Late Industrialisation under Platform Capitalism

Wim Naudé

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Abstract

The digital (or 4th industrial) revolution has made industrialisation harder by being less consequential for structural transformation that was initially hoped for and by giving rise to digital platforms that have come to dominate the global economic landscape. This paper explains why diminished expectations of the 4th industrial revolution are justified and describe the rise of digital platforms and platform capitalism. The implications for late industrialisation are discussed, and three broad recommendations for digital industrial policies are made. First, digital industrial policies should respond appropriately to the industrial policies of advanced manufacturing countries wherein digital platforms are increasingly taking centre stage. Two, regulation, including setting the rules for markets under digital platform capitalism, is necessary for developing countries to limit the potential adverse consequences of digital platforms. Third, a more supportive environment for home-grown digital platforms in late industrialising countries are needed, such that home-grown platforms can avoid being locked into the West or China's technology hardware, standards, and cyber governance systems on adverse terms.

Keywords: Digitisation, digital platforms, industrialisation, competition policy

JEL codes: O25, O33, O14, L52

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1. Introduction

Platform capitalism refers to the growing dominance of digital platform firms in the global economy[1]. Digital platform firms are online firms that intermediate transactions between businesses, consumers, and peers and extract rent from this (Parente et al., 2018). Formally, a digital platform[2] is "a delocalised marketplace the foundation of which is a distinct technological core and a set of self-imposed rules (defining its functionality for its complementors and users) that acquires data from complementors and users while facilitating market transactions" (Butollo, 2019, p.8). Through their technology and business models, digital platforms link consumers and producers so comprehensively "everyone can become a supplier for all sorts of products and services at the click of a button," which "is the real innovation that companies of the platform capitalism variety have introduced" (Langley & Leyshon, 2017, p.4).

Digital platforms rely on their technology and access to big data to generate and benefit from data network effects[3]. Data gathered from users' behaviour online is central in this, not only to improve their products and services but also to sell this data to advertisers and other users (Rubinfeld & Gal, 2017). Often, digital platforms even collect data first and then consider how to monetise[4] it (Sadowski, 2020).

These data network effects often result in such firms establishing a dominant market position. A representative example is Amazon, an online retailer and one of the largest online marketplaces in the world, with more than 2 billion visits per month by mid-2021. Other well-known examples are Uber and Facebook. The former is a ride-hailing digital platform that intermediates between people seeking transportation and drivers, appropriating the fee, and paying drivers a percentage thereof. The latter is a social media platform relying on users who have free access to provide content and selling advertising to third parties. Digital platform firms have become hugely influential and disrupt traditional businesses wherever they compete (Ojala et al., 2018). By 2020, more than 10,000 digital platforms were active in Europe alone (Cabral et al., 2021). Eight of the ten most valuable firms globally, based on

[1]Platform markets and the network economies that drive their growth are not new. Before digital platforms, the most salient platform markets included newspapers, credit cards, barcodes, container shipping, real estate brokerages, shopping malls and stock exchanges (Eisenmann et al., 2011).
[2]Thomas et al. (2014) classifies "platforms," into five types, namely organisational platforms, product platforms, market intermediary platforms, platform ecosystems, and general technology platforms.
[3]There are direct and indirect network effects. A direct network effects occur when "the value of a product or service increases as more users utilise the platform and expand the network" (Parente et al., 2018, p.54). An indirect network effect occurs when "demand for the good depends on the provision of a complementary good, which in turn depends on demand for the original good (Rysman, 2009, p.127).
[4]The value of data for platforms is reflected in the fact that Amazon derived US $125 billion in 2017 from data (Li et al., 2019).

market capitalisation, were digital platform firms. The COVID-19 pandemic has accelerated the dominance of these firms (Kenney & Zysman, 2020).

Market competition is increasingly taking place *against* digital platforms (e.g., Apple's watch competing against the Swiss watch industry), *between* digital platforms (e.g., between Apple and Google), or *on* digital platforms[5] (e.g., between app-developers). This change in market competition is a further stage in modern capitalism. According to Grabher & van Tuijl (2020, p.1011), "The platform might even be placed in the succession of transformative stages of modern capitalism", by which they mean that the digital platform will be as essential in the future as was the factory for the 1st Industrial Revolution, the corporation for the late 19th and early 20th century, and global value chains for the late 20th century. Platforms are reconfiguring "globalisation itself" (Kenney & Zysman, 2016, p.61).

