Data Observer

Open Access

Irene Bertschek, Jörg Ohnemus* and Steffen Viete

The ZEW ICT Survey 2002 to 2015: Measuring the Digital Transformation in German Firms

DOI 10.1515/jbnst-2016-1005

1 Introduction

Modern Information and Communication Technologies (ICT) have been proliferating through the entire business sector over recent decades. This increasing digitalization is having a substantial impact on economic activity and is continuously changing the nature of production processes and our day-to-day working life. Since 2002, the ICT Survey carried out by the Centre for European Economic Research (ZEW) has tracked the diffusion and use of ICT in different industries within the German economy.¹ Further surveys were conducted at irregular intervals in 2004, 2007, 2010 and 2015.² The survey was designed by ZEW's Research Department Information and Communication Technologies. The data was collected via computer-assisted telephone interviews (CATI) by infas Institute for Applied Social Sciences. The central aim of the survey is twofold: Firstly, a representative picture of the use of ICT by German firms is obtained. Secondly, taking account of a large set of further firm characteristics it should allow an analysis of the consequences of employing ICT and ICT-related projects with respect to different measures of firm performance.

Existing alternative related datasets on German firms suffer from various shortcomings which prevent a thorough analysis of ICT in relation to the firms' characteristics and performance. Overall, there is no readily available dataset for German firms

1 A previous survey with a specific focus on IT skill shortage was conducted on behalf of the German Ministry of Education and Research in 2000.

2 See ZEW IKT-Report (2003, 2005, 2007, 2010, 2015) for selected representative results based on the ICT survey data on the diffusion and use of ICT in Germany.

***Corresponding author: Jörg Ohnemus**, Centre for European Economic Research (ZEW), Mannheim, Germany, E-mail: ohnemus@zew.de

Irene Bertschek: E-mail: bertschek@zew.de, **Steffen Viete**: E-mail: viete@zew.de, Centre for European Economic Research (ZEW), Mannheim, Germany

which links information on ICT use with background characteristics and measures of firm performance. While the Federal Statistical Office in Germany started to conduct an administrative ICT survey in 2003 within the framework of the Eurostat Community survey on ICT usage in enterprises (Destatis 2015),³ one big disadvantage of this data is that it is limited to a narrow set of variables focusing solely on the use of ICT within the firm. Background firm characteristics needed for comprehensive empirical research are beyond the scope of the survey.⁴ Furthermore, the administrative survey intentionally excludes firms who took part in the previous year's survey in order to avoid too much effort on the part of the firms.⁵ Thus, it is not possible to build a panel or even to make year-to-year comparisons. The information contained in the ICT survey conducted by the Federal Statistical Office has recently been integrated into the Eurostat-funded ESSLait project. However, the available Micro Moment Database does not contain information at the firm-level but micro-aggregated harmonized industry-level data (Bartelsman et al. 2013). Moreover, surveys of various official statistics have by now been combined into an administrative firm-level longitudinal dataset within the AFiD project (Wagner 2016). However, the administrative ICT survey is not included in the AFiD Modules yet.⁶ So far, the ZEW ICT Survey is the only dataset which enables the joint analysis of ICT and multiple background characteristics for German firms in the cross-section and over time.

This paper is organized as follows: Section 2 provides an overview of the survey methodology, including population, sampling frame and data processing. Section 3 summarizes the main contents of the ZEW ICT Survey with a focus on the current wave collected in 2015. Section 4 provides information on data protection and data access at the ZEW Research Data Centre (ZEW-FDZ).

2 Survey design

The population of the ZEW ICT Survey is comprised of all firms based in Germany with at least 5 employees⁷ belonging to the manufacturing sector and selected services industries (see below).

3 Another reason ZEW started its own ICT survey in 2002 was the lack of administrative data available at that time on the distribution of modern ICT in German firms.

4 Other large scale firm surveys in Germany, such as the IAB Establishment Panel, only contain rudimentary information on the firms' ICT use.

5 Of course, this does not apply to all firms. Especially large firms have to remain on the panel since there are only few firms of their size available.

6 See also http://www.forschungsdatenzentrum.de/afid.asp#p_afid.

7 This refers to the first time drawing of the firms. Panel firms with less than 5 employees are also kept in the sample.

