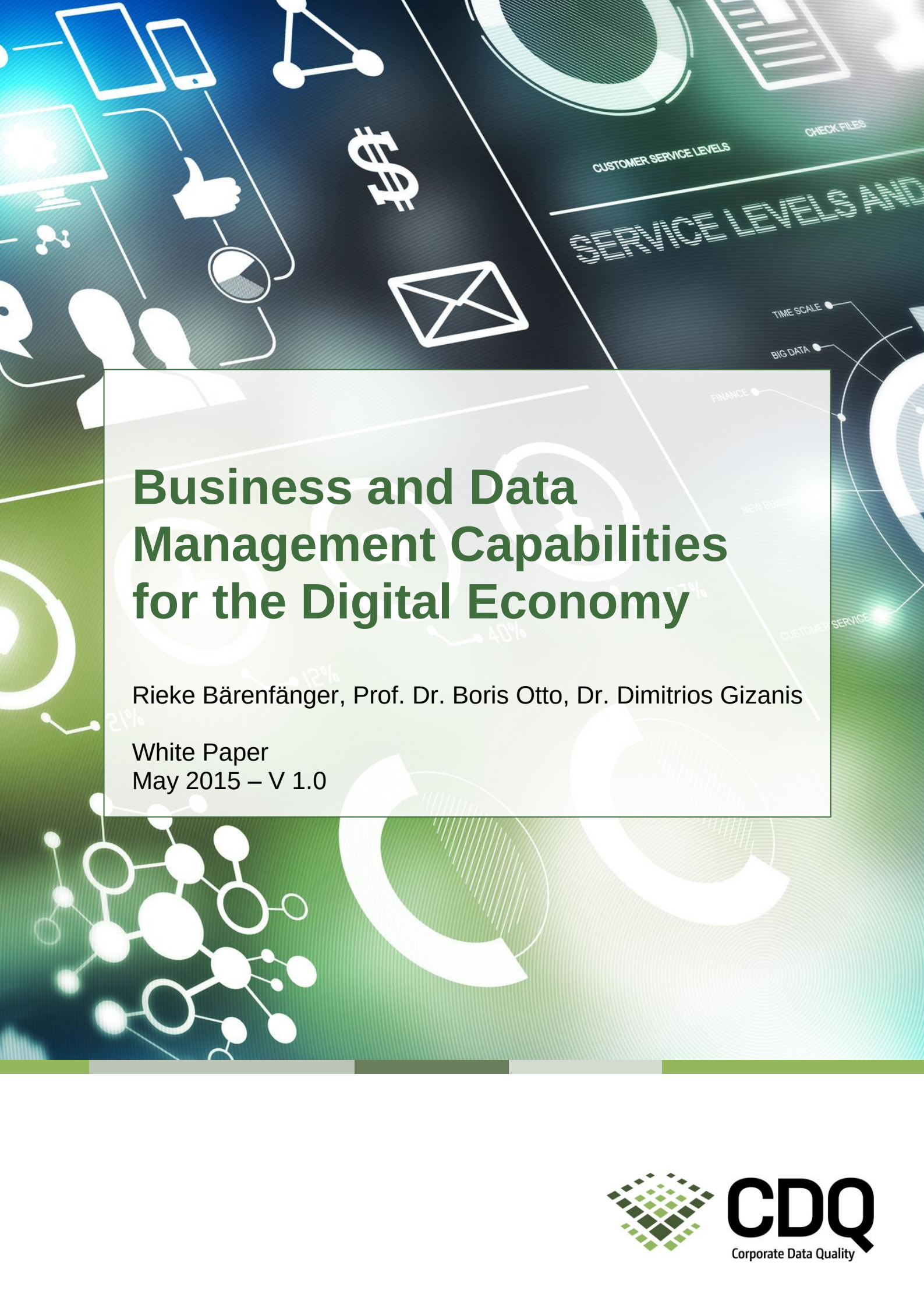




Business and Data Management Capabilities for the Digital Economy

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CDQ
Corporate Data Quality

About the CC CDQ

The Competence Center Corporate Data Quality (CC CDQ)¹ is a consortium research program in the field of corporate data management with a special focus on data quality management. The work of the CC CDQ is carried out in close collaboration with renowned European enterprises from various industries. It is driven by the requirements of innovative business models inspired by global market presence, technological innovation, worldwide business process harmonization, industrialized services, and customized operations. Success in these areas relies on consistent, accurate, complete, highly available, secure, and timely corporate data resources.

The CC CDQ comprises researchers from the University of St. Gallen (Institute of Information Management and Institute of Accounting, Control and Auditing) and the Fraunhofer Gesellschaft (Institute for Material Flow and Logistics, Fraunhofer IML). It is headed by Prof. Dr. Boris Otto (Fraunhofer IML and TU Dortmund) and operated by the CDQ AG.

Based on latest scientific insights, the CC CDQ develops methods, architectures, reference models, and prototypes needed for efficient implementation of corporate data (quality) management. The participating companies build critical know-how and exchange best practices with peers in quarterly consortium workshops and multiple bilateral projects. The core objective of the CC CDQ is to transfer theoretical preliminary work and scientific research results in the domain of data management to everyday business practice.

Partner companies of the CC CDQ



Note: The overview comprises previous and current partner companies.

¹ See www.cdg.ch

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Abbreviations

BI	Business Intelligence
B2B	Business-to-business
B2C	Business-to-consumer
CC CDQ	Competence Center Corporate Data Quality
DBMS	Database Management System
DQM	Data Quality Management
DWH	Data Warehousing
e.g.	example given
ESB	Enterprise Service Bus
ICT	Information and Communication Technology
i.e.	<i>id est</i> , that is
IoT	Internet of Things
IS	Information Systems
IT	Information Technology
MDM	Master Data Management
mgmt.	management
PaaS	Platform as a Service
SaaS	Software as a Service
SOA	Service-Oriented Architecture

Management Summary

Buzzwords like big data, the Internet of Things, mobile computing, or Industry 4.0 all build on the conviction that the importance of data and information will keep growing both for businesses and for society as a whole. Data management departments need to revise their existing architectures and processes to get ready for the new requirements, for example regarding data availability, data integration, and data credibility. The report builds on insights collected from the CC CDQ workshops and bilateral projects taking place in 2014. It aims at providing data managers of medium and large enterprises from all industries with useful background information and practical guidance for their journey towards the digital economy.

More precisely, the report

- contributes to a common understanding of the major technological, economic and social drivers behind the evolution of the "digital economy",
- specifies the implications the digital economy has on data management requirements,
- shows how companies react to these new requirements in five short exemplary cases,
- presents a business and data management capability framework for companies operating in the digital economy, and
- describes a possible roadmap for data managers to follow on their company's journey towards digitization.

1. Towards the digital economy

A recent survey among 513 European executives shows a large awareness of the transformational impact of digitization on European businesses across all industries (Accenture 2014). As displayed in Figure 1, approximately two thirds of the managers surveyed believe that digitization will strongly impact the business models in their industries within the next 12 months. The same proportion fears that their companies will lose customers if they are unable to meet the requirements of digitization in decent time. Regarding the perspective of the entire European market, a vast majority of the respondents (96%) thinks that digital technologies will be important, or even critical, for Europe's competitiveness in the global market environment in the next three years.

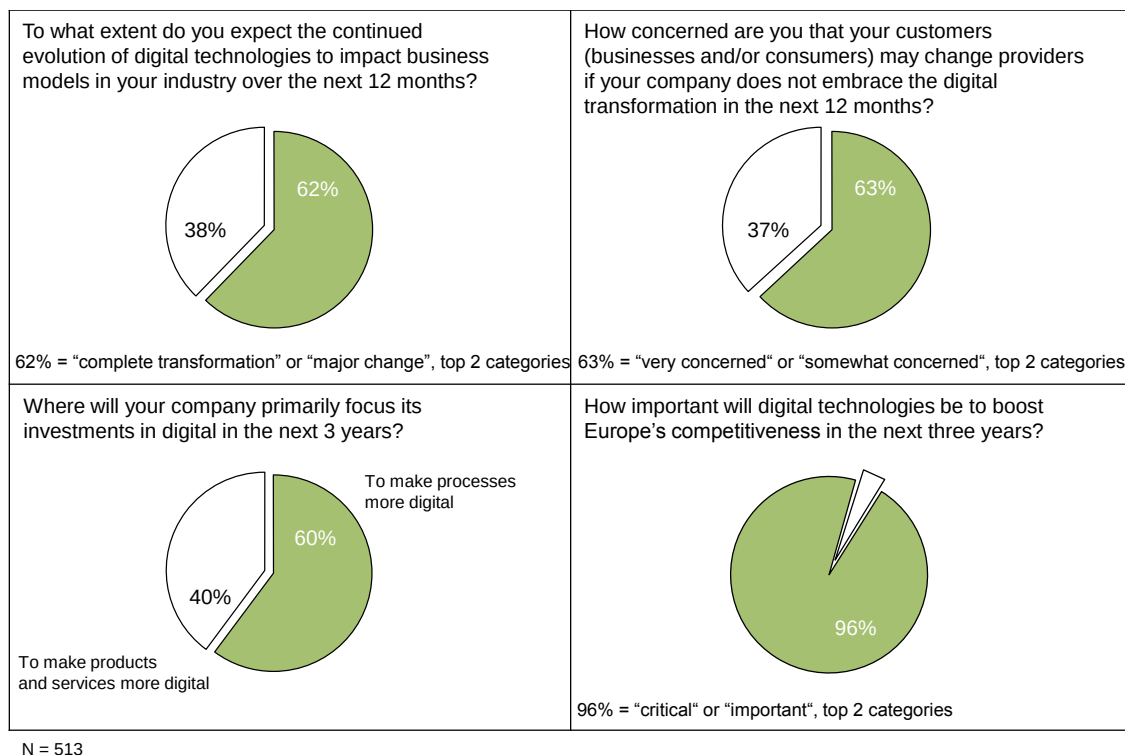


Figure 1: Importance of digitization for European businesses: opinion of European C-level executives (based on Accenture 2014)

A survey conducted during the CC CDQ workshop in Stockholm, Sweden, in June 2014 showed similar results. Of the 46 data management professionals surveyed, a majority considers digitization a relevant issue for their respective organizations. Furthermore, the CC CDQ steering committee, the competence center's overseeing and strategy-defining body, has defined digitization, big data management, and data-driven decision making as top priorities of the 2015 CC CDQ research agenda. Just one year earlier, in the 2014 agenda, these topics did not appear in the top ranks.