Platform capitalism has implications for late industrialisation. One is that productivity-enhancing structural transformation is becoming much harder. As Rodrik (2016, p.14) lamented, "industrialisation has become really hard for all countries of the world." This difficulty is perhaps of even more concern for late industrialisers, given the "small number of non-western countries which have become developed in the past two centuries: less than ten" (Wade, 2016, p.478). As a result, "most middle most middle-income countries have remained stuck in a middle-income trap" (Andreoni & Tregenna, 2020, p.324).

Platform capitalism, as described in the previous paragraphs, is the outcome of the digital revolution[6], sometimes also referred to as the 4th Industrial Revolution (4IR) (Schwab, 2016). While there have been many analyses of industrial policies for late industrialisers considering the digital revolution or 4IR,[7] these have so far stopped short of dealing with the implications of platform capitalism, in particular with the consequences of the changing landscape of competition brought about by digital platforms. The *Oxford Handbook on Industrial Policy* (Oqubay et al., 2020), for instance, have no chapter on industrial policy in an era of big data, and only one chapter concerning digital technologies.

This paper provides an initial step toward addressing this lacuna by outlining three requirements for relevant industrial policies in late industrialising countries given platform capitalism. Before discussing these, however, it is necessary to provide (in section 2) as background a critical description of the digital revolution that has resulted in the technologies allowing the rise of digital platforms and platform capitalism. Then, in section 3, how these technologies and their use by digital platforms make late industrialisation harder are

[5]For example, Apple charges the developers of apps on its platform a 30% commission on their sales for using Apple's consumer data. This has resulted in around US $42.8 billion in revenue for Apple between 2007 and 2017 (Li et al., 2019).

[6]The digital revolution, or "second machine age" refers to the rise in the importance of data, data-based technologies, and digital business models (Brynjolfsson & McAfee, 2016).

[7]The digitalisation of manufacturing has been referred to as "industrie 4.0" or the industrial internet (Butollo, 2019).

explained. Finally, in section 4, three requirements for relevant digital industrial policies to support industrialisation in late industrialising countries are presented and discussed. Section 5 concludes.

2. Background: The digital revolution

This section describes the digital revolution and its resulting digitalisation and digital transformation[8] of the world economy. Subsection 2.1 explains that one of the most meaningful features of the digital revolution has been the rise in connectivity through ICT, which has made possible cyber-physical production systems (CPS) and big data-based business models supporting digital platform firms. CPS and digital platform firms as the consequence of improved ICT connectivity are discussed in subsection 2.2, where the way they increase the complexity of industrialisation is noted.

It is concluded that neither CPS nor digital platforms and the digital technologies underpinning these had so far had the positive outcomes for structural transformation in late industrialising countries that they promised. Thus, diminished expectations of the digital revolution and the 4IR is an appropriate starting point for industrial policies to deal with digital platforms in late industrialisers, and some of the salient aspects of such diminished expectations are outlined in section 2.3.

2.1 Connectivity

The digital revolution refers to the acceleration in digitisation and digital transformation of society through technological innovation, including innovation in hardware and software technologies. It has gone through various waves, with the most recent third wave "a move from a model of accessing the Internet[9] and other networks almost exclusively via a desktop computer to alternative forms of distributed information technologies, such as smartphones, wearable computers, and sensors and microprocessors embedded in everyday objects" (Manwaring & Clarke, 2015, p.586). The number of sensors[10] increased from an estimated 10 million in 2007 to 15 billion by 2015, while more than 1 trillion semiconductors and integrated were circuits sold by 2018 (Patsavellas & Salonitis, 2019). This third wave has seen exponential increases in computing power, as tracked by Moore's Law[11], exponential declines in the cost

[8]Digitalisation refers to "the proliferation and application of digital technologies in the economy" (Matthess & Kunkel, 2020, p.2). Digital transformation refers to adapting business models through digitalisation and can be defined as "using digital technologies to develop new business models" (Broekhuizen et al., 2021, p.847).

