

# illuminating Digital Transformations: A Literature Review to Conceptualize the Impact of Technologies on Human Capital

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## Abstract

Digitalization exerts a strong influence on society, businesses, and consequently also human labor. Human capital as such is not shielded from the impact of digital technologies anymore but suffers and simultaneously also benefits from newly arising possibilities. Nevertheless, digital innovations and their ever-growing importance are summarized with the concise notions of digitization, digitalization, and digital transformation joint with the obscure and universal conception of digital technologies. These terminologies are neither consistently defined nor uniformly understood. In general, the literature indicates that digitization is concerned with the pure conversion of analog information into digital formats, digitalization describes the usage and adoption of those digital formats, and digital transformation covers the all-embracing process from analog to digital. Digital technologies can be further divided into digital artifacts, digital platforms, and digital infrastructure, which are reflected as digital formats in the process of digital transformation. According to the requirements of nominal and meaningful theory concepts, this paper provides a detailed elaboration of the notions and sub-themes which are mainly enlightened by information systems and business research. Finally, a calculation proposal is presented with human capital as input in relation to the total revenue generated which indicates the measurand of return on time invested, targeting a reduction of human labor input to achieve a value increase. Complemented by a research agenda, the overarching objective of the paper reveals the necessity of profound analysis to quantify the impact of digital transformations on firms and human capital.

**Keywords:** Digitalization; Innovation; Labor; Measurement; Technologies.

## 1. Introduction

In current social sciences, digitalization poses the imperative of transdisciplinary research (Legner et al., 2017), mainly overserved in information systems and business research. With a special focus on firms, the former scientific discipline proposes to review a firm's digital transformation process across several functions to holistically understand its impact (Tarafdar & Davison, 2018), while the latter emphasizes a transformation process consisting of three different components: digitization, digitalization and ultimately digital transformation (Verhoef et al., 2021). Business research furthermore focuses on the investigation of business model digitalization through digitalization capabilities (Ritter & Pedersen, 2020). Even today, the literature argues that managers are busy understanding how digitalization will affect business but are also still incapable of profiting from it (Björkdahl, 2020). "To become

digital, leaders must articulate a visionary digital value proposition. This value proposition must reassess how digital technologies and information can enhance an organization's existing assets and capabilities to create new customer value.” (Ross, 2019, p.5). The sole focus on converting analog information into digital formats is not materializing a technology-driven value-added (Kirchner et al., 2018), it is the business enabler (Ross, 2019). On the contrary, literature also interprets the hardware and software of digital technologies as the main effects (Vadana et al., 2020). The impact on firms can holistically also be considered from three different angles: internal efficiency, external opportunities, and disruptive change (Parviainen et al., 2017). Putting the focus on internal efficiency and human labor in particular as well as work input, literature concerning labor market development presents the routine-biased technical change (RBTC) hypothesis (Autor et al., 2003) which still reaches out to current publications (Fernández-Macías & Bisello, 2020). The essence of this hypothesis states the substitution of routine tasks by digital technologies, mainly performed by middle-skilled labor, while high-skilled labor is complemented by its development. Initially, low-skilled labor was deemed as shielded against digital technologies, but due to the latest improvements of robots and artificial intelligence the RBTC hypothesis has changed, emphasizing the impossibility of immunity and that new, even more productive tasks are created for high-skilled labor (Acemoglu & Restrepo, 2018a, 2018b, 2019b). Therefore, human labor as an input factor for work within the course of a firm's digital transformation experiences strong attention. Business research reveals a measurement proposal to enable firms to reflect the value of human labor input: return on time invested (ROTI). Total revenue (TR) divided by the number of employees, deemed as human labor input ( $I_L$ ) (McGrath & McManus, 2020). It is assumed that the increased application of digital technologies (digtech), reduces human labor resources.

$$ROTI = \frac{TR}{I_L} \quad (1)$$

However, McGrath and McManus (2020) disregard the coefficient of time (t) by which the invested time of human labor in relation to total revenue is calculated. Therefore, this paper stresses criticism on the initial idea and proposes an adjustment of ROTI by defining  $I_L$  as  $I_L(t)$  which reflects the working hours of the affected employees in a certain time period. Based on the assumption that the displacement effect of digital technologies (Acemoglu & Restrepo, 2018a, 2018b, 2019b, 2020) only substitutes single or multiple tasks, but not a full-time equivalent employee, the remaining tasks need to be accumulated and distributed newly across the remaining workforce. Consequently, the respective employees need to have the required capabilities and skills to take over these tasks. It is important to emphasize, that the proposal in this paper is hence focusing on single job types since cross-functional task-overlaps can't be covered due to missing employee skills. Ultimately, the corrected formula also captures the job type (j).

$$ROTI(t) = \frac{TR(t)}{I_L(t,j)} \quad (2)$$

ROTI manifests successful progress within the course of a digital transformation, if

$$digtech(t) < digtech(t + 1) \text{ while } I_L(t, j) > I_L(t + 1, j) \quad (3)$$

Additionally,  $j$  implies the existence of delimitable tasks which can be replaced by digital technologies while the remaining tasks can be newly distributed across the employees at  $j$ . Therefore,

$$j = \text{tasks}\{t1; t2; \dots; tx\} \quad (4)$$

while tasks need to be assigned to tasks that can be substituted by digital technologies ( $\text{tasks}_{digtech}^t\{t1; t2; \dots; tx\}$ ) and tasks that are shielded by this effect ( $\text{tasks}_{non-digtech}^t\{t1; t2; \dots; tx\}$ ).