As a sampling frame, the ICT Survey uses the data pool of Verband der Vereine Creditreform e.V. (Creditreform), a credit rating agency, which provides one of the largest publicly available databases on firms in Germany. The statistical unit of the Creditreform database is the legally independent firm.⁸ The sample is drawn using a stratified sampling design. Stratification cells are defined by firm size in terms of the number of employees, as well as firms' industry affiliation. Overall five size classes are defined (5–19, 20–49, 50–249, 250–499, ≥500). Moreover, the sample is stratified by 17 industrial sectors constructed from two-digit standard industry codes (NACE Rev. 2).⁹ Table 1 provides a breakdown of the industry composition of the 2015 wave of the ICT Survey. The ICT Survey distinguishes 17 basic sectors, most of them composed out of several two-digit industries. However, for the drawing of the gross sample, a further differentiation of 3 sectors (consumer goods, basic materials and furniture, toys, medical equipment) was applied due to the greater heterogeneity of their business activities. We therefore ended up using a 22 sector definition for drawing the sample. Until the wave of 2010, the ZEW ICT Survey was additionally stratified according to location, namely whether the firm was based in East or West Germany. For each wave, the gross sample is made up of panel firms which took part in a previous wave of the survey and supplemented by newly drawn firms due to panel attrition.

The target size of the 2015 wave's net sample was 4,500 firms. This number was achieved by applying an adjusted gross sample of slightly more than 30,000 observations, which results in a participation rate of 15 percent. The telephone interviews are preceded by a screening procedure to determine the firms' eligibility for inclusion in the survey. Depending on the size of the firm, survey respondents are generally the firms' owner, manager, or the head of the IT department. For the 2015 wave, the average interview length was 25.7 minutes. In each wave of the survey, the questionnaire undergoes a pretest in the field. Findings of the pretest are integrated into the final survey tool.

The right-hand columns of Tables 1 and 2 give an overview of the number of firm observations included in the 2015 ICT Survey, the overall number of companies in Germany and the share of survey observations out of the total number of companies by industry affiliation (Table 1) and by size class¹⁰ (Table 2). The coverage rate

⁸ See e. g. Bersch et al. (2014) for further details on the Creditreform database.

⁹ The stratification matrix has been changed over time along the industry dimension according to changes in the statistical classification of economic activities in the European Community and subsequently in Germany, as well as changes in objectives in terms of content of the survey.

¹⁰ Size classes according to the number of employees.

Table 1: ZEW ICT survey 2015 industry classification.

No.	ZEW ICT Survey 2015 Industry Classification	NACE Rev. 2/WZ 2008	Description	# firms in population (≥ 5 employees, 2014)	# firms in survey	Share of observed firms in the population (in percent)
1	Consumer Goods	10 11 12 13 14 15 16 17	Manufacture of food products Manufacture of beverages Manufacture of tobacco products Manufacture of textiles Manufacture of clothing Manufacture of leather and related products Manufacture of wood and wood and cork products, excluding furniture; manufacture of straw articles and weaving materials Manufacture of paper and paper products	15.779	272	1.72
2	Chemical and Pharmaceutical Industry	20 21	Manufacture of chemicals and chemical products Manufacture of basic pharmaceutical products and pharmaceutical preparations	2.536	138	5.44
3	Basic Materials	22 23	Manufacture of rubber and plastic products Manufacture of other non-metallic mineral products	4.914 3.570	189 132	3.85 3.70
4	Metal Industry	24 25	Manufacture of basic metals Manufacture of fabricated metal products, excluding machinery and equipment	21.559	276	1.28

(continued)

Table 1: (continued)