[9]The Internet is "a combination of computer networks using a particular set of communications protocols, most importantly the TCP/IP (Transmission Control Protocol and Internet Protocol) protocols" (Manwaring & Clarke, 2015, p.595).

[10]Formally sensors are known as micro-electro-mechanical systems (MEMS).

[11]"Moore's law states that the number of transistors on a microprocessor chip will double every two years or [. . .] [this] transformed the first crude home computers of the 1970s into the sophisticated machines of the 1980s and 1990s, and from there gave rise to high-speed Internet, smartphones and the wired-up cars, refrigerators and thermostats that are becoming prevalent today" (Waldrop, 2016, p.144).

of computing[12], and unprecedented connectivity via the distributed information technologies just mentioned (sensors, smartphones), as well as cloud computing[13] and the "worldwide deployment of more than 400 fibre submarine cables[14] (SMCs) over the period 1990-2018, transmitting more than 99% of international telecommunications" (Cariolle, 2021, p.2). For more detailed discussions of these trends, see, e.g., Brynjolfsson et al. (2017), Friedman (2016), and McAfee & Brynjolfsson (2017).

The combination of cheap PC's, mobile phones, and sensors, all connected to the Internet with its expanding SMC connections, has led to the Internet-of-Things with exponential growth in data creation. By 2020, it was estimated that "for every person on earth, 1.7 MB of data will be created in the duration of every single second" (Patsavellas & Salonitis, 2019, p.1355). The creation of big data[15] has increased the complexity of industrialisation in two ways – by enabling cyber-physical systems (CPS) and digital platform firms with business models based on data and AI (Hirsch-Kreinsen, 2016). In the following sub-section, these will be discussed in greater detail, and their implications for the complexity of industrialisation noted.

2.2 Cyber-Physical Systems

Cyber-Physical Systems (CPS), which integrates sensors, Internet data, algorithms with machinery, improves efficiency in manufacturing by enabling continuous monitoring, feedback, and control of production – often independently of human oversight. One of the significant impacts has been to advance the paradigm of lean, agile, and sustainable manufacturing systems, characterised by flexibility, resource efficiency, individualisation on-demand, short development periods (Maffei et al., 2019). Lean production (lean manufacturing), which, borrowing from Japanese management practices, aims to use technology to increase efficiency in production by reducing stock holdings and waste, speeding up supply chains, predicting maintenance, and providing better value to the consumer (Sundar et al., 2014). More and cheaper sensors and cloud computing help drive automation and predictive maintenance, new connection protocol standards contribute to better monitoring and use of resources, mobile connectivity facilitates customer interaction and customisation, and 3D printing helps with rapid prototyping and agile production (Patsavellas & Salonitis, 2019). Lean production and their CPS are, however, notoriously complex due to its high interdependencies, need for effective coordination and dependence on error-free operation of digital tools. It has been described as a "failure-prone and nervous

[12]For example, the cost of sensors has fallen to below US$0,50 per unit (Patsavellas & Salonitis, 2019).
[13]Cloud computing is where "computing is done on a network of off-site computing resources accessed through the Internet" (Byrne et al., 2018, p.1).
[14]Global submarine cables (SMCs) can be tracked on https://www.submarinecablemap.com.
[15]Gartner IT's Glossary defines big data as "high-volume, high-velocity and high-variety information assets that demand cost-effective, innovative forms of information processing for enhanced insight and decision making" (Gandomi & Haider, 2015, p.138).