However, the conception of digitalization itself accompanies science and business already since years (Stolterman & Croon Fors, 2004) by revealing an intense and steady impact on firms, but the understanding of digitalization related terms still varies from source to source (Harwardt, 2019). Therefore, the paper proposes a conceptual distinction between the digitalization-related terms of digitization, digitalization itself, digital transformation and unravels the term digital technologies. The objective covers an attempt of conceptual clarification to uniformly determine arithmetical measurements such as ROTI. The remainder of the paper is structured as follows: First, a literature analysis to conceptually distinguished the terms, second, illuminating the notion of digital technologies, third, a conceptual proposal about the impact of the notions compiled on human capital in the results, and fourth, a research agenda suggesting advanced research in this field.

## 2. Method

The second section of the paper's body describes the method, a literature review reflecting the current scientific status quo which analyzes the most relevant scholars in this field. Therefore, the paper is devoid of empirical data (Döring & Bortz, 2016), but combines literature from the field of information and business research illuminating a lack of clarity concerning digitalization-related terms and their impact on business efficiency research with human labor and digital technologies as variable input factors for work.

### 2.1 Conceptualization of Digitalization-Related Terms

As presented in the introduction of the paper, digitalization is impacting society, our private lives, and businesses, while the latter constantly follow the endeavors to keep up with the volatile market economy (Legner et al., 2017). However, there is no common conceptual distinction for the terminology digitalization (Botzkowski, 2018; Harwardt, 2019), especially between digitalization and digital (Krickel, 2015; Ritter & Pedersen, 2020). Furthermore, there is frequent confusion between digitalization and digitization as well as digital transformation (Legner et al., 2017; Vial, 2019). For example, Parviainen et al. (2017) use digitalization and digital transformation as a synonym. From technical perspective digitization is the conversion from analog to digital data (Loebbecke, 2006; Loebbecke & Picot, 2015; Negroponte, 1995) which Brynjolfsson and McAfee (2014) highlight in the business and societal context as the headline of their fourth chapter in *The Second Machine Age*: "The digitization of just about everything". There is a clear conceptual clarification required which is elaborated by the overview in table 1.

Table 1: Literature Review of Digitalization-Related Terms

<b>Digitalization</b>	
(Tilson et al., 2010, p.749)	„...a sociotechnical process of applying digitizing techniques to broader social and institutional contexts that render digital technologies infrastructural.”
(Dougherty & Dunne, 2012, p.1467)	“Digitalization goes beyond the technical process of encoding information in digital format and involves organizing new sociotechnical structures (e.g., science) with digitized artifacts.”
(Brennen & Kreiss, 2016, p.6)	“to broadly refer to the structuring of many and diverse domains of social life around digital communication and media infrastructures”
(Legner et al., 2017, p.301)	“While digitization puts emphasis on digital technologies, the term digitalization has been coined to describe the manifold sociotechnical phenomena and processes of adopting and using these technologies in broader individual, organizational, and societal contexts.”
<b>Digitization</b>	
(BarNir et al., 2003, p.792)	“The transition from conducting business activities in a traditional manner to conducting them in a digital form.”
(Johnson & Bharadwaj, 2005, pp.3–4)	“... creation of a technology-based capability to perform activities previously performed by human capital as the digitization of firm capability.”
(Yoo et al., 2010, p.725)	“... carrying out of new combinations of digital and physical components to produce novel products.”
(Tilson et al., 2010, p.749)	“... the process of converting analog signals into a digital form, and ultimately into binary digits (bits).”
(Loebbecke & Picot, 2015, p.149)	„... conversion of analog to digital information ...”
(Brennen & Kreiss, 2016, p.1)	“the technical process of converting streams of analog information into digital bits of 1s and 0s with discrete and discontinuous values.”
(Legner et al., 2017, p.301)	“Digitization dematerializes information and decouples information from physical carriers and storage, transmission, and processing equipment.”
(Ross, 2019, p.3)	“Digitization involves standardizing business processes and is associated with cost cutting and operational excellence.”
<b>Digital Transformation</b>	
(Stolterman & Croon Fors, 2004, p.689)	“The digital transformation can be understood as the changes that the digital technology causes or influences in all aspects of human life.”
(Lucas et al., 2013, p.372)	“... a change precipitated by a transformational information technology”
(Matt et al., 2015, p.340)	“... digital transformation strategy is a blueprint that supports companies in governing the transformations that arise owing to the integration of digital technologies, as well as in their operations after a transformation. ... use of technologies, changes in value creation, structural changes, and financial aspects.”
(Demirkan et al., 2016, p.14)	“Digital transformation is the profound and accelerating transformation of business activities, processes, competencies, and models to fully leverage the changes and opportunities brought by digital technologies and their impact across society in a strategic and prioritized way.”
(Hess et al., 2016, p.124)	“Digital transformation is concerned with the changes digital technologies can bring about in a company’s business model, which result in changed products or organizational structures or in the automation of processes.”
(Li et al., 2018, p.1130)	“... digital transformation highlights the impact of IT on organizational structure, routines, information flow, and organizational capabilities to accommodate and adapt to IT. In this sense, digital transformation emphasizes more the technological root of IT and the alignment between IT and businesses.
(Legner et al., 2017, p.306)	“Digital transformation is the technology-induced change caused by digital business. It embraces the necessary goal-oriented organizational, process, and technological transformation necessary for organizations to succeed in the digital age. Digital transformation requires organizations to understand how business models can be implemented and how digitalization changes how organizations are managed.”
(Vial, 2019, p.121)	“a process that aims to improve an entity by triggering significant changes to its properties through combinations of information, computing, communication, and connectivity technologies”

Source: Own Illustration

The literature review about the manifold conceptual definitions reveals that digitalization is defined as a sociotechnical phenomenon or process (Dougherty & Dunne, 2012; Legner et al., 2017; Tilson et al., 2010). It describes the adoption and usage of digital technologies in different contexts socially, organizationally, and individually (Dougherty & Dunne, 2012; Legner et al., 2017; Loebbecke & Picot, 2015). Whereas Brennen and Kreiss (2016) focus on the structure of the social life around digital technologies, Tilson et al. (2010) omit the application to the individual perspective.

