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The digital economy in Germany: Data availability and initial estimates

Study on behalf of the
Federal Ministry for Economic Affairs and Energy
within the project “Measurement of the Digitalisation of the German Economy” (Project Number: 3/19)
15 December 2020

Study

Institut der deutschen Wirtschaft Köln Consult GmbH · Konrad-Adenauer-Ufer 21 · 50668 Köln
Postanschrift: Postfach 10 19 42 50459 Köln · Eingetragen im Handelsregister Köln HRB 30889
Geschäftsführer: Dr. Karl Lichtblau, Peter Schützdeller · Sitz der Gesellschaft ist Köln

MANAGING WITH FACTS

IW Consult GmbH
Konrad-Adenauer-Ufer 21
50668 Köln
Tel.: +49 221 49 81-758
www.iwconsult.de

Authors
Manuel Fritsch
Karl Lichtblau

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1 Digital satellite account

In a satellite account, a specific horizontal area of the economy is extracted from the System of National Accounts (SNA) and modelled as a separate product or industry group (satellite). The term "satellite" refers to the chosen subsets of sectors or economic activities in that system. The subsets may be distributed across various different economic sectors but still share a strong link to the "core" system. Satellite accounts are regularly used in the context of specific economic activities that cannot be precisely defined by the existing delineation of broader economic sectors or product groups. The purpose of a satellite account is to expand the analytical capacity of national accounting for selected aspect of economic activities. The satellite account provides a more detailed description of a particular economic function or theme, including its interaction with other economic activities and the impact on the economy at large. The international coordination of the definition of a satellite account is of great importance. The results should permit internal consistency with the rest of the statistical system of a country as well as international comparability of the impact of the activities described in the satellite account.

Probably the best known of the frameworks is the Tourism Satellite Account, which was mandated by the World Tourism Organization (see United Nations, 2010). The Tourism Satellite Account includes all the aspects of demand for goods and services which might be associated with tourism. These include, for example, hospitality services, which are traditionally associated with tourism, but also the purchase of souvenirs produced by various branches of the manufacturing industry, or passenger transport services. By combining data for the total tourist consumption and total production and imports of touristic goods and services the direct economic impact of tourism can be calculated. The Tourism Satellite Account is based on an international harmonized framework. National results can thus easily be compared across countries.

Other recent sectors of interest for satellite accounts are the sports sector, the audio-visual media sector and, in particular, the information society, or digital economy.

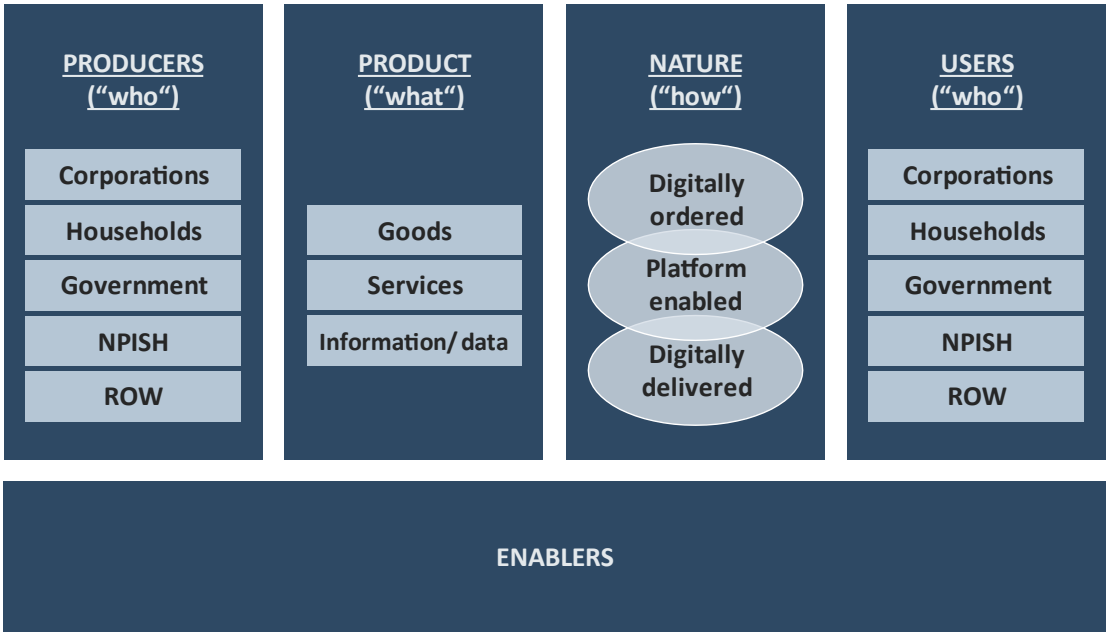
The publication of the Guide to Measuring the Information Society (OECD, 2011) represented a first important step towards defining the digital economy. The Guide defined the Information an Communication Technology – ICT goods and services sector and the products and services they produce. However, the Guide stressed future challenges in defining "new indicators in areas that are inherently difficult to measure" from a statistical perspective, such as e-business or ICT education and skills. In recent years, the OECD Working Party on International Trade in Goods and Trade in Services Statistics (2017a, b, c) has published several working papers to develop and define a structural framework for measuring the impact of the digital economy that could provide the basis for the development of

satellite accounting systems for macro-economic statistics. Recent publications by the OECD (2019) underline the importance of "making the digital economy visible in economic statistics".

1.1 Digital value added in the System of National Accounts

Figure 1-1 shows the dimensions of the digital economy as defined by the OECD. The framework has a broad multi-dimensional scope that includes the nature of the transaction ("how"), the product ("what") and the partners involved ("who (producers and users)"). An "enablers" category is included too. Enablers are defined as "complementary drivers of digital transformation". The enablers category works as a kind of wildcard for economic activities that are not covered by the "nature" dimension but nonetheless have an important impact on the digital economy.

Figure 1-1: Dimensions of the digital economy



Rest of world (ROW); non-profit institutions serving households (NPISH)
Source: OECD (2017c), authors' illustration

The two main defining categories of the digital economy framework are the "nature" and "enablers" components. They define the types of goods and services that should be included in the statistical framework.

Enablers

The summary of the exchange with national statistical offices and other relevant experts (OECD, 2017b) defines the "enablers" category quite broadly. Most of the responding statistical authorities included

- ICT equipment assets
- Software and database assets
- Telecommunications and Internet access
- Communication infrastructure
- Data
- Cloud computing facilities

as enablers of the digital economy. The experts conclude that to enable digital transactions, ICT products like computers, phones and the software installed on them are necessary too. Also, a communications infrastructure is needed to connect the producer and the user of the digital transaction, while data centres and cloud computing facilities form the basis for data processing for various digital use cases. Data are also included in the list of enablers. However, the term "data" is not further specified and can include a broad range of activities. From a technical perspective, data are just information that is processed or stored by a computer. This information can be in the form of text documents, images, audio clips, arrays etc. Thus, data in a broad sense enable almost any electronically operated business.

The OECD (2017b) also mentions the possibility of including sensors, control devices, data analytics and the Internet of things (IoT) as an enabler of digital production. Industrial robots, "smart factories" or the digitization of production processes can be considered as enablers too. Since the paper only mentions this possibility in a subsidiary section of the document, it can be concluded that the national statistical authorities have not yet reached consensus on the issue.

The OECD underlines the fact that the "Enablers" column is not limited to goods or services that are included in the "Nature" column. The addition of the additional economic activities defined as "Enablers" thus describes a broader area of the economy as digital.

Nature

The central part of the framework is the definition of digital goods and services in the "Nature" dimension of the framework. A digital good or service is either (and/or)

- Digitally ordered
- Platform enabled
- Digitally delivered.

It is important to note that the OECD Advisory Group has not yet reached agreement as to which products should be classified as digital under each dimension of the defined framework and whether all the products that match the described characteristics should be included as digital. To get a more complete picture of the "Nature" dimension, the characteristics are described in more detail in the following.

Digitally delivered describes "those services and data flows that are delivered digitally as downloadable products". This definition includes software, e-books, data and database services. Physical products are not included. There is, however, a debate among the OECD group of experts concerning 3D printing. If a blueprint for an object that is printed by the customer is delivered in digital form, the printing of the 3D object could in future be considered digital as well. However, this "as a service" approach needs to be fundamentally different from the trade in 3D blueprints (OECD, 2017a).

The narrow definition of digitally delivered products is linked to the highest approval rate across the OECD Advisory Group. A total of 14 out of the 18 experts would include all those products that are digitally delivered in a future satellite account of the digital economy. The responses of the Advisory Group also highlight some problems regarding the extent to which digitally delivered products should

be included in a satellite account. An insurance contract that is sent by email is a digitally delivered service, for example. The digital value added of this transaction may, however, be very small. In the past, the contract could have been sent by snail mail without the core of the product being changed. The same is true for plane e-tickets or a consultant's report.

We find the remark that only transactions should be classified as digitally delivered if they "could not occur without digitalization" very appealing. If a product or service is only deliverable digitally, then we would consider this to be a digital product. In the case of optional digital services (e.g. an e-ticket), we agree that only the additional value created by delivering the service digitally should be included and not the full value of the transaction. It is, however, only possible to select the value added if data for differentiating between the traditional and the digital value added of the transaction are available.