system" (Butollo, 2019, p.3). Thus, while CPS and lean production can improve manufacturing efficiency when firms can get it right[16] (Brynjolfsson & McElheran, 2019), the general roll-out across firms and countries and underpinning of CPS has been slower than was initially expected or hoped. A further reason for the slow adoption and low impact of CPS and lean production is that, as Hatton & Webb (2020) pointed out, within the Internet-of-Things, there is no universal standard (yet) for connecting distributed devices as there is, for instance, for Wi-Fi. The rise in connectivity and data has also increased the complexity of industrialisation by supporting digital platform firms. Specifically, the connectivity through cloud computing has facilitated the establishment and scaling up of digital platform firms that use data and AI at the core of their business model. Digital platform firms are firms that provide multi-sided online marketplaces where transactions between multiple agents – consumer to consumer (C2C), business-to-consumer (B2C) and peer-to-peer (P2P) - are enabled. The importance of cloud computing for digital platform firms is that it reduces the investment and maintenance cost of ICT equipment and services and raises the productivity from using software (Byrne et al., 2018). The largest provider of cloud computing services in the world at the time of writing is Amazon Web Services (AWS) – part of Amazon, one of the largest global digital platforms, who had a market capitalisation value of US$1.6 trillion in August 2021, making it one of the five most valuable companies in the world. As was mentioned, digital platform firms are based on business models that depend on big data and AI. The global platform giants, such as Google, Amazon, and Facebook, amongst others, are amongst the largest investors in developing and deploying AI. To them, AI is a handy tool to extract intelligence from the mass of big data.

Although the term AI was coined in 1956 (Moor, 2006), it was only in the last 12 years or so that modern AI, based on Machine Learning (ML), came into use, following the mentioned availability of big data, as well as advances in computing, such as the development of efficient Graphical Processing Units (GPUs) for computers in the video gaming industry, and the elaboration of algorithmic techniques that could combine these to allow computer programs to recognise patterns in data and make predictions, and learn to improve these over time (Cano, 2017; LeCun et al., 2015; Hinton & Salakhutdinov, 2006; Hinton et al., 2006). With its ability to spot patterns and make predictions, AI is used mainly by large platform firms with access to big data and computing and IT skills resources in applications such as recommender systems, targeted advertising, chatbots, search engines, and translation. The development and use of AI are heavily concentrated in the USA and China, where the world's leading digital platforms are located, and where the vast bulk of AI patents are held (WIPO, 2019). AI is yet to have a significant impact on manufacturing and the economies of developing countries. There have, however, been expectations that AI will revolutionise manufacturing, for instance, through predicting when maintenance is needed (which is already possible) to

[16]Brynjolfsson & McElheran (2019) found from a database of 30,000 USA manufacturing firms that adopted data-driven management techniques achieved better performance than those who did not, and that their adoption depended on having access to skilled workers, ICT infrastructure, and the size of the firm.

enable autonomous driving and self-organising factories (not yet implementable at scale and cost) (MIT, 2020). AI is, however, not diffusing very fast, nor is its technical potential yet attained. AI remains expensive, primarily available only to large digital platforms and out of reach of small businesses, who do not have access to large enough datasets to train AI models, as well as not safe or ethical enough, and increasingly burdened in its implementation by (expensive) regulations (Bergstein, 2019; Farboodi et al., 2019; Naudé, 2021).

Furthermore, in addition to these unfavourable cost-benefit features of AI, the technology has come under scrutiny, not only for posing possible long-term existential threats (Bostrom, 2014) but having shorter-term negative consequences[17], such as intrusive surveillance and erosion of privacy, creation of AI weapons, job losses due to automation, higher inequality, and fuelling discrimination and biased policy-making (Frey & Osborne, 2017; Korinek & Stiglitz, 2017; Feldstein, 2019; Russel et al., 2015). These downsides of AI raise the risk to firms from using AI and hence increase the complexity of industrialisation and of crafting industrial policies in the digital age. It moreover suggests that much more investment, development and regulations may be needed in AI and its supportive infrastructure before it can be scaled through the manufacturing sector and benefit producers in developing countries. Just as CPS and AI-driven business models of digital platforms make industrialisation harder, a much older technology – 3D printing – has been similarly hyped as a 4IR technology but has been found to raise complexity and have less than hoped for impacts. 3D printing (or additive manufacturing) has been hyped as a "spark" of the new (4IR) industrial revolution (Weller et al., 2015, p.43) even though it is essentially a 1980s technology.