From the technical perspective, digitization focuses on the transition or conversion of analog to digital signals (Tilson et al., 2010) or information (Brennen & Kreiss, 2016; Loebbecke, 2006). Emphasizing the business perspective, it is also understood as the digital conversion of activities in a traditional manner (BarNir et al., 2003) and activities previously performed by human labor (Johnson & Bharadwaj, 2005). Yoo et al. (2010) concentrate on the combination of both, digital and physical components, to create novel products whereas Legner et al. (2017) stress a decoupling and dematerialization of information. Furthermore, the understanding also implies business process standardization accompanied by operational excellence and cost-cutting effects (Ross, 2019), which also relates to efficiency increases.

The third conceptual dilution is caused by the term digital transformation. It comprises the resulting alterations through digital technologies affecting all aspects of human life (Stolterman & Croon Fors, 2004), society (Demirkan et al., 2016), organizational structures, and value creation (Matt et al., 2015) as well as the transformation of business processes and activities (Demirkan et al., 2016; Hess et al., 2016) including firm's business models (Hess et al., 2016). Legner et al. (2017) offer a vast scope of conceptual determinations within the context of organizations. They underline the technology-induced change, the required success in the digital era as well as the understanding of how organizations are managed. It is not only a change but also opportunities arising (Demirkan et al., 2016). Li et al. (2018) emphasize the impact of information technology on organizations accompanied by its alignment with businesses functions whereas Lucas et al. (2013) argue solely a change encompassed by digital technologies. Ultimately, Vial (2019) creates a definition derived out of 23 unique definitions through grounded theory methodology. He however stresses that his definition is "not organization-centric" (Vial, 2019, p.121).

The literature already proposes a relationship between the three synonymously-used terminologies and determines them as single steps within the whole process to become digital (Verhoef et al., 2021). However, the determination, scope, and application of digital technologies still stay vague. Digitalization and digital transformation embrace the usage and adoption of digital technologies (Demirkan et al., 2016; Hess et al., 2016; Legner et al., 2017; Matt et al., 2015; Stolterman & Croon Fors, 2004) for which literature applies synonyms such as digitizing techniques (Tilson et al., 2010) digitized artifacts (Dougherty & Dunne, 2012), transformational information technology (Lucas et al., 2013) or information technology (Yoo, 2010; Yoo et al., 2010). The compilation of the conceptual variety of digital technology and its synonyms reveals a broad set of different manifestations. Denner et al. (2018) furthermore emphasize in their business process management research the lack of conciseness of the terminology of digital technologies and propose to focus on the classification of different digital technologies. Vial (2019) supports this point of view and provides an intensive literature analysis of digital technologies while disrupting the competitive landscape and describing its nature. Furthermore, the distinction between digitization and digitalization is

besides high focus in information systems research, also represented in recent marketing scholars (Ramaswamy & Ozcan, 2018).

## 2.2 Conceptualization of Digital Technologies

Nambisan (2017) proposes the consideration of three different but connected elements: digital artifacts, platforms, and infrastructure, which are components of a digital transformation as such, illuminating subtleties of the conceptuality, in contrast to the sole consideration of digital technologies.

Table 2: Unravelling Digital Technologies

<b>Digital Technologies</b>	
(Legner et al., 2017, p.306)	"... social media, bigdata, the Internet of Things, mobile, computing, and cloud computing ..."
(Legner et al., 2017, p.302)	"... digital technologies complement and/or enrich existing products and services and allow building entirely new business models."
(Ross, 2019, p.3)	"powerful, accessible, and potentially game-changing technologies like social, mobile, cloud analytics, internet of things, cognitive computing, and biometrics."
(Ritter & Pedersen, 2020, p.181)	"Information technology uses binary digits, such that a digit can have a value of either 0 or 1. When digits are used to represent data, the data become digitized. In contrast, analog data are not available as strings of zeros and ones."
<b>Digital Artifacts</b>	
Ekbia (2009, p.2555)	"It has aspects that make it special—an active, immanent, unstable, and loosely bounded entity that meaningfully constitutes, and is constituted by, its environment. It is a quasi-object."
Nambisan (2017, p.1031) summarizes the understandings of Ekbia (2009) and Kallinikos et al. (2013)	"... a digital component, application, or media content that is part of a new product (or service) and offers a specific functionality or value to the end-user."
<b>Digital Platforms</b>	
Tiwana et al. (2010, p.675)	"... extensible code base of a software-based system that provides core functionality shared by the modules that interoperate with it and the interfaces through which they interoperate"
McAfee and Brynjolfsson (2017, p.118)	"a platform can be described as a digital environment characterized by near-zero marginal cost of access, reproduction, and distribution."
Nambisan (2017, p.1032) summarizes Parker et al. (2016) and Tiwana et al. (2010)	"a shared, common set of services and architecture that serves to host complementary offerings, including digital artifacts"
Sebastian et al. (2017, p.203) refer to a digital service platform	"...the technology and business capabilities that facilitate rapid development and implementation of digital innovations."
Reinartz et al. (2019, p.352)	"Platforms are digital intermediaries that efficiently link external producers/sellers to consumers, thereby enabling value-creating interactions."

