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ORIGINAL ARTICLE

Prolegomena to social studies of digital innovation

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Abstract
The rise of the digital economy, in terms of digital innovation (DI), requires the reconsideration of the notion of innovation to clarify its conceptualisation in a post–industrial digital economy. The current science, technology, innovation (STI), and social studies of innovation are lacking conceptual, theoretical, and analytical grounds for the exploration of DI, despite their pervasive impact on our lives. The aim of this study is to provide a conceptual framework for the exploration of DI, driven by growing recognition of the fact that the concept of innovation is faced with contemporary crises due to the theoretical and analytical limits of industrial innovation when adapting to socio-economic changes. This article discusses the ways in which intrinsic features of DI differentiate from industrial innovation, constructing the concept of DI around its two distinctive features: raising social inequality through four selected mechanisms and disrupting business models with ambivalent consequences. These characteristics have been identified to be the most intriguing when attempting to understand the nature of DI in today's digital society. This research applies an intersectional and interdisciplinary approach, allowing for a critical and qualitative analysis of the current concepts of DI in different scientific fields and their convergence into a common theoretical ground for the social science of DI.

Keywords Digital innovation · Conceptual framework · Science technology and innovation (STI) studies · Social studies of innovation · Digital transformation · Social inequality · Digital entrepreneurialism · Digital monopolies

1 Introduction

The aim of this study is to provide a conceptual framework for the exploration of digital innovation (DI) within social and STI (science, technology, and innovation) studies of innovation. This research framework focuses on two distinctive features of DI. The first relates to the four factors that increase social inequality and the second refers to, on the one hand, disruptive business models that enable entrepreneurship dynamics and, on the other hand, market monopolies that destroy equal entrepreneurial opportunities. This study has been instigated by the increasing recognition of the fact that STI and social studies of innovation are facing contemporary crises, as it seems that industrial-inspired analyses of innovation have reached their intrinsic limits, not only within STI studies (Soete 2019) but also within economic theories (Cowen 2011; Gordon 2016) and theories of capitalism (Haskel and Westlake 2018). Many leading scientists, across a range of disciplines, such as innovation studies (Fagerberg et al. 2013; Martin 2016), innovation management (Nambisan et al. 2017; Nylen and Holmstrom 2015), innovation policies (Schot and Steinmueller, 2018; OECD 2018a, p. 83), and entrepreneurship (Nambisan 2016; Autio et al. 2018), have estimated that our current concept of innovation has reached its limit and thus requires re-conceptualization.

The driver of the current crisis in innovation research can be seen in digital transformation. This makes contemporary innovation an uncharted territory, thereby encouraging a radical rethinking of how individuals and organizations may innovate and raising questions regarding their socio-economic impacts (Nambisan et al. 2019). The frontiers of research on innovation, innovation systems, and policies were well defined in industrial and knowledge-based economies because they were very much grounded in the theoretical and conceptual foundations laid by the neo-Schumpeterian, evolutionary, and institutional schools of economics. These strains of thoughts were pioneered by leading scientists, such as C. Freeman, G. Dosi, and R. Nelson, whose seminal contributions gave rise to the growth

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of these fields. Within the industrial society, innovation was understood to be a commercial application of research and development (R&D), embodied in new products, processes, and services (OECD 1971). This forms the backbone of innovation policy, which is focused on setting up institutions and programmes to accelerate the dynamicity of technology-based innovations in a specific national environment, usually known as the "national system of innovations" (Freeman 1988). Within the knowledge-based economy (which has become an extension of sorts to the industrial development model, but with more of a focus on scientific knowledge, high technologies, and service innovation), the nature of innovation did not change much.

However, with the rise of digital technologies, intangible economy, "smart" Industry 4.0, and artificial intelligence, the world of innovation has been seriously shaken. The various digital components—internet, networks, hardware, software, big data, and cloud computing—are infiltrating the business and social world, reshaping not only the techno-economic fundamentals of innovation generation but also the nature and structure of social interaction. Social consequences which are dictated, to some scholars, by an exploitative ideology of digital economy (Betancourt 2015), invasion of privacy (Zuboff 2015), and platform capitalism (Srnicek 2016), or by digital platforms that meddle with a state's sovereignty (van Dijck et al. 2018), seem to be dramatically greater.

The basic thesis of this research is that the change in the nature of innovation itself—that is, the replacement of physical industrial innovation with digital innovation—is in the midst of deep structural changes with regards to economy and society. The upsurge of DI affects not only the technological basis of innovation, including production, employment, markets, and public policies for fostering innovation (OECD 2018a), but also social environments and relationships captured by the rising number of sociological studies (Marres 2017; Lupton 2014; Selwin 2019) and critical readings in platform economy (Betancourt 2015; Srnicek 2016) and society (van Dijck et al. 2018; Zuboff 2015).

Digital innovation constitutes today, to paraphrase Marres's definition of "digital" (Marres 2017), a "total social fact", i.e. a factor that affects all aspects of the economy and society. This makes the process of digital transformation a global practice; one which no economy or society can ignore if it wants to prosper. As such, understanding the nature of DI and related technological changes seems to be an essential prerequisite for exploiting the potential of digital transformation for the success of not only the national economy but society as well.

However, DI and digital transformation are somewhat absent in recent theories of innovation, STI studies, and social studies of innovation. There is little conceptual and empirical research that examines DI and how it differs from other types of innovation, especially industrial innovation. The new features of innovation, which could form a potential common ground for the conceptualisation of DI, remain mostly unexplored. This suggests that the theory of innovation within social and STI studies might be stuck in the past, lagging behind—theoretically and conceptually—real changes in the nature and practice of DI.

Therefore, the aim of this research is to provide a possible conceptual approach for the exploration of DI within the social study of innovation and STI studies. Following the previous conceptualisation of DI, especially those devised by Fichman et al. (2014) and Yoo et al. (2010), DI is understood quite broadly as a complex socio-economic and technological phenomenon, based on digital technologies which can be embodied in a product, process, or business model and have a pervasive impact on the entire socio-economic system.