In recent years, it has improved by being linked to the digital economy through the separation of product design from manufacturing capabilities and use together with 3D CAD software and Computer Numerical Control[18] (CNC) machining (Berman, 2012; HUBS, 2020). The potential of 3D printing as a spark of the new industrial revolution is discussed in Karlgraad (2011), Anderson (2012) and Rayna et al. (2015), amongst others. For late industrialising countries, the attractiveness of 3D-printing is in being able potentially to avoid realising economies of scale in production, obtaining cheaper inputs and spare-parts in manufacturing, being able to make more affordable and faster prototypes, reduce assembly costs, and customise production to local demand (Berman 2012; Kleer and Piller, 2019; Weller et al., 2015, Khajavi et al., 2014). It is, however, the case that, as with artificial intelligence (AI) that 3D-printing is still not widely adopted[19], mainly due to the high cost of printers, the limited

[17]The GitHub site Awful AI contains a repository of some of the negative consequences of AI. See: https://github.com/daviddao/awful-ai

[18]Computer Numerical Control (CNC) machining is the use of pre-programmed computer software to dictate "the movement of factory tools and machinery [. . .] to run them via software in repetitive, predictable cycles, all with little involvement from human operators" (Hess, 2017).

[19]Countries lagging in industrial development such as those in Africa are not yet using 3D-printing, with 95% of global demand for 3D-printing in 2019 coming from advanced economies. Only South Africa, Tunisia and Morocco were noted as African countries with some demand for 3D-printing (HUBS, 2020).

range of materials and colours available, high-energy needs[20], the generally insufficient quality of products, and increased knowledge requirements – and copyright implications – posed by the software (Rayna et al., 2015; Chan et al., 2018). These obstacles thus complicate the process of technology deployment and industrialisation in the manner described by Andreoni et al. (2021). The discussion in the preceding paragraphs suggests that while there has been a digital revolution marked by remarkable advances in various ICT technologies, especially in connecting and combining technologies and their users, the implications for industrialisation has been to make it more complex, harder, and uneven. While the complexity and limitations of the individual 4IR technologies and their consequences in terms of CPS and digital platforms have been noted, it remains to elaborate on the uneven impact and why the digital revolution may be less promising for late industrialisers than has been hoped.

2.3 Diminished expectations

The impact of the digital revolution on structural change requires meaningful metrics to analyse, track and study how various sectors are being affected. In this regard, Calvino et al. (2018) proposed a taxonomy to measure the extent to which sectors are being digitised. Their key indicators of digitalisation are i) ICT investment, ii) purchases of ICT intermediates, iii) ICT specialists, and iv) online sales. Applying this to various sectors, they distinguish between digital and less digital intensive industries. Their overall (global) results (Calvino et al., 2018, p.31) make a distinction between low, medium-low, medium-high, and high digital intensive sectors and compares this between 2001-2003 and 2013-2015. Table 1 denotes this, showing which manufacturing sectors are more "digital" than others. Table 1 shows that the digitally most intensive sectors transport equipment, followed by machinery and equipment, electrical equipment, computer products and wood and paper products. Only transport equipment has a high digital intensity.

Calvino et al. (2018) find that unlike manufacturing, where most sectors are either medium-low or medium-high digital intensity, it is the services sectors that have been "going digital" – particularly telecommunications, IT and other information services, finance and insurance, legal and accounting activities, scientific research, advertising and market research and administrative and support services are all highly digitally intensive sectors. Thus, compared to services, manufacturing has not seen similar digitalisation – the relative digital intensity of computer and optical products even declined from high in the 2001-2003 period to medium-high in 2013-2015.

[20]The energy needs of 3D-printing is "100 times higher than that of traditional manufacturing" (Chan et al., 2018, p.156).