### Digital Infrastructure

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Tilson et al. (2010, p.748)	“... digital infrastructures can be defined as the basic information technologies and organizational structures, along with the related services and facilities necessary for an enterprise or industry to function.”
Hanseth and Lyytinen (2010, p.4) <sup>1</sup>	“... a shared, open (and unbounded), heterogeneous and evolving socio-technical system (which we call installed base) consisting of a set of IT capabilities and their user, operations and design communities.”
Henfridsson and Bygstad (2013, p.908) summarize the understanding of Braa et al. (2007) and Tilson et al. (2010).	“... the collection of technological and human components, networks, systems, and processes that contribute to the functioning of an information system...”
Nambisan (2017, p.1032)	“... digital infrastructure is defined as digital technology tools and systems (e.g., cloud computing, data analytics, online communities, social media, 3D printing, digital makerspaces, etc.) that offer communication, collaboration, and/or computing capabilities to support innovation and entrepreneurship.”

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Source: Own Illustration

Table 2 enlightens the possible differentiation into more than only one category of digital technologies. Examples of digital artifacts are webpages, blogs, social network environments (Ekbia, 2009) bookings, and currency exchange systems (Kallinikos et al., 2013). Kallinikos et al. (2013) additionally present an overview of several understandings: quasi-objects (Ekbia, 2009), combinability, immaterial, non-rival nature reproducible, reproducible (Faulkner & Runde, 2009), reprogrammable and self-referential entities (Yoo, 2010; Yoo et al., 2010). Yoo (2010) presents examples such as refrigerators, televisions, or telephones determined as digitized in the context of everyday artifacts. An utilized synonym is also digital object characterized by four different attributes to determine its constitution (Kallinikos et al., 2013). First, editable to continuously update and modify items, digital content, and data, second, interactive to explore information, increase flexibility and responsiveness, third, accessible and modifiable by further digital objects (Yoo, 2010) and fourth, distributed, borderless, and can enable various combinations of programs and items (Kallinikos et al., 2013). Yoo (2010) presents an understanding of digital artifacts by homogenizing data from non-digital artifacts (digitization). On the one hand, they can be autonomous hardware or software components on physical artifacts, and on the other hand an integrated component operating on digital platforms (Nambisan, 2017).

The conceptual analysis of digital artifacts already involves the modularity of a digital platform consisting of components which are “an add-on software subsystem that connects to the platform to add functionality to it” (Tiwana et al., 2010, p.675) following the understanding from Nambisan (2017) of integrated digital artifacts. Examples are platforms operating a system such as Android and iOS (Nambisan, 2017; Reuver et al., 2018; Tiwana et

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<sup>1</sup> Initially utilizing the terminology „information infrastructure“

al., 2010) which Tiwana et al. (2010) use as examples to explain the definition of digital platforms and the example of iPhone apps to clarify the understanding of modules. When defining digital platforms, literature also reveals a technical and sociotechnical perspective. The technical view explains digital platforms as “an extensible codebase to which complementary third-party modules can be added” (Reuver et al., 2018, p.127) while the sociotechnical view describes “technical elements (of software and hardware) and associated organizational processes and standards” (Reuver et al., 2018, p.127). To differentiate digital from non-digital platforms the necessity of several components such as the hardware and software (operating system and applications) is emphasized (Reuver et al., 2018). With a focus on business communities, digital platforms are also described as a digital infrastructure supporting interconnected business processes (Markus & Loebbecke, 2013), such as marketing processes and activities (Rangaswamy et al., 2020).

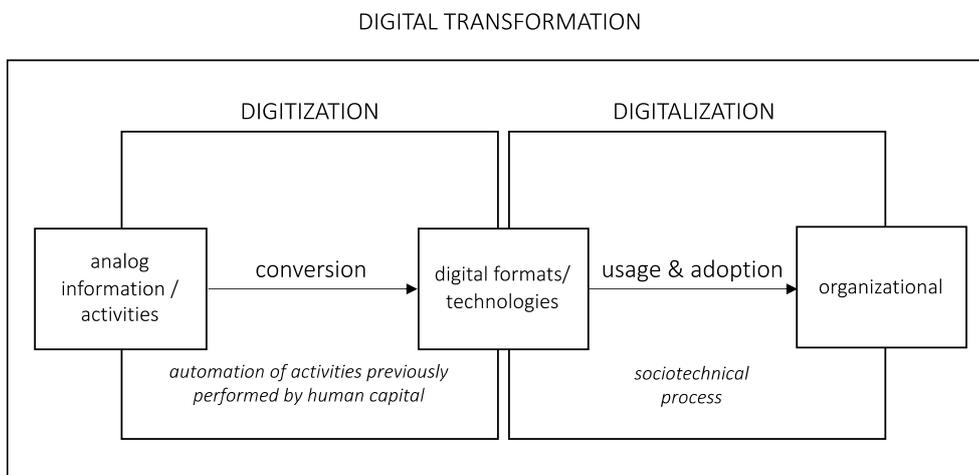
The description of digital infrastructures has developed from a pure understanding of autonomous information systems to an understanding of collective interconnected systems (Henfridsson & Bygstad, 2013). Conceptually, Tilson et al. (2010, p.751) even compound digital infrastructure “as a new type” of IT artifacts but also highlight its necessity for stability to interact with new artifacts (2010, p.754). The composition of the three notions modules, digital platforms, and corresponding ecosystems, which is the collection of modules and platforms (Cusumano & Gawer, 2002; Tiwana et al., 2010), can also be grasped as digital infrastructure.