The main research question is: What distinctive characteristics of digital innovation open up new research domains in STI and the social study of innovation?

To address this question, this research is divided into two parts. The first discusses the exiting concepts and definitions of DI to shed additional light on the differences between digital and industrial innovation and to provide answers to the following questions: What do we mean when we think of DI? How is DI different from industrial innovation? Is the digital materiality of DI a distinct type of intangibility of knowledge (ideas, R&D, know-how, etc.) embedded in industrial products and, if so, how is it different? This research requires a critical qualitative analysis of the theoretical frameworks and concepts drawn from existing literature; mainly information system and business management research.

The second part of this article offers a possible conceptualisation of DI as a complex, socio-economic phenomenon related to two distinct characteristics: social inequality and disruptive changes in business models. More specifically, it is argued that DI, as a result of its specific nature, can increase social inequality through different mechanisms, disrupting existing business models that favour entrepreneurial types of innovation over R&D. However, it might also, on the other hand, create market monopolies that hinder entrepreneurialism.

These features, related to social inequality, disruptiveness, entrepreneurialism versus monopolies, are deemed to be the most intriguing when attempting to understand the nature of DI, as their meanings persist as ambiguous, inconclusive, and dichotomous, from both a theoretical and practical point of view. On the other hand, they have a great impact on society and economy, and, therefore, are a set of research themes that can provide a future research agenda for STI and social studies of innovation. Needless to say, this does not mean that there are numerous other

themes that are equally productive when comprehending DI. This research only tends to shed some light on new opportunities in social and STI studies with regards to the pervasive impact of digitalisation, as illustrated by the theoretical analyses of the impact of DI in the broader context of socio-economic changes.

After a brief description of the methodology (Sect. 2), the study begins with a search for the definition of digital innovation and its distinctive characteristics in relation to industrial innovation (Sects. 3 and 4). The analysis is then expanded, with the conceptualisation of DI based on two distinct features considered to be the most important when gaining a deeper understating of the nature of DI (Sect. 5). The conclusions and the implications of the research are presented in Sect. 6.

2 Methodology

This research is primarily conceptual and relies, from a methodological point of view, on the integrative literature review approach, which aims to critically synthesize the literature on a research topic in a way that allows for new theoretical frameworks and perspectives (Snyder 2019, p. 335). In comparison to other literature reviews—primarily those that are systematic and semi-structured—an integrative review is recommended when studying broader subjects or new and emerging topics within diverse disciplines. This could render a full systematic review process difficult (Snyder 2019) or lead to the provision of an exhaustive list of literature that fails to provide a coherent conceptual structure for the topic itself (Webster and Watson, 2002). For this research, a new research topic requires a new theoretical framework from an interdisciplinary perspective regarding the phenomenon of DI. An integrative review, seeking to create initial or preliminary conceptualizations and theoretical models, seems to be an appropriate methodological approach to facilitate further conceptualization of DI. The integrative review places more focus on amassing a creative collection of different literature resources, combining perspectives from different fields or research traditions, rather than covering every article ever published on a certain topic. In the absence of any established theoretical and analytical grounds, this research draws on existing literary and theoretical sources from a range of disciplines, mostly from the economics of innovation, entrepreneurship, business management, organizational studies, information sciences, and STI studies. It relies on intersectional and interdisciplinary analyses which allow for critical and qualitative assessments of diverse strands of thought when it comes to the current concepts of DI and its selected features.

3 What is digital innovation?

The task of defining DI as a subfield of innovation studies is also quite difficult because it is estimated (Herterich and Mikusz 2016) that the body of knowledge on digital artefacts and innovation is disparate, complex, and interdisciplinary, and researchers face difficulties in overseeing existing literature. While academic literature concerning the social aspects of DI has been rather silent so far, literature on the economics of innovation, innovation management, and information systems has taken the lead, focusing their efforts on the technological and economic aspects of DI.

Research on DI has its roots in information system literature (Warner and Wäger 2019; Nambisan et al. 2017). For four decades, scholars have examined the emergence and the consequences of digitalisation. The most recent studies in information systems research relevant to the conceptualisation of DI are focused on the distinctive features of DI (Fichman et al. 2014; Yoo 2010; Yoo et al. 2012); its layered architecture (Hylving and Schultze 2013; Yoo et al. 2010); and new types of innovation, such as digitised service innovation (Herterich et al. 2016), etc. On the other hand, economic and management studies are mainly interested in the influence of DI on economic growth (Brynjolfsson and McAfee 2014; Paunov and Planes-Satorra 2019; Gordon 2016; Cowen 2011), productivity paradoxes (Andrews et al. 2018; Crosculo 2015), the digital transformation of incumbent companies (Singh and Hess, 2017; Warner and Wäger 2019; D'Ippolito 2019), and new organization models (Hinings et al. 2018), etc.

These many approaches are reflected in the variety of definitions of DI (Table 1). However, the majority of definitions mirror the most common and frequently referenced definition offered by Yoo et al. (2010. p. 725), by which DI is "the carrying out of new combinations of digital and physical components to produce novel products". Nambisan et al. (2017, p. 224) and Fichman et al. (2014) extend the definition of DI beyond digital products alone. According to these researchers, DI includes the creation of (and consequent change to) market offerings, business processes, business models, and even platforms resulting from the use of digital technology. For Fichman et al. (2014), DI is a fundamental and powerful concept (FPC), which means that the concept of DI can be used to explain a number of questions, problems, information, and situations. This conceptualization includes three types of DI innovation (i.e., process, product, and business model innovation), and four stages for the overall innovation process (i.e., discovery, development, diffusion, and impact).