No.	ZEW ICT Survey 2015 Industry Classification	NACE Rev. 2/WZ 2008	Description	# firms in population (≥ 5 employees, 2014)	# firms in survey	Share of observed firms in the population (in percent)
5	Electrical Industry	26	Manufacture of computer, electronic and optical products	7.738	233	3.01
		27	Manufacture of electrical equipment			
6	Machinery	28	Manufacture of machinery and equipment n.e.c.	10.371	229	2.21
7	Automotive Industry	29	Manufacture of motor vehicles, trailers and semi-trailers	2.271	106	4.67
		30	Manufacture of other transport equipment			
8	Furniture/Toys/ Medical Equipment	31	Manufacture of furniture	3.123	134	4.29
		32	Other manufacturing	6.508	186	2.86
		33	Repair and installation of machinery and equipment	5.160	88	1.71
9	Retail	45	Wholesale and retail trade and repair of motor vehicles and motorcycles	81.819	216	0.26
		47	Retail trade, excluding retail of motor vehicles and motorcycles			
10	Wholesale	46	Wholesale trade, excluding trade of motor vehicles and motorcycles	39.061	183	0.47

(continued)

Table 1: (continued)

No.	ZEW ICT Survey 2015 Industry Classification	NACE Rev. 2/WZ 2008	Description	# firms in population (≥ 5 employees, 2014)	# firms in survey	Share of observed firms in the population (in percent)
11	Transportation	49 50 51 52 53 79	Land transport and transport via pipelines Water transport Air transport Warehousing and support activities for transportation Postal and courier activities Travel agency, tour operator and other reservation services and related activities	34,368	213	0.62
12	Content and Media	18 58 59	Printing and reproduction of recorded media Publishing activities Motion picture, video and television programme production, sound recording and music publishing activities	8,262	157	1.90
13	IT and Tele- communication	60 61 62 63	Programming and broadcasting activities Telecommunications Computer programming, consultancy and related activities Information service activities	14,931	210	1.41

(continued)

Table 1: (continued)

No.	ZEW ICT Survey 2015 Industry Classification	NACE Rev. 2/WZ 2008	Description	# firms in population (≥ 5 employees, 2014)	# firms in survey	Share of observed firms in the population (in percent)
14	Financial Services	64	Financial service activities, excluding insurance and pension funding	6.831	215	3.15
		65	Insurance, reinsurance and pension funding, excluding compulsory social security			
		66	Activities auxiliary to financial services and insurance activities			
15	Consulting and Advertising	69 702 73	Legal and accounting activities Management consultancy Advertising and market research	32.809	217	0.66
16	Technical Services	71 72	Architectural and engineering activities; technical testing and analysis Scientific research and development	18.790	182	0.97
17	Enterprise Services	74 78 80 81 82	Other professional, scientific and technical activities Employment activities Security and investigation activities Service to buildings and landscape activities Office administration, office support and other business support activities	31.833	235	0.74

Source: ZEW ICT Survey, 2015; Destatis, 2008 and 2016.

Table 2: ZEW ICT survey 2015 by size class.

Size Class	# firms in population (≥ 5 employees, 2014)	# firms in survey	share of observed firms in the population (in percent)
5–19 employees	246.860	1.599	0.65
20–49 employees	64.529	843	1.31
50–249 employees	38.725	1.185	3.06
250–499 employees	5.322	249	4.68
≥ 500 employees	3.931	258	6.56

Source: ZEW ICT Survey, 2015; Destatis, 2008 and 2016.

increases continuously with firm size, starting at 0.65 percent for the smallest firms (5–19 employees) and ending at 6.56 percent for the large firms with 500 employees or more. Differences in the coverage rate by industries are essentially due to different size structures in the various industries and a predefined upper limit of interviews to be realized per drawing cell (i. e. sector-size class combination).-

After the field phase, a couple of data processing steps are performed on the raw data to ensure high data quality. For example, to verify the firms' industry affiliation, each firm is assigned manually to an industry at the three-digit NACE Rev. 2 level.¹¹ This assignment is based on the firms' statements on their product or service with the largest sales share. The manual assignments to industry codes were carried out twice by different individuals. Cases of disagreement were subsequently checked again. Key variables such as sales, the number of employees and investments, are checked for consistency and plausibility and detected outliers are manually cross-validated based on publicly available data.