Table 1: Digital Intensity of Manufacturing Sectors

Manufacturing sector	Digital intensity 2001-2003	Digital intensity 2013-2015
Food products, beverages, tobacco	Low	Low
Textiles, wearing apparel, leather	Medium-low	Medium-low
Wood and paper products, and printing	Medium-high	Medium-high
Coke and refined petroleum products	Medium-low	Medium-low
Chemicals and chemical products	Medium-low	Medium-low
Pharmaceutical products	Medium-low	Medium-low
Rubber and plastic products	Medium-low	Medium-low
Basic metals and fabricated metal products	Medium-low	Medium-low
Computer, electronic and optical products	High	Medium-high
Electrical equipment	Medium-high	Medium-high
Machinery and equipment n.e.c.	High	Medium-high
Transport equipment	High	High
Furniture; other manufacturing	Medium-high	Medium-high

Source: Calvino et al. (2018, p.31)

Why may this be the case? One reason may be that "since a disruption of established processes is laborious and risky, the implementation of new digital technologies has tended to be pursued rather in an incremental manner than as radical change" (Butollo, 2019, p.3).

Other related reasons are no doubt the increased complexity of utilising the new technologies and the risks that the gains from these technologies may not be significant nor sustainable. This raises a relevant consideration for late industrialising countries – namely that the notion that the digital revolution will have sweeping changes to manufacturing (industrie 4.0) and will be a force for structural change may have been exaggerated, and that diminished expectations may be in order. According to Deichmann et al. (2016, p.21- 22):

> "There have been many claims of immediate and large effects, not least from politicians and technology boosters in industry. Solid empirical evidence based on careful identification of impacts is much harder to come by [. . .] there has been surprisingly limited evidence of aggregate improvements in important development outcomes. Globally, productivity growth has slowed, inequality is a rising concern not just in rich but also in low- and middle-income countries and technology has not led to the widespread improvements in governance that many had predicted."

This quote from Deichmann et al. (2016) alludes to several reasons for justifying diminished expectations of the 4IR. There are at least five such reasons. Three of these are generally well recognised and relates to the lack of aggregate improvements in development outcomes (growth, jobs, productivity) and (data) governance problems as noted in the Deichmann et al. quote, and two which are, per the arguments in the introduction, somewhat neglected –

relating to the rise of digital platform firms. The remainder of this sub-section will elaborate on these reasons, and the next section, section 3, will elaborate on the implications of digital platforms.

The first reason for justifying diminished expectations of the 4IR is that industrial policies will have to contend with the likelihood that digital technologies and their business model consequences will have less of an impact on productivity growth than earlier technologies had during the 1st and 2nd industrial revolutions. It is a well-established fact that productivity growth in advanced economies had slowed down since the 1970s, and particularly in manufacturing since around 2007-2010 when the development of the digital economy and digital platforms accelerated. As Lawrence (2017, p.5) shows, "since 2010 the rapid productivity growth in [US] manufacturing has ground to a halt: Between 2010 and 2016, output per full-time employee in manufacturing declined by 2.2 per cent." This likely reflects that "ongoing innovation has been less potent in boosting productivity growth compared to earlier decades of the post-war era" (Gordon & Sayed, 2020, p.50). See also Bloom et al. (2017), who documents the decline in USA research productivity.

A second reason for justifying diminished expectations of the 4IR is that digital industrialisation will not automatically lead to sustainable or green industrialisation. Digitalisation poses many new challenges for achieving the Sustainable Development Goals (SDGs) relating to climate change actions. There are concerns about the high carbon footprint of many new digital technologies, including cloud computing, artificial intelligence (AI) and distributed ledger technologies (DLT) such as bitcoin. For example, cloud computing has led to a proliferation of data management centres which will, according to estimates, consume between 13% and 51% of global electricity in 2030 and will be responsible by then for 23% of all CO2 (Patsavellas & Salonitis, 2019). The energy needs of 3D printing are "100 times higher than that of traditional manufacturing" (Chan et al., 2018, p.156) and training a large AI model emits as much CO2 as five large American motor vehicles over their entire lifetimes (Naudé, 2021).

