industry dynamics and small firm shares it is useful to have a look at the relationship between industry dynamics indicators and small firm shares. These indicators are often thought to measure similar dynamics. However, the graphical analysis in Figure 4-1 shows that the relationship is more complex. The left upper quadrant depicts the relationship between HGF shares and the entry rate. The visual inspection shows that most Austrian sectors (in red) are below average, but more interestingly the relationship between entry rates and the HGF rate appears to be non-linear: for low levels of entry rates there appears to be a positive association with HGF rates, while for high entry rates there appears a negative relationship. This can be explained by the fact that high entry barriers usually entail a high level of sunk costs and strong competition from incumbents. Therefore, both the entry rate and the rate of HGF should be low (cf. Hölzl 2015). Lowering sunk costs should therefore increase both entry and the number of high-growth firms. However, if entry costs are low and the minimum efficient scale of operations (that can be thought to be a function of sunk costs) decreases, then the share of HGFs should decline as the new opportunities and the room left by exiting firms is taken up not by incumbents but entrants. This shows that it is possible that a digital transformation that affects the level of entry barriers and sunk costs may affect the entry rate and the share of HGFs differently. The upper right quadrant of Figure 4-1 shows the relationship between the HGF share and the share of microenterprises at the industry level. The relationship seems to be negative: a higher share of microenterprises is associated with a lower share of HGFs. However, the relationship is not statistically significant.

The lower left quadrant depicts the association between the entry rate and the micro-enterprise share. The quadratic prediction suggests that on average there is no strong relationship. A similar picture emerges in the lower right quadrant for the relationship between the entry rate and the SME share.

These scatter diagrams do not control for industry- and country-specific factors that may affect the level industry dynamics and SME shares. Therefore, Table 4-1 presents regression results that control for both industry and country fixed effects.

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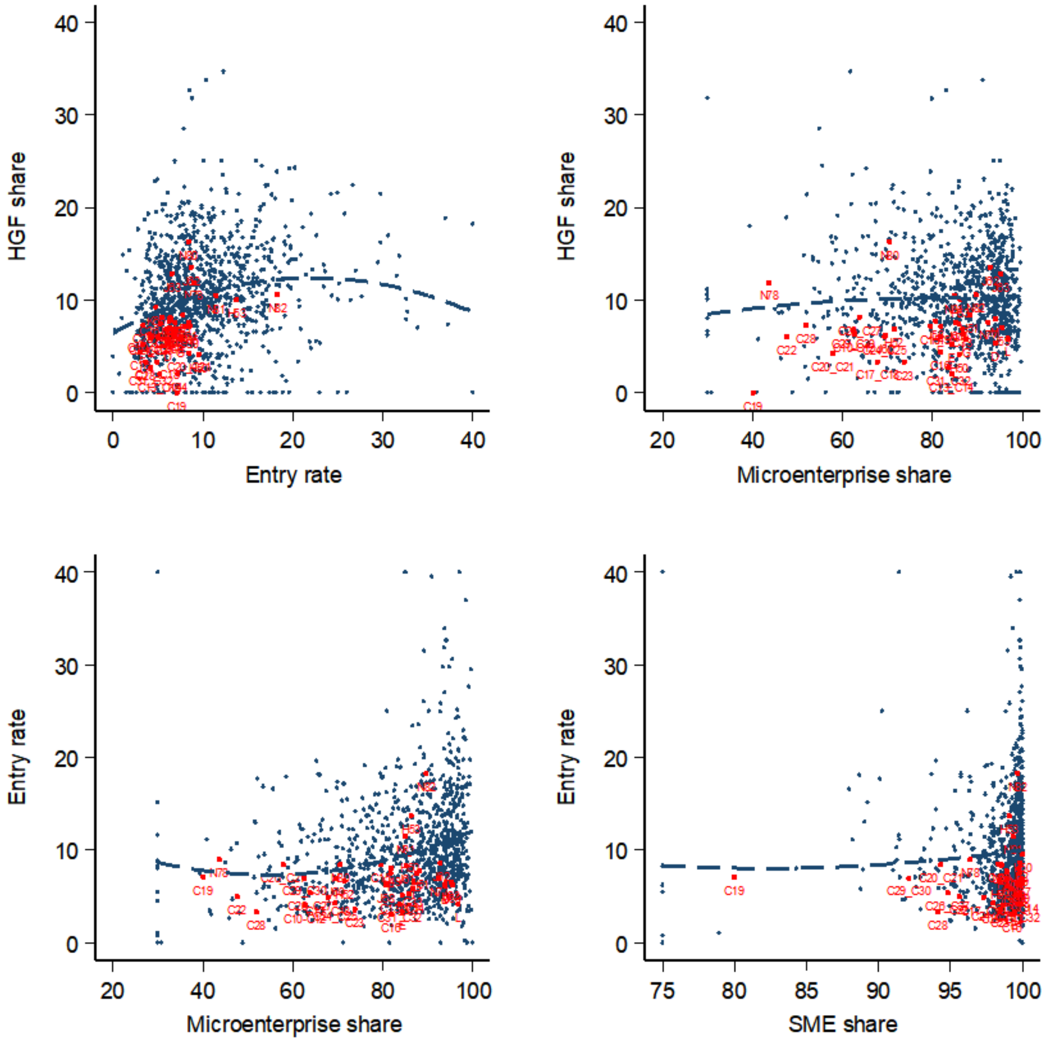
43 There exist a variety of approaches to measure high growth firms, and there is even some controversy on what the best measure is. However, nevertheless there is mounting evidence about some robust regularities of HGFs at the firm level (cf. Coad et al. 2014, Henrekson - Johansson 2010).

Figure 4-1: Scatter diagrams of selected industry dynamics indicators and SME shares



Source: Eurostat, SME database for the SME Performance Review. Note: Values are average values over the period 2004 to 2007. SME shares and micro-enterprise shares do not cover financial and insurance services (NACE K). Lines correspond to quadratic prediction without control variables. Austrian sectors are in red. For presentation purposes the micro-enterprise share was set to 30% if it was below 30% and the SME share was set to 75% if it was below 75%.

The results in Table 4-1 do only partially confirm the results in Figure 4-1 and suggest that industry-specific factors such as structural entry barriers and country-specific factors such as general regulations, law and institutions play an important role. We observe no statistically significant relationship between the entry rate, the turnover rate and the HGF share. The HGF share has also no statistically significant association with the SME share and the micro-enterprise share. This suggests that the presence of small firms or micro-enterprises is per se not associated with the presence of high-growth firms. The entry rate is obviously positively related to the turnover rate. The association with the SME share is insignificant. But the relationship between the entry rate and the micro-enterprise share is positive and statistically significant, suggesting that the presence of micro-enterprises goes hand in hand with a higher entry rate. Finally, the SME share is not statistically significantly associated with the turnover rate, implying that a high SME share does not necessarily go hand in hand with high industry turbulence. The SME share is positively associated with the micro-enterprise share.

Table 4-1: Relationship between industry dynamics indicators and small firm shares

	(1) HGF share	(2) HGF share	(3) HGF share	(4) HGF share	(5) Entry rate	(6) Entry rate	(7) Entry rate	(8) SME share	(9) SME share
Entry rate	0.037 (0.040)								
Turnover rate		0.010 (0.025)			0.591*** (0.035)			-0.032 (0.042)	
SME share			-0.072 (0.092)			-0.038 (0.165)			
Microenterprise share				-0.018 (0.022)			0.060** (0.030)		0.151*** (0.022)
Industry dummies	y	y	y	y	y	y	y	y	y
Country dummies	y	y	y	y	y	y	y	y	y
Observations	1,066	1,064	990	990	1,081	1,014	1,014	1,003	1,014
R-squared	0.556	0.552	0.572	0.572	0.912	0.532	0.540	0.513	0.668

Source: Eurostat, SME database for the SME Performance Review. Note: Values are average values over the period 2004 to 2007; SME shares and micro-enterprise share do not cover financial and insurance services (NACE K). Sig. levels *** p<0.01, ** p<0.05, * p<0.1.

4.3.4. Small firms and industry dynamics in ICT-producing sectors

The comparative performance of Austria vis-à-vis to the comparison countries and country groups is reported in Table 4-2.[44] In the ICT-producing sector most countries and the Innovation Leaders on average have a higher entry rate, a higher turnover rate and a higher share of high-growth firms. However, compared to ICT services the industry dynamics indicators in the ICT manufacturing sector are close to the values observed in the Innovation Leader countries and in the EU28. The difference between Austria and the Innovation Leaders is small. Finland in general and Germany, Denmark and Sweden in selected indicators rank below Austria. Nevertheless, for the ICT service sector we observe that all countries have higher entry and turnover rates and higher HGF shares. The difference in values is also more substantial. For example, while for ICT manufacturing the difference between Austria and the Innovation Leaders is 0.1 percentage points, the difference in ICT services is 4.8 percentage points.

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44 Data limitations did not allow to use the 2006 OECD definition of ICT sectors in full. Only for the entry and the turnover rate the data refers to the OECD 2006 definition of the ICT manufacturing sector. The other numbers refer only the two-digit Manufacture of computer, electronic and optical products (C26). Similarly, the ICT service sector does also cover only J61 - Telecommunications, J62 - Computer programming, consultancy and related activities and -63 Information service activities. For the ICT service sector (465) Wholesale of information and communication equipment, (582) Software publishing and (951) Repair of computers and communication equipment are not considered.

Table 4-2: Small firm presence and industry dynamics in the ICT-producing sectors

Country	Entry rate	Turnover rate	HGF share	SME share	Microenterprise share
ICT Manufacturing					
Austria	6.6%	12.7%	10.3%	96.7%	70.8%
Innovation Leaders	6.7%	13.7%	10.4%	95.0%	68.1%
EU28	6.8%	13.7%	11.0%	98.4%	75.7%
Denmark	10.3%	23.3%	8.4%	97.8%	59.8%
Finland	5.5%	12.7%	9.8%	97.1%	72.1%
Germany	5.5%	13.0%	11.5%	97.4%	61.2%
Netherlands	7.9%	14.3%	11.0%	99.3%	82.8%
Sweden	6.7%	11.9%	11.3%	99.1%	85.6%
ICT Services					
Austria	8.0%	14.1%	13.1%	99.8%	93.2%
Innovation Leaders	12.9%	22.4%	17.9%	99.8%	92.2%
EU28	13.1%	22.1%	18.8%	99.8%	94.3%
Denmark	17.7%	33.9%	15.7%	99.8%	90.4%
Finland	10.8%	19.7%	17.8%	99.5%	88.1%
Germany	9.7%	20.1%	19.8%	99.6%	88.7%
Netherlands	10.9%	17.5%	19.8%	99.9%	96.4%
Sweden	8.6%	15.3%	20.2%	99.9%	95.8%

Source: Eurostat, SME database of the SME Performance Review. Note: The ICT-manufacturing sector refers to C26 – Manufacture of computer, electronic and optical products except for the entry rate where it refers only to C261 – C264 and C268. ICT services refers to J61 – Telecommunications, J62 – Computer programming, consultancy and related activities and J-63 Information service activities. SME shares and micro-enterprise shares do not cover financial and insurance services (NACE K). Cells in blue indicate a share/rate that is higher than in Austria.

This finding mirrors the findings in FTB (2016) that the low performance in industry dynamics in Austria compared to the Innovation Leader is mainly driven by the lower Austrian entry rates and HGF shares in the knowledge-intensive services and lower technology manufacturing sectors, while the performance in the high technology manufacturing sectors is on par with the Innovation Leader countries.

4.3.5. Small firms and industry dynamics in ICT using sectors

In this analysis we follow – as in the remainder of the report – the new OECD taxonomy of digital intensive sectors (Calvino et al. 2018) and compare the Austrian SME and industry dynamics indicators to the Innovation Leaders and the reference countries.

Table 4-3 presents the results. Overall, the results confirm that, on average in comparison, Austria has a lower rate of industry dynamics. For the industry grouping with high digital intensity Austria has the lowest entry rate (7.0%), which is also much lower than the average of the Innovation Leaders (by 4.4 percentage points or 38%). This is also true for the other industry groupings, even if there the distance is lower in relative terms – a 20% to 26% lower entry rate is observed for Austria than for the Innovation Leader average. The same also holds true for the other industry turbulence indicators, the exit rate and the turnover rate. Furthermore, these indicators show the largest relative distance to the Innovation Leader average for the high digital intensity industry grouping.

Table 4-3: Small firm presence and industry dynamics in the ICT-using sectors

Country	Entry rate	Exit rate	Turnover rate	HGF share	Microenterprise share	SME share
Industries with high digital intensity (OECD)						
Austria	7.0%	5.6%	12.7%	4.8%	92.8%	99.8%
Innovation Leaders	11.4%	8.7%	20.0%	6.8%	95.0%	99.8%
EU 28	11.1%	8.5%	19.5%	6.5%	95.7%	99.8%
Denmark	13.3%	13.3%	26.6%	3.4%	94.2%	99.8%
Finland	9.0%	7.7%	16.8%	6.9%	94.2%	99.8%
Germany	8.3%	8.7%	17.1%	5.9%	91.0%	99.7%
Netherlands	10.5%	6.4%	16.9%	8.0%	97.0%	99.9%
Sweden	7.4%	5.5%	12.9%	8.4%	97.1%	99.9%
Industries with medium-high digital intensity (OECD)						
Austria	7.0%	6.6%	13.5%	2.7%	86.2%	99.6%
Innovation Leaders	8.7%	8.6%	17.3%	4.2%	89.3%	99.7%
EU 28	8.6%	8.4%	17.1%	3.9%	92.6%	99.8%
Denmark	9.1%	11.0%	20.2%	1.7%	83.2%	99.6%
Finland	6.8%	7.4%	14.3%	3.6%	89.1%	99.6%
Germany	6.3%	7.4%	13.8%	3.8%	81.0%	99.5%
Netherlands	10.1%	7.3%	17.3%	5.1%	93.9%	99.8%
Sweden	7.2%	6.9%	14.2%	5.2%	93.3%	99.8%
Industries with medium-low digital intensity (OECD)						
Austria	4.8%	4.4%	9.2%	2.5%	70.5%	97.9%
Innovation Leaders	6.1%	6.3%	12.4%	3.9%	78.9%	99.1%
EU 28	7.5%	7.1%	14.5%	3.9%	81.2%	99.3%
Denmark	6.2%	8.3%	14.5%	2.1%	68.0%	98.4%
Finland	4.3%	5.6%	10.0%	3.3%	80.6%	99.2%
Germany	3.6%	4.9%	8.6%	3.5%	62.8%	98.1%
Netherlands	6.4%	4.6%	11.0%	3.9%	85.2%	99.4%
Sweden	4.6%	4.9%	9.5%	4.2%	87.2%	99.5%
Industries with low digital intensity (OECD)						
Austria	6.9%	6.5%	13.4%	3.0%	83.6%	99.8%
Innovation Leaders	9.3%	7.8%	17.2%	5.0%	90.4%	99.8%
EU 28	9.5%	8.4%	17.8%	3.8%	91.7%	99.8%
Denmark	10.0%	10.6%	20.6%	2.3%	87.4%	99.7%
Finland	5.9%	5.4%	11.7%	5.5%	91.0%	99.8%
Germany	6.9%	7.4%	14.5%	3.0%	78.0%	99.7%
Netherlands	8.8%	5.6%	14.4%	5.2%	94.3%	99.8%
Sweden	7.2%	5.9%	13.1%	6.4%	92.3%	99.9%

Source: Eurostat, SME database of the SME Performance Review. Note: SME shares and micro-enterprise shares do not cover financial and insurance services (NACE K). Cells in blue indicate an adoption share that is higher than the adoption rate in Austria.

About the HGF share we observe that Austria has a below-average HGF share (4.8%) that is well below the average value of the Innovation Leader countries (6.8%) and the EU28 average (6.5%). The Netherlands and Sweden have HGF share of above 8% in industries with high digital intensity. In industries with medium-high and medium-low digital intensity the picture is repeated: Austria has a low HGF share. In these country groupings Denmark displays an even lower HGF share. For industries with low digital intensity, the Austrian HGF share (2.5%) is also below the Innovation Leader average and the EU-28 average.

For the micro-enterprise share, we observe that Austria has one of the lowest shares of micro-enterprises (92.8%) in the industry grouping with high digital intensity, and only Germany has a lower share (91%). But for the other groupings Austria never records a micro-enterprise share that is higher than the micro-enterprise share of the Innovation Leader and the EU28 average values. The SME shares are in general quite close to each other. Only for the industries with medium-low digital intensity does Austria record an SME share that is consistently lower than the SME share of the other countries.

The regression results in Table 4-4 report the regression of the industry dynamics and SME indicators as the independent variable and the digital intensity taxonomy as the dependent variable. The regression analysis includes time and country dummies in order to isolate the relationship between digital intensity and the industry dynamics and SME indicators.

Table 4-4: Industry dynamics and SME indicators and the digital intensity taxonomy

	(1) Entry rate	(2) Turnover rate	(3) HGF share	(4) SME share	(5) Microenterprise share
High	0.681** (0.336)	1.224** (0.495)	2.426*** (0.283)	0.523** (0.211)	4.719*** (0.564)
Medium high	-2.530*** (0.317)	-3.556*** (0.438)	-0.959*** (0.275)	0.900*** (0.205)	2.028*** (0.539)
Medium low	-3.144*** (0.342)	-4.306*** (0.500)	-1.726*** (0.331)	-1.677*** (0.380)	-8.832*** (0.754)
Country dummies	y	y	y	y	y
Time dummies	y	y	y	y	y
Observations	2,051	1,989	1,996	4,056	4,056
R-squared	0.350	0.352	0.366	0.047	0.208

Source: Eurostat, SME database of the SME Performance Review. Note: SME shares and micro-enterprise shares do not cover financial and insurance services (NACE K). Sig. levels *** p<0.01, ** p<0.05, * p<0.1.

The benchmark category in the analysis is the industry grouping with low digital intensity. The analysis reveals that when controlling for country and time effects, digital-intensive sectors are characterized by higher entry and turnover rates, a higher HGF share as well as a higher SME and micro-enterprise share. In contrast, the medium-high and medium-low industries are characterized by a lower entry rate, a lower turnover rate and a lower HGF rate compared to the industry grouping with low digital intensity, but have a comparatively higher SME share. These results do not allow any causal interpretation, but they show that highly digital-intensive sectors are on average more dynamic, have higher entry rates, a higher HGF share and a larger share of smaller enterprises. These relationships are likely to be driven by technology, as technology is an important element in determining the competitive environment.

4.3.6. Summary

In this subsection we analysed the relationship between industry dynamics indicators (entry rate and high-growth firm share), indicators of small firm presence (SME share and micro-enterprise share) at the industry level. These indicators are not strongly related to each other. We find a statistically significant relationship after controlling for industry and country-fixed effects only between the turnover rate and the entry rate, the entry rate and the micro-enterprise share and the SME share and the micro-enterprise share. This suggests that the different indicators are related to different economic reallocation processes.

The evidence for Austria confirms a weak performance of industry dynamics vis-à-vis the comparison countries with the exception of ICT manufacturing, where the Austrian entry rate, turnover rate of firms and the HGF share are close to the Innovation Leaders. But the industry dynamics (entry rate and HGF share) in the ICT service industries are substantially lower than in the countries of comparison. This finding is unrelated to the presence of micro-enterprises and SMEs in those sectors.

A similar picture of lower industry dynamics also emerges for the ICT-using sectors using the OECD taxonomy of digital-intensive sectors. For all of the four ICT-intensity industry classes Austria has lower entry rates, exit rates and HGF shares than the Innovation Leader group and most of the comparison countries. In all of these industry groupings Austria also has a lower share of micro-enterprises than the Innovation Leader, but not necessarily a lower SME share.

The analytic results show that there is a positive relationship between high digital intensity and all indicators of industry dynamics (entry rate and HGF share) as well as with the SME indicators (SME share, micro-enterprise share). This confirms that digital-intensive sectors are on average more dynamic, have higher entry rates, a higher HGF share and a larger share of smaller enterprises.

4.4. The adoption of digital technologies in Austrian SMEs in European Comparison

4.4.1. Comparison of adoption of digital technology in the small firm sector

To present the state of comparative evidence on the adoption of digital technologies and digital business practices in small and medium-sized firms, we focus on the 7 indicators that were already presented in section 2.2.1 of the present report.[45] The 7 technologies are:

a) % of enterprises with enterprise-resource-management (ERP) solutions,

b) % of enterprises with RFID for production or distribution purposes,

c) % of enterprises with at least two types of social media (Social Media),

d) % of enterprises that use electronic invoices,

e) % of enterprises with medium and high cloud computing solutions

f) % of enterprises with customer-relationship-management (CRM) solutions,

g) % of enterprises with automated data transfer with customers and suppliers (SISC).

These seven indicators cover different aspects of digital business solutions and can be seen as proxies for the ambitious digital transformation of business processes. The data on firm size distribution is only available at the country level. Therefore, our analysis cannot explicitly take into account industry-specific determinants of the adoption of digital technologies that were discussed in section 2.2.1 of the report Table 4-5 reports the descriptive statistics.[46]

Enterprise resource planning (ERP) systems are probably the best-known representatives of enterprise information systems. Regarding the use of ERP software Austrian enterprises are among the leading enterprises in Europe. The adoption rate for all size classes is well above the EU28 average and the average of the Innovation Leader countries. For small enterprises (10 to 49 employees) 34% of Austrian firms use ERP software. Only for the Netherlands is a higher adoption rate observed for small enterprises (41%). Overall, the adoption of ERP solutions is size-dependent.

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45 Microenterprises are not covered in the survey.

46 Figure B-56 and

Figure B-57 in the Appendix present the evolution of the adoption of digital technologies across firm sizes across time for Austria and the EU 28 average.

The percentage of large firms is clearly higher than the adoption rate among small enterprises across all countries and country groups.

The usage of radio frequency identification (RFID) technologies allowing to identify, track, sort or detect products and components is not very common in the EU. The share of firms with at least ten employees using RFID is around 4% on average in both the EU28 and the Innovation Leader countries. The adoption of RFID is strongly size dependent. In Austria 19% of large firms, 11% of medium-sized firms and 4% of small enterprises use RFID technologies in production and distribution. This is a higher adoption rate across all size classes compared to the EU28 and Innovation Leader averages. Among the Innovation Leader countries only Finland has a higher adoption rate than Austria for both large and small enterprises.

In the use of social media, Austria is lagging behind the adoption rates of many of the countries of comparison. In the aggregate, the share of firms using more than one type of social media in Austria is equal to the EU average (AT 20%, EU28 21%), but well below the value recorded for the Innovation Leaders (30%). This pattern is observed across the firm size distribution. Social media is less often used in Austria compared to the Innovation Leader countries. In Austria around 18% of small firms use at least two different types of social media, and only in Germany (of the comparison countries listed) is the share lower (14%). The highest share is observed for the Netherlands, where 35% of all small enterprises use at least two types of social media.

Electronic systems easily provide the opportunity to deliver invoices directly from the business application. However, e-invoices in an agreed standard format (as EDIFACT, XML, etc) which allows their automatic processing are also not yet very common in most EU MS. Except for Finland, Denmark, Slovenia, Sweden, Italy and Spain the shares of firms that employed at least 10 people, sending e-invoices to other enterprises or public authorities have not reached 30 percent. In Austria around 25% of all firms use electronic invoicing, while in the EU28 average 18% of enterprises used e-invoices suitable for automatic processing. Between 2014 and 2016 Austria’s firm shares more than doubled (2014: 11%, 2016: 25%). While the use of e-invoices is stronger for large firms, the share of small firms using e-invoices is higher in Denmark and Finland than the share of large firms using e-invoicing in Austria (54%). Thus, the use of e-invoicing seems to be more country-specifically determined than the use of other digital technologies, and is likely dependent on network effects; if more customers are able to automatically process e-invoices the use of e-invoices increases. The use of e-invoicing among the reference countries is lower in Germany and the Netherlands across all firm sizes, while it is substantially higher in Denmark and Finland among all firm size classes. Sweden, among the reference countries, shows a slightly higher propensity to use e-invoices.

Table 4-5: The adoption of digital technologies over the firm size distribution

	ERP				RFID			
	All enterprises	Large enterprises	Medium enterprises	Small enterprises	All enterprises	Large enterprises	Medium enterprises	Small enterprises
Austria	40.0	89.0	68.0	34.0	6.0	19.0	11.0	4.0
Innovation Leaders	36.3	77.3	60.3	30.3	4.0	15.3	6.2	3.2
EU28	34.0	76.0	57.0	28.0	4.0	15.0	8.0	3.0
Denmark	40.0	82.0	68.0	34.0	2.0	9.0	3.0	2.0
Finland	39.0	88.0	68.0	32.0	7.0	22.0	7.0	6.0
Germany	38.0	82.0	62.0	31.0	4.0	14.0	7.0	3.0
Netherlands	48.0	86.0	73.0	41.0	5.0	14.0	9.0	4.0
Sweden	31.0	76.0	55.0	26.0	2.0	14.0	4.0	1.0

	Social Media				Electronic invoices			
	All enterprises	Large enterprises	Medium enterprises	Small enterprises	All enterprises	Large enterprises	Medium enterprises	Small enterprises
Austria	20.0	49.0	30.0	17.5	25.0	54.0	34.0	23.0
Innovation Leaders	29.8	63.5	42.8	26.3	26.5	48.1	34.1	23.9
EU28	20.5	48.5	30.0	18.5	18.0	38.0	24.0	16.0
Denmark	28.0	59.5	37.0	25.0	64.0	76.0	68.0	63.0
Finland	27.5	75.0	45.0	22.5	72.0	86.0	80.0	70.0
Germany	17.0	43.0	24.0	14.0	16.5	41.0	24.0	14.0
Netherlands	38.5	70.5	51.5	35.0	19.0	42.0	26.5	16.0
Sweden	24.5	63.0	39.5	20.5	33.0	63.0	45.0	30.0

	Cloud				CRM			
	All enterprises	Large enterprises	Medium enterprises	Small enterprises	All enterprises	Large enterprises	Medium enterprises	Small enterprises
Austria	18.0	34.5	23.5	16.5	43.0	73.0	60.0	39.0
Innovation Leaders	46.6	66.2	54.9	44.2	38.0	69.3	54.2	34.0
EU28	21.0	42.0	27.0	19.0	33.0	62.0	48.0	30.0
Denmark	44.0	62.5	49.0	42.0	36.0	71.0	54.0	31.0
Finland	59.0	79.0	71.0	56.0	39.0	78.0	57.0	34.0
Germany	14.0	33.0	18.0	14.0	47.0	71.0	61.0	43.0
Netherlands	33.0	51.0	39.0	31.0	47.0	76.0	62.0	43.0
Sweden	46.0	66.0	56.0	44.0	35.0	69.0	55.0	31.0

	Automatically linked (SISC)			
	All enterprises	Large enterprises	Medium enterprises	Small enterprises
Austria	16.0	58.0	34.0	12.0
Innovation Leaders	17.8	46.3	29.0	14.8
EU28	18.0	47.0	28.0	15.0
Denmark	23.0	58.0	34.0	20.0
Finland	22.0	61.0	36.0	18.0
Germany	30.0	64.0	42.0	26.0
Netherlands	19.0	51.0	35.0	15.0
Sweden	13.0	41.0	22.0	10.0

Source: Eurostat, WIFO calculations. Note: Values are averaged over the years 2016 and 2017, and indicate % of firms having adopted a specific technology. For some country-technology pairs data for 207 is not available (e.g. for e-invoices for AT, UK, SE; for cloud computing for UK, NL, FR). Cells in blue indicate an adoption share that is higher than the adoption rate in Austria.

The use of cloud computing has been recognised as an important area for IT innovation and investment, also for smaller firms. Cloud computing application services allow to share software use among employees, customers and suppliers. Moreover, cloud computing makes infrastructure investment at least partially scalable, as cloud computing allows to use IT infrastructure on demand. Beside increased flexibility, cloud computing allows to always access the latest technology. For users of cloud systems IT capital at least partially becomes a variable cost component. This is likely especially relevant for small firms that require different hardware, storage and computing resources, including software, at different times. While Finland, Sweden and Denmark are characterised by small firm shares clearly above the EU and the Innovation Leader average, Austria's share of small firms using sophisticated cloud computing services (17%) is lower than the EU average (19%). Only one out of ten Austrian firms (11%) bought cloud computing services in 2017. Of the comparison countries only Germany has an even lower use of sophisticated cloud computing services among small, medium and large firms than Austria. The low adoption in small firms may be related to the adoption weakness of larger firms, as no role models are available. In Austria large and medium-sized firms are also reluctant to adopt cloud computing services. However, the interviews also revealed that this may be related to the fact that some of the most used industry-specific solutions in specific applications are solutions that do not provide cloud services. This may also affect the adoption of cloud services by firms, as firms – except in the case of computing power and storage – do not generally look for cloud-based solutions, but for solutions for specific applications. The adoption rate of small firms for medium and high cloud computing services may rise when firms switch to different applications. Indeed, the trend is increasing and the newest data for 2018 from Statistics Austria also shows an increase to 21% of small firms using cloud services.

However, when we consider customer relationship management (CRM) systems, we see that Austrian firms are well on the top, compared to both the EU28 and the Innovation Leader average. Around 39% of Austrian small enterprises use a CRM solution, only for Germany and the Netherlands does a larger share of small enterprises use CRM solutions.

Interestingly, the high use of CRM and ERP software by Austrian small enterprises does not translate into good performance concerning in the adoption of technologies that provide an automatic link to suppliers and/or customers (SISC). By sharing information along a supply chain, companies can gain some advantages. This measure can be thought of as a measure of the digital integration of supply chain management (SCM). While Austrian large and medium-sized enterprises adopted technologies that allow them to automatically exchange information with suppliers and customers to a larger extent than the EU28 average and the Innovation Leader average, small Austrian firms lag behind in the adoption of such technologies. For large enterprises, only Germany and Finland have higher adoption rates, while the adoption rate for small enterprises is below all considered reference countries, with the exception of Sweden. This picture suggests that in Austria larger and medium-sized enterprises are much more tightly integrated in their value chains than small enterprises (see also section 3.1 in the present report). This suggests that there is a specific weakness in the adoption of technologies that provide an automatic link to suppliers and/or customers of small firms compared to larger firms in Austria. However, the adoption of these technologies not only requires a considerable investment, but also that a sizeable part of customers and/or suppliers that use such systems.

Since the adoption dynamic over time is rather weak, the increasing availability of digital technologies might not by any means mean that they will be adopted (Tichy 2016). At the firm level, the commercial viability of the deployment of new technologies often requires complementary investments at the operational level, as well as changes in business processes and skills.

4.4.2. Economic analysis

In order to further explore the relationship between the adoption of digital technologies at the firm level and indicators of small firm presence and industry dynamics, we present a correlation analysis between SME and industry dynamics indicators and the adoption of digital technology indicators at the industry level. The data from the survey on ICT use in enterprises by Eurostat does not provide industry information at the firm size breakdown. For this reason we use industry data on technology adoption at the industry level. The measures are adoption in % of enterprises, so that the indicator should primarily cover the adoption of the most numerous group of enterprises: small firms.

The analysis in section 2.2.1 confirms that, beside country effects, adoption is also characterized by industry-specific factors.[47] Simple regressions that control for fixed country effects and fixed industry effects can provide further insights into the relationship between SME shares, industry dynamics indicators and the adoption of digital technologies. The regression equation used is:

$$ad_{ij} = \alpha + \beta I_{ij} + \mu_i + \gamma_j + \varepsilon_{ij} \qquad 4\text{-}1$$

where ad_{ij} denotes a digitalisation adoption indicator, α is the intercept, β is the coefficient on the SME or industry dynamics indicator I_{ij}. μ_i and γ_j are the country and industry fixed effects and ε_{ij} is an error term; *i* and *j* are country and sector indices. β is the coefficient of interest; it measures the association when country and industry fixed effects are accounted for.

Table 4-6: Fixed effects regressions of SME and industry dynamics indicators on adoption of digital technology indicators, EU countries

VARIABLES	ERP	RFID	Social Media	eInvoices	Cloud	CRM	Automated information Sharing
Entry rate	0.321**	0.090	0.455***	0.250*	0.229***	0.229**	0.572**
	(0.137)	(0.078)	(0.109)	(0.132)	(0.080)	(0.105)	(0.287)
Turnover rate	0.170	0.074	0.298***	0.116	0.158***	0.116	0.365*
	(0.104)	(0.051)	(0.075)	(0.102)	(0.060)	(0.076)	(0.201)
HGF share	-0.867***	-0.084	0.082	-0.121	0.343***	-0.208	-0.229**
	(0.180)	(0.064)	(0.156)	(0.135)	(0.123)	(0.147)	(0.100)
SME share	-5.075***	-0.647***	-0.996**	-2.037***	-1.213***	-1.735***	-1.079*
	(0.985)	(0.233)	(0.487)	(0.634)	(0.317)	(0.618)	(0.562)
Microenterprise share	-0.230*	-0.016	-0.052	-0.094	0.010	-0.043	-0.029
	(0.128)	(0.024)	(0.061)	(0.089)	(0.039)	(0.093)	(0.056)
Sector dummies	y	y	y	y	y	y	y
Country dummies	y	y	y	y	y	y	y

Source: Eurostat, SME database of the SME Performance Review; WIFO calculations. Note: Values for SME indicators, industry dynamics indicators and adoption indicators are averages over the period 2014 and 2017. Malta and Luxembourg due to missing values. SME shares and micro-enterprise shares do not cover financial and insurance services (NACE K). Sig. levels *** p<0.01, ** p<0.05, * p<0.1.

Table 4-7 reports the results. As most of the variation of the regressions is accounted for by the fixed effects, only the coefficients β are reported. The entry rate and the turnover rate are positively associated with technology adoption measures. This suggests that when industry and country-specific factors are put aside, a higher entry rate is statistically significantly and positively associated with the use of ERP software, the use of social media, electronic devices, cloud services, CRM solutions and the automatic information exchange with customers and/or suppliers. For the turnover rate we observe a positive association for social media use, cloud computing and the automatic information exchange with customers and/or suppliers.

This result suggests that more dynamic industries are *ceteris paribus* characterized by a higher propensity to use digital technologies. The evidence for the HGF share is more mixed. We observe a statistically significantly negative association between the HGF share and the use of ERP solutions, as well as the automated exchange of information with customers and supplier. This may be related to the fact that most manufacturing industries, where ERP solutions and the automated exchange of information with customers and suppliers are used especially by firms in value chains and in retail and wholesale trade, usually display a lower share of HGFs than most of the service industries. The share of HGFs is positively associated with the use of medium and high cloud services. For the share of SMEs, we observe a statistically significantly negative relationship for all

[47] In Appendix B.3.2 a correlation table (including the adoption indicators as well as the industry dynamics indicators), which neglects any sector- or country-fixed effects, is presented.

adoption indicators. This confirms that on average smaller firms have a lower propensity to adopt new technologies due to missing scale economies and the cost of investment. This is also confirmed by the result on the share of micro-enterprises, as the coefficient is almost always negative (the exception is the use of cloud services), but statistically significantly negative only for ERP solutions which are used to a larger extent in manufacturing, where the share of micro-enterprises is lower.

We compare these results with regressions that use only the Austrian data. Table 4-9 reports the results for Austria.[48] The number of significant results is lower, which is not surprising given that the number of observations is much lower. The regression analysis shows that in Austria the entry rate and the turnover rate are not as clearly positively associated with the adoption of new digital technologies, i.e. no coefficient is statistically significant. The results for the HGF share confirm the positive associations to social media and cloud computing. The SME share is negatively associated with the use of ERP systems. The micro-enterprise share shows a negative correlation with e-invoicing and a positive one with cloud computing, thus broadly confirming the evidence from the more general correlation analysis covering the EU countries. This suggests that the basic economic factors determining the adoption of new digital technologies across sectors are broadly the same between Austria and the other countries, except very specific regulatory and administrative factors.

It is important to note that these results do not imply a causation but only reflect a correlation; causation could in principle go both directions. However, if the SME and industry dynamics indicators are interpreted as structural indicators, then causality should run primarily from industry characteristics to the adoption of digital technologies. Seen from such a perspective the results broadly confirm that industry dynamics are drivers of structural change and technology adoption, and that the share of small or microenterprises is per se not an indication of ambitious entrepreneurship.

Table 4-7: Regressions of SME and industry dynamics indicators on the adoption of digital technology indicators, Austria

VARIABLES	(1) ERP	(2) RFID	(3) Social Media	(4) eInvoices	(5) Cloud	(6) CRM	(7) Automated information Sharing
Entry rate	-1.420	0.092	-0.386	0.576	0.316	-1.519	-0.573
	(2.058)	(0.332)	(1.512)	(0.472)	(0.670)	(1.842)	(0.775)
Turnover rate	-1.087	0.049	-0.187	0.327	0.179	-0.857	-0.310
	(1.114)	(0.184)	(0.823)	(0.255)	(0.373)	(1.023)	(0.421)
HGF share	0.281	-0.273	3.175*	0.034	1.705**	1.687	-0.116
	(2.620)	(0.413)	(1.616)	(0.635)	(0.587)	(2.299)	(0.997)
SME share	-10.395**	-1.341	3.561	-1.830	1.951	2.092	-3.074
	(4.110)	(0.793)	(3.910)	(1.228)	(1.629)	(4.939)	(1.900)
Microenterprise share	-0.587	-0.108	0.509	-0.277**	0.407**	0.706	-0.183
	(0.615)	(0.094)	(0.374)	(0.104)	(0.150)	(0.532)	(0.206)

Source: Eurostat, Annual report on European SMEs; WIFO calculations. Note: values for SME indicators, industry dynamics indicators and adoption indicators are averages over the period 2014 and 2017. Sig. levels *** p<0.01, ** p<0.05, * p<0.1.

4.4.3. Summary

In this subsection we analysed the adoption of digital technologies amongst Austrian SMEs. The results show a mixed picture concerning different technologies. In European comparison, Austrian SMEs have a very high adoption rate in enterprise resource planning (ERP), customer relationship

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48 Appendix B.3.2 presents the respective correlation table that only considers Austrian SMEs.

management (CRM) solutions and RFID technologies. In these technologies the adoption rate is above the average adoption rate in the EU28 and the Innovation Leader countries. The adoption of social media, cloud computing and f automatically linked business processes with customers and/or suppliers is below the average of the EU28 and the Innovation Leader countries. With regard to the adoption of e-invoicing, Austria is above the EU28 average but slightly below the Innovation Leader average. However, the adoption of e-invoicing shows very large differences across countries. The adoption pattern of SMEs largely follows the patterns observed for large and medium-sized firms, except for the adoption of systems that automatically link to suppliers and/or customers.

The economic analysis links industry dynamics indicators (entry rate, HGF share) and small firm presence to the adoption of digital technology indicators. The results after controlling for fixed sector and industry effects show a generally positive relationship between the entry rate and the adoption of digital business solutions, and a negative relationship between the SME share and the adoption of digital technologies at the firm level. This suggests that more dynamic industries are characterised by a higher propensity to use digital technologies but also that there are considerable differences between industries.

While these results do not imply causation, if the industry dynamics and the SME presence indicators are interpreted as structural indicators of industries, these results broadly confirm that industry dynamics (entry rate) are drivers of structural change and technology adoption, as well as that the share of small and micro-enterprises is per se not an indication of ambitious entrepreneurship.

4.5. Digitalisation in the Austrian micro-enterprise sector

4.5.1. Digital awareness and planned digitalisation projects

Representative data on the digitalisation of micro-enterprises is difficult to come by. The Eurostat survey on ICT use in enterprises does not cover micro-enterprises. Thus, no comparative evidence on the specificities of hampering factors and the needs of micro-enterprises are available. Fortunately, there are a few studies for Austria that also cover microenterprises. The most important study is the internal presentation of Knoll (2018) that uses the special questions on digitalisation introduced into the aws-WKO KMU-Marketmind survey 2018 to study the digitalisation in a representative sample of Austrian SMEs that also covers microenterprises. This allows to check whether firm size determines the approach to digitalisation, whether microenterprises have different hampering factors than larger firms, and whether microenterprises have specific needs.

The survey was conducted in early 2018 and is based on cooperation between the Austrian Economic Chambers (WKO) and the Austria Wirtschaftschaftsservice Gesellschaft (aws), the Austrian federal development and financing bank for the promotion and financing of companies.[49] The survey is designed to be representative for the Austrian SME population, with representation in industries as well as regionally. It covers many micro-enterprises and allows to draw conclusions about the digitalisation of Austrian micro-enterprises in 2018. Table 4-10 displays the firm composition of the survey and the basic digitalisation indicators: 65.2% of enterprises in the sample are micro-enterprises with 0 to 9 employees. 29.5% are small enterprises with 10 to 49 employees and 5.3% are medium enterprises with 50 to 249 enterprises. The answers clearly indicate that the number of firms that deal with digitalisation increases with firm size. Around 72.6% of micro-enterprises already deal with with digitalisation. Compared to micro-enterprises, only 3.1 percentage points more of small enterprises (75.7%) compared to 15.2 percentage points of medium-sized enterprises (87.8%) deal with digitalisation. The evidence is even stronger when we consider firms that plan to carry out digitalisation projects in 2018. 53.5% of micro-enterprises

[49] We thank Norbert Knoll for providing us with important insights and the AWS and the Austrian Economic Chambers for the possibility to use these results in the report.

planned a digitalisation project in 2018, compared to 62.0% of small enterprises and 78.4% of large enterprises.

Table 4-8: Digitalisation by enterprise characteristics

	Number of enterprises	Percentage of total	SME deals with digitalization	Percentage of total	SME plans to carry out digitisation projects in 2018	Percentage of total
Total	1,395	100.0%	1,036	74.3%	799	57.3%
Size						
Micro enterprises	910	65.2%	661	72.6%	487	53.5%
Small enterprises	411	29.5%	311	75.7%	255	62.0%
Medium enterprises	74	5.3%	65	87.8%	58	78.4%
Sector						
Manufacturing	188	13.5%	125	66.5%	88	46.8%
Construction	193	13.8%	128	66.3%	98	50.8%
Trade	268	19.2%	201	75.0%	156	58.2%
Business services	320	22.9%	267	83.4%	215	67.2%
Other	426	30.5%	316	74.2%	243	57.0%
Age						
Age < 5	232	16.6%	169	72.8%	130	56.0%
Age > 5	1081	77.5%	807	74.7%	623	57.6%
Not known	82	5.9%	61	74.4%	47	57.3%
Investment intensity						
High (multiple of depreciation)	225	16.1%	185	82.2%	158	70.2%
Medium (in the range of depreciation)	524	37.6%	427	81.5%	372	71.0%
Low (< annual depreciation)	646	46.3%	425	65.8%	270	41.8%

Source: Knoll 2018; AWS-WKO KMU-MARKETMIND survey 2018.

Compared to firm size the age of enterprises does not play a large role. The share of young enterprises (age<5) that deals with digitalisation is slightly lower than the share of the older enterprises (age>5). This might be associated with the fact that most younger firms are also small, and that the propensity of an enterprise to deal with digitalisation increases with enterprise size. However, this finding puts the view that new firms are the primary drivers of digitalisation into perspective. This is also true when considering whether the enterprise plans to carry an investment project in 2018: the numbers are very similar (57.6% and 56.0%) and in line with the overall number of 57.3%.

Interestingly, the enterprises in business services are most likely to deal with digitalisation and to implement a digitalisation project in 2018, followed by enterprises in trade (retail and wholesale). Construction and manufacturing firms are least likely to deal with digitalisation and to implement a project according to the survey. The evidence regarding investment intensity is also insightful. Firms with a medium and high investment intensity have a much higher propensity to deal with digitalisation than firms with a low investment intensity.[50] This suggests that dealing with digitalisation and even implementing digitalisation projects goes hand in hand with investment plans. Interview partners told us that most, if not all, new investment projects at the enterprise level

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50 This connects nicely to the results for larger firms in section 3.1 of the report, where more than 30% of enterprises stated that they expect digitalisation to lead to a higher investment share.

contain some element of ICT and digitalisation, even if the investment projects as such could not be classified as digitalisation project, but as replacement or expansion investments.

This picture is broadly confirmed when compared to the findings of the Arthur D. Little studies of 2017 and 2018. In the 2017 studies, differences in the digitalisation index are reported by firm size. Large firms achieve an average index value of 46.0, medium-sized firms 38.0, small firms 36.1 and micro-enterprises 31.1. Thus, in line with the evidence from the study by Knoll (2018), this suggests that the difference between large and small enterprises is substantially higher than for small and micro-enterprises. The study also finds that enterprises in a business-to-business market have dealt more with digitalisation than firms that are exclusively active in a business-to-consumer market. These studies (Arthur D. Little 2017, 2018) also confirm that business services are the most digitally aware sectors, while manufacturing and transportation lag behind.

Table 4-9 returns to the AWS-WKO KMU-Marketmind survey and presents evidence regarding the size of digitalisation projects in 2018 of firms dealing with digitalisation. The firms can be classified by the size of the digitalisation project – whether it exceeded the volume of 50,000 Euro[51] or remained below. Most firms dealing with digitalisation planned small digitalisation projects (60%), 22.9% did not plan a digitalisation project, and 17.1% had planned a large digitalisation project with a volume of more than 50,000 Euro.

Table 4-9: Planned digitalisation projects of firms dealing with digitalisation in 2018

	Digitisation projects planned for 2018 with costs of up to 50,000; in % of firms dealing with digitalizatation	Digitisation projects planned for 2018 with costs above 50,000; in % of firms dealing with digitalizatation	SME deals with digitalization but has no digitization projects in 2018; in %
Total	60.1%	17.1%	22.9%
Size			
Micro enterprises	63.2%	10.4%	26.3%
Small enterprises	59.8%	22.2%	18.0%
Medium enterprises	29.2%	60.0%	10.8%
Sector			
Manufacturing	42.4%	28.0%	29.6%
Construction	67.2%	9.4%	23.4%
Trade	63.7%	13.9%	22.4%
Business services	58.8%	21.7%	19.5%
Other	63.0%	13.9%	23.1%
Age			
Age < 5	62.1%	14.8%	23.1%
Age > 5	59.5%	17.7%	22.8%
Not known	62.3%	14.8%	23.0%
Investment intensity			
High (multiple of depreciation)	51.4%	34.1%	14.6%
Medium (in the range of depreciation)	66.7%	20.4%	12.9%
Low (< annual depreciation)	57.2%	6.4%	36.5%

Source: Knoll 2018; AWS-WKO KMU-MARKETMIND survey 2018. Note: n=1,036.

Important differences emerge regarding firm size: many of the medium-sized enterprises planned large digitalisation projects for 2018 (60%), but only a small number of the micro-enterprises did so (10.4%). Most of the micro-enterprises dealing with digitalisation planned small digitalisation projects (63.2%). This is certainly associated with the fact that a value of 50,000 Euro is different

[51] To be precise 2% of SMEs planned projects above 250,000 Euro in 2018, 4% projects with volume between 100,000 and 250,000 Euro and 7% with a volume between 50,000 and 100.000 Euro, 44% planned projects a volume up to 50,000 Euro. 43% of enterprises did not plan a digitalisation project for 2018 (n=1395).

for small and large enterprises. If one considers the numbers for investment intensity, however, the picture emerges that firms with a higher investment intensity also have a higher propensity to plan a large digitalisation project (volume > 50,000 Euro). 34.1% of firms with a high investment intensity and 20.4% of firms with a medium investment intensity but only 6.4% of firms with a low investment intensity planned a digitalisation project with a value of more than 50,000 Euro in 2018. This confirms that many digitalisation projects go hand in hand with investment activity.

Larger digitalisation projects were planned especially by firms in the manufacturing and in business services industries, while construction firms had the lowest propensity to plan a large digitalisation project. Again, while there is a substantial difference in the size of digitalisation projects in terms of industry, firm size and investment intensity, the age of the firm does not seem to make much difference for the size of the digitalisation project.

Table 4-10: Fields of planned digitalisation projects

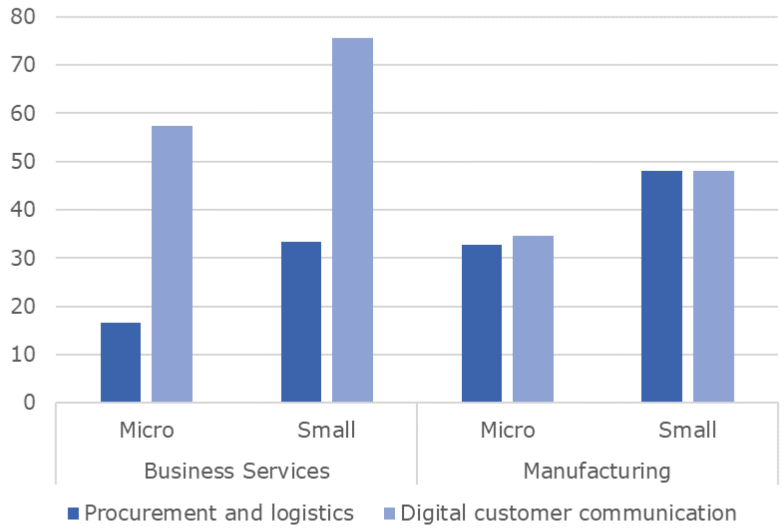
	SMEs that deal with digitalizaiton; in %	Microenterprises that deal with digitalizaiton; in %	Small enterprises that deal with digitalization, in %	SMEs with large investment projects, in %
Networking and data integration within the company	62.8%	56.4%	70.4%	74.0%
Digital customer communication	54.6%	52.5%	56.9%	65.5%
Data evaluation to meet customer requirements	46.5%	41.3%	54.7%	64.4%
Data exchange in the production process	42.5%	39.3%	48.2%	47.5%
Development of new business models	31.4%	31.6%	30.5%	46.9%
Procurement and logistics	30.7%	24.2%	43.4%	36.2%
Service functions for partners in the value chain	20.4%	18.5%	22.8%	35.6%
No firms	1,037	661	311	177

Source: Knoll 2018; AWS-WKO KMU-MARKETMIND survey 2018. Note: n=799, the number of firms with plans for digitalisation projects.

Table 4-10 presents the fields of application and topics of planned digitalisation projects. Here, the firms could select more than one of the fields. Thus, the result suggests that many of the projects (small and large) likely affected more than one of the topics. The most relevant field of application was the networking and data integration within the company (62.8% of enterprises with digitalisation projects). The second most important topic is digital communication with customers (e.g. via portals, Apps), selected by 54.6% of enterprises with digitalisation projects. 46.5% of enterprises said that their planned digitalisation project concerns the systematic preparation and evaluation of digital data to better meet customer needs. 42.5% of projects also target the digital data exchange with suppliers and/or customers in the production process. 31.4% of enterprises said that the digitalisation projects will lead to the development of new business models for offering products and services, 30.7% of enterprises said the digitalisation project will include digital applications in procurement and logistics and, finally, 20.4% of firms said that the digitalisation project will provide digital service functions for value chain partners.

Table 4-10 also reports the fields of planned digitalisation projects for micro-enterprises that deal with digitalisation, for small enterprises that deal with digitalisation and for SMEs with large investment projects. Micro-enterprises plan significantly less frequently than larger firms to invest in networking and data integration within the company and procurement and logistics, but are slightly more likely to invest into a new business model. Interestingly, there are considerable differences between the planned applications of enterprises in the business service sectors and those in manufacturing. Manufacturing firms have a much higher propensity to invest in digitalisation projects that support purchasing and logistics than firms in business services, and for the goal of digital customer communication it is the opposite. This suggests that sector composition matters for the fields of planned digitalisation projects.

Figure 4-2: Differences between business services and manufacturing firm’s fields of planned investment projects



Source: Knoll 2018; AWS-WKO KMU-MARKETMIND survey 2018. Note (n=799, the number of firms with plans for digitalisation projects).

In comparison to these fields of applications, the project priorities that firms prioritize in the Arthur D. Little (2018) study are slightly different: 40% of enterprises selected data back-up solutions, 39% own web presence, 34% internet banking, 26% social media presence, 25% IT security solutions, 23% mobile applications, 23% e-mail newsletters, 22% e-invoicing, 21% digital signatures, 21% cloud services. Only 8% considered ERP software, 9% electronic procurement and 10% work-flow solutions. These differences are rooted in the very different survey questions and the filtering of the question in the KMU-MARKETMIND questionnaire.

4.5.2. Challenges of digitalisation

Table 4-11 depicts the challenges of digitalisation of the enterprises with digitalisation projects based on the KMU-Marketmind survey. The most important challenges for enterprises are internal factors related to the technical and organisational know-how and competencies of the employees. As many as 58.8% of all enterprises mentioned internal factors as a challenge when planning and implementing digitalisation projects. The distribution across types of firms is quite similar. Interestingly, an above-average number of medium-sized enterprises (64.6%) and firms with a larger investment intensity (68.1%) mentioned this factor. This reflects the fact that larger firms with established and often formalized business processes face stronger internal problems when implementing digitalisation projects that change these established business processes and require new skills and substantial reorganisations to be successful. As our interview partners emphasized, it is often the case that larger companies face stronger headwinds when implementing digitalisation processes: “If 300 employees are used to a process and I change the process, then I guarantee 6-18 months of chaos in the company. This also has a financial impact, effectiveness is reduced, mistakes happen. People also resist changes.” However, it is also important to note that 57.7% of the micro-enterprises mentioned internal factors as an important challenge for digitalisation projects.

The second most frequently mentioned challenge is regulations and laws. This seems to be related to the introduction of the General Data Protection Regulation in 2018. 46.6% of all enterprises mentioned this as an important challenge. This challenge is mentioned by all types of firms with the same intensity.

The third factor is financing. 31% of firms mentioned financing as an important challenge in the planning and implementation of digitalisation projects. Here we observe some differences across firm types. Financing seems to be a greater problem for micro-enterprises (35.9%) than for small (23.2%) or medium-sized enterprises (18.5%). For younger firms, financing is a bigger problem (47.3%) than for older, established enterprises (27.7%), even if they have almost the same propensity to pursue a digitalisation project (see Table 4-8). Also, enterprises with larger digitalisation projects and firms with a large investment intensity in 2018 mention financing as a challenge to an above average extent.

Table 4-11: Challenges of digitalisation

	Internal factors; in %	Regulation & laws; in %	Financial factors; in %	Supply side factors; in %	Other factors; in %
Total	58.7%	46.6%	31.0%	24.2%	26.3%
Size					
Micro enterprises	57.6%	48.9%	35.9%	26.3%	22.4%
Small enterprises	59.8%	43.4%	23.2%	19.9%	31.8%
Medium enterprises	64.6%	38.5%	18.5%	23.1%	40.0%
Sector					
Manufacturing	70.4%	32.0%	21.6%	21.6%	29.6%
Construction	62.5%	48.4%	29.7%	31.3%	27.3%
Trade	58.2%	47.3%	34.3%	21.4%	30.3%
Business services	53.2%	51.3%	34.5%	25.8%	25.5%
Other	57.6%	47.2%	30.1%	22.8%	22.8%
Age					
Age < 5	53.3%	43.2%	47.3%	27.8%	26.6%
Age > 5	60.3%	47.7%	27.6%	23.0%	26.3%
Not known	52.5%	41.0%	29.5%		
Digitisation projects planned for 2018					
With costs of up to 50,000	59.1%	47.7%	30.8%	24.7%	27.1%
With costs above 50,000	61.6%	45.8%	43.5%	27.1%	29.4%
Investment intensity					
High (multiple of depreciation)	68.1%	49.7%	42.7%	23.8%	21.1%
Medium (in the range of depreciation)	58.1%	47.1%	34.7%	24.6%	28.1%
Low (< annual depreciation)	55.3%	44.7%	22.1%	24.0%	26.8%

Source: Knoll 2018; AWS-WKO KMU-MARKETMIND survey 2018. Note: (n=1036, the number of firms that deal with digitalisation.

Supply side problems, i.e. a lack of available solutions on the market (e.g. regarding reliability and sophistication, scalability, standardization requirements, etc.), is mentioned by 24.2% of firms. Not much variance is observed across enterprise types: micro-enterprises mention this to an above average extent (26.4%), as do younger firms (27.8) and firms with larger digitalisation projects (27.1%).

26.4% of firms refer to other, non-specified factors. A clear difference exists with respect to firm size. While medium-sized firms mention other factors as the second most important challenge (40.0% of firms), micro-enterprises mention other factors much less (22.4%).

This impression is broadly confirmed by the Arthur D. Little study (Arthur D. Little 2018). In 2017, missing know-how for implementation (36%), missing or difficult-to-define targets (32%), too little information (31%), missing financial resources (27%) and legal requirements as hurdles (24%) were the five most-mentioned challenges in this study, while in 2018 the implementation of the general data protection regulation is mentioned by 54% of surveyed firms, followed by missing financial resources (36%), missing know-how for implementation (36%), legal requirements as hurdles (31%) and too little information (31%) were the most often mentioned challenge of digital transformation.

4.5.3. Case studies

The data do not allow to pin down the very specific problems of micro-enterprises in different economic contexts. To provide an additional context for the assessment of the digitalisation challenges of micro-enterprises in specific economic environments, we provide three case studies covering different industries that are characterized by a high share of micro-enterprises, but face different digitalisation challenges. The data sources for these studies come from industry studies and expert interviews. Box 4-1 discusses the case of a traditional craft and trade segment: carpenters. It is an industry where computerized production machinery has been used since the mid1980s to support flexible manufacturing strategies with low lot sizes. At the same time, the trade of carpenters covers many small enterprises that perform service jobs. In general, enterprises in the traditional trade and craft segments are seen to be less digitalised than their larger cousins in industry (Henkel 2016). Box 4-2 discusses the case of the legal profession that is part of the free professions and faces very different challenges that are related to the introduction of expert systems and the automatisation of cognitive work. Finally, Box 4-3 discusses the case of retail trade. Traditional retail trade is primarily affected by e-commerce and the online competition by large multinational retailers, which primarily come from the IT segment. These case studies show how digitalisation is and will affect professions and trades through different mechanisms.

Box 4-1: Digitalisation of carpenters

Around 8,134 carpenters and joiners are currently active in Austria, with around 29,000 employees of which around 2,400 are apprentices. The structural change associated with digitalisation and globalisation leads to an increasing number of enterprises, but the number of manufacturing enterprises is decreasing. According to the membership statistics, in 2007 91.7 percent of all enterprises in the sector were micro-enterprises, 7.6% small enterprises and 0.7% medium-sized enterprises. The trend towards self-employment and very small enterprises is driven by service firms. Around 43 percent of the trade licensees are self-employed with no employees and are mainly active in service activities – the assembly of industrial products such as floors, doors, windows and kitchens. Digitalisation affects most carpenters, the mechanisation of production and CNC machinery (computer-aided manufacturing, CAM) has for a long time been a reality for the large carpenters and wood-working firms. Small-scale CNC machinery has also been available for quite some time and the integration of CAD (computer aided design) and CAM is an ongoing process. The heterogeneity of diffusion of this CAM and CAD is best explained by the fact that individual enterprises – especially smaller ones – tend to stick with whatever is profitable, and their time and money for trying out alternatives is limited. This explains how a wide range of generations of wood-working machines can coexist at the same time. As remarked earlier, digitalisation affects carpenters and wood designers heterogeneously. In a small online survey (n=43) by the trade journal Tischlermagazin carried out in 2015, 51% of enterprises said that they use CNC machinery, 17% said that they use external firms that do CNC tasks for them, and 20% said they will invest in the future in CNC machinery (Tischlermagazin 2015a). Especially smaller handicraft-oriented and service firms may be affected less by the digitalisation of production. In the production of individual furniture items and the provision of services at location, CNC machinery does not provide that much cost-saving potential, although one must also consider that CNC milling machines are already available for hobbyists. Large and medium-sized carpenters are much more affected by the digitalisation of production, where the integration of design, machine operation and accounting are reality and the organisation is characterized by high degrees of networking and automatisation (Tischlermagazin 2015b, 2017), including automated inventory systems that pre-sort materials as well as building information modelling (BIM). But it needs to be emphasized that there are also very small enterprises with a few employees that have a high degree of automatisation (e.g. Tischlermagazin 2018).

A second aspect that becomes more relevant is digital customer communication and social media. The channels of marketing depend strongly on the business model. Using Pinterest or Instagram is probably most relevant for furniture producers and furnishers. Platforms do not yet play a dominant role. Most business models focussing on the online customer design of furniture are still in their infancy, have still-limited configuration possibilities and are closed, not two-sided platforms. in Austria only a few firms are beginning to take up the challenge of unlocking the opportunities of mass customization for consumers. Other platforms concentrate on establishing a market place not for products but for services. Here platforms like MyHammer exists. No evidence for Austria is available, and none for carpenter services. Fredriksen and Runst (2016) report that in Germany only a small fraction of very small craft firms are registered on MyHammer, but suggest platforms such as MyHammer can provide opportunities for micro-enterprises.

For many small carpenters digitalisation is a major challenge. They see their traditional business model threatened by digitalisation, because they have problems coping with digital technology and with competitors from other markets, especially the ICT and internet segments. But the case of carpentry also shows that digitalisation is already a reality in production and increasingly so in marketing. The changes associated with industry 4.0 in production, 3D visualisation, virtual reality and social media require especially that micro-enterprises to develop a focused and specialized business model (KMUDigital 2018). The threat that carpentry could primarily become a planning job exists, but digitalisation also creates new opportunities, because people's desire to buy sustainable and long-lasting products is on the rise again. Regionality, quality craftsmanship and the ecological material wood also remain relevant in the digital economy.

Box 4-2 Challenges of digitalisation in the legal profession

Overall, around 6,238 Austrian lawyers are currently active, which represents an increase of 22% within the last 10 years (2007: 5,129) (Österreichischer Rechtsanwaltskammertag (ÖRAK), 2018). In addition, in 2017 there were 2,215 candidate lawyers (i.e. attorneys trainees) registered with the Austrian bar, the self-administered professional association of lawyers and trainee lawyers in the Austria. Moreover, according to the Austrian bar about 87 lawyers established or residing in other EU Member States are currently operating in Austria – most of them from Germany (43) or Great Britain (11) (Österreichischer Rechtsanwaltskammertag (ÖRAK), 2018). Digitalisation has the potential to re-shape legal professions in Austria. According to a survey among Austrian households (n=500) by LexisNexis in 2017 68% of the respondents said that they would seek automated, computer-generated legal advice (LexisNexis, 2017). However, half of the persons would use the automated legal consultancy as initial input or advanced information, and more than two-thirds assume that digital legal advice will substitute attorneys, provided the system is maintained by lawyers and data security is guaranteed. New technologies in terms of semantic search and cloud computing algorithms combined with standardized legal advice are likely to generate efficiency gains, especially thanks to time-saving in research work and decreased prices. Consideringe frequent changes in the legislation – since 2000 almost 430 changes in the Austrian tax legislation were passed by the Austrian National Council, i.e. one every two weeks (LexisNexis 2017) – and thus, the increasing flood of legislation and its complexity, as well as legal data bases, will be key drivers for productivity enhancements.

Moreover, new business models based on fully automated legal advice systems processing standardized mass data as well as new entrants, such as the Big Four, will increase competition and price pressure. New online platforms offering automated legal advice have already emerged. Most of them focus on supporting the enforcement of consumer rights. Examples are fairplane.at, which estimates the success probability of legal actions in case of flight delays, or mietfuchs.at, which provides rental auditing and automatically performs a reimbursement procedure. These business models are mainly based on unbundling single routines of legal consultancy services and offering them as (partly) automated mass services at significantly lower prices. And there definitely is a relevant market for these services: according to the survey most people would use automated legal advice in case of compensation claims (47%) and rental law services (45%) (LexisNexis 2017). However, these new services do not represent a substantial danger for Austrian lawyers because those cases have mostly been covered by the consumer protection (VKI) service. In contrast, automated document production services constitute strong competition for Austrian lawyers. It is assumed that especially small law offices with 1-3 partners, i.e. about 86% of all Austrian lawyers, will come under severe pressure (LexisNexis 2017).

That digitalisation can be pushed by (supra-)national regulations proves the example of the Austrian notaries. Since 1.1.2017, when opening a bank account the digital identification of customers (“Videoident-Verfahren”) has been allowed by Austrian regulators and was immediately implemented by Austrian banks. As a result, the establishment of a limited company (GmbH) became easier since the founder is no longer required to make the initial contribution at a bank or a notary. The answer of the notary chamber came swiftly in the form of a pilot project: Austrian notaries now offer a secure online connection between notaries and customers, including identification as well as legal advice for all parties included per video chat. The competition from banks are taken seriously. Notaries provide additional digital services such as checking for politically exposed persons or money laundering, to vertically differentiate themselves from the electronic identification proceedings of banks (Notar.at 2018).

Austrian courts and administrative bodies are also facing digital transformations. Since 2016 the IT programme “Justiz 3.0” has been installed in four Regional Courts. 9000 workplaces and 700 hearing rooms have been adjusted to guarantee digitally integrated work environments. Due to these pilot projects, currently more than 3,600 lawsuits and proceedings are exclusively performed electronically (LexisNexis 2017).

However, the digital transformation also requires respective skills of lawyers. 98% of the consulted Austrian lawyers said that there is too little focus on IT skills during their legal studies (LexisNexis 2017). Especially, IT skills in terms of research data bases (70%) but also IT security and LegalTech (each 63%) should be better imparted. In the future, while 60% of the consulted Austrian lawyers are considering the use of LegalTech software (e.g. intelligent research data bases), 10% of lawyers refuse to use digital technologies at all and 29% have not yet thought about it.

Box 4-3: Challenges of digitalisation in retail trade

More than 150.000 retail and wholesale entrepreneurs with trade licences were active in Austria in 2017, according to the membership statistics of the Austrian Chambers of Commerce. 48.8% of these were self-employed with no employees. Retail trade accounted for a large part of these activities. According to the structural business statistics, retail trade accounted for more than 42,500 enterprises, employing 197,000 employees. Most of the enterprises are small: 89.6 percent of all enterprises were micro-enterprises. The SME share is 99.8%.

The structural change associated with digitalisation affects both enterprises that sell via the internet and traditional brick and mortar retailing, as the rise of the internet dramatically increased price transparency for customers. The internet creates a high transparency of prices, as customers can use price comparison platforms and online shops to compare prices. This leads to increased price pressures, also for enterprises that do not trade over the internet.

Small retailing firms are also facing challenges in setting up a successful online presence and e-commerce solutions. Internet retailing requires a different set of competencies and know-how than brick and mortar retailing. Digitalisation requires changes in the business model, modes of distribution and in marketing. Firms are forced to focus and develop unique selling propositions. This explains why, according to Gittenberger and Ziniel (2018), 81% of retailing entrepreneurs see internet commerce as a long-term threat for their business models. The number of stationary retail shops is decreasing, while the number of online shops is increasing. The numbers from KMU Forschung Austria show a decline in stationary retail shops from 47,000 to 37,400 between 2006 and 2017, while the number of online shops increased from 1,200 to 9,000 during the same period. This shows that the dominant form of retailing in Austria is still the retail shop. But four of 10 retail shops are operated by chain retailers. Many online shops are connected to retail shops (bricks and clicks), others combine mail order and online (clicks and sheets), but there are also pure players. In terms of turnover, clicks and sheets and bricks and clicks are more relevant than pure players (Gittenberger – Ziniel 2018).

The most important market segments in Austria are clothing and textiles, books, electronic appliances, shoes, and sporting wear. Firm size plays an important role; While 90% of the large retail firms have internet sales, 65% of medium-sized enterprises, but only 26% of small and 21% of microenterprises. This suggests that it is difficult for small enterprises and micro-enterprises to operate both a stationary retail shop and an internet shop. This is also confirmed by the enterprise survey (KMU Forschung 2014). Online shops require different competencies and focus as they face different logistics costs, have to deal with returns, require an efficient warehousing approach that is integrated into the online shop, and operate in a slightly different legal framework. The digital transformation in the retailing business not only affects micro-enterprises; traditional micro-retailers in particular face stiff challenges.

4.5.4. Summary

To summarize, the results reported in this section show three important points:

(1) Most micro-enterprises are aware of digitalisation. Around 50% of micro-enterprises implemented digitalisation projects in 2018, even if the study also confirms that the readiness to implement digitalisation projects depended more on firm size than the age of enterprise

(2) Digitalisation projects in SMEs and micro-enterprises are often closely related to broader investment projects. This is also confirmed for larger enterprises. Section 3.1.3 reports that many larger firms expect digitalisation to lead to a higher investment share.

(3) There are important differences across sectors and firm sizes when it comes to the fields of application of the planned investment projects. Manufacturing firms are more likely to put projects in place that concern procurement and logistics than are service-sector firms. Micro-enterprises are less likely to invest in solutions regarding procurement and logistics as well as networking and data integration within the company than their larger peers. However, they are equally likely to use new digital solutions to change their business model. The specific case studies show that challenges are highly different across professions and industries.

(4) The most important challenges of micro-enterprises are not found on the supply side (availability of solutions) but rather within the enterprises, related to the organisation, qualifications and know-how of the employees. This confirms that successful digitalisation projects require organisational and technological know-how and often also a reorganisation of business processes. This is true for larger enterprises, but also for micro-enterprises.

(5) Financial factors are relevant for larger digitalisation projects (investment projects) especially for micro-enterprises and young enterprises.