All research strands on DI emphasise, however, that the specific materiality of DI, as a special mode of

Table 1 Examples of definitions of DI

Nambisan et al., 2017	Digital innovation is the use of digital technology during the process of innovating. We conceptualize digital innovation as the creation of (and consequent change in) market offerings, business processes, or models that result from the use of digital technology
Hylving and Schultze, 2013	Digital innovation entails the combining of digital and physical components to produce novel products. The materiality of digital artefacts, particularly the separation between their material (e.g., hardware) and immaterial features (e.g., software and data), which is expressed through a layered architecture, lays the foundation for the generative potential of digital innovation
Herterich and Mikusz, 2016	Digitized artefacts are characterized by both digital and physical materiality. 'Connected cars' are an example of such digitized artefacts
Fichman et al. 2014	We define digital innovation quite broadly as a product, process, or business model that is perceived as new, requires some significant changes on the part of adopters, and is embodied in or enabled by IT
Hinings et al., 2018	As such, digital innovation is about the concerted orchestration of new products, new processes, new services, new platforms, or even new business models in a given context

intangibility, makes it fundamentally different from non-digital innovations, which rapidly change the nature of the innovation processes (Yoo et al. 2010, 2012; Hylving and Schultze 2013; Herterich et al. 2016). The materiality of DI is comprised of either immaterial digital features (e.g. software or data) or it entails both digital and physical components to produce novel products (e.g. smart wallet). Digital products can therefore be either intangible digital artefacts (e.g. digital music streams), which are characterized by a purely digital materiality (Herterich and Mikusz 2016), or they can also be a combination of digital and physical components, by which digitalisation adds new material properties (digital materiality) to previously non-digital artefacts (Yoo 2010; Yoo et al. 2012).[1] Such products are known as "hybrid" or "smart" products (Nylen and Holmstrom 2015). This digital materiality, either alone or embedded in physical artefacts, adds value to products and services and lays the foundation for the novelty of DI in contrast to products and processes from the industrial era (Yoo et al. 2012; Hylving and Schultze 2013; Herterich et al. 2016). However, digital materiality or intangibility is rather different from the classical notion of intangibility, as will be elaborated upon in the next section.

4 Does DI differ from industrial innovation?

Innovation theory and mere everyday experiences demonstrate that innovation is becoming increasingly ethereal, disembodied, and intangible, with the help of digitalisation. Central to the definition of digital innovation is its digital materiality or intangibility, which makes it distinct from standard industrial innovations. The augmentation of common things, like books, clothing, home appliances, cars, and so forth, with digital materiality, such as software or sensors, provide novel functions that dramatically improve product designs, production, and distribution and, in essence, have a transformative impact on industrial-age products (Yoo et al. 2010).

However, one might notice that innovations from the industrial age (whether they be as simple as a pencil or as complex as the invention of plastics or television) also consist of two components—the physical and the intangible. The latter relates to human ideas, knowledge, or know-how, which is built into products or processes. This raises the question as to whether digital materiality can be identified through the intangible components of industrial products embodied in human knowledge (ideas, R&D, know-how, etc.). Is digital materiality a distinct type of intangibility embedded in industrial products and, if so, how is it different?

This explanation is offered by Yoo (2010; 2012), who developed the most comprehensive approach in exploring the nature of DI (Herterich et al. 2016) and explaining how digital materiality or digitalisation extends physical products in seven ways: (1) programmability (performing multiple functions); (2) addressability (uniquely identified by RFID chips, for example); (3) sensibility (the ability to monitor and respond to changes in the environment, e.g. the ability of a mobile phone to identify its location using a built-in GPS chip); (4) communicability (the ability to digitally communicate with other objects); (5) memorability (the ability to record and store information, e.g. to remember where they were, who used them, the outcomes of the interactions, etc.); (6) traceability (the possibility of digitally tracing the conditions, movements, and interactions of objects with others, e.g. Wikipedia's history page, which shows the entire revision history of the page); and (7) associability (the ability to be related to and identified with other entities, such as other

[1] A digital artefact is defined as 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 (Nambisan, 2016).

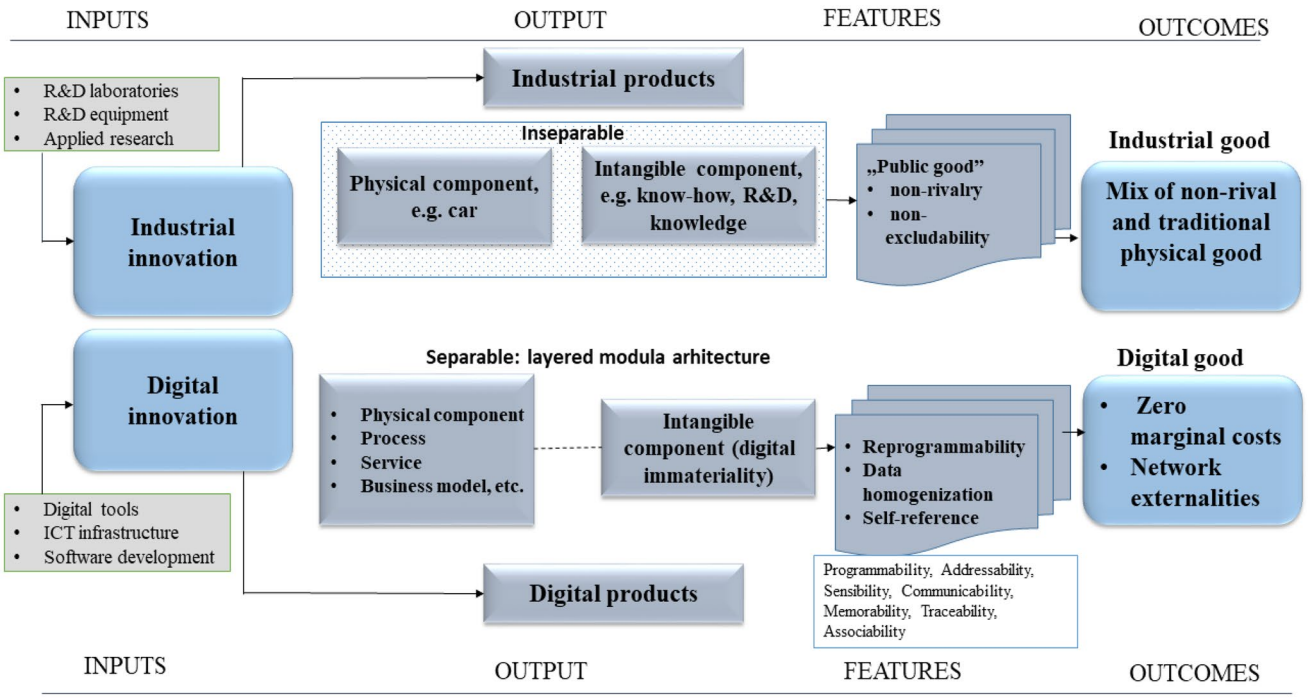

Fig. 1 The differences between industrial and digital innovation

artefacts, places, and people, based on certain commonly shared attributes (Yoo 2010)).