The underlying notion of digitization is that information technology is increasingly permeating all areas of life (Otto & Österle 2015), leading to a "hyper-connected", "networked" society and a "digital economy". Data is the key resource at the heart of this

development, in the course of which individuals, organizations, and physical devices leave more and more digital traces in the networked society. This trend is fueled by the rise of new technologies and growing customer expectations regarding transparency and convenience. Start-up companies develop new business models taking into account these developments, while incumbent market players often struggle to maintain their position and to find the right approach to transform their business in view of digitization.

As a response to this development, responsible (data) managers face three main tasks:

1. **Understand the drivers and characteristics** of digitization with its opportunities for business in general and its impact on different areas of data management in particular.
2. **Determine the strategic priorities for digital initiatives.**
3. **Plan concrete actions to implement digital initiatives** and to prepare the organization for the requirements of the digital economy.

Regarding **(1)**, the report identifies and describes the main drivers that constitute the phenomenon called “digitization” (chapter 2). These drivers and their impact on data management are then illustrated by means of brief case studies (chapter 3) and by a structured list of data management requirements (chapter 4).

As for **(2)**, the report presents a selection of relevant digital business capabilities managers may choose to implement depending on their company’s needs. This selection is presented in the top layer of the capability framework in Figure 5 (chapter 5).

Regarding **(3)**, after managers have prioritized the business capabilities and identified concrete use cases for digital initiatives, the capability framework also serves as a high-level roadmap allowing managers to translate business requirements into actions for business-IT alignment and data management (chapter 6).

2. Drivers of digitization

Digitization is a global trend that is driven by multiple factors. Three cornerstones are social, business, and technological drivers. Taken together, they frame what can be called “the digital economy”. Figure 2 shows the main drivers from these three areas.

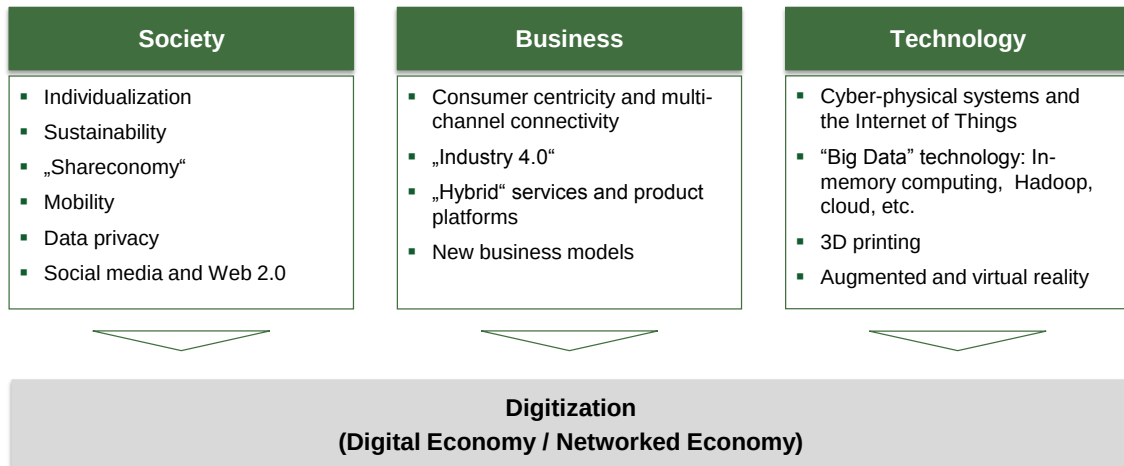


Figure 2: Drivers of digitization

2.1 Social drivers

Individualization

For many people it has become a major desire to emphasize their individuality in many areas of life. Companies aim at satisfying this demand by “mass customization” of their products and services. Since this term came up in the 1990s (Pine 1993), technical progress, globalization, and optimized supply chains have made customized products affordable to large groups of consumers who would never have dreamed of a “classical” customized product like a tailored suit in the past. Almost any product (personal computers, cars, running shoes, etc.) can be customized (or personalized) to reflect individual style and preferences, personal affiliations, or social status. In the automotive industry, for example, mass customization today means that only a single-digit percentage of all cars of a certain model is produced identically. Information technology plays an important role as facilitator of the entire customized order fulfillment process. In a wider sociological understanding besides the consumer world, individualization of course also covers other long-term developments such as the one towards individual fulfillment.

Sustainability

People become increasingly aware of environmental and social threats such as climate change, the growing pollution of air, water, and soil, and the growing amounts of waste. According to a Eurobarometer survey from 2013, about 50 percent of all Europeans “have taken some form of action in the past six months to tackle climate change” (European Commission 2013, p.42), including reducing and recycling waste, buying local

and seasonal products, buying more energy-efficient household appliances, choosing environmentally-friendly forms of transportation, and improving home insulation. Customers also expect environmentally responsible action from companies and have begun to be interested in sustainability measures taken by them like the carbon footprint of certain products.

Shareconomy

The term “shareconomy” describes a counter-trend to individual consumption and excessive private property. Especially in highly developed countries, a growing number of individuals find they do not need to own expensive, yet often unused, goods. Instead, they prefer borrowing (or renting out) such goods on demand. Examples of this trend are increasingly popular services for car sharing like car2go and DriveNow or the private lodging service Airbnb (Bubner et al. 2014, p.8). Using shareconomy services, people no longer need to acquire an expensive good and incur the operating expenses that are traditionally attached to it (as in the case of a car with its high up-front purchasing costs and considerable follow-up costs like insurance fees). Instead, cost can be refined to the pay-as-you-use principle. Vice versa, in the case of renting out own property to others (Airbnb), it is even possible to generate additional income. Shareconomy services use state-of-the art information and communication technology (ICT) to efficiently connect buyers and sellers remote from one another, thereby scaling the idea behind traditional sharing platforms such as bulletin boards or neighborly connections. Besides the motivation to save money, environmental considerations inspire shareconomy models as well. By relinquishing infrequently used goods, people hope to reduce waste and contribute to a more sustainable society.

Mobility

Today’s societies are more mobile than ever before. It has become commonplace to commute long distances to arrive at one’s workplace and long-distance flights connect almost every region in the world. Liberalized public transportation markets (in Germany, for example), allow new competitors to enter the medium-distance transportation market, reducing prices for this kind of mobility (BMVI 2014). The transformation of the workspace is another area where mobility can be observed; one example is the increasing number of knowledge workers, who can flexibly perform their work from multiple locations like their home office or while traveling. This development towards remote work has been enabled by today’s ICT devices (especially laptops, smartphones, and tablets) and the exhaustive internet coverage.

Data privacy

The enthusiastic use of smartphones and the internet has raised personal data privacy and data security concerns. Fueled by the PRISM scandal, a large-scale private communications surveillance program by the American National Security Agency (NSA), which was leaked in 2013, internet and telecommunication users all over the world had to learn that any allegedly private communication via electronic networks of major American internet technology companies is systematically recorded and analyzed by this agency (Lee 2013). Besides data abuse by national agencies, collection and analysis of personal data by private companies like Google or Amazon is a growing con-

cern of privacy groups and regulators. Consequently, multinational companies must comply with many different data privacy regulations in their global operating markets. One important new directive in the European market will be the “General Data Protection Regulation” (GDPR), which regulates data protection and privacy not only for companies situated in the EU, but also for any company outside the EU processing data of EU residents (European Parliament 2014). The directive is still under development and is expected to be adopted in 2015. Surprisingly, consumer awareness of data privacy issues is not yet high enough to cause any noteworthy behavioral changes. In view of recurring data security breaches and increasing data analytics abilities, it remains to be seen whether consumers will demand more transparency and control over their private data in the future.

Social media and Web 2.0

The terms “social media” and “Web 2.0” refer to the evolution of the internet towards a collaboration platform that allows users to interact with each other and contribute own web contents. The rise of social media and Web 2.0 has influenced the ways companies interact with their customers and stakeholders. Many companies thereby hope to strengthen the bonds with customers and improve communications with suppliers and external partners. Furthermore, Web 2.0 may encourage idea sharing and facilitate access to expert knowledge, hence deepening companies’ knowledge pools (McKinsey 2009). While image-based and micro-video platforms such as Flickr or youtube have gained importance in B2C marketing, business networking platforms such as LinkedIn are increasingly also attracting B2B marketers (Forbes 2014).

2.2 Business drivers

Consumer centricity and multi-channel connectivity

Consumer centricity refers to the trend towards individualization from a business perspective. It means that more markets are becoming buyers’ markets, which are characterized by increasing power of customers in general, and consumers in particular. Individual consumers can be identified easily by tracking their digital traces on the web, via their smartphone usage profiles, or – in rather conventional ways – through the use of retail loyalty cards. Companies are expected to reach out to their customers via different channels, not just the direct sales channel. A major data management challenge of this trend is to keep track of one unique customer identity across all channels. Another sign of the increased focus on the consumer is the direct integration of customers in the value creation process, for example through crowdsourcing. Because of this changing relationship between companies and consumers, the consumer is now sometimes also referred to as “prosumer” (a word assembled by combining “professional” and “consumer” or, alternatively, “producer” and “consumer”) (EY 2011, p.6).

Industry 4.0

The term “Industry 4.0” is gaining popularity since it was coined in one of the German Federal Government’s high-tech strategy projects in 2012 (BMBF 2014)². It describes the “fourth industrial revolution”, which is currently transforming industrial production. Industry 4.0 assumes state-of-the-art automation of production processes according to the principle of subsidiarity, process virtualization by optimal information transparency, batch size of one, and the interconnection of machines, workpieces, and workers (see also *cyber-physical systems and IoT*). Furthermore, entire production networks are expected to become even more integrated over the value chain (Forschungsunion & Acatech 2013, p.6). In the new “smart factories” enabled by Industry 4.0, workers will require more ICT-related skills and larger responsibility for monitoring automated production facilities.