4.6. The policy environment

4.6.1. Main playing field for policy interventions

The main players in the field of digitalisation at the federal level are the Austrian Federal Ministry of Transport, Innovation and Technology (bmvit) and the Austrian Federal Ministry for Digital and Economic Affairs (bmdw). The ministries are supported by agencies, most importantly the Forschungsförderungsgesellschaft (FFG), the Austria Wirtschaftsservice (aws) and the Digitalisierungsagentur (DIA). The latter was only instituted as a coordination agency in the field of digitalisation in September 2018 and is still in the phase of build-up. The Austrian Economic Chambers also play an important role in the policy landscape through the programme KMU Digital, which includes financial support, consulting services, events, webinars, analysis tools and training programs.

Table 4-12: Use of latest technologies and digital methods in business operations

	All sectors		Industry	
	Micro-enterprises	All SMEs	Micro-enterprises	All SMEs
The company has a competitive advantage due to digitization measures	9.0%	11.0%	0.0%	7.0%
Thanks to digitization measures, operational performance is at on par with competitors.	15.0%	18.0%	8.0%	15.0%
The company plans to make better use of the potential of digital technologies and processes .	30.0%	33.0%	34.0%	50.0%
The company mainly uses proven technologies does not plan to change its direction towards digitalization.	39.0%	34.0%	36.0%	27.0%

Source: Arthur D. Little 2018. Note: Question: To what extent does your company utilize the potential of the latest technologies and digital methods to make operations effective and efficient? The percentages do not sum up to 100% because firms did not tick one of these answers (do not know).

The main challenge of the diffusion policy is depicted in Table 4-12, which draws on the results from the Arthur D. Little (2018) study for the Austrian Economic Chambers on the digitalisation of SMES. The results clearly indicate that only a few SMEs consider themselves to have a competitive advantage vis-à-vis competitors due to digitalisation measures. 15% of micro-enterprises say that digitalisation measures put them into a competitive position on par with competitors. However, a much larger share of micro-enterprises plan to put digitalisation measures in place (30% of micro-enterprises), while 39% of micro-enterprises do not plan to change their direction towards digitalisation. Table 4-12 also reports the results for industry (part of the manufacturing sector not associatiated with the traditional craft production). Here, the difference between micro-enterprises and the overall sample is very large, also because in this segment of the economy larger firms are more prevalent.

4.6.2. Needs of micro-enterprises and SMEs to cope with the challenges of digital transformation

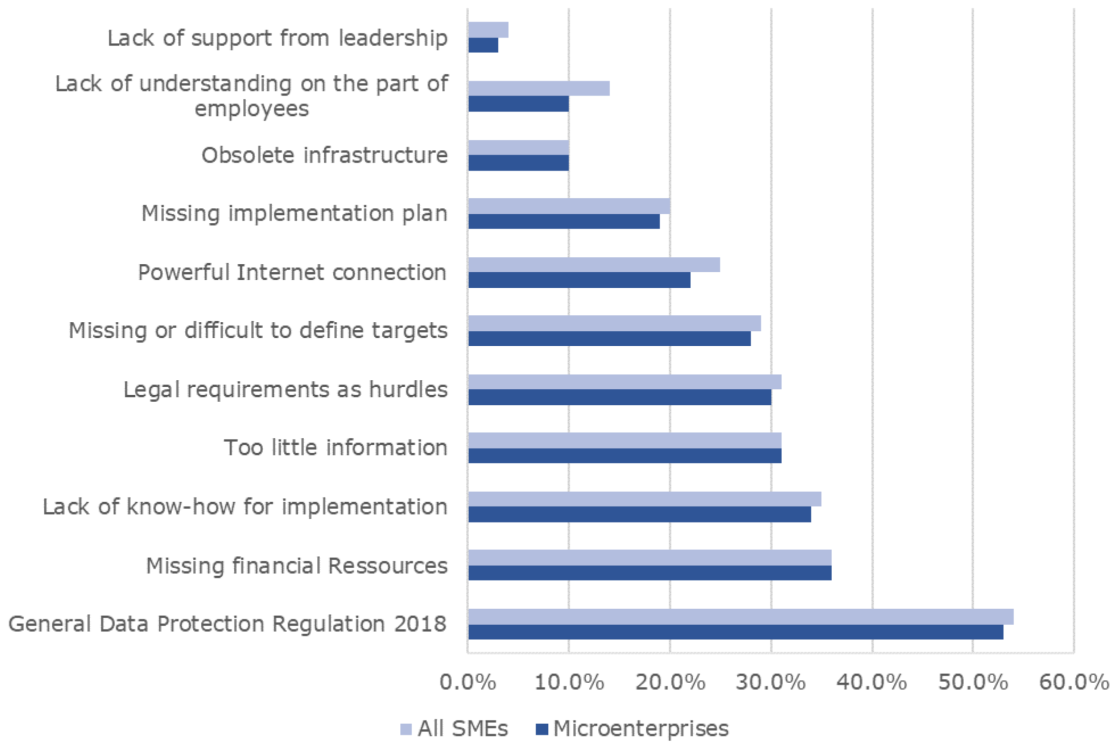
The evidence in previous sections suggests that most small enterprises and micro-enterprises are aware of digitalisation and also have plans to implement digitalisation projects. The most important hampering factors identified in the study by Knoll (2018) were (i) factors internal to the firm related to information, competencies and knowledge with regard to digitalisation, (ii) issues related to regulations and the law – related to the implementation of the General Data Protection Regulation in 2018, (iii) financial factors and (iv) supply factors related to the available ICT solutions and (v) other factors.

The study of Arthur D. Little for the Austrian Economic Chambers (Arthur D. Little 2018) provides a different view of the challenges of digital transformation of micro-enterprises and SMEs.[52] Figure 4-3 presents the results from this survey with more than 700 observations for micro-enterprises and more than 1,100 SMES in the sample. The results clearly indicate that the main challenge in 2018 was the implementation of the General Data Protection Regulation. 53% of micro-enterprises called it an important challenge. Lack of financial resources was mentioned by 36% of micro-enterprises as an important challenge. Followed by two items that are related to missing information and knowledge: Lack of know-how for the implementation of digital transformation in the enterprise was selected by 34% of micro-enterprises and too little information about digital transformation by 31% of micro-enterprises. Also the items missing or having difficult-to-define targets (28%) and missing an implementation plan (19%) can be classified under the heading information and/or knowledge deficits. Legal requirements as hurdles was selected by 30% of enterprises. 22% of enterprises mentioned a powerful internet connection as a hurdle. This emphasizes that the infrastructure deficit described in section 2 is also of relevance for micro-

[52] We wish to thank Arthur D. Little and especially Alexios Seibt for providing us with the information on microenterprises that is not contained in the official publication.

enterprises. 10% of micro-enterprises mention an outdated computer infrastructure as a hampering factor, 10% a lack of understanding on the part of employees and 3% a lack of support from the leadership of the enterprise. The latter two are directly related to organisational deficits.

Figure 4-3: Challenges of the Digital Transformation for SMEs and micro-enterprises, 2018

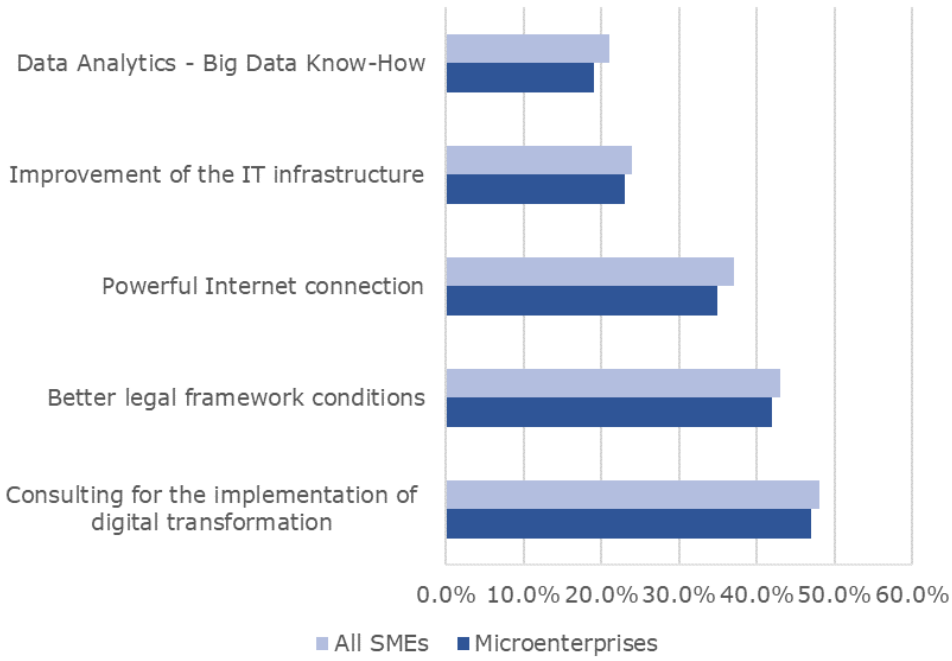


Source: Arthur D. Little 2018. Note: Question: In your opinion, what are the biggest challenges of digital transformation for your company?

Interestingly the results for micro-enterprises are very similar to those for the overall population of firms. However, regarding the lack of understanding on the part of employees, a quite large difference between micro-enterprises and all firms (including micro-enterprises) is observed. This is likely related to the larger number of employees in larger enterprises. To understand this difference, an important point was made by our interview partners. They emphasized that the digital transformation is more difficult to grasp for micro-enterprises than for large enterprises. While large enterprises often have organizational problems in implementing new digital business processes, for micro-enterprises information, financing constraints, missing knowledge and the awareness of the owner/entrepreneur are central.

Figure 4-4 reports the survey results regarding the need for support in the course of digital transformation. Around 47% of micro-enterprises say they need consulting for the implementation of the digital transformation, 42% mention better legal framework conditions, 35% a powerful internet connection, 23% an improvement of IT infrastructure and 19% more big data know-how. Again, the results are quite similar for micro-enterprises (around 700 observations) and all SMEs (around 1,100 observations).

Figure 4-4: Need for support of micro-enterprises and SMEs in the course of the digital transformation, 2018



Source: Arthur D. Little 2018. Note: Question: In order to meet the challenges of digital transformation in the future, what form of support and advice would you need for your company?

4.6.3. Raising awareness, information and knowledge

In line with the results in the previous section, most of our interview partners emphasized that the primary problems of micro-enterprises are information deficits and missing awareness of the potential of digital solutions. While larger firms have managerial competencies and resources with which to monitor technological change and decide whether to adopt new digital solutions or not, very small firms most often do not have the capacities and resources with which to assess the advantages of new digital solutions. Our interview partners highlighted that it is often very difficult for very small firms to adopt digital technologies, let alone digital business models from different markets or sectors of the economy. Small enterprises do not only need general information, but information and consulting that is specifically targeted to their situation. They need examples tailored to their business models and activities to understand the potential of digitalisation. This is important, our interview partners added, because tools and challenges from the ongoing digitalisation process can be quite heterogeneous and specific across industries and professions. Another important point that emerged from the expert interviews is that most entrepreneurs tend to think about digitalisation not in terms of innovation but in terms of cost-saving and rationalisation. The digital transformation is often associated with a reduced workforce. Interview partners said that this constitutes a problem because cost-saving is essentially a defensive strategy, whereas the successful implementation of digitalisation projects most often requires an offensive entrepreneurial orientation towards opportunities not operational costs. The empirical evidence has shown that there are important deficits in the adoption of digital technologies in the Austrian SME sector. These are mainly related to the adoption of communication and advertising (social media) and automatic linkages with customers and/or suppliers. But the evidence also shows that the adoption of new digital technologies is affected by firm size: the smaller the firm, the lower the adoption rate.

Overall, these results suggest that raising awareness and providing support for micro-enterprises to implement digitalisation projects can be differentiated into three different types of complementary support measures concerning the provision of information:

(1) Providing information for entrepreneurs that are not yet aware of the importance of the possibilities and opportunities of the digital transformation for their enterprises (know-

that). The main task of policy measures is to inform entrepreneurs by providing role models and information that is easy to digest.

(2) Providing support to reduce the substantive uncertainty of entrepreneurs. The substantive uncertainty is related to information deficits on the technologies that are available and best-suited to their specific situation (know-what). Here, the task of policy is to reduce the uncertainty related to the different solutions by providing information that is specific to the economic situation of the entrepreneur, including support for general digitalisation consulting.

(3) The third aspect is the procedural uncertainty related to the implementation of digitalisation projects (know-how). In order to be effective and efficient, many digital solutions require changes in operational business processes, required qualifications and even in business models. Here, the main task for public policy is to ensure that qualified consultants are available that can help in setting up an implementation plan, and help the small enterprise through the implementation process and to provide support for the training and re-training of the workforce.

At the federal level, the most important programme targeted at raising awareness and providing information and advice in the form of financial support for consulting services is KMU Digital (SME digital) provided by the Austrian Economic Chambers in cooperation with the Ministry of Digital and Economic Affairs. This programme covers all of the three aspects associated with providing information for SMEs discussed earlier. The programme has existed since 2017 and bundles many different policy instruments for SMEs under a common heading, while focussing explicitly on raising digital awareness among SMEs and improving the digital competencies of Austrian SMEs. The main focus is on advice for SMEs on how to best implement digitalisation projects:

- It provides online and offline information about digitalisation, from information events to a free online status check for enterprises and webinars. Until now, 10 different digitalisation manuals have been developed for specific professions. This considers that raising awareness requires the presentation of digitalisation examples that are tailored to the contexts of the enterprises.
- A free potential analysis (100% of costs up to a maximum of 600 € is supported) by a certified consultant is provided on demand. In addition, the programme supports more dedicated digitalisation consulting for the implementation plan of digitalisation projects (50% of the costs with a maximum of 1,000 €). Different certifications exist for three different topics (e-commerce and social media, business models and operations, IT security and data protection).
- It provides support for courses and training to foster the digital competencies of enterprises. 50% of the cost of selected courses is supported up to a maximum of 4,000 € per enterprise.

According to KMU Digital, by November 8,576 companies submitted a support application to KMU Digital. This included 3,731 potential analyses and 2,219 dedicated digitalisation consultancies (31% in the realm of e-commerce and social media, 32% in the realm of IT security and data protection and 37% in the realm of business models and processes). 991 courses and trainings have been supported in order to further digital competencies within SMEs. In the potential analyses, data protection topics were prevalent, with 58% of the potential analyses covering the topic of data protection. In all industries, data protection, social media, digital presence and customer relationship management systems were among the top 10 topics. To set up an own digital presence is relevant for many SMEs – it ranks 1st or 2nd in 7 out of 10 industries. For around a quarter of enterprises, further education and training in the field of digital competencies is an important topic. Most of the firms (around 84%) using the potential analysis consider digital trends to be an opportunity. More than half of the companies see digital presence as the most important opportunity at the moment. This is related to the fact that many enterprises see a primary opportunity in the digitalisation of customer relations and marketing. The potential analyses also show that small enterprises prefer small steps. The target of the digitalisation projects is generally a low-cost, but realistic target.

The numbers suggest that this initiative achieves its goal to be an effective instrument to reach interested small and medium-sized enterprises. Many micro-enterprises need some kind of "digital coaching" to accompany them through the challenges of digitalisation. KMU digital was developed with this in mind. The education of consultants is an important and defining element of KMU Digital. KMU Digital is essentially built around a new form of certified digitalisation consultant that is able to provide the essential information for small and micro-enterprises.[53] KMU Digital trained around 1,144 management consultants and certified about half (491) of them. According to our interview partners, this is important as management consultants need digitisation know-how, while classical IT consultants need management know-how to provide a good job for micro-enterprises.[54]

The federal innovation promotion agency FFG is providing grants to set up Digital National Innovation Hubs (financed by the Ministry for Digital and Economic Affairs) that will be located at research institutions. A call for expression of interest was launched in 2017 and the first call for proposals in 2018. The Digital Innovation Hubs have the goal to provide a first point of contact for SMEs. Therefore, the services will also be tailored to regional needs, and the focus will be on the topics of Artificial Intelligence, Security, Blockchain and 3D-Printing. A digital transfer centre with a similar agenda has already opened in Salzburg (Digitales Transferzentrum of FH Salzburg and Salzburg research) at the regional government's initiative and focusses on providing information and know-how especially for manufacturing SMEs. A new federal player beside FFG and the Austrian Chambers of Commerce is the Digitalisierungsagentur (DIA) currently established under the roof of FFG. The aim of DIA is to improve awareness for all fields of digitalisation and to foster co-ordination between the actors at the federal and regional levels. A focus of DIA will be the coordination of activities and information on the digitalisation of SMEs and small firms.

Box 4-4: Information and regulation in the case of the General Data Protection Regulation

The provision of information for SMEs was especially important for the implementation of the general data protection regulation. This also shows up in the data. Arthur D. Little (2018) documents that the fraction of firms that selected the General Data Protection Regulation as an important challenge jumped from 10% in 2017 to 54% in 2018.

Our interview partners were in general impressed by the information quality professional associations provided to their members regarding the needed changes due to the implementation of the GDPR. This was also confirmed by the interview partners. Their experiences show that the implementation of the general data protection regulation was of course a challenge for micro-enterprises and in Austria. But it also led to greater awareness of the possibilities and opportunities of digitalisation in one's own enterprise.

Some interview partners said that they have the impression that with the implementation of the regulation more companies started using electronic invoicing and automated bookkeeping. In the process of adapting to the GDPR they used consultants and came to the conclusion that new electronic tools offer advantages. A similar effect was observed during and after the

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[53] This certification scheme is organized by Incite, which is the academy of the Austrian Professional Association for Management Consultants and Information Technology (Fachverband UBIT) also part of the Austrian Economic Chambers.

[54] KMU Digital in its present form will end in March 2019. Most interview partners said that it will continue in some form, probably including also some financing instruments. Additional federal initiatives to provide information for SMEs are under way.

implementation of the cash register regulation in Austria, which required enterprises to use cash registers. This created much controversy among micro-enterprises, but led to the adoption of new digital solutions.

This clearly illustrates the power of regulations to raise awareness among small enterprises. However, regulations also come with substantial costs, as many regulations often create permanent administrative costs.

4.6.4. Financing gaps as barriers to digitalisation

In the Arthur D. Little (2018) survey financing gaps rank second in the list of important challenges, and in the results of the AWS-WKO KMU-MARKETMIND (Knoll 2018), where financing factors are mentioned by 31% of surveyed firms. However, it is important to note that the adoption of digital solutions is more akin to ordinary investment projects than to innovation projects. The high technological risk of innovation projects and appropriability problems associated with innovation are largely absent in the case of digitalisation. Here, the investment risk is primarily associated with the appropriate reorganisation of business processes and the choice of appropriate digital solutions. This consideration suggests that providing support to enterprises requires instruments that reduce possible financing gaps when projects are large compared to the size of the enterprise.

Regarding financing gaps it is important to recognize that financing constraints arise for firms that need finance. Most firms that do not seek external finance do not need any. In addition, it is well known that financing gaps define a situation that is not related to the cost of finance but to the availability of the desired amount of external financing that increases with the size of the desired volume compared to the size of the enterprise. The evidence in section 4.5.3 suggests that financing needs are strongly correlated with the overall investment intensity and higher for larger digitalisation projects (> 50,000 €).

The main agency for the promotion and financing of companies in Austria is the aws (Austria Wirtschaftsservice) that provides support in the form of grants, loans and guarantees to finance projects in Austrian enterprises, especially amongst SMEs. Aws has a broad set of programmes for the financing of start-ups, business expansion and technological innovation. Several instruments deal with the support of innovative projects. However, grants and loan guarantees are often provided for expansion projects, where investment needs are large compared to the size of the company. According to our interview partners a large share of investment projects today is associated with some form of digitalisation, as many modern production techniques and business management systems (ERP, CRM, etc) are part of business modernization that is usually implemented with new investment projects.

aws provides one dedicated programme – Industrie 4.0 – that focusses on the implementation of modern manufacturing technologies (Industrie 4.0) and provides support for the analysis and concept phase, investments in industry 4.0 related equipment and training, and qualification measures needed to implement the new technologies. It is very much focussed on Industry 4.0. themes and supports the change of business operations and business models in manufacturing. Thus, its goals are essentially directed at digitalisation in manufacturing covered in the present report in chapter 3. The programme AT:net provided by the FFG focusses on start-ups and SMEs, but also on larger firms and supports the market launch and establishment of digital applications and products. The monetary support through AT:net is between 10,000 and 200,000 euros depending on the projects. This project is in principle a diffusion project that has a strong focus on SMEs. It has been in place since 2007 and has supported around 500 ambitious digitalisation projects. Its future is at the moment not clear, as the responsibility of the programme moved to the bmdw, but the financing is still at the bmvit.

Most support of aws is provided in broad and very general programmes. These programmes do not have an explicit digitalisation focus. However, interview partners emphasized that most extensive investment projects contain elements of digital transformation. These programmes thus do not target the digital transformation in an explicit way but implicitly. Thus, aws supports diffusion, technology development and entrepreneurship related to digitalisation in various programmes through guarantees, equity or loans (e.g. erp Kredit, Aplus b scale up, double equity, loan guarantees, seed financing, Gründerfonds). For incubators and accelerators, the aws provides the "JumpStart" programme Austria Wirtschaftsservice GmbH (aws) that aims at strengthening the range of support available for young, innovative companies. The focus is on the support and further development of the service and competence portfolio of selectively selected incubators and accelerators to create better (soft) framework conditions for start-ups with high growth potential. More dedicated support schemes have been set up by the Austrian Bundesländer to support digitalisation projects in SMEs that set up own programmes to support digitalisation in SMEs (e.g Tirol[55], Carinthia[56], Salzburg[57]). These programmes were set up because the available dedicated digitalisation programmes at the federal level are focussed very much on manufacturing and very ambitious business transformations (aws Industrie 4.0, AT:net). These initiatives are quite new – most of them were only recently implemented by the respective Bundesländer.

Given the deficits of diffusion of digitalisation in Austria, dedicated programmes seem necessary. However, there is also a problem for dedicated projects to create a value added. In order to minimize deadweight effects – that is, supporting projects that would have also been implemented without any public support – such programmes need to be designed in quite a restrictive way, leading to considerable administrative overhead as well as a limited set of potential target firms. The fact that financial factors are primarily mentioned by firms that have large digitalisation and/or large investment projects suggests that the financing gaps and financing constraints related to the diffusion of digital transformation in the SME and micro-enterprise sector in Austria is not due to a specific "digitalisation funding gap" but related to general financing gaps and constraints to do with investment projects that are large compared to the size of the enterprise. The existing regulations for supporting large investment projects in the general programmes of aws focus on expansion projects. This could create a bias against digitalisation projects, as many digitalisation projects involve rationalisation, and even large digitalisation projects need not be associated with large firm expansion. Nevertheless, the implementation of large digitalisation projects is likely to be affected by financing gaps. Mitigating this kind of market failure would require closing financing gaps – not financing costs – for enterprises with ambitious digitalisation projects. The appropriate tools would be the provision of guarantees and loans at market costs to close these financing gaps and support for the training and re-training of employees. Most digitalisation projects require changes in operational routines and the skills and competencies of employees. Support for the training and re-training of employees exists in many programmes starting from KMU Digital to more ambitious programmes such as Industrie 4.0 and AT:net.

The results in section 4.3 in this chapter show that Austria displays overall low entry rates and low shares of high-growth firms compared to the comparison countries, except in the ICT manufacturing industries. Especially in the ICT service industries, both the entry rates and the share of high-growth firms are low compared to those of the comparison countries. Two issues are often mentioned to explain this economy-wide situation: regulations and a lack of external market-oriented financing. Austria is a well-functioning bank-based system with a low share of external equity financing (Hölzl – Böheim – Friesenbichler 2016). Especially for entrepreneurship and growing firms in sectors characterised by large shares of intangible capital, the availability of alternatives to bank credit is relevant. Venture capital and alternative capital sources like crowd funding are relevant for innovative digital start-ups. Bank finance is often no option for start-ups due to their risk-averse strategy and the stricter regulations related to collateral requirements

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[55] https://www.tirol.gv.at/arbeit-wirtschaft/wirtschaftsfoerderung/technologiefoerderungsprogramm/digitalisierungsfoerderung/tiroler-digitalisierungsfoerderung/

[56] https://www.kwfkath.at/foerderungen/kwf-ausschreibung-digitalisierungsoffensive/

[57] https://www.salzburg.gv.at/wirtschaft_/Seiten/digitalisierungsoffensive.aspx

associated with the improved banking regulation since the financial crisis. This can be overcome by public support schemes and by regulation to foster the provision of private risk capital. Over the past years improvements in the Austrian regulatory landscape have been made. Starting with the passing of a new act for alternative financing ("Alternativfinanzierungsgesetz-AltFG") that liberalised the conditions for crowd financing to the reform of the Aktiengesetz in November 2018, which made it once again possible to use unregistered shares in the OTC Segment of Wiener Börse. This change was necessary because new OTC listings (non-regulated market segment) of firms were practically impossible due to very restrictive legislation regarding dividend payments for registered shares (Hölzl – Böheim – Friesenbichler 2016). These changes will primarily affect ambitious and innovative firms. More traditional larger SMEs and micro-enterprises that need to make a digital transition will rely on bank financing as the main source of external finance. To change this, policy must address not only the supply of finance but also the demand for market-based finance by firms. This includes investment readiness programmes for firms interested in market finance, the reduction of control aversion of entrepreneurs vis-à-vis external market finance and a reduction of the regulatory cost of using market-finance (Hölzl et a. 2018).

4.6.5. Regulations as a barrier to digital entrepreneurship

The evidence of lower entry rates, lower turnover rates and lower HGF shares in section 4.3 suggests that regulation may affect the digitalisation of businesses by hampering competition and the entry of more digitalised firms. The economics literature is supportive of this perspective (e.g. Klapper et al. 2006). Crafts (2006) emphasizes that the most important impact of regulation may be on innovation and investment incentives. Regulations that affect or even determine enterprise size (e.g. through the regulation of permissible legal forms) change incentives to use modern ICT technologies. This provides arguments that a deregulation could foster the speed of adoption of digital technologies.[58]

Starting up a GmbH (limited company) is costly in Austria, especially for innovative firms (Kiendl et al. 2017; Ruhland – Kaufmann 2017). The additional costs compared to sole proprietors consist of mandatory notary costs, legal and court fees, costs for contract design and legal advice. Ruhland and Kaufmann (2017) estimate that setting up a GmbH with different entrepreneurs requires between five and six thousand euros. In addition, there is no possibility to create classes of shares for investors or employees for an Austrian limited company. The Austrian limited liability has been assessed as a particularly bureaucratic and inflexible legal form in European comparison (Industriellenvereinigung 2013). Setting up a firm also requires different permits and and entry in the company register. As regards permits, Austria is known to have a quite complex licensing system (Calogirou et al. 2010). After the entry in the commercial register, new companies are usually required to get one or several trade licenses ("Gewerbeberechtigung"). Here, problems arise for new business models. Figuring out how many and what kind of trade licence(s) are required can be difficult.

Some reforms have been introduced in the last years. However, most measures including the deregulation law in 2017 ("Deregulierungsgesetz") have not resulted in the facilitation of the start-up of innovative enterprises. Here, reforms to reduce the real costs of establishment would be

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[58] Böheim - Pichler (2016) and Köppl-Turyna – Lorenz (2016) argue that in Austria many sectors are characterized by overregulation and high administrative burdens. They call for thinning of the regulation density, starting from entry regulations in the trade regulations. Commercial activity in trades and crafts is governed in Austria by the Austrian Trade Regulation Act (Gewerbeordnung) that presents entrepreneurs with entry barriers, especially when they want to be active in activities in one of the so-called regulated trades (82 at present). These regulated trades a certificate of qualification (Befähigungsnachweis) and a managing director under trade law who possess such qualifications for the corresponding trade. Most of the traditional trade and craft are deeply connected with the dual education system. The free professions fall outside the Gewerbeordnung but have entry and conduct regulations that are even stricter (Böheim - Pichler 2016).

greater than the impact of selective derogations which make the system even more complex (Ruhland – Kaufmann 2017). The amendment of the Austrian trade regulation in Mai 2018 (Novelle der Gewerbeordnung 2018) provided small changes in trade licencing. A registered enterprise is now allowed to be active in another field of free (regulated) trade without a proper trade license as long as the return of these activities remains below 30% (15%) of the total annual turnover (public procurement contract value). The total amount of all ancillary services may not exceed 30% of a firm's total annual turnover. However, these amendments are associated with new uncertainties. During the financial year it is difficult for firms to fix order volumes with respect to a potentially achievable annual total turnover.

The link between entry regulation and digitalisation is indirect. A more direct link – and one running in the opposite direction – running from the impact of regulation to the adoption of ICT is provided by implementation of the GDPR, reviewed earlier. The GDPR had the effect of fostering digitalisation, because it forced firms to deal with digitalisation (see Box 4-4). This shows that regulation also has the possibility to provide incentives to deal with digitalisation for enterprises, which might have a higher impact than forcing firms to interact electronically with public offices.

A third aspect of regulation and norms that emerged in the interviews concerning the challenges of digitalisation for micro-enterprises, SMEs and also in the survey of large Austrian manufacturing enterprises (section 3.1) is the fact that enterprises assess the standardization of data interfaces to be an important challenge of digitalisation. While large firms can use very flexible solutions and costly workarounds, for smaller firms the heterogeneity of interfaces, especially at the boundary of the firm in the interaction with suppliers and customers increases costs (e.g. in the field of construction, if large construction firms require subcontracting firms to use different protocols). A harmonisation of interfaces could reduce costs and increase competition.

4.7. Summary and conclusions

This chapter provided evidence on the state of digital transformation in the Austrian micro-enterprise and SME sector, including an assessment of policy initiatives that support the diffusion of digital technologies and business models among Austrian SMEs and micro-enterprises. The main results of this chapter are summarized as follows:

- From a bird's eye view of micro-enterprises, SMEs and industrial dynamics it emerges that the Austrian business sector is characterized by lower industry dynamics (firm entry rate, firm turnover rate, HGF share) than are the comparison countries.
- This result holds for all sector groups identified by the OECD classification of digital-intensive industries and the ICT service sector. The only exception is ICT manufacturing, where Austrian performance is comparable to the performance of the Innovation Leader countries.
- According to the results, this is not related to a higher SME share or a higher micro-enterprise share in Austria.
- The analysis of the diffusion of digital business technologies in the Austrian SME sector confirms the mixed performance for the general economy (section 2 of the present report). Great heterogeneity of the adoption of different technologies is observed.
- Austria is among the top adopters in terms of ERP and CRM solutions and RFID technology use. These technologies are internal to firms (except CRM).
- Austria is behind comparison countries in social media, e-invoicing, cloud computing and systems that automatically link to customers/suppliers. These technologies extend beyond the boundaries of the enterprise.
- General insights from a quantitative analysis show that the adoption is lower in sectors with a higher SME share. Sectors with higher use of social media and cloud computing generally have higher industry dynamics. Sectors with a higher entry rate have a higher adoption of the different technologies.

Regarding the digitalisation of micro-enterprises, the following picture emerges:

- Most Austrian micro-enterprises are aware of the megatrend of digitalisation. More than 50% of micro-enterprises carry out digitalisation projects. The implementation of digitalisation often goes hand in hand with larger investment projects in the enterprises.
- Micro-enterprises implement digitalisation projects that focus on networking internal to the firm but also digital customer interaction. Only a minority of firms implements new projects to develop new business models or to digitalise functions for partners in the value chain.
- The most important challenges regarding digitalisation projects, according to micro-enterprises, are internal to the firm and related to technical and organisational known-how. Regulation and financial factors are also assessed as important factors. From this it emerges that the most important policy priorities for SMEs and micro-enterprises are the provision of information and consulting services for the implementation of digital transformation projects, better legal framework conditions, financial support and, finally, a good internet infrastructure. Regarding these results, it needs to be taken into account that the implementation of the GDPR in 2018 increased the sensitivity of enterprises to regulatory and legal framework conditions.

The Austrian policy environment for digitalisation in SMEs and micro-enterprises is quite well-developed. The new Digitalagentur (DIA) also has one of its focusses on the coordination of digitalisation support for SMEs. Gaps exist especially in the regulatory framework to support industry dynamics. The findings concerning the most salient issues are:

(1) Awareness and information about digitalisation

- The most important programme at the federal level is KMU Digital. The programme provides information and supports consulting services as well as courses and training to foster digital competencies in enterprises. The programme provides information for firms interested in digitalisation and provides measures to reduce substantive uncertainty (what can we do) and (c) procedural uncertainty that are associated with digitalisation programmes at the enterprise level.
- KMU Digital also supports the training of consultants that are able to provide appropriate consulting services for small and very small enterprises.
- Other support schemes are planned. Digital Innovation Hubs should act as entry points for SMEs interested in digitalisation.

(2) Funding:

- The Austrian enterprise support schemes that foster innovation and investment are also open for digitalisation projects, provided they are large. At the federal level, the aws provides a large set of investment support schemes. Two programmes exist that support ambitious digitalisation projects (AT:net and Industrie 4.0). For smaller digitalisation projects the Bundesländer set up support programmes that aim at also supporting smaller digitalisation projects.
- The focus of programmes to support digitalisation often lies on grants. This is appropriate for the support of qualification and training but less for the support of investment projects. Here, the instruments should be oriented at closing the funding gap.
- Gaps exist in the market-based financing of firms. The private risk capital market and the capital markets in general are not well developed. This may hamper the start-up of ambitious ICT firms and new business models that are dependent on

external equity capital. Further support for the establishment of market-based financial ecosystems is warranted to increase industry dynamics.

(3) Regulation:

- Data protection legislation led to a push in digitalisation in SMEs and micro-enterprises. However, this is likely a one-time effect, which nevertheless shows that regulation can induce digitalisation processes.
- Sector-specific entry and conduct regulations are likely to be one of the causes of the low industry dynamics in Austria. Further pushes in welfare-improving and growth-enhancing deregulation should foster industry dynamics and the diffusion of digital technologies. The barriers are highest in regulated trades and free professions. However, the welfare effects of deregulation need to be assessed on a profession-by-profession basis.
- Starting up a more complex limited liability company is burdensome in Austria, especially if it interacts with entry regulations. While further steps to make the set-up of the limited liability less complex will not necessarily increase the entry rate, it will allow entrepreneurs to do that what they should be doing: business.

(4) Infrastructure:

- SMEs and micro-enterprises need fast internet connections for their digitalisation projects. This requires stepping up investment in the broadband network infrastructure.

Table 4-13: Policy transferability table

Observed problem	Drivers	Solution taken in Austria / [proposed solution]	Lessons learnt
Adoption rates of digital technologies by small and micro enterprises low.	Lack of information about digital solutions targeted to microenterprises	KMU-Digital for enterprises in WKO provides comprehensive information about digitalisation. [Digital Innovation Hubs, Measures by the Digitalisation agency]	SMEs and micro-enterprises need information and consulting services targeted to their specific situation.
Financing is reported as important by micro-enterprises and enterprises with larger investment projects	Financing gaps (market failure) and uncertainty	Some Bundesländer have put into place dedicated support schemes; firms with large expansion investment projects are eligible for support (AWS)	The teaching of digital skills requires digital equipment.
Low industry dynamics in general and in ICT services.	Barriers to entry in regulated trades and free professions. High cost and duration to set up a limited company.	Trade regulation law 2017; Deregulierungsgesetz 2017; some reforms in free professions. [further deregulation of entry and conduct regulation in digital-intensive industries]	Obsolete and inefficient regulations may reduce entry and hinder the emergence of new innovative digital business models.
Low level of private risk capital	Regulation and control aversion of enterprises	Liberalisation of Crowd funding; public support for risk capital [measures to support the creation of a private risk capital market]	Digitalisation with a focus on intangible capital requires market-based finance.

5. IMPACTS OF DIGITALISATION ON THE WORKFORCE

5.1. Introduction

The impact of the implementation of digital technologies in firms on the labour force and labour processes is controversially discussed with respect to risks and opportunities (e.g. Frey-Osborne 2013, 2017; Arntz – Gregory – Zierahn 2016). Digitalisation is expected to increase automatization, to change the skill requirements in the work force and to change job profiles. This is likely to not only affect labour demand but also labour market institutions and social security systems. In this chapter we take a closer look at Austria. It covers a wide range of education-specific issues, from the main activities to the phenomenon of platform work.

5.1.1. Organisation of the chapter

In section 5.2 we first discuss the changing skill requirements stated by employers, based on Eurostat-data and the WIFO business survey. Here, we also take a closer look at the need for general ICT skills and possible skill shortages. There is a difference between basic ICT skills and specialist ICT skills. According to expert interviews, the Austrian labour market seems to require not only ICT specialists, but also workers with a (specific ICT-related vocational) education.

Section 5.3 addresses the role of initial formal education and points to the importance of basic skills for school results and school success as well as later labour market integration. We discuss the role of basic skills and show that a lack of these increases the risk of unemployment and reduces employability. We do this based on published, standards-based proficiency test results. We also look at the digital infrastructure in the different types of schools in Austria because such infrastructure is necessary for teaching digital skills in schools.

Section 5.4 addresses the impact of digitalisation on the Austrian labour market. It looks at the changes in the Austrian labour market from a task-based perspective using Eurostat-data that are enriched with information on job tasks. We first depict the changing task structure over the last 20 years and provide forecasts. The results show that professions characterized by high-skilled and diverse tasks will grow in importance. The analytical part studies the relationship between level and growth rates of task profiles with digital technology adoption indicators at a sector level. It addresses whether changes in the sector-specific task composition are associated with ICT, along with the relationship between economic outcome variables and the task structures of occupations, by using ICT taxonomies, DESI indicators and ICT investment data.

Section 5.5 considers the Austrian framework for social security in the context of platform work. We explain the phenomenon and discuss regulatory issues and the regulatory status quo. The Austrian system is compared to other selected member states. Finally, section 5.6 summarizes the findings and provides a discussion of policy implications and transferability to Member States.

5.1.2. Methods used in the chapter

This chapter draws on a variety of methods to study the impact of digitalisation on the workforce. For comparative analyses we used data from Eurostat and the OECD. The sections on education, platform work and the policy assessments were mainly based on desk research and information from published and unpublished sources. Interviews with experts provided very fruitful insights, especially for the analysis of ICT experts in Austria. This allowed to validate and interpret the quantitative information. The analysis on the task profiles used labour force data that was enriched with information on job tasks and used econometric methods to link the task structure to digitalisation indicators.

5.2. ICT skills

5.2.1. Introduction

The availability of an appropriately skilled workforce is considered to be a crucial factor of the competitiveness of countries and enterprises. The focus is often on high skills, which are essential for innovation-based growth. At the same time technical change affects the appropriateness of the right skill mix, so that an asymmetrical pace of development in skill demand and supply may result in skill mismatches or shortages. Consequently, in this section the demand for ICT skills by enterprises and the possibility of ICT skill shortages in Austria with regard to both ICT specialists and broad digital skills in the workforce are discussed.

The first subsection provides a broader background on the discussion on labour shortages in Austria that is relevant to assess shortages of ICT skills. The next section focuses on ICT specialists. We bring together data on skill shortages, the development of the employment of ICT specialists and changes in their job task profiles as well as qualitative information to provide a picture on the labour market for ICT specialists in Austria. The findings indicate a shortage of persons with ICT skills in Austria that coincides with a strong demand for ICT specialists from the private sector. The patterns of change over time show that employed ICT specialists are increasingly highly skilled.

5.2.2. Labour shortages in Austria

Over the last two years Austria has experienced an economic expansion that has been accompanied by growing employment. As the same time, demographic factors are beginning to bite, there emerges the impression that labour shortages are a binding problem. According to population statistics[59], the number of young persons aged 15-19 in Austria has been falling in the years since 2010 (with the exception of 2016 due to flight-migration). This age group determines the skill mix of entry cohorts into the market with their education decisions (full-time general or vocational education or part-time apprenticeship training, transition to tertiary education). In addition, the number of people in prime age has also dropped in the recent past (40-44 since 2008, 45-49 since 2014).

Figure 5-1 shows that labour as a factor limiting production is pro-cyclical, but it also shows that experienced (skilled) labour shortages are higher in this ongoing phase of expansion than in past episodes. Also, in neighbouring countries firms are experiencing similar labour shortages that are often related to specific jobs descriptions and skills. The Manpower Group categorizes Austria as a country with above-average difficulty in hiring (Manpower 2018a). In all sectors of the Austrian economy, especially in medium-sized companies, skill shortages are reported: in production and engineering, marketing/sales/customer service, as well as in the craft and technical field, and in tourism (Hölzl et al. 2018; Manpower 2018b; Ernest and Young 2018; Dornmayr and Winkler 2018). Particularly, skilled trades (electricians, welder, mechanics), sales representatives and drivers are required, while IT experts (e.g. cybersecurity experts, network administrators, technical support) do not rank among the top 10 skills in demand in Austria (compared to rank 6 worldwide) (Manpower Group 2018b).

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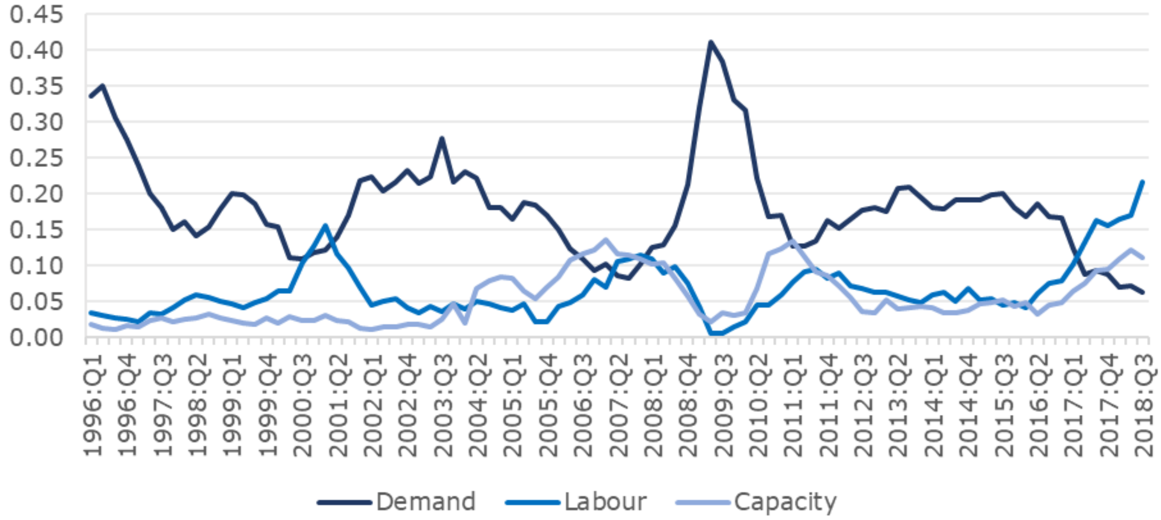
59 http://www.statistik.at/web_de/statistiken/menschen_und_gesellschaft/bevoelkerung/bevoelkerungsstruktur/bevoelkerung_nach_alter_geschlecht/index.html.

Figure 5-1: Factors limiting production in Austrian manufacturing: 1996 - 2018



Source: WIFO business surveys, seasonally adjusted. Note: Enterprises are allowed to select whether they experience hampering factors to production, and if so, they can select the primary hampering factor: (a) demand, (b) labour, (c) materials/capacity, (d) finance, (e) other.

Considering this evidence, the question arises whether this reported labour shortage is related to the ongoing digital transformation, or whether it is primarily related to cyclical factors or past failures to anticipate changes in demographics, changes in individual educational behaviour (full-time vocational education at the expense of apprenticeship training) and changing skill needs in the education, both in the general and the vocational education and training system (including apprenticeship training). However, digital transformation does not exclusively lead to an increased demand of ICT specialists; ICT skills are required in many professions and complement other skills. Bock-Schappelwein – Famira-Mühlberger – Leoni (2017) argue that workers – both in manufacturing as well in the service sectors – often need a combination of professional skills and IT skills. In the remainder of this section these issues are disentangled by looking at ICT specialists and assessing the importance of ICT skills as basic skills.

*Box 5-1**:** VET schools and colleges (secondary technical and vocational schools and colleges for higher vocational education) and the apprenticeship system in Austria*

Secondary technical and vocational schools and colleges for higher vocational education comprise general education and technical theory in the respective fields as well as practical training (compulsory work placements varying from school to school). Secondary technical and vocational schools (BMS)[60] provide for vocational qualifications and general education (1 to 4-year courses) and end with a final exam. Those BMS, that last one or two years, provide a partial vocational

[60] Main types of BMS: Secondary Technical, Commercial and Crafts School, Secondary Business School, Vocational School for Economic Professions, Vocational School for Fashion, Vocational School for the Hotel and Restaurant Industry, Vocational School for Tourism, Vocational School for Social Professions, Federal Sports Academy, Vocational School for Social Care Professions, Vocational School for Healthcare and Nursing, Vocational School for Agriculture and Forestry, Vocational School for Social Services, Vocational School for Economic Professions (see https://www.bildungssystem.at/en/school-upper-secondary/school-for-intermediate-vocational-education/).

training. Those with a training period of three or four years end with a final examination[61] and provide for complete vocational training.[62]

Secondary technical and vocational colleges (BHS)63 provide a higher level of vocational training in five years and end with a double qualification: the "Reifeprüfung"-Certificate (i.e. university entrance qualification) and TVE (technical and vocational education and training) – Diploma (Diplomprüfung), which does not only provide access to university education but also qualifies graduates for jobs on the executive level.[64]

The apprenticeship training offers young people vocational training in one of around 200 recognized apprenticeship trades (included in the list of apprenticeship trades) and lasts for 2 to 4 years. The apprenticeship training combines – as a "dual vocational training system" – company-based training and compulsory part-time vocational education (Berufsschule) (about 20% of the training period). The apprenticeship training ends with an apprenticeship leave exam.[65]

According to the Ministry of Education 40% of Austrian teenagers decide in favour of an apprenticeship training, 23% opt for further education at a technical and vocational college (BHS), 14% attend a secondary technical and vocational school (BMS) and 20% attend an upper level of a secondary academic school (AHS).[66]

5.2.3. ICT specialists

Although ICT specialists might not be the primary source of labour shortage issues in Austria, our interview partners and industry experts report on industrial firms facing difficulties in recruiting ICT specialists. This evidence is confirmed by the information on enterprises trying to recruit personnel with ICT specialist skills in the Eurostat ICT usage of enterprises survey. Table 5-1 shows these statistics for Austria and the comparison countries. The data is collected in terms of the number of firms employing ICT specialists or recruiting/trying to recruit ICT specialists. Thus, the average number (all firms) is essentially driven by the small firm population, and therefore also the percentages for the large firm population, which is more likely to employ ICT specialists. Austria displays a higher share of firms employing ICT specialists than most comparison countries in 2017, particularly for large firms only, where Austria ranks first (87%), closely followed by Finland but well above other Innovation Leader countries such as Sweden.

[61] Young people completing this type of education will be subject to the relevant entitlements laid down in the Trade and Industry Code (see https://www.bildungssystem.at/en/school-upper-secondary/school-for-intermediate-vocational-education/).

[62] https://www.bildungssystem.at/en/school-upper-secondary/school-for-intermediate-vocational-education/

[63] Main types of BHS: Higher Federal Technical College, Secondary College of Business Administration, Secondary School for Fashion, Secondary School for Artistic Design, Secondary School for Tourism, Secondary School for Economic Professions, College for Agriculture and Forestry, College for Early Childhood Pedagogy, College for Social Pedagogy (see https://www.bildungssystem.at/en/school-upper-secondary/college-for-higher-vocational-education/).

[64] The Diploma examination provides access to legally regulated professions in accordance with the Trade and Industry Code (see https://www.bildungssystem.at/en/school-upper-secondary/college-for-higher-vocational-education/)

[65] https://www.bildungssystem.at/en/school-upper-secondary/part-time-vocational-school-and-apprenticeship/

[66] https://bildung.bmbwf.gv.at/enfr/school/secon/secon.html

Table 5-1:Firms hiring ICT specialists, 2017

	Percent of firms that employ ICT specialist	Percent of firms that recruited/tried to recruit ICT specialists all firms	Percent of firms that had hard-to-fill vacancies	Percent of firms that tried to recruit and had hard-to-fill vacancies
all firms				
Austria	23.0%	10.0%	6.0%	67.0%
Innovation Leaders	24.0%	11.0%	6.0%	58.0%
EU28	19.0%	8.0%	4.0%	48.0%
Denmark	24.0%	12.0%	7.0%	61.0%
Finland	26.0%	10.0%	6.0%	59.0%
Germany	19.0%	8.0%	5.0%	58.0%
Netherlands	27.0%	13.0%	8.0%	61.0%
Sweden	20.0%	10.0%	5.0%	55.0%
large firms				
Austria	87.0%	49.0%	35.0%	72.0%
Innovation Leaders	78.0%	47.0%	27.0%	57.0%
EU28	75.0%	42.0%	22.0%	53.0%
Denmark	84.0%	55.0%	34.0%	61.0%
Finland	86.0%	43.0%	25.0%	57.0%
Germany	77.0%	45.0%	28.0%	62.0%
Netherlands	79.0%	48.0%	30.0%	61.0%
Sweden	73.0%	46.0%	26.0%	57.0%

Source: Eurostat.

In 2017 the statistics suggest that around 10% of all Austrian firms recruited or tried to recruit ICT specialists. Of these firms 67% had hard-to-fill vacancies for ICT specialists, the respective share of large firms is even higher (72%). This suggests that labour shortages in the ICT specialists segment seem to be higher than in countries of comparison. This is broadly consistent with the information from the expert interviews, where experts and chief information officers told us that in the ICT specialist segment the labour market does not work with job applications anymore, but rather through headhunting, and that many firms are trying to acquire talents very early (sometimes already a year before final exams and by providing internships). In addition, the shortage occupation list 2018 provided by the Austrian federal government[67] lists technicians with a higher level of training and graduate engineers for data processing as eligible for the Red-White-Red Card that organizes criteria-based immigration from third countries to Austria.[68]

Table 5-2 reports the number of ICT specialists in percent of total employment for the years 2015 to 2017. The growth of the share of ICT specialists was considerable, from 2015 to 2017 the share

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67 Available at https://www.migration.gv.at/en/types-of-immigration/permanent-immigration/skilled-workers-in-shortage-occupations/shortage-occupations-list-2018/.

68 The Red-White-Red card is issued for a period of 24 months and entitles holders to a fixed-term settlement and employment by the employer specified in the application. Eligible for a Red-White-Red card are very highly qualified works, skilled workers in shortage occupations, other key workers, graduates of Austrian Universities and colleges of Higher Education, self-employed workers and start-up founders. Additional requirements are adequate means of subsistence, health insurance coverage, adequate accommodation (e.g. lease) and that the person is no threat to public order or security. (https://www.migration.gv.at/en/types-of-immigration/permanent-immigration/)

of ICT specialists increased by 0.4 percentage points; only Sweden and Denmark had higher growth rates. The highest levels are observed for Finland and Sweden.

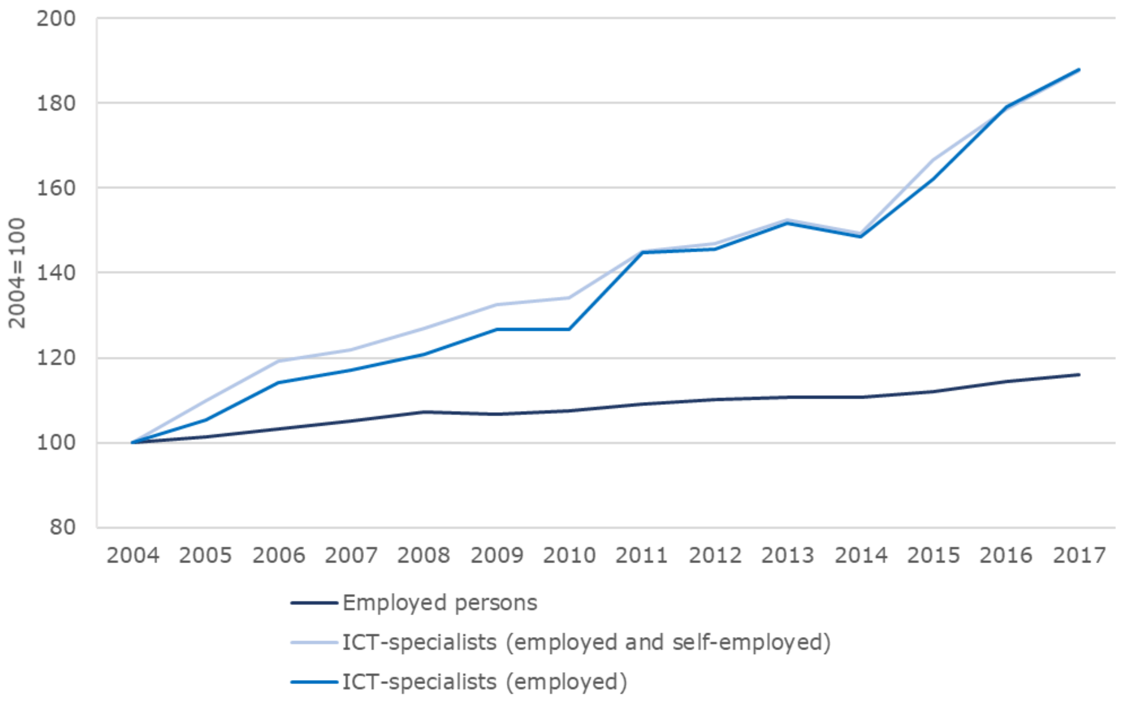
Table 5-2: ICT specialists in percent of total workforce, 2015 to 2017

	2015	2016	2017
Austria	4.0%	4.2%	4.4%
Innovation Leaders	5.2%	5.2%	5.5%
EU28	3.5%	3.7%	3.7%
Denmark	3.9%	4.2%	4.4%
Finland	6.5%	6.6%	6.8%
Germany	3.7%	3.7%	3.8%
Netherlands	5.0%	5.0%	5.0%
Sweden	6.1%	6.3%	6.6%

Source: Eurostat.

Figure 5-2 plots the employment growth of total employed persons and ICT-specialists in Austria between 2004 to 2017, where self-employed ICT specialists are also considered. The graph shows clearly that the growth rate of the number of ICT specialists is above the growth rate of total employment in that period in Austria. The pattern of growth also shows that the crisis in 2009 and the weak performance of the Austrian economy in the period thereafter was associated with a moderate growth of ICT specialists in total employment compared to the time since 2014, where the number of ICT specialists in Austria increased by 26.6% from 128,829 (2014) to 163,096 (2017). From this figure it can also be deduced that in recent years the demand for employees in the form of self-employed ICT-specialists has been equally high. The share of self-employed ICT-specialists is about 13%.

Figure 5-2: Employment growth of ICT specialists and total workforce in Austria, 2004 to 2017



Source: WIFO, based on data from Statistics Austria.

Box 5-2: Job task description (see also chapter 5.4)

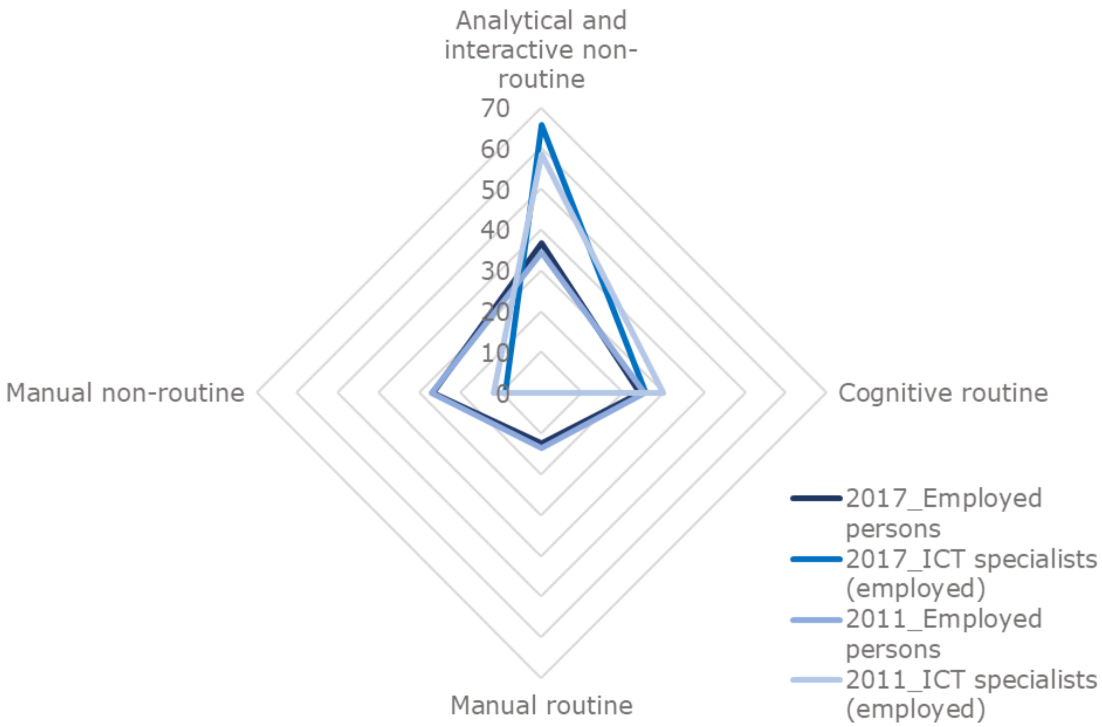
Following Spitz-Oener (2006), we define five main areas of job tasks: analytical non-routine, interactive non-routine, cognitive routine, manual routine, manual non-routine.

According to Spitz-Oener (2006, p. 243), **analytical non-routine tasks** include “researching, analyzing, evaluating and planning, making plans/constructions, designing, sketching, working out rules/prescriptions, and using and interpreting rules”; according to Dengler -Matthes - Paulus (2014) terms such as leadership or design describe this area of activity. **Interactive non-routine tasks** are more related to communication-specific factors such as negotiating, teaching, managing or presenting, and are often needed in the areas of commerce, counselling, mentoring, training, marketing or advertising. According to Spitz-Oener (2006, p. 243), “negotiating, lobbying, coordinating, organizing, teaching or training, selling, buying, advising customers, advertising, entertaining or presenting, and employing or managing personnel” are one of them. **Manual non-routine tasks** are characterized by artisan work that does not follow standardized patterns such as repairing, restoring, renovating or even activities in the tourism or care sector, Spitz-Oener (2006, p. 243) mentions “repairing or renovating houses/apartments/machines/vehicles, restoring art/monuments, and serving and accommodating”. **Cognitive routine tasks** cover equally a wide range of job contents, Spitz-Oener (2006) lists “calculating, bookkeeping, correcting texts/data, and measuring length/weight/temperature”. Dengler – Matthes – Paulus (2014) list metrology, administration, network technology, surveying, monitoring, diagnostics, etc. **Manual routine tasks** are much more narrowly defined and are mainly aimed at machine operators, Spitz-Oener (2006, p. 243) mentions “operating or controlling machines and equipping machines”.

Highly interesting is the decomposition into task groups of total employment and employed ICT specialists between 2011 and 2017[69] into analytical and interactive non-routine, cognitive routine, manual routine and manual non-routine task groups, which will be analysed in section 5.4 of the present study in more detail. Figure 5-3 shows the decomposition of total employment. Only comparatively small changes are observed over time. The share of jobs that consist mostly of analytical and interactive non-routine tasks increases by 2.4 percentage points while the share of jobs consisting mainly of cognitive routine tasks decreases by 1.0 percentage points, the share of jobs mainly characterized by manual routine jobs decreases by 1.4 percentage points and the share of jobs mainly characterized by manual non-routine jobs remains almost constant (minus 0.1 percentage points). In contrast to this, the task group composition of ICT specialists changes more dramatically: the already very high share of high-skilled jobs characterized primarily by analytical and interactive non-routine tasks increases further by 7.4 percentage points. In 2017 65.8% of all ICT specialist jobs are classified in this task group. The share of jobs with mainly cognitive routine tasks decreases by 4.4 percentage points and the small share of jobs characterized mainly by manual non-routine tasks by 3.0 percentage points. As expected, none of the ICT specialist jobs is primarily characterized by manual routine tasks. Many ICT specialist jobs are focused on developing and supporting the automatization of routine tasks, which can be automatized by machines in production, administrative and service activities. Given the strong growth in absolute numbers – between 2011 and 2017 the number of employed ICT specialists in Austria rose by 37,631 persons –the declining segments amongst ICT specialists also saw absolute increases in numbers (4,062 for the cognitive routine task group). Most of the increase was accounted for by the analytical and interactive non-routine task group (+34,003). The share of ICT specialists in total employment increased by 0.8 percentage points in the period 2011-2017 (2011: 3.6%, 2017: 4.4%). The employment growth of ICT specialists is thus also relevant from an aggregate perspective and an important element of the structural change of task profiles that characterizes the modern knowledge economy.

[69] Since 2011 ISCO-08, before that ISCO 88.

Figure 5-3: Changes in task profiles: total employment and employed ICT specialists between 2011 and 2017



Source: WIFO, based on data from Statistics Austria.

This rise in employment and the evidence on shortages of ICT specialists (and ICT-skills as complementary to professional skills) shows that the supply of ICT specialists is an important element to support the ongoing process of digitalisation. However, based on the expert interviews it is unclear for which kind of ICT specialist the shortage constraints are most binding. According to our interview partners, the shortages are observed at every level, from apprentice applications for ICT jobs to very specific software developers. A consequence of the labour shortage is that firms are doing marketing not to sell products, but to be attractive for employees. However, the interviews indicate that the technical attractiveness of a job is a relevant criterium to fill a vacancy. Interview partners also emphasized that the school system should provide more network skills that allow to connect different fields of knowledge. The overall impression is that the education of ICT specialists in higher technical institutes (technical colleges), applied universities and universities is very good in Austria. Many firms already start early in securing the talents through internships and supporting education through part-time and holiday jobs. Moreover, interview partners emphasized severe impediments to criteria-based immigration (Red-White-Red-Card) when it comes to the hiring of ICT specialists from third countries. Especially the duration of the process and the de facto requirement of an Austrian residence is an obstacle in the global competition for talent. Particularly in the fast-moving ICT labour market, administrative delays result in specialists taking alternative offers in countries with lower bureaucratic burdens.

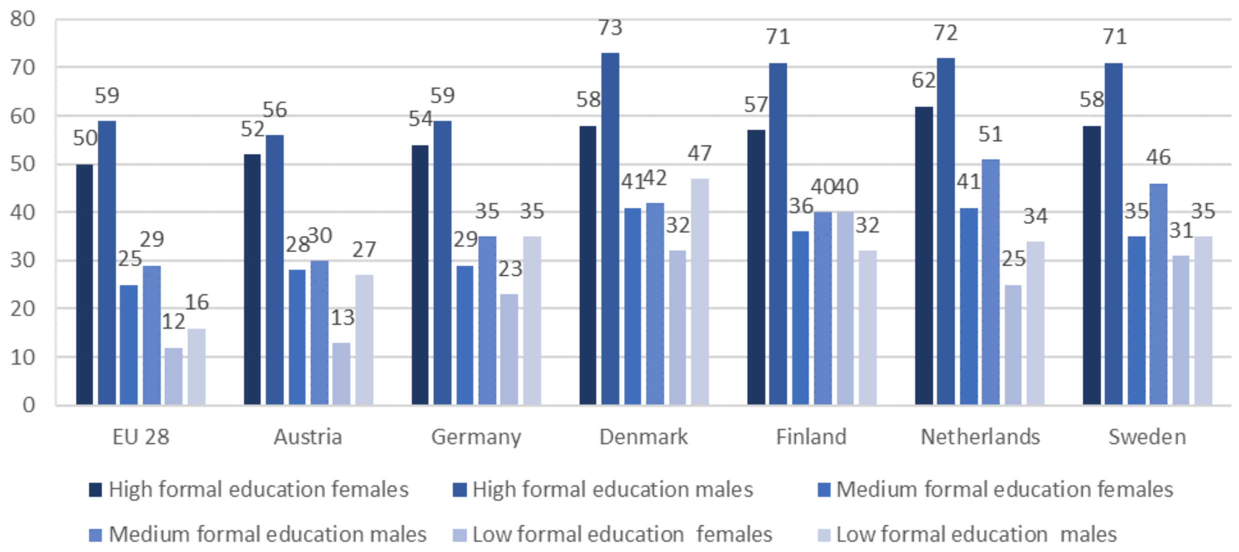
According to the interview partners, software developers and network security experts are most desperately sought after. However, the demand for ICT specialists, especially for software developers, is heterogeneous, which is reflected in very specific vacancies (programming language, development frameworks). The interview partners also emphasized that the ongoing wave of digitalisation – at least in many industrial applications – requires combining different technologies, which were separate in the past. Due to the focus on networking, a good industrial software developer today needs to be able to master application programming, network security and integration into predefined frameworks (for example provided by company-wide ERP solutions). However, there is also a demand for very specialized software developers, which often also work freelance. This directly links to the issues related to the gig economy and crowd work. Some of our interview partners also emphasized that the digitalisation not only requires digital skills from ICT specialists that create and administer the machinery associated with networked production, networked service provision and the internet, but also basic digital competencies in the workforce.

5.2.4. Digital skills in the population

Indeed, digitalisation affects the required basic skill mix, i.e. skills to use computers in very different ways and not limited to advanced programming skills. The results for the OECD Survey of Adult Skills (PIAAC) suggests that the Austrian adult population has a lower proficiency in digital problem-solving than its peer countries.[70] Comparing the shares of population with problem-solving skills in technology-rich environments between EU member states indicates that Austria is lagging behind most Innovation Leader countries in all cohort groups.[71]

Closer inspection of the data on above basic digital skills reveals that compared to other countries the educational attainment is a driving factor in Austria (Figure 5-4). Austrians with low formal education have quite a distant relationship to digital technologies. Moreover, the difference between males and females is larger than in most comparison countries, particularly Finland or Sweden.

Figure 5-4: Above-basic digital skills, 2017



Source: Eurostat. Note: Above-average skills are defined as the ability to create documents which integrate text, pictures, tables and charts; to use advanced spreadsheet functions to organise and analyse data; to write code in a programming language; to transfer files between computers or other devices; to change the settings of operational systems and security programmes; and to upload self-created content to websites.

This finding is insofar interesting as it contrasts with the finding in the Cedefop skills and jobs survey 2014, where Austria shows one of the highest levels of jobs that require some form of ICT skills (CEDEFOP 2018). This was also confirmed by our interview partners who emphasized that basic or medium ICT skills are needed in many jobs (see also Bock-Schappelwein – Famira-Mühlberger – Leoni 2017). While most of the jobs do not need ICT specialist skills, almost all jobs need interaction with computers and basic, above-average digital skills or a combination of

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70 The OECD Survey of Adult Skills defines digital problem-solving skills as the capacity to solve problems using a computer. These skills include writing an e-mail and browsing the web (level 1), implementing more advanced tasks involving multiple steps (level 2), and the capacity to use both generic and specific software applications with inferential reasoning (level 3).

professional skills and IT skills. It was emphasized that job tasks change due to digitalisation. These jobs cannot be filled by ICT specialists but require a combination of ICT skills and other job-specific competencies (e.g. craft and technical jobs, CR). The training of employees can relax some of these skill shortages (combined with measures that help finance education, training and re-training), but it also requires forward planning in the formal education systems: young people need digital (basic) skills and basic skills in literacy and numeracy as a basis for upper secondary education after completing compulsory education. The Institute for Youth Cultural Research (*Institut für Jugendkulturforschung*) examined the digital skills of young people (15-19 years) in Vienna in 2016. The study shows clear differences between young people with lower formal education and those with higher formal education, especially when using the internet for work or school. Young people with higher education more often than those with lower formal education use the internet at home for home exercises and research, test preparation or as a learning platform.[72]

5.2.5. Summary

According to Eurostat data, there is a significant increase in the number of ICT specialists in Austria, especially those with higher qualifications. Quantitative evidence and the findings from the expert interviews also suggest that Austrian firms have difficulties in recruiting ICT specialists. But there is no clear indication for which kind of ICT specialists the shortage constraints are binding; the shortage can be seen at every level, from apprenticeship applications for ICT jobs to very specific software developers or network security experts. Apart from ICT specialist skills, basic digital skills are required in many jobs. However, low-skilled Austrians, particularly women and young people respectively, have a quite distant relationship to digital technologies.

5.3. Education

5.3.1. Introduction

In work processes or workplaces, the use of digital technologies has far-reaching implications for employment, working conditions and skill requirements. Workers are expected to have a mix of formal qualifications, competencies and skills that notably distinguish them from robots or programmed algorithms. Enough basic skills in literacy and numeracy are indispensable in this environment. These are taught in the initial training system and form the basis for any further (formal) education and training. Unfortunately, not all pupils in Austria have acquired these basic skills by the end of compulsory education. The next section discusses the role of basic skills in an economic environment characterized by digitalisation and focus on the available ICT infrastructure in Austrian schools as a tool with which to impart IT skills to the younger population.

5.3.2. Digitalisation and education

The use of digital technologies requires individual skills, such as understanding, interpreting and communicating information, solving unstructured problems or performing non-routine activities, which distinguish human labour from robots or programmed algorithms. Formal qualifications, specific and general skills, work experience and network thinking (Buhr – Trämer 2016) combined with digital skills, social skills, communications skills, creativity and empathy etc. are essential for performing non-standardised tasks (Bock-Schappelwein 2016). Contrary, standardised tasks, including growingly complex ones such as pattern recognition (Tichy 2016), are being increasingly automated or digitalised (given low costs, infrastructure, economic situation etc.). Such standardised tasks are most frequently carried out by low-skilled workers. In 2015, around one third of low-qualified workers in Austria were employed in occupations characterized by manual routine tasks, while this only applies to one-seventh of apprenticeship graduates (14.2%). Hardly

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72 https://media.arbeiterkammer.at/wien/PDF/studien/bildung/Digitale_Kompetenzen_ Kurzbericht.pdf

any highly-qualified worker (less than 5%) practices a profession characterized by manual routine tasks (Bock-Schappelwein 2016, p. 120).