In addition to this, Yoo et al. (2010, p. 726) explain that digital innovation is different from standard innovation owing to three distinct properties of digital technologies: (1) reprogrammability, which allows a digital device to perform a wide array of functions (such as calculating distances, word processing, video editing, and Web browsing); (2) data homogenization (with which any type of digital content can be stored, transmitted, combined, and manipulated by the same media, and networks); (3) the self-referential nature of digital technologies, which means that digital innovation requires the ubiquitous use of digital technology (e.g. the Internet) for its creation and diffusion, creating positive network externalities and drastically reduced entry barriers, learning costs, etc., meaning that anyone—individuals or companies—can participate in the innovation process, thus democratising innovation.

Layered architecture makes the intangibility of DI rather distinct from the intangibility of industrial products, which are usually embodied in human knowledge as a result of R&D, know-how, etc. Human knowledge (despite is non-rivalry type of good, which can be used infinite times, just as DI can) is embedded in innovative products only once and makes inseparable unity with its product, functioning as the physical carrier of knowledge. In contrast, the success of DI rests on the separation of the two. The price of industrial goods includes the cost of the physical object (car, book, etc.) while the layered architecture of DI allows ideas and knowledge, encoded in electronic bits (software, sensors), to be disseminated everywhere instantaneously, at a quasi-zero marginal cost (Guellec and Paunov 2017). This means that this intangible part of a physical object can be rapidly added to a wide range of other digital products at a marginally negligible cost (Huang et al. 2017; Henfridsson et al. 2014, p. 30).[2] The near to zero marginal costs, in combination with the "platform business model" or network company, enable a "network effect". This means that a platform company such as Uber, due to the large number of users who generate value at almost no marginal costs within the platform, may enjoy rapid, exponential growth and unprecedented capital accumulation over a relatively short period of time. Finally, inputs in DI require a broad range of digital tools and infrastructure, such as 3D printing, data analytics, mobile computing, etc. (Nambisan et al. 2017), while intangible components of industrial innovation requires standard R&D laboratories, equipment, and applied research.

It can be concluded that DI is a fairly distinct type of innovation (Fig. 1), which differs from industrial innovation because it possesses a specific digital materiality that dramatically changes the characteristics of physical objects by augmenting them with seven immaterial properties:

[2] Marginal cost is the cost of producing an additional unit of a good or service after fixed costs have been absorbed.

programmability, addressability, sensibility, communicability, memorability, traceability, and associability. Most importantly, DI allows for a layered modular architecture that decouples the physical from the intangible components of objects, which generates new products and services at a marginally negligible cost ("scale without mass") and initiates new business models, strategies, and organizational forms (e.g. digital platforms) (Herterich and Mikusz 2016; Warner and Wäger 2019; Hylving and Schultze 2013; Yoo et al. 2012; Autio et al. 2018; Huang et al. 2017). These new forms require serious changes to innovation management (Nambisan et al. 2017), the organization of companies (Yoo et al. 2010; Autio et al. 2018), business processes (Warner and Wäger 2019; Huang et al. 2017), and even new types of economy catered towards intangibles, as highlighted by Haskel and Westlake (2018).

This characteristic of DI, which makes reproduction costs almost irrelevant, leads us to the examination of other particularities of DI that bring about dramatic changes to the socio-economic system and could serve as a common ground for its conceptualization.

5 Conceptualisation of DI

The concept of DI in this research involves two distinct characteristics. These are linked to social inequality and disruptiveness, which have been identified to be the most intriguing aspects of DI and could therefore form an experimental and provisional set of research themes towards a future research agenda for STI and the social study of innovation. More specifically, it is argued that DI, as a result of its specific nature, has the following properties:

- DI may increase social inequality.
- DI has the ability to disrupt existing business models, including conventional socio-economic categories, such as markets, employment, tax regulations, etc.
- New business models favour entrepreneurial innovation over research-based innovation, contributing to entrepreneurial dynamics whilst also endorsing the emergence of digital monopolies that stifle market competition and entrepreneurialism.

In the following sections, these properties will be considered, providing an introduction for future STI research and the social study of DI.

5.1 DI and social inequality

Growing socio-economic inequality is receiving considerable attention from academics and policy makers on a global scale (Atkinson 2015). Although a certain degree of inequality can provide an incentive for people to invest to move ahead in life, recent scholarly literature tends to converge on the estimation that today's inequalities do not stimulate healthy competition, but rather pose a threat to social stability. Inequality erodes social cohesion, diminishes confidence in politics and institutions, and supports populist parties and actions, such as Brexit (Haskel and Westlake 2018). Sources of inequality are seen today in various factors, such as inherited wealth accumulation (Piketty 2014), rent-seeking economies, biased public policies (Stiglitz 2013), income differences (Guellec and Paunov 2017), properties of intangible economy (Haskel and Westlake 2018), and the current nature of technological change reflected in secular stagnation (Gordon 2016; Cowen 2011).