Hybrid products and product platforms

In the digital economy, products are increasingly turning into “hybrid service offerings”. This change has two elements: Firstly, it means that products are increasingly computerized and electronically interconnected by the integration of ICT components. For example, cars are today equipped with various ICT components besides the mechanical engineering core. These components, for example, allow monitoring the vehicle status including its surroundings (rain sensors, parking assistance systems) and offer new ways of connection with the driver (bluetooth music player connected to driver’s MP3 player) and even with the outer world (GPS, remote service). Another example are “wearables”, i.e. clothes with integrated computer chips. As these complex products often consist of multiple “layers” (device, network, content, service), with the software or content being provided by one company and the basic physical product components by another, products are increasingly turning into “product platforms” (Yoo et al. 2010). Secondly, the servitization trend transforms product offerings in the digital economy. Companies try to market the final performance (i.e. value for the customer) of a product instead of merely selling the product itself, which is sometimes called “performance contracting”. For example, companies can offer a vertical transportation service instead of just selling elevators or an airplane propulsion service instead of aviation turbines. This goes beyond just offering additional services alongside the core product, which has almost become a necessity in both B2C and B2B markets.

New business models

The transformation of value propositions towards hybrid services can affect entire business models. A business model describes the underlying business logic of a company (Teece 2010) including value offerings, customer segments, value creation activities and capabilities, and revenue models. A changing business model means that a company’s entire underlying business logic is affected by either an important external developments or an internal decision (e.g., an innovation regarding the value proposition, which requires substantial changes to the company’s mechanisms for creating and capturing value). An example where a business model transformation can be observed is the logistics industry, where some companies are evolving from providers of

² Outside Germany, the terms “smart manufacturing” or “industrial internet” are used for the same development.

logistics services to data providers, e.g. by offering location data for location based services from third parties (Jeseke et al. 2013, p.13f.)³.

2.3 Technological drivers

Cyber-physical systems and the Internet of Things

The major technological driver behind “Industry 4.0” is the vision of the Internet of Things (IoT). The IoT is based on the notion that every physical device and even human being will be electronically identifiable and connected to the internet in the future. This will have a profound impact on the way supply chains and shop floor production processes work and are represented in information systems. Whereas today carriers or groups of items, like pallets or production batches, can be identified and then tracked and traced through the supply chain, smaller and cheaper sensors and computer chips make item-level tagging and tracing feasible. Depending on the “intelligence” of these items and their production systems, new levels of factory automation beyond basic “track and trace” are imaginable. For example, a product may tell the conveyor belt how to proceed with the production process or initiate its delivery (Roland Berger 2014, p.9). Necessary conditions for this scenario are real-time status monitoring capabilities and bilateral information and control flows between the workpiece, its production process, and the production system. Another term for such a network of physical objects and their production systems is “cyber-physical system”.

“Big data” technology: in-memory computing, Hadoop, and cloud

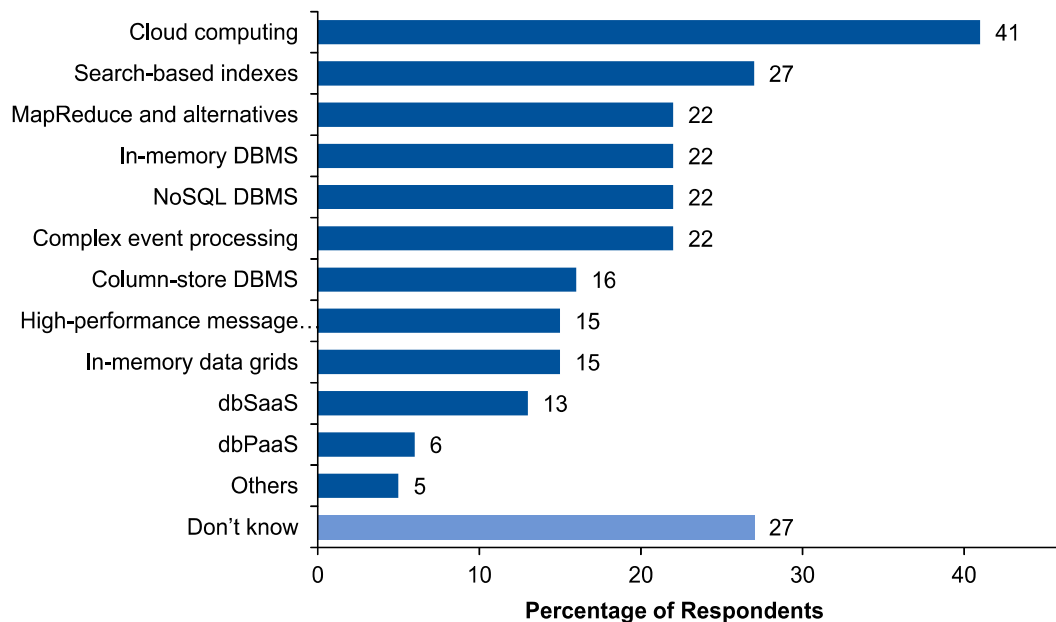
“Big data” refers to “high volume, velocity and variety information assets that demand cost- effective, innovative forms of information processing for enhanced insight and decision making” (LeHong & Fenn 2013, p.48). The “3 Vs” (for volume, velocity and variety) are by now relatively accepted to summarize the core characteristics of big data, although the definition is occasionally complemented by other letters such as “C” (for complexity), or additional “Vs” (for variability or veracity). Data variety means that the range of data sources is extended from primarily internally generated data (e.g. transaction data and master data) to externally-generated data such as Web data, location data, or data from the IoT. Furthermore, companies try to use more of their data that is “hidden” in documents or presentations. The greater source variety combined with more sources and shorter data acquisition intervals inevitably lead to greater data volumes. Data velocity, finally, refers to faster data acquisition, data transformation and processing, and data delivery (or access).

It is commonly held that today’s ever-increasing amount of data is a) potentially valuable for businesses if this data can be exploited, and b) that doing so is no trivial task⁴. A

³ Of course, a partial change (i.e. an adjustment) of a business model in only a few of the dimensions mentioned happens more often (and more easily) than a change of the entire business model. The adoption of eOrdering/eInvoicing for more efficient transactions between business partners is one simple example of changing value creation activities in core processes.

⁴ Therefore, the “big data” definitions often come with the addition that these are data volumes which cannot be handled “by conventional information processing systems”.

recent survey on promising big data technologies by analyst company Gartner is shown in Figure 3. A brief explanation of three core technologies is given in the next paragraphs.



N = 465 (multiple responses allowed)

Key: DBMS – Database Management System; SaaS – Software as a Service; PaaS – Platform as a Service

Figure 3: Technologies used to derive value from big data (Kart et al. 2013, p. 20)

Cloud computing services are data processing-related capabilities offered for rent by external service providers. Cloud strategies are considered as alternative to classical hardware and software acquisition strategies to address big data-related challenges like limited in-house data storage space or insufficient data processing power. Cloud computing providers offer, for example, virtual data warehousing space, often extended by data management services, which companies take advantage of to reduce the capital equipment risk attached to large server farms, and which releases them from the obligation to have all skills available in-house. Furthermore, externally contracted storage and data processing capacity theoretically is infinitely scalable. Although cost savings and reduced efforts for database operations management are strong arguments in favor of cloud offerings, doubts can be raised regarding data security in both public and private cloud environments (cf. *data privacy*).

In-memory database technology, also called in-memory data management or in-memory computing (IMC), is another technology that has received considerable attention in recent years. In-memory databases store data in main memory instead on disk, which enables faster data access than hard disk I/O (Gill 2007, p.61). Combined with other database optimizations such as column storage and the associated data compression potential, IMC allows very fast data processing even of large datasets.

Apache Hadoop is a Java-based software framework for distributed storage and processing of very large data sets (Henschen 2011, p.20). Data storage is done by the Hadoop Distributed File System (HDFS), while data processing is performed by the *MapReduce* engine, which spreads a computing task across multiple nodes in a computing cluster and later merges the results. Hadoop is easily scalable and relatively inexpensive since storage and processing tasks are distributed across commodity computer hardware clusters. The main application area for Hadoop-related solutions is batch analytics of large datasets, e.g. of Web data (Leveling et al. 2014, p. 919). Hadoop is considered as an entire ecosystem because other software packages work on top or alongside of it – which is facilitated by the fact that the framework is available open source. With HBase it also features a type of NoSQL database. NoSQL (“not only SQL”) databases are generally less strict with respect to data schemas in contrast to conventional relational SQL databases.

3D printing

3D printing is a technology that seems to be reviving science fiction movie dreams with its manufacturing process that creates physical multidimensional objects from a range of basic materials. 3D printing allows creating 3D objects of almost any shape and size from suitable design templates by a manufacturing principle called “additive manufacturing”. The technology offers two major benefits: it allows to produce complex internal structures that are impossible to construct by means of traditional manufacturing techniques, and it has huge potential for product mass customization, given that the printer itself and the raw materials are affordable (Manyika et al. 2013, p.105). Therefore, 3D printing can be expected to impact the ways how products for both B2B and B2C markets are designed, produced and distributed. For example, it is quite conceivable that spare parts could be 3D printed at a customer site – reducing the need for large spare parts inventories and delivery operations.

Augmented and virtual reality

Augmented reality (AR) is a variation of virtual reality (VR). While in virtual reality the user completely immerses into a synthetic environment, augmented reality allows the user to see the real world with virtual objects superimposed upon it (Azuma, 1997, p.355f.). The technology has advanced quickly over the past few years, driven by crowd-funded start-ups (e.g. “Meta”) and major tech companies such as Google (“Google Glass”) or Microsoft (“Hololens”) alike. Another well-known example is the Facebook-owned “Oculus VR”, which has already sold more than 100’000 of its Oculus Rift headset’s developer kits (a prototype) in an effort to establish it as a computing platform (The Guardian 2014). The scope of applications in which augmented reality devices are or can be used is wide, including gaming, education, medical engineering, commerce and logistics. For example, DHL, one of the world’s leading logistics company, is currently experimenting with the use of augmented reality and smart glasses for warehousing (Augmented Reality Trends 2015). The majority of virtual reality products is still in the development phase, but can be expected to reach consumer markets in the near future.