### 3. Results

The literature analysis reviewing mainly scholars in information and business research, reveals an extensive intersection between digitalization-related terms. The fallacy of utilizing the notions of digitization, digitalization, and digital transformation without experiencing an effect of confusion is still observable. Additionally, the term digital technologies is on the one hand defined as such, but on the other hand split into the three different sub-themes of digital artifacts, digital infrastructure, and digital platforms. However, even for the sub-themes literature is applying synonyms such as information infrastructure (Hanseth & Lyytinen, 2010) or information technology (Lucas et al., 2013). Important to mention is also the missing stringency in literature, as the explanation of digital artifacts is by some authors described with the example of computers (Yoo, 2010) and others use the example of computers to describe digital technologies (Yoo et al., 2010).

Therefore, when considering the impact of technologies on human labor within the course of a digital transformation, it is recommendable to distinguish between the concepts. Figure 1 provides an approach to conceptualizing the terms digitization, digitalization, and digital transformation according to their intentional meanings derived from the literature analysis in the previous chapter.

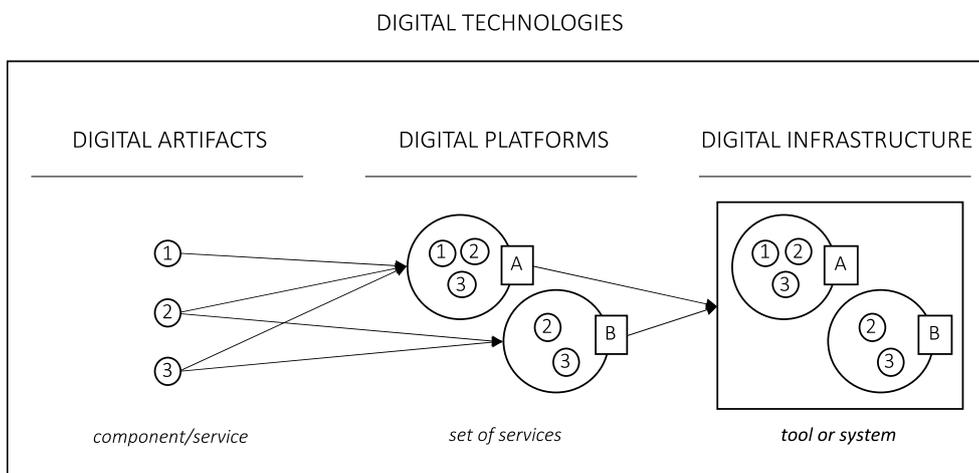
Figure 1: Digitization vs. Digitalization vs. Digital Transformation



Source: Own Illustration

Furthermore, figure 2 builds upon the strategic development and understanding of digitalization-related terms. The conceptualization of digital technologies into three sub-categories represents a more subtle determination of the terminologies to ultimately increase the level of detail when incorporating the impact of digital technologies on human capital.

Figure 2: Digital Technologies and Subordinated Terminologies



Source: Own Illustration

Referring to the task approach (Autor et al., 2003), the main influence factor on human labor is stated as technologies. Later, advanced research building upon this idea of the concept becomes more and more concrete when for example using robotics (Acemoglu et al., 2020), artificial intelligence (Acemoglu & Restrepo, 2019a), or machine learning (Brynjolfsson & Mitchell, 2017) as a replacement for technologies and main forces exerting pressure on human labor. However, to conceptualize the impact of technologies on human capital it is not satisfying to simply apply job or task categorizations such as manual, non-routine analytic, non-routine interactive, abstract and cognitive for high-skilled labor, manual cognitive, manual, and routine for middle-skilled labor, and non-routine manual, manual and social tasks for low-skilled labor (Acemoglu & Autor, 2011; Autor et al., 2003; Autor et al., 2006; Autor et al., 2008; Autor & Dorn, 2013; Autor & Handel, 2013; Beaudry et al., 2016;

Fernández-Macías & Hurley, 2017; Goos et al., 2009, 2014; Goos & Manning, 2007; Michaels et al., 2014; Spitz-Oener, 2006).

Therefore, creating a concept about technologies and their impact on human labor requires the detailed delimitation of main terms like digitization, digitalization, and digital transformation to understand at which stage of change the impact on human labor becomes relevant. Furthermore, digital technologies as such can be distinguished into several different components and consequently represent the urge to define the impact on human capital in a more detailed manner.

Ultimately, the determination of digital technologies (digtech) as input factor for work and as a lever for human capital requires a more specified depiction as part of the model: digital artifact (digart), digital platform (digplat), and digital infrastructure (diginfr).

$$digtech(t) = digart(t); digplat(t); diginfr(t) \quad (5)$$

Finally, the task assignment for digital technologies ( $tasks_{digtech}^t$ ) itemizes accordingly and represents a more detailed model for effect calculation purposes of digital technologies correlating with human capital.

$$tasks_{digart/digplat/diginfr}^t \{t1; t2; \dots; tx\} \quad (6)$$

#### 4. Conclusion

Digitalization is strongly impacting society, businesses, and the ways of working. These changes are neither new to society nor business, but they are characterized by the development of many incidences simultaneously. Labor market developments are explained by the routine-biased technical change hypothesis, arguing the substitution of routine jobs by technologies. Important to mention, the technologies are not described in detail, and so-called engineering bottlenecks hinder jobs to become fully replacing human labor (Frey & Osborne, 2017). Accompanied by unclear conceptual distinctions of digitalization-related terms as well as a split of the notion of digital technologies into three sub-notions, the holistic development of the digital era seems vague and difficult to determine based on details. Therefore, this paper provides a proposal of how to conceptualize the existing terms and presents a research agenda to identify the impact on human labor in a more detailed manner. Digitization describes the conversion of analog information into digital formats, digitalization represents the usage and adoption of those digital formats, and digital transformation covers the process of holistic alteration. Digital technologies can be further divided into digital artifacts, digital platforms, and digital infrastructure. Based on the proposed concept, further research is recommended to model a possible determination of the impact of technologies on human capital in the all-embracing process of digital transformation from analog to digital.