Significant drivers of inequality can also be perceived in digital technologies embodied in DI. Despite the fact that many studies have shown that digitalisation contributes to economic growth, increases in productivity, and employment (OECD 2017, p.13; WEF, 2017), there are also opposing and equally plausible theories which express scepticism for social and economic ambiguity and uncertainty brought about by the technological changes created by digitalisation and intangible economy. In contrast to the standard literature on economic growth (Solow 1957; Romer 1989), which has so far shown that the rate of technological changes increase total factor productivity and labour productivity, thus contributing to wages, social equality, and progress, the specific properties of DI put the benefit of the digital economy at stake. The most common inequalities driven by DI are inequalities in income, the labour market, employment, and market competition among companies, which lead to inequalities in wealth and the perception of disparities in social status, with adverse political consequences.

Inequalities stemming from digital technologies can be tentatively divided in four groups by their main drivers:

- Technological change.
- Properties of intangible economy.
- "Winner-takes-all" market dynamics.
- Skill-biased technological change.

Inequality related to **technological change** relies upon theories which suggest that developed market economies (e.g. United States) entered a period of secular stagnation (a long term period of stagnant economic growth) due to the slowing technological change with regards to DI (Frey 2015; Gordon 2012). Cowen (2011) suggests that DI cannot contribute to economic growth when compared to breakthrough innovations created throughout modern history, specifically in the 1880–1940 period ("low-hanging fruits" like electricity, refrigerators, motor cars, etc.). Gordon (2012) also claims that the third industrial revolution, which began around 1960 and centred around computers and the Internet,

created only a short-lived growth revival between 1996 and 2004. The most important achievement of this revolution is the replacement of many tedious and repetitive jobs with computers, however, it failed to upgrade the standard of living, especially for those at the bottom on the income scale. Both authors believe that digital technologies are centred around entertainment (producing fun activities, such as games, chat rooms, and Twitter) (Cowen 2011) and communication devices that are smaller and smarter but do not fundamentally change labour productivity or standards of living (Gordon 2012, p. 2). Income gains have been concentrated to only a small number of company founders (e.g. Facebook) and a very small layer of reach (1%–5% of population) and do not contribute to median family incomes at a national level. These studies converge with other pieces of scholarly literature on inequality, especially that of Piketty (2014), who suggested that inequalities and justice are not neutral in terms of economic efficiency. In contrast, they affect not only economic outcomes, but also investment and, therefore, the efficiency of the whole economy. Although Gordon and Cowen's theories received much criticism and remained controversial, they are also welcome in scholarly circles as original contributions enabling an understanding of current economic impediments in advanced economies.

Another problem related to digital technological change is the fundamental paradigm shift in the relationship between capital and labour. Frey (2015) suggests that digital technologies after the 2000s have been much less capital-absorbing, creating insufficient investment and employment opportunities which drive inequality. The economic analysis of Pinney (2014) shows that tangible goods and services are produced with very little need for human labour, except for skilled workers who design and manage technology. Pinney (2014) suggests that the share of total national income going to workers was relatively stable, at around 70%, until decade ago, with the share going towards capital—mainly corporate profits and returns on financial investments—making up the other 30%. The share of the total national income going towards labour in many developed countries has been falling slowly but steadily, while the share going towards capital owners has gone up. Therefore, all around the world, labour is losing out to capital, resulting in the skyrocketing wealth of the top 1% of capital owners.

Inequality produced by DI related to **intangible economy** emerges from the digital (im)materiality of DI, which makes it an intangible asset, typical of an intangible economy and a key component of the production function for many firms. A such, it reflects all properties of the intangible economy which is, according to the widely discussed analysis of Haskel and Westake (2018), fundamentally different from the previous economic regimes and thus a source of many economic malfunctions, from economic inequality and stagnating productivity to populist movements. Investments in intangibles, such as DI, R&D, brands, trademarks, business organisation, marketing, training, etc., share the "unusual economic characteristics" Haskel and Westlake (2018) which are summed up in four S's: Scalability (intangibles can be reused infinite times, like Google's algorithms, Uber's driver network, or Genentech's patents); Sunkenness (costs are lost in the case of failed businesses as it is hard to re-sell intangible assets); Spillovers (firms can use their rivals' tangible assets, such as knowledge, know-how, etc.); and Synergies (intangibles are worth more when combined with other assets, e.g. software with physical devices or within network companies such as Uber).

For Haskel and Westlake (2018), the synergies, spillovers, and scalability created by intangibles increase inequality between competing companies as they allow large and profitable firms to emerge, raising productivity and profit margins between leaders and laggards. Inequality between companies leads to increasing differences in employee pay. The increase in wage is concentrated in the very top income groups, as observed by Piketty (2014). Managing intangibles requires a particular set of skills and education and people with these skills, especially top managers, IT experts, or financial investors, cumulate in high-paid jobs in intangible-intensive firms. In addition to income inequalities, there are many other undesirable consequences of intangibles, such as rising inequalities in wealth, difficulties in taxation (intangibles seamlessly flow across national borders), and growing perceptions that the population is dividing into two halves: one being cosmopolitan, educated, and liberal, and the other being more traditionalist, unable to manage in the digital globalised economy. This has dramatic political consequences in politics, for instance, as in Brexit.

To understand the inequalities produced by digital innovation, it is necessary to distinguish between intangibles in knowledge economy and intangibles in the digital economy as they produce quite oppositional outcomes. Intangibles in knowledge economy consist, according to the endogenous growth theory (Romer 1989, p. 6) of knowledge or ideas. Knowledge has characteristics for the public good, i.e. it is non-rivalrous and non-excludible (it can be used an infinite number times) and produces spillover effects (positive externalities or benefits for those who have not participated in the creation of knowledge) which enable, simply put, synergies at many levels, resulting in constant economic growth and social welfare. This is not, however, the case with the intangibles in the digital economy, as digital innovation possesses digital non-rivalry, which is different from standard non-rivalry. The latter must be embodied in a tangible good (physical carrier) making the price of the goods higher as this includes the cost of a physical object. Therefore, standard non-rivalry is only partial, and the knowledge economy is a mix of non-rival and traditional physical goods economics (Guellec and Paunov 2017, p. 7). With computers and

the Internet, the need for a physical carrier disappears, as ideas, once encoded in electronic bits, can be disseminated everywhere instantaneously, at a quasi-zero marginal cost. This total or digital non-rivalry allows for massive economies of scale and market concentration, ultimately resulting in inequalities.