In addition to the technological trends covered here, Gartner's 2013 hype cycle for emerging technologies provides a more comprehensive list of relevant technological innovations in the digital economy. It is included in the Appendix.

Similar to the hype (or maturity) cycle for technologies, enterprises from different industries are at different stages of their journey towards the digital economy. Whereas some industries, like retail (because of the exposure to e-commerce) or media (because of the rise of social media platforms and free information distributors such as blogs and web news portals), were forced to respond to the digital transformation process for several years already, other industries, like manufacturing or transportation, are just about to react to digitization in their core business areas. "Industrie 4.0", the new buzzword in Germany, now helps to raise awareness of the need for change among business managers and data managers alike. A clear need for a better understanding of the possible impact of digitization on business models and data management practices can certainly be identified.

3. Illustrative short case studies in the digital economy

This chapter presents five short case study descriptions from the extended practitioner and research network of the CC CDQ to illustrate how companies react to digitization with data management-related initiatives. Each case refers to data management requirements that are typical of the digital economy, which are later summarized and explained in Table 1 in chapter 4.

Fraunhofer IML, Mars, Rewe, and CHEP: A cloud solution for real-time logistics flow tracking – The smaRTI project

The smaRTI (smart reusable transport items) project is a collaborative applied research project led by the Fraunhofer Institute of Material Flow and Logistics (Fraunhofer IML), which developed a service for real-time tracking and tracing of transport structures like pallets (LT-Manager 2013). In line with the concept of the Internet of Things, pallets can be identified on a unit level and can be traced on their journey along the entire supply chain. The solution uses RFID technology for pallet tagging and a cloud software architecture for data integration and analysis, enabling the collaboration of different business partners to optimize their jointly used pallet pool. The project implemented a fully functional pilot application, which connected pallets used by the supply chain partners Mars and Rewe and their pallet pool service provider CHEP, plus four other pilot scenarios with other companies' pallet pools. To satisfy all functional and non-functional requirements, (e.g. regarding pallet traceability, inventory management transparency, cycle time transparency, data shareability, and data security), the smaRTI project partners decided to use a NoSQL architecture after thorough testing of alternative architecture options. The solution addresses several data management requirements of the digital economy such as **transparency**, **collaboration**, and **scalability**. For further information on smaRTI please visit the project homepage⁵.

CC CDQ: The Corporate Data League – a collaborative data management platform

The Corporate Data League (CDL) is a platform for collaborative master data and data quality management of business partner data. The CDL is a pilot application which was developed by the CC CDQ. It builds on the fact that large corporations often have identical (supplier) master data that need to be maintained in every company's IT systems, causing redundant data maintenance and DQM costs in each of the companies. Instead of each company maintaining these records on its own, the CDL offers a platform for sharing those data maintenance activities for general, public attributes of business partner data records (name, legal form, address, etc.). The pilot application is currently being implemented as a functional web platform featuring anonymous cleansing of business partner data, duplicate matching, shared data quality management, and a semantic meta-data and reference data repository. The CDL addresses the data management requirement of **more efficient data quality management**. Furthermore, it

⁵ See <http://www.smart-rti.de/>

implements a **novel data governance concept** for shared master data. More information can be found on the CDL homepage⁶.

Lanxess: Margin simulation with in-memory computing

Lanxess is a German specialty chemicals company. To address growing business intelligence (BI) requirements regarding flexibility and speed of its analytics services, Lanxess migrated its business warehouse to the in-memory database *SAP HANA*. Two new BI scenarios enabled by this new technology included a management dashboard for an improved overview of key financial performance indicators and a powerful margin simulation tool (Schuster 2013). The former allows to create individualized reports with short response times for insights as detailed as the individual record level. The latter allows simulating the development of Lanxess' profit margins depending on changes of internal and external parameters such as raw material prices or inter-company transfer prices. This is valuable because the specialty chemicals industry is highly dependent on such external factors and because Lanxess operates many production sites across the globe, which cover different steps in the value creation process. The tool supports both business unit and central views. The new BI environment addresses multiple modern data management requirements, especially **higher convenience** and **self-service BI** for business users, new **data models**, **new technologies**, and **integration of internal and external data sources**.

Bayer HealthCare: Advanced customer data integration

Bayer HealthCare, a German provider of pharmaceutical products and consumer health care products, launched a project for integration of its customer data across multiple source systems to gain a comprehensive customer profile across the entire customer lifecycle (Maasz 2014). As it is typical of the health care business, customers get in touch with Bayer HealthCare in different roles over their lifetime, for example as medicine student, as physicist of their own doctor's office, and finally as patient. All these interactions take place across different channels. In the past, the data about these interactions was traditionally stored across multiple Bayer IT systems, which impeded a unified view on the customer. With the new solution, data from various internal source systems can be connected, cleansed, and will in the future be enhanced with data from external sources, e.g. social media data. The project addresses multiple new and extended data management requirements listed in Table 1, including **cross-channel and cross-system data integration** for better customer centricity, development of new data models, as well as the potential for offering **new information services** for product development and/or marketing & sales by improved customer insights.

Otto Group: Predictive analytics for supply chain management

Multichannel retailer Otto Group has been facing increasing challenges in making reliable demand forecasts. This is mainly due to the apparel industry facing volatile demand patterns and shorter product life cycles, leaving Otto with the usual inventory management risks of either underpurchasing (and risking lost sales and customer dis-

⁶ See <https://www.corporate-data-league.ch/>

satisfaction) or overpurchasing (and incurring additional inventory holding and capital costs). As its traditional demand forecasting mechanisms no longer lived up to expectations, Otto implemented a new predictive analytics software tool by the company *blue yonder* which calculates demand forecasts based on 200 input variables as well as historical data and whose algorithm also features self-learning (Stüben 2012). The predictive analytics tool was integrated with Otto's inventory management and order system and helped improve ordering and delivery performance in both offline and online sales channels. The solution helps to achieve better customer centricity and mainly addresses the data management requirements ***internal and external data integration***, and ***prescriptive decision support***.

The five short case studies give examples of valuable business use cases in the digital economy and highlight the enabling role of data management⁷. Based on these cases and extended research, the following chapter summarizes the new requirements posed on data management in the digital economy.

⁷ More use cases involving "big data technology" are described in a recent BITKOM study (BITKOM 2015). Moreover, the CC CDQ described case studies with a focus on in-memory computing technology in a research study report entitled "Value Potential of In-Memory Data Management". It is available for CDQ members on the CC CDQ website (Bärenfänger 2014).

4. New and extended requirements for data management

In 2009, the international Data Management Association (DAMA) published their “Guide to the Data Management Body of Knowledge” (DAMA-DMBOK) in order to structure and characterize the most important areas (called “functions”) of corporate data management (DAMA 2009)⁸. The CDQ framework (see Appendix) is a reference framework that covers most of the DAMA functions in its six design areas. However, since the DAMA list provides a more granular structure and includes Business Intelligence (BI) and Data Warehousing (DWH) aspects, it was chosen here for the analysis of new and extended data management requirements in light of digitization. Table 1 presents these requirements and also refers to the cases from chapter 3.

Data management function	New and extended data management requirements following from digitization
1. Data governance	▪ Define ownership of digital innovation topics by establishing a central team or body overseeing these innovation topics in the company (e.g. exploration of IoT scenarios, Industry 4.0 scenarios, or new technology pilots (e.g. SAP HANA, Hadoop) to prevent duplicate efforts and to pool experiences). ▪ Appoint an authority representing IT and data management in digital business strategy. ▪ Design concepts for data governance of external and shared data, for example in cloud projects (cf. <i>project smaRTI</i>, <i>Corporate Data League</i>, Ch. 3). ▪ Develop “information services” for internal and external customers, which make use of the available data in novel, valuable ways.
2. Data architecture management	▪ Ensure the enterprise data model for external business objects and data objects is up to date; simultaneously make sure the model is built for flexibility. ▪ Prepare the architecture for new requirements regarding performance (higher speed), scalability (new storage capacity), and integration (semantic unambiguity). Appropriate measures may include, but are not limited to, cloud architectures, new data modeling, new industry standards, and paradigms like Service-Oriented Architecture (SOA) or other Enterprise Service Bus (ESB) solutions. ▪ Ensure integrated management of customer-facing elec-

⁸ Please see Appendix 0 for more information on the ten functions.

	tronic touch points and digital channels to support customer-centricity and the need for data ubiquity (e.g. homepage, portals, mobile apps, social media, etc.).
3. Data development	▪ Ensure integrity, usability, and maintainability not just of internal and structured data assets, but also of <i>external</i> and/or <i>unstructured</i> data assets (e.g. from web logs, emails, sensors, social media), and adapt data models accordingly.
4. Database operations management	▪ Prepare for “big data requirements”: optimize scalability and speed (including real-time when necessary) by integration of adequate database technologies such NoSQL and in-memory databases (cf. <i>in-memory computing</i> cases, Ch. 3).
5. Data security management	▪ Develop and implement data security strategy for cloud services. ▪ Develop and implement data security policies for more diverse devices and equipment, including not just desktop PCs and notebooks, but also smartphones and tablets. ▪ Establish customer data privacy policies.
6. Reference & master data management	▪ Go beyond the “golden record”: provide not just an unambiguous, but also a “semantically enriched” view of core business objects (e.g. customers) by integrating information from all relevant internal and external sources (cf. project CDIS at <i>Bayer HealthCare</i>, Ch. 3).
7. Data warehousing & Business Intelligence (DWH & BI) management	▪ Prepare DWH & BI tools and skills for more complex analytics and decision-support requirements (predictive, prescriptive, and real-time analytics), including adequate visualization techniques (cf. <i>Lanxess in-memory case</i>, <i>Otto Group SCM analytics</i>, Ch. 3). ▪ Provide BI information for increased convenience and ubiquity requirements: ▪ Control multiple channels for both internal and external customers (e.g. web portals, mobile apps, etc.). ▪ Offer BI self-service for business users and improved ease of use as in consumer IT.
8. Document & content management	▪ Manage not just internal documents and contents but also those from outside the organization.

ment	
9. Metadata management	▪ Enhance metadata for increased business process automation / virtualization and security requirements (e.g. for autonomous order processing or automatic data access processes). ▪ Establish metadata concepts for unconventional and externally sourced data (e.g. regarding data lineage and data credibility).
10. Data quality management (DQM)	▪ Ensure more efficient DQM in view of increasing data volumes and data variety: ▪ Intensify use of business rules for preventive DQM. ▪ Check options for replacement of reactive data quality measures by improved data analytics (e.g. improved fuzzy search algorithms). ▪ Enrich your data with data from external sources (e.g. <i>Corporate Data League, Ch. 3</i>; services like Factual).