Low-skilled workers are also affected by a high risk of unemployment and employment loss: in 2017 the unemployment rate of low-skilled persons (who completed compulsory education at most) is almost three times higher (25.3%) than the overall economic average (8.5%), with high distance to the highly qualified (3.4%).[73] The share of workers with at most compulsory education in total employment has halved since the mid-1990s (1995: 24.4%, 2017: 12.2%). At the same time, the share of workers with a tertiary education doubled (1995: 8.6%, 2017: 18.9%); the proportion of medium-skilled workers remained relatively stable at around 70% (Bock-Schappelwein – Huemer 2017).

Horvath – Mahringer (2014) show that persons with only low or fragmented numeracy or literacy skills are more often unemployed or less frequently employed than persons with comprehensive skills. Only three-quarters of all persons (of working age between 16 and 65 years) with very low literacy and numeracy skills are employed, while this applies to almost all persons with highest literacy and numeracy skills. Lentner – Bacher (2014) calculated that around 11% of young adults living in Austria between the ages of 16 and 29, i.e. around 150,000 people, are affected by a lack of skills in reading and numeracy. They are significantly more likely to work in low-skilled and low-paid jobs and are more likely NEETs. The data on employment and unemployment by educational attainment level underline the role of formal education in employability. The acquisition of basic skills – as should be imparted by the initial education system – is indispensable as a basis or first step for educational pathways after completing compulsory education and enables people to acquire occupation-specific and/or general skills (Breit – Bruneforth – Schreiner 2016).

5.3.3. Austrian standards-based proficiency test results

But not all young people in Austria can achieve the learning goals in literacy and numeracy in compulsory school. They are affected by fragmented skills, as the Austrian standards-based proficiency test in German, Mathematics and English for the 4th (at the end of primary school) and 8th (at the end of a general or academic-track secondary school) grade[74], implemented in 2012 in the Austrian education system, shows.[75]

Pupils tend to have fewer difficulties achieving the learning outcomes in mathematics, whereas in German (reading) they are comparatively more difficult to achieve. This finding is also valid for boys in the 8th grade, although there are significant performance differences between general and academic-track secondary schools. Top-performing pupils more often attend an academic-track secondary school after primary school (Breit – Bruneforth – Schreiner 2017). The learning outcomes are significantly better in the academic-track secondary schools than in the general secondary schools.

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[73] The national calculation method based on PES-data and social security employment data is used.

[74] Examinations have been made at the 4th grade in Mathematics in 2013 and in 2015 in German (reading and writing), and at the 8th grade, the educational standards were tested in 2012 in Mathematics and 2013 in English; in 2016, educational standards were recorded in German and 2017 in Mathematics.

[75] Conducted by BIFIE (Bundesinstitut für Bildungsforschung, Innovation & Entwicklung des österreichischen Schulwesens/Federal Institute of Educational Research, Innovation and Development of the Austrian Educational Sector), it reviews the expected learning outcomes, focusing on the core areas of a subject to be achieved by the pupils at the end of primary school at the 4th grade in German (reading and writing) and Mathematics and at the 8th grade in German, Mathematics and English in the academic-track secondary schools (Gymnasium/Allgemeinbildende Höhere Schule AHS) and general secondary schools (Neue Mittelschule) (Eurydice 2009). The results are to be understood as system feedback and less as individual feedback to the pupils.

At grade 4 in Mathematics (at the end of primary school) 11% of the pupils (girls: 13%, boys: 10%) did not achieve the defined learning goals and another 12% only partially reached the learning goals (girls: 12%, boys: 11%) in 2013 (Figure 5-5). Comparatively poor results were obtained by children with a migrant background or children from schools with a very high social disadvantage (for definition see Schreiner – Breit 2012). In the latter, 29% of pupils did not reach educational standards and 18% did so only partially (Schreiner – Breit 2014).

At grade 8, which is characterized by a separation into academic-track secondary schools and general secondary schools, in 2012, 24% of pupils in general secondary schools were unable to reach the learning objectives in Mathematics (girls: 26%, boys: 23%) and another 33% reached them only partially (girls and boys 33% each) (

Figure 5-6). In the academic-track secondary schools these shares are markedly lower; at 1% of pupils who were unable to reach the learning objectives (girls: 2%, boys: 1%) and 12% who partially reached the goals (girls: 14%, boys: 10%). Thus, more than half of the pupils in the general secondary schools and around 10% in the academic-track secondary schools were unable to or only partially able to achieve the learning goals. Conversely, almost 90% of academic-track pupils achieved or surpassed the goals, compared to just 43% in the general secondary schools (Schreiner – Breit 2012). At the end of primary school more pupils have difficulties reaching the learning goals in reading: In 2015, 13% were unable to reach the goals (girls 10%, boys 16%) and another 25% only partially reached them (girls 23%, boys 28%) (Figure 5-5). This means that every third girl and almost every second boy has reading difficulties at the end of primary school. They often cannot read and comprehend texts to an adequate level. (see Figure 5-5)

In 2016 at grade 8 more than half of girls and almost two-thirds of boys in general secondary schools were unable to achieve the goals (girls: 19%, boys: 29%) or only partially did so (girls: 33%, boys: 36%) (

Figure 5-6). Particularly young people with an immigrant background had difficulties achieving the learning objectives. In the academic-track secondary schools, on the other hand, 13% of girls and 21% of boys found it difficult to reach the learning goals. 41% of the pupils in general secondary schools were able to reach or even exceed the learning goals; in academic-track secondary schools this share was more than twice as high (83%).

5.3.4. ICT Infrastructure Survey

Due to the digital transformation, workers not only need basic and professional skills, but also IT skills. Therefore, the curricula have to be supplemented with IT skills[76] and appropriate technical equipment in schools must be provided.[77] The latest data from the ICT Infrastructure Survey 2016[78] of the Federal Ministry of Education indicate a need to catch up in the field of primary schools and part-time vocational schools. Table 5-3 reports internet connections by school type. The share of classrooms with internet access is 97% in secondary technical and vocational schools and colleges for higher vocational education, 95% in academic-track secondary education, 83% in part-time vocational schools, 77% in general secondary schools and 79% in primary schools. 13% of secondary technical and vocational schools and colleges for higher vocational education as well as academic-track secondary schools have a data transmission rate of more than 100 Mbit/s. In all other types of schools, this share is (slightly) higher: 15% in primary schools, 17% in general secondary schools and 23% in part-time vocational schools.[79]

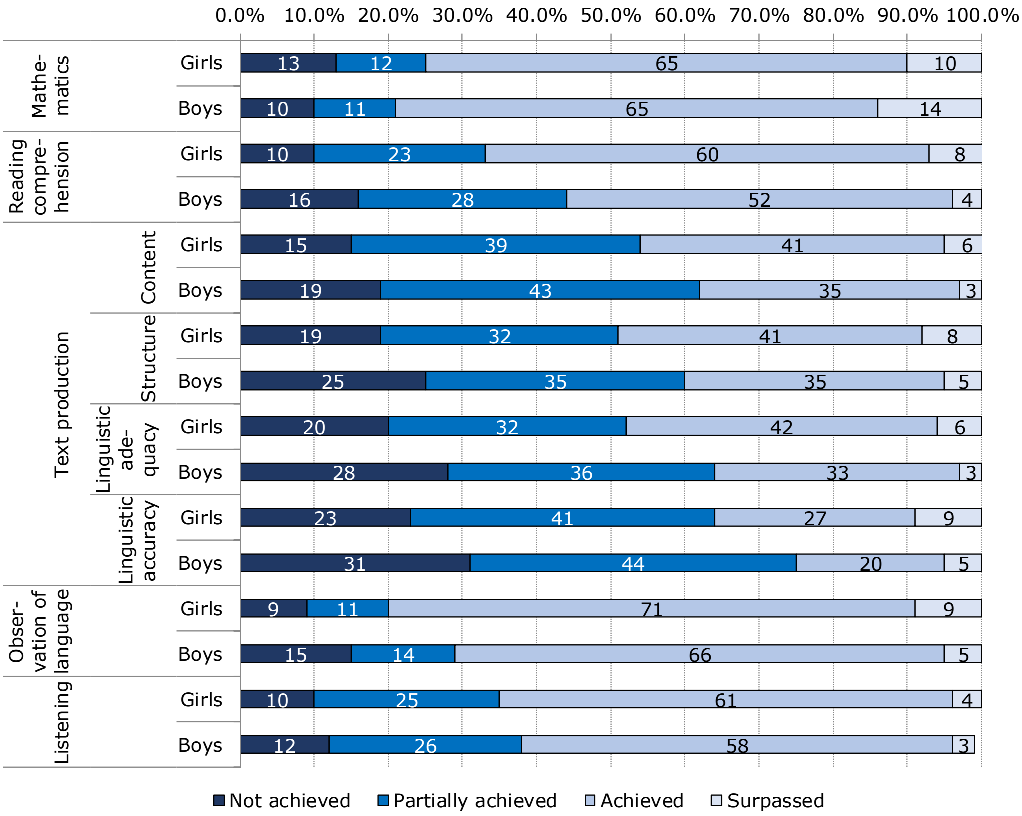
Figure 5-5: Austrian standards-based proficiency test in German (reading, writing) and Mathematics: 4th grade results

[76] In 2017/18, the mandatory exercise "Digital Basic Education" (Digitale Grundbildung) started as a pilot project (in 178 general secondary and academic-track secondary schools). From the school year 2018/19, the curriculum applies and the nationwide implementation for all secondary schools starts (see https://bildung.bmbwf.gv.at/schulen/schule40/dgb/index.html, https://www.ris.bka.gv.at/eli/bgbl/II/2018/71/20180419).

[77] The federal government is responsible for school buildings in which academic-track secondary schools or secondary technical and vocational schools and colleges for higher vocational education are located. The federal states are responsible for part-time vocational schools and primary schools, while general secondary schools are in the common responsibility of the federal states and municipalities.

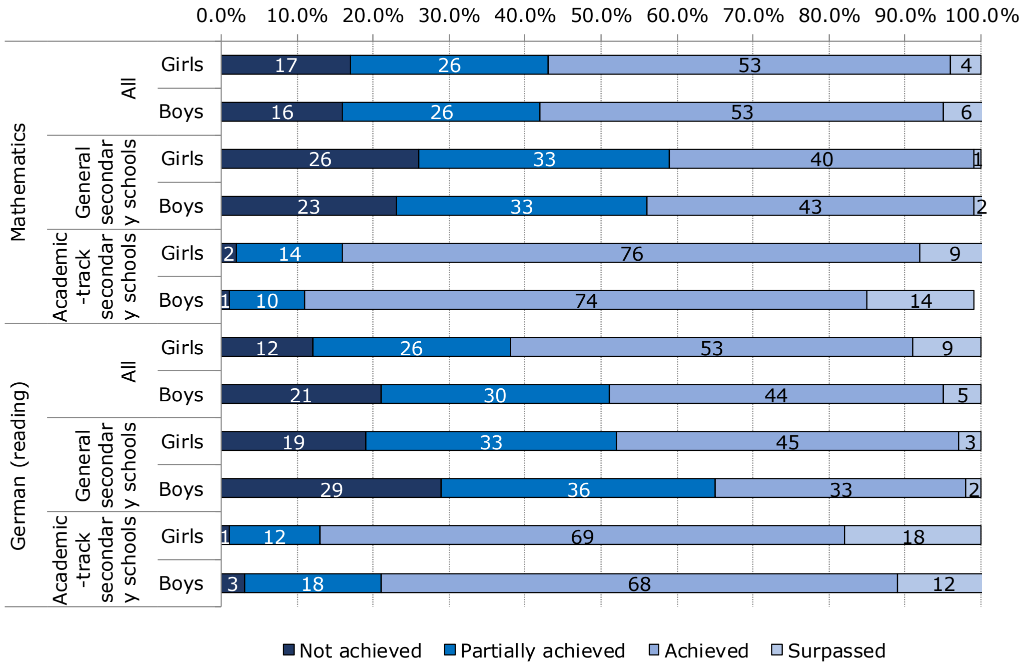
78 https://bildung.bmbwf.gv.at/schulen/schule40/iktie.html

[79] For a detailed description differentiating between different types of internet connections (WLAN, etc.) see the appendix.



Source: Schreiner – Breit 2014; Breit – Bruneforth – Schreiner 2016.

Figure 5-6: Austrian standards-based proficiency test in German (reading, writing) and Mathematics: 8th grade results



Source: Schreiner – Breit 2012; Breit – Bruneforth – Schreiner 2017.

Table 5-3: Internet connections by school type

		Primary school	General secondary school	Academic-track secondary education	Secondary technical and vocational schools and colleges for higher vocational education	Part-time vocational school
LAN-connections	No connection available	22.1%	5.7%	0.4%	0.4%	4.9%
	In up to 50% of rooms	18.8%	24.6%	9.0%	5.6%	2.5%
	In more than 50% of rooms	24.1%	24.3%	21.3%	19.2%	21.3%
	In all rooms	35.0%	45.4%	69.3%	74.8%	71.3%
WLAN in the school buildung	No WLAN available	41.3%	19.5%	12.7%	8.8%	43.4%
	In up to 50% of rooms	17.0%	23.8%	31.5%	17.2%	18.9%
	In more than 50% of rooms	13.2%	19.5%	16.5%	21.2%	7.4%
	In the whole school building	28.4%	37.1%	39.3%	52.8%	30.3%
Data transmission rate	Up to 10 Mbit/s	36.7%	18.3%	12.4%	10.4%	28.1%
	10 to 30 Mbit/s	26.2%	37.0%	46.8%	35.2%	25.8%
	30 to 100 Mbit/s	22.3%	27.5%	27.7%	41.2%	23.4%
	More than 100 Mbit/s	14.8%	17.2%	13.1%	13.2%	22.7%
Internet access	Open	22.8%	24.8%	26.6%	43.6%	18.0%
	Restricted	56.2%	54.5%	67.0%	54.8%	72.1%
	No access	21.0%	20.7%	6.4%	1.6%	9.8%
Share of classrooms with internet access		79.0%	77.3%	94.9%	97.1%	82.5%

Source: ICT Infrastructure Survey 2016. Note: Part-time vocational schools without agricultural part-time vocational schools.

5.3.5. Summary

Insufficient or missing basic skills are not just a problem for adults – expressed in high risk of unemployment or employment loss, but also for pupils. Not all young people achieve the learning goals in literacy and numeracy in compulsory school (at grade 4 and grade 8 respectively). They possess basic skills in literacy and numeracy at most and can use them, if at all, for routine procedures only. Particularly young people with a migration background or from schools with a very high social disadvantage have difficulties in achieving the learning goals at the end of primary school. 4 grades later, at grade 8, young people with a migration background (especially those in general secondary schools) once again face huge difficulties in achieving the learning goals. In an economic environment characterised by digitalisation, apart from possessing enough basic skills, it is increasingly essential to have the appropriate digital skills. The imparting of such skills must already start in school, for which a suitable infrastructure of equipment is indispensable. However, the available data on the infrastructure equipment of Austrian schools shows that it varies considerably between school types. Especially in primary schools and in general secondary schools there are still many classrooms (around one in five) without an internet connection.

5.4. Task-based approach

5.4.1. Introduction

The effects of the implementation of digital technologies in firms on the labour force and labour processes are controversially discussed concerning risks and opportunities (e.g. Frey-Osborne 2013, 2017; Bowles 2014; Arntz – Gregory – Zierahn 2016). According to Frey – Osborne (2013, 2017), 47% of jobs in the US are potentially at high risk of automation. Bowles (2014) transferred this approach to EU countries and calculated that in Austria more than half of all jobs could be affected by automation. However, rather than entire occupations, specific job tasks might be replaced, supported or created by using digital technologies (Bonin et al. 2015; Dengler – Matthes 2015, 2016; Arntz – Gregory – Zierahn 2016; Nagl et al. 2017). Using the task-based, the OECD (Arntz – Gregory – Zierahn 2016) calculated that in Austria 12% of employees work in jobs with a high risk of automation. According to Nagl et al. (2017), 9% of the employees in Austria have a job profile that has a high potential to be replaced by machines or technology. Nedelkoska – Quintini (2018) built on the approach of Frey – Osborne (2013) as well as on those of Arntz – Gregory – Zierahn (2016) and calculated an average automation potential of 48% for Austria.

However, to assess potential future labour market trends resulting from digitalisation, it is necessary to understand how employment has developed in recent years. Since the current discussion aims at the potential for automation, employment must also be distinguished according to these characteristics. By structuring occupations with predominantly routine versus non-routine tasks or manual versus non-manual tasks, structural characteristics of employment in Austria can be derived in the task-based approach, which also provide information on the risk of occupations/tasks to be automated or to assess the impact of using robots on employment.

In this chapter we summarize the characteristics of paid employment using the main tasks in current occupations. In the next section, we start by sketching the methodology that we use to assign each occupation a main task. Employment by main task is analysed since the mid-1990s and a forecast for the next few years is provided. Finally, the changes in the sectoral task composition (based on occupations) associated with ICT are analysed.

5.4.2. Methodology

The analysis is based on the categorization of each 3-digit-occupation by main task used by Bock-Schappelwein (2016). In this way, the structure and development of paid employment can be presented according to the main task. Five types of tasks focusing on the work of Spitz-Oener (2006) and Dengler – Matthes – Paulus (2014) are used:

- Analytical non-routine tasks: According to Spitz-Oener (2006, p.243), analytical non-routine tasks include “researching, analysing, evaluating and planning, making plans/constructions, designing, sketching, working out rules/prescriptions, and using and interpreting rules”; for Dengler -Matthes - Paulus (2014) terms such as leadership or design describe this area of activity.
- Interactive non-routine tasks: Interactive non-routine tasks are more related to communication-specific factors such as negotiating, teaching, managing or presenting, and are often needed in the areas of commerce, counselling, mentoring, training, marketing or advertising. According to Spitz-Oener (2006, p. 243), “negotiating, lobbying, coordinating, organizing, teaching or training, selling, buying, advising customers, advertising, entertaining or presenting, and employing or managing personnel” are one of them.
- Cognitive routine tasks: Cognitive routine tasks cover an equally wide range of job content, Spitz-Oener (2006) lists “calculating, bookkeeping, correcting texts/data, and measuring length/weight/temperature”. Dengler – Matthes – Paulus (2014) list metrology, administration, network technology, surveying, monitoring, diagnostics, etc.
- Manual routine tasks: Manual routine tasks are much more narrowly defined and are mainly aimed at machine operators; Spitz-Oener (2006, p. 243) mentions “operating or controlling machines and equipping machines”.
- Manual non-routine tasks: Manual non-routine tasks are characterized by artisan work that does not follow standardized patterns such as repairing, restoring, renovating or even activities in the tourism or care sector, Spitz-Oener (2006, p. 243) mentions “repairing or renovating houses/apartments/machines/vehicles, restoring art/monuments, and serving and accommodating”.

The assignment of one main task to a specific occupation was carried out according to the description to ISCO (International Standard Classification of Occupations) at the ISCO-3-digit-level. Bock-Schappelwein (2016) compared each job with the assignment of key areas of activity, as was done by Spitz-Oener (2006) and Dengler – Matthes – Paulus (2014). In the case of the ISCO-08-classification (since 2011), a set of 127 occupations and, in the case of the previously used occupational classification ISCO-88, a set of 110 occupations (except soldiers) has been categorized with one of the five types of tasks.

Table 5-4: Tasks structured by job description: ISCO-88-3-digit-level and ISCO-08-3-digit-level

Task	ISCO-88		ISCO-08	
	N	in %	N	in %
Analytical non-routine	20	18.2%	35	27.6%
Interactive non-routine	16	14.5%	15	11.8%
Cognitive routine	16	14.5%	20	15.7%
Manual routine	30	27.3%	23	18.1%
Manual non-routine	28	25.5%	34	26.8%
Total	110	100.0%	127	100.0%

Source: Bock-Schappelwein 2016.

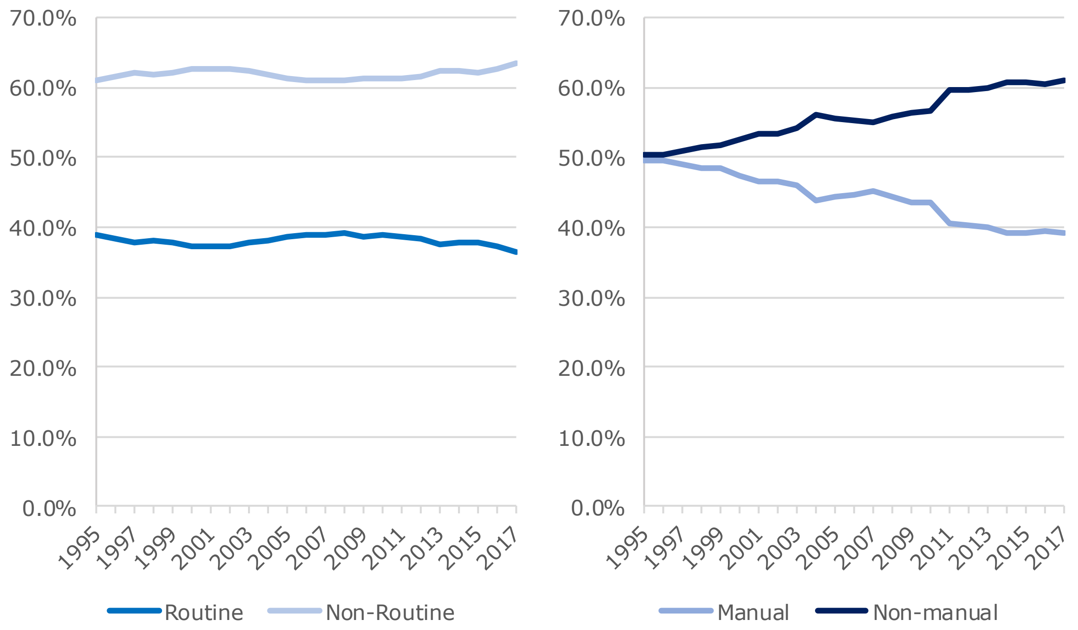
5.4.3. Status quo

Using labour force data enriched with information on job tasks, Bock-Schappelwein (2016) found a relatively stable relationship between employed persons in jobs focusing on routine tasks on the one hand and on non-routine tasks on the other since the mid-1990s in Austria. Around 60% of total employment (employees only) in the period 1995 to 2017 was accounted for by occupations or jobs that are characterized by non-routine tasks (non-routine 2017: around 64%), while the remaining around 40% was accounted for by routine activities (Figure 5-7). Conversely, the author found shifts between occupations in favour of non-manual tasks, which account for around 61% of employment in 2017 as well (1995: around 50%).

The number of employed persons in jobs with mainly manual tasks has not only proportionately declined in importance, but also in absolute numbers, as shown by Bock-Schappelwein (2016). Compared to the mid1990s, the number of jobs with mainly manual tasks has been steadily declining, while the number of jobs with predominantly non-manual tasks has increased significantly. Compared to 1995, the number of employed persons in jobs with predominantly manual tasks of 1,454,600 in 2017 was around 6% below the starting level, while non-manual tasks increased by almost 44% to 2,268,400 since the mid1990s. Overall, according to LFS data, the number of employed persons increased by around 19% to 3,723,000 in this period (except soldiers). (see Figure 5-8)

Within the manual task category Bock-Schappelwein (2016) explains that not only jobs with mainly manual routine tasks but also, albeit less strongly, with mainly manual non-routine tasks have lost employment. In 2017, the number of employees employed in jobs with a focus on manual routine tasks was 457,600, around 12% below the 1995 level, while manual non-routine work fell by -3% (to 997,000). In terms of total employment, the proportion of jobs with a focus on manual routine tasks decreased by 4 percentage points to 12% and that of jobs focusing on manual non-routine activities by 6 percentage points to 27%.

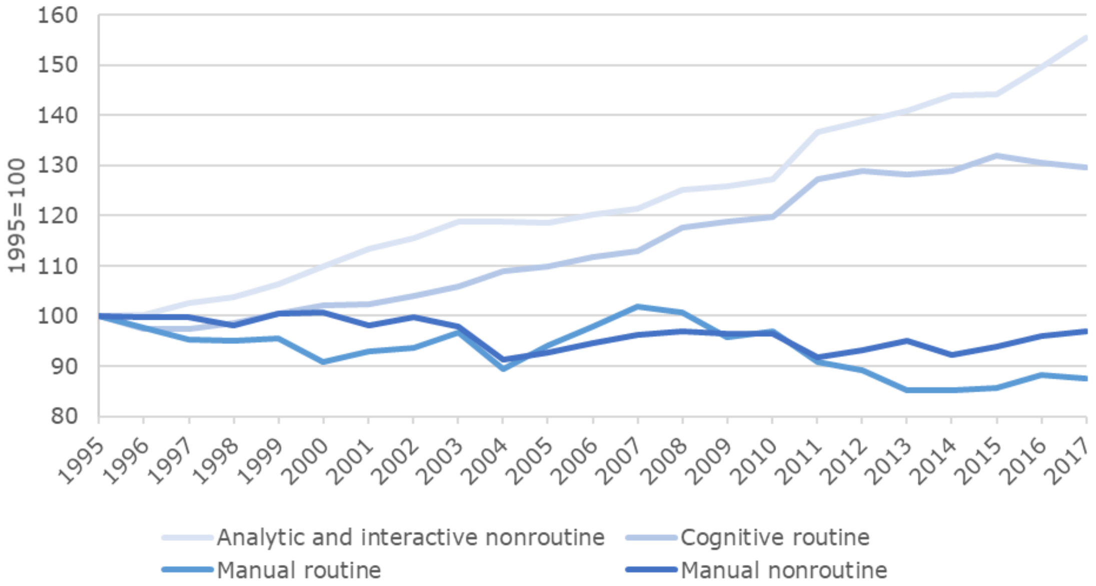
Figure 5-7: Employment by task in Austria (1995-2017)



Source: Statistics Austria: LFS, WIFO-calculations. Note: 2010/2011 break in data base. ISCO-88 1995-2010, ISCO-08 2011-2017. Break in data base 2003/04: change LFS calculations.

Regarding non-manual tasks, employment in both analytical and interactive non-routine tasks and in the field of cognitive routine tasks has been significantly expanded. In analytical and interactive non-routine tasks, employment increased by 55% compared to 1995 to 1,367,500 (2017) and in the field of cognitive routine tasks by 30% to 900,900. The share of total employment increased by 9 percentage points to 37% for analytical and interactive non-routine tasks and 2 percentage points to 24% for routine cognitive tasks in 2017.

Figure 5-8: Employment growth by task in Austria (1995-2017)



Source: Statistics Austria: LFS, WIFO calculations. Note: 2010/2011 break in data base. ISCO-88 1995-2010, ISCO-08 2011-2017. Break in data base 2003/04: change LFS calculations.

On the sectoral level, Bock-Schappelwein – Famira-Mühlberger – Leoni (2017) found strong evidence of a massive reduction of jobs with a focus on manual routine tasks and manual non-routine tasks in manufacturing in 1995-2015 (–37% to 340,000 between 1995 and 2015), while jobs with mainly analytical and interactive non-routine tasks doubled to 137,400. In the service sectors the evidence shows that all types of jobs rose in 2005-2015, however, manual routine tasks to a much smaller extent (+6%) than cognitive routine tasks (+40%), analytical and interactive non-routine tasks (+36%) or manual non-routine tasks (+25%). According to the authors, in 1995-2015 a shift in the employment structure by task from manual to non-manual tasks characterised almost all sectors studied in the manufacturing sector, such as in the food, chemical, electrical and electronic industry or engineering. In 2015, the share of employed persons in occupations with predominantly non-manual tasks dominated, for example, in the chemical and electrical and electronic industry. In the service industries, the share of employed persons in occupations with mainly non-manual tasks dominated almost all service industries in 2015. Only in tourism and, to a lesser extent, in transport and warehousing, the share of employed persons in occupations with mostly manual tasks outweighed them.

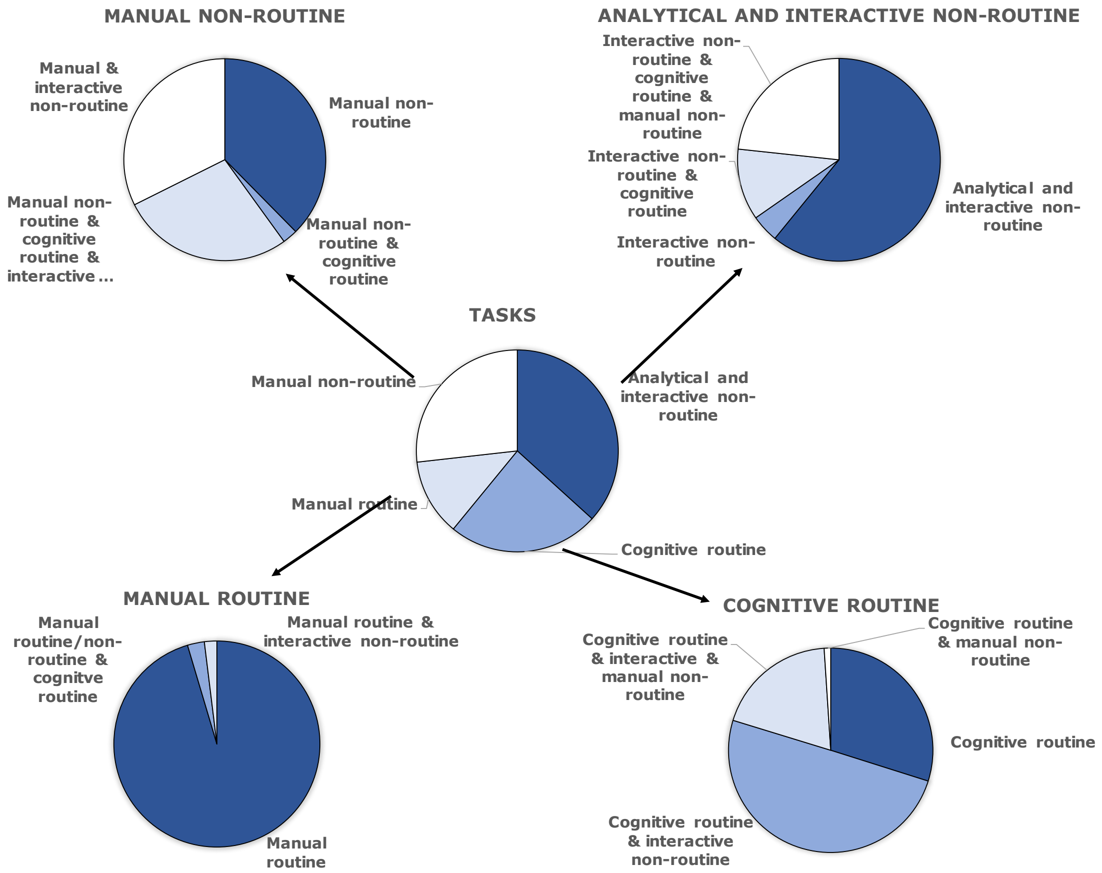
However, occupations are often characterised not only by one main field of activity, but by a bundle of several tasks. Therefore, we use the assignment from 2016 to identify – in addition to the already defined main task for each 3-digit profession (based on ISCO 08) – other equally relevant tasks. Such a view complements the standard employment analysis by one main task qualitatively, stating in which professions or professional groups bundles of tasks are more important.

From the extended classification it can be deduced that medium-skilled professions are more often characterized by bundles of tasks, while high-skilled professions (managers and academic professionals; major groups 1 and 2) on the one hand, and low-skilled professions (plant and machine operators and assemblers as well as elementary occupations; major groups 8 and 9) on the other hand, can be represented very well by the so-far-specified main task.

Within medium-skilled jobs, professions in major groups 3 and 4 (technicians and associate professionals and clerical support workers) are often characterised by a set of cognitive routine and interactive non-routine tasks. In the major groups 5 and 6 (services and sales workers and skilled agricultural, forestry and fishery workers) the bundles are often more complex including manual and interactive non-routine tasks as well as cognitive routine tasks. In major group 7 (craft and related trades workers) the focus of activity is on manual non-routine tasks, which are sometimes complemented by interactive non-routine tasks. (see Figure 5-9)

Based on tasks, bundles of tasks usually can be found above all in professions characterised predominantly by cognitive routine or manual non-routine tasks. Professions with predominantly cognitive routine tasks are often also characterised by interactive non-routine tasks (and vice versa), occasionally also by manual non-routine tasks. In professions showing a predominance of manual non-routine tasks, the task bundle often includes cognitive routine tasks and interactive non-routine tasks as well. In contrast, in highly skilled professions with predominantly analytical and interactive non-routine tasks as well as in low-skilled professions with mainly manual routine tasks, task bundles can only rarely be identified.

Figure 5-9: Main tasks and bundles of tasks (2017)



Source: WIFO, based on Statistics Austria: LFS-data (3-digit-ISCO, employed persons) and ISCO-description[80].

5.4.4. Task forecasts and ICT taxonomies

Based on their findings, Bock-Schappelwein – Famira-Mühlberger – Leoni (2017) concluded that, in the recent past, jobs with higher skill requirements of the workforce such as jobs with mainly analytical and interactive non-routine and cognitive routine tasks have experienced employment gains, while jobs with mainly manual tasks, particularly in manufacturing, have lost importance. For the near future they conclude that, building on a similar trend in employment as in recent years, the number of jobs with analytical and interactive non-routine and cognitive routine tasks is likely

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80 https://www.ilo.org/public/english/bureau/stat/isco/isco08/ (accessed on 9 November 2018)

to expand, whereas jobs with predominantly manual routine tasks, particularly in manufacturing, should continue to shrink.

Fink et al. (2017) expect a similar development for the Austrian labour market in a medium-term perspective.[81] In their medium-term sectoral and occupational employment forecast (38 sectors and 59 occupations), they estimate that employment over the period 2016 to 2023 is expected to increase by +325,300 or +1.3% annually to 3,826,600. They likewise predict a clear trend towards higher skill requirements and service-oriented activities. Academic occupations show clearly above-average growth, while professions with higher proportions of low-skilled employees show employment losses.

Bock-Schappelwein – Böheim (2018) used this forecast as a starting point for estimating employment growth by tasks. According to the forecast, employment gains of about +270,000 to 2023 can be expected in analytical and interactive non-routine tasks as well as in routine cognitive tasks (based on social security data). For the manual non-routine tasks, employment growth of around +65,000 is also expected. The current trend in manual routine tasks is assumed to continue, which should result in a further decline in employment of around 15,000 to 2023.

Using these future employment growth rate trends by tasks which are based on social security data and merging the growth rates with the LFS-data base creates a new data set that covers the years 1995 to 2023. Based on underlying assumptions, it is expected that employment in occupations with predominantly analytical and interactive non-routine tasks will increase by an average of +2.0% p.a. over the period 2018 to 2023, and on average by +1.4% p.a. in cognitive routine cognitive tasks. In the field of jobs with predominantly manual non-routine tasks employment increases of +1.0% p.a. are expected in a medium-term perspective. In predominantly manual routine jobs, the decline in employment is likely to continue by -0.5% p.a. on average. (see Figure 5-10 & Figure 5-11)

Using this forecast, no significant structural changes in the composition of employment by task are to be expected in the medium term. The relatively stable relationship between persons employed in occupations focussing on routine tasks on the one hand and on non-routine activities on the other will persist over the next few years, although the first signs of an emerging structural shift in occupations with predominantly non-routine tasks are beginning to emerge in this perspective. For occupations with a predominantly manual and non-manual focus, the trend of recent decades in favour of non-manual activities of similar intensity is likely to continue. By 2023, the share of employees in occupations with predominantly manual tasks is likely to fall to 37%.

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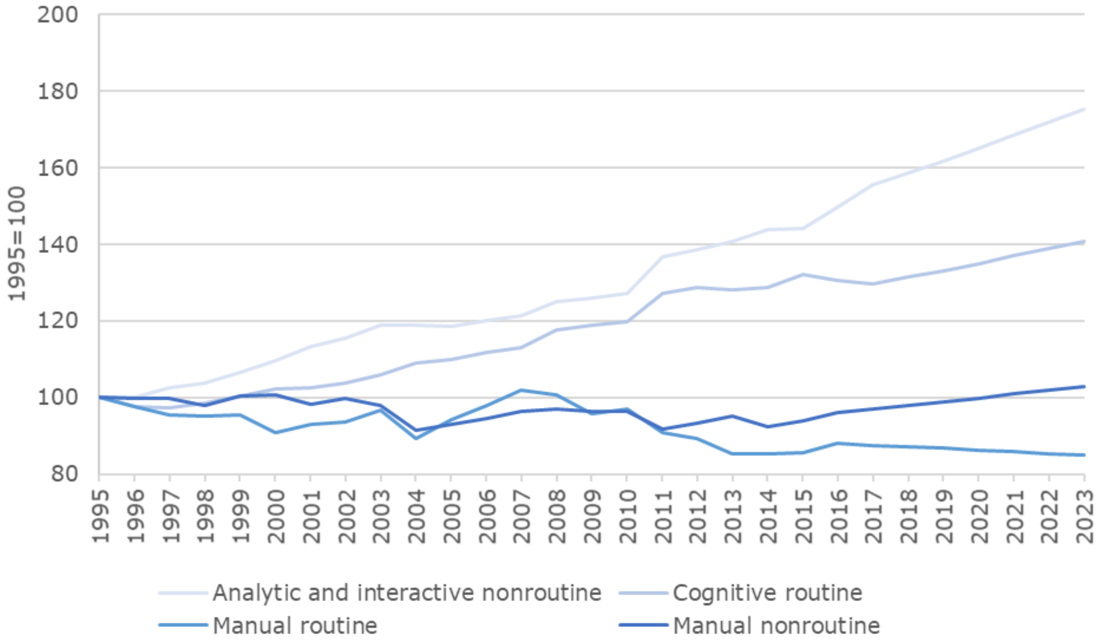
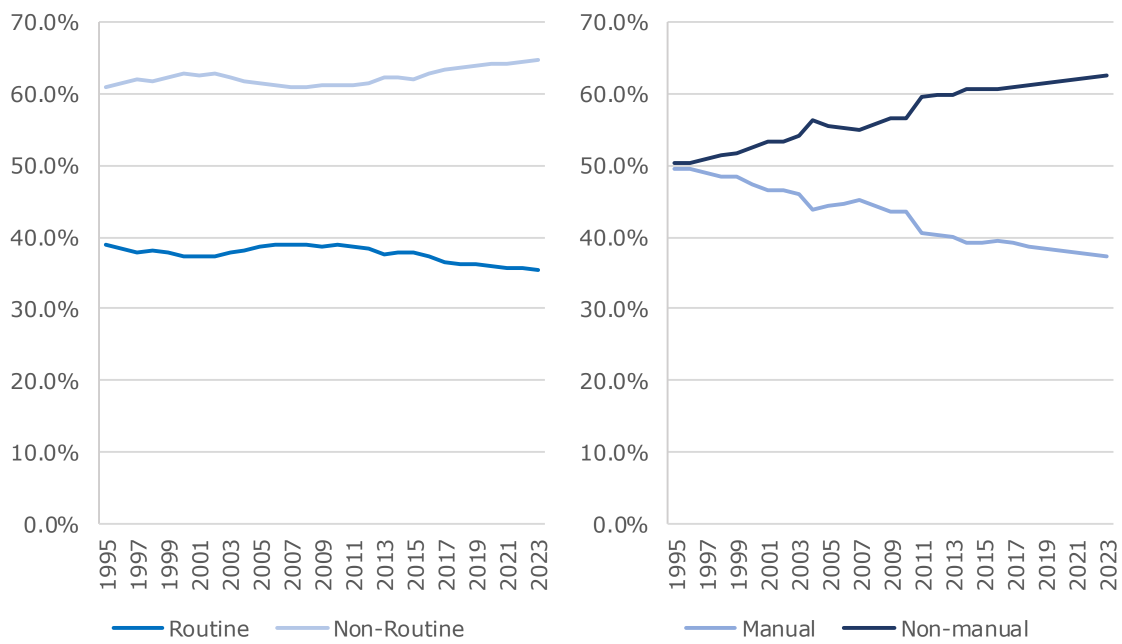
81 Structural change reflects technical and organizational innovations, for example through digitalisation or automation, international division of labour and changes in consumer behaviour. The change in demand for occupational activities is driven on the one hand by sectoral shifts and on the other by changes in job profiles and skill and competence requirements; the forecast of employment by occupational group considers both factors.

Figure 5-10: Employment growth by task in Austria: current trend and mid-term forecast (1995-2023)



Source: Statistics Austria: LFS, WIFO-calculations. Note: 2010/2011 break in data base. ISCO-88 1995-2010, ISCO-08 2011-2017. Break in data base 2003/04: change LFS calculations, 2018-2023: forecast.

Figure 5-11: Employment by task in Austria: current trend and mid-term forecast (1995-2023)



Source: Statistics Austria: LFS, WIFO-calculations. Note: 2010/2011 break in data base. ISCO-88 1995-2010, ISCO-08 2011-2017. Break in data base 2003/04: change LFS calculations, 2018-2023: forecast.

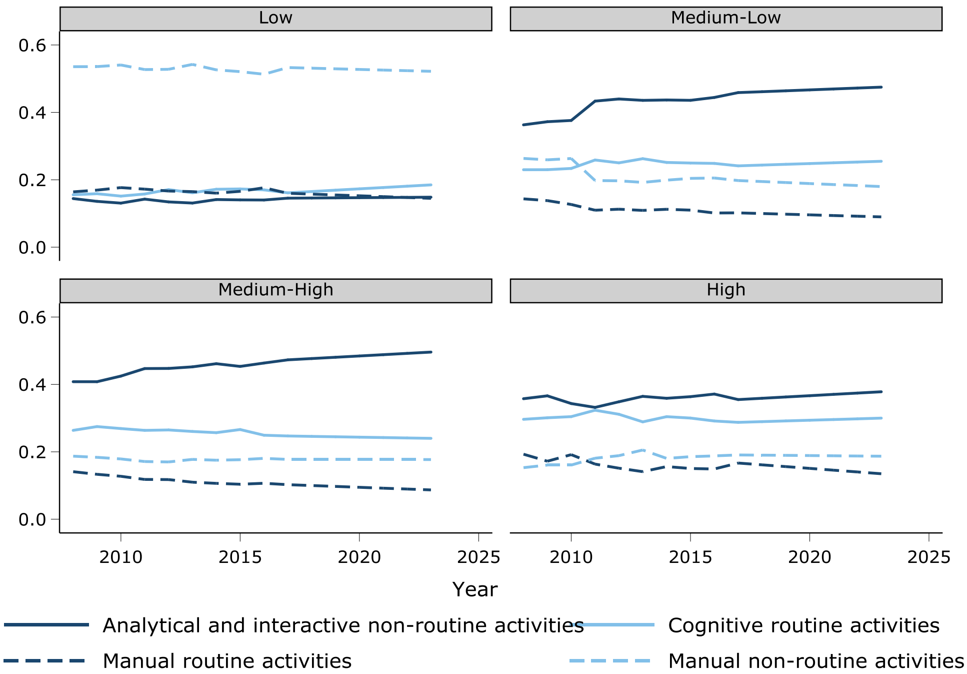
In a next step, these economy-wide task trends are related to the sectors defined in the OECD taxonomy of ICT intensity. In other words, the aggregate forecasts are de-composed in separate forecasts for sectors classified by their ICT-intensity proposed by the OECD (Calvino et al. 2018). The taxonomy draws on a set of indicators to classify 36 ISIC Rev. 4 sectors over the period 2001-2015, comprising the share of ICT tangible and intangible (i.e. software) investment; share of purchases of intermediate ICT goods and services; stock of robots per hundreds of employees; share of ICT specialists in total employment; and the share of turnover from online sales. Four distinct sector groups are defined, which have been applied to the current sector structure of the task-based approach: sectors with low, medium-low, medium-high and high ICT-intensity.

In a first step, the trends in the task composition are used to obtain baseline forecasts. The obtained growth rates at the sector level are then calibrated using sector weights in order to obtain consistency with the aggregate forecast. The weights rely on employment data, i.e. data on persons employed obtained from Eurostat (EMP_DC_THS_PER).

The forecasts also consider a continuation of current trends in the sector composition itself. These imply minor changes in the sector composition. In, the year 2017, sectors with low ICT-intensity accounted for 25.2% of total employment (2008: 26.7%), sectors with medium-low ICT-intensity for 23.5% (2008: 22.1%), medium-high ICT using sectors for 31.9% (2008: 32.9%), and sectors with high ICT-intensity made for 19.3% (2008: 18.4%).

The picture obtained shows an increase in abstract non-routine activies in all sectors, even though this seems to be less pronounced in sectors with low ICT-intensity. These are expected to slightly lose sector shares, too. Manual routine activities are declining slightly in all sectors (see Figure 5-12).

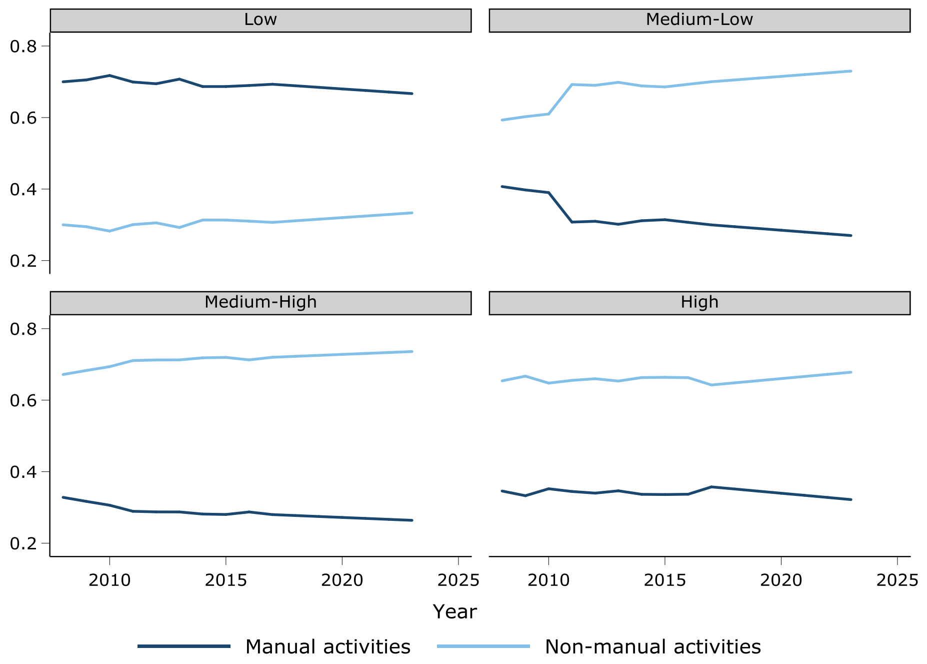
Figure 5-12: Employment by task across ICT-intensities: current trend and mid-term forecast (2008-2023)



Source: OECD (Calvino et al. 2018), Eurostat, LFS, WIFO calculations. Note: Data after 2017 is forecast. ISCO-88 1995-2010, ISCO-08 2011-2017. Break in data base.

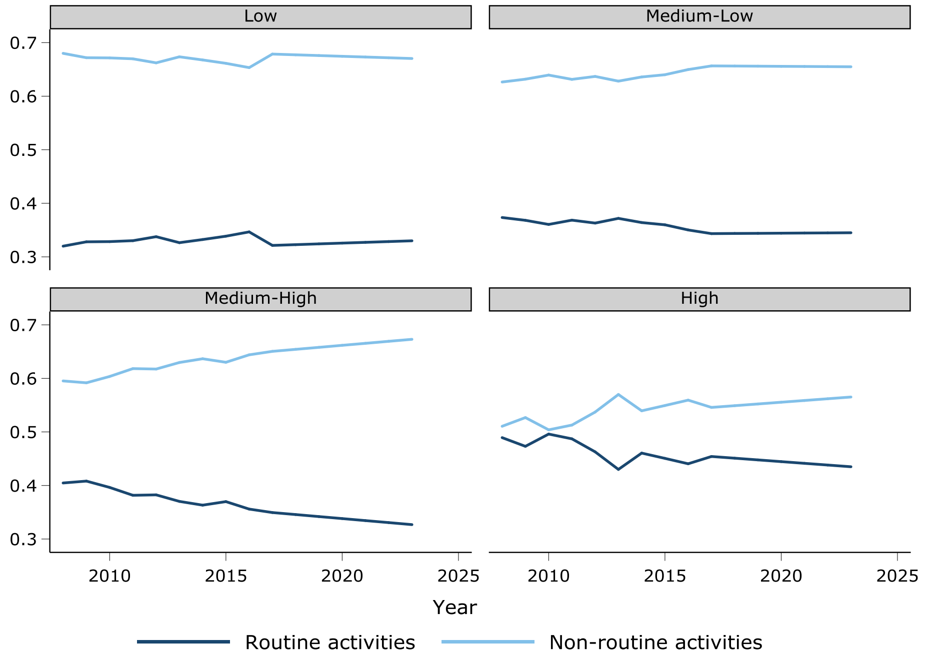
These forecasts indicate bigger trends. Manual occupational tasks are more common in sectors with low ICT-intensity. These are generally declining slightly in favour of non-manual activities. This effect is particularly strong in sectors with low and medium-low ICT-intensity (see Figure 5-13). In addition, non-routine occupational activities are on the rise, especially in ICT-intensive sectors (see Figure 5-14).

Figure 5-13: Employment by manual and non-manual activities across ICT-intensities: current trend and mid-term forecast (2008-2023)



Source: OECD (Calvino et al. 2018), Eurostat, LFS, WIFO calculations. Note: Data after 2017 is forecast. ISCO-88 1995-2010, ISCO-08 2011-2017. Break in data base.

Figure 5-14: Employment by routine and non-routine activities across ICT-intensities: current trend and mid-term forecast (2008-2023)



Source: OECD (Calvino et al. 2018), Eurostat, LFS, WIFO calculations. Note: Data after 2017 is forecast. ISCO-88 1995-2010, ISCO-08 2011-2017. Break in data base.

The OECD taxonomy is broadly defined, and the indicators comprehensively capture an industry's ICT-intensity. This includes aspects of ICT-capital (e.g., software), which may interact with occupational tasks in complex ways[82].

5.4.5. Sector performance and changing tasks structures: Some empirical findings

Information and communication technologies are a widely acknowledged changer of job structures. This is thought to enhance the shift in favour of non-manual tasks (Figure 5-7), and therefore the substantial loss of jobs characterised by manual routine tasks observable in Austria. While ICT can be associated with automation and thus non-standard occupations, it is also strongly associated with non-routine activities. However, the latter show a relatively stable relationship between routine and non-routine tasks since the mid-1990s.

This leads to the guiding first question of this section. Are changes in the sectoral task composition (determined by occupations) associated with ICT? This is a multi-faceted question, since information and communication technologies themselves are a bin category incorporating a multitude of aspects. To this end, this report will shed light on three different aspects.

- It will use an OECD taxonomy of ICT-intensities (Calvino et al. 2018) to explain the main task structures of occupations. It will ask if more ICT-intensive sectors can be linked to certain sectoral task structures.
- It will draw on DESI indicators to shed light on different aspects of ICT at the sector level and explore how these are associated with sectoral task structures of occupations.
- Sectoral task structures are the outcome of complex processes in the input factor 'labour'. These are likely to be intertwined with the capital stock. Hence, different types of ICT investments obtained from EUKLEMS data are used to explain sectoral task structures.

The chosen approach allows linking ICT with broader trends in occupational task structures instead of focusing on ICT skills alone. It thereby offers a viable alternative to studying the impact of ICT skills on jobs, for which there are no data in Austria.

The second guiding question concerns the relationship between economic outcome variables and the task structures of occupations at the sector level. To this end, a variety of outcome variables is presented: value added growth, labour productivity in both levels and growth rates, employment growth and the sector-specific unemployment rates.

To capture job structures – and their changes – and thus analyse past labour market and job task trends, the 'task approach' is implemented (see e.g. Autor – Levy – Murnane 2003; Autor 2013, 2015). To this end, a WIFO-enriched labour force survey (LFS) dataset is used, also containing information on job tasks. These bin job profiles into four broad categories: abstract, analytical, interactive non-routine, cognitive routine, manual routine and eventually manual non-routine activities. The occupations are based on ISCO88-3-digit level and ISCO08-3-digit level respectively (except soldiers) and cover the years 1995 to 2017 (see Bock-Schappelwein 2016). To accommodate changes in the industry classification, only Nace Rev. 2 data will be used, which are available after the year 2008. This leads to the time coverage from 2008 to 2017 (see also the previous chapter).

Task groups are defined to portray wider trends with respect to the sectoral occupation structures that have emerged. These groups are the total share of (i) routine tasks, consisting of cognitive routine activities as well as manual routine activities, and (ii) non-routine tasks, consisting of abstract non-routine tasks (analytical and interactive non-routine) and manual non-routine

[82] To ensure the robustness of these results, this exercise was repeated using a recently published ICT-taxonomy (Peneder – Firgo - Streicher 2018; Appendix B.4.4).

activities. In addition, (iii) manual activities (both non-routine and routine) and (iv) non-manual (both abstract non-routine and cognitive routine) are assigned to a category. The two extreme poles are considered separately: (v) abstract non-routine and (vi) manual routine.

Eventually, ratios of these three task groups are also used in order to gain insights into replacement effects. In other words, the ratios simultaneously consider the interplay of two variables. These are non-routine to routine tasks, non-manual to manual tasks and abstract to manual-routine tasks.

The following will present a series of regressions and correlations to empirically establish the presumed relationships. It is important to stress that this exercise is exploratory. While the revealed patterns are plausible and supported by the literature, the results should not be interpreted in a causal way. Methodologically, OLS regressions with year dummies and robust standard errors, clustered at the sector level are implemented. Even though the data is in a panel format, the authors refrained from a fixed-effects regression due to the structural nature of the data. In other words, structural variables exhibit little variance over time, which renders the variables of interest statistically insignificant when including time-invariant fixed-level effects.

5.4.5.1. Linking the OECD ICT taxonomy with the task approach

An ICT taxonomy recently published by the OECD (Calvino et al. 2018) can be used to associate the ICT-intensity across sectors with the occupational structure. The ICT taxonomy can be interpreted as a measure of the "digitalisation intensity" of economic sectors. The taxonomy covers a total of 36 ISIC revision 4 sectors over the period from 2001 to 2015. This ICT taxonomy is related to the shares of the task groups (at sectoral level) and the ratios capturing the joint developments of different aspects of the task structures. A first descriptive tabulation using the main tasks (determined by occupations) reveals interesting structural patterns (see Table 5-5).

Table 5-5: Task structure by OECD ICT taxonomy

ICT Type (OECD)	Abstract	Cognitive	Manual	Manual
Routine activities	N	Y	Y	N
Low	15.9%	16.6%	17.7%	49.8%
Medium-Low	27.7%	23.1%	23.4%	25.8%
Medium-High	29.9%	27.4%	14.4%	28.2%
High	34.6%	27.9%	15.8%	21.8%
Total	27.7%	24.4%	17.7%	30.2%

Source: OECD (Calvino et al. 2018), Eurostat, LFS, WIFO calculations.

Abstract (analytical and interactive non-routine) and cognitive tasks are more common in ICT-intensive sectors than sectors which are classified with a low ICT-intensity. Manual non-routine tasks are less common in ICT-intensive sectors. Interestingly, the intensity of manual routine tasks does not seem to differ across sectors.

Next, the task groups are used as dependent variables in exploratory regressions. Hence, the right side variable is the OECD’s ICT taxonomy, using industries with a low digital intensity as a benchmark. These regressions associate the ICT taxonomies with the task groups (routine versus non-routine, manual versus non-manual). To control for time effects, year dummies are used in each specification.

The results support the descriptive statistics. Especially high levels of manual tasks (at the sectoral level) are negatively related with high digital intensity. The coefficients for manual routine tasks are also negative, but statistically much weaker and of a lesser magnitude. There is a weakly significant relationship between routine tasks and sectors with medium-low digital intensity (see Table 5-6).

Table 5-6: Task structures explained by OECD ICT taxonomy

VARIABLES	(1) Routine	(2) Non-routine to routine	(3) Manual	(4) Non-manual to manual	(5) Abstract	(6) Manual, routine	(7) Abstract to Manual Routine
Medium-Low	0.12** (0.059)	-0.2 (0.831)	-0.18** (0.082)	1.61 (1.162)	0.12 (0.085)	0.06 (0.049)	2.95 (2.795)
Medium-High	0.08* (0.041)	-0.42 (0.330)	-0.25*** (0.074)	1.85* (0.917)	0.14** (0.061)	-0.03 (0.035)	3.45 (2.078)
High	0.09* (0.048)	-0.57 (0.343)	-0.30** (0.122)	5.22 (3.192)	0.19** (0.085)	-0.02 (0.065)	5.27* (2.980)
Constant	0.36*** (0.026)	1.91*** (0.257)	0.71*** (0.045)	0.17 (0.190)	0.13*** (0.034)	0.20*** (0.026)	-0.23 (0.557)
Observations	290	290	290	290	290	290	290
R-squared	0.12	0.03	0.22	0.15	0.11	0.13	0.06

Source: OECD (Calvino et al. 2018), Eurostat, LFS, WIFO calculations. Note: Robust standard errors clustered at the sector level in parentheses; Unreported time dummies included in all specifications. Sig. levels *** p<0.01, ** p<0.05, * p<0.1.

In addition, the impact on changes in the task structures were analysed, both in terms of changes over three-year periods (see Table 5-7) and in terms of year-to-year differences (see

Table 5-8). The level of the respective dependent variable in the base year was used as an additional control variable in all regressions together with time-fixed effects.

The results from these regressions indicate the same trend but show a weaker effect. The changes in the task structures towards non-routine activities in sectors with a high digital intensity come at the cost of routine activities. Abstract non-routine tasks tend to displace manual routine activities in ICT-intensive sectors.[83]

Table 5-7: Three-year changes in task structures explained by OECD ICT taxonomy

3 yrs. growth	(1) Routine	(2) Non-routine to routine	(3) Manual	(4) Non-manual to manual	(5) Abstract	(6) Manual, routine	(7) Abstract to Manual Routine
Base year, level	-0.10**	0.07	-0.01	0.10	-0.02	-0.09***	0.47*
	(0.038)	(0.095)	(0.008)	(0.064)	(0.028)	(0.023)	(0.273)
Medium-Low	-0.00	0.22	-0.02**	0.30	0.03**	-0.00	0.41
	(0.012)	(0.141)	(0.009)	(0.204)	(0.010)	(0.006)	(0.367)
Medium-High	-0.01	0.15	-0.02***	0.23	0.02***	-0.01***	1.07
	(0.008)	(0.097)	(0.006)	(0.160)	(0.006)	(0.004)	(0.731)
High	0.00	0.02	-0.00	-0.51	0.00	-0.01**	-2.03
	(0.013)	(0.189)	(0.007)	(0.356)	(0.010)	(0.003)	(1.527)
Constant	0.03*	-0.15	-0.02*	0.08	0.01*	-0.01	-0.46
	(0.017)	(0.140)	(0.010)	(0.229)	(0.006)	(0.008)	(0.793)
Observations	87	87	87	87	87	87	87
R-squared	0.12	0.08	0.15	0.13	0.09	0.17	0.27

Source: OECD (Calvino et al. 2018), Eurostat, LFS, WIFO calculations. Note: Robust standard errors clustered at the sector level in parentheses; Unreported time dummies included in all specifications. Sig. levels *** p<0.01, ** p<0.05, * p<0.1.

83 As a robustness check these regressions are repeated using a recently made available sector taxonomy that relies on ICT-specialists (Peneder – Firgo - Streicher 2018), which provides a more direct link to occupational tasks (Appendix B.4.4).

Table 5-8: Y-o-Y Changes in task structures explained by OECD ICT taxonomy

Y-o-Y growth	(1) Routine	(2) Non-routine to routine	(3) Manual	(4) Non-manual to manual	(5) Abstract	(6) Manual, routine	(7) Abstract to Manual Routine
Base year, level	-0.03**	0.02	-0.00	0.03	-0.01	-0.03***	0.16*
	(0.013)	(0.031)	(0.002)	(0.021)	(0.009)	(0.008)	(0.090)
Medium-Low	-0.00	0.07	-0.01**	0.10	0.01**	-0.00	0.14
	(0.004)	(0.046)	(0.003)	(0.067)	(0.003)	(0.002)	(0.121)
Medium-High	-0.00	0.05	-0.01***	0.08	0.01***	-0.00***	0.36
	(0.003)	(0.032)	(0.002)	(0.053)	(0.002)	(0.001)	(0.241)
High	0.00	0.01	-0.00	-0.17	0.00	-0.00**	-0.68
	(0.004)	(0.062)	(0.002)	(0.117)	(0.003)	(0.001)	(0.503)
Constant	0.02**	-0.10	-0.00	-0.01	-0.01	0.00	-0.40
	(0.008)	(0.079)	(0.007)	(0.078)	(0.006)	(0.006)	(0.382)
Observations	261	261	261	261	261	261	261
R-squared	0.05	0.03	0.06	0.08	0.07	0.07	0.06

Source: OECD (Calvino et al. 2018), Eurostat, LFS, WIFO calculations. Note: Robust standard errors clustered at the sector level in parentheses; Unreported time dummies included in all specifications. Sig. levels *** p<0.01, ** p<0.05, * p<0.1.

5.4.5.2. Task structures and selected ICT adoption indicators

The first insights from the general ICT taxonomies are complemented by a more nuanced picture of the use of ICT technologies across sectors. The task groups – in both levels and growth rates – are confronted with information on ICT adoption. The indicators analysed are

- ERP, internal electronic information sharing (percent of enterprises) routine, which are automated;
- Enterprises using Radio Frequency Identification (RFID) technologies for after sales product identification or as part of the production and service delivery (percent of enterprises)
- Social Media (percent of enterprises)
- eInvoices (percent of enterprises)
- Cloud (percent of enterprises)
- CRM, Customer Relationship Management (percent of enterprises)
- Automated information sharing with customer and/or supplier (percent of enterprises)

The ICT adoption indicators were matched with sectoral information on the task structures (determined by occupations) in twelve broadly defined sectors.[84] This led to a limited sample size, which renders exploratory regressions unfeasible.[85]

Using sector means allows showing correlation coefficients with the indicators for task structures. The overall results show few statistically significant relationships. The data does not show a significant relationship between task structures and ERP (information sharing), RFID, and e-

[84] The sectors are C10_18, C19_23, C24_25, C26_33, D35_E39, F41_43, G45_47, H49_53, I, J58_63, L68 and N77_N82.

[85] Due to insufficient sample size the indicators ‘SMEs selling online as a share of total SMEs”, “eCommerce turnover as a share of total turnover” and “SMEs selling online cross border as a share of total SMEs” has not been included.

invoicing. In addition, there is no relationship between routine and non-routine tasks and the used ICT adoption indicators (see Table 5-9).

Sectors in which task structures are dominated by manual tasks use less social media, CRM technologies and cloud services. In addition, sectors in which abstract tasks are more common, and in sectors in which the ratio of abstract to manual labour is high, this relationship is particularly pronounced. In other words, the use of ICT technologies such as CRM and cloud services are associated positively with shares of non-routine tasks and with shares of abstract tasks. Social media is also positively associated with sectors with a prevalence of non-manual tasks.

The analysis of changes in the task structures in the entire period observed (2008-2017) largely confirms this picture. The use of cloud services, CRM and social media is positively associated with the ratio of non-manual to manual tasks. In addition, e-invoicing and cloud services are positively correlated with changes to abstract and non-manual activities. Sectors in which the ratio of non-manual to manual increased also show higher levels of social media presence (see Table 5-10).

This points towards different effects of the analysed technologies. Social Media can be associated with non-manual, cognitive activities, while CRM corresponds with not standardised, non-routine tasks. When internal processes are automated and become routine, the activities are compensated by abstract activities. What is also striking is that ICT used for processes external to the firm show more positive correlations than ICT used for internal processes. This might indicate that internal knowledge is a prerequisite for changing task structures, but not the driver.

Table 5-9: Correlations between task groups and ICT adoption indicators for Austria, indicator means

Task indicator	Routine	Non-routine to routine	Manual	Non-manual to manual	Abstract	Manual, routine	Abstract to Manual Routine
ERP, info sharing	-0.5608	0.4283	-0.4666	0.3616	0.3828	-0.6775	0.3745
RFID	0.1716	-0.1675	0.0990	-0.3423	-0.1965	0.0660	-0.3389
Social media	-0.5425	0.5247	-0.8078*	0.9553*	0.7265*	-0.7181*	0.8384*
e-invoices	-0.4652	0.3960	0.2631	-0.1193	0.2449	0.1442	-0.3339
Cloud	-0.5558	0.5686	-0.9127*	0.9593*	0.7986*	-0.7568*	0.9478*
CRM	-0.7512*	0.7297*	-0.7627*	0.7852*	0.8375*	-0.7422*	0.6475*
Autom. Info sharing	-0.6846*	0.6332*	-0.3351	0.1849	0.5903	-0.4238	0.0225

Source: Eurostat, LFS, WIFO calculations. Note: Stars are set at the 95% significance level.

Table 5-10: Correlations between changes in task groups and ICT adoption indicators for Austria

Growth rate	Routine	Non-routine to routine	Manual	Non-manual to manual	Abstract	Manual, routine	Abstract to Manual Routine
ERP, info sharing	-0.4739	0.4951	-0.6969	0.3534	0.7995*	-0.3163	0.3951
RFID	-0.1030	0.0234	0.2237	-0.3881	-0.1631	-0.2800	-0.3523
Social media	-0.1992	0.3106	-0.1724	0.9504*	0.3701	-0.0486	0.2392
e-invoices	-0.7122*	0.6596*	-0.4696	-0.0620	0.7346*	-0.6832*	0.6520*
Cloud	-0.7099*	0.8115*	-0.0215	0.9259*	0.6465	-0.1934	0.9348*
CRM	-0.3770	0.4944	-0.3662	0.7375*	0.5256	-0.2710	0.3759
Autom. Info sharing	-0.5175	0.5755	-0.4929	0.1246	0.5684	-0.5140	0.4944

Source: Eurostat, LFS, WIFO calculations. Note: Stars are set at the 95% significance level.

5.4.5.3. Can ICT investments explain task structures?

The previous sections shed light on ICT as an underlying factor that explains sectoral occupational (and task) structures. The micro-dynamics that lead to the establishment of task structures are the outcome of complex processes in the production factor 'labour'. These are likely to be intertwined with the capital stock, into which many ICT technologies are embedded.

The following asks if different types of ICT investments, obtained from EUKLEMS data, can explain sectoral occupational structures (expressed in tasks). In other words, we ask whether the structural changes in the task shares across sectors are reflected by ICT investments. To isolate ICT from overall investments, this report follows Calvino et al. (2018) and uses the share of ICT investments in gross capital formation. Hence, the focus is on the relative importance of ICT investments in total investments. Three different types of ICT investments are used:

- Computing equipment (I_IT)
- Communications equipment (I_CT)
- Computer software and databases (I_Soft_DB)

These may have different implications for the respective task groups. Hence, the following uses a slightly different structure and jointly discusses aspects that thematically belong together.

The first set of regressions (see Table 5-11) finds that higher investments into communications equipment and into computer software and databases are associated with a lower share of occupations with mainly manual tasks. Investments into computing equipment and communications equipment are associated with a higher ratio of non-manual to manual tasks. Especially investments in communications equipment seem to accompany the shift from manual to non-manual tasks.

Table 5-11: Regression results for ICT investments explaining manual tasks

Dep. Var.	(1) Manual	(2) Manual	(3) Manual	(4) Nonmanual to Manual	(5) Nonmanual to Manual	(6) Nonmanual to Manual
Comp. Equ.	-5.26 (3.046)			131.07** (48.786)		
Comm. Equ.		-0.99*** (0.267)			30.30*** (6.933)	
Software, DB			-0.97*** (0.317)			12.65 (10.593)
Constant	0.57*** (0.066)	0.56*** (0.062)	0.51*** (0.065)	0.19 (0.755)	-0.31 (0.740)	2.14 (1.468)
Observations	144	144	144	144	144	144
R-squared	0.104	0.277	0.132	0.141	0.579	0.052

Source: EUKLEMS data, LFS, WIFO calculations. Note: Robust standard errors clustered at the sector level in parentheses; Unreported time dummies included in all specifications. Sig. levels *** p<0.01, ** p<0.05, * p<0.1.

The next series of regressions (see Table 5-12) explores the two extremes of the analysed tasks: abstract (analytical and interactive) non-routine tasks on the one hand, and manual routine tasks on the other hand. The results show that the shift away from manual routine towards abstract activities is accompanied by investments in both computer equipment and communications equipment.