#### References

Acemoglu, D., & Autor, D. (2011). Skills, tasks and technologies: Implications for employment and earnings. In O. Ashenfelter & D. Card (Eds.), *Handbook of labor economics* (4B, pp. 1043–1171). [https://doi.org/10.1016/S0169-7218\(11\)02410-5](https://doi.org/10.1016/S0169-7218(11)02410-5)

- Acemoglu, D., Lelarge, C., & Restrepo, P. (2020). Competing with robots: Firm-level evidence from France. *AEA Papers and Proceedings*, 110, 383–388. <https://economics.mit.edu/files/20339>
- Acemoglu, D., & Restrepo, P. (2018a). Low-skill and high-skill automation. *Journal of Human Capital*, 12(2), 204–232. <https://doi.org/10.3386/w24119>
- Acemoglu, D., & Restrepo, P. (2018b). The race between man and machine: Implications of technology for growth, factor shares, and employment. *American Economic Review*, 108(6), 1488–1542. <https://doi.org/10.1257/aer.20160696>
- Acemoglu, D., & Restrepo, P. (2019a). Artificial intelligence, automation, and work. In A. Agrawal, J. Gans, & A. Goldfarb (Eds.), *The economics of artificial intelligence: An agenda* (pp. 197–236). The University of Chicago Press.
- Acemoglu, D., & Restrepo, P. (2019b). Automation and new tasks: How technology displaces and reinstates labor. *Journal of Economic Perspectives*, 33(2), 3–30. <https://doi.org/10.1257/jep.33.2.3>
- Acemoglu, D., & Restrepo, P. (2020). The wrong kind of AI? Artificial intelligence and the future of labour demand. *Cambridge Journal of Regions, Economy and Society*, 13(1), 25–35. <https://doi.org/10.1093/cjres/rsz022>
- Autor, D., Katz, L., & Kearney, M. (2006). The polarization of the U.S. Labor market. *American Economic Review*, 96(2), 189–194.
- Autor, D. H., & Dorn, D. (2013). The growth of low-skill service jobs and the polarization of the US labor market. *American Economic Review*, 103(5), 1553–1597. <https://doi.org/10.1257/aer.103.5.1553>
- Autor, D. H., & Handel, M. J. (2013). Putting tasks to the test: Human capital, job tasks, and wages. *Journal of Labor Economics*, 31(2), Article 2, 59–96.
- Autor, D. H., Katz, L. F., & Kearney, M. S. (2008). Trends in U.S. Wage inequality: Revising the revisionists. *Review of Economics and Statistics*, 90(2), 300–323. <https://doi.org/10.1162/rest.90.2.300>
- Autor, D. H., Levy, F., & Murnane, R. J. (2003). The skill content of recent technological change: An empirical exploration. *Quarterly Journal of Economics*, 118(4), 1279–1333.
- BarNir, A., Gaullaugh, J. M., & Auger, P. (2003). Business process digitization, strategy, and the impact of firm age and size: The case of the magazine publishing industry. *Journal of Business Venturing*, 18(6), 789–814.
- Beaudry, P., Green, D. A., & Sand, B. M. (2016). The great reversal in the demand for skill and cognitive tasks. *Journal of Labor Economics*, 34(1), 199–247.
- Björkdahl, J. (2020). Strategies for digitalization in manufacturing firms. *California Management Review*, 62(4), 17–36. <https://doi.org/10.1177/0008125620920349>

- Botzkowski, T. (2018). *Digitale Transformation von Geschäftsmodellen im Mittelstand*. Springer Fachmedien Wiesbaden. <https://doi.org/10.1007/978-3-658-20333-7>
- Braa, J., Hanseth, O., Heywood, A., Mohammed, W., & Shaw, V. (2007). Developing health information systems in developing countries: The flexible standards strategy. *MIS Quarterly: Management Information Systems*, 31(2), 381–402.
- Brennen, J. S., & Kreiss, D. (2016). Digitalization. In K. Jensen, E. W. Rotherbuhler, J. Pooley, & R. T. Craig (Eds.), *The international encyclopedia of communication theory and philosophy* (pp. 1–11). John Wiley & Sons, Inc.
- Brynjolfsson, E., & McAfee, A. (2014). *The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies*. Norton.
- Brynjolfsson, E., & Mitchell, T. (2017). What can machine learning do? Workforce implications. *Science*, 358(6370), 1530–1534. <https://doi.org/10.1126/science.aap8062>
- Cusumano, M. A., & Gawer, A. (2002). The elements of platform leadership. *MIT Sloan Management Review*, 43(3), 51–58.
- Demirkan, H., Spohrer, J. C., & Welser, J. J. (2016). Digital innovation and strategic transformation. *IT Professional*, 18(6), 14–18. <https://doi.org/10.1109/MITP.2016.115>
- Denner, M.-S., Püschel, L. C., & Röglinger, M. (2018). How to exploit the digitalization potential of business processes. *Business & Information Systems Engineering*, 60(4), 331–349.
- Döring, N., & Bortz, J. (2016). *Forschungsmethoden und Evaluation in den Sozial- und Humanwissenschaften*. Springer Berlin Heidelberg. <https://doi.org/10.1007/978-3-642-41089-5>
- Dougherty, D., & Dunne, D. D. (2012). Digital science and knowledge boundaries in complex innovation. *Organization Science*, 23(5), 1467–1484. <https://doi.org/10.1287/orsc.1110.0700>
- Ekbia, H. R. (2009). Digital artifacts as quasi-objects: Qualification, mediation, and materiality. *Journal of the American Society for Information Science and Technology*, 60(12), 2554–2566. <https://doi.org/10.1002/asi.21189>
- Faulkner, P., & Runde, J. (2009). On the identity of technological objects and user innovations in function. *Academy of Management Review*, 34(3), 442462.
- Fernández-Macías, E., & Bisello, M. (2020). A taxonomy of tasks for assessing the impact of new technologies on work. *A Joint European Commission–Eurofound Report, JRC Technical Report*.
- Fernández-Macías, E., & Hurley, J. (2017). Routine-biased technical change and job polarization in Europe. *Socio-Economic Review*, 15(3), 563–585. <https://doi.org/10.1093/ser/mww016>