We would also like to mention that services that are based on the transmission of digital signals (telecommunications, radio and TV) have been delivered "remotely over information and communications technologies networks" (UNCTAD, 2015) since day one. In our view, including all these services represents a broader definition of digitalization than what is typically referred to as the "digital economy" or "data economy". If we consider the criterion that a service "could not occur without digitalization" this should exclude analogue television or radio services even if they were transmitted by IP-based telecommunication networks.

The second dimension of the "Nature" column checks whether the product is **digitally ordered**. It refers to e-commerce transactions between enterprises, households, individuals, governments, and other public or private organizations. How digitally ordered products should be included in the framework can be interpreted as a challenging question. Only six members of the OECD Advisory Group said that the full value of products that are digitally ordered should be included in the digital economy. Twelve members said that it should not. One of the main problems seems to be the value of the e-commerce transaction. Members feel strongly that only the additional value created by the e-commerce transaction should be included and not the full value of the transaction. To do that, the difference between e-tailers' margins and those of normal distributors must be determined.

Goods ordered via e-commerce channels also have to be distinguished statistically from orders placed by telephone, snail mail, fax or manually typed email. For exclusively internet-based traders in the retail sector this may be easier to accomplish than for companies in the business-to-business (B2B) sector, especially the industrial or manufacturing sectors. Data for determining the digital value added of a transaction described by the OECD (2017b) will be complicated to come by: "An enterprise in country A purchases a good online, directly at the supplier of the products located in country B, via the supplier's web-shop or EDI." This creates a huge challenge when it comes to measuring the value added of the digital delivery in the B2B sector.

The third dimension of the nature of the product mentioned in the framework is **platform enabled**. The definition of the framework thus tries to cover the impact of "the emergence of intermediary platforms such as Amazon, Uber, Alibaba or Airbnb" (OECD, 2017a). It is important to note that products that are platform enabled are also digitally ordered, since the ordering process is always done via an online platform.

The platform enabled classification is probably the most complex of the three "nature" characteristics, since using a platform involves two transactions: 1. the transaction between the customer and the platform, and 2. the transaction between the platform and the provider of the product or service. Therefore, the feedback from the Advisory Group was mixed as far as coverage of platform enabled products is concerned. Some experts mentioned that they would only include the value added of the intermediary service in the digital economy. Some statistical authorities also pointed out that the data

needed to track the value added of the digital intermediary might be difficult to come by, especially in the case of foreign platforms. Also, since a lot of the big platforms are located outside of Europe, where the value added of these platforms should be reported is still an open question. Since a decision on where to register the value added of the platforms could also have international tax implications, we do not expect an internationally harmonized solution to this question to be forthcoming in the near future.

Data limitations

Statistically measuring the data needed to quantify the digital economy in the SNA context will likely be very challenging. This is especially true for the value added associated with data. For most companies it is hard to tell what the economic value of their respective datasets is (Krotova et al., 2019). The OECD (2010) recommended valuating databases at their market price if the data is for sale or on a sum of cost basis in the absence of a more satisfactory alternative. Even the delimitation of the exact costs of collecting the data cannot be determined precisely in many cases. Since data are mostly used as part of a product or service, their contribution to the added value of the final product is often hard to define exactly.

A lot of statistical authorities in the OECD Advisory Group also mentioned data gaps when it comes to measuring the digital economy. They in particular refer to data on the income of self-employed persons and the activity of digital intermediaries (digital platforms). Other challenges are the collection of data on imports of digital services and the inclusion of these services in the price measurement process.

A total of 14 out of 17 responding statistical authorities said that they did not have sufficient information to highlight the digital economy (OECD, 2017b). The three positive responses in particular relate to e-commerce transactions that three of the authorities are already registering in more detail.

Also, most statistical authorities responded that they did not yet take digital services like streaming services (e.g. Netflix), accommodation platforms (e.g. Airbnb) or personal transportation services (e.g. Uber) into account when calculating consumer price indices.

1.2 Digital value added in business models

The OECD stresses that the scope for digitalization should be different for different research questions (OECD, 2017b). The framework presented in section 1.1 represents a broad approach that could be modified in the sense that only selected parts of the definition could be used when addressing different questions concerning digitalization.

If we take a step back from the SNA perspective, the key research questions concerning digitalization are, in our view, the impact of digitalization on the economy and the diffusion of digitalization in the economy.

The first question is usually answered by drawing on statistical data for digital enabler variables in an international context. Digital enablers such as the availability of broadband infrastructure (Czernich et al., 2009; Koutroumpis, 2009; Bertscheck et al., 2016 for an overview), fibre-based gigabit networks (Van Baal et al., 2016; Briglauer & Gugler, 2018), the use of computers and Internet access (Dewan et al., 2005), ICT investment (Draca et al., 2007, Cardona et al., 2013 for an overview), or a combination of different directly observable variables (Katz & Koutroumpis, 2014) are used as a proxy or enabler

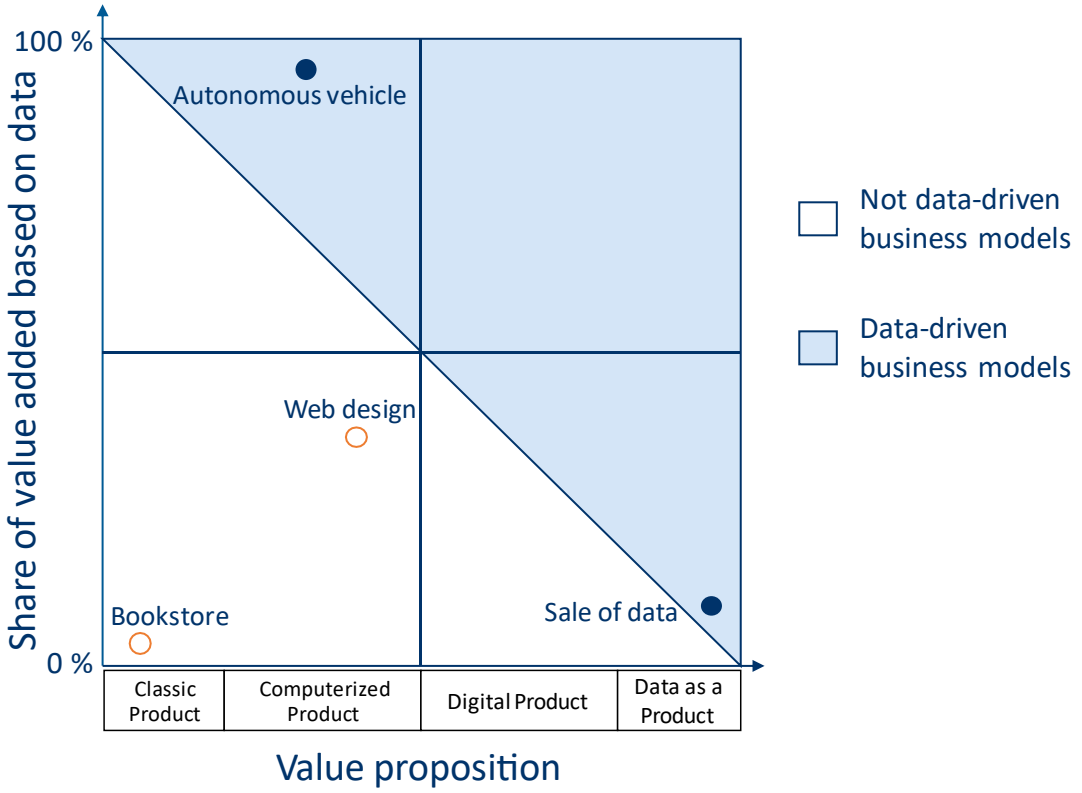
for the use of digital tools in the national economy. The studies quantify the positive effects of digitalization on economic growth (GDP, employment) using regression models.

The second question on the measures of digitalization often result from detailed company surveys, since most official statistics lack the level of detail to describe the different maturity levels of digitalization in the economy. A lot of surveys concentrate on specific economic sectors, since there are many different aspects to digitalization (in detail), and the focus in individual economic sectors varies. Examples of readiness models in Germany are the Industry 4.0 Readiness Model (Bertenrath et al., 2015) and the Industry 4.0 Maturity Index (Schuh et al., 2017) for the manufacturing sector or the recently developed Data Economy Readiness Model (Azkan et al., 2019). A broad range of digital maturity models have been available in the international context for 15 years now. Fritsch & Krotova (2019) list 17 models that specifically take the use of data into account.

In our view, when considering the evolution of digitalization or the digital change in the economy, changes in business models with respect to the use of data are the most explicit modification. When it comes to the impact of the digital economy, or more precisely the data economy, the switch to incorporating the use of data or the creation of new business models are the most accurate indicators.

In our paper on the path to data-driven business models (Fritsch & Krotova, 2020a), we define the two main characteristics that differentiate data-driven business models from traditional business models (Figure 1-2). We distinguish between classical and data-driven business models based on two main characteristics of the business model: value proposition and value added. The model can be shown in a two-dimensional coordinate system. While classic business models are in the lower left corner of the coordinate system, business models that have a data product and only show data-driven value creation are shown in the upper right corner. Companies that combine elements of both classic and data-driven business models are in the area in-between. The diagonal line marks the border between a classical and a data-driven business model. For companies in the white area, the data-driven value-added components tend to support the real processes, while data play a more complementary or supporting role as far as the value proposition is concerned. The opposite is true for companies in the blue area, where real value-added components tend to have a complementary function to the core data-driven business models, while data represent an indispensable part of the value supply.