3 Contents of the survey

The ZEW ICT Survey regularly includes questions which are intended to describe the **general ICT intensity** of the firm. Many of these measures are by now also

¹¹ For Germany, the "Wirtschaftszweignklassifikation 2008" (WZ 2008) is the equivalent of the NACE Rev. 2 classification for the economic activities relevant to us (see Destatis 2008).

reflected in the Eurostat Community Survey framework and are therefore comparable to measures used in the administrative surveys. Measures for overall ICT intensity range from the percentage of employees working predominantly with computers, which has been employed in numerous econometric studies as a measure of overall ICT intensity, or proxy for ICT capital respectively (e. g. Bloom et al. 2012), to IT expenditure and the number of IT staff employed by the firm.

Figure 1 provides an exemplary analysis of the data contained in the ZEW ICT Survey. Showing in-sample averages over different waves, the figure depicts the digitalization of workplaces in German firms. The data suggest that working with personal computers, which became widespread mainly during the 1980s and 1990s, as well as the use of the internet at the workplace have remained quite stable since 2002. In recent years, however, the data reflects the rapid proliferation of mobile devices like smartphones, tablets and notebooks, which provide internet access via cellular networks and are supplementing traditional work at desktop PCs (Bertschek/Niebel 2016).

Figure 1: Diffusion of ICT in the workplace (share of employees in percent).

Share of employees in the average firm in the sample working predominantly with personal computers, having access to the internet at the workplace, and being equipped with mobile ICT, such as smartphones, notebooks or tablets, by the employer.

Source: ZEW ICT Survey 2015.

Besides measures for general ICT intensity, the ZEW ICT Survey contains data on more **specific technologies**, which typically serve a particular purpose. Some of these technologies are covered in multiple waves, such as Enterprise Resource Planning software (ERP). The current wave of the survey, for instance, includes information on the use of technologies such as cloud computing and the different types thereof, the use of Big Data Analytics, current and planned 'Industry 4.0'

projects, and the firms' development of mobile applications. Figure 2 depicts the in-sample shares of firms offering mobile product or service apps and the share of firms which systematically analyze large amounts of data to support business operations (Big Data Analytics) by industry.

Figure 2: In-sample shares of firms offering mobile apps and systematically analyzing big data (share of firms in percent).

Left column: Share of firms offering specific product or service apps for mobile devices. Right column: Share of firms systematically analyzing large amounts of data to support business operations. Source: ZEW ICT Survey 2015.

The data includes an extensive list of **background characteristics** of the firms, ranging from basic characteristics, such as the number of employees, or information on the qualifications and age structure of employees, to the use of organizational and human resource practices like incentive pay. The data also contains balance sheet information, such as personnel costs or expenditures on intermediate inputs, which are important for econometric analyses.

The ICT Survey also covers a wide variety of **performance measures**, which are typically included in all waves of the survey, such as total sales or export status and share. Additionally, items included on innovation and R&D activities follow the Community Innovation Survey (CIS) and the guidelines of the Oslo Manual by the OECD and Eurostat (2005).

Table 3 provides an overview of the items collected in the last wave of the ZEW ICT Survey in 2015.

Table 3: Exemplary list of collected items in the ZEW ICT Survey 2015.

Category	Items
General ICT intensity	<ul style="list-style-type: none"> – Share of employees <ul style="list-style-type: none"> – working predominantly with personal computers – with access to the internet – equipped with mobile devices connected to wireless internet – IT-expenditures – IT-investment – IT-staff – IT-training – Quality of internet access
Background characteristics and performance measures	<ul style="list-style-type: none"> – Sales – Employees – Investments – Major product or service – Product and process innovation – R&D expenditures – Exports – Qualification structure (employees with different forms of formal education) – Age structure – Share of female employees – Part-time employment – Payroll – Cost of intermediate inputs – Information on organizational and human resource management practices – Presence of works council
Specific Technologies	<ul style="list-style-type: none"> – Enterprise software – E-commerce (sales over the internet) – Social Media software – Cloud Computing – Big Data Analytics – Development of mobile apps – ‘Industry 4.0’ projects

Source: ZEW ICT Survey 2015.

Finally, each wave of the ZEW ICT Survey includes **focus topics** that are covered by a more extensive list of questions (Table 4). Focus topics are selected according to their overall relevance at the time the survey is conducted, their suitability for paving the way for further research with the

Table 4: Overview of focus topics in the ZEW ICT Surveys 2002–2015.