- Frey, C. B., & Osborne, M. A. (2017). The future of employment: How susceptible are jobs to computerisation? *Technological Forecasting and Social Change*, 114, 254–280. <https://doi.org/10.1016/j.techfore.2016.08.019>
- Goos, M., & Manning, A. (2007). Lousy and lovely jobs: The rising polarization of work in Britain. *Review of Economics and Statistics*, 89(1), 118–133.
- Goos, M., Manning, A., & Salomons, A. (2009). Job polarization in Europe. *American Economic Review*, 99(2), 58–63. <https://doi.org/10.1257/aer.99.2.58>
- Goos, M., Manning, A., & Salomons, A. (2014). Explaining job polarization: Routine-biased technological change and offshoring. *American Economic Review*, 104(8), 2509–2526. <https://doi.org/10.1257/aer.104.8.2509>
- Hanseth, O., & Lyytinen, K. (2010). Design theory for dynamic complexity in information infrastructures: The case of building internet. *Journal of Information Technology*, 25(1), 1–19. <https://doi.org/10.1057/jit.2009.19>
- Harwardt, M. (2019). *Management der digitalen Transformation*. Springer Fachmedien Wiesbaden. <https://doi.org/10.1007/978-3-658-27337-8>
- Henfridsson, O., & Bygstad, B. (2013). The generative mechanisms of digital infrastructure evolution. *MIS Quarterly: Management Information Systems*, 37(3), 907–931.
- Hess, T., Matt, C., Benlian, A., & Wiesboeck, F. (2016). Options for formulating a digital transformation strategy. *MIS Quarterly*, 15(2), 123–139.
- Johnson, D. S., & Bharadwaj, S. (2005). Digitization of selling activity and sales force performance: An empirical investigation. *Journal of the Academy of Marketing Science*, 33(1), 3–18. <https://doi.org/10.1177/0092070304266119>
- Kallinikos, J., Aaltonen, A., & Marton, A. (2013). The ambivalent ontology of digital artifacts. *MIS Quarterly: Management Information Systems*, 37(2), 357–370.
- Kirchner, K., Lemke, C., & Brenner, W. (2018). Neue Formen der Wertschöpfung im digitalen Zeitalter. In T. Barton, C. Müller, & C. Seel (Eds.), *Digitalisierung in Unternehmen* (pp. 27–48). Springer Fachmedien Wiesbaden.
- Krickel, F. (2015). Digitalisierung in der Energiewirtschaft. In W. Hecker, C. Lau, & A. Müller (Eds.), *Zukunftsorientierte Unternehmenssteuerung in der Energiewirtschaft* (41–74). Springer Fachmedien Wiesbaden.
- Legner, C., Eymann, T., Hess, T., Matt, C., Böhm, T., Drews, P., Mädche, A., Urbach, N., & Ahlemann, F. (2017). Digitalization: Opportunity and challenge for the business and information systems engineering community. *Business & Information Systems Engineering*, 59(4), 301–308. <https://doi.org/10.1007/s12599-017-0484-2>
- Li, L., Su, F., Zhang, W., & Mao, J.-Y. (2018). Digital transformation by SME entrepreneurs: A capability perspective. *Information Systems Journal*, 28(6), 1129–1157. <https://doi.org/10.1111/isj.12153>