Figure 1-2: Features of data-driven business models



Source: Fritsch & Krotova (2020a), authors' illustration

Value proposition is a pretty straightforward indicator. It defines which performance by a company brings which benefit to customers and consists of two building blocks: the product/service and the benefits/added value for the customer. If the product is the sale of data itself, then the business model should be classified as a data-driven business no matter what the value-added component of the data. For example, an (online) shop that is merely a reseller of data without doing any further analysis or work with the data would fall into this category. A practical example would be the sale of addresses for survey purposes, even though in most cases a company that offers such services would have done some (value-added) work on the data beforehand (like combining information, clearing or sorting the data for the customer).

A very classic value proposition is the sale of a physical good or traditional service at a bricks and mortar store (e.g. a local bookshop). Other services like transportation or publishing an article also have a dominant classic value proposition.

This does not mean that the production or sale of physical goods cannot be a data-driven business model. The second dimension of our model features the data-driven value-added aspect of the business model. The "value added" dimension includes the building blocks key resources, key activities, key processes, core competences/skills and governance. Put simply, what is being measured is how high the share of data-driven value creation is. An example of a company that sells a classic product but whose own value creation is quite data driven is the sale of an autonomous vehicle, where the seller is not the manufacturer but only integrates a data-based mobility solution. As in the case of an ordinary vehicle, the value proposition is still mobility. However, this is facilitated for the customer with the help of data. Due to the strongly data-driven value creation and a partly data-driven value

proposition (classic product, with data enrichment), the business model “autonomous vehicle” is in the blue area and is considered to be data driven.

Since digitalization is transforming many established business models, we expect a significant number of business models to be undergoing a process of transformation towards a more data-driven business model that does not change their core value proposition but raises the data-driven value added to increase competitiveness. However, this does not mean that every company will be transformed into a data-driven business. Labour-intensive activities often have no or only a marginal share of data-driven value creation – for example when the payment process in a restaurant is handled via an app.

ICT services, such as those of a web designer, have a certain degree of digital value added because they use data-driven tools and usually create an end product that contains some data-driven value propositions. However, the classic component predominates both in terms of value creation (the web designer’s creative work) and value proposition (the layout and visual presentation of content-based standardized tools). Such a business model could become data driven by means of a higher degree of data-driven value creation (algorithm-based creation of content) or value proposition (provision of a data-driven toolbox for the end customer’s own web design). An example in which this transformation process has already taken place is the creation of maps for travel guides. The final classic product has not changed (a map) but the value-added process has become more and more data driven: from hand-drawn maps to digitally drawn maps to maps created by a geoinformation system (GIS).

This kind of evolution is also evidenced in the telecommunications sector. Taking the example of a telecommunications reseller (excluding the construction of/investment in mobile radio towers or the laying of fibre optic cables, which in our view is a classic business model), then the service being sold is connectivity (for phone calls or the Internet). The value added proportion 100 years ago was quite classic, with the central office connecting the two subscribers by hand. With increasing computerization more and more processes where automated. Since the switch was made to IP telephone calls, the network management process is now quite digital with a significant share of data-driven value added.

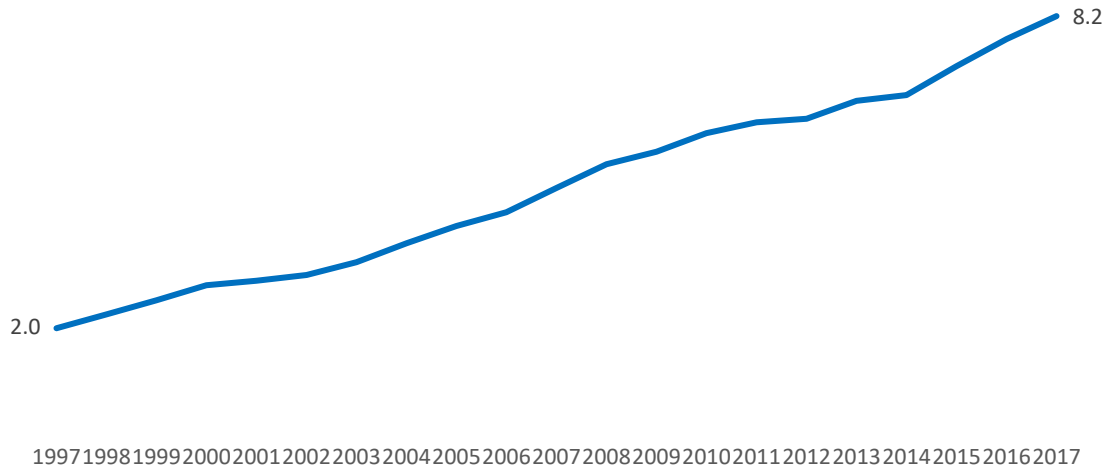
To measure the extent of digitalization in the economy and the impact it has had, we would prefer a more focused look at the digital economy in line with the comments made by the United States that “a satellite account focused on specific dimensions of digitalization and how it affects economies would be more informative than a satellite account that’s too broad in scope” (OECD, 2017b, p. 13). In our view, measuring digitalization based on enablers is only the second-best option. It should only be used if data relating to primary factors (like digital value added and digital value proposition) are not available.

This once again raises the issue of data availability. It would be very helpful, when it comes to measuring the digital economy, if data on the data-driven value added of economic sectors were available. Regarding those economic sectors whose value proposition is not strongly data driven, this would probably need to be addressed by changing statistical surveys.

2 The BEA approach and results for the United States

The first national statistical authority to release its own estimates regarding the extent of the national digital economy was the U.S. Bureau of Economic Analysis (BEA) (see Barefoot et al., 2018). The paper, published in 2018, describes in detail the work of the BEA on developing estimates regarding the construction of a digital economy satellite account for the United States. The report was updated one year later (Jolliff & Nicholson, 2019) based on the same methodology. The BEA presented data for each year from 1997 to 2017. Figure 2-1 shows the results of the impact of the digital economy in the United States over time. The value-added share increased from around 2.0 per cent in 1997 to around 8.2 per cent in 2017.

Figure 2-1: Value-added share of the digital economy in the United States (in %)



Source: Jolliff & Nicholson (2019), authors' illustration

From a methodological point of view the construction of the digital satellite account for the United States is the most interesting part, since it was the first estimate of the digital economy done within a supply-use framework for national accounts and is designed to lay the foundation for a digital economy satellite account in the United States.

Like the OECD, the BEA took the ICT sector as its point of departure for the definition of the digital economy. The ICT sector was defined in the previous work of the BEA and is based on the OECD (2011) definition. In addition to goods and services in the ICT sector, the BEA defined three main groups that are, in its view, to be included in the definition of the digital economy. The main groups are defined as

- Digital-enabling infrastructure
- E-commerce
- Digital media.

The **digital-enabling infrastructure** consists of a combination of goods and services in the ICT sector and additional enablers. It includes

- ICT hardware, such as computers, semiconductors, and audio and visual equipment
- Software
- Telecommunications equipment
- Structures, such as investment in fibre-optical cables and data centres
- IoT devices, such as connected cars, machinery and appliances
- Support services, such as digital consultancy and computer repair services.

The **e-commerce** component of the framework aims to address

- B2B e-commerce between manufacturers, wholesalers and other industries
- Business-to-consumer (B2C) e-commerce, generally online retail trade
- Peer-to-peer (P2P) e-commerce, better known as the sharing economy, or digital platforms like ride dispatching, accommodation rentals, or delivery and courier services.

The third component of the framework includes **digital media** products like

- Direct sale digital media, i.e. digital media through subscription services or direct sales
- Free digital media, i.e. media that are financed by selling advertising space (e.g. Facebook or YouTube), as well as free P2P digital media
- Big data, i.e. the sale of data or knowledge created (e.g. consumer behaviour) through a combination of several data points, but also companies that leverage the knowledge created in other ways.

It is worth noting that even though the BEA would have liked to include all these products and services, some of them had to be left out of the statistics reported because of the unavailability of data for distinguishing between these goods and services in national account statistics.

That is the case even though the BEA has very detailed supply and use tables at its disposal. The BEA states that the classification based on the North American Industry Classification System (NAICS) used in the framework includes about 5,000 categories of goods and services. This is almost twice the number of individual goods and services that the detailed German Classification of Products by Activity (CPA) provides (2,643 individual categories). That being said, staff in the German statistical office state that the German classification is very detailed in an international comparison.

From these around 5,000 categories, the BEA selected more than 200 goods and services categories for their preliminary estimates of the digital economy.

The categories the BEA had to leave out of its estimate because of a lack of detailed data on the digital component of these goods and services were

- Structures
- IoT infrastructure
- P2P e-commerce
- Free digital media revenues.

IoT goods like smart fridges were left out of the final estimate because the digital value of a smart fridge was deemed to be relatively small. After all, the main purpose of this good is to keep food fresh, which cannot be classified as “digital”. Industrial IoT devices were not specifically mentioned. Here the same conditions would apply.

While the BEA states that it collects data on the value of P2P activities such as ride dispatching and accommodation, this category was left out of the final estimate because it was not possible to clearly identify what the additional value of these transactions was in monetary terms.

Also, the advertising revenues of free digital media were left out of the estimate, because again it was not possible to identify which portion of the advertising revenue was associated with these websites.