2002	2004	2007	2010	2015
– Training and IT-Staff	– Use of Management	– Use of Management	– Web 2.0/Social Media	– Social Media Marketing
– E-Commerce	– Consultancy	– Consultancy	– Outsourcing	– Cloud Computing
	– IT Outsourcing	– IT Outsourcing		– Workplace Flexibility
	– E-Commerce	– Business Process Outsourcing		
	– On-the-Job Training			

Source: ZEW ICT Surveys.

collected data, and following a broad discussion with internal and external experts on the topic of interest. For example, one of the focus topics of the last wave in 2015 was ‘Social Media Marketing’. The respective block of questions covers a comprehensive list of items on the use of different social media channels, from corporate blogs to profiles in online social networks. Further questions deal with the goals and barriers to the firms’ social media activities. Moreover, the focus topic introduces new measures for firms’ background characteristics and performance, such as the amount of sales generated by new customers.

4 Data protection, provision and access

ZEW makes use of the ICT Survey data for its own research projects, which are funded in part through academic and public funds and partly conducted on behalf of third parties, such as national ministries, EU institutions and private companies. Apart from this, the data from the ZEW ICT Survey is available to interested researchers from outside the ZEW. Interested researchers will be provided with an overview of collected items over all waves of the panel upon request. The data is accessible for scientists based at universities and publicly financed research institutions for non-commercial basic research purposes. Use of the data for commercial or any other business purposes is not permitted. The available data is formally anonymized, i. e. they contain neither names nor addresses, but all other original data gathered in the survey is included. Each wave of the data is usually made available 12 months after the end of the field phase of the survey. To facilitate the external access, ZEW has established a Research Data Centre (ZEW-FDZ), which manages the external usage of ZEW research data. Upon request,

scientists have the opportunity to work with the formally anonymized ZEW ICT Survey data within the FDZ premises at ZEW.¹²

References

- Bartelsman, E.J., E. Hagsten, M. Polder (2013), Cross-Country Analysis of ICT Impact Using Firm-Level Data: The Micro Moments Database and Research Infrastructure, Eurostat.
- Bersch, J., S. Gottschalk, B. Müller, M. Niefert (2014), The Mannheim Enterprise Panel (MUP) and Firm Statistics for Germany, ZEW-Discussion Paper 14-104.
- Bertschek, I., T. Niebel (2016), Mobile and More Productive? Firm-Level Evidence on the Productivity Effects of Mobile Internet Use, Telecommunications Policy 40(9): 888–898.
- Bloom, N., R. Sadun, J. Van Reenen (2012), Americans Do IT Better: US Multinationals and the Productivity Miracle, American Economic Review 102(1): 167–201.
- Destatis (2008), Classification of Economic Activities, Edition 2008 (WZ 2008), Wiesbaden.
- Destatis (2015), Unternehmen und Arbeitsstätten – Nutzung Von Informations- und Kommunikationstechnologien in Unternehmen, Wiesbaden.
- Destatis (2016), Unternehmensregister, Sonderauswertung, Registerstand 29.02.2016, Wiesbaden.
- OECD and Eurostat (2005), Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data. Paris, OECD Publishing.
- Wagner, J. (2016), Kombinierte Firmenpaneldaten: Datenangebot Und Analysepotenziale. 1–12 in: S. Liebig, W. Matiaske, S. Rosenbohm (Hrsg.), Handbuch Empirische Organisationsforschung. Wiesbaden, Springer Fachmedien Wiesbaden.
- ZEW IKT-Report (2003), Unternehmen in der Internetökonomie, ZEW, Mannheim.
- ZEW IKT-Report (2005), Internet bestimmt den Geschäftsalltag, ZEW, Mannheim.
- ZEW IKT-Report (2007), Internetwirtschaft weiter auf dem Vormarsch, ZEW, Mannheim.
- ZEW IKT-Report (2010), Interaktiv, mobil, international – Unternehmen im Zeitalter von Web 2.0, ZEW, Mannheim.
- ZEW IKT-Report (2015), Industrie 4.0: Digitale (R)Evolution der Wirtschaft, ZEW, Mannheim.

¹² Please consult <http://kooperationen.zew.de/en/zew-fdz/home.html> for further information on data access.