The intangible character of DI, based on software codes and data as the raw material of DI, is perceived by some scholars as drivers of **"winner-takes-all" market structures** (Guellec and Paunov 2017), the rise of superstar firms like Facebook, Apple, Amazon, AirBnB, or Walmart (Autor et al. 2020; van Dijck et al. 2018), and the concertation of industries (OECD 2018a), which all contribute to inequality. The increasing importance of DI in an intangible based economy magnifies, to Guellec and Paunov (2017), innovation-based rents. These contribute to increasing the income share of the top income groups. Digital non-rivalry allows for massive economies of scale, reducing the costs of innovation (the more products sold, the lower the average cost), and thus favouring concentrated market structures. This concentration eventually ends with only a few companies supplying most of the market, magnifying their mark rents.

The phenomenon of companies' concertation is well described in a fascinating book by van Dijck et al. (2018) which outlines the platform society, showing how platform companies, especially Big Five infrastructural companies (Alphabet-Google, Facebook, Apple, Amazon, and Microsoft) shape the way we live and organise society. For example, Alphabet-Google embraces around 18 companies (which is not common knowledge), such as YouTube, Google maps, Google Chrome, and others that are deeply integrated into our lives. It controls, together with Facebook, more than 60% of online advertising—the dominant component of many Web-based business models. The seminal work of van Dijck et al. (2018) shows that inequalities related to market concertation are not only about disparities in salaries or market opportunities typically emphasised by economic literature. They also relate to new types of dependencies and hierarchies which are embedded in the platforms' architecture, as well as their economic power in establishing their own system of norms and values (mostly profit driven), which may collide with the sovereignty of states and public good. The dependency of the European Union's online infrastructure on mostly US connective platforms (van Dijck et al. 2018, p.164) is a banal example of a dependency which could threaten European democracy through false yet viral news or ad hoc website seeking for quick profits through attracting advertising.

Finally, the largest and the most common type of inequality driven by DI concerns the changes in **labour market, employment, and the future of work**. The literature on this matter is rather abundant and equally polarized between techno-pessimistic and techno-optimistic views (Hirsch-Kreinsen, 2016). Techno-pessimists suggest that the future of work is subject to technological unemployment and skill-biased technological changes which lead to job losses, large earnings gaps between high- and low-skilled workers, job polarization, and the vanishing of middle-class workers. They argue that a compensatory mechanism, which allows for the growth of employment in the transition from agrarian to industrial society, is not workable in the case of a transition to a digital economy, and a large number of jobs will be automated in the near future (Degryse 2017; Frey and Osborn 2017) or will completely disappear altogether (Ford 2015; Grace et al. 2018). Frey and Osburn (2017), in their pioneering study, estimated that, in the coming years, 47% of US jobs could be automated through the application of new digital technology. Recent studies suggest that those in the middle working class (manufacturing and clerical professions), whose jobs are subject to algorithmic processing or automation, will disappear and the remaining jobs will be highly polarised between low-educated and low-paid workers, and a handful of individuals with high incomes (OECD 2015; Makridakis 2017; Cowen 2013).

Although digital work has some advantages (e.g. flexibility, greater autonomy, the ability to work remotely), it is generally connected with poor working conditions and different types of non-standard work (temporary, part-time, gig-work, on-call work, and self-employment out of necessity (OECD 2015), which eventually terminate labour rights and collective agreements. This brings low wages, job insecurity, and social exclusion (OECD 2015; Eurofound 2018), creating a new class of Cyber-Proletariats (Dyer-Witheford 2015) or globalization losers (Degryse 2017) who are exposed to poverty and socio-economic exclusion on a broad scale (Atkinson 2015; Codagnone et al. 2016). Guaranteed minimum income and a strong welfare state with free health and education as a way for redistribution of gains from DI can become a necessity (Ford 2015; OECD 2015).

The above arguments are still inconclusive, often exaggerated, and also heavily criticised by techno-optimists who see digitalisation and robotization as an opportunity for departure from alienated, monotonous, and repetitive work and a move towards a rise in creative work. Digitalisation requires a higher level of knowledge and analytical thinking; new skills, such as critical thinking; complex problem solving; active learning; business decision-making; communication; etc. (Codagnone et al. 2016; OECD 2015). Therefore, digitalisation raises levels of education and income, as has been the case with the introduction of all new technologies over the last 30 years (Arntz et al. 2016). For techno-optimists, digitalisation is a process of "major restructuring" that seeks new work skills, work organization (Hirsch-Kreinsen 2016), and a factor of optimization that results in zero marginal costs (Rifkin 2014), free services, and optimization of work. According to the "techno-optimists", there is almost no doubt that digital

technologies are disruptive in nature, but that they represent progress that will transform "life, business and economy" (Makridakis 2017). According to Brynjolfsson and McAfee (2014, p.11), digitalisation and robotization will revolutionize society as electrical energy once did. The steam engine enhances our muscle strength, and so computers will enhance our mental power (Brynjolfsson and McAfee 2014, p. 11).

5.2 DI and the disruption of business models

DI is usually thought of as a disruptive form of innovation which destroys established business models and existing value chains. Technology giants like Facebook, Amazon, Apple, Netflix, and Google (FAANG) (Song 2019) are all companies which have abandoned the usual way of doing business and established new business models and value chains grounded in network effects and platform structures, by which they have not only destroyed competitors but also transformed entire industries. For example, Netflix disrupted video rental stores, Uber disrupted taxi services, and Amazon disrupted book retail.

The term 'disruptive innovation' still arouses controversy among experts as the current use of the term does not follow the original notion coined by Christensen (1997) in his highly popular book *The Innovator's Dilemma*. Disruption is essentially a process by which a smaller company with fewer resources is able to successfully displace established, market-leading firms based on their novel business model. However, Christensen's concept of disruptive innovation is relatively narrow and includes innovations that are cheap, have originated outside of mainstream markets, and are worse in terms of performance than established products (e.g. personal computer versus mainframes) (Danneels 2004). Entrepreneurs are faced with the dilemma of choosing between business models based on sustainable technology (which follow the customer's need to improve the product's performance) and business models based on the cheap and technologically inferior innovation aimed at niche sets of customers who remain under the radar of incumbents. The book suggests that following sustainable technology, which is usually the first choice of incumbents is, in fact, a bad business model which results in losses in terms of leadership positions.