Table 1: Data management functions and new or extended data management requirements in the digital economy

The table reveals a need for action in many areas of data management. Whereas it is unlikely that every company will have to tackle all areas at the same time and with the same intensity, most will have to face multiple of these requirements and will then be forced to **prioritize** their efforts. This **prioritization should depend** on the **company's business capabilities** and **high-priority use cases** following from these capabilities. The next two chapters explain this **top-down approach**.

5. Business and data management capabilities in the digital economy

Based on the drivers of digitization described in chapter 2, the case studies from chapter 3, and the collection of new and extended data management requirements in chapter 4, the CC CDQ has developed a **high-level framework of business and data management capabilities for the digital economy**⁹. A conceptual version of the framework is shown in Figure 4, whereas Figure 5 shows the complete high-level capability framework. The goal of the framework is to highlight important business and data management capabilities for business models in the digital economy and to provide a high-level roadmap to translate business requirements into actions for data management.

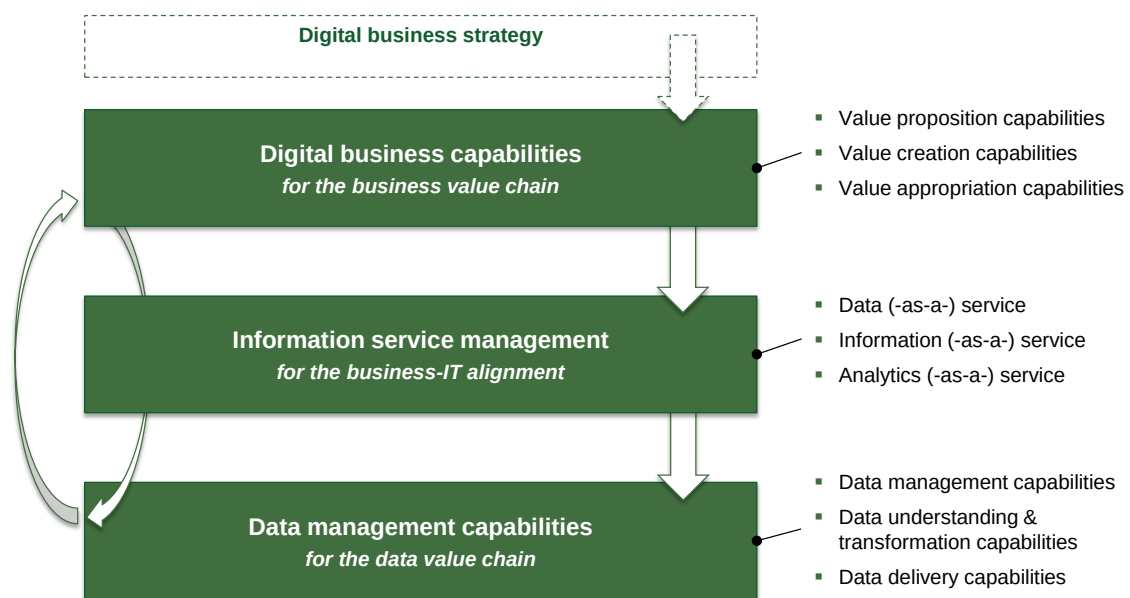


Figure 4: Conceptual capability framework

Capabilities refer to a company's abilities to acquire, utilize, and leverage its resources and routines in order to achieve certain business objectives. They have also been described as the "secret ingredient in explaining the development and maintenance of competitive advantage" (Wu et al. 2010, p.722). Capabilities describe *what* a company does (with a focus on what it *should* do) instead of describing *how*, *why*, or *where* something is done. In doing so, capabilities describe the core functions of a business. Of course, capabilities relate to other structural elements of the organization like business processes, organizational roles, information, and other resources (see Appendix for an illustration of this relationship).

⁹ The framework was developed throughout 2014 and early 2015 and was repeatedly discussed with the CDQ consortium in the CDQ workshops. For example, preliminary versions of the model were presented and discussed in the CDQ workshops and breakout sessions in Munich (April 2014), Stockholm (June 2014), Berlin (December 2014), and Interlaken (February 2015).

Furthermore, a more recent understanding views capabilities as being adaptive and forward-looking. This implies that “dynamic” capabilities requires a “propensity to sense opportunities and threats, to make timely and market-oriented decisions, and to change [the] resource base” (Barreto 2009, p.271). Some of the capabilities in our capability framework explicitly incorporate this dynamic aspect, but even those that do not should not be seen as static in the light of today’s rapid technological progress and volatile market environments. In the context of IS/IT and data management, capabilities are understood as abilities related to IT infrastructure management, IT management, IT-business partnerships, IT skill and experience management, etc. (Bharadwaj et al. 1999).

Capabilities can be a valuable **approach for organizational planning** as they span departmental and functional boundaries and provide a more stable, implementation-independent view of what the business *should* do than business processes usually do. From a data management and IS/IT perspective, capabilities offer the opportunity to highlight the contribution of individual projects to strategic business objectives and therefore an approach for improved business-IT alignment.

Figure 5 shows the complete high-level capability framework:

- The **upper layer** of the figure lists the main high-level **business capabilities** for the digital economy.
- The **middle layer** of the figure connects the business and data management perspectives by a layer called “**information service management**”.
- The **lower layer** list critical **data management capabilities** from an information processing perspective, a “data value chain”.

The three layers of the framework are described in the sections 5.1 to 5.3.

Digital business capabilities for the business value chain			Primary capabilities
Value proposition capabilities	Value creation capabilities	Value appropriation capabilities	
■ Smart hybrid product & service development ■ Product & service individualization	■ Process digitization (advanced automation & virtualization) ■ Multi-channel ecosystem connectivity ■ Ecosystem control ■ Business analytics & evidence-based decision-making	■ Revenue model execution for smart hybrid products	
■ Market sensing agility	■ Operational adjustment agility ■ Data-oriented mindset & culture	■ Cost optimization and process & resource efficiency	
Information service management			Support cap.
■ Business capability specification and information service design ■ Data (-as-a-) service; ■ Information (-as-a-) service; ■ Analytics (-as-a-) service			
Data management capabilities for the data value chain			Primary / operational cap.
Data management capabilities	Data understanding & transformation cap.	Data delivery and exploitation cap.	
■ Data collection and integration of internal & external sources ■ MDM and DQM across systems and ecosystems	■ Ad-hoc, predictive, and prescriptive analytics processing	■ Information service visualization ■ Self-service BI provisioning	
■ Governance model and architecture design for external and shared data	■ New databases and BI tools integration ■ Analytics ability: relevant data recognition and extraction	■ Digital initiative ownership definition	

Figure 5: High-level capability framework for the digital economy

5.1 Business capabilities: the business value chain

The upper layer of the framework in Figure 5 summarizes essential business capabilities for the digital economy. They are grouped along three common elements of business models: value proposition, value creation, and value appropriation (cf. Timmers 1998; Al-Debei & Avison 2010). To be successful in the digital economy in the long run, a company will possess multiple of these business capabilities. For companies at the beginning of the digital journey, it will be necessary to prioritize these capabilities based on their business strategy and to start with use cases from high-priority capabilities. The “primary capabilities” are seen as being more closely related to the value-creating aspects of a business and can thus lead to digital initiatives, whereas the “support capabilities” assist in the efficient execution of the primary capabilities.

Primary business capabilities:

- **Smart hybrid product and service development:** Develop value propositions featuring (a) a combination of services and products (“servitization”) and (b) the integration of ICT into physical products (“smart” / “hybrid products”). This may lead to a modular product structure.
- **Product/service individualization:** Customize product and service offerings according to individual customer needs.
- **Process digitization (advanced automation & virtualization):** Establish business process “digitization” by greatest possible level of automation and virtualization throughout the entire organization (especially production processes,

cf. Industry 4.0). Technically, this requires concepts like cyber-physical systems and the Internet of Things.

- **Multi-channel connectivity to ecosystem:** Be connected to all partners of the company's ecosystem (also beyond the traditional supply chain). Includes customers (/ consumers), business partners (e.g. suppliers or co-creators of value), and public stakeholders. This connectivity covers the capability for inbound and outbound communication via multiple channels as well as a superior understanding of each partner based on all relevant internal and external information sources.
- **Ecosystem control:** Translate ecosystem knowledge and connectivity into actual control over suppliers and other partners in order to achieve business goals.
- **Business analytics and evidence-based decision making:** Achieve well-informed decision making and problem solving based on an adequate and reliable data (analysis) base in all areas of the organization. This envisions enablement of all organizational members to decide and act on the basis of high-quality and timely information. It also requires that people are enabled to implement decisions and act in a timely manner.
- **Revenue creation models for hybrid modular products:** Develop and operate sustainable revenue models (e.g. pricing schemes) for the new smart hybrid product and service portfolio.