Table 5-12: Regression results for ICT investments explaining abstract and manual routine tasks

Dep. Var.	(1) Abstract	(2) Abstract	(3) Abstract	(4) Manual routine	(5) Manual routine	(6) Manual routine	(7) Abstract to Manual routine	(8) Abstract to Manual routine	(9) Abstract to Manual routine
Comp. Equ.	7.56*** (1.673)			-2.23** (0.896)			247.46** (89.878)		
Comm. Equ.		0.97*** (0.208)			-0.27** (0.095)			34.27*** (9.606)	
Software, DB			0.54 (0.374)			-0.45*** (0.130)			31.58 (18.276)
Constant	0.16*** (0.033)	0.21*** (0.057)	0.28*** (0.063)	0.23*** (0.034)	0.21*** (0.030)	0.21*** (0.035)	-1.28 (1.412)	0.17 (1.450)	1.96 (1.852)
Observations	144	144	144	144	144	144	144	144	144
R-squared	0.225	0.287	0.045	0.116	0.126	0.162	0.202	0.295	0.130

Source: EUKLEMS data, LFS, WIFO calculations. Note: Robust standard errors clustered at the sectoral level in parentheses; Unreported time dummies included in all specifications. Sig. levels *** p<0.01, ** p<0.05, * p<0.1.

Eventually, the relationship between routine tasks occupations and ICT investments is studied empirically (Table 5-13). Only investments in computer equipment (as a share of total investments) can be weakly associated with the share of occupations with mostly routine tasks. This result might be due to the definition of the indicator. The diversity of required tasks in the occupations used for defining the group of routine tasks complicates an unambiguous interpretation. Hence, ICT investment indicators are, by and large and as expected, statistically insignificant.

Table 5-13: Regression results for ICT investments explaining routine tasks and the ratio of non-routine to routine tasks

Dep. Var.	(1) Routine	(2) Routine	(3) Routine	(4) Non-routine to routine	(5) Non-routine to routine	(6) Non-routine to routine
Comp. Equ.	-4.53** (1.911)			31.21* (15.227)		
Comm. Equ.		-0.24 (0.175)			0.30 (1.933)	
Software, DB			-0.02 (0.204)			-1.52 (2.031)
Constant	0.51*** (0.045)	0.44*** (0.047)	0.41*** (0.043)	1.14*** (0.292)	1.74*** (0.473)	1.86*** (0.398)
Observations	144	144	144	144	144	144
R-squared	0.212	0.051	0.005	0.076	0.003	0.009

Source: EUKLEMS data, LFS, WIFO calculations. Note: Robust standard errors clustered at the sectoral level in parentheses; Unreported time dummies included in all specifications. Sig. levels *** p<0.01, ** p<0.05, * p<0.1.

5.4.5.4. Tasks explaining economic outcomes

The previous sections have shown that task groups at the sector level are associated with different aspects of ICT. This corroborates the idea that changes of job profiles are not independent of technological dynamics. Yet, it remains unclear whether occupational content, mirrored by the presently used task groups, is a fixed, structural factor or whether task groups are related to economic outcome variables. This implies a change in the implemented approach. The task groups are now explanatory variables and the dependent variables are outcome indicators.

The outcome indicators cover a variety of economic aspects, which also suggest that task structures have different effects on these indicators. The following aspects are explored:

- Value added growth as a key economic outcome variable.
- Labour productivity as an indicator of sectoral efficiency.
- Labour productivity growth as an indicator of efficiency growth.
- Employment growth, which is not only politically relevant, but also in itself an indicator of structural shifts.
- Sector-specific unemployment rates, which – cognisant of conceptual restrictions – may help fine-tune

Box 5-3: Variable definitions

Information on real value added and employment has been obtained from Eurostat. The sector-specific unemployment rates are based on information provided by Statistics Austria (ST.AT).

Value added growth is defined as a three-year logarithmic growth rate, which is based on real value added. Real value added is computed using " B1G_CP_MEUR", i.e. the value added in current million Euro. Real figures are obtained using "B1G_PD10_EUR", which is a Euro-based price index (implicit deflator). The year 2010 is used as the base.

Labour productivity, and its growth rate, are computed as real value added over hours worked. The indicator used is "EMP_DC_THS_HW", which captures the hours worked.

Employment growth is based on the variable "EMP_DC_THS_PER", which is a sectoral measure of the persons employed.

Sectoral unemployment rates are defined using administrative data provided by the Public Employment Service (PES Austria, unemployed) and the Main Association of Austrian Social Security Institutions (HSV, employment). It is defined as the number of registered unemployed, whose last employment was in a given sector, weighted by the labour force (number of employees and unemployed persons) in that given sector.

Time dummies and the output gap control for cyclicality in the level equations. A logarithmic growth rate is used over a three-year period in order to account for the structural nature of the occupational characteristics used. In addition, the levels of the underlying variable in the base year are used to control for a sector-specific characteristic. This is size in the case of the regressions explaining value added and employment, and initial productivity, or efficiency, respectively, in the regressions explaining productivity growth. The output gap controls for cyclicality in the growth equations.

The first set of regressions uses the task groups (determined by occupations) to explain value added growth. Only the share of jobs with mostly manual tasks, and especially the share of jobs with mainly manual routine tasks seems to be negatively associated with value added growth. All other variables are statistically insignificant (see Table 5-14).

Table 5-14: Regression results for task groups explaining sectoral value added growth

Dep. Var.	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Real Value added growth, log. growth rate						
Routine	0.07 (0.077)						
Non-routine to routine		-0.00 (0.004)					
Manual			-0.11** (0.048)				
Non-manual to manual				0.00 (0.001)			
Abstract					0.07 (0.048)		
Manual, routine						-0.16* (0.090)	
Abstract to Manual Routine							0.00 (0.000)
Base year, levels	0.01 (0.013)	0.01 (0.012)	-0.00 (0.013)	0.01 (0.013)	0.00 (0.013)	-0.01 (0.012)	0.01 (0.013)
Output gap	-0.03 (0.028)	-0.03 (0.028)	-0.03 (0.028)	-0.03 (0.028)	-0.03 (0.028)	-0.03 (0.028)	-0.03 (0.028)
Constant	-0.28 (0.298)	-0.18 (0.276)	0.13 (0.296)	-0.11 (0.293)	-0.09 (0.297)	0.18 (0.288)	-0.13 (0.285)
Observations	84	84	84	84	84	84	84
R-squared	0.034	0.029	0.073	0.034	0.039	0.053	0.032

Source: Eurostat data, LFS, WIFO calculations. Note: Robust standard errors clustered at the sectoral level in parentheses. Sig. levels *** p<0.01, ** p<0.05, * p<0.1.

Labour productivity in levels is negatively, yet weakly, associated with jobs with predominantly manual tasks (Table 5-15). Again, all other coefficients are statistically insignificant. The results for labour productivity growth show largely insignificant coefficients. The ratio of occupations with mainly non-routine to routine tasks are weakly, yet negatively, associated with productivity growth (see Table 5-16).

Table 5-15: Regression results for task groups explaining sector-specific labour productivity

Dep. Var.	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Labour productivity (VA per hrs worked), levels in nat. logs						
Routine	0.47 (0.703)						
Non-routine to routine		-0.04 (0.042)					
Manual			-0.70* (0.363)				
Non-manual to manual				0.02 (0.011)			
Abstract					0.46 (0.374)		
Manual, routine						-0.60 (0.662)	
Abstract to Manual Routine							0.01 (0.006)
Output gap	-0.04* (0.020)	-0.03** (0.014)	-0.01 (0.013)	-0.02 (0.014)	-0.02 (0.013)	-0.02 (0.018)	-0.02 (0.016)
Constant	3.53*** (0.273)	3.79*** (0.137)	4.06*** (0.175)	3.68*** (0.113)	3.59*** (0.170)	3.84*** (0.134)	3.70*** (0.115)
Observations	280	280	280	280	280	280	280
R-squared	0.023	0.017	0.125	0.031	0.040	0.040	0.012

Source: Eurostat data, LFS, WIFO calculations. Note: Robust standard errors clustered at the sectoral level in parentheses; Unreported time dummies included in all specifications. Sig. levels *** p<0.01, ** p<0.05, * p<0.1.

Table 5-16: Regression results for task groups explaining sectoral labour productivity growth

Dep. Var.	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Labour productivity growth (VA per hrs worked), log. growth rate						
Routine	0.14 (0.081)						
Non-routine to routine		-0.01* (0.005)					
Manual			-0.04 (0.051)				
Non-manual to manual				0.00 (0.002)			
Abstract					0.01 (0.053)		
Manual, routine						0.02 (0.077)	
Abstract to Manual Routine							-0.00 (0.001)
Base year, levels	-0.02 (0.034)	-0.01 (0.031)	-0.02 (0.032)	-0.01 (0.031)	-0.01 (0.032)	-0.01 (0.032)	-0.01 (0.032)
Output gap	-0.02 (0.028)	-0.02 (0.028)	-0.02 (0.028)	-0.02 (0.028)	-0.02 (0.028)	-0.02 (0.028)	-0.02 (0.028)
Constant	0.02 (0.110)	0.08 (0.104)	0.09 (0.123)	0.06 (0.103)	0.05 (0.100)	0.05 (0.111)	0.05 (0.104)
Observations	84	84	84	84	84	84	84
R-squared	0.034	0.025	0.015	0.009	0.008	0.009	0.012

Source: Eurostat data, LFS, WIFO calculations. Note: Robust standard errors clustered at the sectoral level in parentheses. Sig. levels *** p<0.01, ** p<0.05, * p<0.1.

Table 5-17: Regression results for task groups explaining sectoral employment growth

Dep. Var.	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Persons employed, log. growth rate						
Routine	-0.07 (0.079)						
Non-routine to routine		0.01* (0.004)					
Manual			-0.05 (0.041)				
Non-manual to manual				0.00 (0.002)			
Abstract					0.05 (0.043)		
Manual, routine						-0.12 (0.083)	
Abstract to Manual Routine							0.00** (0.000)
Base year, levels	0.01 (0.012)	0.01 (0.010)	0.01 (0.009)	0.01 (0.009)	0.01 (0.010)	0.01 (0.012)	0.01 (0.009)
Output gap	-0.01 (0.013)	-0.01 (0.012)	-0.01 (0.013)	-0.01 (0.012)	-0.01 (0.012)	-0.01 (0.013)	-0.01 (0.012)
Constant	-0.01 (0.082)	-0.06 (0.046)	-0.02 (0.054)	-0.06 (0.045)	-0.06 (0.046)	0.00 (0.066)	-0.06 (0.045)
Observations	84	84	84	84	84	84	84
R-squared	0.093	0.099	0.106	0.082	0.097	0.124	0.106

Source: Eurostat data, LFS, WIFO calculations. Note: Robust standard errors clustered at the sectoral level in parentheses; Unreported time dummies included in all specifications. Sig. levels *** p<0.01, ** p<0.05, * p<0.1.

The regressions for employment growth, which can be interpreted as an indicator that measures changes in sector structures, support the previously shown trends in the task composition. The ratios of jobs with mainly non-routine to routine tasks and of abstract non-routine to manual routine tasks are both marginally positive and weakly significant (see Table 5-17).

The final set of regressions relates sector-specific unemployment rates to the task structure (see Table 5-18). This analysis confirms that labour market outcomes are worse for sectors that exhibit higher shares of occupations with mainly manual tasks, and better for sectors where the ratio of jobs with predominantly non-manual tasks is higher. The results for other task indicators are statistically insignificant, which may relate to how the measure is constructed. Occupations with mainly manual tasks may have a stronger industry-specific component than occupations with mostly abstract, non-routine tasks.

Table 5-18: Regression results for task groups explaining sector-specific unemployment rates

Dep. Var.	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Sector-specific unemployment rate						
Routine	-3.03 (6.280)						
Non-routine to routine		0.17 (0.481)					
Manual			5.98** (2.838)				
Non-manual to manual				-0.19** (0.095)			
Abstract					-2.96 (2.813)		
Manual, routine						8.57 (5.224)	
Abstract to Manual Routine							-0.08 (0.057)
Output gap	-0.65*** (0.191)	-0.69*** (0.139)	-0.82*** (0.139)	-0.76*** (0.130)	-0.76*** (0.137)	-0.86*** (0.181)	-0.76*** (0.174)
Constant	8.05*** (2.512)	6.50*** (1.263)	3.95*** (1.198)	7.35*** (1.001)	7.66*** (1.391)	5.25*** (0.872)	7.14*** (1.038)
Observations	310	310	310	310	310	310	308
R-squared	0.037	0.031	0.132	0.066	0.045	0.106	0.047

Source: PES, HSV, LFS, WIFO calculations. Note: Robust standard errors clustered at the sectoral level in parentheses; Unreported time dummies included in all specifications. Sig. levels *** p<0.01, ** p<0.05, * p<0.1.

5.4.6. Summary

The task-based approach allows to structure employment based on occupations. By classifying occupations with mainly routine versus non-routine or manual versus non-manual tasks, distinctive characteristics of employment structure in Austria can be analysed. Using this approach, we see that Austria is characterised by a relatively stable relationship between employed persons in jobs consisting mainly of routine tasks at around 40% (of all employees) and non-routine tasks at around 60% (of all employees) in the past two decades. If we look at manual tasks, we can see that the employment structure in Austria is shifting away from manual toward non-manual tasks. This process of divergence between manual and non-manual tasks is increasing. Recently, around 60% of all employees have been engaged in occupations with mainly non-manual tasks (after around 50% in the mid-1990s). The proportion of jobs with mainly manual routine tasks – such tasks that are at high risk of automatization – is around 12%. However, occupations are characterised not only by one single main task, but by a bundle of different tasks. The specific bundle of tasks in an occupation is a deciding factor, whether workers benefit from automation or whether they are negatively affected. Medium-skilled occupations are more often characterised by bundles of tasks than low-skilled and high-skilled occupations. In Austria, about two thirds of all employees are engaged in medium-skilled occupations (ISCO major groups 3-7).

ICT is typically associated with changes in job structures. Using task groups (determined by occupations), this section asks if, and how, changes in the sectoral task composition (based on occupations) are associated with ICT. This approach allows linking ICT with broader trends in occupational structures instead of focusing on (narrowly defined) ICT skills alone. Hence, the analysis provides an alternative to studying the impact of ICT skills, for which there are no data for Austria, by linking general task trends to ICT indicators. The discussion drew on main tasks (for each occupation) which were structured in task groups to show characteristics of 'bundles of tasks', such as the degree to which they are routine or manual activities.

First, this chapter explored the relationship between the ICT taxonomy proposed by the OECD (Calvino et al. 2018) and the sectoral task groups (determined by occupations). Both descriptive statistics and regression results point in the same direction: the higher the digital intensity of a sector, the lower the shares of occupations with mainly manual tasks. In addition, ICT-intensive sectors show a trend in their task structures towards occupations with mainly non-routine tasks at the cost of routine tasks. In particular, occupations with mainly abstract non-routine tasks seem to displace such with manual routine tasks in ICT-intensive sectors.

This general picture was then complemented by relationships between task structures (based on occupations) and the use of ICT technologies obtained from DESI. While some indicators (such as RFID) do not show any relationship with occupations expressed in one main task, the use of cloud services, CRM and also social media is associated with a shift from occupations with mostly manual to non-manual tasks. There is also an aspect of automation. Technologies such as cloud services are negatively correlated with the sectoral share of occupations with predominantly routine tasks, from which occupations with mainly non-routine, abstract tasks benefit.

ICT technologies are in many cases embedded in the capital stock, which illustrates that task groups (determined by occupations) – a structural characteristic of the use of labour – is not independent from investments. Hence, the relative importance of ICT investments (i.e. ICT investment share in total investments) is used to explain task structures across sectors. Especially investment in communications equipment seems to explain differences in the use of occupations with predominantly manual as opposed to non-manual tasks. The shift away from occupations with mainly manual routine towards abstract tasks is accompanied by investments into both computer equipment and communications equipment.

When using task structures (based on occupations) as explanatory variables for economic outcomes, most results are statistically insignificant. This seems to mirror an economy-wide trend, which is hardly related to labour productivity (real value added per hour worked) or labour productivity growth. Value added growth is, however, negatively related to the share of occupations with mostly manual tasks.

The regressions for employment growth support the previously shown trends in the task composition. The ratios of occupations with mainly non-routine to routine tasks and of abstract non-routine to manual routine activities are conducive to employment growth. However, one must keep in mind that employment growth should be interpreted as another indicator that measures changes in sector structures, i.e. two structural indicators are used in this regression. Eventually, labour markets seem to cope less well with occupations with mainly manual tasks and better if the ratio of occupations with mostly non-manual to manual workers is higher. That is, the sector specific unemployment rates are higher (or lower, respectively) when there are more employed persons in occupations with mostly manual tasks. The measure seems to be less applicable to employed persons in occupations with mostly abstract, non-routine tasks.

Overall, the results confirm that the changes in the task structure are related to the digitalisation of the Austrian economy. Digitalisation goes hand in hand with a movement from manual routine tasks towards abstract non-routine tasks especially in more ICT-intensive and growing industries of the Austrian economy.

These findings are relevant for policy. On the one hand, they support a straightforward policy recommendation by the OECD, which ranks "promoting ICT-related skills and competencies" as a top-three policy priority for digitalisation developments (OECD ICT Outlook 2017) for all employees and all educational attainment levels. On the other hand, the results rely on occupations depicted in general task groups. This implies that ICT skills are embedded in wider skill requirements that come with structural change. Hence, ICT skills should be an element of the education system's (initial education system as well as the further education system) response to wider developments in skill demand.

5.5. Platform work

5.5.1. Introduction

According to Eurofound (2018a), platform work is an employment form in which organisations or individuals use an online platform to access other organisations or individuals to solve specific problems or to provide specific services in exchange for payment. Previously, a variety of terms like 'crowd employment', 'sharing economy', 'collaborative economy' and many others were used to capture this form of organising work and to deliver services (cf. Eurofound 2018a, p. 10). Over a very brief time the phenomenon has changed rapidly and now encompasses many more types of tasks beyond classic online 'click-work'. Most recently, the term 'platform work' has become more and more common and was also used by Eurofound (2018a) in its latest publication describing the main features of platform work as follows:

(1) paid work is organised through online platforms

(2) three parties are involved: the online platform, the platform worker and the client

(3) work is contracted out

(4) jobs are broken down into tasks

(5) services are provided on demand.

Platform work attempts to increase flexibility for the client and to reduce the cost of 'empty' or unproductive moments, whilst at the same time maintaining full control over the process of work in order to keep transaction costs to a minimum. To meet these seemingly contradictory goals, two preconditions must be met: first, the crowd of platform workers must be large enough to always have individuals available when needed, and to maintain enough competition between platform workers so as to keep prices low. This is usually achieved through platforms' large and active crowds, with different platforms specializing in different segments of the platform economy. Second, instead of the command-and-control systems inherent in 'traditional' employment relationships, users and platforms rely on 'digital reputation' mechanisms to guide the selection of platform workers and ensure efficient performance control. Individual models vary, but the fundamental approach is consistent: platform workers are awarded points, stars or other symbols of status by the user after completing a task. Quality control itself can thus be crowdsourced by the platform to its customers or other users in order to determine the performance levels of each individual platform worker (Risak 2017a, p. 22).

Platform work may be delivered either online or locally (in person). The most common tasks performed include professional tasks (e.g. software development or graphic design); transport (e.g. person transport or food delivery); household tasks (e.g. cleaning); micro-tasks (e.g. tagging images on web pages) (Eurofound 2018a, p. 5; cf. Schmidt 2017).

5.5.2. *Overview of existing studies estimating the size of this segment of the economy*

Eurofound (2018a p. 11) points out that, in general, very limited data are available across Europe on the number of platforms, workers and clients involved in platform work, and on the tasks, revenue and value-added created. Therefore, most of the available evidence is anecdotal, descriptive and narrow in scope. Nevertheless, a number of data-collection efforts have shed light on platform work and its development (see for an overview Eurofound 2018b). Most of these data come from surveys though and different surveys return different findings, which can be hard to compare due to variations in the terminology and survey method.

For the EU as a whole, Fabo et al. (2017) identified 173 active labour platforms. According to Pesole et al. (2018), around 2% of the European working-age population (aged 16–74) in 14 Member States are engaged in platform work as a main job. For around 6%, platform work generates a significant income (at least 25% of the average wage for a standard working week of 40 hours), and almost 8% perform tasks through digital platforms at least once a month.

For Austria only two studies – Huws – Joyce (2016) and the European Comission (2016) – have quantitatively assessed the prevalence of platform work in Austria. Other information is anecdotal (Eurofound 2018c p. 5). For the Huws – Joyce (2016) study, 2,003 Austrians aged 18-65 were surveyed online and responded about their work experiences via 'sharing economy' platforms in April 2016. It covered the demographic characteristics, work activities and income of platform workers. Some 18% of the respondents indicated they had found work via sharing economy platforms in the last year. 5% of the respondents indicated they found paid work via online platforms at least once a week, while 9% do so at least once a month. The rest responded they perform such work sometimes or never. The majority (59%) of the Austrian platform workers were found to be men. Moreover, platform work is somewhat more likely to be performed by younger people. Most of the platform work is conducted as a side activity. Of the 451 Austrians who had found paid platform work, 2% indicated they receive all their income from platform work, 11% receive more than half, while 59% earn less than half. The remaining 28% responded they do not know or prefer not to say. However, this study was criticized for its methodology (cf. Eurofound 2018c p. 6). The Eurobarometer telephone survey (European Commission 2016a) found that less than 2% (7 out of 501 respondents) regularly offer services using platforms (on a monthly basis). This figure is less than a quarter of the previously outlined findings of Huws – Joyce (2016), but fits in well with the findings of Pesole at al. (2018). Furthermore, 15% of Austrians responded that they had used the services of a platform at least once. However, awareness of the existence of platforms was found to be quite high compared to other European nations. 62% of Austrians had heard of platforms, and by this metric only three EU nations (France, Estonia and Ireland) had a higher awareness rate.

5.5.3. *The regulatory issues*

At the core of platform work is the so-called 'classification problem', i.e. if a platform worker is to be considered an employee and therefore protected by labour laws, including the right to organize and to bargain collectively, or if he/she is a self-employed person that does not enjoy any of these rights (Prassl - Risak 2016). It is therefore important to analyze where the line is drawn between the status of an employee and a self-employed person (European Parliament 2017, p. 67). The received analytical approach, however, was developed in the context of bilateral employment relationships and will therefore struggle with platform work, given the involvement of the platform in addition to the platform workers and users. In order to highlight the problems resulting from a binary contractual analysis of multi-partite contracts, two main questions are at stake: Who are the contractual partners? And, second, if a contractual relationship has been entered into, the question as to its classification arises: What is the nature of the contract between the respective parties? The answer to this question requires an overall assessment of the actual situation, and is of considerable practical importance: employment law protection does not attach to genuine independent contractors but only to employees (European Parliament 2017 p. 67). The exercise one has to undertake to classify the contractual relationships underlying platform work often proves to be complicated and it frequently becomes clear that although numerous arguments exist for the existence of an employment relationship it can be very hard for platform workers to prove this in a court of law. This is due to the complexity of the web of contracts underlying platform work and the sheer impossibility of platform workers gaining insight into the internal workings of the platform. In addition to this, it is not clear who is the employer and whether there is an ongoing employment relationship or just a sequence of fixed-term contracts (Risak 2018).

Risak (2017b) for the Austrian as well as Prassl – Risak (2017) for the EU context have pointed out different ways of dealing with the challenges involved in platform work. They start out with an approach that focusses on who is the employer based on a functional concept developed by Prassl (2015) asking who can best meet the responsibilities deriving from the employer functions. Another approach is the widening of the notion of the employee, which up to now has been primarily based on organizational criteria (cf. Brodl – Risak – Wolf 2016, p. 41) and less on the economic dependency on a single or few contractual partners. A third solution might be the introduction of an intermediate category or, where it already exists, the extension of the employment law provisions applying to this group. The last regulatory avenue explored is the special statutory regulation of platform work, similar to temporary agency work.

It must be pointed out though that the different ways of dealing with the legal and social problems of platform work are complementary rather than mutually exclusive to one another. They also solve the underlying problems to a different extent: while an extension of the notion of the employee for example will bring more platform workers into the protective scope of employment law, this solution does not clearly solve those issues connected with multiple-party work relationships. In any case, some form of statutory regulation dealing with the special problem involved with platform work is considered to be of essence (Risak 2018, p. 10; Eurofound 2018c, p. 11) because of the specific problems connected to platform work, such as unfair terms and conditions, unclear contractual situations and the significant importance of the so-called digital reputation.

Another issue is the social protection of platform workers. This very much depends on the coverage of the social security system in place, i.e. if it only covers employees there is more of an issue than with systems that also provide protection for self-employed persons.

5.5.4. The regulatory status quo and legislative projects in Austria

As no specific regulatory framework has been developed for platform work in Austria, general regulatory frameworks apply (Eurofound 2018c, p. 5; European Commission 2016b). This means on the one hand that the specific problems connected to platform work are not yet regulated and that on the other hand the often difficult classification exercise has to be undertaken in order to find out whether the platform worker is an employee. There are no published cases on platform work but anecdotal evidence suggests that the distinction between employees and self-employed in the platform economy is difficult and keeps platform workers from enforcing their rights.

For some cases a solution may be found with the existing category of "arbeitnehmerähnliche Personen" (employee-like persons). A limited portion of labour legislation applies to economically dependent self-employed individuals, including self-employed platform workers if the criteria for being classified as an employee-like person are met. This group is defined as persons who perform work/services by order of and on account of another person without being in an employment relationship, but who may be considered employee-like due to their economic dependence (Risak – Rebhahn 2017, p. 20). Only some provisions of labour law apply to employee-like persons, especially those on the competence of the labour courts, agency work, employee liability and anti-discrimination. The courts also apply (a few) other provisions, if they do not require personal subordination (e.g. notice periods).[86] Therefore, many important provisions of labour law are not

[86] (Austrian) Supreme Court of 29.1.2010 – 1 Ob 190/09m, wbl 2010, 300.

applied to this group, such as dismissal protection, paid holidays or sick leave payment, as they require full employee status. Collective labour rights (especially with respect to collective bargaining and work place representation) also do not extend to employee-like persons in Austria.

Online platform work performed in the home of the platform worker is not covered by the Home Work Act (Heimarbeitsgesetz) that might provide a certain protection including the possibility of stipulated minimum wages to self-employed who work from home to produce or pack specific goods for an employer. However, as the law stands, the Home Work Act is limited to production, processing, or packaging of goods in a worker's home or workplace of choice. Platform work, however, concerns the delivery of services or – in the case of online work – intellectual services that are not covered by this Act (Eurofound 2018b, p.8). In the literature it has been suggested to amend the Home Work Act to include platform workers (Warter 2016). This would only cover online work but not the growing sector of services that are delivered locally like transportation or cleaning (Risak 2017a, p. 57).

In 2017 under the then grand coalition between the Social Democrat Party and the conservative People's Party there was one concrete effort to introduce a dedicated regulatory framework for platform work. An Austrian legal scholar was commissioned by the Social Ministry to draft a piece of legislation that would define 'platform work' and related terms, and would contain a clear regulatory framework. It would have entailed a shift in burden of proof; platforms would have been assumed to have an employment relationship with platform workers, which would have been rebuttable. Other components of the platform work legislation would have ensured, among other items, the portability of ratings, and forbidden the practice of keeping completed work while refusing to pay for it. This draft piece of legislation has not been subject to public debate or passed as law (Eurofound 2018c, p. 11). In any case, the project was not followed up on by the new government coalition in place since late 2017 between the People's Party and the Freedom Party.

In cases concerning cross-border platform work, Regulation (EC) Number 593/2008 of the European Parliament and of the Council on the law applicable to contractual obligations (Rome I Regulation) applies. According to this Regulation, the governing principle is freedom of choice regarding the applicable law (Article 3). However, this is limited when it comes to consumer contracts (Article 6) and employment contracts (Article 8). In these cases, the level of protection cannot fall below that which would be provided in the absence of choice. However, a consumer contract does not exist in the case of platform work, as the associated contracts can be attributed to the platform workers' professional or commercial activity, thus not matching the legal definition of Article 6 of the Rome I Regulation. In the event platform workers can be deemed employees Article 8 of the Rome I Regulation stipulates, the parties' choice of law cannot lead to the employees being deprived of the protection that they would have had in the event of absence of choice. Therefore, the (relatively) mandatory provisions of the state's labour law in which the work is normally rendered applies at the very least. This circumstance alone shows the importance of the correct classification of platform workers (Risak 2018, p. 11).

As concerns social security coverage, since 1998 Austria has a mandatory social security system that encompasses all forms of employment – from dependent employment (employees) to independent work (self-employed). The Austrian mandatory insurance system is composed of health insurance, pension insurance, workplace accident insurance and unemployment insurance (Bruckner – Krammer 2017). The only distinction between employees and self-employed as regards mandatory insurance cover arises with unemployment insurance. The self-employed are not automatically subject to unemployment insurance, but have the possibility to voluntarily 'opt-in'. There are no special rules for platform workers (Eurofound 2018c, p. 8), but they are covered either as employees or self-employed. In detail, the insurance of these two groups is somewhat different, as the contributions are split between employer and employees or persons working under employee-like free service contracts while the self-employed have to pay the full contributions themselves. The latter also have to administer their social insurance on their own, while this is the obligation of employers for their employees or persons working under employee-like free service contracts (cf. Bruckner – Krammer 2017).

5.5.5. Comparisons – weaknesses and strengths of the Austrian system compared to select EU member states

If one compares the Austrian system to select EU member states, it can be said that the system has its weaknesses and its strengths when it comes to the social protection of platform workers. On the weakness side there is not only the non-existence of an encompassing regulation of platform work (something that is, however, lacking in all EU member states) but also the limited number of laws that apply to the intermediary category of employee-like persons. This is of importance as employee status is often hard to prove in a court of law and therefore an intermediary category may help, not only with the classification but also with the enforcement problem.

In the United Kingdom (Jones - Prassl 2017, p. 753) the law has increasingly provided a number of secondary gateways into a smaller but substantive set of basic employment rights for workers. This includes the right to the national minimum wage, protection against unlawful deductions from wages, the statutory minimum level of paid holiday, the statutory minimum working time regulations (rest breaks and maximum weekly working time), protection against unlawful discrimination and in the case of ‘whistleblowing’.[87] Interestingly, the famous case against Uber (Aslam, Farrar & Others vs Uber B.V., Uber London Ltd and Uber Britannia Ltd[88]) was brought before the court based on the argument that the drivers concerned were workers and not employees. In Germany, employee-like persons (Waas 2017, p. 273) are also entitled to bargain collectively as they are covered by a special provision in the Act on Collective Bargaining (Tarifvertragsgesetz). They also enjoy the right to annual leave, are covered by anti-discrimination laws and fall under the competence of the labour courts. The situation is similar in Spain (Murcia – Cardo 2017, p. 673, Corujo 2017, p. 35), where the intermediate category of economically-dependent self-employed workers (trabajadores autónomos económicamente dependientes) was introduced. For this group, certain guarantees are (partly) secured by the law regarding conditions on contract termination, working time limitations, coverage against work-related accidents and cessation of activities, and the recognition of collective agreements.

The experiences with the intermediate category are, however, mixed. De Stefano (2016, p. 20) warns, citing the Italian case, that regulating dependent self-employment is no panacea for addressing the changes in business and work organisation driven by the disintegration of vertical firms. Nor should it be overseen that persons qualifying for full protection as employees under the current legal tests would likely become deprived of many rights if they were crammed into an “intermediate bucket”. Intermediate categories can, therefore, prove to be an obstacle in achieving full labour protection when employment relationships are disguised.

Some of these problems could be solved by the special statutory regulation of platform work, preferably on the EU-level in the form of a “Directive on Fair Working Conditions in the Platform Economy” (Risak 2017b, Risak 2018, Eurofound 2018c). At the heart of such specialized regulation should be a rebuttable legal assumption that the important underlying contractual relationship to provide platform work is an employment contract between the platform worker and the platform. An additional solution could be the creation of a catalogue of criteria that indicate the existence of an employment relationship. It might also include prohibitions to recruit for services that are paid below the applicable minimum wages as well as certain contractual clauses and special provisions on digital reputation (ratings) including their portability to another platform. Of essence is the clarification that the right to organize in unions, to bargain collectively and to exercise co-determination at the workplace and company level also applies to platform workers as

87 Cf. https://www.gov.uk/employment-status/worker (23.10.2018).

88 https://www.judiciary.uk/wp-content/uploads/2016/10/aslam-and-farrar-v-uber-employment-judgment-20161028-2.pdf (23.10.2018).

well as the explanation of who is responsible for employer obligations, including the joint responsibilities of users where appropriate.

One of the definitive strengths of the Austrian system is the extensive social security coverage that extends not only to employees but also to the self-employed. This becomes especially clear when looking at the situation in Germany (Eurofound 2018d, p. 6), where full social security coverage is only mandatory for employees in the strict sense. German solo self-employed individuals can only opt into the obligatory social security system and receive sickness insurance, long-term care insurance, and pension insurance, but they are responsible for 100% of the contribution.

5.5.6. Summary

The Austrian system of labour laws and social security regulations has its weaknesses and strengths when it comes to the social protection of platform workers. On the downside there is the non-existence of an encompassing regulation of platform work – as in most European countries and the limited number of laws that apply to the intermediary category of employee-like persons. On the strength side is the extensive social security coverage that extends not only to employees but also to the self-employed. Self-employed individuals are also covered by provision of law by the obligatory social security system (except unemployment insurance that they may opt into). In the case of working under employee-like free service contracts, the contributions are even split between such service providers and their contractual partners.

5.6. Summary and conclusions

This chapter covers a wide range of education-specific and labour-related issues, beginning with skills (ICT skills, basic skills) and employment by task to platform work. The main results are as follows:

- There is a significant increase in the number of ICT specialists in Austria, especially of ICT specialists with higher qualifications. Nevertheless, quantitative evidence and findings from the expert interviews suggest that Austrian firms have difficulties in recruiting ICT specialists. But there seems to be no clear indication of for which kind of ICT specialists the labour shortage constraints are binding.
- Apart from ICT specialist skills, basic digital skills are required in many jobs. However, Austrians with low educational attainment have a quite distant relationship to digital technologies.
- Insufficient or missing basic skills are not just a problem for adults, expressed in high risk of unemployment or employment loss, but also for pupils and students. This creates problems in an economic environment characterised by digitalisation, where it is increasingly essential to have digital skills, which require basic skills as a foundation.
- The imparting of such skills must already start in school, for which suitable infrastructure equipment is indispensable. The available data on infrastructure equipment in Austrian schools, however, shows that it varies considerably between school types. Especially in primary schools and in general secondary schools there are still many classrooms (around one in five) without an internet connection.
- Austria has been characterised by a relatively stable relationship between employed persons in jobs focusing on routine tasks (around 40% of employees) and non-routine tasks (around 60% of all employees) over the past two decades. Structural change due to digitalisation primarily affects manual work. The share of jobs characterized by non-manual tasks has increased from around 50% in the mid-1990s to around 60% in the most recent years. The proportion of jobs with mainly manual routine tasks – such tasks that are at high risk of automatization and digitalisation – is around 12%.
- Routine manual task tasks are most frequently carried out by low-skilled workers. Low-skilled workers are also subject to a high risk of unemployment and employment loss. The unemployment rate of low-skilled persons (who completed compulsory education at most)

is currently almost three times as high (25.3%, 2017, according to a national calculation method based on PES-data and social security employment data) than the average unemployment rate (8.5%), with a high distance to the unemployment rate of the highly qualified (3.4%).

- Combining task trends with ICT-intensity, ICT technology use across sectors, types of ICT investments shows that a higher digital intensity goes hand in hand with a lower share of occupations with mainly manual (routine) tasks; the use of cloud services is highest in industries with occupations with mainly non-routine tasks; investments in computer and communications equipment are accompanied with shifts away from occupations with mainly manual routine towards occupations with abstract tasks. This confirms that changes in the task structure are associated with the digitalisation of the Austrian economy.
- Digitalisation does not only affect the structure of employment, but also the form of employment. Platform work is an emerging form of work that challenges labour law and social security regulations. The Austrian system of labour laws and social security regulations has its weaknesses and strengths when it comes to the social protection of platform workers, a new form of work associated with the digital transformation. An institutional weakness side is not only the non-existence of an encompassing regulation of platform work, but also the limited number of laws that apply to the intermediary category of employee-like persons. One of the strengths of the Austrian system is the extensive social security coverage that extends not only to employees but also to the self-employed.

Based on these findings, the following policy conclusions can be derived:

(1) Promoting ICT-related skills and competencies for all employees and all educational attainment levels; countering labour shortages

- Reforming the Red-White-Red Card. Labour shortages can be contained by education in the long term, be re-training in the short term and by criteria-based immigration in the short term. The Red-White-Red Card allows criteria-based immigration for workers in shortage occupations. Its requirements are high, and its use is not flexible enough for high-skilled ICT specialists.
- Introducing measures helping finance education, training and re-training Measures are needed to enhance the employability of workers, such as training measures or measures that helps to finance education, training and re-training. In Austria the key tools to help people in further education and training to finance their everyday needs – i.e. educational leave, part-time educational leave, skilled workers' grant and the grant for students who have supported themselves for at least four years before starting their studies – offer insufficient support to those most particularly affected by automatization and the digitalisation of the working world. It seems thus necessary to adapt such tools and focus them on low- to medium-skilled individuals.

(2) Establishing ICT skills as part of the education system (initial education system as well as the further education system)

- Investments in technical equipment in schools: The prerequisite for teaching digital skills is an appropriate infrastructure. This must be ensured for all types of schools in Austria.
- Investments in prevention measures (improving learning outcomes): Investments in the early stages of school careers in primary school (or in kindergarten), especially such that prevent competence weaknesses, can help to train the skills that are decisive for further school education and vocational training and help reduce the proportion of young people with low literacy and numeracy skills.

Table 5-19: Policy transferability table

Observed problem	Drivers	Solution taken in Austria / [proposed solution]	Lessons learnt
Labour shortage in ICT specialists with high qualification	Labour shortages can be filled only by criteria-based immigration.	Reform of Red-White-Red-Card	Criteria-based immigration for ICT specialists from third countries needs to be flexible with regard to requirements.
Different levels of technical equipment in schools (lower in primary schools than in upper secondary schools)	Different responsible authorities in the Austrian federal structure.	Provision of an adequate ICT equipment for all types of schools	The teaching of digital skills requires digital equipment.
Learning outcomes often depending on social background; learning outcomes are significantly better in academic-track secondary schools than in general secondary schools; comparatively poor results for children with a migration background or children from schools with very high social disadvantage	Early separation of pupils into different school types; lack of prevention measures	Prevention measures for poorly performing pupils	Digital skills build on basic skills. Therefore, a focus on learning outcomes for pupils from disadvantaged backgrounds is essential for increasing digital skills in the population.
High unemployment rate of low-skilled workers compared to skilled workers	Lack of (adequate) training measures and measures helping finance education, training and re-training; access difficulties	Obligatory education and training-measure until the age of 18 Measures that help finance education, training and re-training	Vulnerable workers need retraining options.

6. CONCLUSIONS

This report provides a comprehensive overview and analysis of the state of digitalisation in the Austrian economy. Austria aims to become a European Innovation Leader, but indicators suggest that Austria is lagging behind the Innovation Leaders[89] in the crucial field of digitalisation. The report has identified several issues that emerge from the interaction of industrial specialisation patterns, digital infrastructure, the adoption of digital technologies and the need for digital skills.

6.1. Summary of the main findings

The first chapter of the report provides a bird's eye perspective on performance of the Austrian economy regarding a large set of digitalisation indicators that are relevant for assessing the state of play and the development over time. The overall picture that emerges from this exercise is mixed. The ICT-producing sector in Austria is small compared to the Innovation Leaders (3% of GDP compared to 4%).

Given Austria's industrial specialisation in machinery and equipment, patent applications are concentrated in a few fields of digitalisation, especially in domains related to Industry 4.0. Austria lags behind the Innovation Leader countries in terms of patents in digital technologies and non-ICT patents citing ICT patents. However, this gap narrows down when patent quality is taken into account. As regards patenting in the Industry 4.0 technologies, Austria's performance is well above that of the Innovation Leaders. This reflects Austria's industrial specialisation, and shows that in these fields the country is able to develop sophisticated technologies.

Consequently, the portfolio of ICT-intensive products that are exported from Austria is remarkably complex and hints at a high level of product quality despite comparatively low export quantities. Austria's ICT exports are stagnating at a low level and the gap between Austria and the Innovation Leaders regarding ICT exports is increasing.

Regarding technology diffusion in Austria, the picture that emerges is also mixed: Austria scores better than the group of Innovation Leaders in the categories e-invoicing, adoption of ERP systems, adoption of customer relationship management (CRM) software, cross-border online sales and RFID. Its performance is below the Innovation Leaders in the adoption of cloud computing, social media, and adoption of systems that automatically link to customers/suppliers as well as concerning the percentage of business turnover from e-commerce.

As for technology development and exports, some of the national figures of ICT adoption are driven by the sectoral composition of a country or industry-specific results. After correcting for the sectoral composition, the performance of Austria with regard to the adoption of social media improved, but did not reach the level of the Innovation Leader countries. Austrian enterprises generally perform well in the adoption of digital technologies that are implemented in internal business processes but much less so for technologies oriented towards marketing and reaching beyond the boundaries of their firms.

Chapter 3 looked in depth into the digitalisation performance Austrian manufacturing firms.

The evidence for Austrian manufacturing enterprises in digitally intensive sectors shows that Austrian companies derive their competitive advantage from the technological content of their products, the qualification of the work force, product quality and their capability to customise their products. Main challenges from digitalisation for these enterprises are unexpected changes in the

[89] The Innovation Leader in this Study are: Sweden, Denmark, Finland, United Kingdom, the Netherlands and Luxembourg. For more detail see the European Innovation Scoreboard homepage (https://ec.europa.eu/growth/industry/innovation/facts-figures/scoreboards_en).

competitive environment and operative aspects related to the adoption of digital technologies such as the standardisation of data interfaces.

The supply of a skilled workforce is seen by enterprises in industries with medium or high digital intensity as a primary aspect to maintain their competitiveness over time. Large Austrian manufacturing companies perceive the underinvestment in Austria regarding telecommunications infrastructure as an important but not major constraint for their own competitiveness.

Austria is above the average of the EU28 Member States in many indicators for the adoption of Industry 4.0 related technologies (e.g. ERP systems and supply chain integration) in manufacturing industries and for digital platforms in services, but does not figure among the leading countries in Europe.

Weaknesses can be detected, especially concerning the take-up of digitalisation in the service industries. Reform needs emerge regarding the diffusion of digital technologies, as a slower diffusion in SMEs and service industries is observed.

Chapter 4 studied the diffusion of digital technologies in more detail by concentrating on microenterprises, SMEs and industrial dynamics.

Austria has lower industry dynamics (firm entry rate, firm turnover rate, high growth firm share) than the comparison countries, except for the ICT-producing sector, where the Austrian performance is comparable to the performance of the Innovation Leader countries. For ICT services the Austrian performance is below the Innovation Leaders. This result is not related to a higher SME or microenterprise share in Austria. The weakness in industry dynamics shows that there is a need for structural policies to foster business dynamics, as the findings show that the adoption of digital technologies is lower in sectors with a higher SME share and faster in sectors with a higher entry rate.

Most microenterprises in Austria are aware of the challenges and opportunities of digitalisation. Many microenterprises carry out digitalisation projects that are mostly small in scale compared to their total investment. However, larger digitalisation projects are often carried out within larger investment projects. The focus of the digitalisation projects is mainly on firm-internal digital networks (e.g. ERP systems) but also on digital customer interaction (e.g. CRM tools). Only a minority of firms implements new projects to develop new ICT-based business models.

The challenges microenterprises and smaller enterprises face regarding digitalisation are mainly related to information gaps and a lack of know-how. Entrepreneurs face uncertainty about the available technologies and solutions that are available and best suited to their situation (know-what) and uncertainties in deploying digital solutions (know-how), as new digital solutions often require changes in business processes. Regulation and financial factors are also mentioned as important hampering factors holding back digitalisation in microenterprises.

Regarding existing support schemes, the “KMU-Digital” programme provides a good example for a low threshold programme to foster the digitalisation of SMEs. However, most support schemes focus on grants and the manufacturing sector. Here, policies should be broadened to include instruments aimed at closing financing gaps, also for service firms.

Chapter 1 covered a wide range of education and labour related issues of digitalisation. The findings show that the number of ICT specialists increased substantially in Austria, but the evidence shows that Austrian firms have difficulties in recruiting ICT specialists. However, there is no clear indication for which kind of ICT specialists the labour shortage constraints are more pronounced.

Basic digital skills are required in many jobs. However, Austrians with low educational attainment, in particular women and young people, have a quite distant relationship to digital technologies. Low-skilled workers with low educational attainment are subject to a high risk of unemployment and employment loss, as digitalisation is associated with a shift away from manual work

Insufficient or missing digital skills are not just a problem for adults on the labour market but also for pupils. Basic skills in literacy und numeracy are needed for digital skills. In Austria not all students achieve the learning goals in these skill dimensions in compulsory school. They possess basic skills in literacy and numeracy at most and can use them, if at all, for routine and manual work. In an economic environment characterised by digitalisation, apart from possessing enough basic skills, it is increasingly essential to have the appropriate digital skills, which need basic skills as a foundation.

The imparting of such skills must already start in school. This requires that schools have appropriate ICT equipment. Here the available data indicate that the digital infrastructure of Austrian schools shows quite some variation across school types. Especially in primary schools and in general secondary schools there are still many classrooms without an internet connection.

The structural analysis of the task content of Austrian employment revealed a relatively stable pattern between jobs characterized by routine (40%) and non-routine jobs (60%) over the past decade, but at the same time a gradual structural change away from manual work. The analysis confirms that changes in the occupational task structure are associated with the digitalisation of the Austrian economy: Industries with a higher digital intensity have a lower share of occupations with manual tasks, and investment in computer and communications equipment (digitalisation) is accompanied by a shift from occupations with manual routine tasks towards occupations with abstract tasks. This affects labour market outcomes. Manual routine tasks – most highly endangered by digitalisation – are most frequently carried out by low-skilled workers with low educational attainment.

Digitalisation also affects working patterns and the form of employment. Platform work is an emerging form of work that challenges labour law and social security regulations. The Austrian system of labour laws and social security regulations has its weaknesses and its strengths when it comes to the social protection of platform workers, a new form of work associated with the digital transformation. Institutional weaknesses and potential areas of reform are related to the non-existence of an encompassing regulation of platform work and to the limited number of laws that apply to the intermediary category of employee-like persons. One of the strengths of the Austrian system is the extensive social security coverage that extends not only to employees but also to the self-employed.

6.2. Policy towards digitalisation in Austria and needs for structural reform

The Austrian digitalisation policy landscape is currently in a phase of reorganisation. Many federal competences have been centralised in the new Ministry of Digital and Economic Affairs (bmdw). A new agency, the Digitalisierungsagentur (DIA) was established in September 2018. Both institutions are expected to have a positive impact on the effectiveness of policy making and policy coordination in Austria.

However, there are still concerns about the coherent implementation of ICT policies. Coordination challenges are expected to remain, due to split competences among many agents in the federal policy field and the "*fuzzy policy landscape*", which federal governance structures tend to bring about. Drawing on coordination efforts within the "Digital Roadmap", the recently established initiative "Digital Austria" further bundles policy discussions. Compared to the Digital Roadmap, Digital Austria constitutes progress in efforts to streamline and harmonise decision processes among a variety of actors.

The findings suggest that in order to improve policy outcomes,

- a clearer and more transparent prioritisation of policy fields,
- a continuation of the streamlining of competences, and
- the establishment of a monitoring and evaluation framework

are necessary to provide a coherent formulation of policies across the different departments and layers of federal Austrian policy structure.

One important element of digitalisation policy is e-government. In Austria, the “only once” principle is a cornerstone for achieving this goal. However, different speeds of digitalisation in the public administration and last but not least the split competences in many administrative procedures across ministries and administrative units across the federal layers lead to coordination failures and interface problems. The further expansion of e-government requires further efforts to overcome these problems.

A second critical aspect is broadband take-up and network infrastructure, which have both been identified as a key policy priority. Austria underperforms, especially in fixed broadband take-up rates (position 18 in the DESI ranking of 2018). In addition, the per capita infrastructure investments in all telecom infrastructures in Austria are comparatively low. SMEs and microenterprises perceive a need for fast internet connections. This would require stepping up investment in the broadband network infrastructure.

Since 2015, a broadband deployment promotion programme has been in place to address this long-standing bottleneck of digitalisation. It focuses on the establishment of broadband infrastructures and aims to close the digital divide between urban and underserved rural areas. An interim evaluation supports the continuation of the programme. The evaluation also recommended some adjustments in the programme design with respect to a greater focus on 5G readiness and, relatedly, the establishment of a fibre optic grid.

Regarding the promotion of innovative digital products for manufacturing, firms the policy landscape seems to be well developed. However, the findings suggest that measures are somewhat biased towards technological innovation.

At the federal level, the research support agency FFG provides support for R&D projects and laws for innovative start-ups, large expansion investment projects and innovation. Further support agencies exist at lower federal layers (Bundesländer). These agencies provide several support programmes that support enterprises with new innovative digital solutions. Two programmes exist that support ambitious digitalisation projects (AT:net and Industrie 4.0), even though there have been some set-backs, in particular concerning the financing of the AT:net programme. Moreover, the Austrian enterprise support schemes that foster innovation and investment are also open for digitalisation projects, provided that they are large. Thus, public support for R&D and innovation activities related to digitalisation is available from different sources, including financial support, community building and creating awareness for best-practices.

However, this does not extend to services and smaller digitalisation projects from SMEs. For smaller digitalisation projects the Bundesländer have set up support programmes that also aim at supporting smaller digitalisation projects. The focus of most dedicated programmes to support digitalisation are grants. This is appropriate for the support of qualification and training but less for the support of investment projects. Here, reforms should focus on closing funding gaps that prevent firms from implementing digitalisation projects.

The most important policy priorities mentioned by SMEs and microenterprises are the provision of information and consulting services for the implementation of digital transformation projects. At the moment, the most important programme providing such consulting services for micro- and small enterprises is “KMU Digital”. By providing information and advice for firms interested in digitalisation, KMU Digital contributes to reducing substantive uncertainty (what can we do) and procedural uncertainty (how can we proceed) that is associated with digitalisation programmes at the enterprise level. KMU Digital also supports the training of consultants that provide consulting to small and very small enterprises. The new Digitalisierungsagentur (DIA) also has an important focus on the coordination of digitalisation support for SMEs. Digital Innovation Hubs should act as entry points for SMEs interested in digitalisation.

Gaps exist in the regulatory framework to support industry dynamics that are related to:

- Gaps in market-based finance: The private risk capital market and the capital markets in general are not well developed. This may hamper the start-up of ambitious ICT firms and the innovative exploration of new business models. Further support for the establishment of market based financial ecosystems is warranted to increase industry dynamics.

- Sector-specific entry and conduct regulations: Further pushes in welfare-improving and growth-enhancing deregulation should foster industry dynamics and the diffusion of digital technologies. The barriers are highest in reglemented trades and liberal professions. However, the welfare effects of a deregulation need to be assessed on a profession-by-profession basis. Additional steps should be made to reduce administrative burdens for ambitious start-ups. Setting up more complex types of limited liability companies is onerous in Austria compared to many other EU countries.

Reform needs arise regarding the ICT skills and competencies of the workforce. This calls for a reform of the criteria-based immigration system and a stronger focus on ICT in education as well as in the training and re-training of employees.

Labour shortages can be addressed by education in the long term, by retraining in the medium term and by criteria-based immigration in the short term. The Red-White-Red Card allows criteria-based immigration for workers in shortage occupations. However, formal requirements to obtain the Card are high, and its use is not flexible enough for highly skilled ICT specialists. A reform is planned.

Measures financially supporting education, training and re-training are needed to enhance the employability of workers. Austria has in place a number of instruments to secure basic financial subsistence to support education and training investments by persons already integrated in the workforce. The available evidence suggest that these instruments are insufficiently targeted to persons that are primarily affected by automatization and digitalisation.

In the education system the provision of digital skills needs to be a priority. This requires investments in technical equipment in schools, as appropriate equipment is a prerequisite for teaching digital skills. But it also requires stepping up preventive measures to improve learning outcomes at an early age, as basic skills are needed for the development of digital skills. The reduction of the fraction of students with low literacy and numeracy skills needs to be a policy priority, as the digital transformation continues to reduce the share of jobs for the low-skilled.

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APPENDIX: DIGITALISATION IN AUSTRIA: STATE OF PLAY AND REFORM NEEDS

A. Interviews and interview partners

In order to gather additional qualitative information, a number of persons were contacted. They provided important information relevant for the assessment of policy programmes, the working of and transformation of the policy environment in Austria and information about ongoing, but not yet finalised policy initiatives. In addition, they provided more detailed insights into the topics of digitalisation of SMEs, microenterprises and ICT specialists in Austria. Especially relevant for this task were the in-depth background interviews. Here, interview partners were selected that were able to contribute different perspectives and practical experience. The interview partners for the in-depth interviews were:

1. Christian Rupp (Austrian Chambers of Commerce, Speaker of the platform Digitales Österreich)
2. Lucas Bonanni and Evrim Bakir (BaringPoint GmbH)
3. Andreas Stix (Stix Experts)
4. Kristof Kovacs (Online projects)
5. Norbert Knoll (AWS)
6. Wolfram Anderle (AWS)
7. Ralf Mittermayr (Saubermacher)
8. Anton Leitner (NÖM)
9. Peter Voithofer (KMU-Forschung)
10. Richard Lax and Gilbert Konzett (Kapsch Group)
11. Philip Kügler (Pcom Consulting and Optink)
12. Wolfgang Ebner (BMDW)
13. Alexios Seibt (Arthur D Little Austria)
14. Andreas Henkel (WKO Sparte Gewerbe und Handwerk)
15. Michael Binder (FFG)
16. Michael Fellner (Digitalisierungsagentur)
17. Paul Pisjak (RTR)
18. Paul Gültekin (freelance programmer)

Four additional interview partners did not want to have their name and affiliation mentioned in the report.

B. Supplementary material

B.1. Appendix to Chapter 2

B.1.1. Decomposition methodology for a structurally adjusted DESI

The decomposition is based on the following three estimations:

$$Digi_{ijt} = \alpha + \beta_i I + \beta_t T + \epsilon_{ijt}$$

$$Digi_{ijt} = \alpha + \beta_j J + \beta_t T + \epsilon_{ijt}$$

$$Digi_{ijt} = \alpha + \beta_i I + \beta_j J + \beta_t T + \epsilon_{ijt},$$

where the 28 countries are indexed by *i (=1, ..., 28),* and the 12 sector groups are indexed by *j (=1, ..., 12).*[90] $Digi$, *I*, *J* and *T* are various indicators for digitalisation (e.g. DESI indicators), country-, sector- and time-specific vectors of dummy variables respectively. α is the constant, β_i, β_j, and β_t are the vectors of parameters to be estimated.

Equation (**Error! Reference source not found.**) examines the extent to which country-specific conditions explain the variance in different digitalisation indicators. The adjusted R^2 suggests that, depending on what digitalisation indicator is used, national differences explain between 24% (RFID) and 71% (e-invoice) of the variation across the EU MS(Table B-0-1).

Some indicators seem highly dependent on national conditions. These include the variation of the shares of enterprises sending e-invoices to other enterprises or public authorities suitable for automatic processing. Other indicators can hardly be explained by national differences, such as the use of RFID technologies or social media. This suggests that in some cases technological diffusion is mediated or caused by national regulations. The use of such technologies is rather independent of sectoral differences.

54% of the variation in the shares of enterprises buying cloud computing services of medium-high sophistication can be explained by country-specific conditions. Since the legal environment for cloud computing is not only challenging, but has been identified as a key barrier for adoption, national legal requirements (and, relatedly, trust in cloud services) can play a significant role in the explanation of heterogenous diffusion (ETSI 2013). Considering the global nature of cloud computing algorithms, a coordination of legal frameworks across the EU might reduce those heterogeneous country-fixed effects and help improve technological convergence within the Single Market.

Equation (**Error! Reference source not found.**) examines the extent to which sector specifics explain the variation in different digitalisation indicators. The adjusted R^2 shows that sectoral differences explain between 6% (e-invoice) and 60% (social media) of the variation across the EU MS. Especially with respect to social media, but also CRM (46%) and ERP (39%), specific requirements and preferences of certain sectors play a major role in explaining differences in the degree of technological adoption. (Table B-0-2).

For instance, social media is rather used for promotion and information sharing in B2C industries, such as in tourism; the same holds for the use of CRM software in retail trade.

Equation (**Error! Reference source not found.**) includes all three fixed effects. The simultaneous effects of national and industry-specific factors explain between 46% (RFID) and 87% (Social Media) of the variance in digital intensity across countries and industries. (

[90] Malta and the sector group N77 to N82 are used as bases, i.e. all other estimated coefficients must be interpreted in relation to them.

Table B-0-3).

Some technologies, such as RFID, seem to be rather independent of national or sectoral idiosyncrasies, although RFID is particularly often used in retail and wholesale (G45-47) as well as in the energy sector (D35-E39).

The digital-intensive sectors (the publishing, telecommunications, the IT and financial sectors (J58-63)) have the highest coeffients. These sectors are characterised as high-tech and knowledge-intensive industries which offer more opportunities to use digital technologies. These sectors are associated with higher levels of digital adoption. In contrast, some sectors such as construction (F41-43), lag behind. They show a poor performance in technology adoption indicators.

The manufacturing sector shows a significant high adoption rate of ERP and RFID systems, but low use rates of social media or CRM software. However, the significantly low usage of cloud computing solutions in those sectors is unexpected. Especially with respect to the application of cloud computing algorithms Austria is trailing behind. While the nationwide use of e-invoices is significantly higher in Austria than in Belgium (which is our reference country in the regressions), the adoption rate of cloud computing algorithms and ERP systems is, on average, lower.

Since the inclusion of sectoral fixed effects implies that a specific sector has the same impact on a specific digitalisation indicator in every country, equation (3) is augmented by a measure of sector size to control for heterogeneous industry structure. The value added share of every sector in a given country at a given point in time is used to measure sector size.

$$Digi_{ijt} = \alpha + \beta_i I + \beta_j J + \delta_j (VAShare_{ijt} \odot J) + \beta_t T + \epsilon_{ijt},$$

where $VAShare$ is the sectoral value added share measuring sector size, $\odot$ denotes pairwise multiplication of vectors and δ_j, is the respective vector of parameters that controls for heterogeneous industry structures. The explained variance of the various digitalisation indicators ranges between 45% (RFID) and 88% (Social Media). (

Table B-0-4)

This allows estimating the values of the DESI indicators controlling for the industry structure. These results lead to a new country ranking that can be compared with the original (and officially published) country ranking. Due to the industry adjustment, Austria’s estimated average position deviates from the original ranking. In other words, the sector specialisation seems to have an effect on the DESI rankings.

Table B-0-1: Results of the regression of digitalisation indicators on country-specific effects

Countries	ERP	RFID	SM	EINV	Cloud	CRM	SISC
AT	-7,270 (3.05)**	0.374 (0.43)	-2,605 (0.82)	8,139 (4.46)**	-8,795 (3.75)**	1,296 (0.45)	-8,619 (5.45)**
BG	-22,052 (9.88)**	4,448 (5.19)**	-9,572 (3.12)**	-2,869 (1.76)+	-9,785 (4.34)**	-24,870 (9.27)**	-5,888 (3.82)**
CY	-15,290 (6.88)**	-1,626 (1.93)+	13,101 (4.30)**	-6,837 (4.19)**	-7,719 (3.77)**	-11,147 (4.16)**	-11,707 (7.64)**
CZ	-17,290 (7.78)**	-4,357 (5.18)**	-8,115 (2.52)*	-0.387 (0.24)	-5,795 (2.69)**	-23,916 (8.92)**	-8,615 (5.62)**
DE	-6,293 (2.83)**	-1,741 (2.07)*	-4,243 (1.39)	1,181 (0.73)	3,751 (0.71)	3,898 (1.45)	-2,957 (1.93)+
DK	-5,930 (2.53)*	-3,664 (4.36)**	1,510 (0.49)	47,467 (26.85)**	13,524 (6.56)**	-10,073 (3.63)**	-2,897 (1.82)+
EE	-26,067 (11.74)**	-2,434 (2.90)**	-7,399 (2.43)*	2,324 (1.44)	-2,307 (0.98)	-20,870 (7.78)**	-11,378 (7.42)**
EL	-6,337 (2.53)*	-3,562 (3.77)**	-1,962 (0.61)	-9,759 (5.59)**	-12,118 (5.51)**	-24,348 (8.03)**	-9,418 (5.16)**
ES	-10,811 (4.85)**	0.374 (0.45)	4,774 (1.57)	8,575 (4.92)**	-2,129 (1.05)	-8,901 (3.32)**	-8,286 (5.41)**
FI	-7,454 (3.33)**	0.259 (0.31)	8,370 (2.75)**	57,657 (22.74)**	25,621 (12.66)**	-2,681 (0.99)	-2,918 (1.90)+
FR	-6,173 (2.75)**	-1,989 (2.32)*	-3,397 (1.06)	-1,420 (0.56)	-3,423 (1.45)	-14,332 (5.34)**	-13,391 (8.74)**
HR	-19,368 (8.26)**	-1,011 (1.20)	-2,688 (0.88)	-3,387 (2.10)*	1,545 (0.76)	-23,249 (8.57)**	10,038 (6.49)**
HU	-30,006 (13.51)**	-2,357 (2.80)**	-6,284 (2.06)*	-7,912 (4.54)**	-8,744 (4.32)**	-29,947 (11.17)**	-15,615 (10.19)**
IE	-19,314 (8.70)**	0.374 (0.45)	15,101 (4.96)**	4,423 (2.24)*	8,803 (4.13)**	-9,978 (3.72)**	-11,720 (7.65)**
IT	-12,951 (5.80)**	-1,480 (1.74)+	-3,264 (1.07)	6,230 (3.16)**	2,693 (1.14)	-13,224 (4.93)**	-8,470 (5.53)**
LT	-9,216 (4.13)**	0.297 (0.35)	-0.264 (0.09)	8,844 (5.47)**	-2,513 (1.24)	-16,562 (6.18)**	3,306 (2.16)*
LU	-5,904 (2.55)*	0.513 (0.59)	-1,355 (0.43)	-1,863 (0.92)	-4,253 (1.74)+	-6,272 (2.28)*	-3,055 (1.93)+
LV	-30,482 (13.66)**	-3,126 (3.72)**	-7,380 (2.42)*	0.289 (0.17)	-9,191 (4.49)**	-25,470 (9.50)**	-5,273 (3.44)**
MT	-16,147 (7.13)**	-0.283 (0.32)	7,234 (2.32)*	-2,908 (1.62)	-1,199 (0.48)	-16,773 (6.09)**	-9,197 (5.81)**
NL	-5,191 (2.34)*	-1,895 (2.26)*	18,909 (6.21)**	1,767 (1.09)	11,962 (5.06)**	-3,147 (1.17)	-9,602 (6.26)**
PL	-24,030 (10.74)**	-2,203 (2.62)**	-9,111 (2.99)**	-2,938 (1.68)+	-10,571 (5.22)**	-18,141 (6.54)**	-6,820 (4.26)**
PT	-3,735 (1.53)	-0.857 (1.02)	-4,593 (1.45)	1,994 (1.07)	-3,334 (1.50)	-14,006 (4.76)**	7,076 (4.42)**
RO	-25,134 (11.24)**	-2,664 (3.17)**	-10,611 (3.48)**	-5,249 (3.01)**	-11,032 (5.45)**	-25,301 (9.33)**	-14,722 (9.55)**
SE	-1,489 (0.65)	-2,934 (3.49)**	4,236 (1.39)	17,153 (8.69)**	15,693 (6.64)**	-3,178 (1.19)	-3,510 (2.29)*
SI	-12,166 (5.48)**	-0.052 (0.06)	-0.091 (0.03)	16,477 (9.45)**	-3,075 (1.51)	-16,209 (6.04)**	-6,707 (4.38)**
SK	-17,598 (7.92)**	-1,549 (1.84)+	-6,034 (1.98)*	-1,194 (0.68)	-3,340 (1.65)+	-19,916 (7.43)**	-2,326 (1.52)
UK	-30,647 (13.64)**	-3,434 (4.09)**	15,966 (4.84)**	-3,962 (2.01)*	2,500 (1.06)	-18,544 (6.86)**	-12,018 (7.82)**
Constant	47,504 (25.27)**	6,275 (10.26)**	21,361 (8.58)**	17,055 (13.28)**	15,823 (9.36)**	46,613 (20.59)**	21,437 (17.31)**
Observations	2040	699	1,337	1,058	1,050	1,664	1,997
Adjusted R-squared	0.42	0.24	0.27	0.71	0.54	0.34	0.38

Source: WIFO calculations. Note: t statistics in parenthesis; + $p < 0.1$, * $p < 0.05$, ** $p < 0.01$; Time-fixed effects are included; Belgium and the sector group N77 to N82 are used as bases, i.e. all other estimated coefficients must be interpreted in relation to them.

Table B-0-2: Results of the regression of digitalisation indicators on sector-specific effects

Sectors	ERP	RFID	SM	EINV	Cloud	CRM	SISC
C10-18	7,676 (5.55)**	1,355 (2.33)*	-5,294 (3.95)**	3,791 (1.72)+	-6,564 (4.04)**	-4,133 (2.95)**	3,504 (3.26)**
C19-23	21,302 (15.14)**	2,491 (4.29)**	-3,744 (2.76)**	0.827 (0.38)	-5,531 (3.38)**	3,597 (2.38)*	5,536 (4.84)**
C24-25	10,265 (7.30)**	0.683 (1.18)	-8,997 (6.69)**	-2,370 (1.07)	-7,955 (4.81)**	-5,061 (3.35)**	2,849 (2.52)*
C26-33	19,453 (13.99)**	1,864 (3.21)**	-1,242 (0.92)	-0.042 (0.02)	-4,785 (2.93)**	2,081 (1.48)	6,843 (6.35)**
D35-E39	10,459 (7.20)**	3,743 (6.39)**	-5,109 (3.74)**	3,338 (1.48)	-2,739 (1.61)	3,068 (2.10)*	1,590 (1.44)
F41-43	-4,876 (3.54)**	-1,413 (2.44)*	-11,184 (8.35)**	-1,566 (0.71)	-6,285 (3.85)**	-12,361 (8.80)**	-1,808 (1.68)+
G45-47	12,643 (9.17)**	1,828 (3.15)**	0.229 (0.17)	3,244 (1.47)	-3,839 (2.36)*	7,241 (5.19)**	13,513 (12.62)**
H49-53	-0.698 (0.50)	2,337 (4.02)**	-8,472 (6.30)**	-0.897 (0.40)	-5,916 (3.62)**	-6,157 (4.38)**	5,383 (4.99)**
I55	0.608 (0.43)	0.029 (0.05)	17,774 (12.99)**	4,670 (2.10)*	-1,493 (0.90)	7,904 (5.53)**	4,878 (4.50)**
J58-63	20,892 (14.90)**	0.301 (0.52)	34,858 (25.33)**	3,665 (1.65)	20,271 (12.22)**	27,600 (19.50)**	9,675 (8.94)**
K64-66	14,579 (7.12)**	0.000	0.000	0.000	0.000	32,445 (16.15)**	0.000
L68	2,546 (1.73)+	-1,812 (2.94)**	1,403 (0.99)	-3,677 (1.62)	0.234 (0.14)	-0.376 (0.25)	-2,728 (2.42)*
M69-74	5,547 (3.98)**	-1,792 (3.07)**	6,935 (5.16)**	-1,661 (0.75)	4,736 (2.90)**	5,409 (3.84)**	0.269 (0.25)
Constant	24,753 (21.24)**	4,140 (9.70)**	20,491 (19.42)**	15,222 (8.47)**	15,980 (11.87)**	30,034 (26.43)**	11,356 (12.68)**
Observations	2,040	699	1,337	1,058	1,050	1,664	1,997
Adjusted R-squared	0.39	0.22	0.60	0.06	0.32	0.46	0.25

Source: WIFO calculations. Note: t statistics in parenthesis; + p < 0.1, * p < 0.05, ** p < 0.01; Time-fixed effects are included; Belgium and the sector group N77 to N82 are used as bases, i.e. all other estimated coefficients must be interpreted in relation to them.