As scholars face difficulties in identifying disruptive innovations meeting the criteria outlined by Christensen (1997), the notion of disruptive innovation has been significantly broadened over time and currently applies to pervasive changes in technology, society, or economic systems. A good example of disruptive innovation is Instagram, which brings together changes in all three aspects, technological (digital camera, mobile photos), social (photo-sharing social networking services), and economic (the demise of the classic photographic industry).

Today, disruptive innovation is usually related to the digital transformation of a company or the reinvention of business models which assume an organizational transformation that integrates digital technologies and business processes (Warner and Wäger 2019). In contrast to the business model of the industrial era, which regularly uses research and development (R&D) to produce innovation with broader socio-economic implications, the digital transformation of a company relies primarily on entrepreneurial DI as opposed to the research-based innovation dominating the industrial society. This is a rather important feature of digital transformation as it enabled the establishment of equality in society by opening up entrepreneurial opportunities to a greater number of potential entrepreneurs (Yoo et al. 2010; OECD 2018a). This process gave rise to the concept of digital entrepreneurship ecosystems (DEE), mainly celebrated in entrepreneurship literature for having facilitated entrepreneurial opportunities, business model innovation, and value creation through digitalization as opposed to "technology-push" innovation (Autio et al. 2018; Sussan and Acs 2017).

However, the disruption of business models through digital transformation is a double-edged sword. On the one hand, scholars suggest that DI is a special kind of innovation that requires little or no research for it to be developed and commercialized (WEF 2016; Paunov and Planes-Satorra 2019; OECD 2018a). Two basic arguments can be employed to illustrate the R&D-opposed characterisation of DI. Firstly, digital non-rivalry and layered modular architecture both allow for the generation of new products and services at a marginally negligible cost (Guellec and Paunov 2017; Paunov and Planes-Satorra 2019) and, in the case of software, the cost of producing an additional unit is close to zero (OECD 2018a, p. 82), facilitating rapid and limitless growth without R&D. Secondly, software development is an integral part of most DI, however, it is difficult to identify its R&D component if any exists at all (Paunov and Planes-Satorra, 2019, p. 53). Software development is usually performed by developers, not scientists, and such advances are generally incremental rather than genuinely new or radical—a standard property of research-based innovations.

These arguments demonstrate that the creation and diffusion of DI does not require research efforts and expensive or large scale research infrastructures, but mostly involves software codes and data as raw materials, which is less capital-intensive than manufacturing. This potentially lowers barriers for entry into digital business fields for a wide range of potential entrepreneurs as a result of low capital, research intensity, scale without mass production, and reductions of other types of costs, such as launching and selling new goods and services or verifying the reputation of partners (OECD 2018a; Guellec and Paunov 2017; Paunov and Planes-Satorra 2019).

On the other hand, however, research intensity and the role of R&D in the digital sector are far from being well-defined and clear-cut. Scholarly opinions are conflicting on this matter, with no hint of imminent resolution.

According to the European R&D scoreboard (Hernandez et al., 2018) and OECD analysis (Paunov and Planes-Satorra, 2019), leading digital technology firms (e.g. Alphabet, Microsoft, Huawei, Apple, etc.) are among the most research-intensive sectors, along with the top investors in R&D: pharmaceutical companies (e.g. Roche, Johnson & Johnson, Novartis, etc.) and automotive companies (e.g. Volkswagen, Daimler, Toyota, etc.). For instance, in 2011, Facebook was the 295th firm worldwide in terms of R&D investment, but it went up to 15th place in 2017 (Hernandez et al. 2018, p 60).

Big data analytics and software have become core inputs for innovation in digital companies, making scholars consider these activities as new types of R&D for use in securing the competitive advantage of a company (Trabucchi and Buganza 2018). The transformation of data from different resources (person, businesses, research) into accountable knowledge requires, for many firms, considerable investment in technological infrastructure, cognitive skills, and organizational processes, all of which are very difficult to imitate (Gupta and George 2016). Data-driven market efficiency naturally favours firms that are able to concentrate, aggregate, and process massive amounts of data, such as Google or Facebook. A disruptive business model which allows "scale without mass" can therefore be considered a double-edged sword, as previously mentioned. It may facilitate entrepreneurialism on one side but may also lead to natural monopolies on the other (OECD 2018b, p. 12). Equal opportunities in accessing data can translate into unequal achievement, as creating value out of data requires complementary assets, individual skills, and the right institutional setting in which to exploit information, among other factors (OECD, 2018b). This allows firms with the strongest capacities to better take advantage of this data. In their popular book *Myth of Capitalism,* Tepper and Hearn (2019) explain how large digital companies not only dominate the market but also monopolize it. For example, Google controls 90% of online advertising through search engines, while Facebook accounts for almost 80% of mobile traffic on social networks. The power of digital giants is almost unlimited and could threaten the entrepreneurship dynamic. For example, Google, which provides the infrastructure for the World Wide Web, also functions as a "gatekeeper" of Internet searches, which gives it the power to easily get rid of a large number of small and potentially competing companies by simply pushing individual companies to the bottom of the search list. In this way, the market is broken. Digital transformation, instead of delivering the benefits of competition to many, it is driving monopoly profits to a few.

The disruption of markets, through the decimation of a few incumbents that fail to adapt to digital technologies (Danneels 2004; D'Ippolito 2019) to the benefit of many newcomers, may support the Schumpeterian process of "creative destruction", renewing society's dynamism and bringing about new employment opportunities, products, and service for more users (e.g. cheap flights). However, the role of disruptive innovation in social and economic progress remains rather controversial (Soete 2019). On the one hand, disruptive innovation allows for desirable Schumpeterian creative destruction but, on the other hand, it can lead to "destructive creation", wherein innovation destroys many companies to benefit a few. Disruptive innovation is still controversial and vaguely defined as its impact is predicted to grow. Further exploration of its emergence and effect on society is thus indispensable in facilitating an understanding of digital society.