For a detailed list of the goods and services used in the BEA framework, please refer to the Appendix provided by Barefoot et al. (2018).

The collection of data used in the BEA’s estimate is, nevertheless, an impressive accomplishment, because it extends the framework beyond the existing core of ICT goods and services. What is especially striking is that it captures the use of data for e-commerce transactions as the wholesale or retail trade margin on “digitally ordered” goods and services sold over the Internet or through some other electronic market for both B2B wholesale and B2C retail transactions. That means the BEA is already collecting quality data that differentiate between online sales and classic distribution channels and the different trade margins associated with them. The NAICS classification table lists e-tailers, Internet retail sales and Internet auctions as examples of separate classifications.

Further, data on digital media are captured, including streaming services, Internet publishing and Internet broadcasting. Consumer fees are included, but not income generated via advertising. It is also worth noting that the BEA includes data on taxable computer education programs.

The BEA used a binary structure in its classification of goods and services. That means that these were either classified as part of the digital economy or not part of the digital economy.

To generate the nominal value added, output, compensation of employees and employment of the digital economy the BEA used the supply table, adding up the digital goods and services provided by each economic sector. Value added for the digital economy is derived from the relationship between the industry output for the digital economy and total industry output. This assumes that digital goods and services have the same intermediate input ratio as other industry outputs. This is a simplified assumption, as detailed data on the distribution of value added across different goods and services in each sector will likely not be available. Employment and compensation of employees were calculated based on the same assumptions. Since the BEA classifies its results as a first estimate of the digital economy, this approach is the only one at hand until more detailed data become available.

3 Adoption of the BEA framework and first estimates for Germany

Since the OECD released the general framework for the digital economy (Ahmad & Ribarsky, 2018) a total of three national authorities have released first estimates for the national digital economy: Statistics New Zealand (Millar & Grant, 2019) in December 2019, Statistics Canada (2019) in May 2019 and the U.S. Bureau of Economic Analysis (Barefoot et al., 2018) in March 2018. Since the BEA estimate was by far the earliest to be released, it acted as a reference paper for the other statistical offices alongside the OECD framework presented by Nadim & Ribarsky (2017). Since there is great interest in the size of the digital economy in Germany, we adapted the framework used by the BEA to German statistical data as a starting point for our research.

To adapt the BEA framework to German data, we first needed to identify the goods and services in the detailed Classification of Products by Activity (CPA) used in the German data provided by the Federal Statistical Office (Destatis). As a second step, we used the output from the selected goods and services based on detailed data of the supply table to identify the share of digital goods and services for each economic sector. The third step was similar to the BEA framework, namely to derive the value added of the digital economy in Germany based on the percentage shares calculated for each sector. We are aware that using the value added shares of the respective industry for each good provided by the sector is a simplifying assumption and that, as a result, our estimates may not be of high statistical quality. However, the aim was to create a starting point for future research on the digital economy in Germany and to illustrate what data may be needed to get a clearer picture of the digital economy's value added in Germany.

3.1 Selecting digital goods and services

We used the list provided in the Appendix to Barefoot et al. (2018) to define the digital goods and services in the detailed CPA used in Germany. Since the NAICS classification cannot be transferred one-to-one to the CPA classification, we used the OECD's definition of ICT goods and services (2011) when in doubt as to whether the respective CPA category aligns with the BEA definition.

Based on this approach, 117 out of 2,634 goods and services can be identified as “digital”. The results are very close to the existing definition of the ICT sector in Germany. More specifically, digital goods and services consist mainly of goods and services from CPA classes

- 26.1 to 26.4: Electronic components, computers, communication equipment and consumer electronics
- 26.8: Magnetic and optical media
- 58.2: Software publishing services
- 60 to 62: Programming and broadcasting, telecommunications services, computer programming, consultancy and related services
- 63.1: Data processing, hosting and related services, web portals,

all of which have been classified as digital. In addition, there are selected goods from classes

- 18.2: Reproduction services of recorded media
- 26.7: Optical instruments and photographic equipment
- 27.3: Wiring and wiring devices
- 27.9: Other electrical equipment
- 28.2: Other general purpose machinery
- 33: Repair and installation services of machinery and equipment
- 95.1: Repair services of computers and communication equipment.

Table 5-1 in the Annex provides a detailed overview of the selected goods and services.

We were, however, unable to clearly identify the following digital goods and services described by the BEA in the detailed German CPA data, as data for them are only available together with non-digital goods in the German CPA definition:

- Production of video content for streaming services
- Computer and ICT adult education courses
- E-commerce.

The **production of video content for streaming services** could not be clearly identified. While the current CPA framework distinguishes between motion pictures, advertising video and other television programme production services, data on the number of services supplied are only available for the aggregate of CPA code 59.11.1. The available classification provides no insight as to whether these services were used for video content that was produced for classic distribution channels or for streaming services. A movie as the final product in the CPA subclass 59.11.2 distinguishes between TV, cinematic, disk/tape or download use. We would expect to find streaming services in category 59.11.24, Films and other video downloads. The name of the CPA subclass may nowadays be slightly misleading, since streaming services no longer as a rule download the entire movie. Where statistical data for streaming services are available, we would expect to find them in subcategory 59.11.24. Unfortunately, only data for the entire category 59.11.2 were available to us.

CPA class 59.12 includes post-production services for movies and videos like audio-visual editing or animation services, which we find interesting as regards a further analysis of digital value added in the economy. This is especially true when considering the concept described in section 1.2. We expect these services to include a significant share of data-driven value added. We understand the concept of the BEA such that these services should be treated in the same way as the production of video content itself (CPA class 59.11.1). Thus, they would only be included if the video content was intended for streaming.

It would also not be possible to select **Computer and ICT adult education courses** without including huge parts of non-digital services. We expect this to be part of CPA code 85.59.20000 Adult vocational training, which includes all training courses in a professional context. We expect the lack of this category to be a minor detail compared to the other data gaps when considering the GDP created by these activities.

Possibly the biggest data gap will likely be the lack of data covering **e-commerce** activities. Statistics in the German supply and use tables distinguish between goods traded in wholesale and retail trade. There are 123 subcategories for retail trade and 131 subcategories for wholesale trade and trade brokerage. In contrast to the NAICS classification, which has a category for wholesale trade in electronic markets, electronic auctions and electronic shopping, e-commerce transactions could not be identified in the statistical data based on the classification. Therefore, we were not able to create a precise measure for value added in e-commerce that is comparable to the numbers presented by the BEA.

3.2 First estimates for Germany

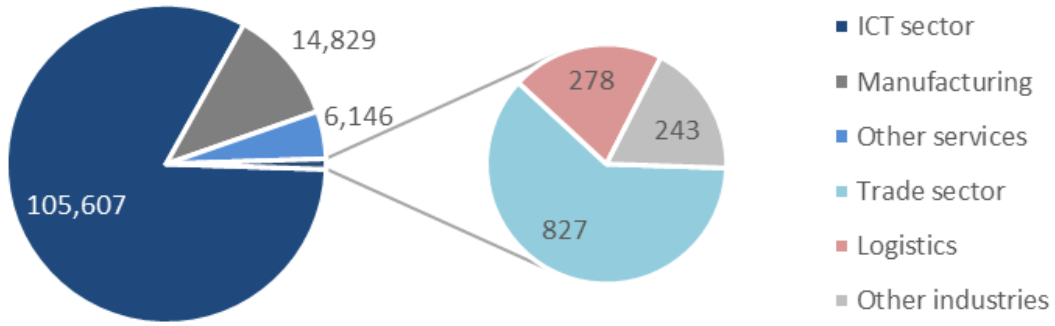
Based on the selected goods and services, a total gross output (at basic prices) of 257.7 billion Euros was assigned to the German digital economy in 2016. This corresponds to around 4.5 per cent of the total gross output of the German economy.

Based on the simplified assumption of constant value-added shares for digital and non-digital goods for each economic sector, this would correspond to a total value added of around 128 billion Euros, or 4.5 per cent of the total economic gross value added in 2016. The real numbers for the digital economy might have been higher if it had been possible to properly take account of e-commerce and other digital goods and services.

Figure 3-1 shows the broad distribution of the digital economy across broad economic sectors. When the digital economy is defined as shown above, ICT services account for around 83 per cent of the digital economy, while the manufacturing sector accounts for around 11 per cent. This share is, of course, mostly due to the ICT hardware sector. Other services account for around 5 per cent of the digital economy. Since it was not possible to take e-commerce transactions into account, the share of the retail trade sector is relatively small. The 827 million Euros account for only around 0.3 per cent of the total value added of the retail and wholesale sector in Germany.

Figure 3-1: Distribution of digital value added in Germany by broad economic sectors

First estimates without missing categories (in million Euros)



Source: authors' calculations based on data provided by Destatis

Estimating missing categories of digital goods and services

Because of the lack of official statistical data for some of the digital services mentioned in section 3.1, the first estimate for the digital economy in Germany based on the BEA definition underestimates the digital value added of the German economy. To get a fuller picture of the digital value added we tried to estimate the values which are missing from the official data by combining official data for the available aggregate services with external data from other sources outside the SNA. The results must be regarded as experimental data, since the methodology used to create them is not identical to the procedures used by statistical offices. They should, however, be helpful in roughly quantifying the scope of digital value added created by those economic activities.