- Loebbecke, C. (2006). Digitalisierung – Technologien und Unternehmensstrategien. In C. Scholz (Ed.), *Handbuch Medienmanagement: Mit 46 Tabellen* (pp. 357–374). Springer.
- Loebbecke, C., & Picot, A. (2015). Reflections on societal and business model transformation arising from digitization and big data analytics: A research agenda. *Journal of Strategic Information Systems*, 24(3), 149–157. <https://doi.org/10.1016/j.jsis.2015.08.002>
- Lucas, H. C., Agarwal, R., Clemons, E. K., El Sawy, O. A., & Weber, B. (2013). Impactful research on transformational information technology: An opportunity to inform new audiences. *MIS Quarterly: Management Information Systems*, 37(2), 371–382.
- Markus, M. L., & Loebbecke, C. (2013). Commoditized digital processes and business community platforms: New opportunities and challenges for digital business strategies. *MIS Quarterly: Management Information Systems*, 37(2), 649–653.
- Matt, C., Hess, T., & Benlian, A. (2015). Digital transformation strategies. *Business & Information Systems Engineering*, 57(5), 339–343. <https://doi.org/10.1007/s12599-015-0401-5>
- McAfee, A., & Brynjolfsson, E. (2017). *Machine, Platform, Crowd: Harnessing Our Digital Future*. NY Norton.
- McGrath, R., & McManus, R. (2020). Discovery-driven digital transformation: Learning your way to a new business model. *Harvard Business Review*, May-June, 124–133.
- Michaels, G., Natraj, A., & van Reenen, J. (2014). Has ICT polarized skill demand? Evidence from eleven countries over twenty-five years. *Review of Economics and Statistics*, 96(1), 60–77. [https://doi.org/10.1162/REST\\_a\\_00366](https://doi.org/10.1162/REST_a_00366)
- Nambisan, S. (2017). Digital entrepreneurship: Toward a digital technology perspective of entrepreneurship. *Entrepreneurship: Theory and Practice*, 41(6), 1029–1055. <https://doi.org/10.1111/etap.12254>
- Negroponte, N. (1995). *Being Digital*. Vintage Books.
- Parker, G. G., van Alstyne, M. W., & Choudary, S. P. (2016). *Platform Revolution: How Networked Markets are Transforming the Economy and How to Make Them Work for You*. WW Norton & Co.
- Parviainen, P., Tihinen, M., Kääriäinen, J., & Teppola, S. (2017). Tackling the digitalization challenge: How to benefit from digitalization in practice. *International Journal of Information Systems and Project Management*, 5(1), 63–77.
- Ramaswamy, V., & Ozcan, K. (2018). Offerings as digitalized interactive platforms: A conceptual framework and implications. *Journal of Marketing*, 82(4), 19–31. <https://doi.org/10.1509/jm.15.0365>

- Rangaswamy, A., Moch, N., Felten, C., van Bruggen, G., Wieringa, J. E., & Wirtz, J. (2020). The role of marketing in digital business platforms. *Journal of Interactive Marketing*, 51(August), 72–90. <https://doi.org/10.1016/j.intmar.2020.04.006>
- Reinartz, W., Wiegand, N., & Imschloss, M. (2019). The impact of digital transformation on the retailing value chain. *International Journal of Research in Marketing*, 36(3), 350–366. <https://doi.org/10.1016/j.ijresmar.2018.12.002>
- Reuver, M. de, Sørensen, C., & Basole, R. C. (2018). The digital platform: A research agenda. *Journal of Information Technology*, 33(2), 124–135.
- Ritter, T., & Pedersen, C. L. (2020). Digitization capability and the digitalization of business models in business-to-business firms: Past, present, and future. *Industrial Marketing Management*, 86, 180–190. <https://doi.org/10.1016/j.indmarman.2019.11.019>
- Ross, J. (2019). Don't confuse digital with digitization. In MIT Sloan Management Review (Ed.), *Who wins in a digital world? strategies to make your organization fit for the future* (pp. 3–7). The MIT Press.
- Sebastian, I. W., Ross, J., Beath, C., Mocker, M., Moloney, K. G., & Fonstad, N. O. (2017). How big old companies navigate digital transformation. *MIS Quarterly Executive*, 16(3), 197–213.
- Spitz-Oener, A. (2006). Technical change, job tasks, and rising educational demands: Looking outside the wage structure. *Journal of Labor Economics*, 24(2), 235–270. <https://doi.org/10.1086/499972>
- Stolterman, E., & Croon Fors, A. (2004). Information technology and the good life. In B. M. Kaplan, D. P. Truex, D. Wastell, Wood-Harper, A. Trevor, & J. I. DeGross (Eds.), *IFIP: Vol. 143. Information systems research: Relevant theory and informed practice* (pp. 687–692). Kluwer Academic Publishers.
- Tarafdar, M., & Davison, R. (2018). Research in information systems: Intra-disciplinary and inter-disciplinary approaches. *Journal of the Association for Information Systems*, 19(06), 523–551. <https://doi.org/10.17705/1jais.00500>
- Tilson, D., Lyytinen, K., & Sørensen, C. (2010). Research commentary —digital infrastructures: The missing is research agenda. *Information Systems Research*, 21(4), 748–759. <https://doi.org/10.1287/isre.1100.0318>
- Tiwana, A., Konsynski, B., & Bush, A. A. (2010). Research commentary —platform evolution: Coevolution of platform architecture, governance, and environmental dynamics. *Information Systems Research*, 21(4), 675–687. <https://doi.org/10.1287/isre.1100.0323>
- Vadana, I.-I., Torkkeli, L., Kuivalainen, O., & Saarenketo, S. (2020). Digitalization of companies in international entrepreneurship and marketing. *International Marketing Review*, 37(3), 471–492. <https://doi.org/10.1108/IMR-04-2018-0129>

- Verhoef, P. C., Broekhuizen, T., Bart, Y., Bhattacharya, A., Qi Dong, J., Fabian, N., & Haenlein, M. (2021). Digital transformation: A multidisciplinary reflection and research agenda. *Journal of Business Research*, 122, 889–901. <https://doi.org/10.1016/j.jbusres.2019.09.022>
- Vial, G. (2019). Understanding digital transformation: A review and a research agenda. *Journal of Strategic Information Systems*, 28(2), 118–144. <https://doi.org/10.1016/j.jsis.2019.01.003>
- Yoo, Y. (2010). Computing in everyday life: A call for research on experiential computing. *MIS Quarterly: Management Information Systems*, 34(2), 213–231.
- Yoo, Y., Henfridsson, O., & Lyytinen, K. (2010). Research commentary —the new organizing logic of digital innovation: An agenda for information systems research. *Information Systems Research*, 21(4), 724–735. <https://doi.org/10.1287/isre.1100.0322>