Table B-0-3: Results of the regression of digitalisation indicators on sector-and country-specific effects

Countries/ Sectors	ERP	RFID	SM	EINV	Cloud	CRM	SISC
AT	-7,046 (4.17)**	0.064 (0.09)	-2,611 (1.94)+	8,166 (4.72)**	-9,841 (7.36)**	-0.456 (0.29)	-8,621 (6.28)**
BG	-23,240 (14.68)**	4,301 (5.92)**	-11,584 (8.90)**	-3,265 (2.11)*	-12,711 (9.87)**	-27,363 (18.43)**	-5,902 (4.42)**
CY	-16,638 (10.56)**	-1,598 (2.25)*	11,086 (8.58)**	-7,068 (4.58)**	-9,967 (8.54)**	-13,640 (9.19)**	-11,554 (8.69)**
CZ	-18,638 (11.82)**	-4,329 (6.09)**	-10,142 (7.43)**	-0.612 (0.40)	-7,859 (6.40)**	-26,409 (17.79)**	-8,462 (6.37)**
DE	-7,699 (4.87)**	-1,713 (2.41)*	-5,932 (4.58)**	1,034 (0.67)	-11,898 (3.92)**	1,378 (0.93)	-2,804 (2.11)*
DK	-6,830 (4.11)**	-3,637 (5.11)**	-0.056 (0.04)	47,199 (28.17)**	11,436 (9.74)**	-11,439 (7.46)**	-3,059 (2.21)*
EE	-27,416 (17.39)**	-2,406 (3.38)**	-9,414 (7.29)**	2,100 (1.37)	-4,364 (3.24)**	-23,363 (15.74)**	-11,225 (8.45)**
EL	-6,270 (3.53)**	-3,336 (4.17)**	-1,668 (1.21)	-9,986 (6.04)**	-12,448 (9.94)**	-25,755 (15.31)**	-9,082 (5.74)**
ES	-11,999 (7.58)**	0.402 (0.57)	2,759 (2.14)*	8,347 (5.05)**	-4,200 (3.64)**	-11,394 (7.67)**	-8,133 (6.12)**
FI	-8,562 (5.40)**	0.287 (0.40)	6,355 (4.92)**	57,395 (23.90)**	23,550 (20.41)**	-4,281 (2.87)**	-2,764 (2.08)*
FR	-7,234 (4.54)**	-2,081 (2.87)**	-5,424 (3.97)**	-1,681 (0.70)	-5,479 (4.07)**	-16,825 (11.33)**	-13,238 (9.96)**
HR	-20,630 (12.41)**	-0.983 (1.38)	-4,703 (3.64)**	-3,612 (2.36)*	-0.527 (0.46)	-25,432 (16.94)**	10,019 (7.47)**
HU	-31,354 (19.89)**	-2,329 (3.28)**	-8,299 (6.42)**	-8,140 (4.92)**	-10,815 (9.37)**	-32,440 (21.85)**	-15,462 (11.63)**
IE	-20,663 (13.11)**	0.402 (0.57)	13,086 (10.13)**	4,184 (2.24)*	6,734 (5.54)**	-12,471 (8.40)**	-11,567 (8.70)**
IT	-14,138 (8.93)**	-1,536 (2.14)*	-5,280 (4.09)**	5,992 (3.20)**	0.636 (0.47)	-15,717 (10.59)**	-8,317 (6.26)**
LT	-10,404 (6.57)**	0.325 (0.46)	-2,280 (1.76)+	8,619 (5.63)**	-4,585 (3.97)**	-19,055 (12.83)**	3,459 (2.60)**
LU	-7,004 (4.26)**	0.398 (0.54)	-2,643 (2.00)*	-2,459 (1.28)	-6,301 (4.53)**	-8,652 (5.68)**	-3,332 (2.43)*
LV	-31,670 (20.01)**	-3,098 (4.36)**	-9,395 (7.27)**	0.063 (0.04)	-11,435 (9.81)**	-27,963 (18.83)**	-5,120 (3.85)**
MT	-17,582 (10.94)**	-0.175 (0.24)	4,827 (3.65)**	-3,218 (1.89)+	-3,264 (2.32)*	-18,951 (12.45)**	-9,684 (7.06)**
NL	-6,540 (4.15)**	-1,867 (2.63)**	16,893 (13.08)**	1,542 (1.01)	9,905 (7.35)**	-5,640 (3.80)**	-9,449 (7.11)**
PL	-25,660 (16.16)**	-2,175 (3.06)**	-11,126 (8.61)**	-3,165 (1.92)+	-12,642 (10.96)**	-21,830 (14.21)**	-7,099 (5.12)**
PT	-6,202 (3.57)**	-0.829 (1.17)	-4,207 (3.12)**	1,370 (0.78)	-4,602 (3.63)**	-17,786 (10.92)**	6,846 (4.93)**
RO	-26,242 (16.54)**	-2,637 (3.71)**	-12,626 (9.77)**	-5,476 (3.31)**	-13,104 (11.36)**	-26,893 (17.93)**	-14,641 (10.95)**
SE	-2,866 (1.76)+	-2,906 (4.09)**	2,220 (1.72)+	16,915 (9.05)**	13,636 (10.12)**	-5,671 (3.82)**	-3,356 (2.53)*
SI	-13,515 (8.57)**	-0.199 (0.27)	-2,107 (1.63)	16,244 (9.84)**	-5,125 (4.43)**	-18,701 (12.60)**	-6,554 (4.93)**
SK	-18,947 (12.02)**	-1,521 (2.14)*	-8,049 (6.23)**	-1,422 (0.86)	-5,412 (4.69)**	-22,409 (15.09)**	-2,172 (1.63)
UK	-31,669 (19.88)**	-3,406 (4.79)**	14,090 (10.08)**	-4,200 (2.25)*	0.444 (0.33)	-20,925 (13.99)**	-11,946 (8.96)**

C10-18	7,725 (8.14)**	1,332 (2.75)**	-5,270 (6.85)**	3,824 (3.29)**	-6,312 (8.29)**	-3,786 (4.43)**	3,255 (3.85)**
C19-23	21,868 (22.63)**	2,536 (5.24)**	-3,550 (4.56)**	0.906 (0.78)	-5,482 (7.14)**	4,780 (5.18)**	5,504 (6.10)**
C24-25	11,043 (11.43)**	0.659 (1.36)	-8,955 (11.61)**	-2,499 (2.13)*	-8,329 (10.74)**	-3,985 (4.32)**	2,800 (3.14)**
C26-33	19,731 (20.65)**	1,841 (3.80)**	-1,201 (1.55)	-0.010 (0.01)	-4,659 (6.07)**	2,478 (2.89)**	6,649 (7.83)**
D35-E39	11,861 (11.87)**	3,760 (7.69)**	-4,705 (6.01)**	3,666 (3.08)**	-2,826 (3.52)**	4,466 (5.01)**	1,522 (1.75)+
F41-43	-5,018 (5.31)**	-1,400 (2.90)**	-11,161 (14.54)**	-1,533 (1.32)	-6,238 (8.14)**	-12,365 (14.43)**	-2,021 (2.38)*
G45-47	12,502 (13.22)**	1,804 (3.73)**	0.254 (0.33)	3,276 (2.82)**	-3,633 (4.76)**	7,351 (8.64)**	13,244 (15.69)**
H49-53	-0.308 (0.32)	2,313 (4.78)**	-8,472 (10.99)**	-0.954 (0.81)	-5,772 (7.53)**	-6,069 (7.08)**	5,347 (6.29)**
I55	0.971 (1.01)	0.088 (0.18)	17,930 (22.83)**	4,676 (3.97)**	-1,370 (1.75)+	9,008 (10.31)**	4,714 (5.52)**
J58-63	21,531 (22.36)**	0.277 (0.57)	34,818 (44.08)**	3,618 (3.07)**	20,389 (26.03)**	28,039 (32.44)**	9,507 (11.14)**
K64-66	15,258 (10.82)**					33,557 (27.31)**	
L68	4,387 (4.32)**	-1,324 (2.57)*	1,505 (1.85)+	-3,542 (2.96)**	-0.294 (0.36)	1,256 (1.39)	-2,588 (2.91)**
M69-74	5,896 (6.17)**	-1,792 (3.68)**	6,908 (8.96)**	-1,684 (1.44)	4,862 (6.35)**	5,883 (6.84)**	0.113 (0.13)
Constant	40,070 (27.32)**	5,461 (8.90)**	22,074 (18.82)**	16,507 (11.41)**	19,429 (17.83)**	46,405 (34.01)**	17,696 (14.61)**
Observations	2,040	699	1,337	1,058	1,050	1,664	1,997
Adjusted R-squared	0.71	0.46	0.87	0.74	0.85	0.80	0.53

Source: WIFO calculations. Note: t statistics in parenthesis; + $p < 0.1$, * $p < 0.05$, ** $p < 0.01$; Time-fixed effects are included; Belgium and the sector group N77 to N82 are used as bases, i.e. all other estimated coefficients must be interpreted in relation to them.

Table B-0-4: Results of the regression of digitalisation indicators on sector-and country-specific effects controlling for sector size

Variables	ERP	RFID	SM	EINV	Cloud	CRM	EIS
VAShare-C10-18	-81,479 (3.15)**	-33,995 (2.26)*	-12,641 (0.56)	-51,066 (1.43)	0.659 (0.03)	16,075 (0.61)	-24,620 (0.94)
VAShare-C19-23	68,290 (3.48)**	13,649 (1.40)	-7,818 (0.59)	-28,924 (1.08)	1,148 (0.08)	-14,480 (0.80)	26,351 (1.38)
VAShare-C24-25	163,844 (3.34)**	58,983 (2.38)*	31,485 (0.86)	-35,625 (0.61)	57,099 (1.59)	96,594 (2.02)*	67,865 (1.39)
VAShare-C26-33	101,678 (6.38)**	14,054 (1.71)+	11,247 (0.90)	16,245 (0.90)	6,478 (0.51)	37,151 (2.42)*	28,162 (1.77)+
VAShare-D35-E39	63,631 (1.11)	-85,449 (2.94)**	-56,630 (1.30)	-110,027 (1.59)	-92,040 (1.77)+	45,679 (0.85)	-112,831 (2.06)*
VAShare-F41-43	50,699 (1.54)	-3,682 (0.19)	22,570 (0.80)	-22,424 (0.47)	15,615 (0.55)	31,615 (0.97)	9,620 (0.29)
VAShare-G45-47	-6,058 (0.32)	-0.106 (0.01)	17,590 (1.11)	0.720 (0.03)	20,746 (1.31)	-13,177 (0.70)	1,718 (0.09)
VAShare-H49-53	83,095 (3.08)**	0.111 (0.01)	69,629 (3.14)**	55,660 (1.58)	62,660 (2.92)**	106,547 (3.87)**	13,496 (0.48)
VAShare-I55	116,390 (4.70)**	-10,495 (0.82)	129,990 (7.03)**	110,342 (3.88)**	-1,076 (0.06)	137,794 (5.60)**	41,974 (1.67)+
VAShare-J58-63	-91,292 (2.74)**	3,619 (0.22)	184,457 (7.21)**	-17,378 (0.40)	109,803 (4.00)**	47,905 (1.48)	-6,185 (0.19)
VAShare-L68	0.305 (0.02)	-0.034 (0.00)	9,833 (0.81)	10,449 (0.54)	8,461 (0.72)	-5,162 (0.33)	5,892 (0.35)
C10-18	13,515 (6.57)**	3,704 (3.19)**	-4,389 (2.51)*	7,455 (2.67)**	-6,368 (3.56)**	-4,840 (2.34)*	5,411 (2.60)**
C19-23	17,766 (11.81)**	1,703 (2.20)*	-3,068 (2.76)**	2,655 (1.33)	-5,564 (4.82)**	5,870 (4.11)**	4,167 (2.80)**
C24-25	6,075 (3.46)**	-1,152 (1.27)	-9,925 (7.37)**	-1,400 (0.64)	-10,091 (7.51)**	-6,690 (3.90)**	0.883 (0.50)
C26-33	10,083 (5.67)**	0.509 (0.55)	-2,286 (1.62)	-1,524 (0.74)	-5,280 (3.73)**	-0.900 (0.52)	4,009 (2.26)*
D35-E39	8,499 (2.68)**	8,010 (5.25)**	-1,940 (0.85)	9,274 (2.49)*	1,794 (0.65)	2,190 (0.74)	7,891 (2.65)**
F41-43	-9,410 (3.13)**	-1,093 (0.65)	-13,016 (5.34)**	0.307 (0.07)	-7,547 (3.03)**	-15,311 (5.21)**	-2,791 (0.92)
G45-47	13,635 (3.71)**	1,826 (0.88)	-3,035 (0.99)	3,142 (0.62)	-7,555 (2.45)*	10,157 (2.78)**	13,142 (3.47)**
H49-53	-8,125 (3.00)**	2,305 (1.58)	-14,958 (6.81)**	-6,331 (1.76)+	-11,776 (5.39)**	-16,301 (5.96)**	4,351 (1.57)
I55	-4,325 (2.96)**	0.559 (0.73)	11,754 (10.18)**	-0.611 (0.34)	-1,336 (1.17)	3,249 (2.25)*	3,027 (2.06)*
J58-63	28,685 (10.32)**	-0.005 (0.00)	19,951 (9.09)**	4,940 (1.39)	11,860 (5.25)**	25,220 (9.23)**	10,507 (3.86)**

L68	4,376 (1.53)	-1,312 (0.95)	-0.034 (0.02)	-5,110 (1.63)	-1,607 (0.82)	2,879 (1.12)	-3,204 (1.17)
AT	-8,201 (4.68)**	-0.015 (0.02)	-1,551 (1.14)	8,321 (4.49)**	-8,738 (6.29)**	0.231 (0.13)	-7,441 (4.79)**
BG	-23,195 (14.25)**	4,702 (6.02)**	-10,704 (8.09)**	-2,832 (1.70)+	-11,699 (8.77)**	-25,866 (16.00)**	-3,818 (2.52)*
CY	-16,841 (10.27)**	-1,320 (1.72)+	10,616 (8.06)**	-8,240 (4.89)**	-9,406 (7.72)**	-12,128 (7.46)**	-10,331 (6.80)**
CZ	-20,142 (12.29)**	-4,631 (6.03)**	-9,108 (6.56)**	-0.071 (0.04)	-6,557 (5.13)**	-25,953 (15.93)**	-7,623 (5.03)**
DE	-7,277 (4.43)**	-2,012 (2.63)**	-4,992 (3.79)**	1,371 (0.83)	-10,690 (3.54)**	3,245 (1.98)*	-0.223 (0.15)
DK	-7,481 (4.39)**	-3,925 (5.20)**	-0.255 (0.19)	47,613 (26.71)**	11,721 (9.69)**	-10,193 (6.17)**	-1,564 (1.01)
EE	-27,714 (17.04)**	-2,228 (2.93)**	-8,685 (6.65)**	2,678 (1.63)	-3,486 (2.52)*	-20,814 (12.87)**	-10,200 (6.78)**
EL	-6,254 (3.39)**	-3,217 (3.69)**	-1,698 (1.19)	-10,689 (5.91)**	-10,955 (8.33)**	-24,176 (13.35)**	-8,299 (4.48)**
ES	-12,765 (7.84)**	0.616 (0.81)	2,647 (2.03)*	8,064 (4.56)**	-3,265 (2.74)**	-10,126 (6.26)**	-7,406 (4.91)**
FI	-8,421 (5.17)**	0.396 (0.52)	6,450 (4.94)**	57,470 (22.50)**	23,611 (19.80)**	-3,056 (1.89)+	-1,775 (1.18)
FR	-6,956 (4.25)**	-2,057 (2.66)**	-5,013 (3.65)**	-1,597 (0.63)	-4,683 (3.38)**	-14,433 (8.93)**	-12,249 (8.15)**
HR	-20,327 (11.91)**	-0.415 (0.54)	-3,824 (2.91)**	-3,342 (2.02)*	0.876 (0.73)	-23,678 (14.45)**	9,582 (6.28)**
HU	-32,410 (19.86)**	-2,540 (3.33)**	-7,389 (5.64)**	-8,128 (4.58)**	-9,656 (8.05)**	-29,995 (18.47)**	-15,216 (10.09)**
IE	-19,861 (11.89)**	0.329 (0.42)	13,515 (10.04)**	5,071 (2.47)*	7,734 (5.96)**	-10,304 (6.17)**	-10,608 (6.83)**
IT	-14,955 (9.19)**	-1,530 (2.00)*	-4,464 (3.42)**	5,678 (2.85)**	1,814 (1.31)	-13,586 (8.40)**	-8,208 (5.46)**
LT	-10,225 (6.25)**	0.616 (0.80)	-1,913 (1.45)	9,328 (5.62)**	-4,019 (3.34)**	-15,280 (9.39)**	5,463 (3.60)**
LU	-6,236 (3.68)**	0.328 (0.41)	-2,655 (1.98)*	-2,284 (1.11)	-5,803 (4.03)**	-5,327 (3.16)**	-2,246 (1.43)
LV	-31,398 (19.27)**	-2,929 (3.85)**	-8,977 (6.87)**	0.462 (0.26)	-10,621 (8.80)**	-26,502 (16.38)**	-4,813 (3.19)**
MT	-17,277 (10.31)**	0.194 (0.24)	4,138 (3.07)**	-3,248 (1.76)+	-2,654 (1.82)+	-18,293 (10.96)**	-9,188 (5.85)**
NL	-4,940 (3.04)**	-2,019 (2.67)**	16,868 (12.96)**	1,592 (0.97)	9,840 (7.11)**	-2,062 (1.28)	-8,627 (5.75)**
PL	-25,811 (15.71)**	-2,043 (2.68)**	-9,840 (7.50)**	-2,454 (1.38)	-11,332 (9.47)**	-19,746 (12.00)**	-5,775 (3.75)**
PT	-6,343 (3.56)**	-0.348 (0.46)	-3,885 (2.86)**	1,336 (0.71)	-3,455 (2.65)**	-16,947 (9.61)**	6,695 (4.27)**
RO	-26,813 (16.35)**	-2,501 (3.28)**	-11,762 (8.96)**	-4,749 (2.67)**	-11,995 (10.01)**	-25,725 (15.78)**	-14,081 (9.28)**
SE	-2,939 (1.74)+	-3,018 (3.98)**	1,443 (1.11)	17,166 (8.61)**	13,472 (9.73)**	-4,710 (2.91)**	-4,594 (3.06)**
SI	-15,311 (9.41)**	-0.379 (0.49)	-1,095 (0.84)	16,805 (9.50)**	-4,104 (3.42)**	-16,837 (10.40)**	-5,907 (3.93)**
SK	-20,401 (12.49)**	-1,712 (2.24)*	-7,366 (5.61)**	-0.992 (0.56)	-4,329 (3.61)**	-22,109 (13.61)**	-2,169 (1.43)
UK	-31,172 (19.01)**	-3,348 (4.41)**	13,454 (9.53)**	-4,126 (2.07)*	0.757 (0.55)	-18,422 (11.27)**	-10,214 (6.76)**
Constant	40,395 (27.13)**	5,411 (8.39)**	17,794 (14.73)**	16,393 (10.76)**	18,553 (16.70)**	44,344 (30.51)**	16,662 (12.41)**
Observations	1,830	645	1,231	967	966	1,240	1,582
Adjusted R-squared	0.74	0.45	0.88	0.73	0.85	0.80	0.53

Source: Eurostat, WIFO calculations; Sectoral information on value added is not available for sectors K64-66, M69-74; Note: t statistics in parenthesis; + $p < 0.1$, * $p < 0.05$, ** $p < 0.01$; Time-fixed effects are included; Belgium and the sector group N77 to N82 are used as bases, i.e. all other estimated coefficients must be interpreted in relation to them.

Table B-0-5: Country estimates of digitalisation indicators; lower and upper bound of the 95% confidence interval

ERP						RFID					
Country	Estimate	Lower	Upper	New Rank	Rank	Country	Estimate	Lower	Upper	New Rank	Rank
BE	40.40	37.48	43.32	1	1	BG	10.11	8.58	11.65	1	1
SE	37.46	34.15	40.76	2	2	ES	6.03	4.53	7.52	2	4
NL	35.45	32.27	38.64	3	5	LT	6.03	4.52	7.53	3	6
LU	34.16	30.83	37.49	4	7	FI	5.81	4.31	7.30	4	7
EL	34.14	30.52	37.76	5	6	IE	5.74	4.20	7.28	5	4
PT	34.05	30.56	37.55	6	3	LU	5.74	4.17	7.31	6	2
FR	33.44	30.22	36.65	7	8	MT	5.61	4.03	7.18	7	10
DE	33.12	29.90	36.34	8	9	BE	5.41	4.14	6.68	8	8
DK	32.91	29.58	36.25	9	4	AT	5.40	3.85	6.94	9	3
AT	32.19	28.76	35.63	10	10	PT	5.06	3.56	6.56	10	11
FI	31.97	28.78	35.17	11	11	SI	5.03	3.50	6.56	11	9
LT	30.17	26.96	33.38	12	12	HR	5.00	3.50	6.50	12	12
ES	27.63	24.44	30.82	13	13	CY	4.09	2.58	5.60	13	15
IT	25.44	22.25	28.63	14	15	IT	3.88	2.38	5.39	14	13
SI	25.08	21.89	28.28	15	14	SK	3.70	2.20	5.20	15	14
CY	23.55	20.34	26.77	16	16	DE	3.40	1.90	4.90	16	16
MT	23.12	19.83	26.41	17	17	NL	3.39	1.91	4.88	17	17
IE	20.53	17.26	23.81	18	20	PL	3.37	1.87	4.87	18	19
CZ	20.25	17.04	23.47	19	18	FR	3.35	1.83	4.87	19	18
HR	20.07	16.72	23.42	20	21	EE	3.18	1.69	4.68	20	21
SK	19.99	16.79	23.20	21	19	RO	2.91	1.41	4.41	21	22
BG	17.20	14.01	20.39	22	22	HU	2.87	1.37	4.37	22	20
PL	14.58	11.36	17.81	23	23	LV	2.48	0.99	3.98	23	24
RO	13.58	10.37	16.80	24	24	SE	2.39	0.90	3.88	24	23
EE	12.68	9.49	15.87	25	25	EL	2.19	0.48	3.91	25	25
UK	9.22	6.01	12.44	26	28	UK	2.06	0.57	3.55	26	26
LV	9.00	5.80	12.19	27	27	DK	1.49	0.00	2.97	27	27
HU	7.99	4.78	11.19	28	26	CZ	0.78	-0.73	2.29	28	28

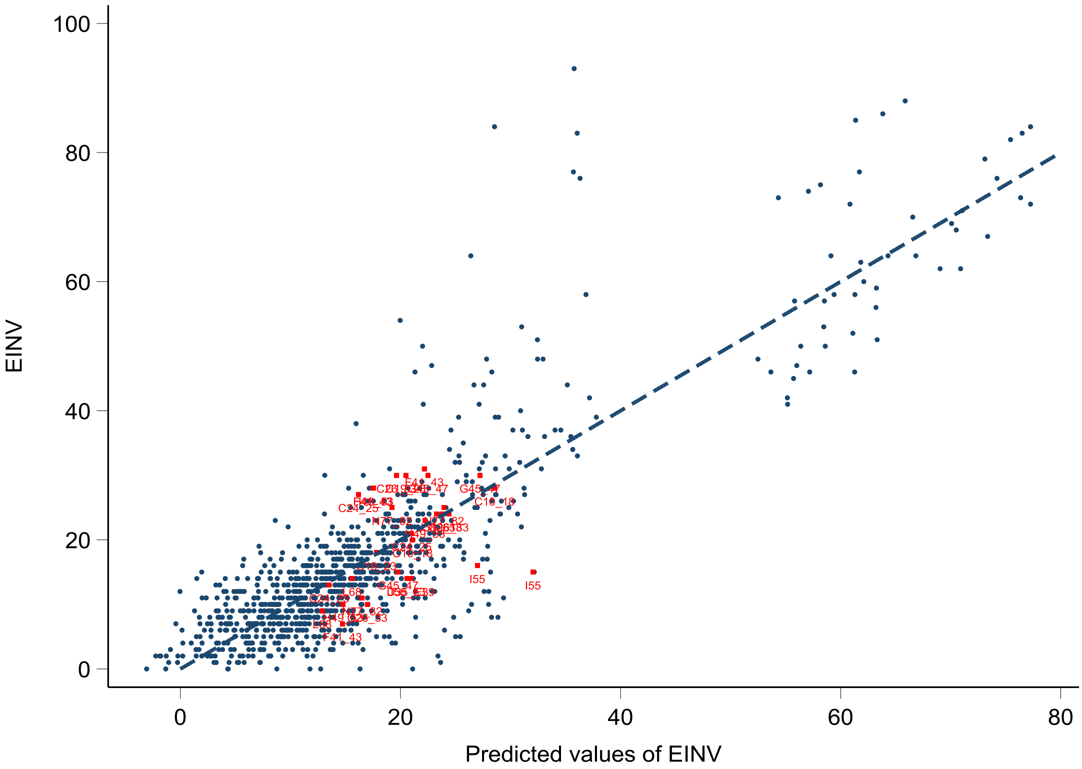
Social Media						E-Invoice					
Country	Estimate	Lower	Upper	New Rank	Rank	Country	Estimate	Lower	Upper	New Rank	Rank
NL	34.66	32.11	37.22	1	1	FI	73.86	68.85	78.87	1	1
IE	31.31	28.67	33.95	2	3	DK	64.01	60.51	67.50	2	2
UK	31.25	28.48	34.02	3	2	SE	33.56	29.65	37.47	3	3
CY	28.41	25.83	30.99	4	4	SI	33.20	29.73	36.67	4	4
FI	24.24	21.68	26.81	5	5	LT	25.72	22.47	28.98	5	6
MT	21.93	19.29	24.57	6	6	AT	24.71	21.07	28.35	6	7
ES	20.44	17.88	23.01	7	7	ES	24.46	20.99	27.93	7	5
SE	19.24	16.68	21.80	8	8	IT	22.07	18.16	25.99	8	8
BE	17.79	15.42	20.16	9	10	IE	21.46	17.44	25.49	9	9
DK	17.54	14.93	20.15	10	9	EE	19.07	15.85	22.30	10	10
SI	16.70	14.13	19.27	11	11	NL	17.98	14.78	21.19	11	11
AT	16.24	13.57	18.92	12	17	DE	17.76	14.50	21.02	12	13
EL	16.10	13.31	18.89	13	14	PT	17.73	14.05	21.40	13	15
LT	15.88	13.30	18.46	14	12	LV	16.86	13.37	20.34	14	14
LU	15.14	12.51	17.77	15	13	BE	16.39	13.40	19.38	15	17
HR	13.97	11.39	16.54	16	16	CZ	16.32	13.07	19.58	16	18
PT	13.91	11.24	16.58	17	20	SK	15.40	11.91	18.89	17	16
IT	13.33	10.77	15.89	18	18	FR	14.80	9.79	19.80	18	12
DE	12.80	10.22	15.39	19	19	LU	14.11	10.08	18.14	19	20
FR	12.78	10.08	15.48	20	15	PL	13.94	10.45	17.42	20	19
SK	10.43	7.85	13.01	21	21	BG	13.56	10.29	16.84	21	21
HU	10.41	7.83	12.98	22	22	MT	13.14	9.53	16.76	22	23
EE	9.11	6.55	11.67	23	25	HR	13.05	9.81	16.29	23	22
LV	8.82	6.25	11.38	24	24	UK	12.27	8.35	16.18	24	25
CZ	8.69	5.96	11.41	25	23	RO	11.64	8.16	15.13	25	24
PL	7.95	5.38	10.53	26	26	HU	8.27	4.78	11.75	26	26
BG	7.09	4.49	9.69	27	27	CY	8.15	4.85	11.46	27	27
RO	6.03	3.46	8.61	28	28	EL	5.70	2.16	9.25	28	28

Cloud						CRM					
Country	Estimate	Lower	Upper	New Rank	Rank	Country	Estimate	Lower	Upper	New Rank	Rank
FI	42.16	39.82	44.50	1	1	DE	47.59	44.38	50.80	1	1
SE	32.03	29.31	34.74	2	2	AT	44.58	41.08	48.07	2	2
DK	30.27	27.90	32.65	3	3	BE	44.34	41.49	47.20	3	3
NL	28.39	25.68	31.11	4	4	NL	42.28	39.11	45.45	4	5
IE	26.29	23.74	28.83	5	5	FI	41.29	38.11	44.46	5	4
IT	20.37	17.65	23.09	6	8	SE	39.63	36.46	42.81	6	6
HR	19.43	17.08	21.78	7	7	LU	39.02	35.71	42.32	7	7
UK	19.31	16.59	22.03	8	9	ES	34.22	31.05	37.39	8	8
BE	18.55	16.37	20.73	9	10	DK	34.15	30.91	37.39	9	9
MT	15.90	13.03	18.77	10	13	IE	34.04	30.76	37.32	10	10
ES	15.29	12.95	17.63	11	11	CY	32.22	29.02	35.41	11	11
PT	15.10	12.54	17.66	12	14	IT	30.76	27.59	33.93	12	12
EE	15.07	12.35	17.79	13	17	FR	29.91	26.74	33.08	13	14
LT	14.53	12.17	16.89	14	12	LT	29.06	25.87	32.26	14	16
SI	14.45	12.09	16.80	15	15	SI	27.51	24.33	30.68	15	15
SK	14.22	11.87	16.58	16	16	PT	27.40	23.94	30.86	16	13
FR	13.87	11.15	16.59	17	18	MT	26.05	22.78	29.33	17	17
LU	12.75	9.92	15.58	18	20	UK	25.92	22.71	29.13	18	19
CZ	12.00	9.49	14.50	19	19	PL	24.60	21.37	27.83	19	18
AT	9.82	7.09	12.54	20	22	EE	23.53	20.36	26.70	20	21
CY	9.15	6.76	11.54	21	21	SK	22.23	19.05	25.42	21	20
HU	8.90	6.54	11.25	22	23	HR	20.67	17.45	23.88	22	22
LV	7.93	5.56	10.30	23	24	EL	20.17	16.61	23.72	23	23
DE	7.86	1.94	13.79	24	6	RO	18.62	15.42	21.82	24	26
EL	7.60	5.02	10.18	25	28	BG	18.48	15.31	21.65	25	25
PL	7.22	4.87	9.57	26	26	CZ	18.39	15.19	21.59	26	24
BG	6.85	4.24	9.47	27	25	LV	17.84	14.67	21.02	27	27
RO	6.56	4.21	8.91	28	27	HU	14.35	11.16	17.54	28	28

SISC					
Country	Estimate	Lower	Upper	New Rank	Rank
HR	26.24	23.25	29.24	1	1
PT	23.36	20.28	26.43	2	2
LT	22.12	19.15	25.10	3	3
BE	16.66	14.03	19.30	4	4
DE	16.44	13.47	19.41	5	7
DK	15.10	12.05	18.15	6	9
FI	14.89	11.94	17.84	7	6
SK	14.49	11.53	17.46	8	5
LU	14.42	11.33	17.50	9	8
BG	12.84	9.87	15.82	10	12
SE	12.07	9.12	15.01	11	10
LV	11.85	8.89	14.81	12	11
PL	10.89	7.87	13.91	13	14
SI	10.75	7.80	13.71	14	13
ES	9.26	6.30	12.21	15	15
AT	9.22	6.17	12.27	16	18
CZ	9.04	6.07	12.01	17	17
IT	8.45	5.50	11.40	18	16
EL	8.36	4.73	11.99	19	21
NL	8.04	5.09	10.98	20	20
MT	7.47	4.40	10.55	21	19
EE	6.46	3.51	9.41	22	22
UK	6.45	3.49	9.41	23	25
CY	6.33	3.35	9.31	24	23
IE	6.05	3.01	9.10	25	24
FR	4.41	1.46	7.36	26	26
RO	2.58	-0.40	5.56	27	27
HU	1.45	-1.51	4.40	28	28

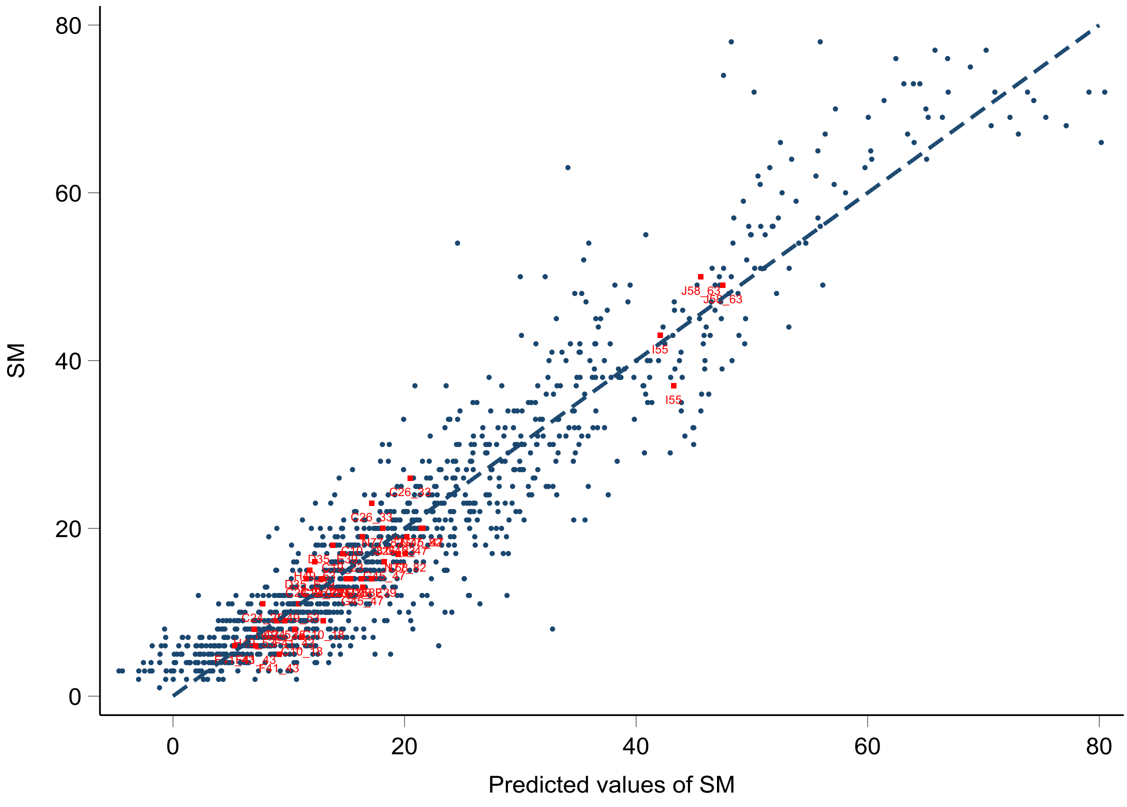
Source: European Commission 2018, WIFO calculations.

Figure B-1: Scatter plot of actual and fitted shares of firms using e-invoice



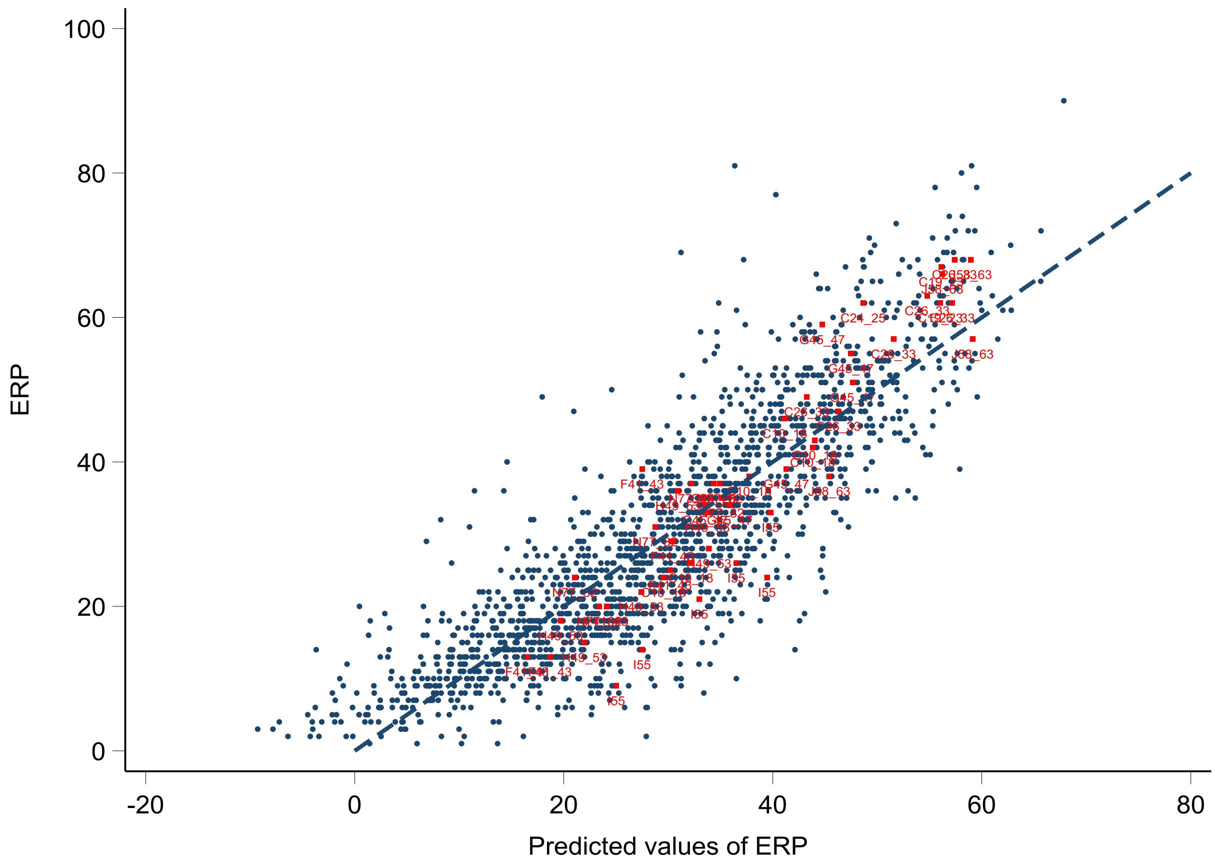
Source: Eurostat, WIFO calculations. Note: Austria is marked in red and labelled with the respective sectors. The dashed line represents a 45° line.

Figure B-2:Scatter plot of actual and fitted shares of firms using social media



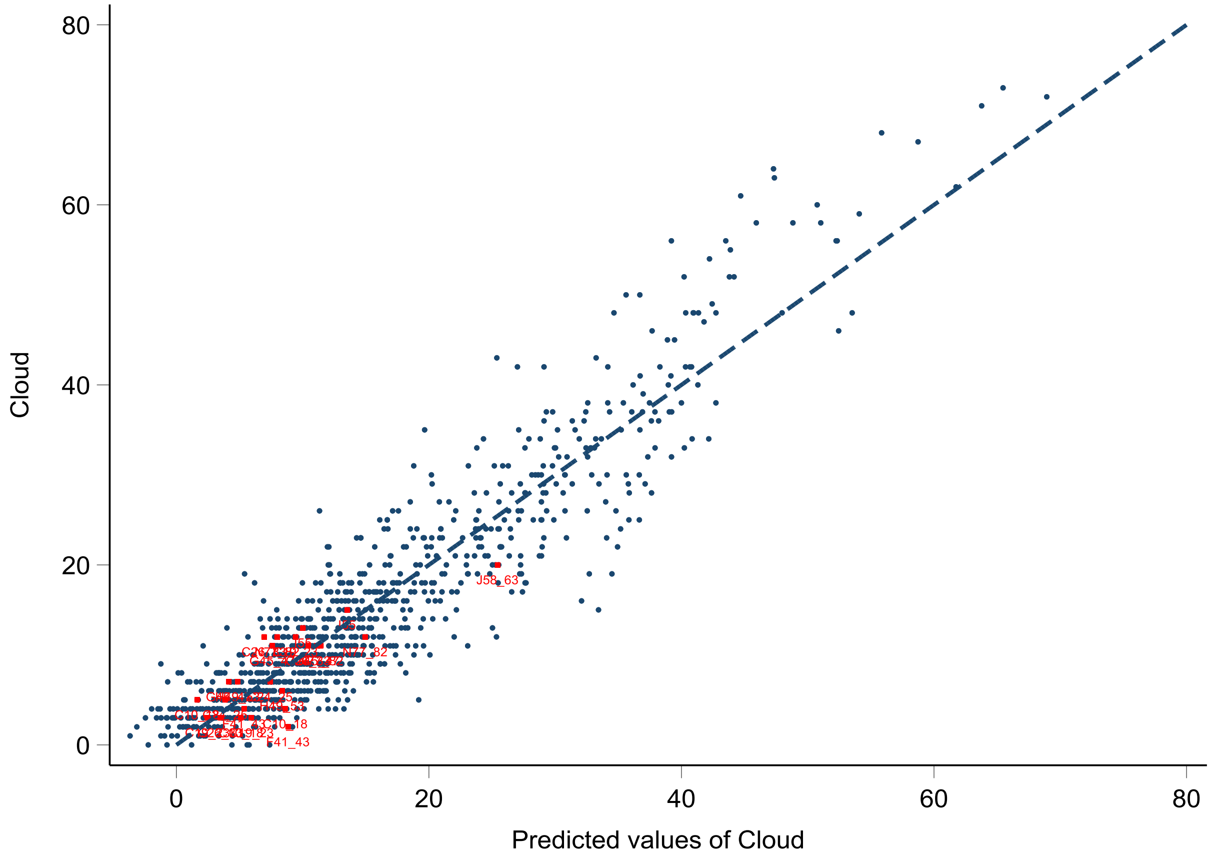
Source: Eurostat, WIFO calculations. Note: Austria is marked in red and labelled with the respective sectors. The dashed line represents a 45° line.

Figure B-3: Scatter plot of actual and fitted shares of firms using enterprise resource planning systems



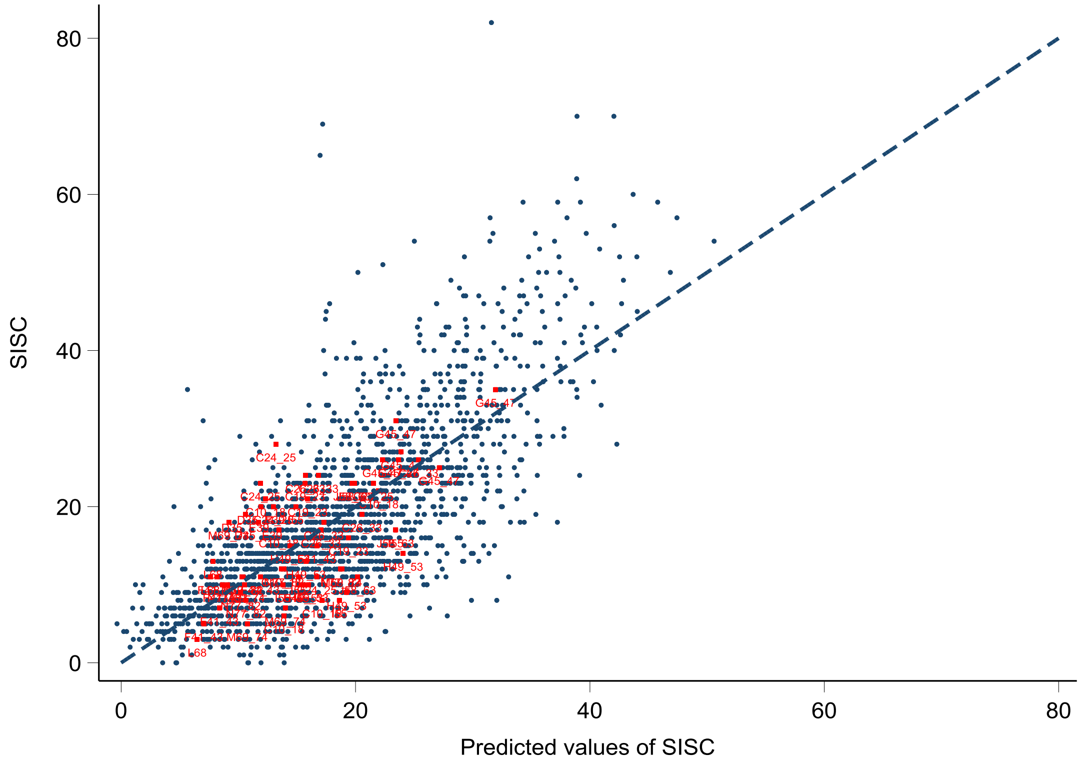
Source: Eurostat, WIFO calculations. Note: Austria is marked in red and labelled with the respective sectors. The dashed line represents a 45° line.

Figure B-4: Scatter plot of actual and fitted shares of firms buying cloud computing solutions



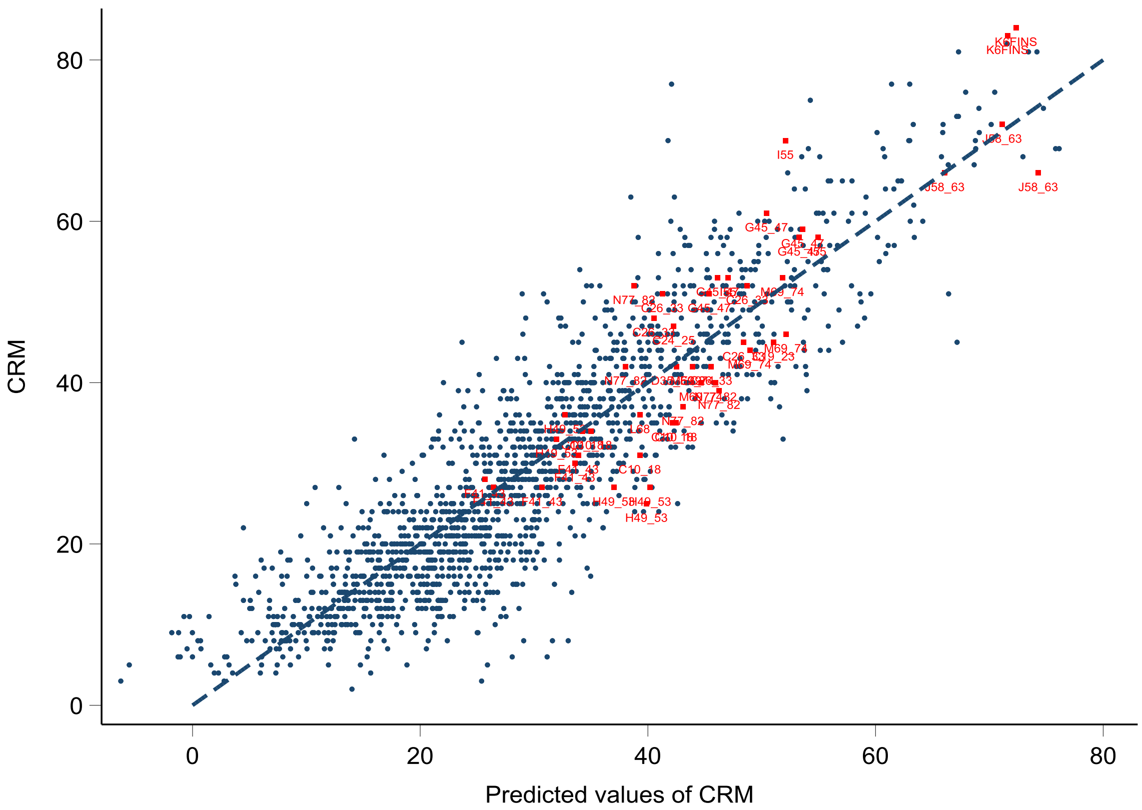
Source: Eurostat, WIFO calculations. Note: Austria is marked in red and labelled with the respective sectors. The dashed line represents a 45° line.

Figure B-5: Scatter plot of actual and fitted shares of firms whose business processes are automatically linked to those of their suppliers and/or customers (SISC)



Source: Eurostat, WIFO calculations. Note: Austria is marked in red and labelled with the respective sectors. The dashed line represents a 45° line.

Figure B-6: Scatter plot of actual and fitted shares of firms using Customer Relationship Management software (CRM)



Source: Eurostat, WIFO calculations. Note: Austria is marked in red and labelled with the respective sectors. The dashed line represents a 45° line.

Table B-0-6: Difference between fitted and actual values of digitalisation indicators

Deviation	Country	sector	Year	Deviation	Country	sector	Year
ERP- Extreme negative deviations ($\hat{y}$ -y)				ERP- Extreme positive deviations ($\hat{y}$ -y)			
-28.13	LT	C19_23	2010	30.79	PT	D35_E39	2012
-26.52	LU	I55	2015	31.06	SK	I55	2014
-25.90	DE	I55	2013	36.71	DE	L68	2015
-25.40	FI	I55	2015	37.78	LT	I55	2017
-24.56	BE	I55	2015	44.64	CY	I55	2015
RFID- Extreme negative deviations ($\hat{y}$ -y)				RFID- Extreme positive deviations ($\hat{y}$ -y)			
-7.87	AT	D35_E39	2017	7.21	PL	D35_E39	2017
-6.57	LU	D35_E39	2014	7.66	PT	G45_47	2014
-6.42	DK	D35_E39	2017	8.21	IE	D35_E39	2017
-5.37	HR	C19_23	2017	12.28	SI	I55	2014
-5.35	FR	D35_E39	2014	12.85	HR	L68	2014
SM- Extreme negative deviations ($\hat{y}$ -y)				SM- Extreme positive deviations ($\hat{y}$ -y)			
-24.78	DK	I55	2014	22.10	BE	J58_63	2017
-16.95	IE	F41_43	2016	26.45	IE	I55	2014
-16.85	BG	I55	2017	28.89	CY	L68	2016
-15.51	RO	I55	2017	29.42	MT	L68	2015
-14.97	HU	J58_63	2014	29.78	IE	I55	2015

E-Invoice- Extreme negative deviations ($\hat{y}$ -y)				E-Invoice- Extreme positive deviations ($\hat{y}$ -y)			
-22.64	SI	H49_53	2014	39.68	SI	J58_63	2016
-21.41	SI	F41_43	2014	41.29	SI	G45_47	2016
-21.11	SI	L68	2014	46.94	SI	D35_E39	2016
-20.86	SI	J58_63	2014	55.45	SI	L68	2016
-20.43	SI	C26_33	2014	57.22	SI	I55	2016
Cloud- Extreme negative deviations ($\hat{y}$ -y)				Cloud- Extreme positive deviations ($\hat{y}$ -y)			
-18.43	FI	H49_53	2014	15.64	FI	L68	2017
-16.09	FI	C24_25	2014	16.31	FI	D35_E39	2017
-15.49	SK	J58_63	2016	16.71	FI	N77_82	2017
-14.19	HR	L68	2015	16.80	ES	J58_63	2017
-13.70	SK	J58_63	2015	17.62	IE	L68	2015
CRM- Extreme negative deviations ($\hat{y}$ -y)				CRM- Extreme positive deviations ($\hat{y}$ -y)			
2.00	EL	L68	2009	81.00	DE	K6FINS	2010
3.00	EE	F41_43	2009	81.00	FI	J58_63	2014
3.00	HU	F41_43	2009	82.00	BE	J58_63	2014
3.00	RO	M69_74	2017	83.00	AT	K6FINS	2009
4.00	EE	F41_43	2010	84.00	AT	K6FINS	2010
SISC- Extreme negative deviations ($\hat{y}$ -y)				SISC- Extreme positive deviations ($\hat{y}$ -y)			
0.00	CY	L68	2014	65.00	SI	I55	2014
0.00	CY	C26_33	2014	69.00	SI	I55	2015
0.00	IE	L68	2017	70.00	HR	J58_63	2010
0.00	MT	D35_E39	2015	70.00	PT	I55	2012
0.00	MT	C24_25	2017	82.00	PT	L68	2012

Source: Eurostat, WIFO calculations; Note: Fitted values are based on estimation results of equation (1).

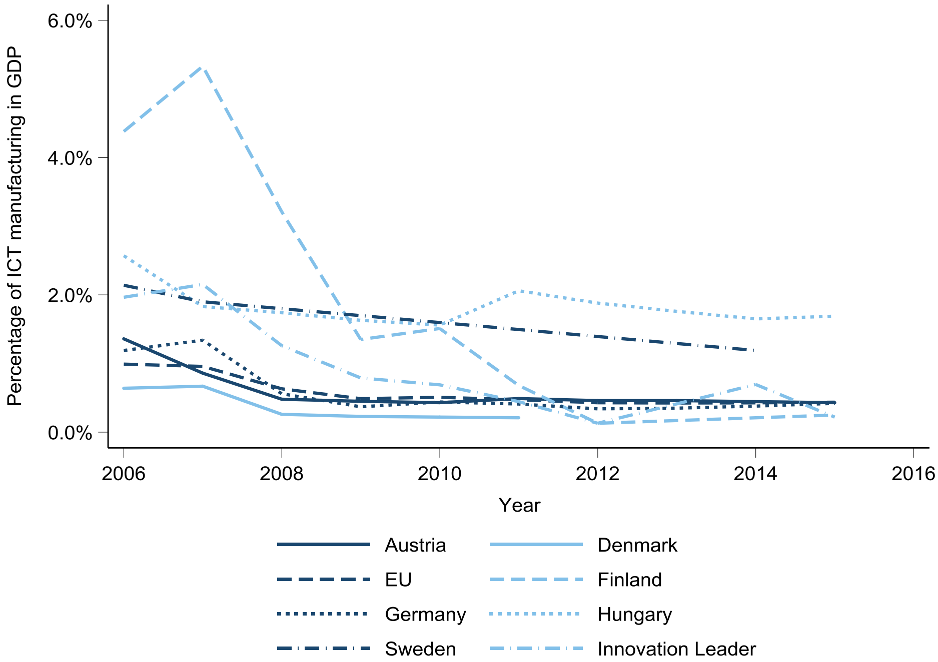
B.1.2. ICT producing sectors – breakdown by sector groups

To have a more detailed look at the composition of Austria’s ICT sector,

Figure B-7 and Figure B-8 show the shares of ICT manufacturing and ICT services in total GDP separately. On average, in the EU the share of ICT manufacturing has slightly decreased and remained rather stable since 2008. Starting with a share slightly above EU-average in 2006, Austria's share has decreased and stabilized around the EU average. In comparison, Hungary's share of ICT manufacturing remained rather stable at a higher level than that of Innovation Leaders and the EU average.

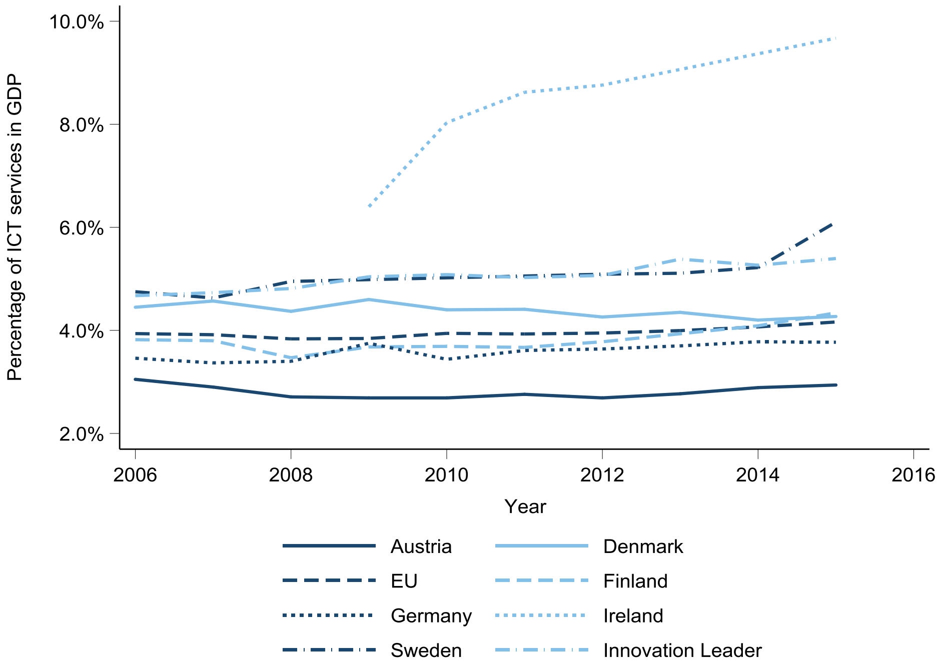
In contrast, the shares of ICT services in total GDP have been slowly rising or remained stable at the same time. Ireland, which has established a robust and successful ICT sector due to attractive tax schemes and an English speaking workforce, is the uncontested leader in the EU with respect to the share of ICT service sectors in GDP. The Innovation Leader countries, particularly Luxembourg – probably due to the importance of the financial sector services, the Netherlands and Sweden, show GDP shares of ICT service sectors well above the EU28 average. While Austria is, again, far behind the Innovation Leader countries as well as well below the EU28 average, the share of Hungary's ICT service sectors in total GDP have been constantly increasing and, thus, remained comparable to the EU28 average share over time.

Figure B-7: Share of the ICT manufacturing sector in GDP



Source: Eurostat, WIFO illustration. Note: The ICT manufacturing sector comprises the following industries (NACE Rev.2): (261) Manufacture of electronic components and boards, (262) Manufacture of computers and peripheral equipment, (263) Manufacture of communication equipment, (264) Manufacture of consumer electronics, (268) Manufacture of magnetic and optical media. VA at factor cost of ICT sector divided by VA at factor costs of all NACE sectors. To calculate the EU average, missing values are replaced by three-year moving averages wherever possible. Cyprus, Luxembourg, Malta is not included in the EU average due to lack of data. The Innovation Leader average includes the following countries: Sweden, Denmark, Finland, the United Kingdom (data for the Netherlands and Luxembourg are missing).

Figure B-8: Share of the ICT service sector in GDP

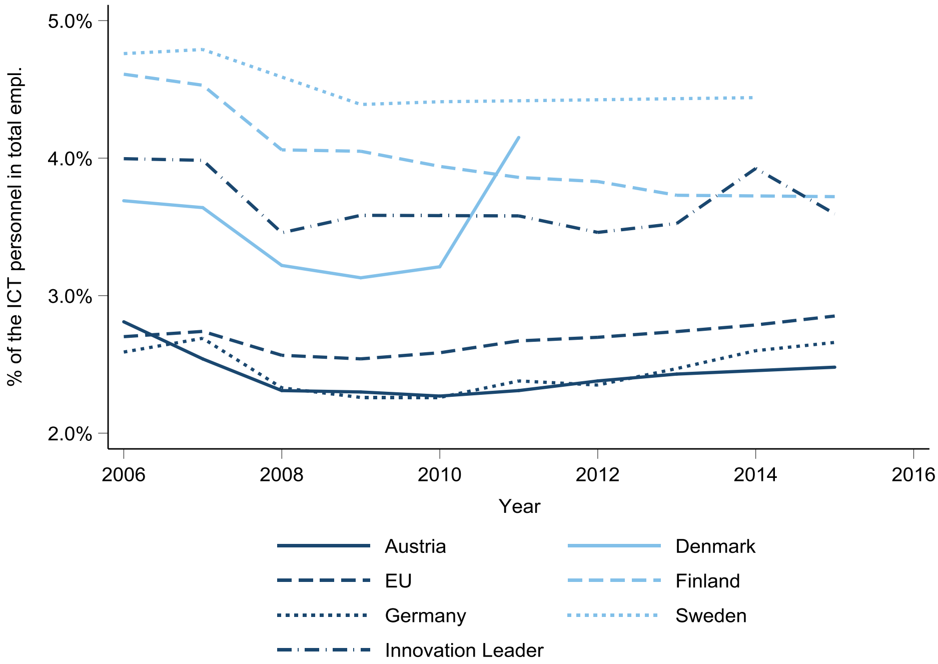


Source: Eurostat, WIFO illustration. Note: The ICT service sector (OECD definition) comprises the following industries (NACE Rev.2): (465) Wholesale of information and communication equipment, (582) Software publishing, (61) Telecommunications, (62) Computer programming, consultancy and related activities, (631) Data processing, hosting and related activities; web portals, (951) Repair of computers and communication equipment. VA at factor cost of ICT sector divided by VA at factor costs of all NACE sectors. To calculate the EU average, missing values are replaced by three-year moving averages wherever possible. Malta is not included in the EU average due to lack of data. The Innovation Leader average includes the following countries: Sweden, Denmark, Luxembourg, the Netherlands, Finland, the United Kingdom.

A similar picture is depicted when looking at the employment shares in the ICT sector (see Figure B-9). Austria's shares of ICT personnel in total employees is well below the EU28 average, though slightly rising. This mediocre share of ICT employees in Austria is independent of any differentiation between the ICT service or ICT manufacturing sector (see

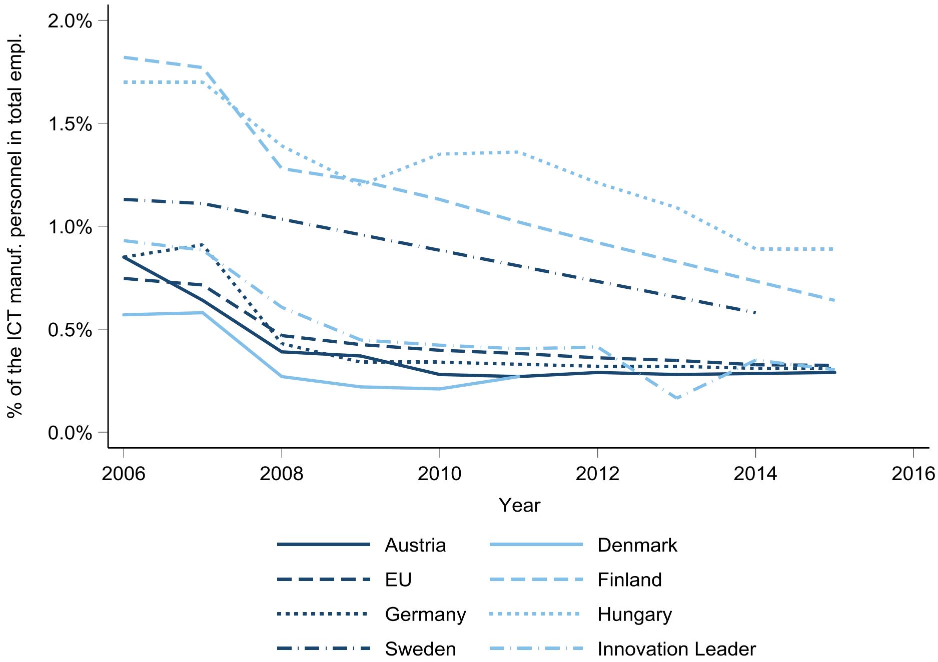
Figure B-10 and Figure B-11). Hungary, Sweden and Finland have the highest shares of ICT manufacturing personnel in total employees, however, the shares have been constantly falling since 2006. The shares of employees in ICT service sectors in Luxembourg, Sweden and Denmark have strongly increased within the last 20 years. Those three countries have the highest shares of employees in ICT service sectors among the Innovation Leader countries.

Figure B-9: Share of the ICT personnel in total employees



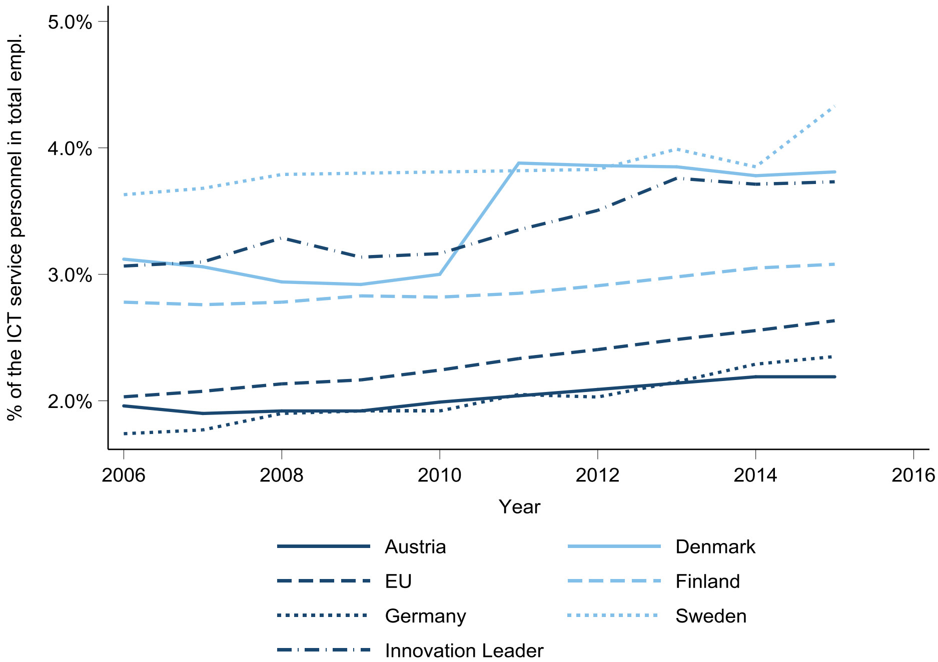
Source: Eurostat, WIFO illustration. Note: The ICT manufacturing sector (NACE Rev. 2): 261, 262, 263, 264, 268, 465, 582, 61, 62, 631, 951. To calculate the EU average, missing values are replaced by three-year moving averages wherever possible. Cyprus, Ireland, Luxembourg are not included in the EU average because of lack of data. The Innovation Leader average includes the following countries: Sweden, Denmark, the Netherlands, Finland, the United Kingdom.

Figure B-10: Share of the ICT manufacturing personnel in total employment



Source: Eurostat, WIFO illustration. Note: The ICT manufacturing sector (NACE Rev. 2): 261, 262, 263, 264, 268. To calculate the EU average, missing values are replaced by three-year moving averages wherever possible. Cyprus, Luxembourg, Malta is not included in the EU average because of lack of data. The Innovation Leader average includes the following countries: Sweden, Denmark, the Netherlands, Finland, the United Kingdom.

Figure B-11: Share of the ICT service personnel in total employment



Source: Eurostat, WIFO illustration. Note: The ICT service sector (NACE Rev. 2): 465, 582, 61, 62, 631, 951. To calculate the EU average, missing values are replaced by three-year moving averages wherever possible. Malta is not included in the EU average because of lack of data. The Innovation Leader average includes the following countries: Sweden, Denmark, Luxembourg, the Netherlands, Finland, the United Kingdom.

B.1.3. ICT investments – breakdown by investment types

Figure B-12, Figure B-14 and

Figure B-13 depict the separate components of the ICT investment share: the share of investments in computing equipment, the share of investments in communications equipment and the share of investments in computer software and databases, respectively.

On average, since the turn of the millennium investment shares in computing equipment have been significantly decreasing in the EU (2000:0.4%, 20014: 0.2%) and in Innovation Leader countries (2000:0.5%, 20014: 0.3%) (Figure B-12). Austria's investment share has always been below the EU average. In contrast, the share of investment in computing equipment remained stable at a high level in the Czech Republic, which has had the highest investment share of computing equipment (2014:0.5%) within the EU.

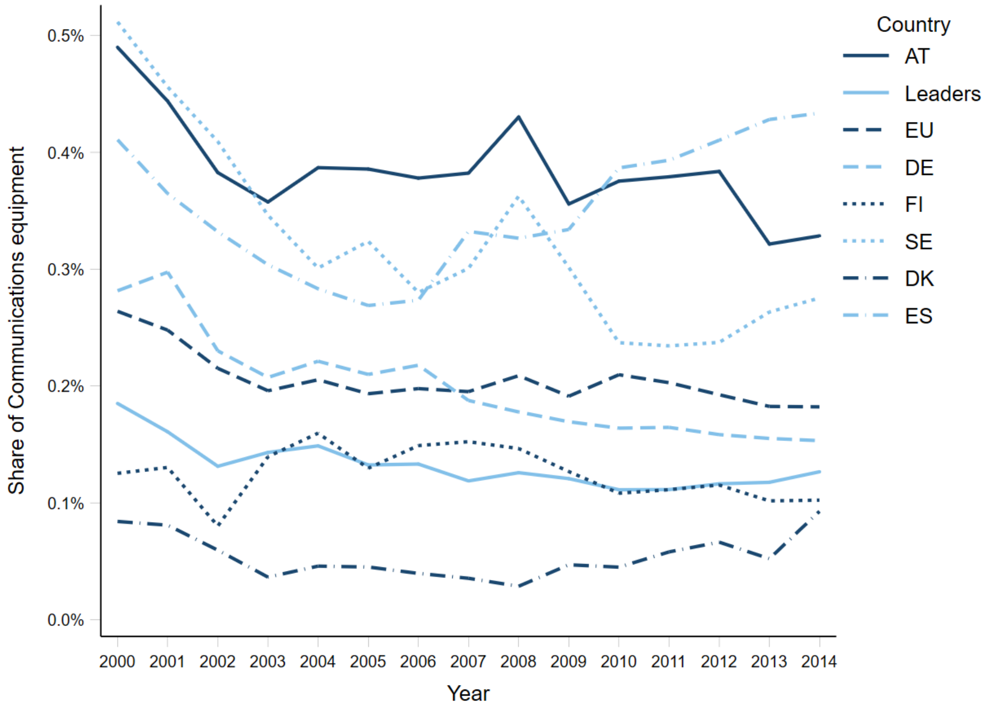
Traditionally, Austria's share of investments in communications equipment of total investments (2014: 0.3%) is one of the highest in the EU (2014: 0.2%). However, similarly to most other EU Member States, the investment shares in communications equipment have been constantly falling.

In contrast to investments in computing equipment, the average shares of investments in software and databases have been constantly rising since the last 15 years in the EU (2000:0.4%, 20014: 0.6%)(Figure B-14). Similarly, Austria increased its share of investments in software and databases in total investments from 0.6% in 2000 to 0.8% in 2014. The Netherlands have increased their share of investments in software and databases from 0.8% to 1.4% of their total investment significantly, and they now show the highest investments shares within the EU.