To quantify the share of the production of video content for streaming services we considered turnover on the video market in Germany as a main indicator of the share of production for streaming purposes. Some of the main figures used in this calculation are brought together from different sources by the German Federal Statistical Office's Film, TV and Radio Division Report (Destatis, 2019). Considering turnover in the German home video market in 2016, video on demand accounts for 488 million Euros out of a total 1.772 million Euros. In addition, turnover for cinemas was listed at 1.021 million Euros. Turnover for the private TV sector was around 10 billion Euros, with public service broadcasting listing a similar income. Films or series account for one third of total broadcasting time when considering TV channels with the highest market shares. Recent data for the ZDF – the TV station with one of the biggest market shares in Germany – lists the budget for movies and series in 2020 at around 400 million Euros (ZDF, 2020). Assuming that this number is representative for other TV stations, the budget for movies and series on German TV could be around 3 to 4 billion Euros. This would mean that the share of video content produced for streaming services would be around 7 to 8 per cent. Using these rough assumptions as a basis for further calculations, around 300 million Euros of additional digital value added could be assigned to the media services sector.

To estimate the share of computer and ICT adult education courses of total adult education courses, we used data provided by the German Federal Statistical Office (Destatis, 2017) on adult education. The report includes two possible sources of data: the share of people taking courses in the category Qualifications for Working Life/IT/Organization/Management at the adult education level (*Volkshochschule*) and the share of those taking the examination to qualify as a Data Processing Specialist (*Fachkraft für Datenverarbeitung*). In 2016, around 5.6 per cent of all those taking part in courses at the adult education level took courses in IT/Organization/Management. However, these courses cover a much wider range of topics than just IT skills. This 5.6 per cent can, therefore, be regarded as the upper limit for the share of adult education ICT courses. By contrast, only around 0.5 per cent of the examinations were part of the audit group for data processing specialists. This number could serve as a lower estimate for the share of adult education computer and ICT courses out of total adult education courses. Since ICT training is becoming more and more important outside of classic ICT jobs, we expect a reasonable value for its share to be around 1 per cent of adult education services. As mentioned in section 3.1, the effects on the total value added of the digital economy are minimal. Using the 1 per cent estimate, only 97 million Euros of additional digital value added are included.

E-commerce is the service category that, if left out of our estimate, would have the biggest effect in reducing the reported share of digital value added in the economy. While no product classification for e-commerce is yet available, data based on the Federal Statistical Office's report on the use of ICT in firms (*Nutzung von Informations- und Kommunikationstechnologien (IKT) in Unternehmen*) (Destatis, 2020) at least provides data on an aggregate level for the share of turnover from websites and applications. We used the share of turnover from websites and applications and thus left out electronic data interchange (EDI) sales. We expect EDI to only represent a change in the final execution of the ordering process. Business deals are mostly concluded using existing channels, such as personal

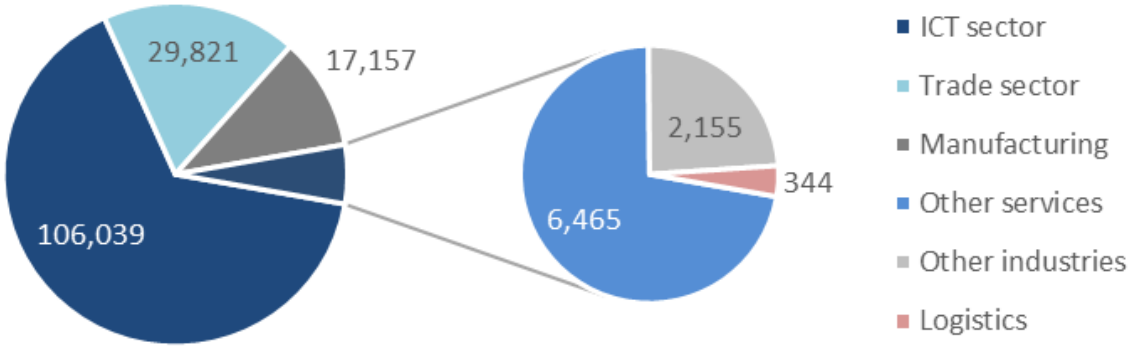
negotiations. EDI systems only organize the time and amount of the distribution. In 2016 around 12 per cent of sales in the German economy were made using websites or apps as their distribution channel. While the share of online sales is not reported for most individual economic sectors, wholesale and retail trade is listed at 13 per cent. Since around 90 per cent of trade services are supplied by the wholesale and retail trade sector, the share of digital turnover in the trade sector dominates. To calculate our first rough estimate of the value added through e-commerce we used 13 per cent for the wholesale and retail trade sector and 12 per cent for other economic sectors.

Using this estimate, around 33.6 billion Euros of digital value added through e-commerce would be registered for 2016. This number should only be seen as a first, rough estimate, since no exact numbers are available for most non-retail economic sectors. Also, the trade margin for e-commerce transactions is likely different than for classic transactions throughout the outputs of the different economic sectors.

As a result, the estimate for total digital value added in Germany increases to around 162 billion Euros, or 5.7 per cent of GDP. Figure 3-2 shows the distribution of digital value added across broad economic sectors, including the estimated values described in the above. The ICT sector is still the biggest contributor in terms of digital value added, accounting for around 65 per cent of the total contribution. The biggest change can be seen in the strong increase in digital value added in the trade sector. At 29.8 billion Euros, it amounts to around 18 per cent of digital value added in Germany.

Figure 3-2: Estimate of digital value added in Germany by broad economic sectors

First results including broad estimates for missing categories (in million Euros)



Source: authors' calculations based on data provided by Destatis

4 Interpretation and comparison

One key result of the calculations reported in section 3.2 is that the share of digital value added based on the BEA concept in Germany (5.7 per cent of gross value added) is significantly lower than that in the United States (8.2 per cent of gross value added). More importantly, however, this difference is due to the specificity of the measurement concept. The definition of digital products is very ICT focused. Many forms of digitalization at the product level are not included. Many machines and systems contain digital components that enable data-driven functions and services. Therefore, especially in Germany with its high industrial share of gross value added, using the BEA method might underestimate the degree of digitalization. The focus on ICT goods and services becomes clear when the BEA approach is compared with a self-assessment company survey of the degree of digitization of products and services.

Products with digital components

In surveys conducted by the IW-Zukunftspanel, companies from the business sector evaluated their turnover structure with regard to the degree of digitalization of their products and services. They divided their turnover into three categories, namely

- Digital products
- Products with digital components
- Non-digital products.

In the case of mixed products, the companies estimated the digital share of the product. In addition, they indicated what the amount of sales of the product would be if they did not have these digital components.

The IW-Zukunftspanel survey shows that in 2020 non-digital products accounted for just under 68 per cent of all sales and digital products for 22.5 per cent (Table 4-1). The digital share includes 9.8 percentage points from sales of mixed products. Measured in terms of value added, the digital share in the business sector is slightly lower (17.6 per cent) than the corresponding share of sales. This is due to the higher vertical integration of the production of digital products and services. The manufacturers of digital products therefore purchase more intermediate inputs per output.

Table 4-1: Survey results – digital output in 2020

Digital share of sales in the German business sector (in %)

Digital products	12.7
Mixed products	19.6
of which digital	9.8
of which non-digital	9.8
Non-digital products	67.7
Sum of digital outputs	22.5

Source: IW Zukunftspanel (2020)

The decisive factor in this finding, however, is the big difference between the value-added share determined using the BEA approach (5.7 per cent) and the corresponding share calculated based on the survey. This is not only due to the fact that the survey results also take mixed products into account. Even when only exclusively digital products are considered, the sales shares of 12.7 per cent are much higher than the shares based on the production values under the BEA approach (5.6 per cent).

IW-Zukunftspanel – IW Company Panel Survey on Structural Change

Since 2005 IW Consult, a subsidiary of the German Economic Institute, has regularly undertaken a large-scale company panel survey on structural change (IW-Zukunftspanel). The main focus of this survey is on the analysis of trends, indicators and relevant determinants of company success, including indicators for innovation, research and development, digitalization, globalization, networking and market conditions. Each survey by the IW-Zukunftspanel, which is conducted up to three times a year, gathers information on around 1,500 companies from all economic sectors (excluding the agricultural, banking, insurance, accommodation and food service sectors). In 2020 the survey was extended to the economic sectors retail, hospitality and tourism. About 2000 companies answered the questionnaire.

A reason for the differences is the measurement concept. The BEA approach is strongly influenced by the ICT definition of goods and services. This excludes many product and industry groups as sources of digital value added. Companies evaluate their product offers differently and have much higher digital shares. This is evident in the comparison in Table 4-2. Under the BEA approach, economic sectors such as the metal industry, the chemicals industry, machinery and equipment, logistics and most other services providers hardly have any digital value-added shares. This obviously does not correspond to reality. Many of these companies, especially in the banking or logistics sectors, have digitalized their product ranges to some extent. However, there are also similarities between the BEA approach and companies' self-assessments. In the manufacturing sector, the electrical industry has above-average digital shares under both approaches. The same applies to the ICT sector.

At this point, it is deliberately left open whether the companies' own estimates are correct and plausible in terms of the amount of digital value added. However, the results give rise to doubts as to whether the BEA approach is a reasonable way of measuring the digital nature of the products. At least the working hypothesis – that the BEA method is underestimating the digital value and therefore needs to be modified and extended – is justifiable.