Supporting business capabilities:

- **Innovation and market capitalizing agility:** Develop an entrepreneurial organizational mindset that is able to quickly spot trends in the market and to develop innovative products and services.
- **Operational adjustment agility:** Enable flexible and fast implementation of operational changes (e.g. supply chain agility) within the organization.
- **Data-oriented mindset and culture:** Understand the relevance of data-driven problem solving and decision-making throughout the entire organization (among IT and non-IT employees) and develop the respective mindset. Implies awareness of the relevance of digitization for each employee's area of work.
- **Cost optimization & scalability of ordinary capabilities / resources:** Be able to utilize all internal resources and basic capabilities in a cost-efficient manner and with adequate flexibility. This requires being able to rapidly scale up, down, and/or out depending on competitive demands.

5.2 Information services: digital solution enablers

The middle layer of Figure 5 is the “**information service management**”, which deals with transforming the requirements from the high-level business capabilities into actual solutions (“information services”), which are to be delivered by data management. An **information service** is a data-related solution developed by data management to support a specific business capability. It can be provided either to internal customers from the business or even to external customers (e.g. for supporting a hybrid product). There may be more than one information service for each business capability.

As a first step, the development of information services requires that the high-level capabilities from Figure 5 are broken down into concrete **lower-level business capabilities**. Whereas the high-level business capabilities are generic and not industry specific, the lower-level business capabilities represent major elements of digital use cases or focus on the goals of major business processes. Each business capability has certain **data needs** or **information requirements**, which are implemented by its information service(s). These information requirements need to be analyzed along with several other functional and non-functional requirements, e.g. regarding analytics abilities (if any), delivery/access speed of a service, the automation degree of a service, and data privacy and security. Possible categories of information services are:

- **Data (-as-a-) service:** Pure data element or object without special context (e.g. a master data value or an invoice number).
- **Information (-as-a-) service:** Data which is enhanced with some context, a collection of data objects in a certain context (e.g., a report), or an abstract representation of a business context (like in an architecture diagram or process model).
- **Analytics (-as-a-) service:** Data which is prepared for advanced decision-support (e.g., as predictive or prescriptive analytics).

There may be, of course, other information services, which will be identified and specified by further research.

5.3 Data management capabilities: the data value chain

The bottom layer of Figure 5 summarizes a set of five primary and four supporting **data management capabilities** that are necessary to implement digital business models. They are enablers of the information services described above. Basically, these data management capabilities summarize the table in chapter 4, which described the new and extended data management requirements for big data and the digital economy. The primary (operational) data management capabilities cover capabilities for all stages of information processing from data capture and data management, over data transformation, to data delivery (the “data value chain”). The supporting data management capabilities cover governance capabilities.

Primary (operational) data management capabilities:

- **Data collection and integration of internal & external sources:** Ensure effective data integration from different internal and external sources in various formats.
- **MDM and DQM across systems and ecosystem:** Ensure trustworthy master data management (MDM) for the central business entities across all systems and, if necessary, also spanning the ecosystem of the company. Data quality management (DQM) and adequate data privacy and security management also need to be in place for core data objects.
- **Ad-hoc, predictive & prescriptive analytics processing:** Ensure sophisticated data analytics modeling and execution, which is supported by adequate software and hardware for relevant digital decision-support and problem-solving scenarios.
- **Information service visualization:** Deliver data (analysis) results in appropriate (i.e., easily understandable) formats across adequate platforms (e.g., on laptops as well as on mobile devices).
- **Self-service BI:** Empower business users to perform desired analyses on their own.

Supporting data management capabilities:

- **Governance model and architecture design for external and shared data:** Design, implement and run new data governance concepts, which account for more diverse data sources. Moreover, design adequate information and system architectures in view of growing diversity of deployment methods and tools (e.g. cloud services or open source software).
- **New databases and BI tools integration:** Evaluate, integrate, and run new databases and tools (especially for analytics, speed, and scalability requirements) within the current IT architecture.
- **Analytics ability: relevant data recognition and extraction:** Develop employees or teams with the necessary technical and business knowledge and skills to extract the relevant data out of the “big data lake” and to prepare it for business decision making and problem solving.
- **Digital initiative ownership definition:** Define and assign clear roles and responsibilities for digital initiatives within the organization, bridging functional boundaries.

6. High-level roadmap for digital transformation

Data managers in charge of supporting digital initiatives may use the capability framework as a guideline for their work. A three-step roadmap applies the framework (see Figure 6).

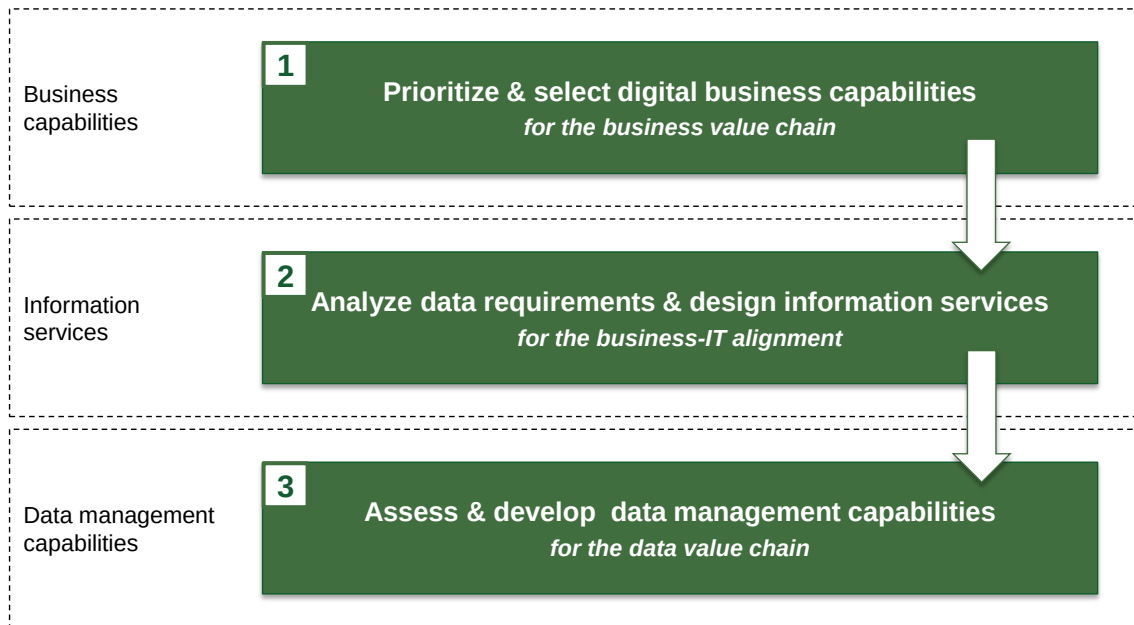


Figure 6: Roadmap towards capability-driven digital transformation

Step 1: Prioritize and select digital business capabilities

Companies will usually have to **prioritize** the **business capabilities** mentioned in Figure 5 and select a limited number of them to start an initiative. Therefore, they need to identify and select appropriate **use cases** or **digital initiatives**. A use case should have a high expectable buy-in from the organizational departments or units affected. Figure 7 presents possible use cases for the different business capabilities.

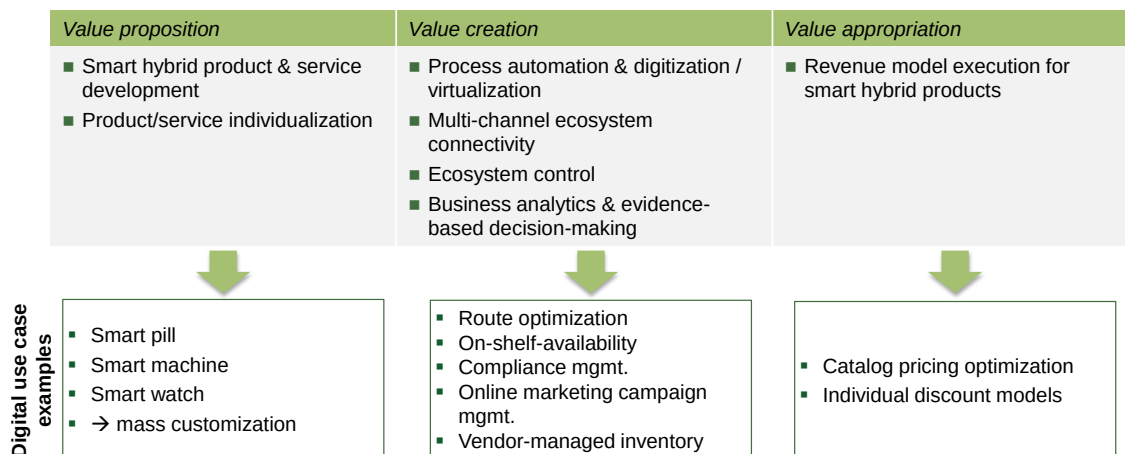


Figure 7: Use case examples for digital business capabilities

Step 2: Analyze data requirements and design information services

For one of the specific use cases determined in Step 1, one or more specific (lower-level) **business capabilities** need(s) to be specified. Based on this specification, one or more **information service(s)** meeting the essential **information requirements** of the business capability should be designed. Figure 8 presents a set of requirements and hints at metadata that should be considered in the process of information service design.

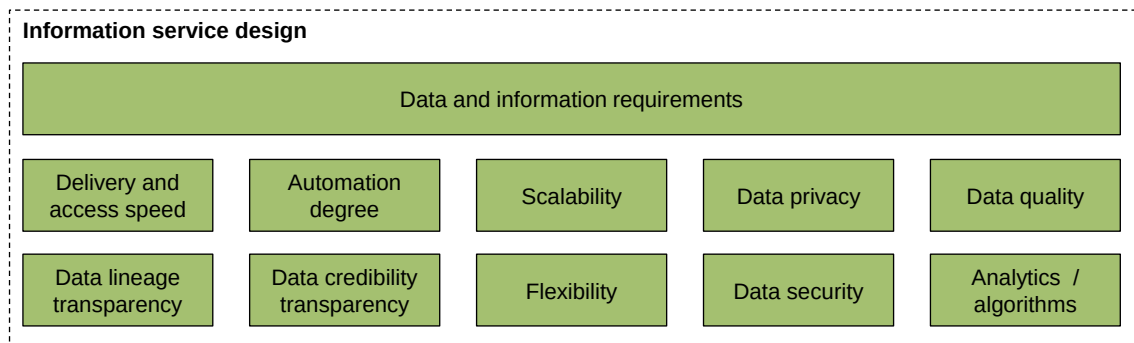


Figure 8: Definition of requirements for information service design

Step 3: Assess and develop data management capabilities

Finally, the information service requirements from Step 2 should be **mapped** against the **data management capabilities** currently available in the organization. It should be determined which of the data management capabilities are most relevant for the specified information service(s). Subsequently, the as-is level of these capabilities can be assessed to develop a project plan (e.g. to determine whether software, hardware, or skills need to be acquired) in order to support the information service(s).