Figure B-12: Share of investments in computing equipment (% of total investments)

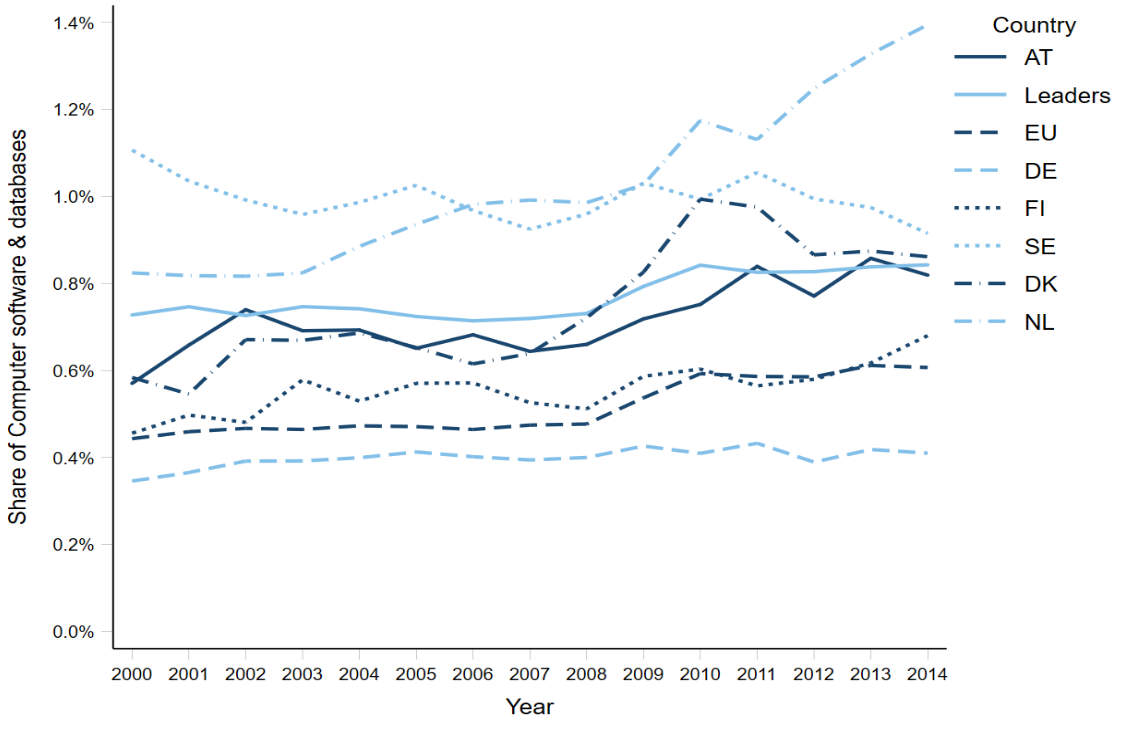
Source: EUKLEMS (Kirsten Jäger (The Conference Board) 2017), WIFO illustration. Note: The EU average is calculated without Belgium, Croatia, Hungary, Poland and Romania due to lack of data.

Figure B-13: Share of investments in communications equipment (% of total investments)



Source: EUKLEMS (Kirsten Jäger (The Conference Board) 2017), WIFO illustration. Note: The EU average is calculated without Belgium, Croatia, Hungary, Poland, and Romania due to lack of data.

Figure B-14: Share of investments in computer software and databases (% of total investments)



Source: EUKLEMS (Kirsten Jäger (The Conference Board) 2017), WIFO illustration. Note: The EU average is calculated without Belgium, Croatia, Latvia, Malta, Romania (data are available from 2011 onwards) and Slovenia due to lack of data.

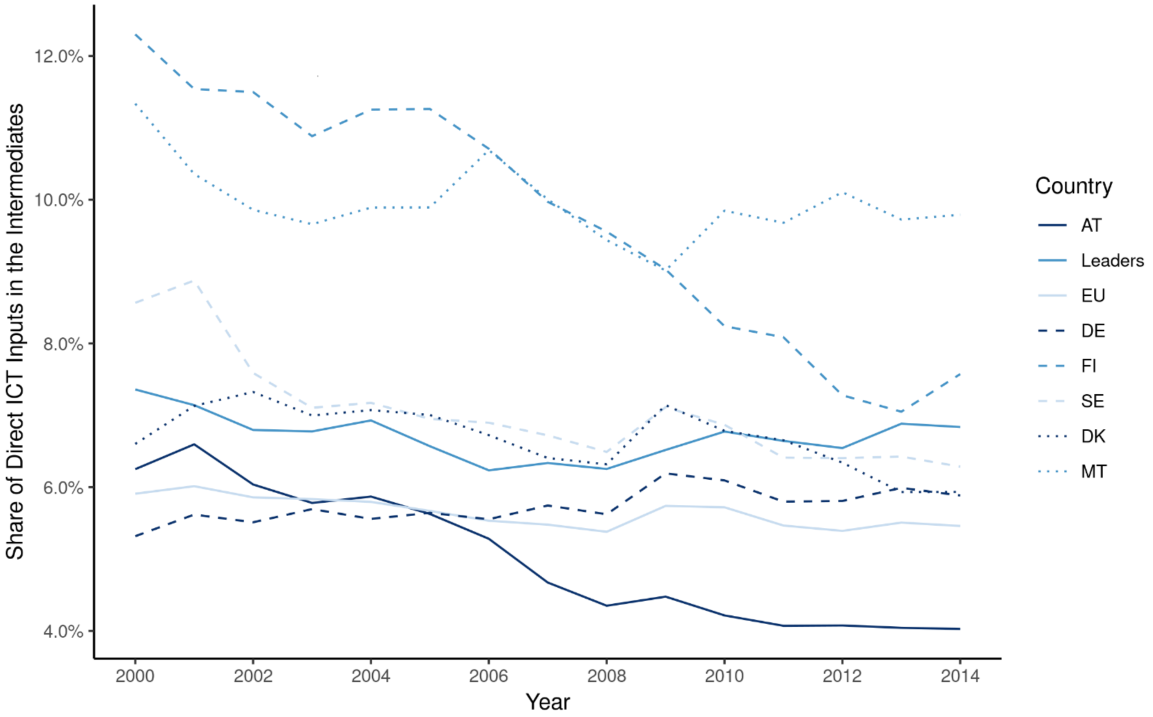
In addition, the purchase of ICT intermediate goods and services provide an important indicator. Because of short software licencing periods and short-lived technological items (e.g. IT consulting and data processing), ICT investments might not provide the whole picture. ICT intermediaries can be used as substitutes (Calvino et al. 2018).

Figure B-15 show the intermediary goods and services provided by ICT producing sectors as a percentage of total intermediates used.

Figure B-16 illustrates the shares of induced value added from the ICT-producing sectors. The difference between the two figures results from including the use of intermediate goods and services from ICT-intensive sectors along the value chain in case of

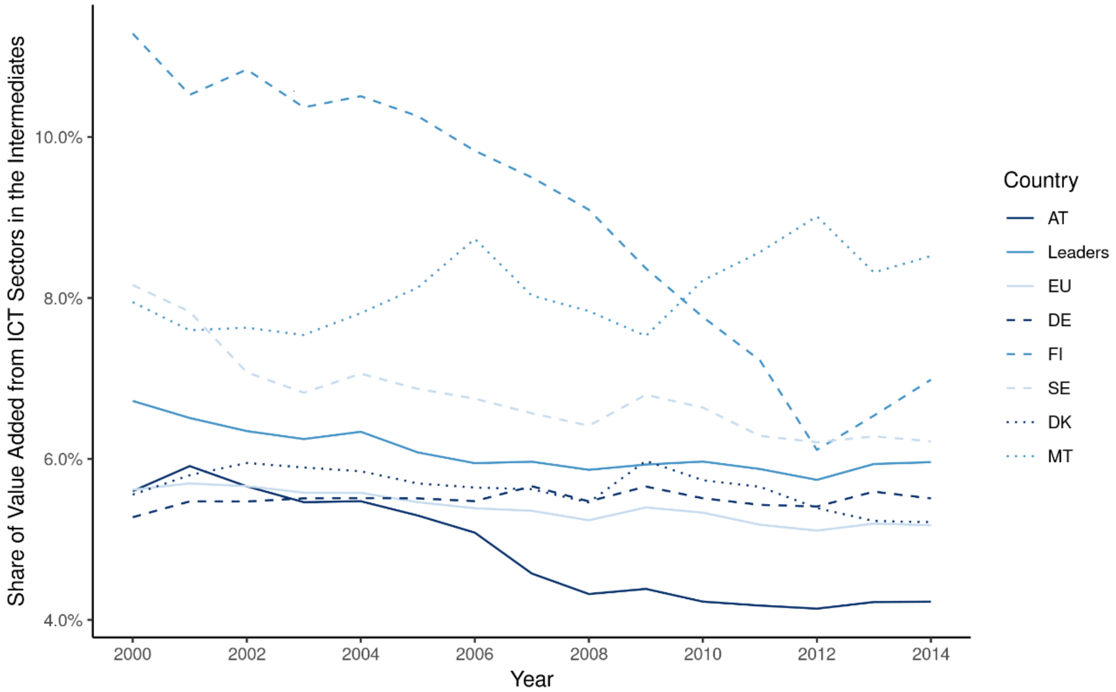
Figure B-16. For Austria, both approaches show a similar situation. In both figures Austria's shares are well below the EU28 average and far behind Innovation Leader countries like Sweden.

Figure B-15: Shares of intermediary goods and services from ICT producing sectors in total intermediates



Source: WIOD, WIFO calculation; Note: The ICT-producing sectors comprise Manufacture of computer, electronic and optical products (C26), Manufacture of electrical equipment (C27), Telecommunications (J61), Computer programming and information services (J62-J63).

Figure B-16: Shares of value added from ICT-producing sectors in total value added (weighted by sector value added)



Source: WIOD, WIFO calculation; Note: Weighted by total sector value added. The ICT producing sectors comprise Manufacture of computer, electronic and optical products (C26), Manufacture of electrical equipment (C27), Telecommunications (J61), Computer programming and information services (J62-J63).

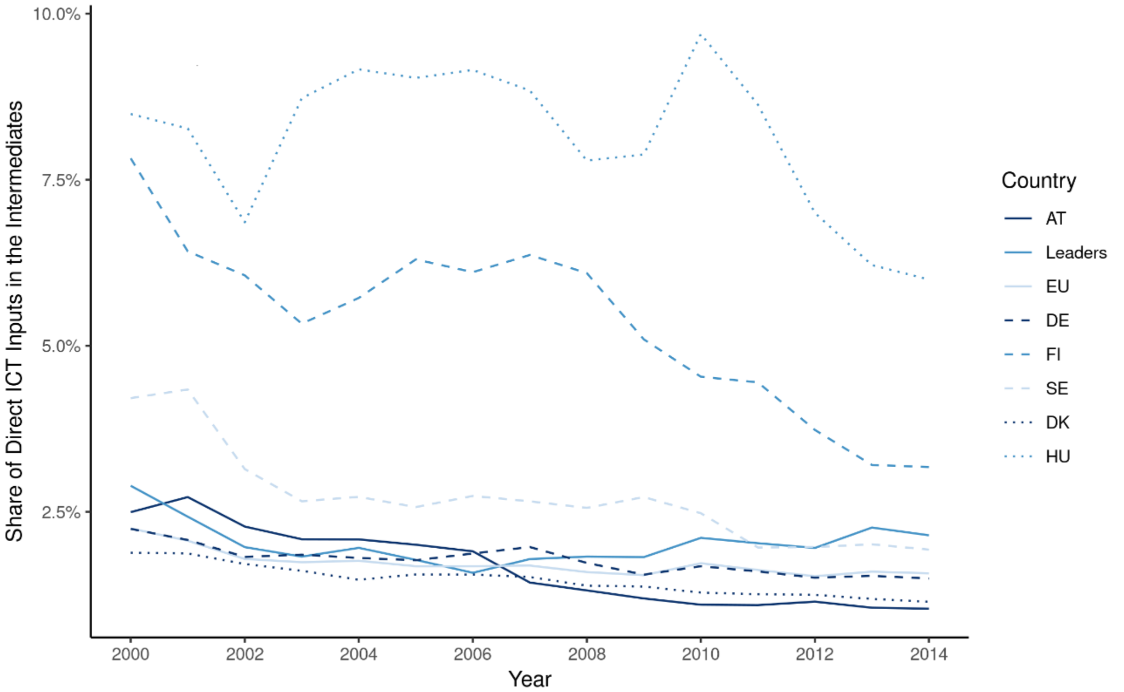
To complement the results from the ICT investment shares presented previously Figure B-17 and Figure B-18 present the use of intermediates for ICT manufacturing and ICT service sectors.

Overall, the direct use of intermediaries from ICT manufacturing sectors has decreased slightly since 2000. In contrast, at the same time the use of intermediaries from ICT service sectors in EU Member States has remained stable or increased. Hungary, a country well embedded in the global value chains and often referred to as the workbench of tech-intensive manufacturing countries such as Germany, has the highest share of intermediaries from the ICT manufacturing sector in total intermediaries among the EU countries. In contrast, Austria's share of intermediaries from the ICT manufacturing sector is below the EU average.

Similarly low is Austria's share of direct intermediaries from the ICT service sectors in total intermediaries compared to the reference countries. Innovation Leader countries, especially Denmark, but also Great Britain, show rather large shares of intermediaries from ICT service sectors compared to intermediaries from the ICT manufacturing sectors. While Germany has significantly increased its share of intermediaries from the ICT service sectors since 2000, Austria's share of intermediaries from the ICT service sectors has been falling constantly at the same time.

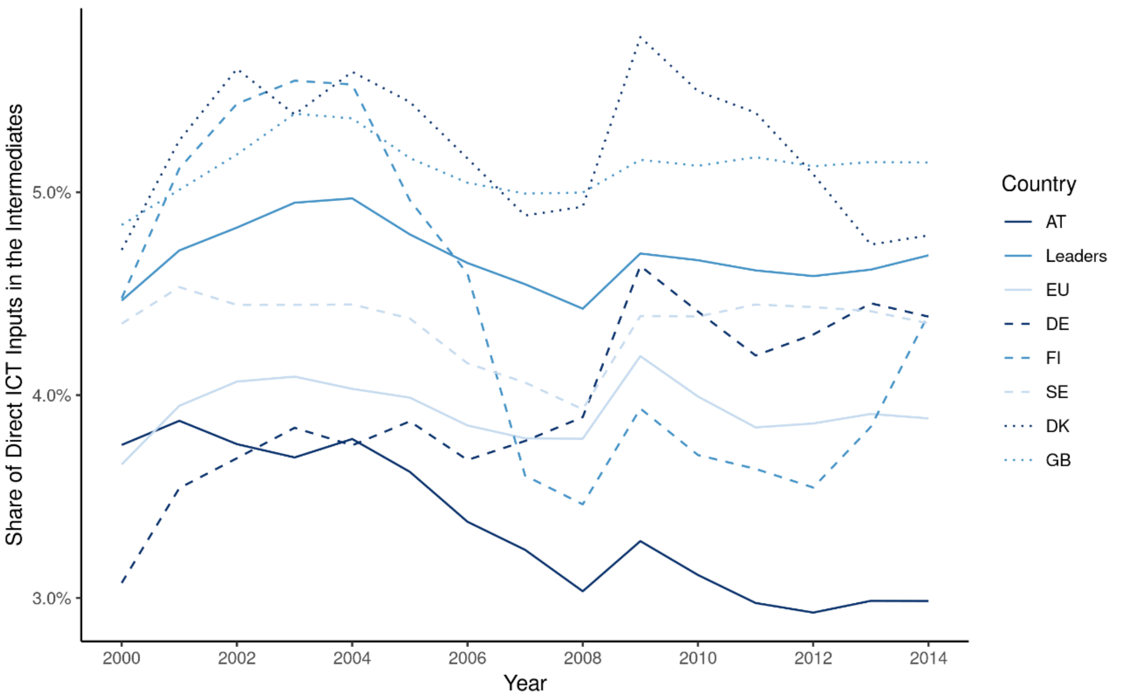
Analogously, Figure B-19 and Figure B-20 show the shares of induced value added from the ICT manufacturing and ICT service sectors separately. Apparently, the top ranking of direct and indirect use of ICT intermediates along the value chain in Ireland is mainly driven by its high value added shares from ICT service sectors, while Hungary remains top-ranked with respect to the values added shares from ICT manufacturing sectors. Austria's position is independent from the differentiation between intermediaries from the ICT manufacturing and service sectors and clearly below the EU average.

Figure B-17: Shares of intermediary goods and services from ICT manufacturing sector in total intermediates



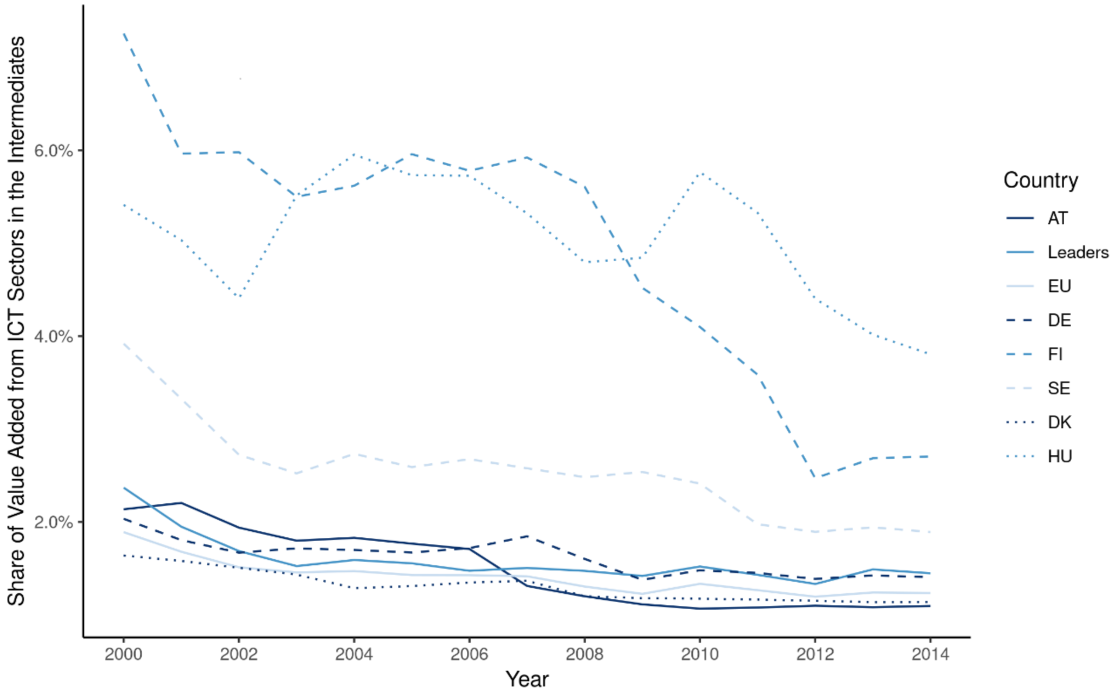
Source: WIOD, WIFO calculation. Note: The ICT manufacturing sectors comprise Manufacture of computer, electronic and optical products (C26).

Figure B-18: Shares of intermediary goods and services from ICT service sectors in total intermediates



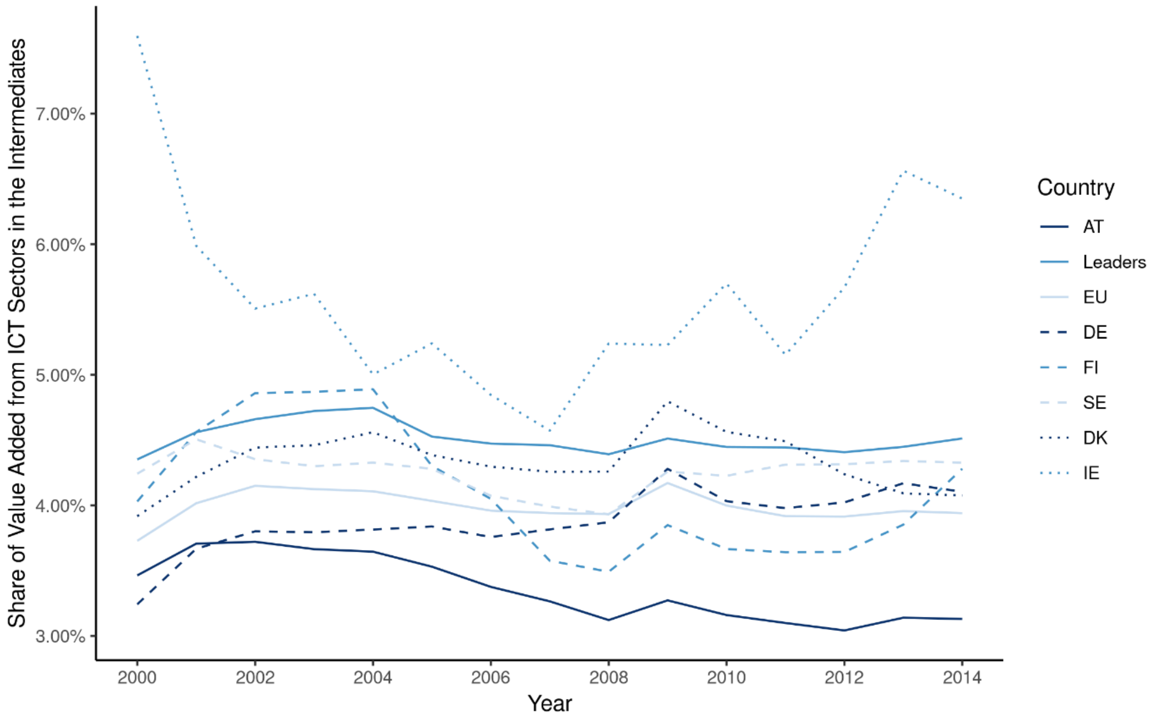
Source: WIOD, WIFO calculation. Note: The ICT service sectors comprise Telecommunications (J61), Computer programming and information services (J62-J63).

Figure B-19: Shares of value added from ICT manufacturing sectors in total value added (weighted by sector value added)



Source: WIOD, WIFO calculation. Note: The ICT manufacturing sectors comprise Manufacture of computer, electronic and optical products (C26).

Figure B-20: Shares of value added from ICT service sectors in total value added (weighted by sector value added)



Source: WIOD, WIFO calculation. Note: The ICT service sectors comprise Telecommunications (J61), Computer programming and information services (J62-J63).

B.1.4. Sector-level evidence on ICT investment and the embedding in digitally intensive value chains

The diffusion of digital technologies happens in various ways. One important channel of diffusion is via trading goods and services. Technology embodied in goods and services strongly differs between industries or industry groups. These technology flows are strongly related to standard goods flows and to supplier relations. A company's own (direct) investment in digital technologies therefore comprises only a fraction of the digital knowledge and technologies contained in its products and services. Whenever a company buys a part, product or new capital good, it also buys the digital knowledge and technologies embedded (indirect digital content). Using WIOD and EUKLEMS data, as well as the sectoral taxonomies of ICT intensity and digital technology by the OECD (Calvino et al. 2018), this subsection assesses the direct intensity of ICT investments in Austrian manufacturing and services sectors, as well as the value-added share of sectors with high digital intensity in the value added of Austrian business sectors. This will provide a first overview on the (embodied) diffusion of digital technologies and products with high digital content into the Austrian economy.

B.1.4.1. ICT capital stocks and investments in ICT in the Austrian business sector over time in comparison to the Innovation Leaders

Direct investments into ICTs are the most direct channel for the diffusion of digital technologies. The EUKLEMS data allow analysing differences in the sectoral investment patterns as well as capital stocks in the Austrian business sector over time and compare them with developments in the countries that are Innovation Leaders. The most recent year in the EUKLEMS data set is 2014.

Figure B-21 presents the ICT capital shares for three points in time (upper panel) and compares them with the weighted average of ICT capital shares observed for the Innovation Leader (lower panel). As would be expected, the ICT capital stocks are highest in service sectors which according to the OECD classification have high digital intensity: telecommunications (61) and sector IT and other information services (62-63), finance and insurance (K), and professional, scientific and technical activities as well as administrative and support service activities (M-N). ICT capital stocks are also high in the publishing, audio-visual and broadcasting sector (58-60), which according to the OECD classification is a sector with medium-high digital intensity. This picture is consistent with what can be observed across OECD and EU countries. In these sectors, ICT capital stocks as a share of total capital in the sector have increased for the publishing and broadcasting sector and finance and insurance, while they have decreased for telecommunications and IT services. They have remained relatively stable between 2000 and 2014 in the professional, scientific and technical activities as well as administrative and support service activities sector.

Looking at the lower panel comparing the ICT capital shares in Austria with the weighted average of observed capital stock share across Innovation Leaders, one can observe that except for finance and insurance (K) capital stocks seem to be consistently higher in these service sectors in Austria than in the reference group.

One important caveat that applies to this evidence is related to the data source. One can observe a strong discrepancy between investment data for the telecommunications sector (61) in Austria in the Structural Business Statistics and the EUKLEMS data. The EUKLEMS data seem to overestimate both investment and ICT stocks in this sector with the likely reason being imputation problems resulting from inconsistent IT and CT definitions across countries. For this reason, the results for sector 61 in Austria should be considered with circumspection.[91]

Looking at the other sectors of the economy for which ICT capital stocks are considerably smaller, it can be observed that in most sectors ICT capital shares have increased over time irrespective of

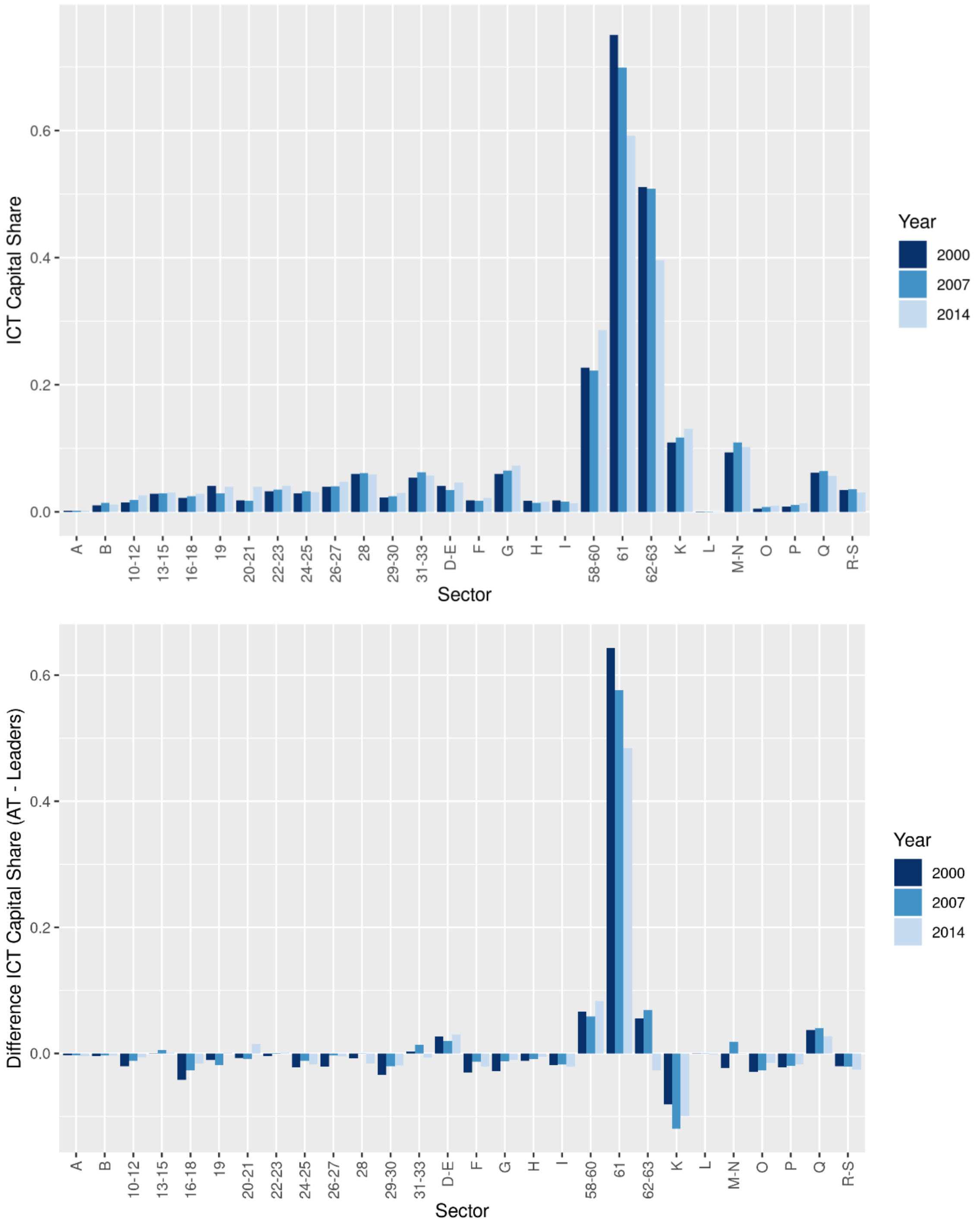
[91] In addition, a general issue related to the ICT investment data in EUKLEMS is the high spread of price indices for these types of investments across countries, which seems not to be very plausible.

whether according to the OECD classification the sectors figure amongst sectors with low or digital intensity. Over time the ICT capital share has increased in all sectors with the exception of coke and petroleum products (19), machinery and equipment (28), production of furniture and other manufacturing (31-33), electricity, gas and water supply (D-E), construction (F), accommodation and food services (I), human health and social work activities (Q), and arts, entertainment and recreation (R-S). In these sectors the ICT capital share has remained relatively constant over time with some minor fluctuations over time. So, to summarise, ICT capital stocks in the Austrian business sector have increased in almost the entire manufacturing sector and in the knowledge intensive service sectors.

To grasp the accumulation dynamics underlying the evidence presented in Figure B-21

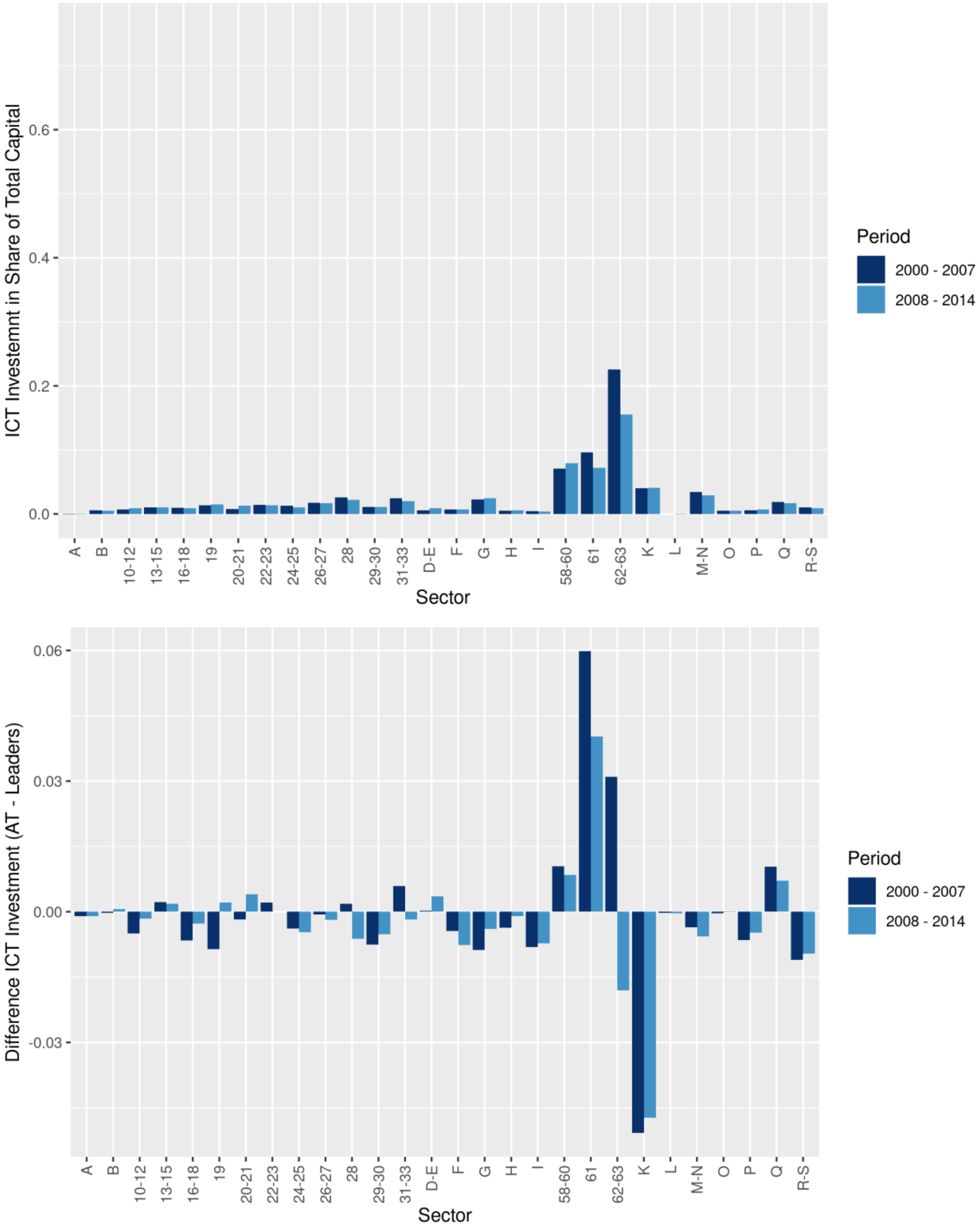
Figure B-22 shows ICT capital formation as a share of the current ICT capital stock. While the caveat for the telecom sector (61) also applies here, the figure shows that the accumulation dynamics have been highest in the service sectors with high digital intensity (upper panel). However, the investment share has been lower in basically all sectors if compared to the weighted average of the investment rates in the Innovation Leader countries. With very few exceptions, this holds for both observed subperiods. Over the period for which data are available, Austrian sectors therefore do not only show a lower ICT share in the total capital stock, but the accumulation dynamics have also been more tamed, relative to the Innovation Leaders.

Figure B-21: ICT capital shares of total capital in the Austrian business sector for the years 2000, 2007 and 2014 in comparison to the Innovation Leaders



Source: EUKLEMS, WIFO calculations.

Figure B-22: ICT investments as share of total capital in the Austrian business sector for the years 2000, 2007 and 2014 in comparison to the Innovation Leaders



Source: EUKLEMS, WIFO calculations.

B.1.4.2. Value added shares from sectors with high digital intensity in the Austrian business sector over time in comparison to the Innovation Leaders

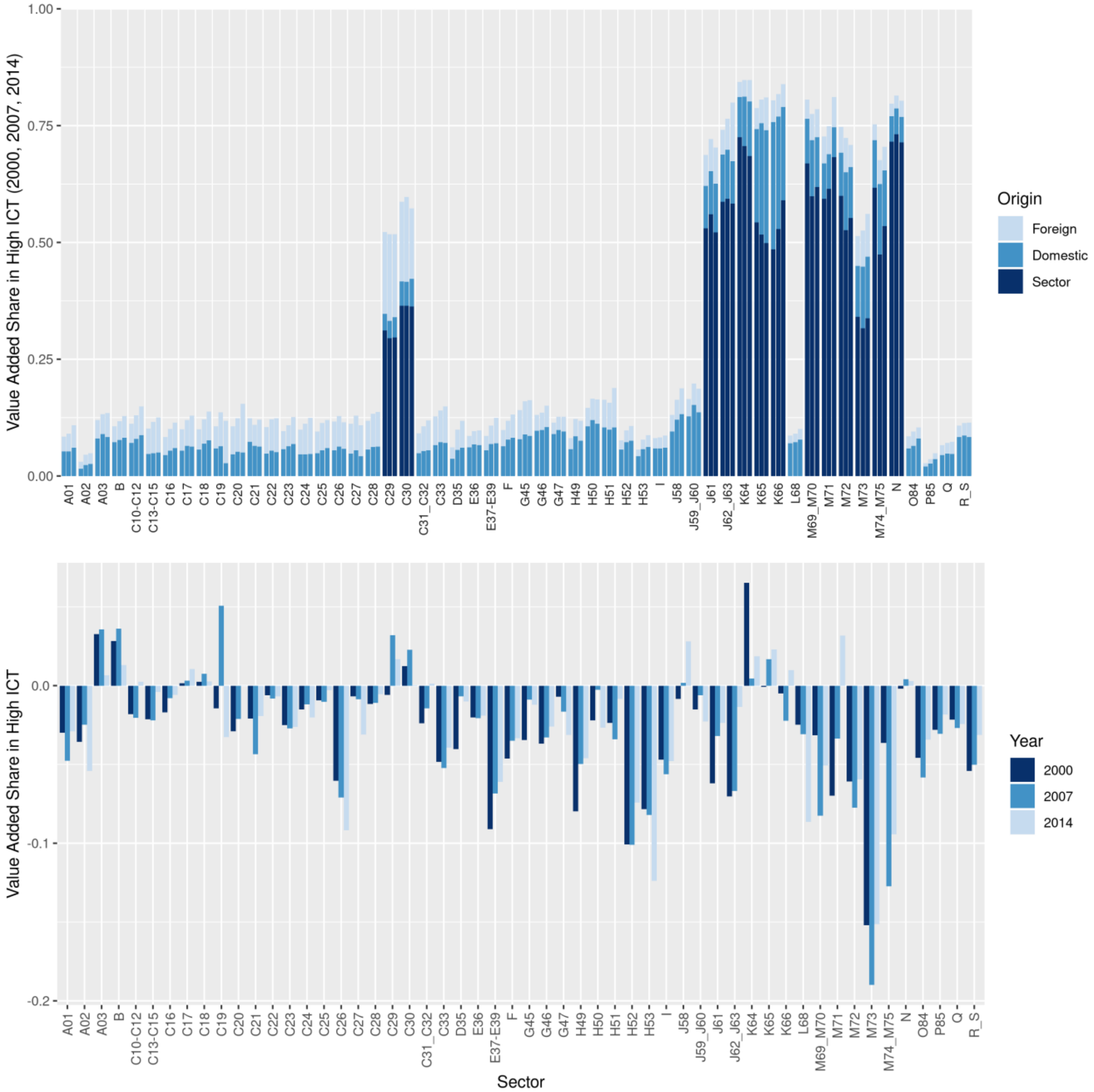
Next to direct investment into ICT technologies, digital technologies and digital content also diffuse through the value chain by means of products and services companies use in their own business activities. This type of diffusion can be proxied by means of the share of value added contained in the output of a sector that derives from intermediates and services from upstream sectors with high or medium-high digital intensity according to the OECD classification. This exercise can be taken on the one hand as a validation of the evidence on ICT investments presented in the previous section, as well as an extension of that analysis towards intermediate products which have a different life span in the production process and therefore potentially unfold effects that are of shorter term than investments in ICT capital. In the exposition that follows we will distinguish between the value added share from products and services stemming from sectors with high digital intensity, and from sectors with medium-high digital intensity. In both cases, we also compare this to the weighted average of the shares observed across the countries that are part of the group of Innovation Leaders.

Figure B-23 shows the share of value added from sectors with high digital intensity in the value added of each Austrian sector for the years 2000, 2007 and 2014 (upper panel) and the comparison with the Innovation Leaders (lower panel). The underlying data base the World Input output database (WIOD) in which the most recent observations end in 2014. For each year, the upper panel also presents the origins of the generated value added, distinguishing between the value added share generated within the sector and from other domestic or foreign sectors with high digital intensity. The representation is slightly more granular than in the previous section as data in WIOD are available at a higher resolution.

The upper panel in Figure B-21 shows that the value added share inputs from downstream sectors with high digital intensity is again very high in service sectors with high digital intensity, namely publishing and broadcasting, telecommunications, IT and other information services, and professional, scientific and technical activities as well as administrative and support service activities (M-N). This mirrors the picture obtained for direct ICT investments and is also a direct consequence of the use of the classification, as value added in the sector is counted into the share, whereas this is not the case for the other sectors. However, comparing the results with the ICT investments discussed earlier, in the manufacturing sector the value added share from upstream sectors with high digital intensity is high for transport equipment sectors (29-30), even if own value added creation is not taken into account. In the manufacturing sector in general it rarely exceeds 10-12%, whereas in the transport equipment sector it is close to 20%.

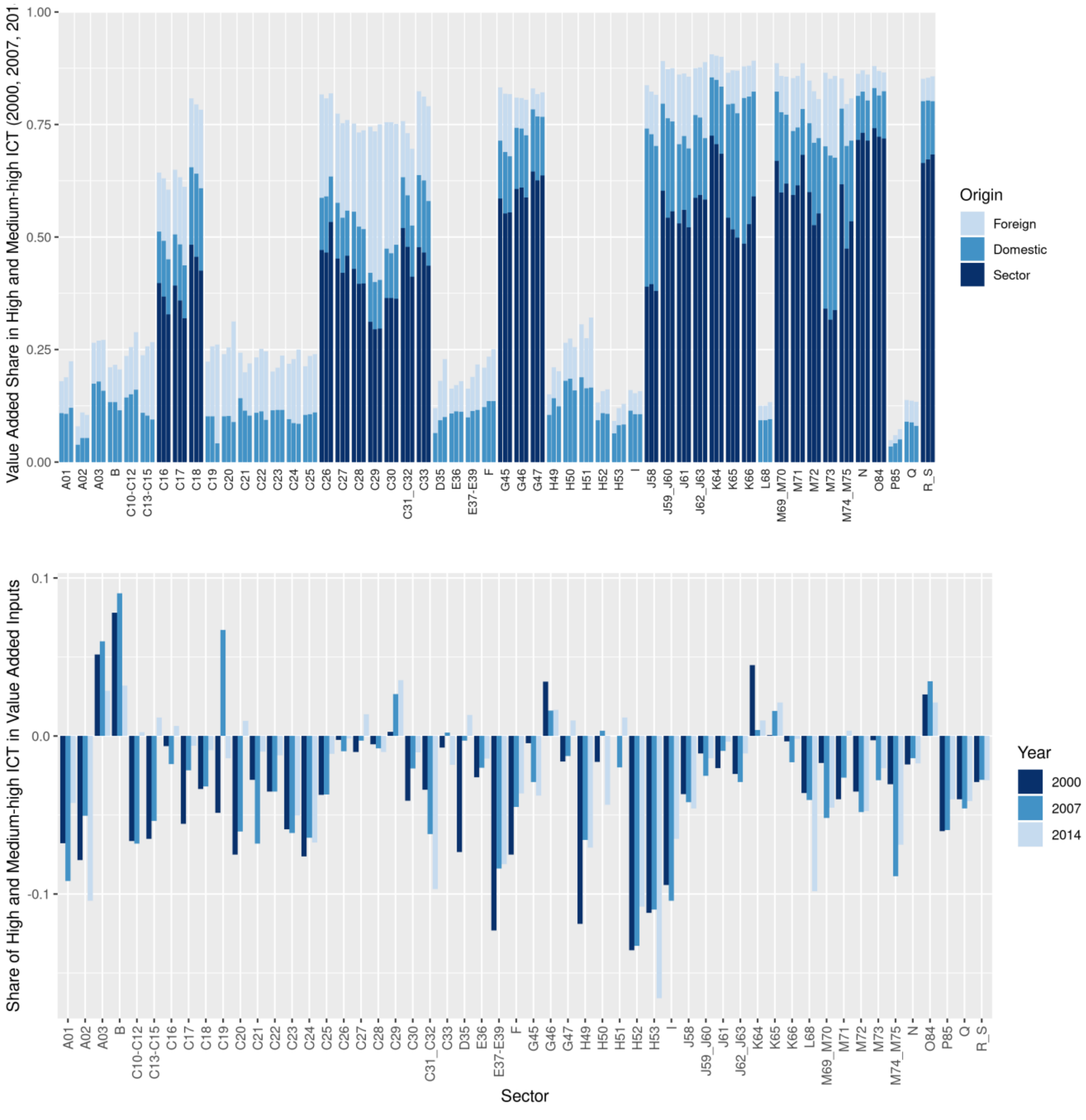
The sources of value added by origin across sectors are largely domestic, with the share of value added created by the sector itself representing the largest part. This picture is consistent with what can also be observed for other countries. The sectors where the highest share of value added is created in other domestic sectors with high digital intensity is the finance and insurance sector, whereas the share of value added stemming from sectors with high digital intensity from abroad are the transport equipment sectors (29-30). The likely reason for this is the high interdependence of these sectors with the German transport equipment industry.

Figure B-23: Share of value added from sectors with high digital intensity in sector value added for years 2000, 2007 and 2014



Source: WIOD, WIFO calculations.

Figure B-24: Share of value added from sectors with high and medium-high digital intensity in sector value added for years 2000, 2007 and 2014 benchmarked against Innovation Leaders



Source: WIOD, WIFO calculations.

Considering changes in the value added shares over time, the data show that the share of value added from industries with high digital intensity has increased for the vast majority of sectors in the Austrian economy over time. The digital intensity of value added creation has therefore increased in the Austrian business sector in the past two decades following a general trend observed in the most advanced economies.

However, the dynamics have been moderate when compared to the developments in the Innovation Leader countries. This follows from the evidence presented in the lower panel of Figure B-23. In comparison to the Innovation Leaders the share of value added from industries with high digital intensity has been consistently below the levels observed in the group of Innovation Leaders. The notable exceptions to this general evidence are, next to agriculture and forestry (A) and mining (B), the transportation equipment sectors (29-30), finance and insurance (64-66) and in recent years also publishing and broadcasting (58) and some of the administrative and support service sectors.

Figure B-24 present the result if vertical linkages are extended to sectors with medium-high digital intensity following the OECD classification. As a consequence, the figure now also shows the direct value added share of the sectors classified as having medium-high digital intensity. For most manufacturing sectors both the digital intensity of value added creation over the value chain increases to values in the range between 20 and 25%. Especially the value added share from foreign sectors increases, reflecting the strong embedding of the Austrian manufacturing industry in global value chains. However, looking at the lower panel of Figure B-24 the Austrian position relative to the Innovation Leaders changes little in the extended view. In almost all sectors value added shares from downstream sectors with high or medium-high digital intensity is well below the values observed for the Innovation Leaders. The picture also does not change if the reference group is changed from Innovation Leaders to the EU27. While in comparison to this group the gaps are smaller, most Austrian sectors show lower digital intensity in their value creation activities than their European peers (see the Appendix to this chapter for evidence).

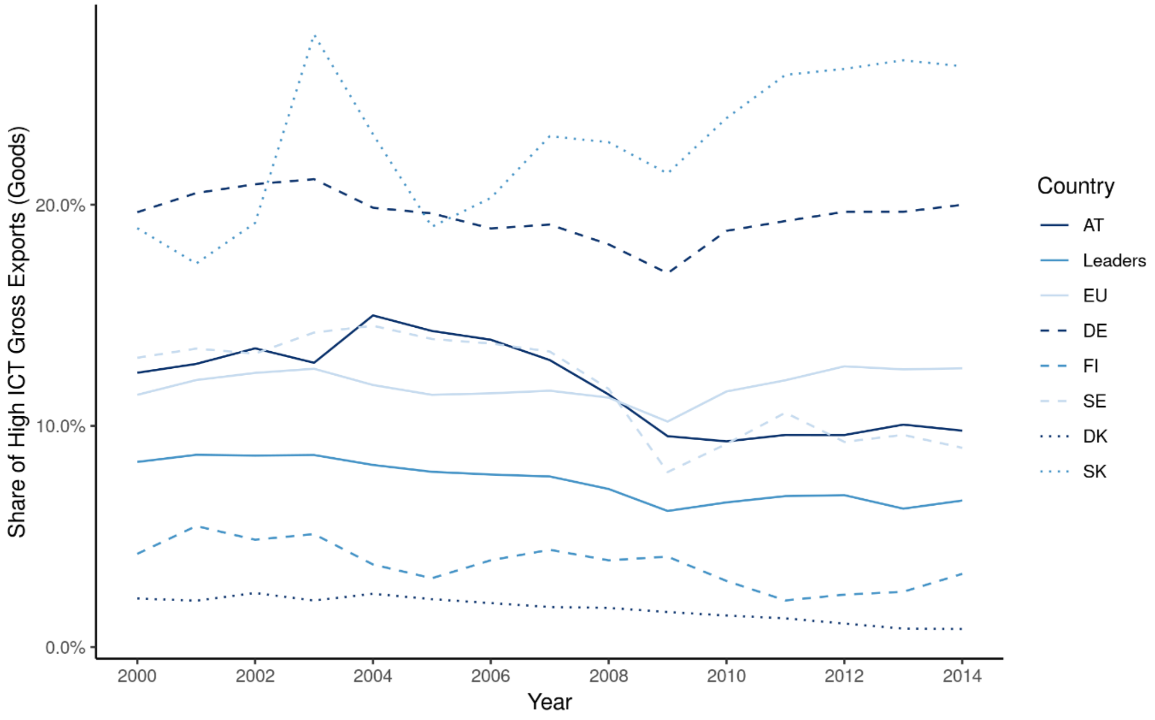
B.1.5. ICT Exports – broad sector and product type breakdown

To provide a more comprehensive picture of Austria's relative position in terms of ICT-intensive sectors and their competitiveness, export shares of the most ICT-intensive sectors are presented in the next Figures. For cross-country comparisons of indicators drawn from the World Input-Output Database (WIOD) the OECD sector classification (Calvino et al. 2018) is used to identify high ICT-intensive sectors.

Looking at the exports of services and goods from the ICT-intensive sector separately reveals that Austria's performance in terms of ICT-intensive exports of goods was clearly above the average shares of the Innovation Leader countries as well as above the EU average until the crisis in 2008/09 (see Figure B-25). After 2008/09, Austria's export shares of ICT-intensive goods dropped to a level below the EU average (but still above the average shares of Innovation Leaders) and have stagnated since then. All Innovation Leader countries show export shares of goods in ICT-intensive sectors that are below the EU average since 2008. In some countries, such as the UK, export shares of goods have started to rise again, but not in Austria.

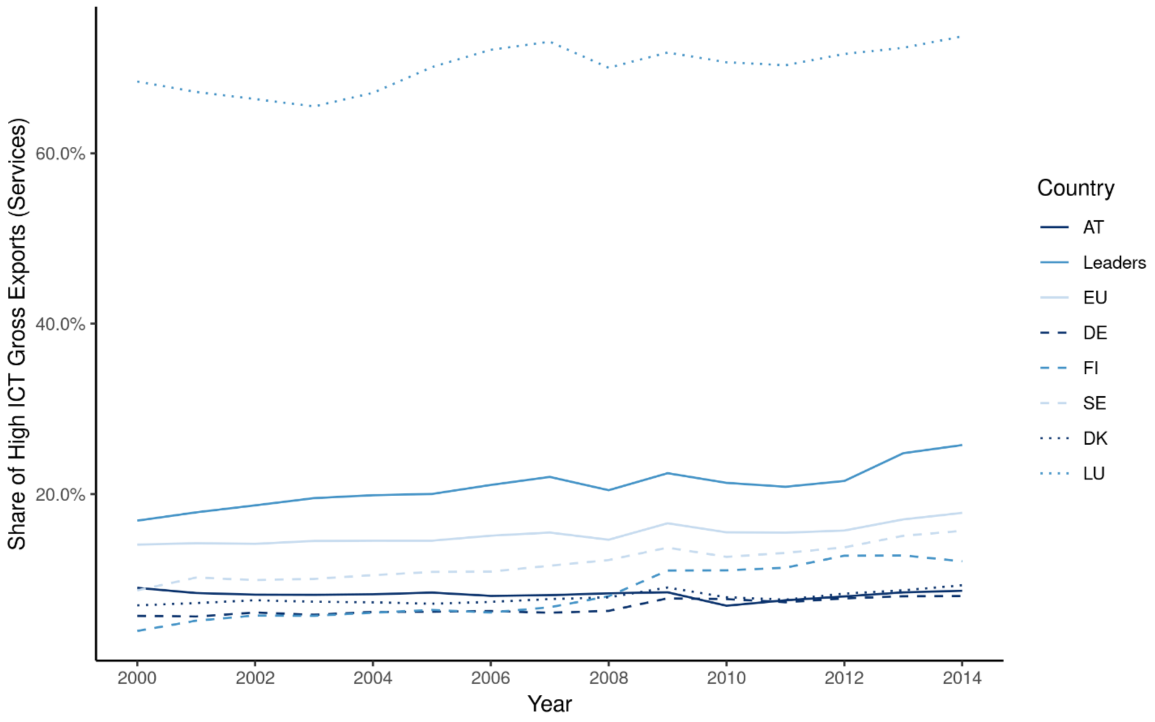
In contrast, Austria's shares of service exports from ICT-intensive sectors have always been clearly below the EU average and far behind the respective shares of Innovation Leader countries (see Figure B-26). Particularly, Luxembourg shows an exceptionally high share of service exports in ICT-intensive sectors of more than 60% of total exports, reflecting the high share of financial service exports. All Innovation Leader countries have increased their service export shares slowly over time, yet Austria's share of service exports in ICT-intensive industries has stagnated since 2000, leading to a slowly widening gap between Austria's export shares of ICT-intensive services and those of Innovation Leader countries.

Figure B-25: Shares of exports in goods of high ICT-intensive sectors between 2000 and 2014



Source: WIOD, WIFO calculation; Note: High ICT-intensive sectors (NACE Rev.2) include (Calvino et al. 2018): Transport equipment (29-30), Telecommunications (61), IT and other information services (62-63), Finance and insurance (64-66), Legal and accounting activities, etc. (69-71), Scientific research and development (72), Advertising and market research; other business services (73-75), Administrative and support service activities (77-82), Other service activities (94-96).

Figure B-26: Shares of service exports of high ICT-intensive sectors between 2000 and 2014



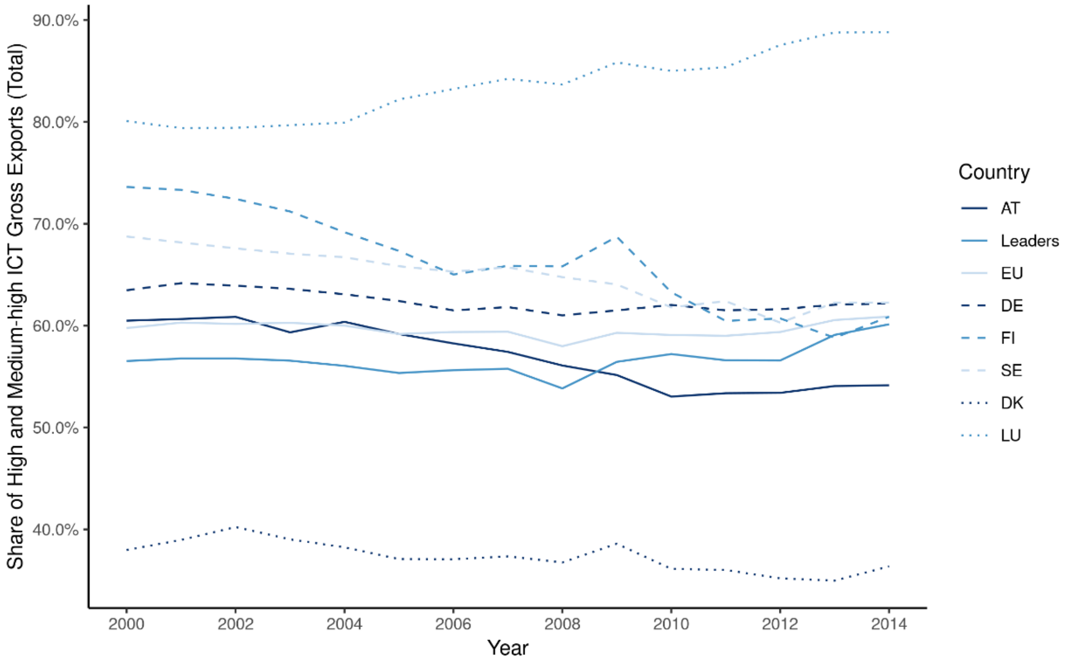
Source: WIOD, WIFO calculation; Note: High ICT-intensive sectors (NACE Rev.2) include (Calvino et al. 2018): Transport equipment (29-30), Telecommunications (61), IT and other information services (62-63), Finance and insurance (64-66), Legal and accounting activities, etc. (69-71), Scientific research and development (72), Advertising and market research; other business services (73-75), Administrative and support service activities (77-82), Other service activities (94-96).

Figure B-27 to

Figure B-28 presents an alternative illustration of Austria's export position of ICT-intensive sectors by also including sectors classified as medium-high ICT-intensive (Calvino et al. 2018), such as "wholesale and retail trade". A positive trend in case of service exports from ICT-intensive industries in all innovation leading countries as well as in the EU on average can be observed, while the opposite is observed for exports in goods. Regarding Austria's relative position, the picture drawn above is confirmed: in terms of service exports from ICT-intensive sectors Austria lags behind the EU average export shares and well behind those of Innovation Leader countries. In contrast, Austria's position measured by export shares in goods from ICT-intensive countries is above those of most Innovation Leaders except for Finland.

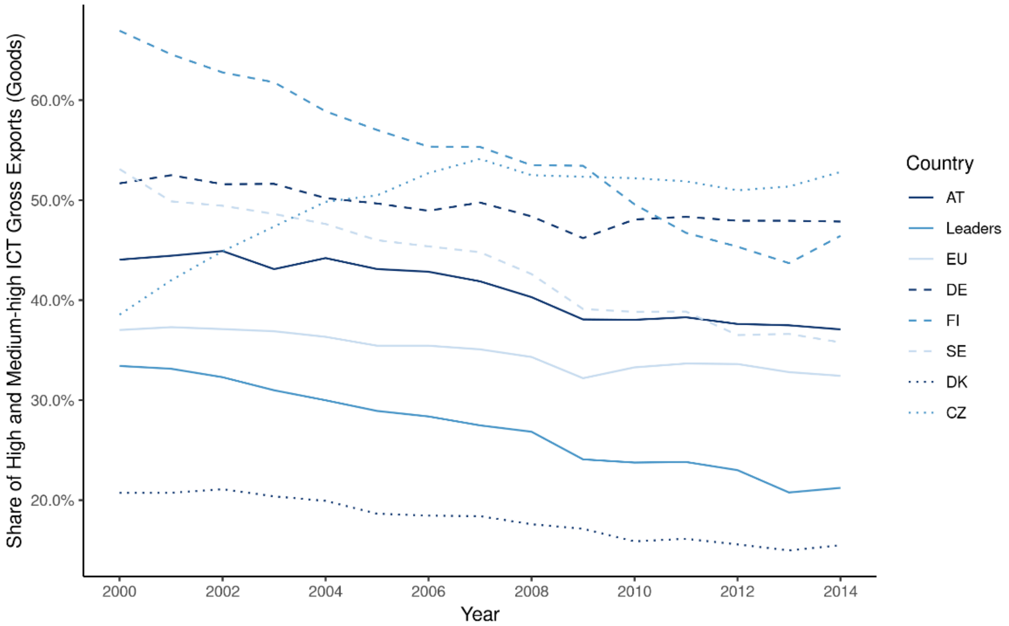
Finally, value added export shares from ICT-intensive sectors can be used to ensure that the value added of products and services generated by ICT-intensive sectors, which have been finally exported from sectors with low ICT intensity, is also included.

Figure B-27: Shares of exports of high and medium-high ICT-intensive sectors between 2000 and 2014



Source: WIOD, WIFO calculation. Note: High and medium-high ICT-intensive sectors (NACE Rev.2) include (Calvino et al. 2018): Transport equipment (29-30), Telecommunications (61), IT and other information services (62-63), Finance and insurance (64-66), Legal and accounting activities, etc. (69-71), Scientific research and development (72), Advertising and market research; other business services (73-75), Administrative and support service activities (77-82), Other service activities (94-96), Wood and paper products, and printing (16-18), Computer, electronic and optical products (26), Electrical equipment (27), Machinery and equipment n.e.c. (28),Furniture; other manufacturing; repairs of computers (31-33), Wholesale and retail trade, repair (45-47), Publishing, audiovisual and broadcasting (58-60), Public administration and defence (84), Arts, entertainment and recreation (90-93).

Figure B-28: Shares of exports in goods of high and medium-high ICT-intensive sectors between 2000 and 2014



Source: WIOD, WIFO calculation. Note: High and medium-high ICT-intensive sectors (NACE Rev.2) include (Calvino et al. 2018): Transport equipment (29-30), Telecommunications (61), IT and other information services (62-63), Finance and insurance (64-66), Legal and accounting activities, etc. (69-71), Scientific research and development (72), Advertising and market research; other business services (73-75), Administrative and support service activities (77-82), Other service activities (94-96), Wood and paper products, and printing (16-18), Computer, electronic and optical products (26), Electrical equipment (27), Machinery and equipment n.e.c. (28),Furniture; other manufacturing; repairs of computers (31-33), Wholesale and retail trade, repair (45-47), Publishing, audiovisual and broadcasting (58-60), Public administration and defence (84), Arts, entertainment and recreation (90-93).

Figure B-29 to Figure B-31 illustrate the total value added export shares from highly ICT-intensive sectors as well as the value added export shares in goods and services from ICT intensive sectors. Again, Austria's relative positions compared to reference countries and the EU average remain unchanged.

The analysis so far assumes that the sectors classified as ICT-intensive sectors are similar in all EU MS. Since the classification for ICT-intensive sectors is based on the averages of different ICT indicators, variations of ICT-intensities within a sector are not considered. However, for one and the same sector the specific sector composition in terms of the produced products can vary between countries depending on their sectoral production portfolios. Thus, the industry-level analysis is extended by data allowing to analyse the product portfolio of different EU MS.

In the following, BACI World trade database is used, which allows a more fine-grained analysis of Austria's ICT intensities at the product level. The principal classification that is used is the recently released OECD classification of ICT products and patents (Inaba – Squicciarini 2017). The OECD ICT product classification relies on 5-digit CPC and 4-digit ISIC product classifications. For these concordance tables to the Harmonised System classification used, the BACI data exists.[92]

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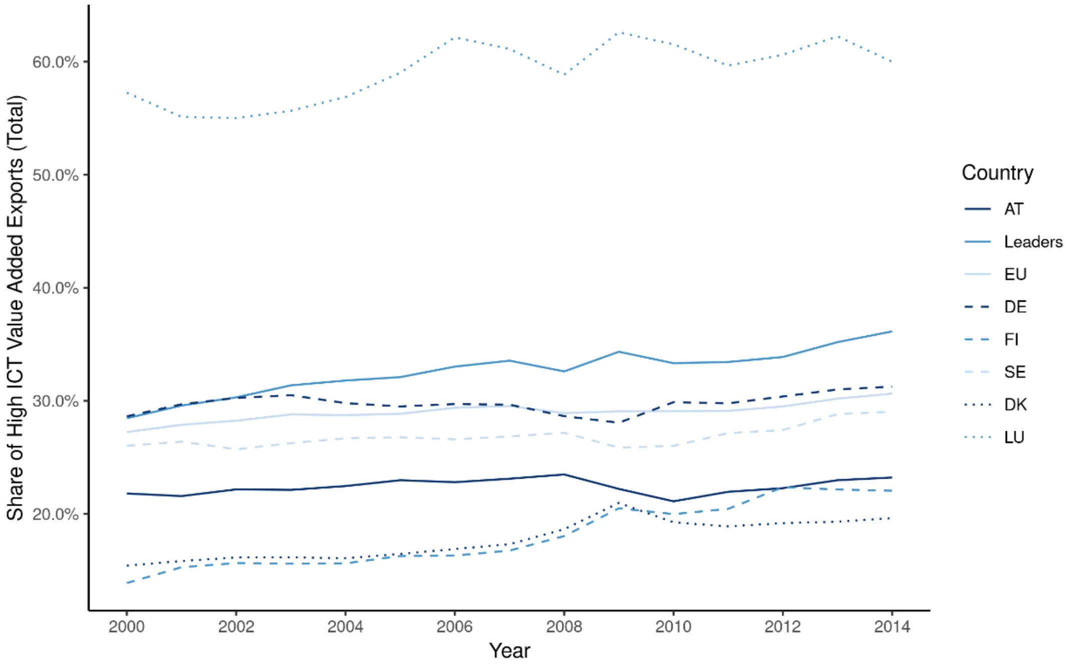
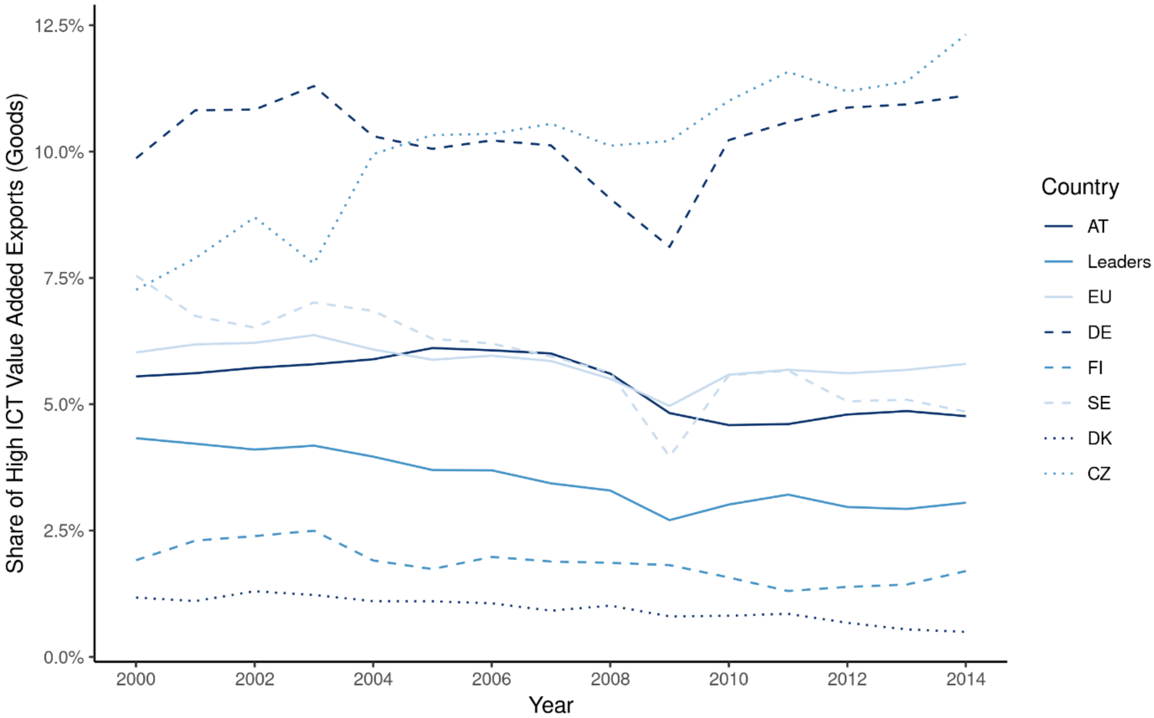
92 HS-CPC concordance: https://wits.worldbank.org/product_concordance.html; http://ec.europa.eu/eurostat/ramon/miscellaneous/index.cfm?TargetURL=DSP_PRD_2008_CPC_2

Figure B-29: Shares of value added exports of high ICT-intensive sectors between 2000 and 2014



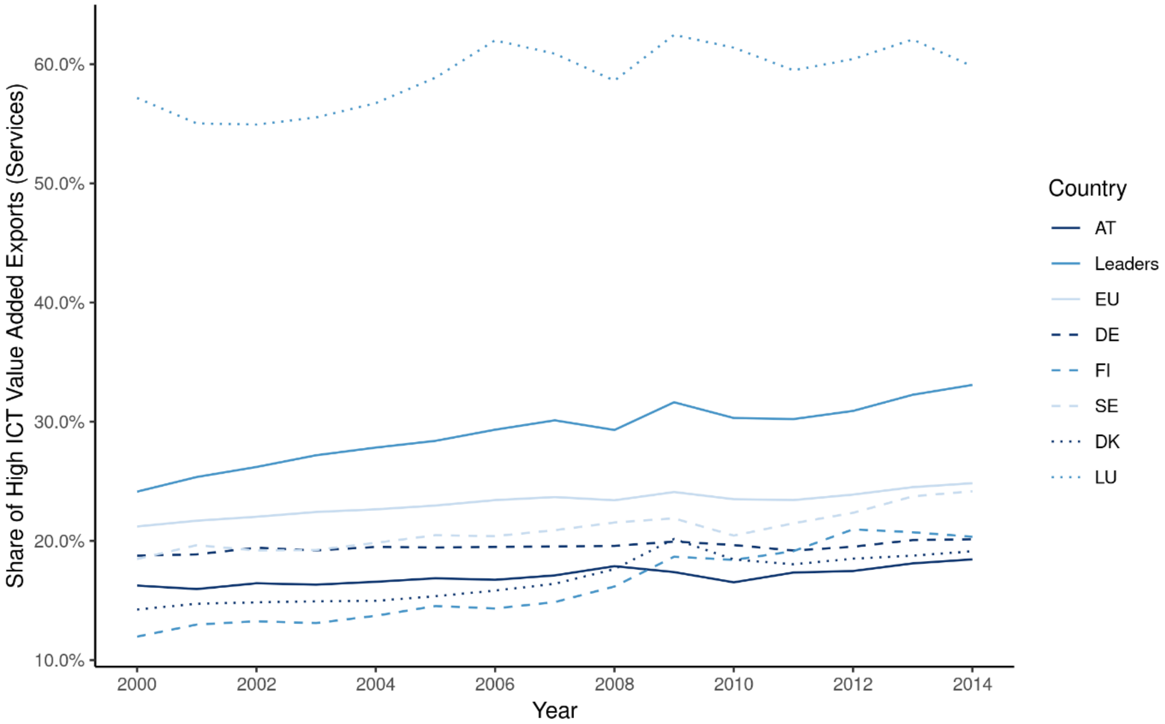
Source: WIOD, WIFO calculation. Note: High ICT-intensive sectors (NACE Rev.2) include (Calvino et al. 2018): Transport equipment (29-30), Telecommunications (61), IT and other information services (62-63), Finance and insurance (64-66), Legal and accounting activities, etc. (69-71), Scientific research and development (72), Advertising and market research; other business services (73-75), Administrative and support service activities (77-82), Other service activities (94-96).

Figure B-30: Shares of value added exports in goods of high ICT-intensive sectors between 2000 and 2014



Source: WIOD, WIFO calculation. Note: High ICT-intensive sectors (NACE Rev.2) include (Calvino et al. 2018): Transport equipment (29-30), Telecommunications (61), IT and other information services (62-63), Finance and insurance (64-66), Legal and accounting activities, etc. (69-71), Scientific research and development (72), Advertising and market research; other business services (73-75), Administrative and support service activities (77-82), Other service activities (94-96).