Table 4-2: Comparing results on a sectoral level

Unweighted average results

	Survey results digital output share	BEA approach digital value added share	
		Without estimates	With estimates
Agriculture	–	0.0	0.0
Mining	–	0.2	0.4
Manufacturing	**12.7**	**1.8**	**2.2**
of which chemicals, pharmaceutical, rubber and plastic products	9.7	0.1	0.6
of which basic metals and fabricated metal products	8.6	0.2	0.4
of which machinery and equipment	14.3	0.6	0.9
of which computer, electronic and optical products, electrical equipment	42.8	15.0	15.4
Services	**24.3**	**6.7**	**8.4**
of which wholesale trade	12.9	0.3	12.6
of which transportation and storage	23.9	0.3	0.3
of which retail trade, accommodation and food services	17.0	0.2	8.7
of which telecommunications, IT and other information services	67.6	53.5	53.6
Total	**22.5**	**4.5**	**5.6**

Source: IW-Zukunftspanel (2020), authors' calculations based on data provided by Destatis

Measuring the degree of digitalization of the processes generating the value added

The theoretical framework for measuring the digital economy presented by the OECD is broader than first estimates presented by the BEA and leaves much room for development. One possible approach is the operationalization of data-driven business models (see Figure 1-2) with the help of empirical data. The model presented has two dimensions: value proposition and value added.

The value proposition of economic sectors can be measured by the degree of digitization of the product ranges, for example on the basis of the self-assessments of companies in the German business sector (Table 4-2).

The digital value added on the ordinate could be measured by the degree of digitalization of the processes generating the value added. One possibility here would be to use companies' digital maturity levels as a benchmark. This requires a maturity model that evaluates the processes and ranks them in ascending order according to their degree of digitalization. A recent version of such a maturity model was developed by the Institute for Industrial Management (FIR) and the IW Consult (Lichtblau et al., 2020) on behalf of the Federal Ministry for Economic Affairs and Energy (BMWi) within the project *Measurement of the Digitalisation of the German Economy*. These data allow the two axes of the business model as shown in Figure 1-2 to be described empirically. Based on their digital maturity, companies can be assigned into three main groups:

- Hardly digital: These companies don not use data or collect most of their data manually. Due to missing basic digital expertise, advanced methods of process digitization cannot be used.
- Weakly digital: These Companies have already taken the first major steps in process digitization. These companies have digital inventory data and a basic stock of digital process data. However digital integration of objects (resources, equipment, processes) is still below average. Process data usually cannot be provided in real time. No or only very few processes are mapped in a data-based enterprise model.
- highly digital: These companies have reached an advanced status in process digitization. Process data is available in digital form at these companies. The exchange of information is no longer analogue, but digital and already at least partially automated in real time via corresponding information systems. Companies are able to create integrated process models for their company and to control the processes within these virtual models. This visualization capability and its use for data-based process control is the decisive characteristic for reaching this level of maturity.

One problem with this measurement concept is that no official data are yet available. It was still possible to describe the value proposition dimension using the data from the BEA approach presented in the above. No official statistics for any of the OECD member states currently contain data suitable for mapping the value-added dimension. In principle, this problem might be solved by means of company surveys, although they have the disadvantage that they only represent samples and are not available in an internationally comparable form. In the European Union, the regular ICT survey could be used for this purpose. The survey concept would have to be adapted accordingly.

Figure 4-1 shows the distribution of the results for Germany. The dimension "value proposition" is represented by the share of digital sales of digital products and services of the companies' total sales. The dimension "value added" is measured by the level of maturity of the companies' processes. The model differentiates between seven levels of maturity. The distribution of the maturity levels across the German business sector is as follows:

- 27 per cent are on the lowest maturity level 0 (hardly digital)
- 33 per cent have reached maturity level 1 (computerized)
- 17 per cent have reached maturity level 2 (connectivity)
- 18 per cent have reached maturity level 3 (visibility)
- 3 per cent have reached maturity level 4 (comprehension)
- 1 per cent have reached maturity level 5 or 6 (forecast and decision)

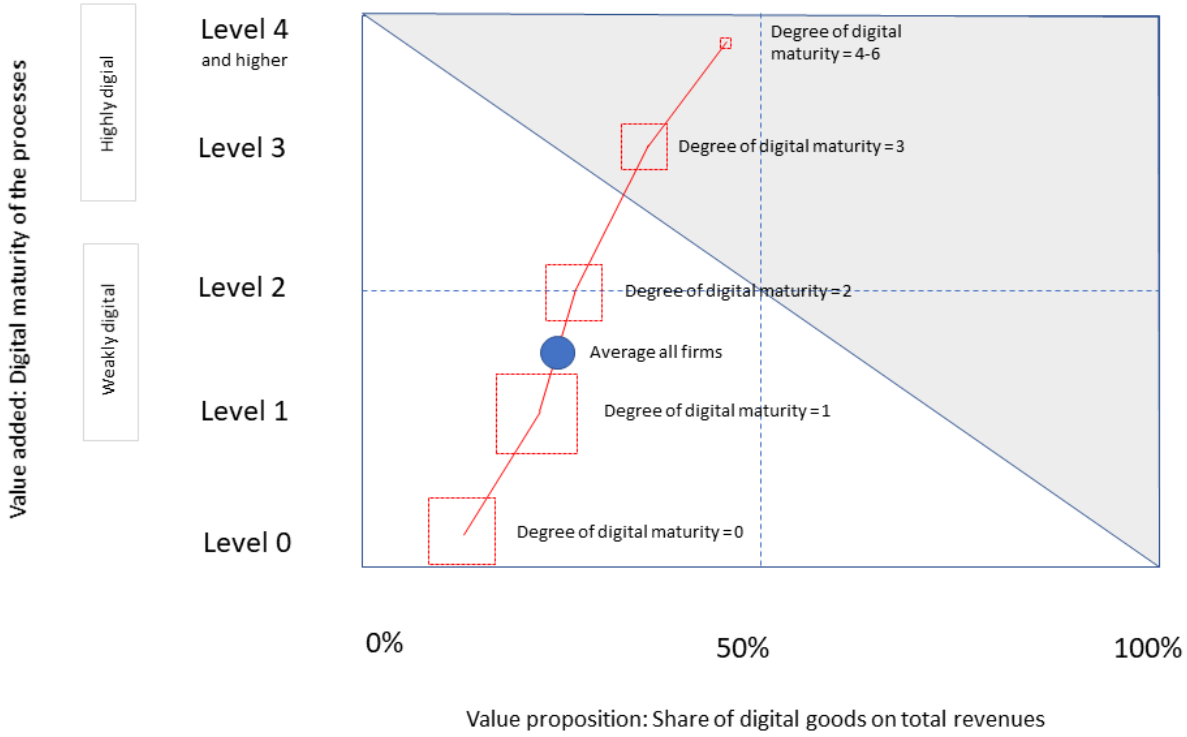
Most companies (77 per cent) have not reached the last four maturity levels and are thus not yet highly digitalized. In manufacturing, the share of highly digitalized companies (maturity level 3 or higher) is 22.8 per cent, compared to 24.5 per cent for the service sector. There is also a clear trend when one

considers company size: for companies with more than 250 employees, the share of highly digitalized companies is 47.1 per cent; only 21.9 per cent of small companies are digitalized.

More importantly, the share of conversion with digital products increases the higher the degree of maturity. It rises from 12.8 per cent among hardly digital companies on maturity level 0 to 43.5 per cent on maturity level 4 or higher. Based on the concept for differentiating between digital business models, only companies on a maturity levels of at least 3 meet these conditions.

Figure 4-1: Digitalization of business models in Germany

Business sector



The size of the boxes is equivalent to the share of companies in the German business sector that have reached this level of digital maturity

Source: IW-Zukunftspanel (2020), Lichtblau et al. (2020), authors' illustration

Conclusion

In conclusion, we find that the BEA approach quantifies some important economic activities, like e-commerce and online streaming, and adds them to the economic discussion. With its strong focus on ICT activities, it resembles an extended account of the ICT-sector defined in the OCED Guide to Measuring the Information Society (OECD, 2011). The ICT Hardware and ICT Services that enable the use of digital Services and processes are used as a central measure to valuate the digital economy of a country. These core sectors are extended by goods and services that have been drastically disrupted

through digitalization. E-commerce and online-streaming are services that would not be possible without the existence of the digital transfer of data through the internet. The digital economy thus is based around a binary classification of products and services that are either enablers of digitalization or have an output that could not be possible without digitalization.

This classification used by the BEA however leads to a concentration of the digital value added in certain economic sectors. The digital value-added shares of some products, services and especially processes are left out of the digital economy. It can be argued that parts of the digitalization of processes are already accounted for by the ICT core sectors as input factors. At the national level, however, this measurement method creates huge discrepancies between countries that are users of ICT (like Germany and other countries with a focus on manufacturing) and the producers of ICT goods and services (like Malaysia or the Philippines, that are huge contract manufacturer of semiconductor products).

From our point of view measuring digitalization based on ICT enablers is only a second-best solution. It should only be used if the internal digitalization of products and processes cannot directly be measured. With the statistical data available now this seems to be the case. There is no official survey data available that measures the digitalization of processes in the economy. The process dimension, however, is very important, as it effects all economic sectors. To get a clear picture of digitalization as we understand it, this lack of data must be addressed in official surveys.