The capability model with its implementation roadmap presented will be tested and revised in the course of practical projects.

7. Summary and outlook

Data may not really be “the new oil”¹⁰ since unlike oil, data does not vanish after consumption, but instead increases its value upon multiple use, processing, and sharing. However, data certainly fuels the digitization process that is currently underway. As the drivers in the social, business, and technological environment and the short case studies have shown, data becomes increasingly important even for traditional “analog”, non-IT companies. The growing importance of data as a resource implies a growing significance of data management.

This report outlined today’s most relevant drivers of digitization and highlighted new and extended requirements towards data management, which can be expected to be relevant for the upcoming decade. It then presented a business and data management capability framework for digital business models, which companies may use on their journey towards the digital economy. Still, plenty of research remains to be done. Topics on the CC CDQ research agenda in the upcoming years include:

- specifying the lower-level business and data management capabilities by means of an application of the roadmap to real-life cases,
- exploring practical data-driven decision support, hybrid digital product, and big data analytics scenarios in detail.
- developing a more detailed methodology for the translation of use cases to concrete data management actions via information services,
- analyzing possible path dependence relationships among capabilities,
- conducting more case studies to identify differences and similarities across different industries, and
- observing the developments regarding database technologies, BI tools, and other technological drivers and their implications for data management.

In the future, data management will take on an important role in supporting business functions to implement digital initiatives. Data management capabilities will become increasingly important for major business processes – and for the long-term success of the business itself.

Digitization is already transforming entire industries. Ignoring this development and not leveraging the potentials of improved knowledge of the customer, greater control over supply chains, and innovative “smart” products and services will no longer be an alternative, as competitors and new players in the market definitely be aware of the new opportunities.

¹⁰ See <http://www.wired.com/2014/07/data-new-oil-digital-economy/> and <http://www.forbes.com/sites/perryrotella/2012/04/02/is-data-the-new-oil/> vs. <https://hbr.org/2012/11/data-humans-and-the-new-oil/>

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Appendix

Hype cycle for emerging technologies

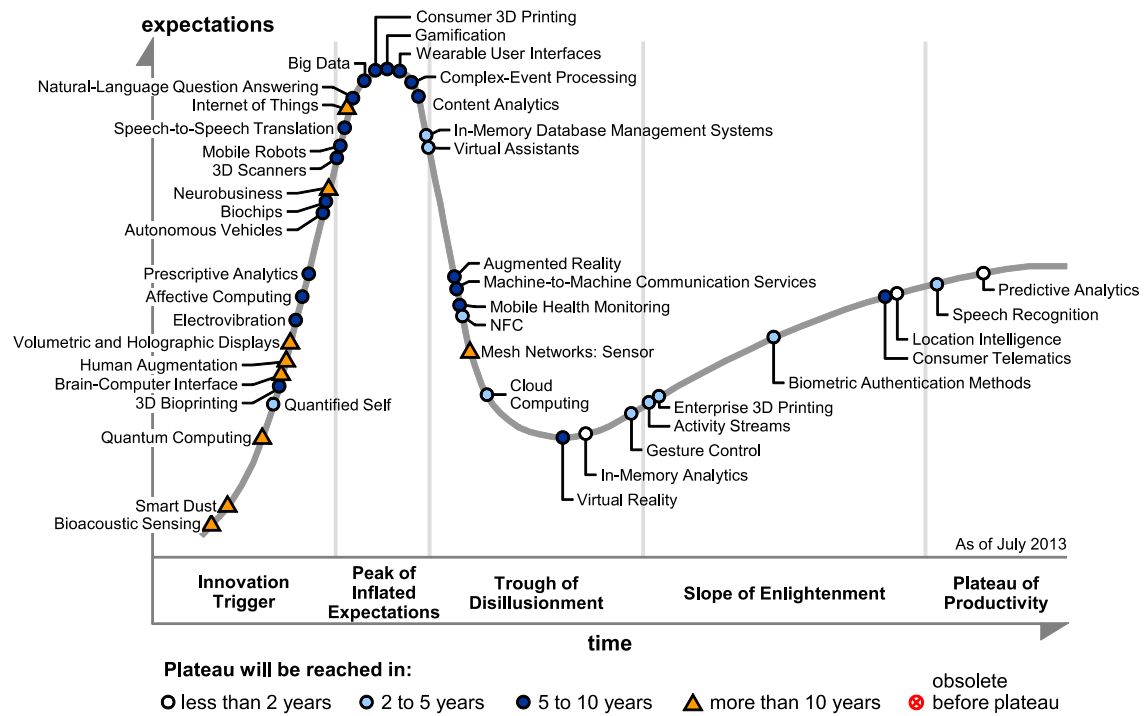


Figure 9: Hype cycle for emerging technologies (LeHong & Fenn 2013, p. 10)

Framework for Corporate Data Quality Management

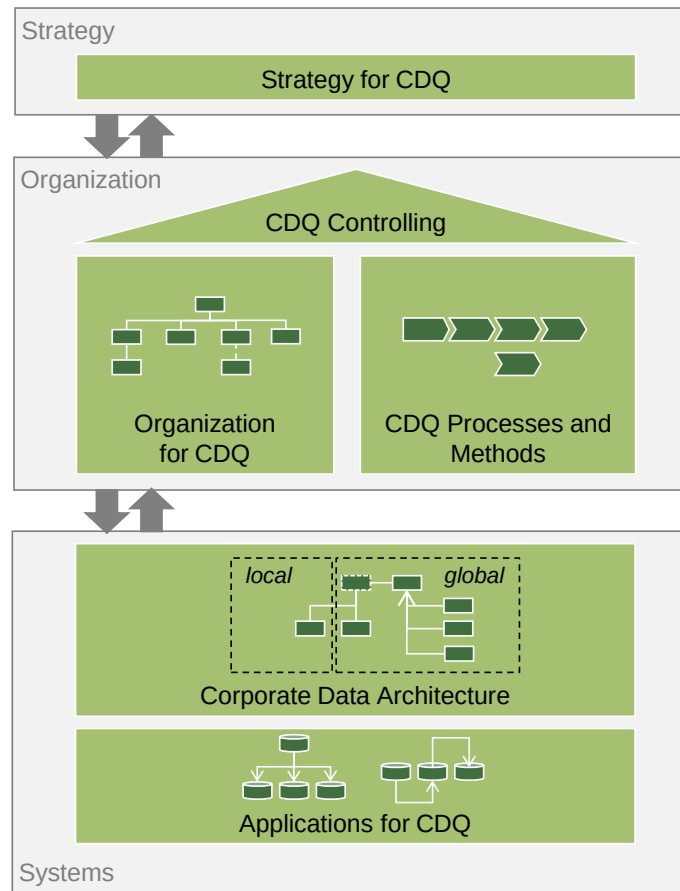


Figure 10: CDQ Framework (Otto et al. 2011, p. 10)¹¹

DAMA data management functions

Background on the data management functions according to the DAMA "Guide to the Data Management Body of Knowledge" (DAMA-DMBOK), (DAMA 2009).

Data management function	Definition and Goals
1. Data governance	Definition: The exercise of authority and control (planning, monitoring, and enforcement) over the management of data assets. Goals: - To define, approve, and communicate data strategies, policies, standards, architecture, procedures, and metrics. - To track and enforce regulatory compliance and conformance to data policies, standards, architecture, and procedures.

¹¹ For more information please also see EFQM 2011.

	▪ To sponsor, track, and oversee the delivery of data management projects and services. ▪ To manage and resolve data related issues. ▪ To understand and promote the value of data assets.
2. Data architecture mgmt.	Definition: Defining the data needs of the enterprise and designing the master blueprints to meet those needs. Goals: ▪ To plan with vision and foresight to provide high quality data. ▪ To identify and define common data requirements. ▪ To design conceptual structures and plans to meet the current and long-term data requirements for the enterprise.
3. Data development	Definition: Designing, implementing, and maintaining solutions to meet the data needs of the enterprise. Goals: ▪ Identify and define data requirements. ▪ Design data structures and other solutions to these requirements. ▪ Implement and maintain solution components that meet these requirements. ▪ Ensure solution conformance to data architecture and standards as appropriate. ▪ Ensure the integrity, security, usability, and maintainability of structured data assets.
4. Database operations mgmt.	Definition: Planning, control, and support for structured data assets across the data lifecycle from creation and acquisition through archival and purge. Goals: ▪ Protect and ensure the integrity of structured data assets. ▪ Manage availability of data throughout its lifecycle. ▪ Optimize performance of database transactions.
5. Data security mgmt.	Planning, development, and execution of security policies and procedures to provide proper authentication, authorization, access, and auditing of data and information. Goals: ▪ Enable appropriate, and prevent inappropriate, access and change to data assets. ▪ Meet regulatory requirements for privacy and confidentiality. ▪ Ensure the privacy and confidentiality needs of all stakeholders are met.
6. Reference & master data mgmt.	Definition: Planning, implementation, and control activities to ensure consistency with a “global version” of contextual data values.