6 Conclusions and implications

The rise of the digital economy revolving around DI requires a reconsideration of the notion of innovation to clarify its concept in a post-industrial digital economy. In this context, this research is initiated by the growing recognition of the fact that current STI and social studies of innovation are lacking conceptual, theoretical, and analytical grounds for the exploration of DI, despite its pervasive impact on our lives. Theoretical and analytical framework for the exploration of DI is inconsistent and deficient. Therefore, to provide theoretical frameworks and concepts through which to study DI, this research addresses two basic questions associated with it: first, what DI is and how it differs from industrial innovation and, second, which distinctive features of DI could form a potential common ground for the conceptualisation of DI for STI and social studies of innovation.

For the first question, this research discusses the specific features of DI that make it differ from the industrial innovation. This segment of analysis reveals that DI possesses a specific kind of intangibility, a digital immateriality which, in combination with its layered modular architecture, generates a new kind of product and service at a marginally negligible cost ("scale without mass") and initiates new business models, strategies, and organizational forms (e.g. platform companies) which enjoy network externalities and effects. The research reveals that such an evolution from industrial to digital innovation requires serious changes to innovation theory, management, and supporting policies, even leading to new types of economies currently recognised in variants of the platform, digital, and intangible economy.

With regards to the second question, this research identifies two distinct characteristics of DI related to social

inequality and disruptiveness, which have been identified as the most specific characteristics for use when conceptualising DI.

The analysis of the first characteristic suggests that DI carries with it the risk of creating social inequality as a result of the four processes brought about by the rise of DI: (1) the slowing down of technological change, (2) the growth of the intangible economy with a decreasing need for labour and investments, (3) "winner-takes-all" market dynamics, and (4) skill-biased technological change. The analysis of these four processes reveals that the rise of DI has not contributed, despite expectations, to better labour conditions, social inclusion, or standards of living. The most common inequalities driven by DI are related to income, labour markets (job polarization, loss of jobs, endangering labour rights), and market competition between companies, which leads to inequalities in wealth and the perception of disparities in terms of social status, with adverse political consequences. DI has brought innovation-based rents and massive economies of scale, reducing the costs of innovation and facilitating the concertation of industries, which eventually ends with only a few companies supplying most of the market, magnifying their mark rents. The rise of digital platforms or superstar companies, such as Alphabet-Google, Facebook, or Amazon, is one of the most criticized consequences of DI because of their dominant market position, their profit interests, and their non-transparent legal statuses evade social responsibility and challenge public goals and values.

The second characteristic was selected to attract the attention of scholars towards the disruptive effects of DI and its ability to shake up existing business models and change conventional socio-economic categories, such as markets, employment, tax regulations, etc. It was also chosen to demonstrate how standard (industrial) activities of R&D are replaced by big data and business analytics leading to disruptive innovation which transform business model with ambiguous and conflicting results: on the one hand it provides market entry to a wide range of entrepreneurs due to the economies of scale based on intangibles while on the other hand it creates monopolistic companies that destroy market competition and equal market opportunities for newcomers. Disruptive innovation creates monopolies in complex socio-technical systems such as digital platform companies, which have the power to change markets, competition regimes, interactions with users, government settings, etc. These companies have been criticised for threatening public values, democracy, social equality, and personal privacy (Betancourt 2015; Srnicek 2016; van Dijck et al. 2018; Zuboff 2015).

The analysis suggests that the change in the business model brought about by DI is so substantial and pervasive that it has the power, as precedent, to ultimately transform our economy and society. The analysis of the selected characteristics reveals that the social and economic implications of DI are rather complex and ambiguous and remain largely unexplored territory, open to different and inconclusive interpretations. The analysis suggests the following conclusions:

- DI is a complex socio-economic phenomenon, driven by digital technologies at a global level, with little sensitivity for various national and socio-political regimes. This makes DI a global phenomenon with global socio-economic consequences.
- DI is a pervasive, formative, and transformative type of innovation which is sweeping away the techno-economic and social postulations of industrial society and transforming our ways of living into a kind of "digital existence".
- The formative power of DI emerges from its ability to shape, often through disruption, business processes and even economic regimes (e.g. digital platform economy or intangible economy) as well as the social activities of people around the world anchored in a "digital existence".
- The characteristics of DI possess an inherent contradiction, as one characteristic may have both positive and negative social consequences. For example, the properties of DI that enable entrepreneurialism also allow for monopolistic companies with massive economies of scale and enormous innovation rents, leading to increased social inequality and division.
- Although DI has advanced our way of living in many ways, it is driven primarily by economic rationality and profit seeking, generating striking socio-economic inequalities that call for a balanced development between economic goals and human values.
- DI tends to produce, due to its digital immateriality, too few winners and too many losers, meaning that it could disturb the current social balance and threaten our way of life as we know it.
- National states and regulators should establish mechanisms to remedy the harmful effects of digitalisation for the benefit of all citizens. These mechanisms are currently missing.

This study aims to contribute to the ongoing discourse on the digitalisation of society, and it offers some themes that are meant to serve as a common conceptual ground for studying DI. Despite the fact that there are many other equally fruitful topics, the analysis of the selected features of DI serves to illustrate the ways in which social and STI studies can be used to approach social transformations brought about by it.

The analysis indicates that the phenomenon of DI has opened up a rich field of research for STI and social studies

of innovation. This can be compared in significance with the transformation of the industrial society. Deliberations concerning digital and political-economic structures, along with their interaction with the socio-cultural sphere, are in their infancy. Therefore, the task of STI and social research on innovation is to contribute to an understanding of DI to critically examine its advantages and disadvantages, gaining control over technological determinism and profit-driven interests in favour of increasing social equality and improving living standards for all.

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