5 Annex

Table 5-1: Digital goods and services

CPA 2010

CPA code	German	English
182020000	Vervielfältigung von bespielten Bildträgern	Reproduction services of video recording
182030000	Vervielfältigung von bespielten Datenträgern	Reproduction services of software
182999999	Vervielfältigung von sonstigen Medien	Reproduction of other media
261110000	Glühkathoden-, Kaltkathoden- und Fotokathoden-Elektronenröhren	Thermionic, cold cathode or photo-cathode valves and tubes, including cathode ray tubes
261120000	Dioden, Transistoren u.a. Halbleiterbauelemente; Leuchtdioden; gefasste oder montierte piezoelektrische Kristalle	Diodes and transistors, including semiconductor devices, light-emitting diodes, mounted piezo-electric crystals, and parts thereof
261130000	Prozessoren und Steuer- und Kontrollschaltungen, auch in Verbindung mit Speichern, Wandlern, Logikschaltungen, Verstärkern, Uhren und Taktgeberschaltungen oder anderen Schaltungen	Electronic integrated circuits
261140000	Teile für elektronische Bauelemente, a.n.g.	Parts of electronic valves and tubes and of other electronic components n.e.c.
261191000	Mit der Herstellung elektronischer integrierter Schaltungen verbundene Dienstleistungen	Services connected with manufacturing of electronic integrated circuits
261210000	Gedruckte Schaltungen	Loaded printed circuits
261220000	Ton-, Video-, Netzwerk- und ähnliche Karten für Geräte der automatischen Datenverarbeitung	Sound, video, network and similar cards for automatic data processing machines
261230000	Intelligente Karten (smart cards)	Smart cards
261291000	Mit der Herstellung gedruckter Schaltungen verbundene Dienstleistungen	Services connected with printing of circuits
261999999	Herstellung sonstiger elektronischer Bauelemente und Leiterplatten	Manufacture of other electronic components and printed circuit boards
262011000	Mobile Computer mit 10 kg oder weniger Gewicht wie Laptops, Notebooks; Personal Digital Assistants (PDA) u.ä. Computer	Portable automatic data processing machines weighing 10 kg or less, such as laptop and notebook computers; personal digital assistants and similar computers
262012000	Zahlungsterminals, Bankautomaten und ähnliche Geräte, die an ein Datenverarbeitungsgerät oder ein Datennetz angeschlossen werden können	Point-of-sale terminals, ATMs and similar machines capable of being connected to a data processing machine or network
262013000	Andere digitale automatische Datenverarbeitungsmaschinen, die in einem gemeinsamen Gehäuse mindestens eine Zentraleinheit sowie, auch kombiniert, eine Eingabe- und eine Ausgabeeinheit enthalten	Digital automatic data processing machines, comprising in the same housing at least a central processing unit and an input and an output unit, whether or not combined

262014000	Andere digitale Datenverarbeitungsmaschinen in Form von Systemen	Digital automatic data processing machines presented in the form of systems
262015000	Andere digitale Verarbeitungseinheiten, auch wenn sie eine oder zwei der folgenden Einheitenarten in einem gemeinsamen Gehäuse umfassen: Speichereinheiten, Eingabeeinheiten, Ausgabeeinheiten	Other digital automatic data processing machines, whether or not containing in the same housing one or two of the following types of units: storage units, input units, output units
262016400	Drucker, Fernkopiergeräte u. a. Maschinen, die an eine ADV-Anlage o. ein Netzwerk angeschlossen werden können, oh. Maschinen zum Drucken mittels Druckformen u. Maschinen, die mind. 2 der Funktionen Drucken, Kopieren od. Übertragen v. Fernkopien ausführen	Printers, fax machines and other machines that can be connected to an ADP system or a network, excluding machines for printing by means of printing forms and machines that perform at least two of the functions of printing, copying or transmitting faxes
262016500	Tastaturen	Keyboards
262016600	Andere Ein- oder Ausgabeeinheiten, a.n.g. (z.B. Mäuse, Scanner und Plotter)	Other input or output units n.e.c. (e.g. mice, scanners and plotters)
262017000	Bildschirme und Bildwerfer, hauptsächlich zur Verwendung in einem System der automatischen Datenverarbeitung	Monitors and projectors, principally those used in an automatic data processing system
262018000	Geräte, die wenigstens zwei der folgenden Aufgaben ausführen: Drucken, Abtasten, Kopieren, Fernkopieren und die an eine automatische Datenverarbeitungsmachine oder ein Netzwerk angeschlossen werden können	Units performing two or more of the following functions: printing, scanning, copying, faxing
262021000	Speichereinheiten	Storage units
262022000	Halbleiter-Datenspeichervorrichtungen, nicht flüchtig, ohne Aufzeichnung	Solid-state non-volatile storage devices
262030000	Andere Einheiten von automatischen Datenverarbeitungsmaschinen	Other units of automatic data processing machines
262040000	Teile und Zubehör für automatische Datenverarbeitungsmaschinen	Parts and accessories of computing machines
262090000	Installation und Veredlung von Computermodulen	Computers and peripheral equipment manufacturing services; sub-contracted operations as part of manufacturing of computers and peripheral equipment
262999999	Herstellung sonstiger Datenverarbeitungsgeräte und peripheren Geräten	Manufacture of other computers and peripheral equipment
263011000	Sendegeräte mit eingebautem Empfangsgerät	Transmission apparatus incorporating reception apparatus
263012000	Sendegeräte ohne eingebautes Empfangsgerät	Transmission apparatus not incorporating reception apparatus
263013000	Fernsehkameras	Television cameras
263021000	Fernsprechapparate für die drahtgebundene Fernsprechtechnik mit schnurlosem Hörer	Line telephone sets with cordless handsets
263022000	Funkfernsprechgeräte für zellulare und andere drahtlose Mobilfunknetze (Mobiltelefone, sog. Handys)	Telephones for cellular networks or for other wireless networks
263023100	Basisstationen	Base stations
263023200	Geräte zum Empfangen, Konvertieren und Senden oder Regenerieren von Tönen, Bildern oder anderen Daten, einschl. Geräte für die Vermittlung (switching) und Wegewahl (routing)	Equipment for receiving, converting and transmitting or regenerating sound, images or other data, including switching and routing equipment
263023300	Fernsprechapparate (ausgenommen Fernsprechapparate für die drahtgebundene Fernsprechtechnik mit schnurlosem Hörer sowie Telefone für zellulare Netzwerke oder für andere drahtlose Netzwerke); Videofone	Telephones (excluding telephones for line telephony with cordless handsets and telephones for cellular networks or for other wireless networks); videophones
263023400	Tragbare Peronenruf-, -warn- oder -suchemfpänger	Portable paging, warning or search receivers
263023700	Andere Sende- o. Empfangsgeräte f. Töne, Bilder o.a. Daten, einschl. Apparate f. die Kommunik. in einem drahtgebund. o. -losen Netzwerk (wie ein lokales Netwerk (LAN) o. ein Weitverkehrsnetzwerk (WAN)), (z.B. Gegensprech- und Konferenzanlagen)	Other transmitting or receiving equipment for sound, images or other data, including equipment for communication in a wired or a wireless network (such as a local area network (LAN) or wide area network (WAN)), (e.g. intercom and conference equipment)