Figure B-31: Shares of value added exports in services of high ICT-intensive sectors between 2000 and 2014

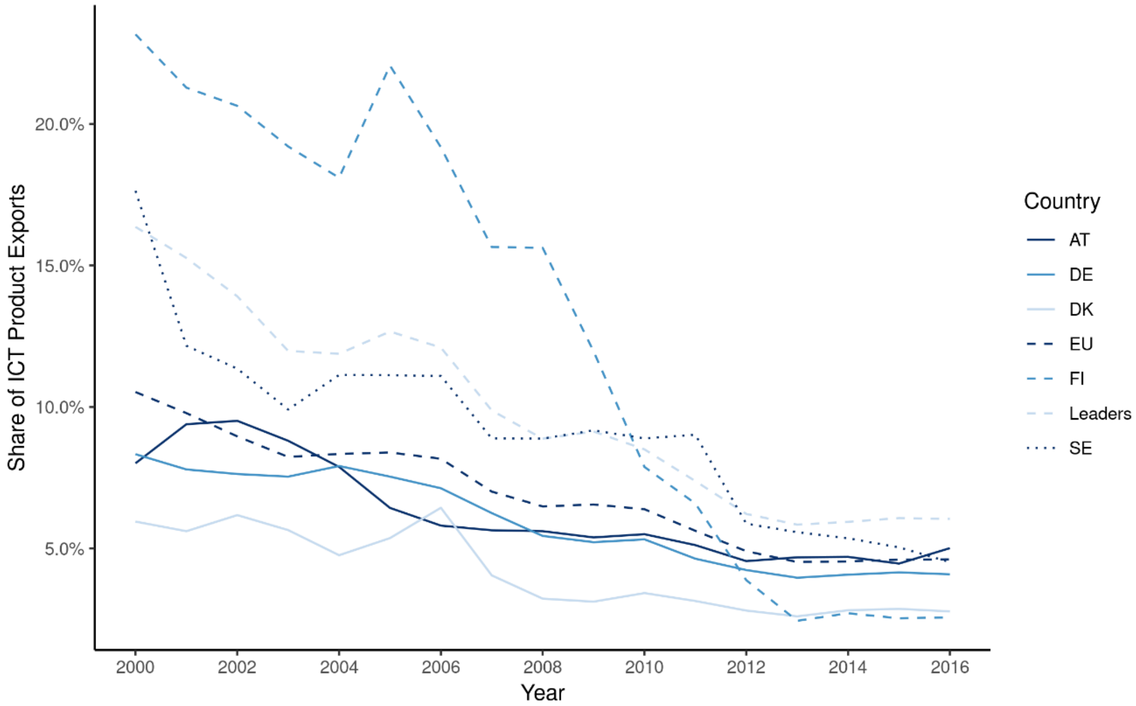


Source: WIOD, WIFO calculation. Note: High ICT-intensive sectors (NACE Rev.2) include (Calvino et al. 2018): Transport equipment (29-30), Telecommunications (61), IT and other information services (62-63), Finance and insurance (64-66), Legal and accounting activities, etc. (69-71), Scientific research and development (72), Advertising and market research; other business services (73-75), Administrative and support service activities (77-82), Other service activities (94-96).

Based on the classification of patents and products by the OECD, in total 61 different products have been identified as ICT-intensive. Among those products are, for instance, (photosensitive) semiconductor devices, cash registers, magnetic discs, electric sound amplifiers, lasers, or parts of the electronic integrated circuits and micro-assemblies.

Figure B-32 illustrates Austria's export shares of these products in comparison to the reference countries. Overall, the export shares of these products have been decreasing in the EU countries. Austria's export shares are similar to the EU average. After persisting and distinct decreases of Finland's export shares (also reflecting the reduction of Nokia's market shares in the mobile phone market), for the last years Sweden has the highest export shares of ICT-intensive products within the EU.

Figure B-32: Share of exports of ICT-intensive products in total exports



Source: BACI, WIFO calculation. Note: Based on the patent classification of the OECD, 61 different products have been identified as highly ICT-intensive. This figure plots the export shares of these 61 products.

While based on export shares alone it is unclear whether the exported ICT-intensive products represent a competitive advantage in the sense of complex product portfolios, complexity scores calculated in line with (Hidalgo – Hausmann 2009) can be used to measure the "ubiquity" or exclusivity of a product.

Box B-1:The Method of Reflections (Hidalgo – Hausmann (2009))

$$k_{c,0} = \sum_p M_{c,p} \text{ … diversification}$$

$$k_{p,0} = \sum_c M_{c,p} \text{… ubiquity}$$

$M_{c,p}$ denotes the country product matrix that contains ones for all country-product combinations in which the country c is a significant exporter of product p, otherwise zeros.

Iterations:

$$k_{c,n} = \frac{1}{k_{c,0}} \sum_p M_{c,p}\, k_{p,n-1} \text{ for } n \geq 1$$

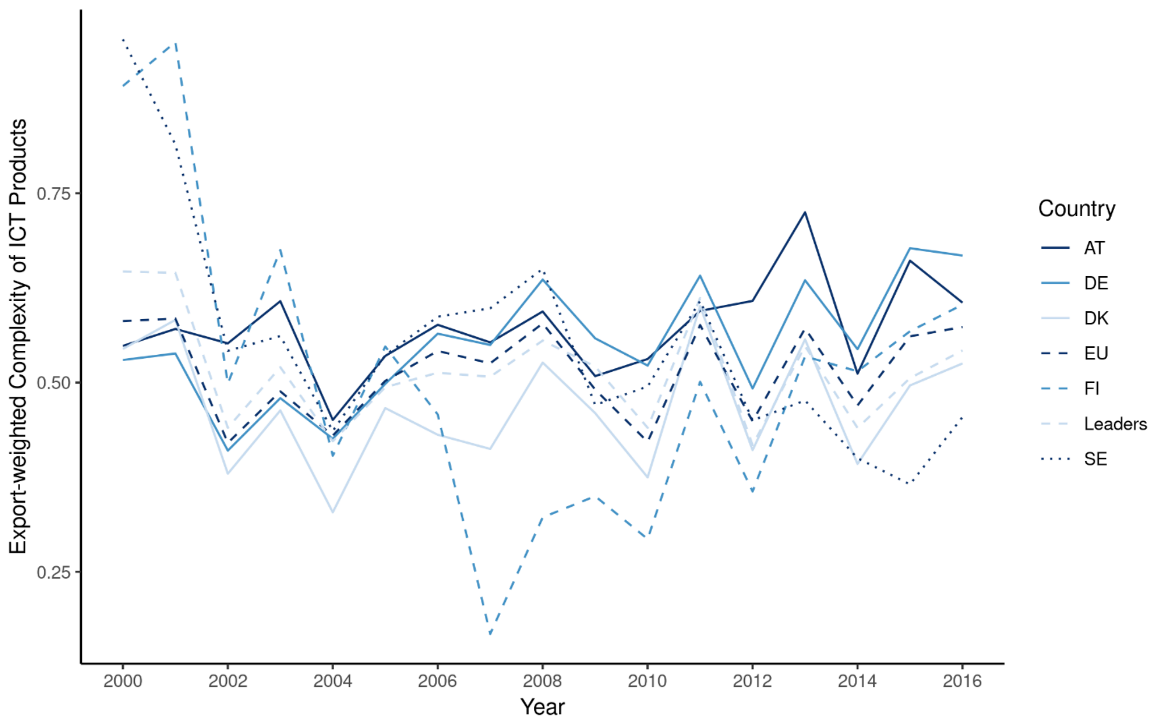
$$k_{p,n} = \frac{1}{k_{p,0}} \sum_c M_{c,p}\, k_{c,n-1} \text{ for } n \geq 1$$

As long as the number of rank changes decreases, iterations are repeated. In case of stability in ranks, the algorithm stops. The country sophistication is obtained by standardizing $k_{c,n}$. The product complexity respectively by standardizing $k_{\mathrm{p},n}$.

The complexity scores capture differences in the technological sophistication of sector-specific product portfolios across countries. They can be considered to capture latent information on the breadth and depth of the knowledge base of a country. A close examination of this indicator in (Reinstaller et al. 2012) has shown that it closely correlates with important indicators on the knowledge and capital intensity (e.g. R&D expenditures, revealed human capital and capital intensity, FDI inflows etc.).

Figure B-33 illustrates the average complexity scores of the ICT-intensive products that are exported by Austria and reference countries. Overall, ICT-intensive products are more complex than the average product (their complexity scores are above zero, which represents the average complexity across all products). Compared to the EU average, the complexity of ICT-intensive products in Austria is high. Since 2011, in the EU only Germany has exported ICT-intensive products that are similar or more complex than those exported by Austria. What components of the ICT-intensive product portfolio of Austria do drive the relatively high complexity score? It turns out that especially electronic integrated circuits, diodes, transistors, and semiconductor devices as well as different types of storage devices are characterised by very high complexity scores. Thus, although Austria is characterized by a rather mediocre export share of ICT-intensive products, the portfolio of these ICT-intensive products that are exported is remarkably complex.

Figure B-33: Export-weighted product complexity of ICT-intensive products



Source: BACI, WIFO calculation. Note: Based on the patent classification of the OECD 61 different products have been identified as highly ICT-intensive. The export-weighted complexity scores are standardized, such that the average complexity of all products is zero. Values above zero indicate complexity scores above the average, while values below zero indicate below-average product complexity of exported products.

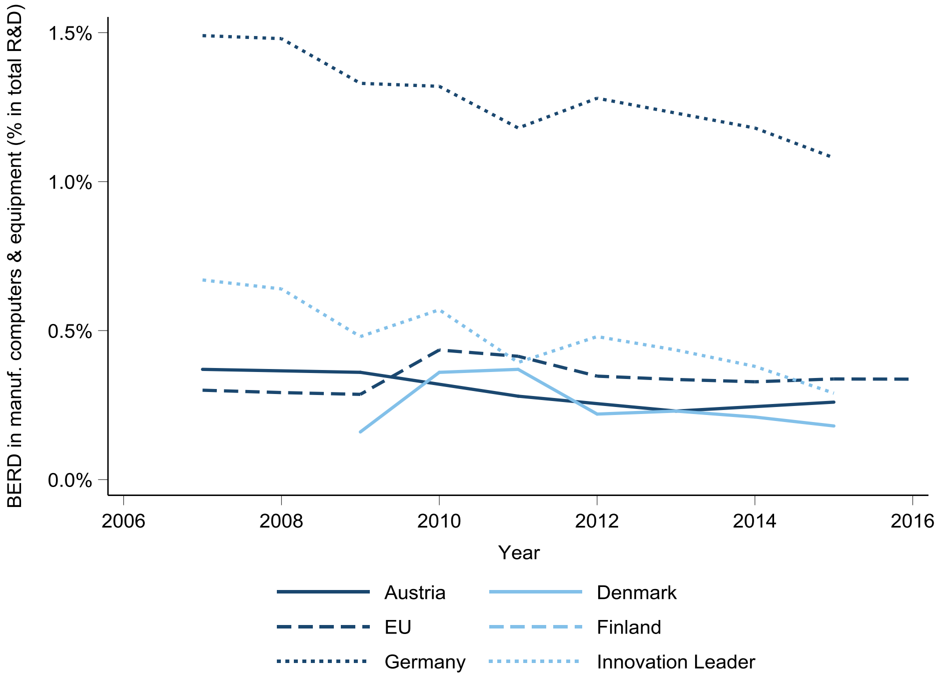
B.1.6. Business R&D investment and ICT-related patenting

B.1.6.1. Business R&D – sector level breakdown

Business expenditures on research and development (R&D) in ICT-intensive sectors provide a first impression of countries' research intensities and reveal considerable heterogeneity. The following figures illustrate business expenditure on R&D (BERD) in manufacturing of computers and peripheral equipment (Figure B-34), in manufacturing of electronic components and boards (Figure B-35) and in computer programming, consultancy and related activities (Figure B-36) as a percentage of total R&D expenditure.

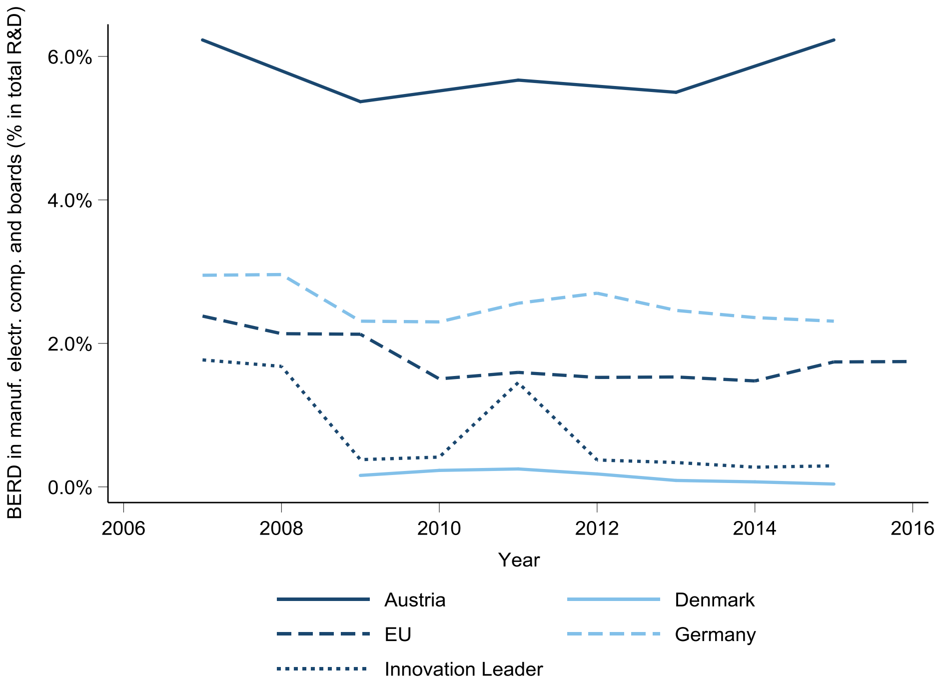
While Austria is well below the Innovation Leaders and similar to or well below the EU average in the manufacturing of computers and peripheral equipment and in computer programming, consultancy and related activities, it has the highest share of BERD in the manufacturing of electronic components and boards among the innovation leading countries and is well above the EU28 average.

Figure B-34: Business expenditure on R&D in manufacturing computers and peripheral equipment (% of total R&D expenditure)



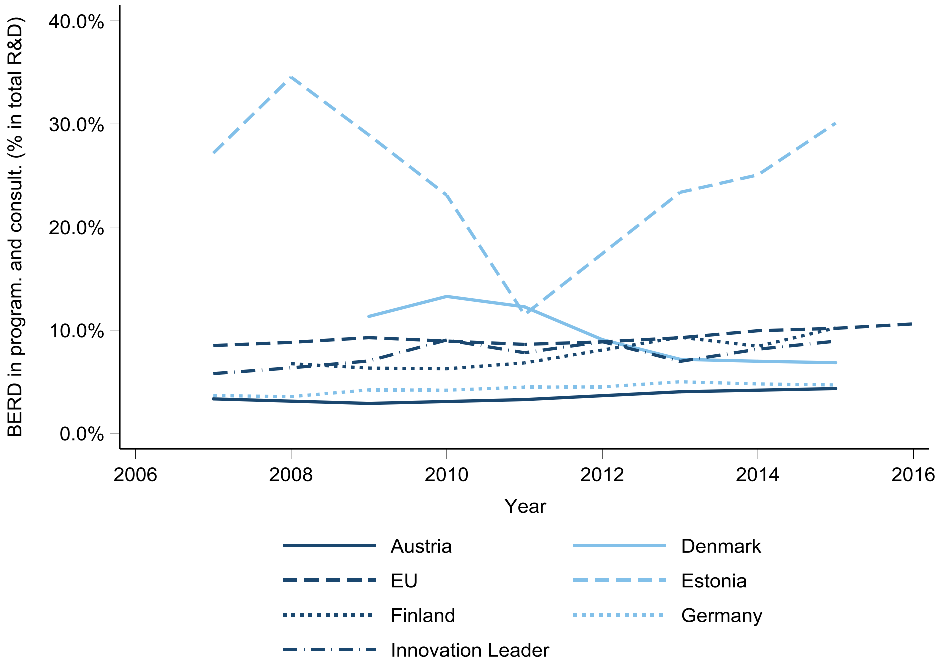
Source: Eurostat, WIFO illustration. Note: Data are missing for Luxembourg, Finland, Sweden, and the Netherlands; To calculate the EU average, missing values are replaced by three-year moving averages wherever possible. Latvia, Luxembourg, Sweden are not included in the EU average due to lack of data. The Innovation Leader average includes the following countries: Denmark, the Netherlands, Finland, the United Kingdom.

Figure B-35: Business expenditure on R&D in manufacturing of electronic components and boards (% of total R&D expenditure)



Source: Eurostat, WIFO illustration. Note: To calculate the EU average, missing values are replaced by three-year moving averages wherever possible. Latvia, Luxembourg, Sweden are not included in the EU average due to lack of data. The Innovation Leader average includes the following countries: Denmark, the Netherlands, Finland, the United Kingdom.

Figure B-36: Business expenditure on R&D in computer programming, consultancy and related activities (% of total R&D expenditure)



Source: Eurostat, WIFO illustration. Note: To calculate the EU average, missing values are replaced by three-year moving averages wherever possible. The Innovation Leader average includes the following countries: Sweden, Denmark, Luxembourg, the Netherlands, Finland, the United Kingdom.

B.1.6.2. Patenting activities – sector-level and technology-specific breakdown

Next to the embodied technology diffusion analysed in the previous section, technological search activities by companies are also an important channel of transmission and diffusion of technological knowledge in the economy. Companies contribute to the development of the technological knowledge base of the economy in digital technologies, both by directly developing new digital technologies and by combining digital technologies with other technologies. This is also reflected in their patenting activities.

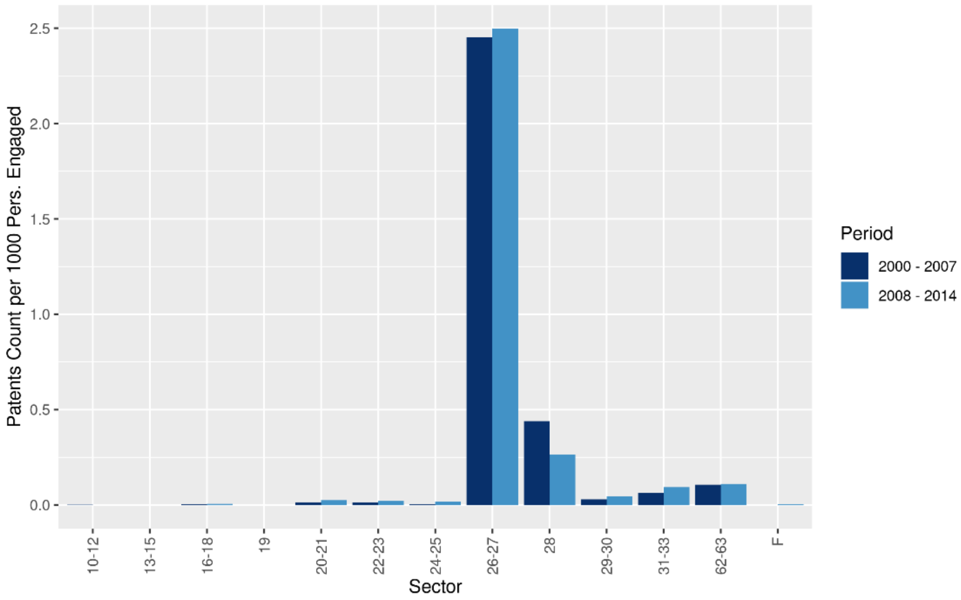
The principal data source for this exercise is the Patstat database of the European Patent Office. To identify patents in relevant digital technologies, this section uses the new OECD taxonomy of ICT technologies based on the international patent classification (Inaba – Squicciarini 2017). Given the publication and citation lags of patents, the indicators presented in this section will have 2014 as the most recent year even though more recent observations are available. However, given these lags, cross-country comparisons and the characterisation of development over time would not be reliable at the current edge.

The indicators are calculated for patent filings at the European Patent Office and are allocated to the inventor's country of residence (in case of multiple inventors, fractionally). The choice of EPO filings is determined by the need to ensure that a home bias in patent filings as well as inconsistencies due to differences in filing procedures and costs across countries are eliminated. The choice to base the counts on inventors is determined by the circumstance that especially in Austria (as in other smaller countries) many larger companies are owned by foreign multinationals that tend to handle their intellectual property through centralised offices in other countries, which would result in an underestimation of effective inventive activities if counts were based on applicants.

The descriptive analysis that follows keeps the development of digital technologies by Austrian companies and the use of such technologies in the development of other technologies than digital ones apart. For the first aspect, the analysis relies on patent counts in digital technologies in general as well as in twelve technology areas inside the broader field of digital technologies. For the second aspect, the analysis relies on patent counts across technological fields (except for digital technologies) and sectors that cite patents for digital technologies and therefore reference their technological content.

Each of the following subsections presents first evidence on the sectoral distribution of inventive activities in Austria. Then this evidence is compared with the sector aggregate of the group of Innovation Leaders using, in addition to simple counts, indicators more strongly capturing the economic value of the patents. Finally, a detailed breakdown for the twelve technological areas identified in the OECD taxonomy of ICT technologies by sector is presented (the OECD actually identifies 13 categories where the thirteenth is a generic catch-all class, which we ignore here for economy of exposition).

Figure B-37: Counts of ICT patent filings at the EPO by Austrian inventors across sectors per 1000 persons engaged in a sector (average per year), Austria



Source: EPO PATSTAT, WIFO calculations.

Figure B-37 shows the distribution of inventive activities in digital technologies in Austria across sectors by means of a simple fractional patent count. Only the sectors where we observe any patent filings between 2000 and 2014 are shown. The figure also breaks the counts down into two distinct subperiods (2000-2007 and 2008-2014). To control for the size of a sector the counts have been normalised by the total number of persons engaged in each sector. These data are drawn from the EUKLEMS database. The figure therefore shows the average number of patents filed at EPO per thousand persons engaged in a sector per year on average. The evidence does not change if PCT patent filings are used in place of filings at EPO.

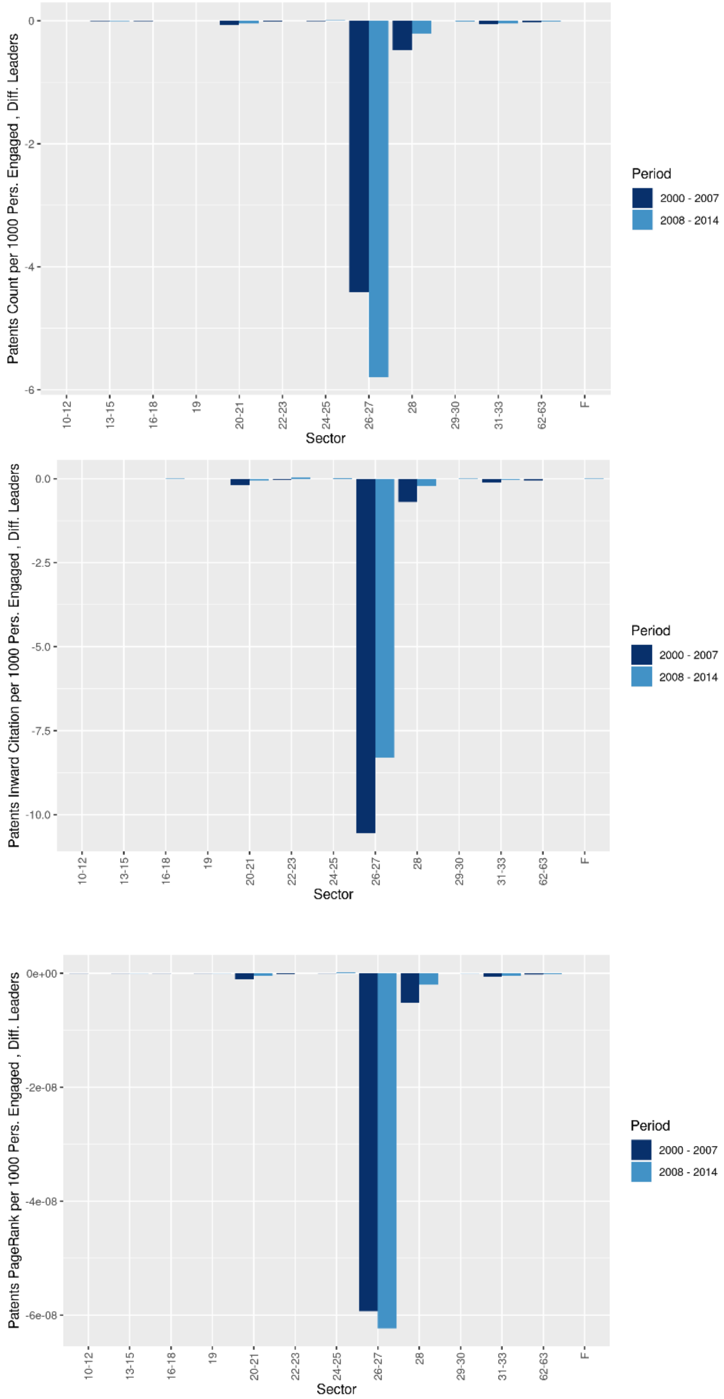
The figure shows that inventive activities related to digital technologies are very concentrated in a few mostly manufacturing sectors. The highest per capita counts in any sector are observed for the computer, electronic and optical products sector (26) and the electrical equipment sector (27). In these two sectors the number of patent filings has slightly increased over time. Another sector in which digital technologies are invented is the machinery and equipment sector (28) where patenting activities have, however, decreased in the recent past. Other sectors with a considerably more limited inventive activity in digital technologies are the transport equipment industry (29-30), other manufacturing including computer repairs (31-33), and IT and information services (62-63). Negligible activities can be observed in the wood and paper industry (16-18), the chemical and pharmaceutical industry (20-21), the rubber and plastic (22-23) and the basic metals and fabricated metal products industries (24-25).

As the analysis focuses on the invention of digital technologies, the observed pattern with its strong concentration of patenting in the ICT and electronics industries is not surprising. It is more informative to look at potential deviations from the sectoral patenting patterns observed for the Innovation Leaders. Figure B-38 shows the differences in sectoral patenting in digital technologies in comparison to the Innovation Leaders. The top panel shows differences in the normalised count as presented in Figure B-39. The middle and bottom panel go a step further and use different weighting schemes for these counts to also capture the potential economic value of the counted patents. Simple counts may not yield information as to whether the counted patents are of any economic value. Most filed patents are not granted and many (filed) patents also never get cited. Starting with the early work by Trajtenberg (1990) the literature has, however, shown that the more patents get cited the higher their economic value tends to be (for some caveats and a discussion see Reinstaller – Reschenhofer 2017).

The middle panel therefore shows differences in Austrian patenting for citation-adjusted counts vis-à-vis the Innovation Leaders, i.e. patents that are cited more often get a higher weight in the count than patents that are not cited. The bottom panel finally uses a measure proposed by Reinstaller and Reschenhofer (2017) based on direct and indirect citations using the well-known Google PageRank algorithm (Brin and Page 1998). This indicator ranks patents higher based on the inward citations of both the cited and all citing patents in the citation network. The rank scores obtained in this way are closely correlated with all indicators typically used to capture the economic value of patents and are an even more accurate measure of economic value than simple citation-weighted counts. The downside of citation-weighted indicators is that they become more inaccurate on the current edge due to the time lags with which citations to a patent can be documented.

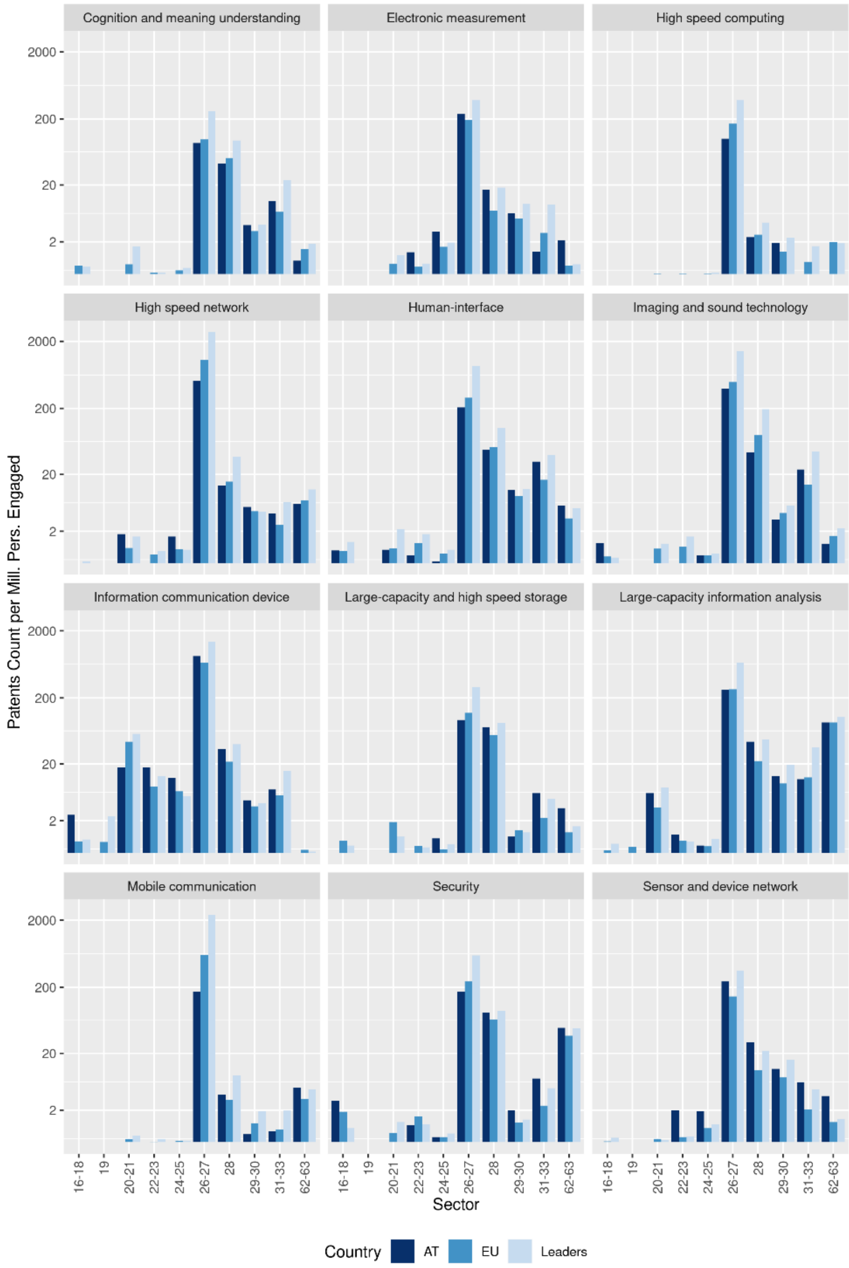
Figure B-38 now shows, in the top panel, that across the sectors that are actively patenting digital technologies, Austria trails the Innovation Leaders. This gap increased between 2008 and 2014, especially in the computer, electronic and optical products sector (26) and the electrical equipment sector (27) and narrowed in the machinery and equipment industry (28). Taking indicators that capture the economic value better, the count-based evidence for a gap is confirmed. However, the evidence provided in the middle and bottom panel suggests that, especially in the computer (26) and electrical equipment sectors (27), the gap may have remained constant or even narrowed over time relative to the Innovation Leaders suggesting that, while in absolute numbers Austrian companies in this sector seem to patent less, their patents have become economically more valuable over time.

Figure B-38: Difference in ICT patent filings at EPO by sector in Austria in comparison to the Innovation Leaders using counts, citation-weighted counts and PageRank scores



Source: EPO PATSTAT, WIFO calculations. Note: patent filings at EPO by inventor location.

Figure B-39: Average number of ICT patents at EPO per year and million persons engaged in a sector filed by Austrian companies in comparison to Innovation Leaders and the EU in different technological areas of digital technologies, 2008-2014



Source: EPO Patstat, WIFO calculations.

Figure B-39 now provides a more granular breakdown of the evidence presented in the previous figures. It shows the average number of patents per year and (million) persons engaged in a sector (cf. Figure B-38) for the period 2008-2014, but for twelve distinct technological fields in line with the OECD, the ICT patent classification. For each patenting sector the indicator is shown for Austria, the sector average across all Innovation Leaders and the sector average across all EU member states.

The breakdown by technological areas in the field of ICT and digital technologies shows that Austrian sectors show consistently lower patenting activities across sectors for cognition and meaning understanding technologies, high speed computing, high speed networks, image and sound technologies, and to a lesser extent also for human interface technologies and mobile communications. The counts for Austrian ICT patents are instead higher than in both the Innovation Leaders and the EU countries in the field of information communication devices and sensor and device networks in almost all sectors. This corresponds to the technological specialisation pattern inside the broader field of ICT and digital technologies already reported in Chapter 2.

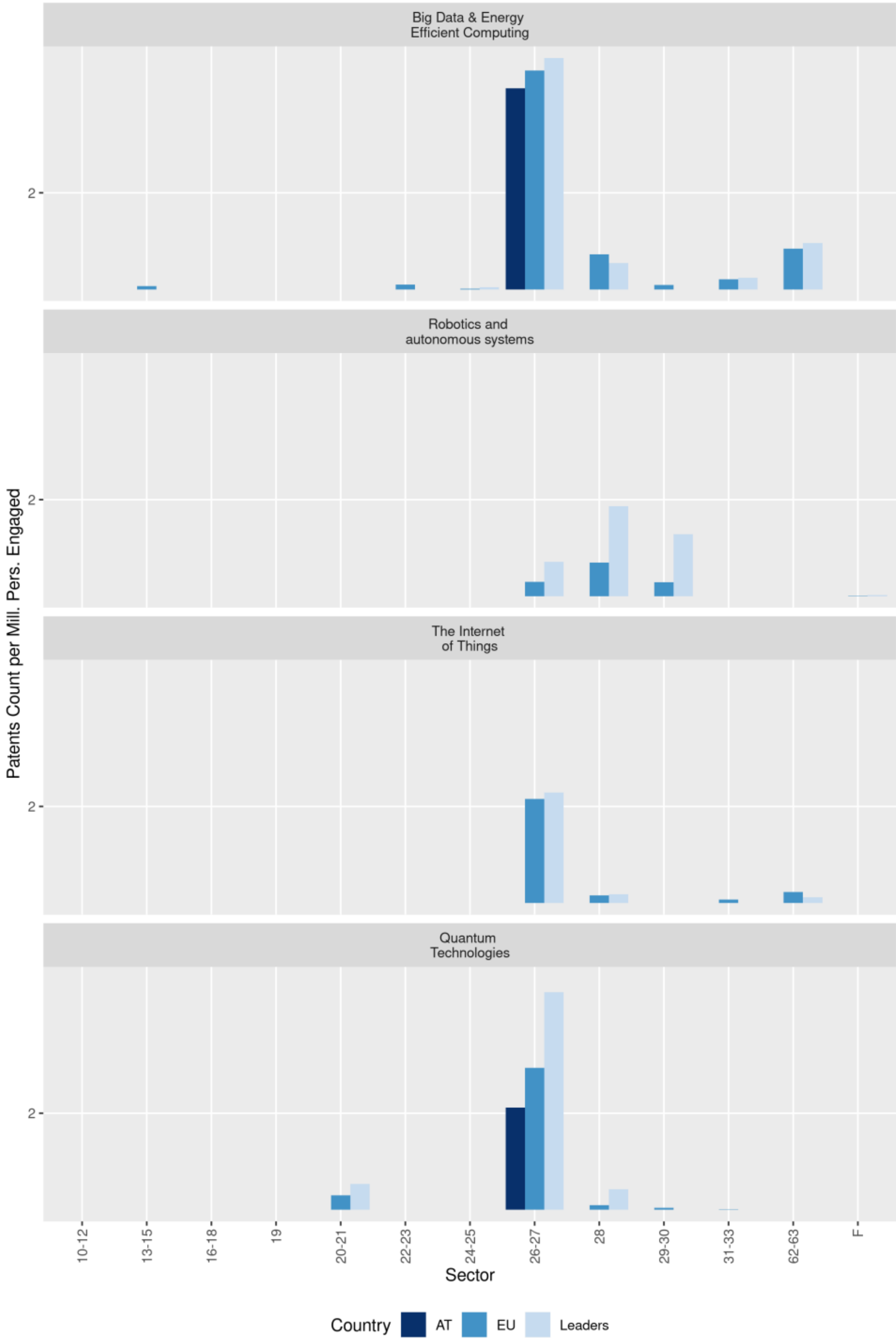
However, beyond this general pattern of specialisation, there is a considerable variation in the performance of ICT patenting in Austria as opposed to the Innovation Leader (and the EU) countries across sectors and technological subfields. The patent output of the computer and electronic/optical products industry (26) is consistently lower than in the reference group across technological areas. The machinery and equipment (28) and the IT service (62-63) sectors, however, show better performance than Innovation Leaders on average in several technological areas. The machinery and equipment industry performs better in ICT patents related to human interface technologies, large-capacity high-speed storage as well as sensor and device networks, and is on par with its peers in the Innovation Leader countries in electronic measurement, security and large-capacity information systems. The IT service sector on the other hand has filed a larger number of ICT patents in security, human interface, large-capacity and high-speed storage as well as sensor and device network technologies. The transport equipment industry (29-30) shows slightly higher ICT-patenting activity than Innovation Leader peers in information and communication device and high-speed network technologies, whereas for other manufacturing including computer repair (31-33) we observe high patent counts per person engaged in security, large-capacity storage, high-speed network as well as sensor and device network technologies.

Figure B-40 presents even more granular evidence on the patenting activities (at EPO) of Austrian companies relative to companies from the EU 28 and the Innovation Leaders in some emergent digital technologies such as big data and energy-efficient computing, robotics and autonomous systems, the internet of things as well as quantum technologies. In order to identify these patents, classifications and search strategies developed by the British Intellectual Property Office (IPO) have been used. As the anaylsis focuses on EPO patent filings the number of cases identified for the whole sample of countries is relatively small. It is also important to notice that a search strategy limited to key-word identification in the patent abstracts only may miss out on relevant cases. Thus, the results in the figure should be taken as being indicative and not exhaustive.

Figure B-40 shows that no patents filed by Austrian companies could be identified in the fields robotics and autonomous systems as well as the internet of things, whereas patents filed by Austrian companies or inventors could be identified in the fields of big data as well as quantum technologies. In both fields, the number of patents with Austrian participation are smaller per year and person engaged than both for the EU average and the Innovation Leaders. The distance is, however, smaller in the field of big data technologies. The technology developments in this field are largely concentrated in the ICT and electronics industries. Keeping in mind the caveats mentioned earlier, Austrian technology development seems to lag behind the Innovation Leaders.

To summarise, while patenting activities of the Austrian business sector in ICT technologies measured as patents filed per person engaged in the industry are below the levels of Innovation Leaders, in single technological domains of Austrian industries we can observe performance levels above those of the Innovation Leaders. The machinery and equipment industry and IT services are of particular relevance here. The overall result is mostly driven by the lower patent output of the computer and electronic/optical products industry (26). The analysis of technological activities of Austrian companies in a number of emergent digital technologies analysed in this section largely mirrors this finding.

Figure B-40: Average number of EPO patents per year and million persons engaged in a sector filed by Austrian companies in comparison to Innovation Leaders and the EU in key emergent digital technologies, 2008-2014



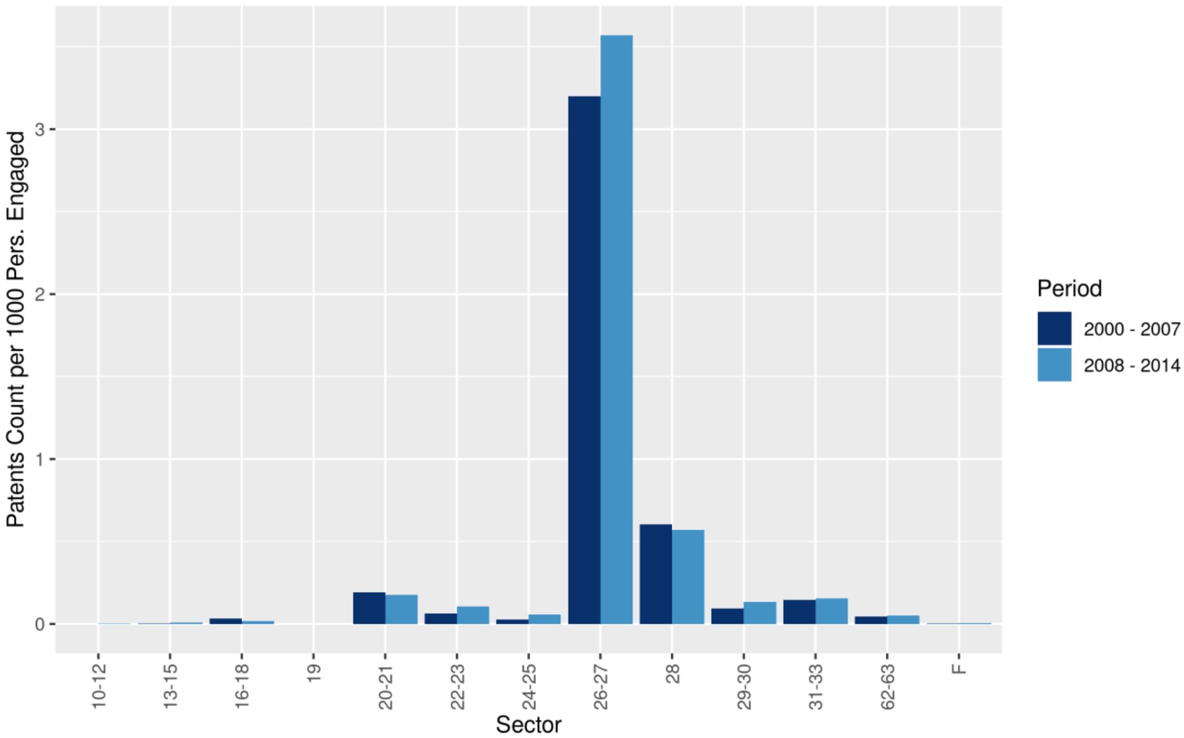
Source: EPO Patstat, WIFO calculations.

B.1.6.3. Patenting activities across Austrian sectors in other technological areas drawing on digital technologies in comparison to Innovation Leaders

Here we present a more detailed analysis of the patenting activities in the Austrian business sector and focus on patents that cite patents for digital and ICT technologies. The citation of patents can be interpreted as a measure for the use and diffusion of technologies.[93]

Figure B-41 shows that there is a high concentration of patenting in technologies other than digital ones that cite ICT/digital patents in digital technology sectors. But there are also considerable patents in the chemical and pharmaceutical (20-21) as well as the rubber and plastic (22-23) industries, This evidence points to a diffusion of digital technologies into technological inventions in other manufacturing sectors.

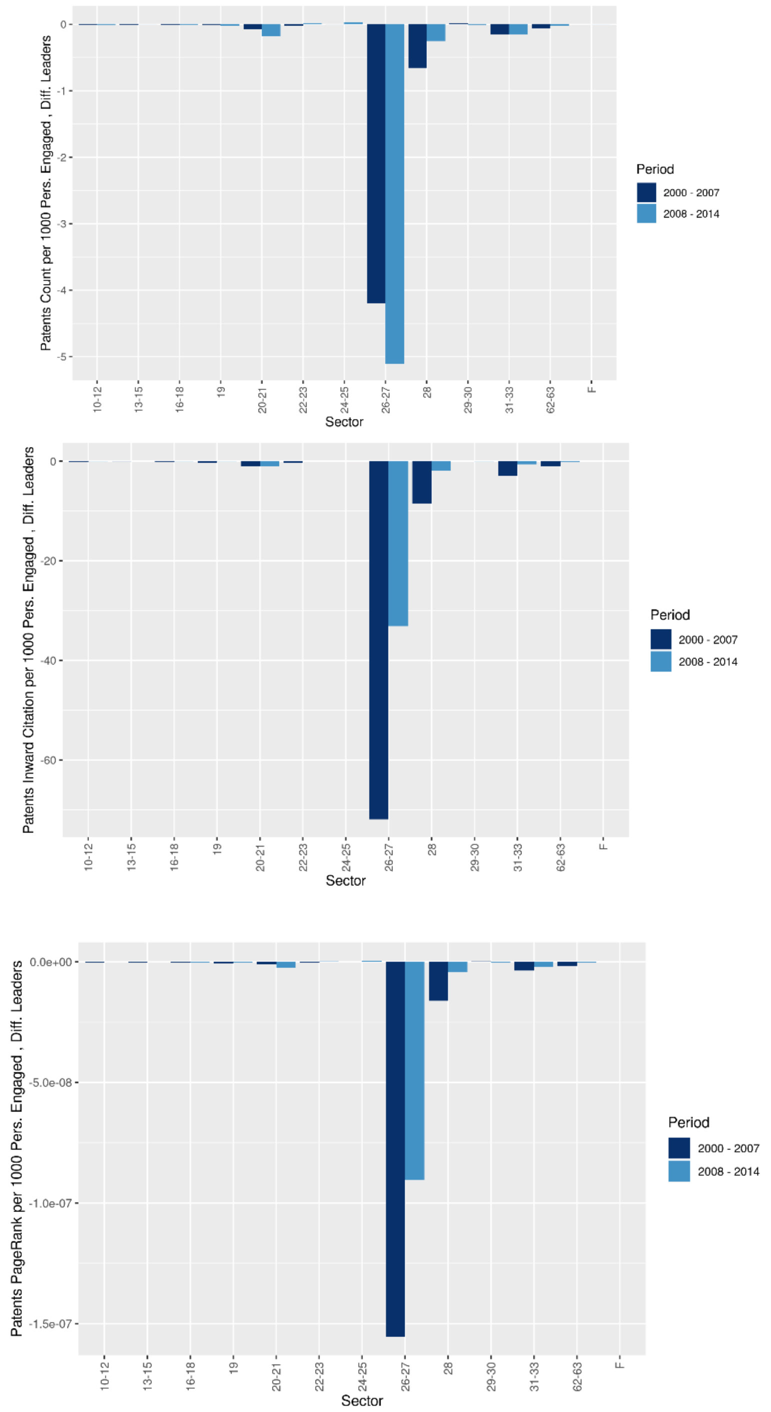
Figure B-41: Counts of patent filings at the EPO citing ICT patents by Austrian inventors across sectors per 1000 persons engaged in a sector (average per year), Austria



Source: EPO Patstat, WIFO calculations.

93 While citations to other patents get inserted into an application often by patent examiners and should therefore not be taken as a measure for direct spillover between two distinct inventions, the fact that a patent cites another invention for digital technologies is a measure for the relevance of this technology for the citing invention irrespective of the source of the citation.

Figure B-42: Difference in patent filings at the EPO citing ICT patents by sector in Austria in comparison to the Innovation Leaders using counts, citation-weighted counts and PageRank scores.



Source: EPO Patstat, WIFO calculations. Note: patent filings at EPO by inventor location.

Whether this diffusion differs from what can be observed on average across countries that are Innovation Leaders is shown in

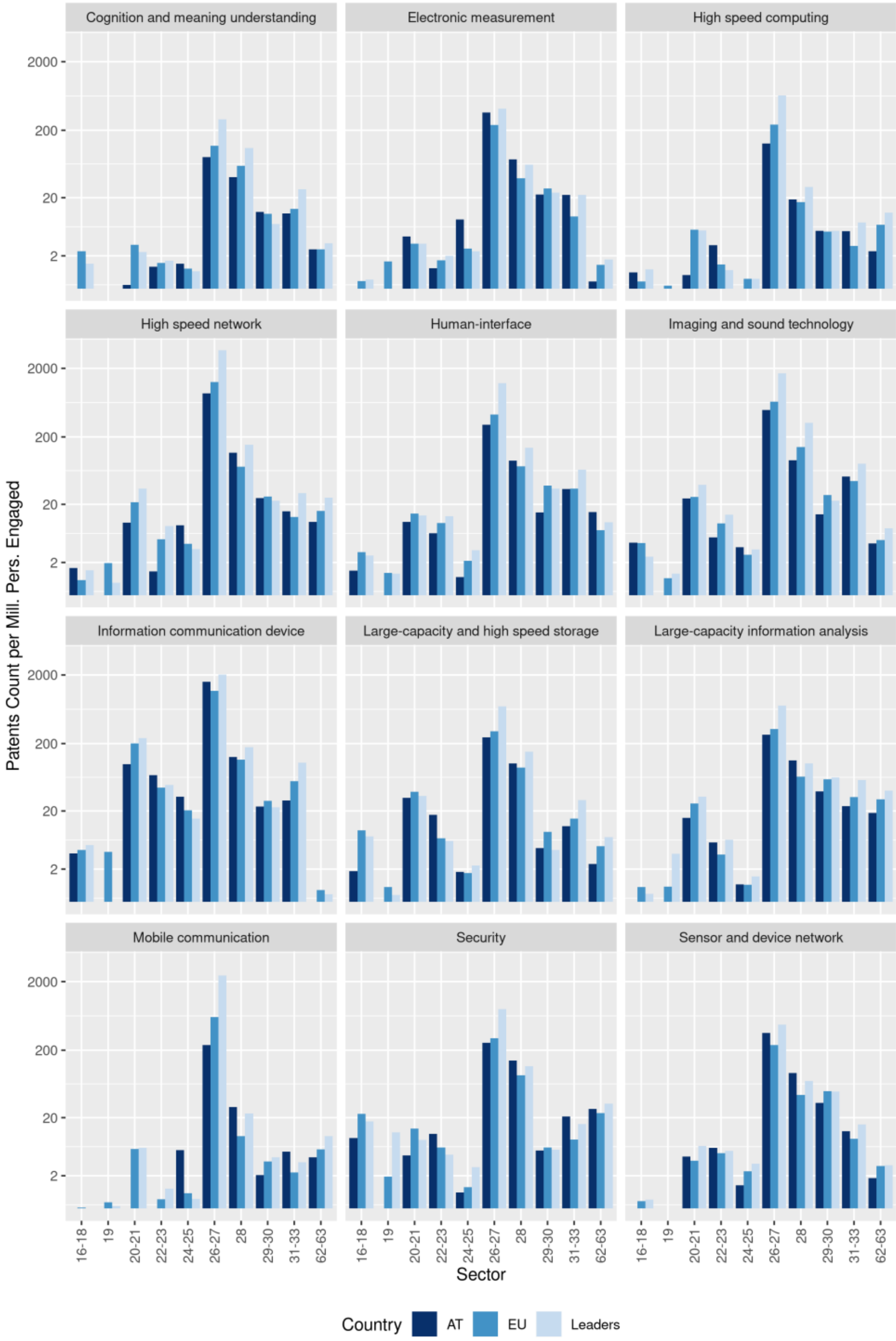
Figure B-42. The comparison shows that Austrian companies file fewer patents referring to digital technologies across all. However, the citation-weighted measures in the middle and bottom panel of the figure show that if one also considers the implicit economic value of these patents, the gap narrows down over time. This is true for all sectors. For non-ICT patents citing ICT/digital patents we can therefore observe a more marked development in terms of patent “quality” as proxied by inward citation measures than for Austrian ICT patents.

The breakdown by technological areas in the field of ICT and digital technologies presented in Figure B-43 shows a more differentiated picture. Across sectors Austrian companies file fewer non-ICT patents referencing digital technologies in the fields of cognition and meaning understanding technologies, high speed networks, human-interface technologies, and image and sound technologies. This is also the case for non-ICT patents referencing large-capacity and high-speed storage technologies as well as large-capacity information analysis across sectors, but to a lesser extent. On the other hand, Austrian patenting activities are consistently higher than in both the Innovation Leaders and the EU countries for non-ICT patents citing patents for electronic measurement technologies, and approximately on par with non-ICT patents citing patents for information communication devices and sensor and device networks.

Electronic measurement technologies are more frequently cited in Austrian non-ICT patents across industries than in the Innovation Leader or the EU countries. This can also be observed for non-ICT patents citing information communication devices and sensor and device networks, even though here the difference is present only for a few sectors. The rubber and plastics (22-23), the basic metals and fabricated metals (24-25), the computer and electronic/optical products (26) and the machinery and equipment (28) sectors all have higher counts for non-ICT patents referencing information and communication devices than their counterparts in the Innovation Leader countries.

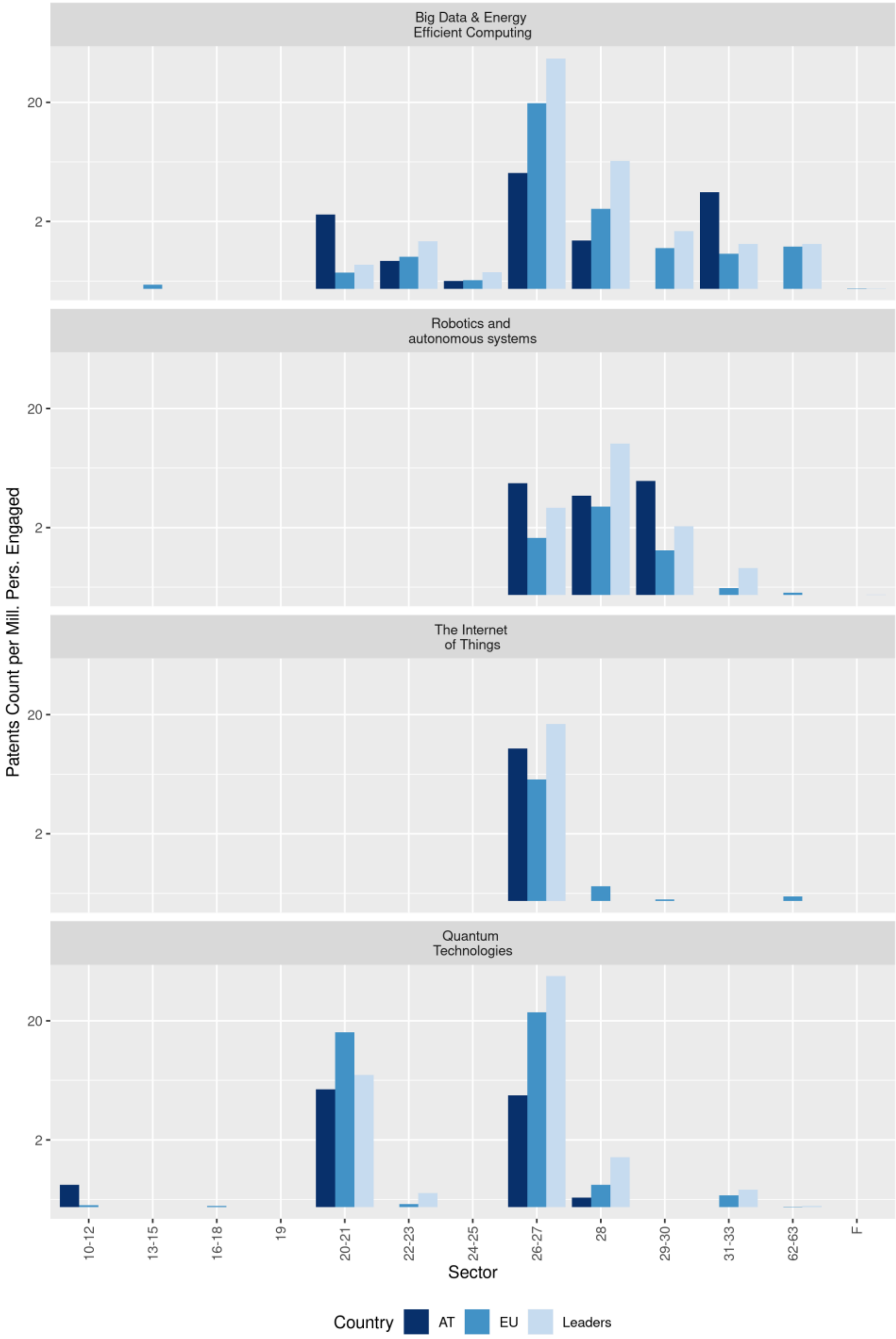
The Austrian machinery and equipment industry (28) is very active in the development of a broad range of non-ICT technologies referencing digital technologies. Patents from this industry reference mobile communication technologies, security, and large-capacity and information analysis more often than is the case on average for companies in the same sector located in one of the Innovation Leader countries. Austrian IT and information services (62-63) filed a larger number of non-ICT patents citing ICT patents than their counterparts across the EU and the Innovation Leaders in the fields of security and human interface technologies. The rubber and plastics sector (22-23) shows a higher count than Innovation Leaders for non-ICT patents citing sensor and device networks, large capacity information analysis, information communication devices and high speed computing. Finally, the count of non-ICT patents of companies from the basic metals and fabricated metal products industry (24-25) referencing information and communication devices and high speed networks is higher than for Innovation Leaders.

Figure B-43: Average number of patent citing digital/ICT patents per year and million persons engaged in a sector filed by Austrian companies at the EPO in comparison to Innovation Leaders and the EU in different technological areas of digital technologies, 2008-2014



Source: EPO Patstat, WIFO calculations. Note: patent filings at the EPO by inventor location.

Figure B-44: Average number of patent-citing emergent ICT technology patents per year and million persons engaged in a sector filed by Austrian companies at the EPO in comparison to Innovation Leaders and the EU in different technological areas of digital technologies, 2008-2014



Source: EPO Patstat, WIFO calculations.

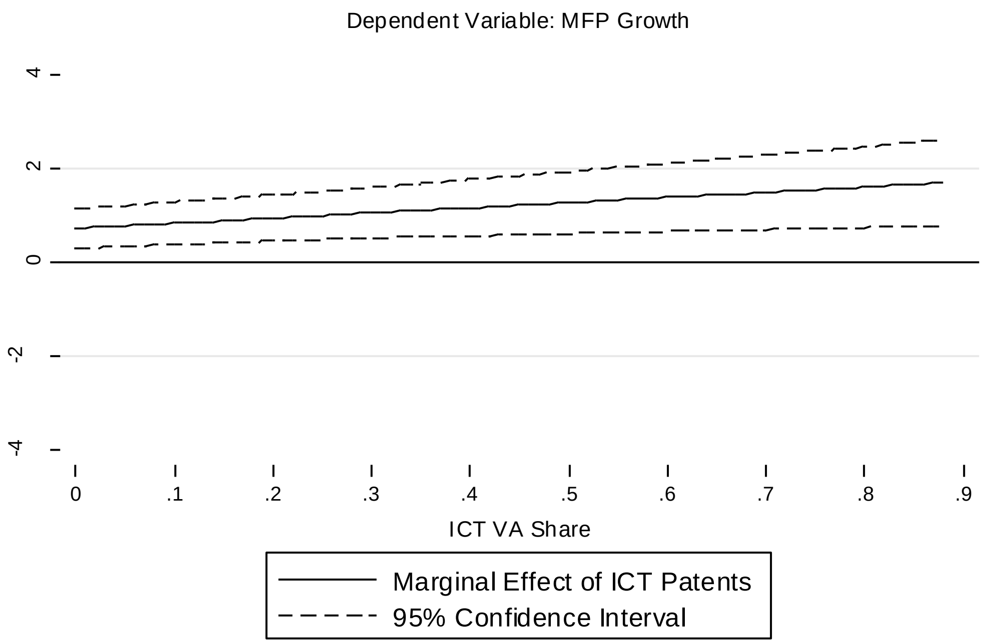
Figure B-44 presents evidence on non-ICT patents citing patents in big data and energy-efficient computing, robotics and autonomous systems, the internet of things as well as quantum technologies. This can again be taken as a measure of the diffusion or take-up of such technologies into the technology development of companies and inventors located in Austria.

The contrast to the evidence presented in Figure B-40 is striking. Whereas in terms of techology development in the fields of robotics and autonomous systems and the internet of things no patent filings with Austrian participation were identified,

Figure B-44 shows that in these two fields the Austrian ICT and electronics, machinery and equipment and the automotive industries are heavily citing patents; in some instances more intensely than the Innovation Leaders. This suggests that Austrian industries are strong users of these emergent technologies in their own technology development related to the Industry 4.0 paradigm. For big data and quantum technologies the picture is more mixed. Here, Austria in most of the cases lies both behind the Innovation Leaders and the EU as a whole in terms of the average number of patents citing these technologies per year and persons engaged in the industry. However, in a few cases Austrian sectors perform better than Innovation Leaders (e.g. in the chemical and rubber product industries or furniture and other manufacturing industries in the case of big data technologies).

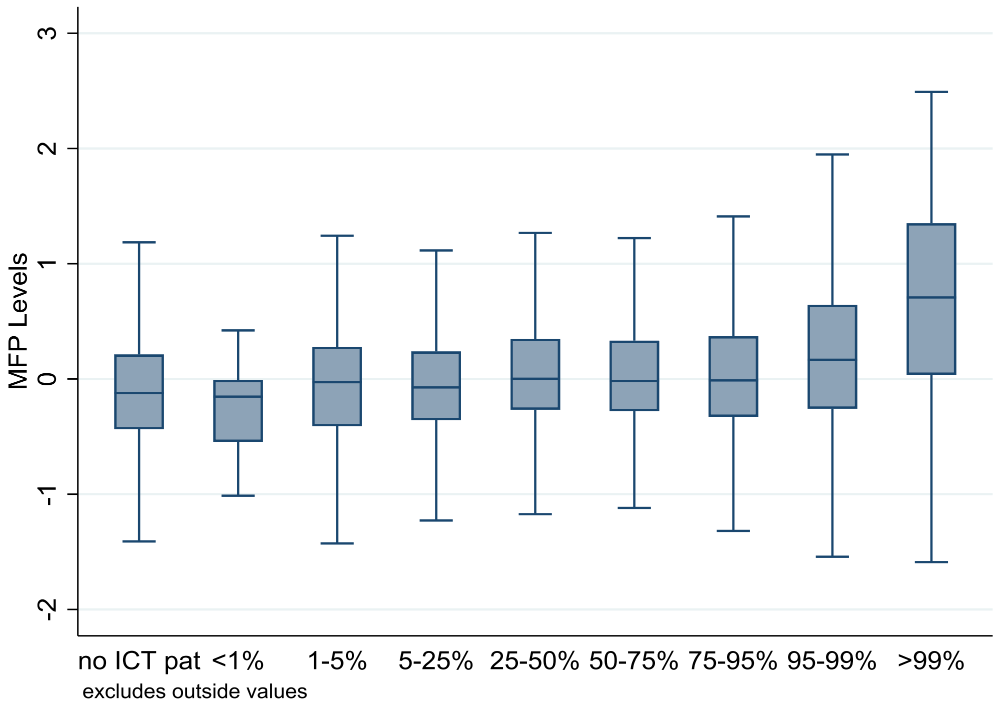
B.1.7. Firm-level productivity analysis – further evidence

Figure B-45: Marginal effect of the ICT patent stock on MFP growth for increasing VA shares from industries with high digital intensity



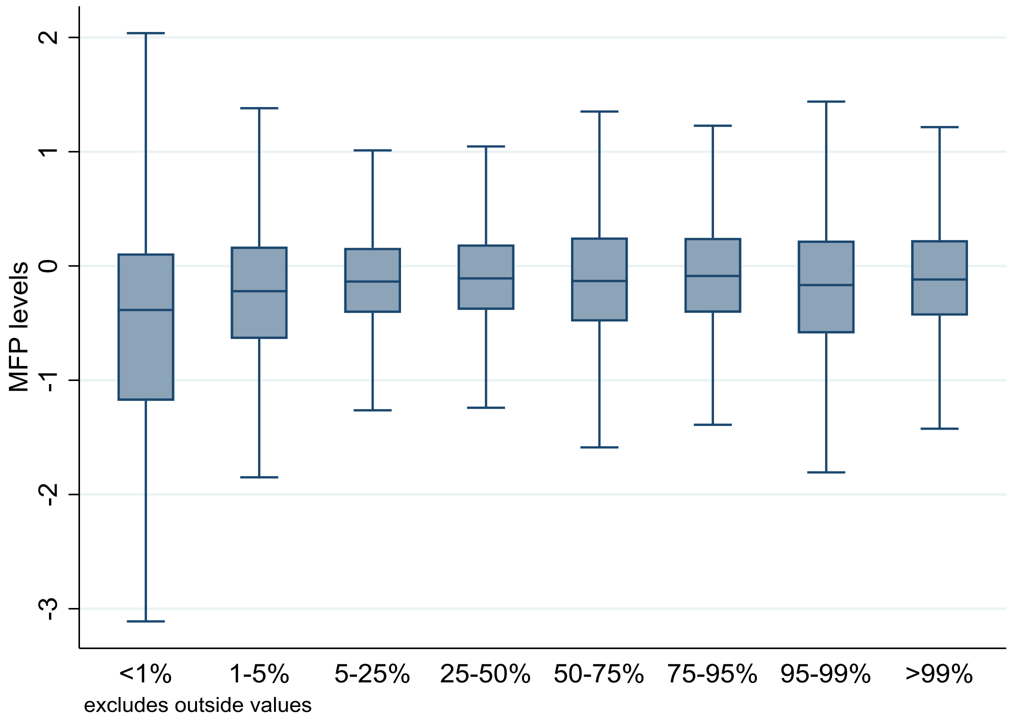
Source: Amadeus (Bureau van Dijk), EPO PATSTAT, WIFO calculations.

Figure B-46: Firm-level MFP-level distribution over ICT patent stock quantiles



Source: Amadeus (Bureau van Dijk), EPO PATSTAT, WIFO calculations. Note: The MFP levels capture a superlative index capturing the relative position to the sample mean. Negative deviations are therefore possible.

Figure B-47: Firm-level MFP-level distribution over value added share from H-MH industries quantiles

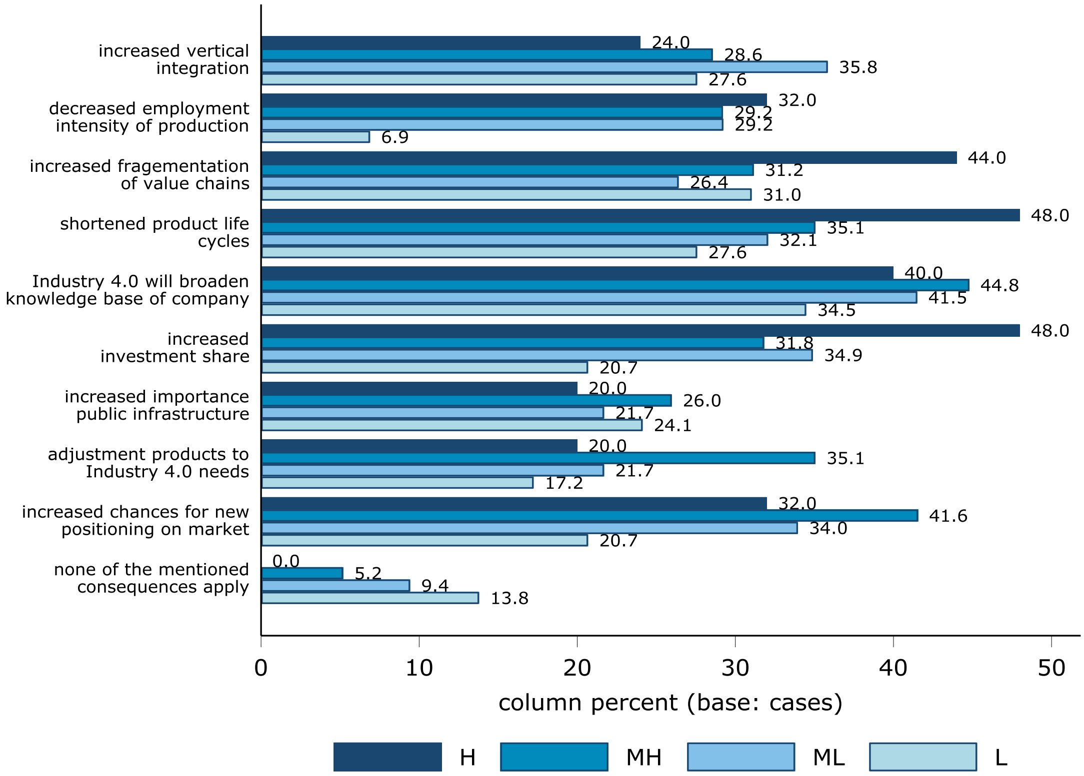


Source: Amadeus (Bureau van Dijk), EPO PATSTAT, WIFO calculations. Note: The MFP levels capture a superlative index capturing the relative position to the sample mean. Negative deviations are therefore possible.