	Goals: ▪ Provide authoritative source of reconcile, high-quality master and reference data. ▪ Lower cost and complexity through reuse and leverage of standards. ▪ Support business intelligence and information integration efforts.
7. Data warehousing & Business Intelligence (DWH & BI) mgmt.	Definition: The planning, execution and oversight of policies, practices and projects that acquire, control, protect, deliver, and enhance the value of data and information assets. Goals: ▪ To understand the information needs of the enterprise and all its stakeholders. ▪ To capture, store, protect, and ensure the integrity of data assets. ▪ To continually improve the quality of data and information. ▪ To ensure privacy and confidentiality, and to prevent unauthorized or inappropriate use of data and information. ▪ To maximize effective use and value of data and information assets.
8. Document & content mgmt.	Definition: Planning, implementation, and control activities to store, protect, and access data found within electronic files and physical records (including text, graphics, images, audio, and video). Goals: ▪ To safeguard and ensure the availability of data assets stored in less structured formats. ▪ To enable effective and efficient retrieval and use of data and information in unstructured formats. ▪ To comply with legal obligations and customer expectations. ▪ To ensure business continuity through retention, recovery, and conversion. ▪ To control document storage operation costs.
9. Metadata mgmt.	Definition: Planning, implementation, and control activities to enable to high quality, integrated meta-data. Goals: ▪ Provide organizational understanding of terms, and usage ▪ Integrate meta-data from diverse source ▪ Provide easy, integrated access to meta-data ▪ Ensure meta-data quality and security.
10. Data quality mgmt. (DQM)	Definition: Planning, implementation, and control activities that apply quality management techniques to measure, assess, improve, and ensure the fitness of data for use.

	Goals: ▪ To measurably improve the quality of data in relation to defined business expectations. ▪ To define requirements and specifications for integrating data quality control into the system development lifecycle. ▪ To provide defined processes for measuring, monitoring, and reporting conformance to acceptable levels of data quality.
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Business capabilities

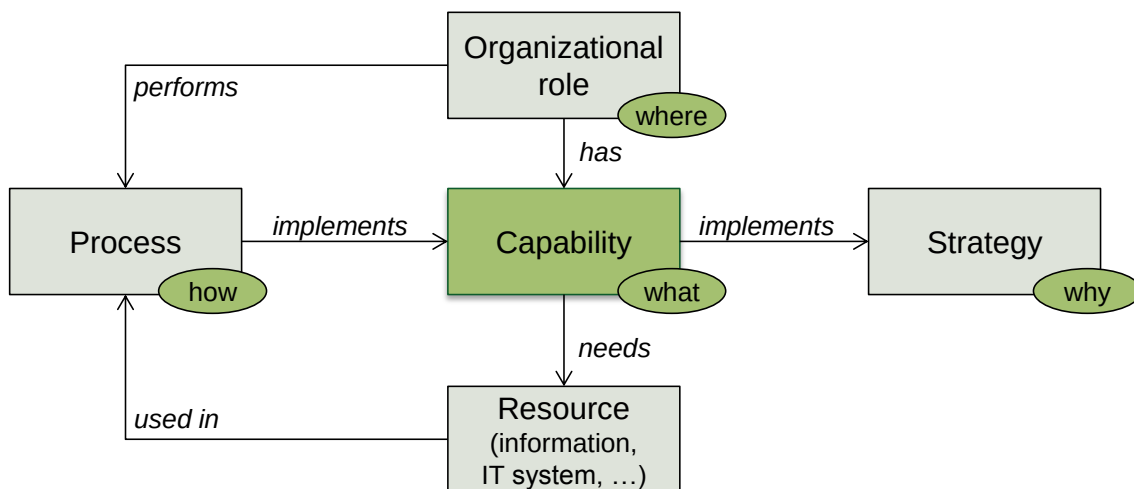


Figure 11: Simplified view on business capabilities and their relation to other organizational design areas

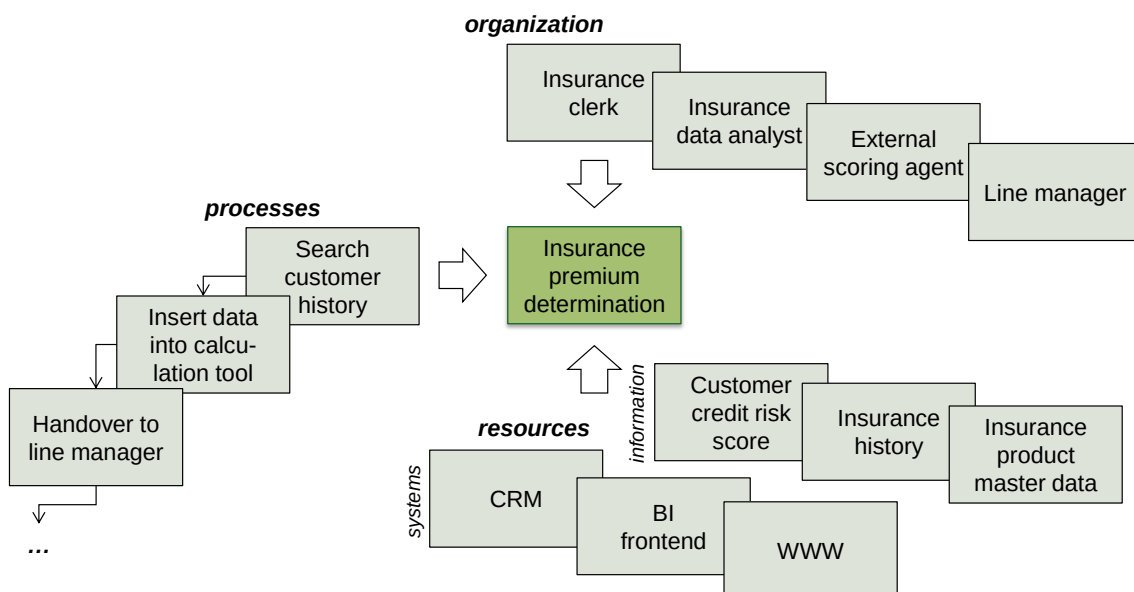
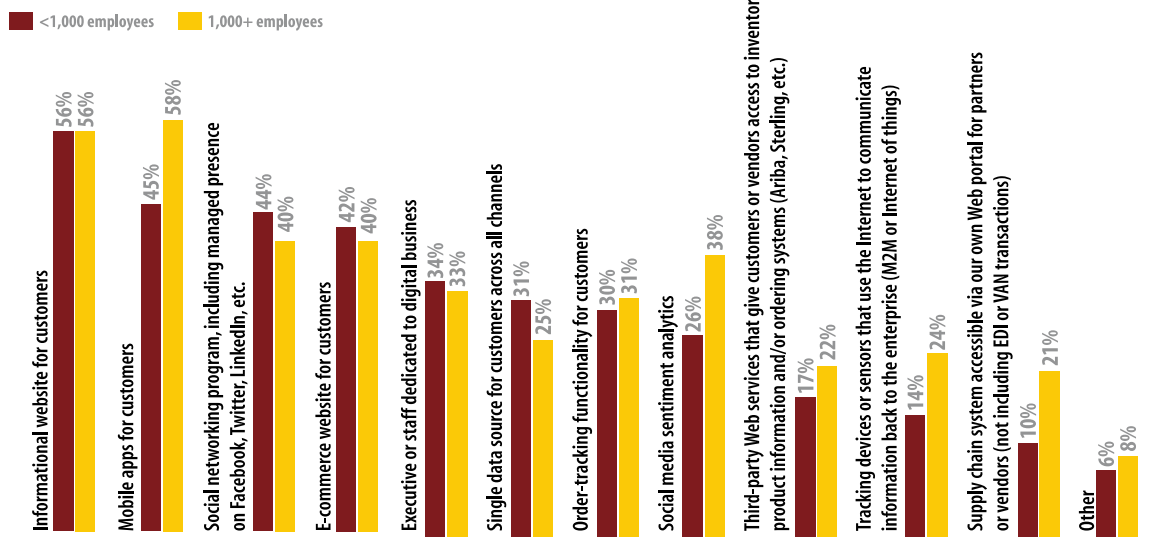


Figure 12: Illustrative example of a business capability and its relationships from the insurance industry

Goals of digital initiatives



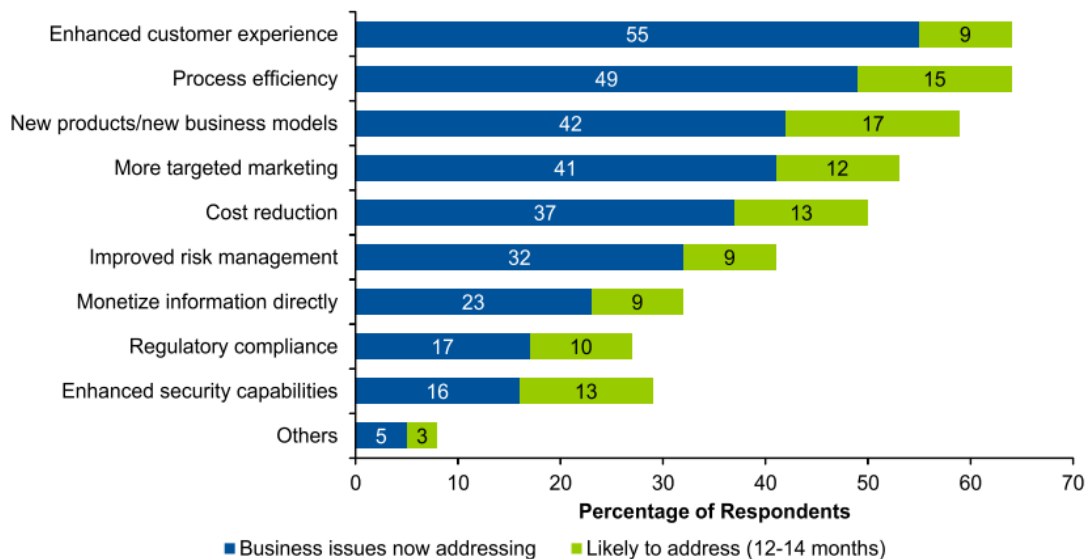
Note: Multiple responses allowed

Base: 202 respondents at organizations with fewer than 1,000 employees and 134 at organizations with 1,000 or more employees with a digital strategy

Data: InformationWeek Digital Business Survey of 510 business technology professionals, November 2013

R7561113/6

Figure 13: “What will be part of your digital strategy in the next 12 months?” (Healey 2014, p.22)



N = 465; multiple responses allowed

Figure 14: “Which business problems are addressed big data?” (Kart et al. 2013, p.8)

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