263030000	Teile für Geräte der Fernsprech- und Telegrafentechnik	Parts of electrical telephonic or telegraphic apparatus
263040100	Teleskop- und Stabantennen für Taschen-, Koffer- und Kraftfahrzeugempfangsgeräte	Telescopic and rod antennas for pocket, suitcase and motor vehicle receivers
263040300	Außenantennen für Rundfunk- und Fernsehempfang	Outdoor antennas for radio and television reception
263040400	Antennen und Antennenreflektoren für Fernsprecher, Sende- oder Empfangsgeräte	Antennas and antenna reflectors for telephones, transmitting or receiving devices
263040500	Innenantennen für Rundfunk- und Fernsehempfang (einschl. Geräteeinbauantennen)	Indoor antennas for radio and television reception (incl. built-in antennas)
263040600	Andere Antennen und Teile für Antennen	Other antennas and parts for antennas
263040700	Andere Teile für Sende- oder Empfangsgeräte für den Funksprech-, Funktelegrafieverkehr, Rundfunk oder Fernsehen sowie für Funkmess-, -navigations- und -fernsteuerungsgeräte	Other parts of transmitting or receiving equipment for radiotelephony, radio-telegraphy, radio-broadcasting or television transmitters or receivers and radio measurement, navigation or remote control equipment
263050000	Einbruchs- oder Diebstahlalarmgeräte, Feuermelder u.ä. Geräte (Hör- und Sichtsignalgeräte)	Burglar or fire alarms and similar apparatus
263060000	Teile für Einbruchs- oder Diebstahlalarmgeräte, Feuermelder und ähnliche Geräte	Parts of burglar or fire alarms and similar apparatus
263999999	Herstellung sonstiger Geräte und Einrichtungen der Telekommunikationstechnik	Manufacture of other appliances and equipment for telecommunications
264011000	Rundfunkempfangsgeräte (ohne solche für Kraftfahrzeuge), auch kombiniert mit Tonaufnahme- oder Tonwiedergabegeräten	Radio broadcast receivers (except for cars) capable of operating without an external source of power
264012000	Rundfunkempfangsgeräte für Kraftfahrzeuge, die nur mit externer Stromquelle betrieben werden können, auch kombiniert mit Tonaufnahme- oder Tonwiedergabegeräten	Radio broadcast receivers not capable of operating without an external source of power
264020000	Fernsehempfangsgeräte, auch mit eingebautem Hörfunkempfangsgerät oder Tonaufzeichnungsgerät, Bildaufzeichnungsgerät oder Bildwiedergabegerät	Television receivers, whether or not combined with radio-broadcast receivers or sound or video recording or reproduction apparatus
264031000	Plattenspieler, Schallplatten-Musikautomaten, Kassetten-Tonbandabspielgeräte und andere Tonwiedergabegeräte, ohne eingebaute Tonaufnahmevorrichtung	Turntables, record players, cassette players and other sound reproducing apparatus without built-in sound recording device
264032000	Magnetbandgeräte und andere Tonaufnahmegeräte	Magnetic tape recorders and other sound recording apparatus
264033000	Videokameraaufnahmegeräte und andere Videogeräte zur Bild- und Tonaufzeichnung oder -wiedergabe, auch mit eingebautem Videotuner	Video camera recorders and other video equipment for image and sound recording or reproduction, whether or not incorporating a video tuner
264034000	Bildschirme und Bildwerfer, ohne eingebautes Fernsehfunkempfangsgerät und nicht hauptsächlich zur Verwendung in einem System der automatischen Datenverarbeitung bestimmt	Monitors and projectors, not incorporating television reception apparatus and not principally used in an automatic data processing system
264041000	Mikrofone und Haltevorrichtungen dafür	Microphones and stands thereof
264042000	Lautsprecher; Hörer, auch mit Mikrofon kombiniert	Loudspeakers; headphones, earphones and combined microphone/speaker sets
264043000	Elektrische Tonfrequenzverstärker; elektrische Tonverstärkereinrichtungen	Audio-frequency electric amplifiers; electric sound amplifier sets
264044000	Empfangsgeräte für den Funksprech- oder Funktelegrafieverkehr, a.n.g.	Reception apparatus for radiotelephony or radiotelegraphy n.e.c.
264051000	Teile für Geräte zur Bild- und Tonaufzeichnung oder -wiedergabe, Mikrofone, Lautsprecher, Hörer, Tonfrequenzverstärker und Tonverstärkereinrichtungen	Parts and accessories of sound and video equipment
264052000	Teile für Rundfunkempfänger und -sender	Parts of radio receivers and transmitters
264060000	Videospielgeräte (zur Verwendung mit einem Fernsehempfangsgerät oder mit eigenem Bildschirm) und andere Geschicklichkeits- oder Glücksspiele mit einer elektronischen Anzeigevorrichtung	Video game consoles (used with a television receiver or having a self-contained screen) and other games of skill or chance with an electronic display
264999999	Herstellung von sonstigen Unterhaltungselektronikgeräten	Manufacture of other entertainment electronics

267013000	Digitalkameras	Digital cameras
267015000	Filmkameras	Cinematographic cameras
268011000	Magnetische Datenträger, nicht bespielt, außer Karten mit einem Magnetstreifen	Magnetic media, not recorded, except cards with a magnetic stripe
268012000	Optische Datenträger, nicht bespielt	Optical media, not recorded
268013000	Andere Aufzeichnungsträger einschl. Matrizen und Mutterplatten für die Herstellung von Platten	Other recording media, including matrices and masters for the production of disks
268014000	Karten mit einem Magnetstreifen	Cards with a magnetic strip
268999999	Herstellung von sonstigen magnetischen und optischen Datenträgern	Manufacture of other magnetic and optical data carriers
273111000	Kabel aus einzeln umhüllten optischen Fasern für die Informationsübertragung	Optical fibre cables made up of individually sheathed fibres
273112000	Optische Fasern sowie Bündel und Kabel daraus (ganze Bündel von Lichtleitfasern in einer Umhüllung)	Optical fibres and optical fibre bundles; optical fibre cables (except those made up of individually sheathed fibres)
273212000	Koaxialkabel und andere koaxiale elektrische Leiter, auch mit Anschlussstücken versehen oder dafür vorbereitet, Daten- und Steuerkabel	Coaxial cable and other coaxial electric conductors
279070100	Elektrische Verkehrssignal-, -sicherungs-, -überwachungs- und -steuerungsgeräte für Schienenwege u.dgl.	Electrical traffic signalling, safety, monitoring and control equipment for railways and the like
279070300	Elektrische Verkehrssignal-, -sicherungs-, -überwachungs- und -steuerungsgeräte für Straßen, Binnenwasserstraßen, Parkplätze, Hafenanlagen u.ä.	Electrical traffic signalling, safety, monitoring and control equipment for roads, inland waterways, car parks, port installations, etc.
282312000	Elektronische Geräte im Taschenformat, zum Aufzeichnen, Wiedergeben und Anzeigen von Daten, mit Rechenfunktionen	Electronic calculators and pocket-size data recording, reproducing and displaying machines with calculating functions
331313000	Reparatur und Instandhaltung von optischen und fotografischen Geräten für gewerbliche Zwecke	Repair and maintenance services of professional optical instruments and photographic equipment
331319003	Reparatur und Instandhaltung 'von nachrichtentechnischen Geräten und Einrichtungen (z.B. Kommuikationssysteme, Netzwerke usw.)	Repair and maintenance of telecommunications equipment and installations (e.g. communication systems, networks etc.)
332042001	Installation von nachrichtentechnischen Geräten und Einrichtungen (z.B. Kommunikationssysteme, Netzwerke usw.)	Installation of telecommunication devices and equipment (e.g. communication systems, networks etc.)
332042004	Installation von gewerblichen Datenverarbeitungsgeräten und -einrichtungen	Installation of commercial data processing equipment and facilities
332042006	Installation von gewerblichen Ausrüstungen für Rundfunk, Fernsehen sowie Bild- und Tonaufzeichnung oder -wiedergabe	Installation of commercial equipment for radio, television and sound and video recording or reproduction
582100000	Verlegen von Computerspielen	Publishing services of computer games
582900000	Verlegen von sonstiger Software	Other software publishing services
582999999	sonstige DL beim Verlegen von Software	Other services for the publishing of software
601000020	DL von Hörfunkveranstaltern (Staat, Eigenverbrauch)	Services of radio broadcasters (state, own consumption)
601000060	DL von Hörfunkveranstaltern (Unternehmen, Eigenverbrauch)	Services of radio broadcasters (business, own consumption)
601999999	sonstige DL der Hörfunkveranstalter	Other services provided by radio broadcasters
602000020	DL von Fernsehveranstaltern (Staat, Eigenverbrauch)	Services of television broadcasters (government, own consumption)
602000060	DL von Fernsehveranstaltern (Unternehmen, Eigenverbrauch)	Services of television broadcasters (business, own consumption)
602001000	Kabelfernsehen	Cable television
602002000	Übertr. und Ausstrahlung von Fernsehsignalen	Transmission and broadcasting of television signals
602999999	sonstige DL der Fernsehveranstalter	Other services provided by broadcasters
611001000	DL in Zusammenhang mit leitungsgebundener Telekommunikation	Services in connection with wired telecommunications
611002000	Datendienste mittels terrestrischer Netze	Data services via terrestrial networks
611003000	Bereitstellung von Übertragungswegen (Mietleitungen)	Provision of transmission paths (leased lines)
611004000	Carrier-Geschäft (Intercooection)	Carrier business (Intercooection)

611999999	sonstige DL der leistungsgebundenen Telekommunikation	Other services of performance-based telecommunications
612001000	Mobiltelefondienst	Mobile phone service
612002000	Datendienste mittels Funk-Netze	Data services via radio networks
612999999	sonstige DL der drahtlosen Telekommunikation	Other wireless telecommunications services
613000000	DL in Zusammenhang mit Satellitentelekommunikation	Satellite telecommunications services
613999999	sonstige DL der Satellitentelekommunikation	Other satellite telecommunications services
619010000	DL von Internetserviceprovidern	Other telecommunications services
619090000	DL in der sonstigen Telekommunikation a. n. g.	Services in other telecommunications n.e.c.
619999999	sonstige DL der Telekommunikation	Other telecommunications services
620100000	Programmierungstätigkeiten	Computer programming services
620100999	selbsterstellte Computerprogramme	Self-developed computer programs
620200000	Erbringung von Beratungsleistungen auf dem Gebiet der Informationstechnologie	Computer consultancy services
620300000	Betrieb von Datenverarbeitungseinrichtungen für Dritte	Computer facilities management services
620900000	Erbringung von sonstigen Dienstleistungen der Informationstechnologie	Other information technology and computer services
620999999	sonstige DL bei der Erbringung von DL der Informationstechnologie	Other services in the supply of information technology services
631100000	Datenverarbeitung, Hosting und damit verbundene Tätigkeiten	Data processing, hosting and related services
631200000	DL von Webportalen	Web portal content
631999999	sonstige DL der Datenverarbeitung, Hosting und damit verbundene Tätigkeiten	Other services of data processing, hosting and related activities
951100000	Reparatur von Datenverarbeitungsgeräten und peripheren Geräten	Repair services of computers and peripheral equipment
951200000	Reparatur von Telekommunikationsgeräten	Repair services of communication equipment

Source: authors' classification based on Barefoot et al. (2018) and OECD (2011)

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