B.2. *Appendix to Chapter 3*

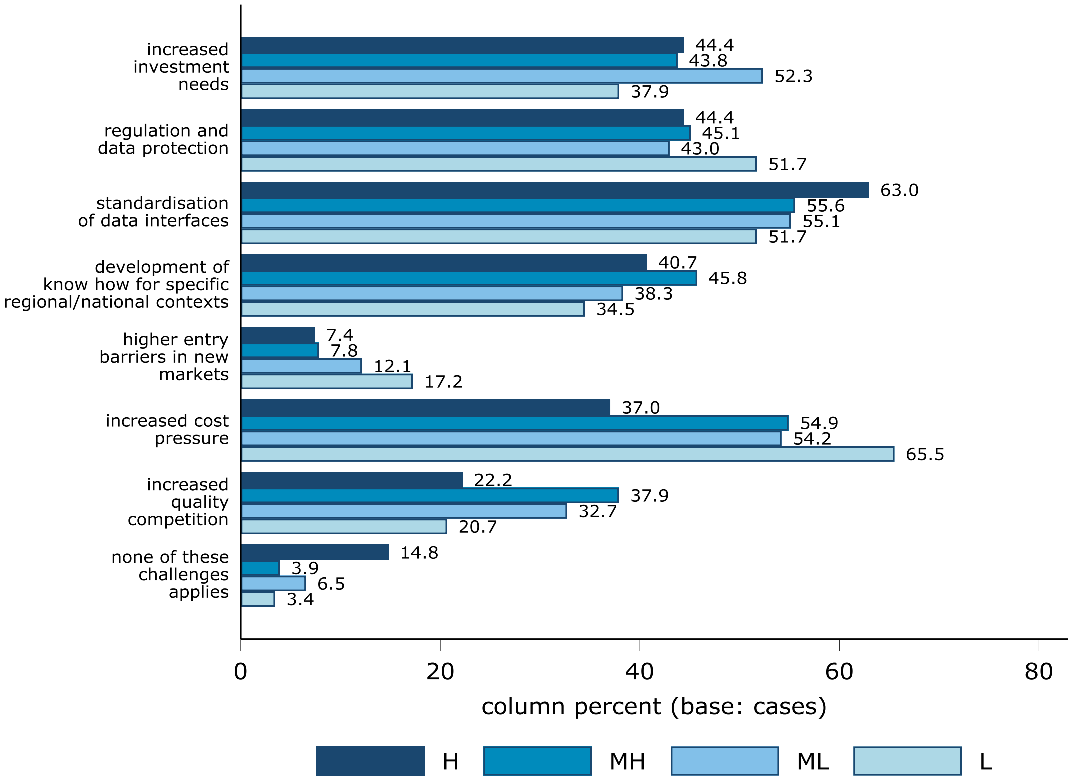
B.2.1. Additional material related to Section 3.1.

Figure B-48: Expected consequences of digitalisation and Industry 4.0 by digital intensity of sector



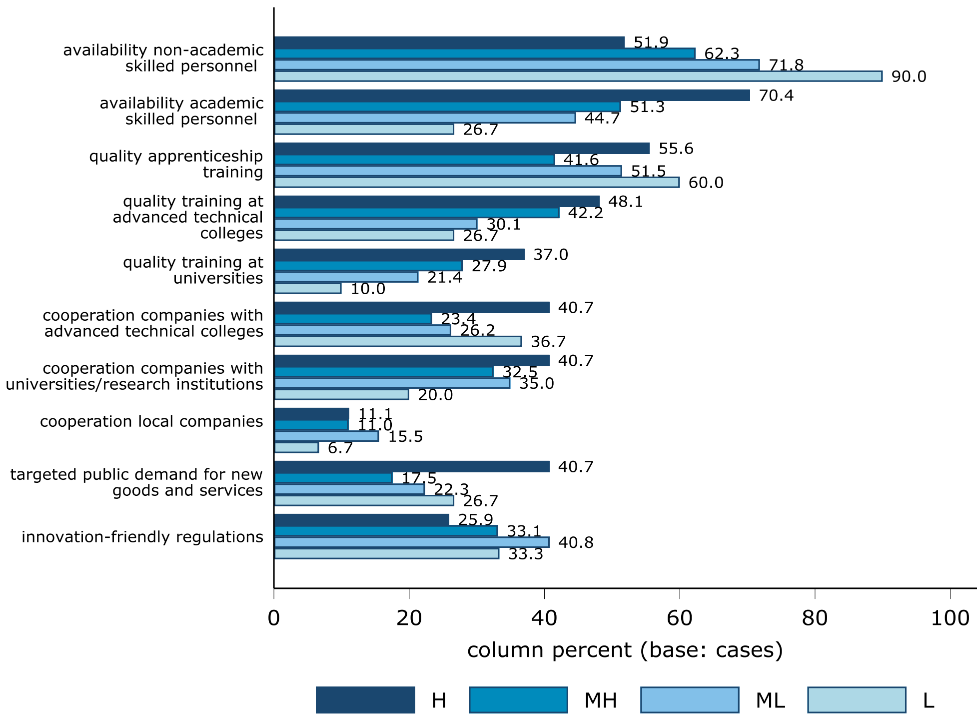
Source: WIFO Industry Survey, WIFO calculations.

Figure B-49: Expected challenges of digitalisation and Industry 4.0 by digital intensity of sector



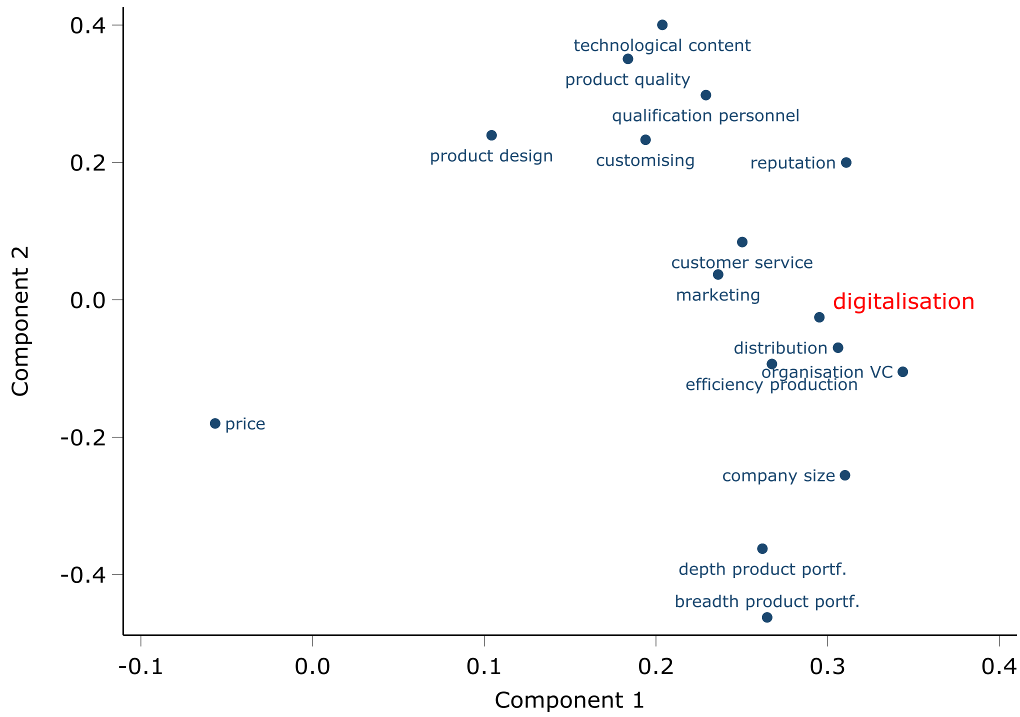
Source: WIFO Industry Survey, WIFO calculations.

Figure B-50: Key location factors to improve the competence base of Austrian manufacturing companies



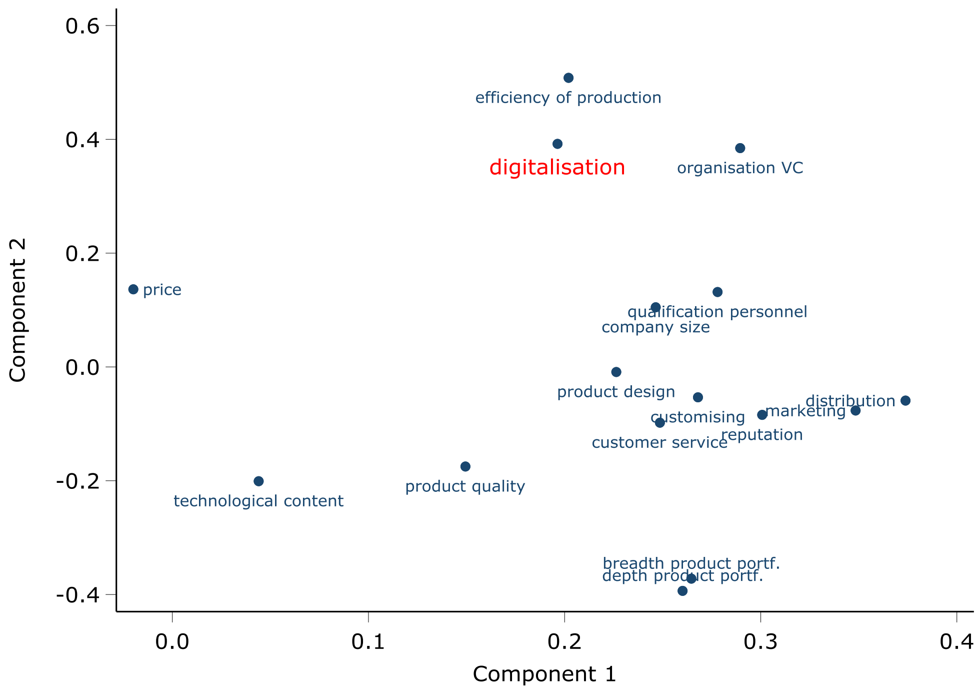
Source: WIFO Industry Survey, WIFO calculations.

Figure B-51: Principal components analysis of response patterns concerning current strength of Austrian manufacturing companies in the high and medium-high sector group



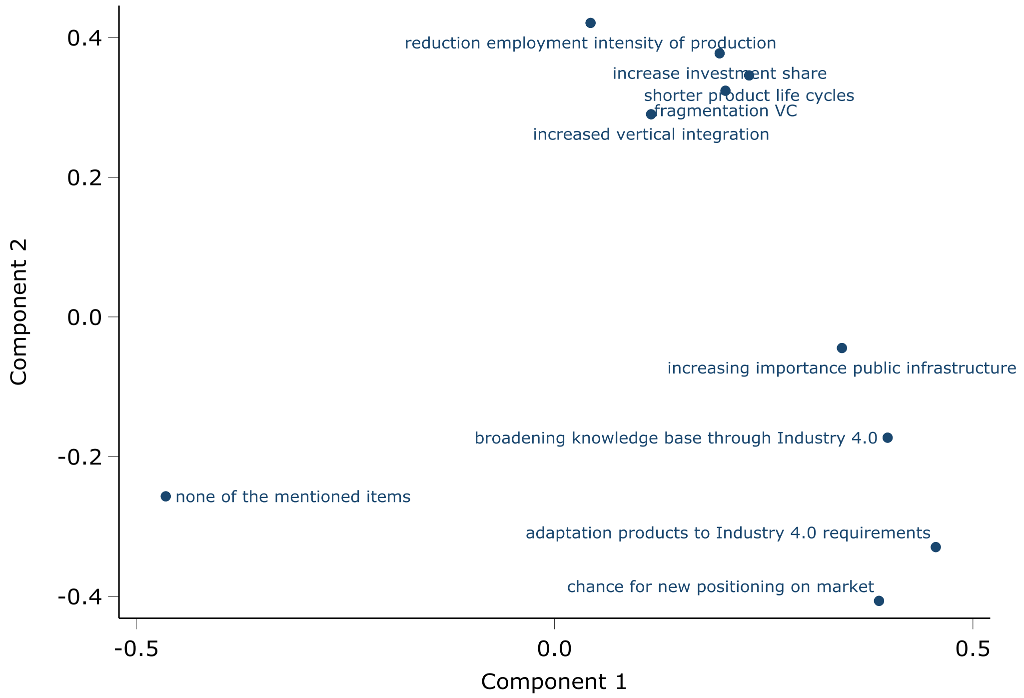
Source: WIFO Industry Survey, WIFO calculations.

Figure B-52: Principal components analysis of response patterns concerning factors with increasing importance for competitiveness in the future of Austrian manufacturing companies in the high and medium-high sector group



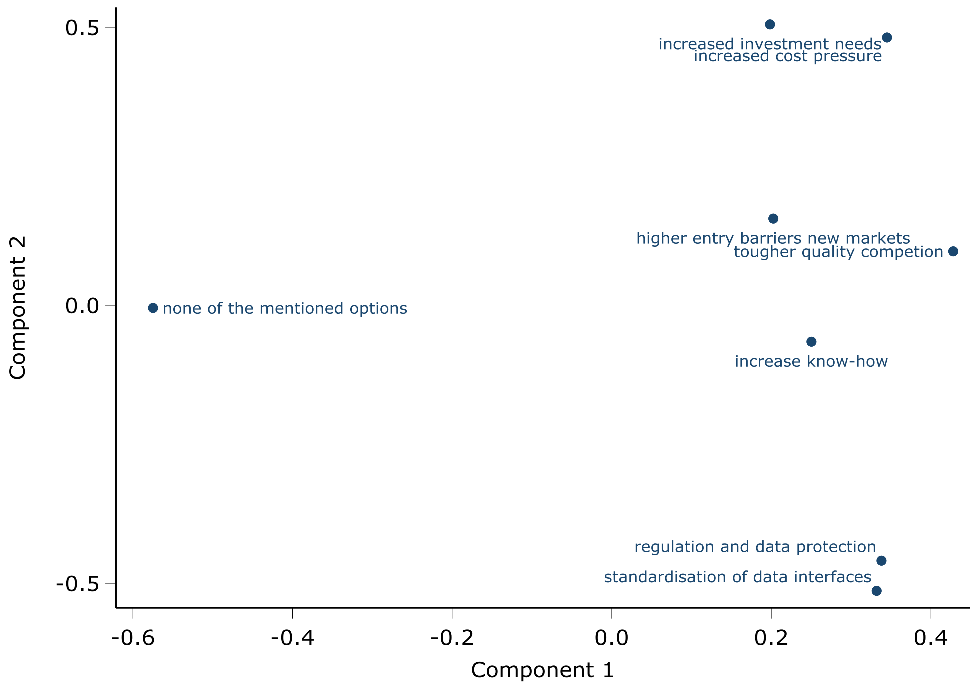
Source: WIFO Industry Survey, WIFO calculations.

Figure B-53: Principal components analysis of response patterns of Austrian manufacturing companies in the high and medium-high sector group concerning consequences of digitalisation



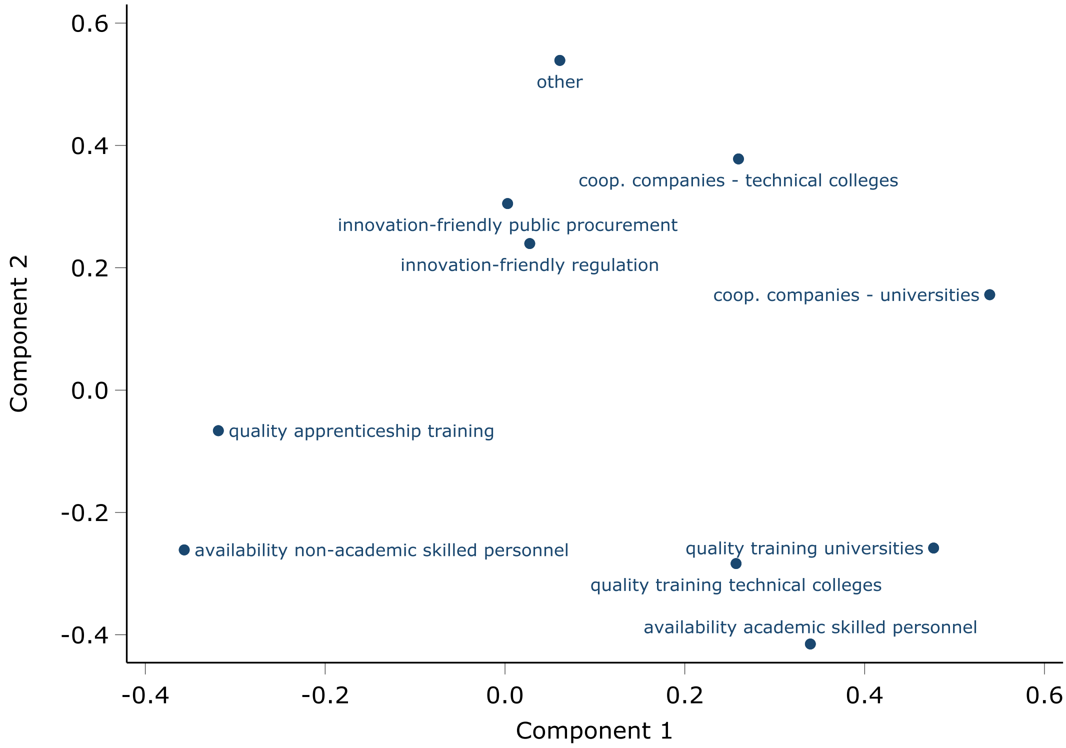
Source: WIFO Industry Survey, WIFO calculations.

Figure B-54: Principal components analysis of response patterns of Austrian manufacturing companies in the high and medium-high sector group concerning challenges of digitalisation



Source: WIFO Industry Survey, WIFO calculations.

Figure B-55: Principal components analysis of response patterns of Austrian manufacturing companies in the high and medium-high sector group location factors to improve their competence base



Source: WIFO Industry Survey, WIFO calculations.

B.2.2. Additional material related to Section 3.2

We first aggregate the Industry 4.0 technologies into three groups:

Digital Management Systems
Product-Lifecycle-Management Systems
Enterprise resource planning software (ERP)
Wireless Human-Machine-Communication
Safe human-machine interaction
Technologies for providing remote services (augmented reality, digital visualisation)
Cyber-Physical-systems (CPS)
Supply chain automation
Systems for automation and management of internal logistics
Near real-time production control systems

Source: EMS 2015.

In a second step we assign values to the index (*I40*). It can take six values:

- 0 if the firm has not yet introduced any technology from the three technology fields
- 1 if the firm has introduced at least one technology from the three different technology fields

- 2 if the firm has introduced technologies from at least two out of three different technology fields.
- 3 if the firm has introduced technologies in all three different technology fields.
- 4 if the firm has introduced technologies from all three different technology fields and at least two technologies from the field “Cyber-physical systems”
- 5 if the firm has introduced all three different technology fields and at least three technologies from the field “Cyber-physical systems”, or in other words, all I4.0 technologies.

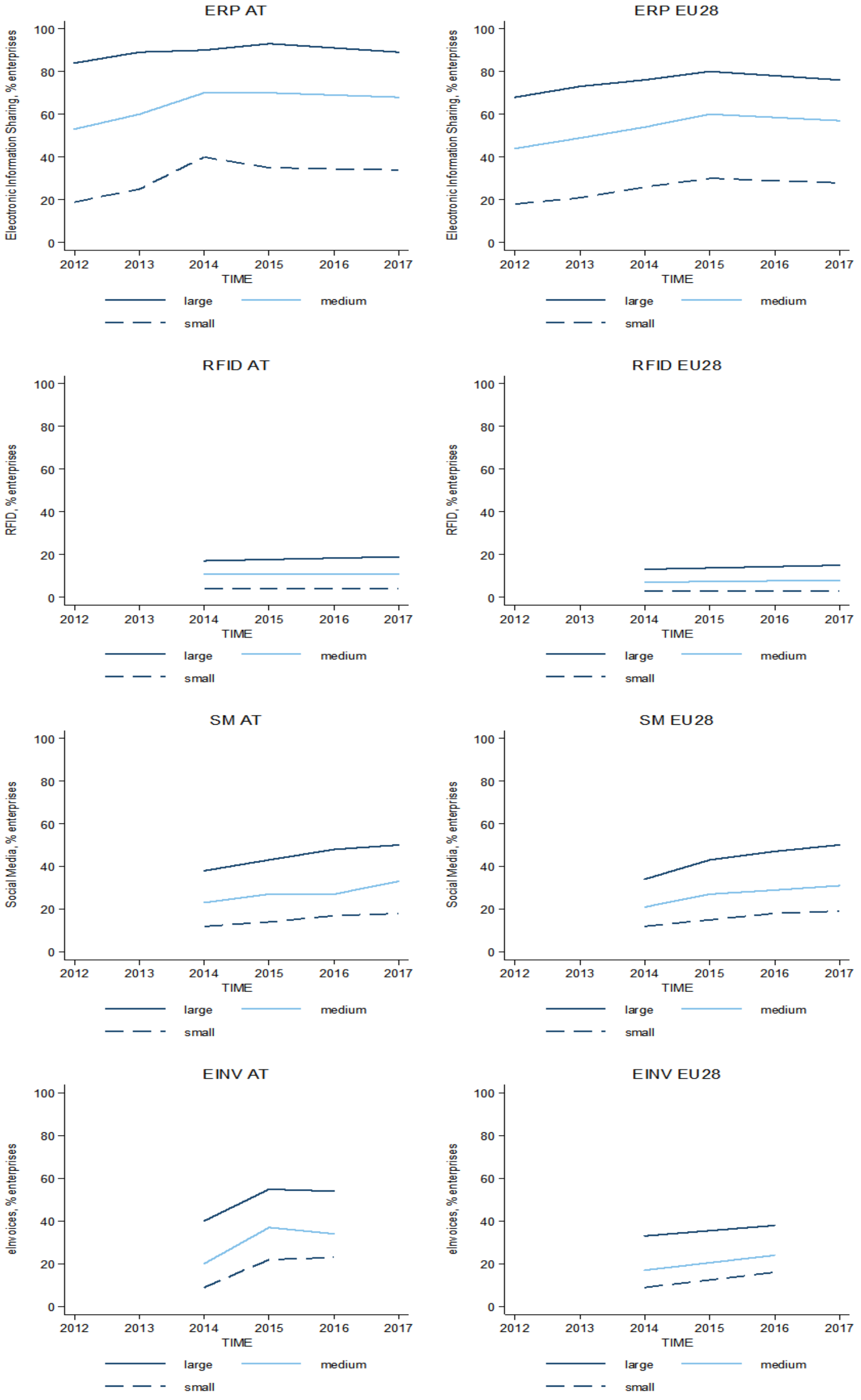
B.3. Appendix to Chapter 4

B.3.1. Additional material related to Section 4.4.1

Figure B-56 and

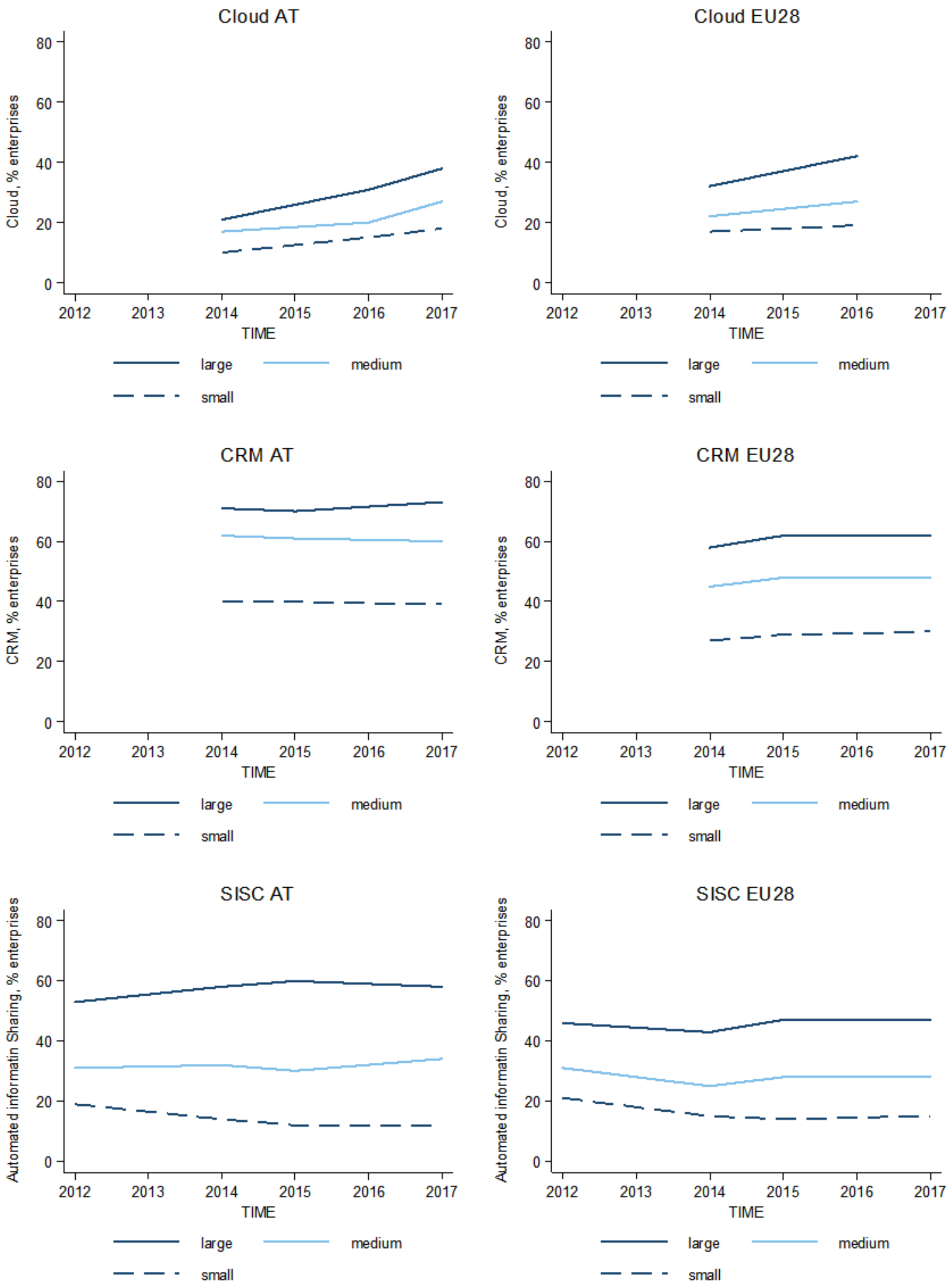
Figure B-57 show the time-series for the adoption variables from 2012 to 2017 for small, medium-sized and large firms for Austria and the EU-28 average. Interestingly, the time-series properties for small firms, medium-sized firms and large firms are very similar. The second observation that emerges is that only a few of the technologies see a clear rising adoption trend: For social media, the use of electronic invoices and cloud computing a clear upward trend can be observed. For CRM, ERP, RDIF and the automatic linking of enterprises with supplier and/customers (SISC) the adoption rates seem to be comparatively stable, at least not indicating a strong increase in adoptions over the past years, neither for large, medium nor small enterprises.

Figure B-56: The adoption of digital technologies over the firm size distribution I



Source: Eurostat. Note: Values indicate % of firms having adopted a specific technology.

Figure B-57: The adoption of digital technologies over the firm size distribution II



Source: Eurostat. Note: Values indicate % of firms having adopted a specific technology.

B.3.2. Additional material related to Section 4.4.2

The correlation analysis in Table B-0-7 suggests that the use of ERP solutions is negatively associated with all SME and industry dynamics indicators. This indicates that in industries with higher industry dynamics ERP adoption should be weaker. For RFID we obtain a similar result. Statistically significant are only the correlations with the SME and the microenterprise share. This shows that RFID is generally used in industries with a larger share of large enterprises. Social media is used more in industries with a higher entry rate, a higher HGF share and a higher microenterprise share. The use of e-invoices seems not to be correlated in any way with industry dynamics and SME shares. The use of medium and high cloud services is positively correlated with the HGF share and the microenterprise share. The use of CRM solutions is negatively associated with a high turnover share and a high SME share. Last but not least, the automated information sharing is negatively correlated with the share of SMEs and the microenterprise share.

Table B-0-7: Correlations between SME shares, industry dynamics indicators and adoption of digital technology indicators, EU countries

	ERP	RFID	Social Media	eInvoices	Cloud	CRM	Automated information Sharing
Entry rate	**-0.2306***	-0.0904	**0.1279***	-0.0267	0.0688	-0.0553	0.0734
Turnover rate	**-0.2737***	-0.0805	0.0716	-0.031	0.0441	**-0.1153***	0.0985
HGF share	**-0.1156***	0.0188	**0.1689***	0.072	**0.3537***	0.0706	0.0194
SME share	**-0.3662***	**-0.3517***	0.0991	-0.0578	0.0775	**-0.1445***	**-0.1343***
Microenterprise share	**-0.2254***	**-0.2530***	**0.1332***	-0.0705	**0.1825***	-0.0953	**-0.1168***

Source: Eurostat, Annual report on European SMEs; WIFO calculations. Note: Values for SME indicators, industry dynamics indicators and adoption indicators are averages over the period 2014 and 2017. Stars are set at the 95% significance level.

Table B-0-8: Correlations between SME shares, industry dynamics indicators and adoption of digital technology indicators, Austria

	ERP	RFID	Social Media	eInvoices	Cloud	CRM	Automated information Sharing
entry rate	-0.2370	0.0921	-0.0804	0.3599	0.1642	-0.2799	-0.2278
turnover rate	-0.3262	0.0894	-0.0716	0.3753	0.1675	-0.2841	-0.2263
HGF share	0.0379	-0.2151	0.5278	0.0168	0.7163*	0.2511	-0.0366
SME share	**-0.6666***	-0.4908	0.2767	-0.4262	0.3898	0.1481	-0.4554
Microenterprise share	-0.3198	-0.3573	0.3948	**-0.6452***	**0.6920***	0.4250	-0.2714

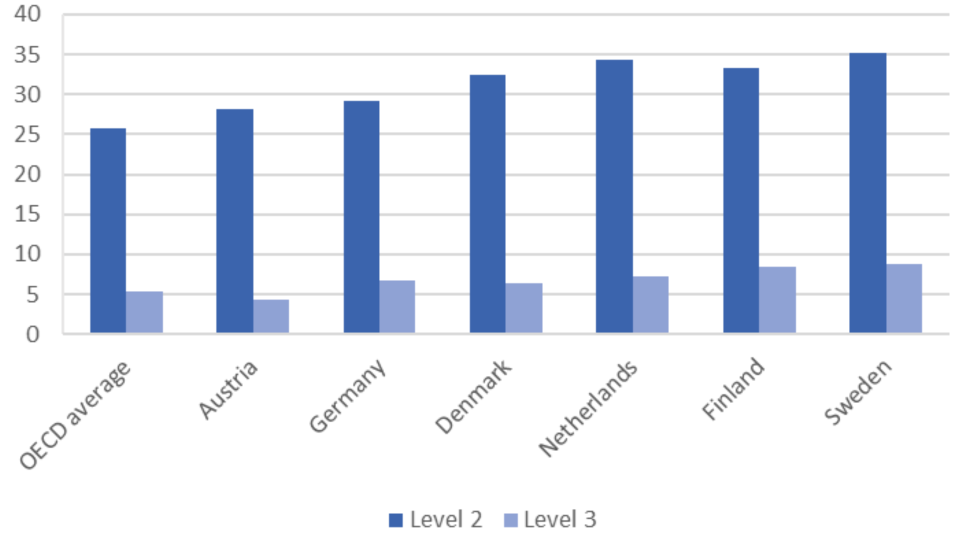
Source: Eurostat, Annual report on European SMEs; WIFO calculations. Note: Values for SME indicators, industry dynamics indicators and adoption indicators are averages over the period 2014 and 2017. SME shares and microenterprise shares do not cover financial and insurance services (NACE K). Stars are set at the 95% significance level.

B.4. Appendix to Chapter 5

B.4.1. Additional material related to Section 5.2.4

Figure B-58 shows that Austria is slightly above the OECD average – in Austria 32.4% of the adult population have problem-solving skills in technology rich environments, while in the comparison countries Germany, Denmark, the Netherlands, Finland and Sweden this number is higher for both level 2 and level 3 problem-solving capabilities. This holds true for the overall cohort (ages 16 to 65 years old) but also for the younger cohort (25 to 34 years old). Also, the European "Digital skills Indicator" based on the data collected in the ICT survey on ICT usage by Household and Individuals paints a similar picture. 67% of the Austrian population had basic or above-average skills in 2017. This value is better than the EU average (57%), but is quite below the best performing countries Sweden (77%) Netherlands (80%) or Finland (75%) and quite close to Germany (68%).

Figure B-58: The adult population's digital problem-solving proficiency



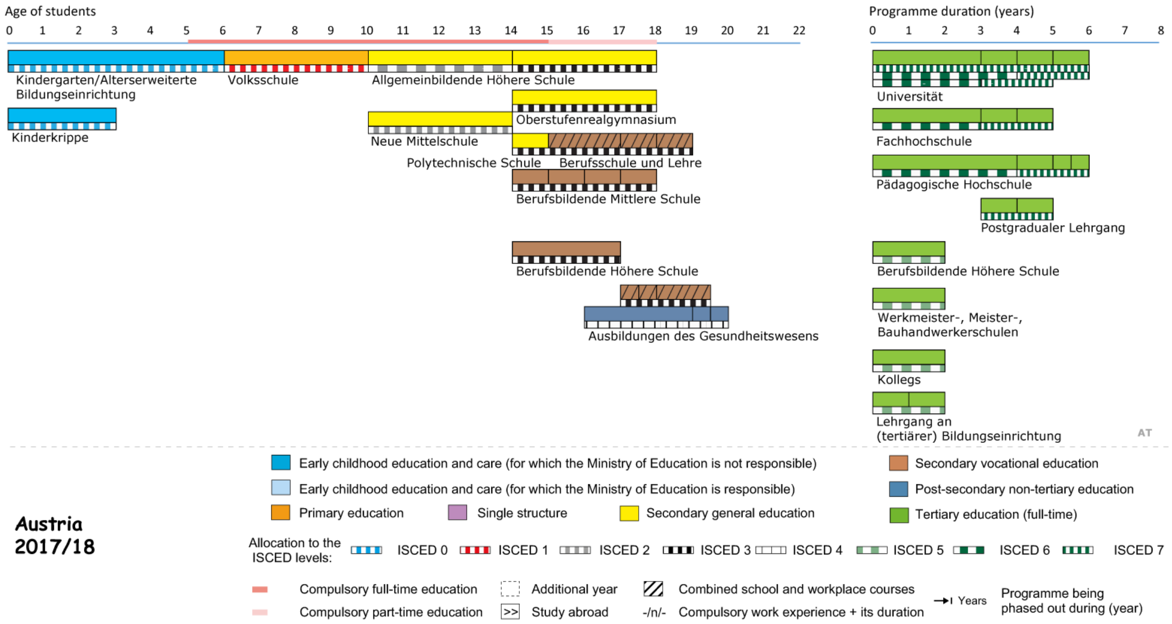
Source: OECD 2016. Note: Digital problem solving is defined as the capacity to solve problems using a computer. These skills include writing an e-mail and browsing the web (level 1), implementing more advanced tasks involving multiple steps (level 2), and the capacity to use both generic and specific software applications with inferential reasoning (level 3).

B.4.2. Additional material related to Section 5.3.3

After the four-year primary school cycle, pupils move on to a four-year lower secondary level. They either attend a general secondary school *(Neue Mittelschule)* for years 5 to 8 or an academic-track secondary school (*Gymnasium/Allgemein-bildende Höhere Schule* AHS) up to year 12. Pupils must have successfully completed year four to be admitted to general secondary school. Pupils wanting to enter an academic-track secondary school must have 'Excellent' or 'Good' grades in German language, Reading, Writing and Mathematics, or they can be admitted upon the recommendation of the teaching staff of the primary school. If a pupil fails to meet these requirements, he or she may take an entrance examination" (see Eurydice 2009, p. 2).

Conducted by BIFIE (Bundesinstitut für Bildungsforschung, Innovation & Entwicklung des österreichischen Schulwesens/Federal Institute of Educational Research, Innovation and Development of the Austrian Educational Sector), it reviews the expected learning outcomes, focusing on the core areas of a subject to be achieved by the pupils at the end of primary school in the 4th grade in German (reading and writing) and Mathematics and in the 8th grade in German, Mathematics and English in the academic-track secondary schools (Gymnasium/Allgemeinbildende Höhere Schule AHS) and general secondary schools (Neue Mittelschule) (Eurydice 2009).

Figure B-59: Schematic structure of the Austrian education system



Source: https://eacea.ec.europa.eu/national-policies/eurydice/content/austria_en.

B.4.3. Additional material related to Section 5.3.4

While there is no in-school LAN connection in only 0.4% of secondary technical and vocational schools and colleges for higher vocational education (both start after grade 8; *Berufsbildende mittlere und höhere Schulen*) and academic-track secondary schools, this applies to 5% of part-time vocational schools (mandatory during the apprenticeship), 6% of general secondary schools and 22% of primary schools. Conversely, 75% of secondary technical and vocational schools and colleges for higher vocational education as well as 70% of academic-track secondary schools have LAN connections in all classrooms and lounges; this also applies to 71% of part-time vocational schools. 45% of general secondary schools and 35% of primary schools have LAN connections in all classrooms and lounges, too.

In only 9% of secondary technical and vocational schools and colleges for higher vocational education and 13% of academic-track secondary schools, there is no WLAN in the school building, while this applies to 43% of part-time vocational schools, 41% of primary schools and 20% of general secondary schools. Contrarily, 53% of secondary technical and vocational schools and colleges for higher vocational education have WLAN everywhere in the school building, followed by 39% of academic-track secondary schools, 37% of general secondary schools, 30% of part-time vocational schools and 28% of primary schools.

The same applies to internet access: while pupils can access the internet in 44% of secondary technical and vocational schools and colleges for higher vocational education, this only applies to 18% of part-time vocational schools (27% of academic-track secondary schools, 25% of general secondary schools, 23% of primary schools). Conversely, in 2% of secondary technical and vocational schools and colleges for higher vocational education there is no internet access for pupils, followed by 6% in academic-track secondary schools, 10% in part-time vocational schools, and 21% in general secondary schools and primary schools, respectively.

B.4.4. Additional material related to Section 5.4.4

Table B-0-9: OECD ICT taxonomy and sectors in the sample

Sector	ICT_Type	Sector	ICT_Type
A+B	med	F	low
C10-C12	low	G	low
C13-C15	low	H	med
C16-C18	low	I	low
C22	med	J	high (producer)
C23	low	K	high (user)
C24	med	M	high (user)
C25	low	N	med
C26	high (producer)	O	low
C27	high (user)	P	low
C28	med	Q	low
C29+C30	high (user)	R	med
C31	low	S	med
C32	med	T	med
C33	high (user)	U	high (user)

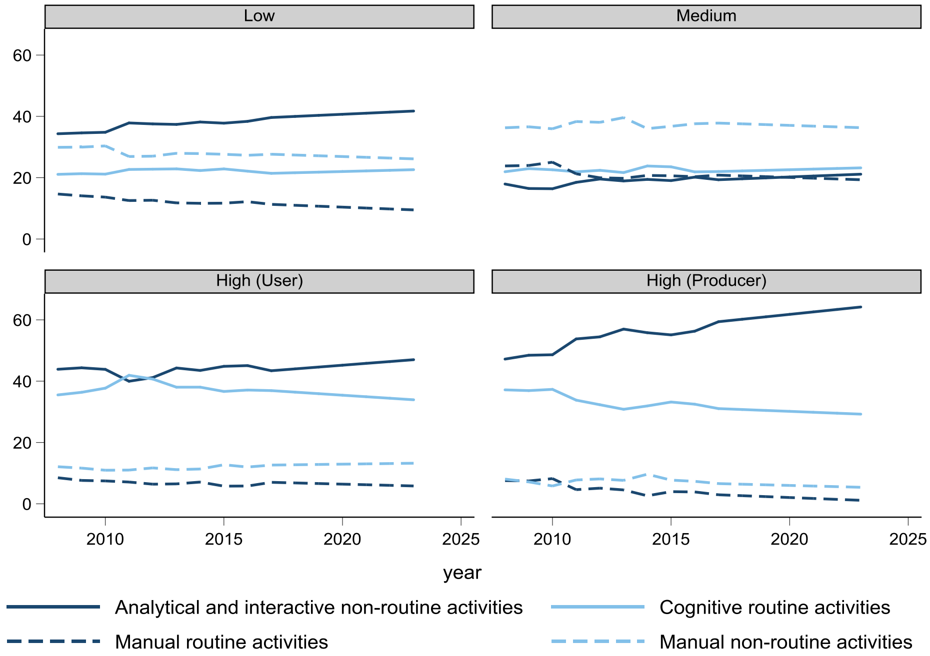
Source: Calvino et al. 2018, WIFO assignment of sector groups.

An alternative taxonomy reflecting sector-specific ICT intesity is based on IT specialists obtained from the European Labour Force Survey (LFS) of Eurostat for the period 2011 to 2016, covering the European Union (EU28) as a whole. The data are a stratified sample representative at the individual economic activity level (NACE Rev. 2, 2-digits). The key indicator is the estimated share of ICT professionals in total employment. Eurostat defines ICT specialists as 'workers who have the ability to develop, operate and maintain ICT systems, and for whom ICT constitute the main part of their job'.94 Again, four distict groups of sectors have been defined. These are sectors with low, medium, high (user) and high (producer) ICT-expert intensity (see 5.4.5.1 for descriptive statistics).

The forecasts using the sector taxonomy that is based on ICT experts show a different sector composition and a slightly different trend in sector shares than the OECD taxonomy. In, the year 2017, sectors with low ICT-intensity accounted for 60.8% of total employment (2008: 60.3%), sectors with medium ICT-intensity for 24.1% (2008: 24.8%), high ICT-using sectors for 11.8%, the same figure as in 2008, and ICT-producing sectors made for 3.3% (2008: 3.1%).

[94] See https://ec.europa.eu/eurostat/cache/metadata/en/isoc_skslf_esms.htm (accessed on 9 November 2018)

Figure B-60: Employment by task across IT expert intensities: current trend and mid-term forecast (2008-2023)

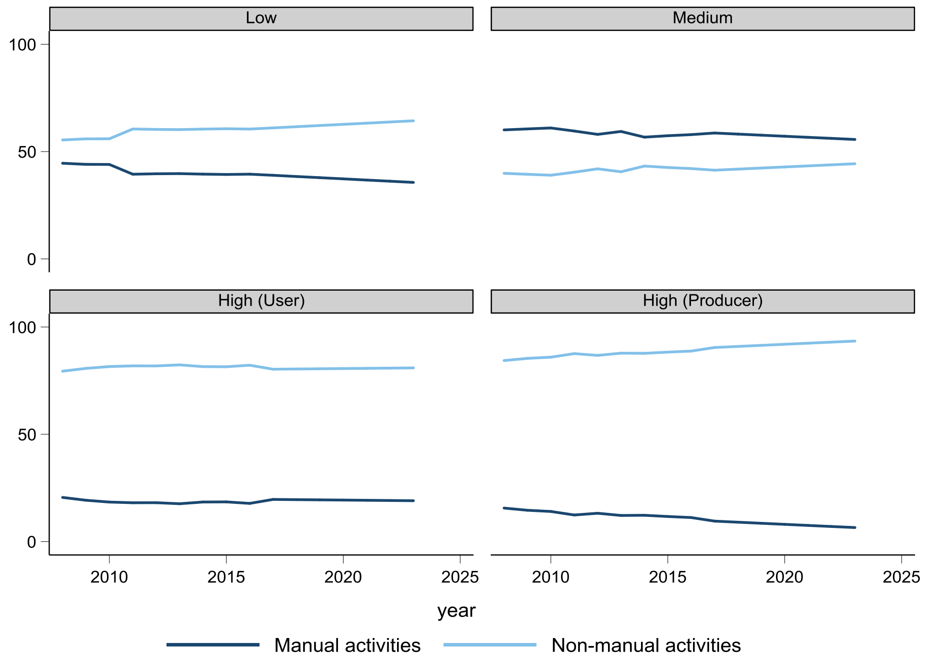


Source: Peneder – Firgo – Streicher 2018, Eurostat, LFS, WIFO calculations. Note: Data after 2017 is forecasted. ISCO-88 1995-2010, ISCO-08 2011-2017. Break in data base.

The picture that is based on the ICT specialist taxonomy (Peneder – Firgo – Streicher 2018) allows for a comparison with the OECD-taxonomy (Calvino et al. 2018) of ICT-intensity. Qualitatively, the picture that emerges from either taxonomy remains unchanged with respect to routine and non-routine activities. Routine activities are on the decline, in particular in sectors with higher ICT-intensity or sectors which employ more ICT specialists, respectively.

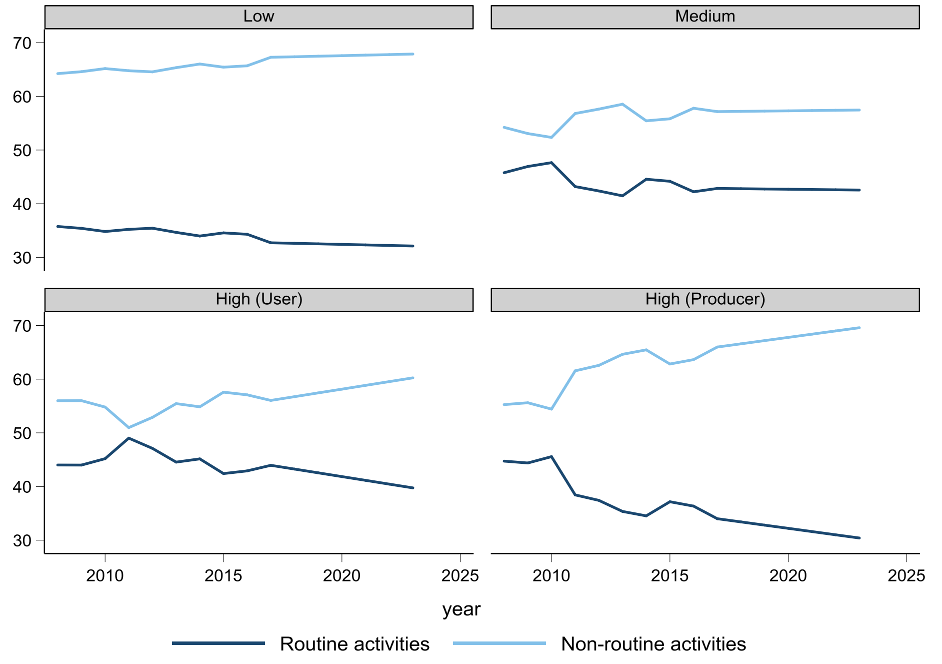
The picture changes slightly in sectors with lower ICT-intensity. The sector groups of low and medium-low (Calvino et al. 2018) and low and medium (Peneder – Firgo – Streicher 2018) show that sectors with a low ICT-intensity have a higher share of manual occupational tasks. However, the opposite holds for the ICT specialist taxonomy, in which in sectors classified as low indicate a higher share of non-manual tasks. This difference is due to the different sector allocation in the taxonomies.

Figure B-61: Employment by manual and non-manual activities across ICT intensities: current trend and mid-term forecast (2008-2023)



Source: Peneder – Firgo – Streicher 2018, Eurostat, LFS, WIFO calculations. Note: Data after 2017 is forecasted. ISCO-88 1995-2010, ISCO-08 2011-2017. Break in data base.

Figure B-62: Employment by routine and non-routine activities across ICT intensities: current trend and mid-term forecast (2008-2023)



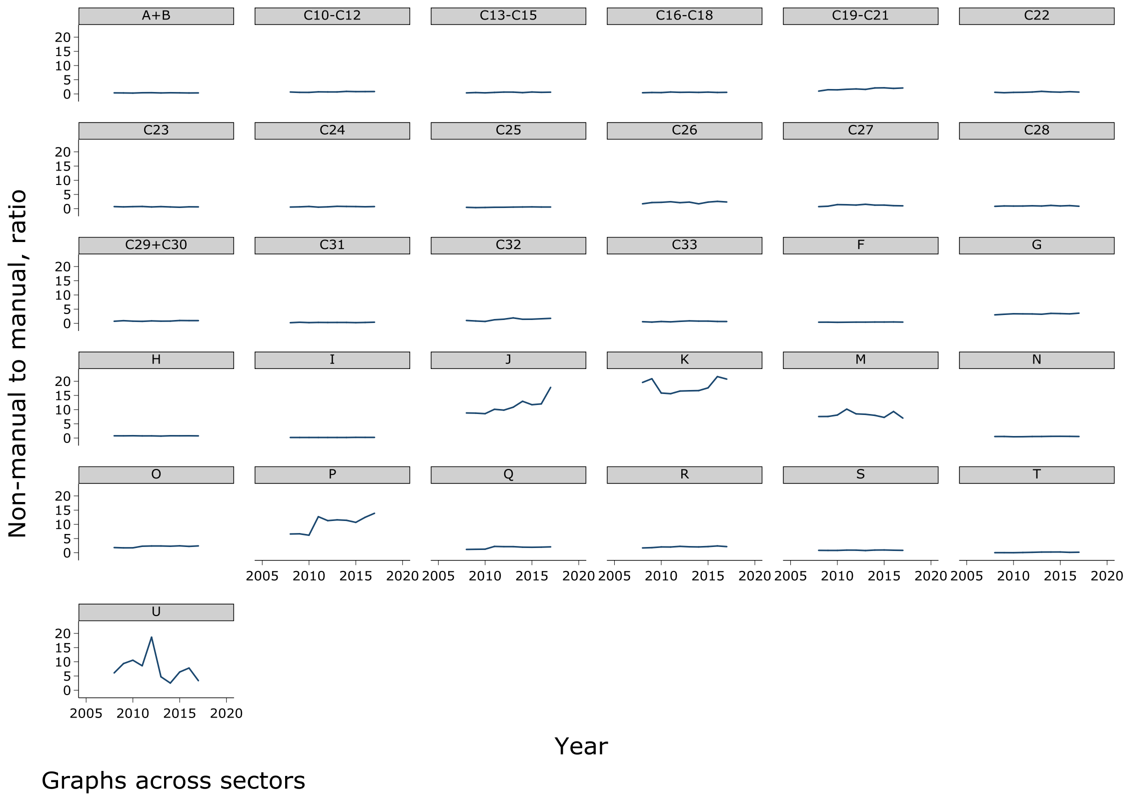
Source: Peneder – Firgo – Streicher 2018, Eurostat, LFS, WIFO calculations. Note: Data after 2017 is forecasted. ISCO-88 1995-2010, ISCO-08 2011-2017. Break in data base.

Table B-0-10: Descriptive statistics for task groups in levels and growth rates

Task shares	Routine	Non-routine to routine	Manual	Non-manual to manual	Abstract	Manual, routine	Abstract to Manual Routine
Mean	0.43	1.65	0.48	2.65	0.28	0.19	4.05
Median	0.43	1.32	0.55	0.83	0.21	0.15	1.22
S.d.	0.13	1.29	0.23	4.24	0.18	0.14	7.26
Obs.	310	310	310	310	310	310	308
Y-o-Y changes in task structures	**Routine**	**Non-routine to routine**	**Manual**	**Non-manual to manual**	**Abstract**	**Manual, routine**	**Abstract to Manual Routine**
Mean	0.00	0.03	-0.01	0.08	0.01	0.00	0.35
Median	0.00	0.03	0.00	0.02	0.00	0.00	0.04
S.d.	0.04	0.31	0.04	1.36	0.04	0.03	3.60
Obs.	279	279	279	279	279	279	276
Three year changes in task structures	**Routine**	**Non-routine to routine**	**Manual**	**Non-manual to manual**	**Abstract**	**Manual, routine**	**Abstract to Manual Routine**
Mean	-0.01	0.09	-0.02	0.23	0.02	-0.01	0.99
Median	-0.01	0.06	-0.01	0.06	0.01	-0.01	0.13
S.d.	0.05	0.40	0.05	1.36	0.04	0.04	4.09
Obs.	93	93	93	93	93	93	92

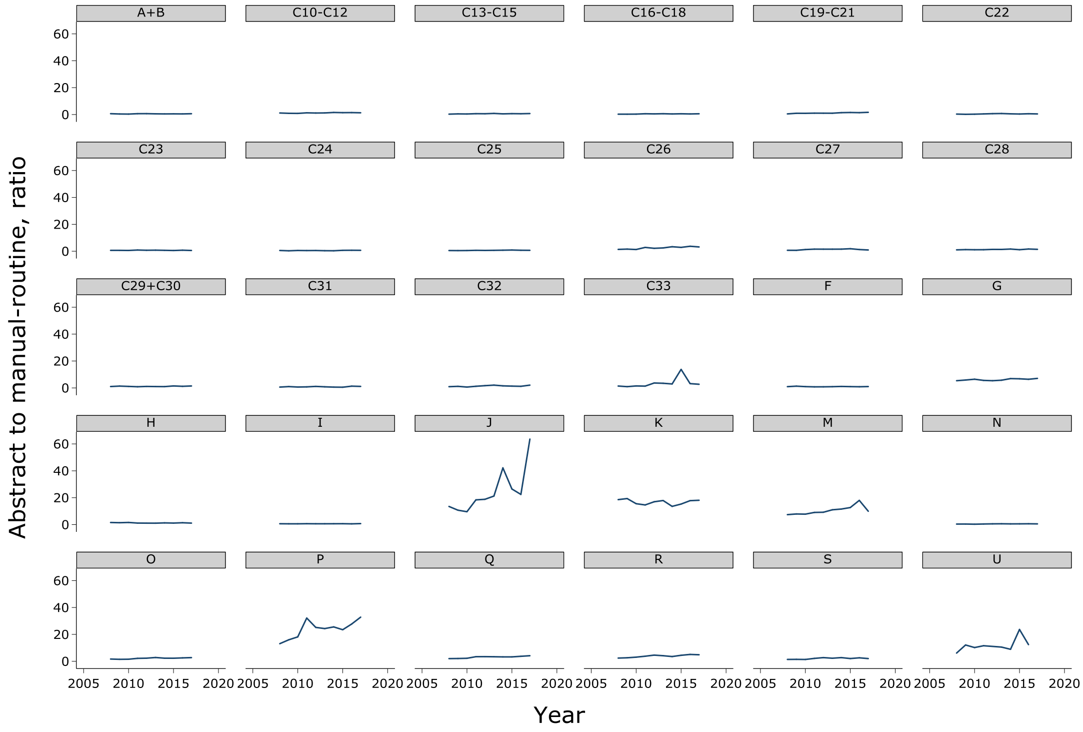
Source: Statistics Austria: LFS, WIFO-calculations. Note: 2010/2011 break in data base. ISCO-88 1995-2010, ISCO-08 2011-2017. Break in data base 2003/04: change LFS calculations.

Figure B-63: Non-manual to manual activities across sectors (ratio)



Source: LFS, WIFO calculations.

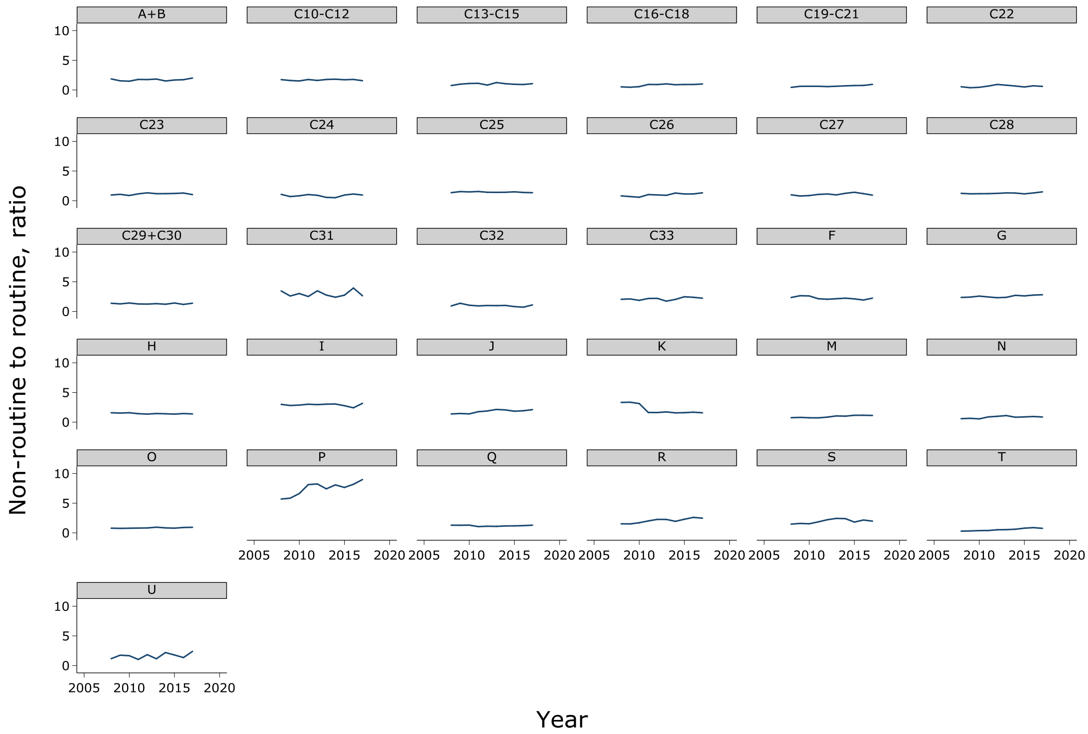
Figure B-64: Abstract to manual routine activities across sectors (ratio)



Graphs across sectors

Source: LFS, WIFO calculations.

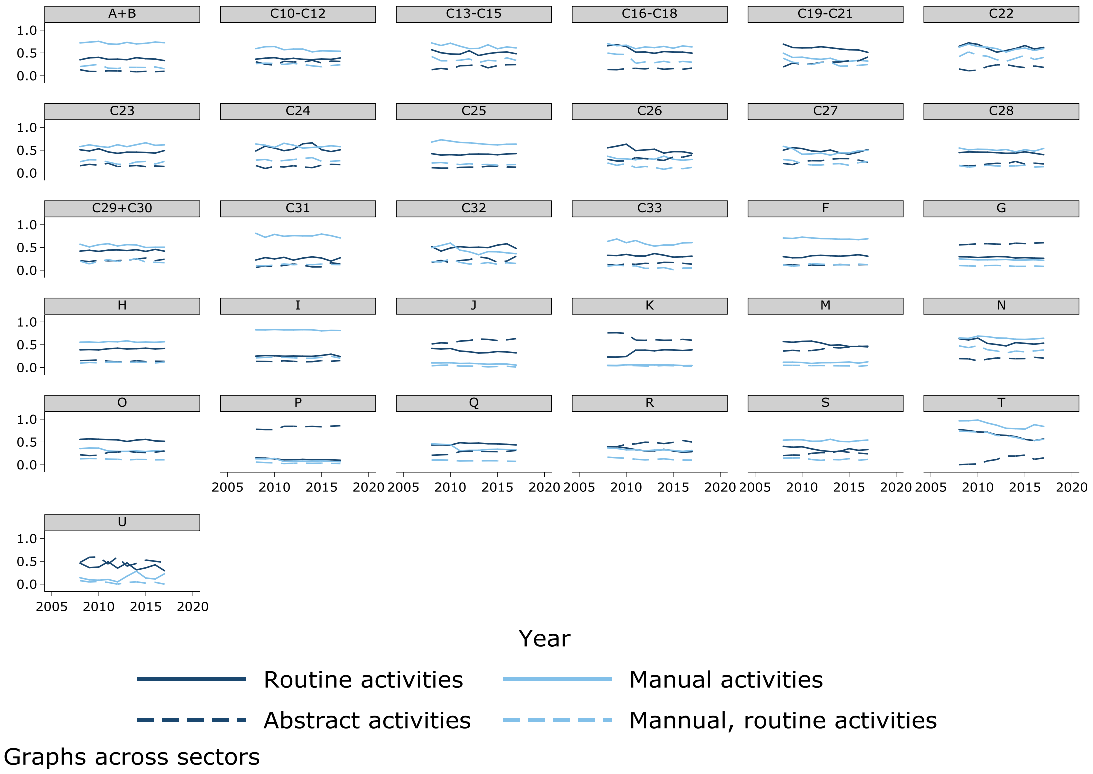
Figure B-65: Non-routine to routine activities across sectors (ratio)



Graphs across sectors

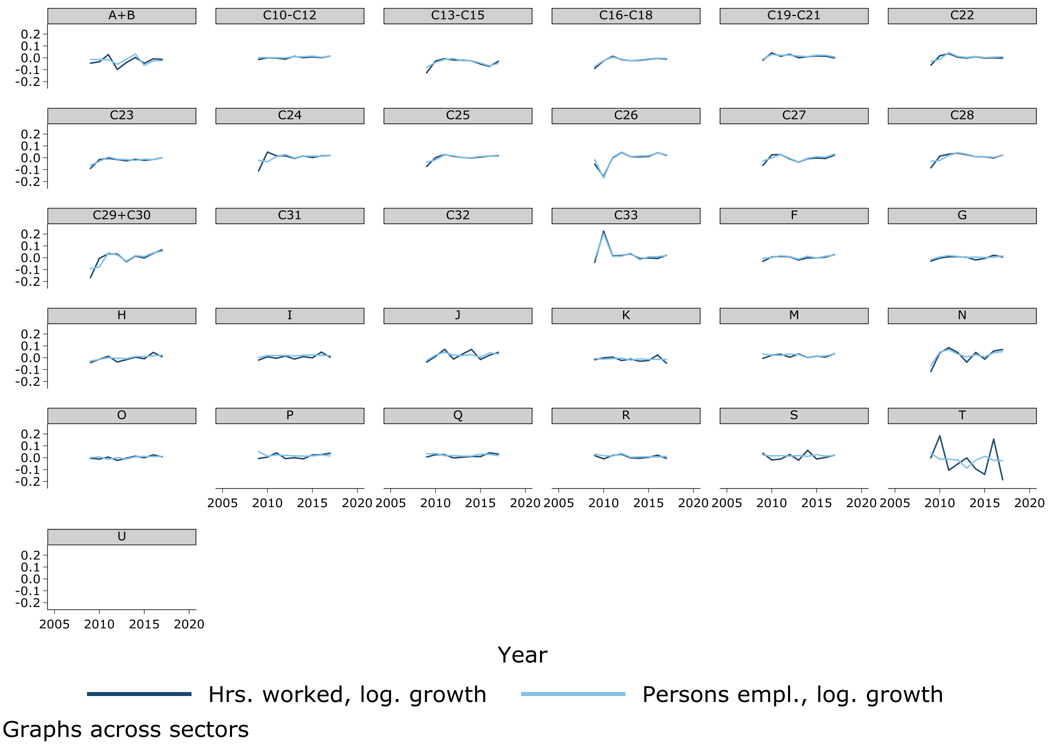
Source: LFS, WIFO calculations.

Figure B-66: Task categories in levels across sectors



Source: LFS, WIFO calculations.

Figure B-67: Logarithmic growth rates of hours worked and persons employed



Source: LFS, WIFO calculations.

B.4.5. Additional material related to Section 5.4.5

The results obtained from the ICT taxonomy published by the OECD (Calvino et al. 2018) are supplemented by the ICT specialist taxonomy (Peneder – Firgo – Streicher 2018). This ICT specialist taxonomy is confronted with the shares of the task groups (at sectoral level) and the ratios capturing joint developments of different aspects of the task structures.

A first descriptive tabulation using the main tasks (determined by occupations) reveals interesting structural patterns (see Table B-0-11). Abstract (analytical and interactive non-routine) and cognitive tasks are more common in ICT-intensive sectors than in sectors which are classified as low or medium ICT-intensive. Manual tasks are less common. Interestingly, there seems to be no difference between routine and non-routine tasks. This points at a differentiated picture of automation through ICT.

Table B-0-11: Task structure by ICT specialist taxonomy

ICT Type (OECD)	Abstract	Cognitive	Manual	Manual
Routine activities	N	Y	Y	N
Low	27.0%	19.6%	18.2%	35.3%
Med	20.2%	21.9%	25.7%	32.3%
High (user)	36.6%	31.6%	9.9%	21.9%
High (producer)	45.0%	35.0%	8.6%	11.5%
All sectors	27.6%	23.7%	18.6%	30.1%

Source: Peneder – Firgo – Streicher 2018, Eurostat, LFS, WIFO calculations.

The following shows regression results in which task groups are used as dependent variables in exploratory regressions. The explanatory variable is the ICT specialist taxonomy (Peneder – Firgo – Streicher 2018), using industries with a low ICT specialist intensity as a benchmark. These regressions associate the ICT taxonomies with the task groups (routine versus non-routine, manual versus non-manual). To control for time effects, year dummies are used in each specification.

The results largely support the descriptive statistics and previous findings which used the OECD taxonomy by showing that especially high levels of manual tasks (at the sectoral level) are negatively related with high digital intensity. The results for manual-routine tasks are also negative, but statistically much weaker and of a lesser magnitude. There is a weakly significant relationship between routine tasks and sectors with medium digital intensity (see Table B-0-12).

Table B-0-12: Task structures explained by ICT specialist taxonomy

Dep. Var.	(1) Routine	(2) Non-routine to routine	(3) Manual	(4) Non-manual to manual	(5) Abstract	(6) Manual, routine	(7) Abstract to Manual Routine
Medium	0.10*	-0.96*	0.05	-0.96	-0.07	0.08	-2.24
	(0.053)	(0.555)	(0.080)	(0.835)	(0.071)	(0.061)	(1.934)
High (user)	0.04	-0.66	-0.22*	4.35	0.10	-0.08*	3.94
	(0.050)	(0.565)	(0.114)	(2.774)	(0.097)	(0.044)	(3.183)
High (prod.)	0.06	-0.80	-0.33***	4.87	0.18	-0.10*	10.14
	(0.067)	(0.606)	(0.107)	(3.391)	(0.117)	(0.049)	(8.377)
Constant	0.40***	0.80***	0.57***	1.44*	0.25***	0.21***	10.12
	(0.042)	(0.133)	(0.065)	(0.710)	(0.062)	(0.033)	(9.024)
Observations	300	300	300	300	300	300	298
R-squared	0.13	0.11	0.29	0.27	0.17	0.22	0.22

Source: Peneder – Firgo – Streicher 2018, Eurostat, LFS, WIFO calculations. Note: Robust standard errors clustered at the sector level in parentheses; Unreported time dummies included in all specifications. Sig. levels *** p<0.01, ** p<0.05, * p<0.1.

In addition, the changes in the task structures were estimated, both in changes over three-year periods (see Table B-0-13) and year-on-year changes (see Table B-0-14). The level of the respective dependent variable in the base year was used as an additional control variable in all regressions, over and above unreported time dummies.

The results from these regressions indicate the same trend, but are weaker in their effect. There are changes in the task structures towards non-routine activities in sectors with a high digital intensity. This comes at the cost of routine activities. Abstract non-routine tasks seem to displace manual routine activities in ICT-intensive sectors.

Table B-0-13: Three-year changes in task structures explained by ICT specialist taxonomy

Dep. Var. (3-yrs growth)	(1) Routine	(2) Non-routine to routine	(3) Manual	(4) Non-manual to manual	(5) Abstract	(6) Manual, routine	(7) Abstract to Manual Routine
Base year, level	-0.10***	0.07	-0.02	0.08*	-0.02	-0.09***	0.36*
	(0.030)	(0.104)	(0.013)	(0.046)	(0.028)	(0.017)	(0.198)
Medium	0.00	0.04	0.01	-0.18	-0.00	0.00	-0.08
	(0.008)	(0.069)	(0.007)	(0.147)	(0.008)	(0.006)	(0.308)
High (user)	0.00	-0.08	0.01	-0.73*	-0.01	-0.01	-1.63*
	(0.012)	(0.168)	(0.008)	(0.411)	(0.009)	(0.005)	(0.926)
High (prod.)	-0.02***	0.16**	-0.01	1.01	0.02***	-0.02***	6.05
	(0.005)	(0.060)	(0.006)	(0.881)	(0.008)	(0.004)	(4.482)
Constant	0.03	-0.04	-0.03**	0.39	0.03***	-0.01	0.07
	(0.018)	(0.103)	(0.012)	(0.325)	(0.008)	(0.009)	(0.852)
Observations	90	90	90	90	90	90	89
R-squared	0.102	0.044	0.102	0.163	0.069	0.155	0.372

Source: Peneder – Firgo – Streicher 2018, Eurostat, LFS, WIFO calculations. Note: Robust standard errors clustered at the sector level in parentheses; Unreported time dummies included in all specifications. Sig. levels *** p<0.01, ** p<0.05, * p<0.1.

Table B-0-14: Y-o-Y Changes in task structures explained by ICT specialist taxonomy

Dep. Var. (Y-o-Y)	(1) Routine	(2) Non-routine to routine	(3) Manual	(4) Non-manual to manual	(5) Abstract	(6) Manual, routine	(7) Abstract to Manual Routine
Base year, level	-0.03***	0.02	-0.01	0.03*	-0.01	-0.03***	0.12*
	(0.010)	(0.034)	(0.004)	(0.015)	(0.009)	(0.006)	(0.067)
Medium	0.00	0.01	0.00	-0.06	-0.00	0.00	-0.03
	(0.002)	(0.023)	(0.002)	(0.048)	(0.003)	(0.002)	(0.103)
High (user)	0.00	-0.03	0.00	-0.24*	-0.00	-0.00	-0.45
	(0.004)	(0.055)	(0.003)	(0.135)	(0.003)	(0.002)	(0.310)
High (prod.)	-0.01***	0.05***	-0.00	0.34	0.01***	-0.01***	2.01
	(0.002)	(0.020)	(0.002)	(0.290)	(0.003)	(0.001)	(1.477)
Constant	0.02*	-0.04	-0.00	0.17	0.00	0.00	-0.11
	(0.008)	(0.074)	(0.007)	(0.144)	(0.007)	(0.006)	(0.432)
Observations	270	270	270	270	270	270	267
R-squared	0.033	0.024	0.062	0.040	0.035	0.085	0.072

Source: Peneder – Firgo – Streicher 2018, Eurostat, LFS, WIFO calculations. Note: Robust standard errors clustered at the sector level in parentheses; Unreported time dummies included in all specifications. Sig. levels *** p<0.01, ** p<0.05, * p<0.1.

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