The third reason for justifying diminished expectations of the 4IR is that manufacturing development can contribute to growing inequalities and that manufacturing has become less of a job creator than in the past. Even without factoring in the rise of digital platforms, the digitisation of manufacturing has raised the possibility that automation could lead to the displacement of low and medium-skilled jobs and complementing of high skilled jobs (e.g. Balsmeier & Woerter (2019), meaning that the digitisation of manufacturing could create relatively more jobs and wage increases in high-income, high-skilled industrialised countries, and lead to job losses in developing countries – exacerbating global inequalities. With the rise of digital platforms, the added complication is that platforms accelerate the automation of jobs and promote potentially poorer quality jobs. For example, by t "taskification", jobs are turned into short-term tasks or gigs where labour sells its expertise on various online gig

platforms[21] (Grabher & van Tuijl, 2020). Graham et al. (2017) investigated the advantages and disadvantages of global online labour markets, finding from an extensive survey of global online labour markets (the gig economy) that there is a "pronounced lack of bargaining power for digital workers" (p. 146). Both automation and the taskification of jobs thus make it more difficult for latecomer industrialisers to realise the traditional employment benefits from manufacturing growth.

The fourth reason for justifying diminished expectations of the 4IR is that whereas in earlier industrial revolutions, new business formation played a role in introducing and commercialising new technologies and, in effect driving structural transformation (Gries & Naudé, 2010) the "burden of knowledge" of participating in the digital economy and leveraging the network economies inherent in multi-sided platforms and their underlying hardware, may reduce new start-ups and new venture creation in the high-tech manufacturing industry – in other words, the burden of knowledge effect can reduce the role of new ventures to push structural transformation through creative destruction (Astebro et al., 2020).

Fifth, the nature of global value chains (GVCs) is being altered by the rising dominance of digital platforms. Grabher & van Tuijl (2020, p.1009-1010) discuss these, indicating that platforms tend to de-emphasise physical production in favour of users and matches; that a platform has more nuanced control imperatives compared to the more hierarchical governance in GVCs; and that firms in platforms are more concerned to leverage resources outside the firm than internal to the firm – i.e., "invert" the firm (Parker et al., 2016). This complicates industrialisation by essential requiring new paradigms for doing business and creating value. Such new paradigms often face resistance in the form of organisational inertia, sunk investment costs, and vested interests.

In conclusion, this section described the digital revolution and drew implications for late industrialisation. These implications were that (i) the technology of the digital revolution complicates the process of industrialisation, as they pose high requirements for complementary skills, capabilities, and infrastructure, and tend to be less consequential for structural transformation than was initially hoped. Diminished expectations of the 4IR imply that late industrialising countries not only need to overcome the complexities of technology but find ways of better leveraging these for better impact and deal with the potential adverse consequences of uneven digital capabilities between countries. The latter requires specifically that late industrialising countries understand and respond to the rise of digital platform firms. The way in which digital platform firms make industrialisation harder is explained in the next section.

[21]The basic problem of many online labour platforms is that "The ownership and control of labour platforms in just a few unaccountable hands means that work tends to be performed outside of the purview of national governments: minimum wages, worker protections, and even taxes, seem to be optional rather than required for both the platforms and the clients that source work through them" (Graham et al., 2017, p.153).

3. Industrialisation Is Becoming Harder

The digital revolution discussed in the previous section has increased the complexity of development along three interrelated dimensions. The first dimension is the availability of more complicated, 'fused' technologies, including Cyber-Physical Systems (CPS) and Artificial Intelligence (AI). These pose substantial demands on complementary skills, infrastructure, intangible investments, and coordination. The second dimension is that the digital revolution is, despite the promising nature of its technologies, not fundamentally as 'revolutionary' as previous industrial revolutions - but subject to more hype and over-optimism. Thus, the requirements of obtaining similar productivity and jobs growth as in the past raise the bar as far as appropriate industrial policies are concerned.

The third dimension in which the digital revolution has increased complexity is perhaps the most significant, namely in enabling new business models that integrate technology, markets, and data and give rise to digital platform firms. This dimension has also been the one most neglected in analyses of industrial policies for late industrialising countries, where most of the attention has been on the first two dimensions. In the remainder of this section, the ways in which platform capitalism makes industrialisation harder is explained. Seven reasons are given.

3.1 Software is Eating the World

The first way platform capitalism complicates industrialisation is that digital platforms have shown themselves to be deadly competitors when they face off against traditional pipeline brick-and-mortar businesses. Examples are Amazon and Netflix out-competing Borders and Blockbuster and driving them out of the market.

The history of competition of digital platforms against traditional "pipeline" businesses caused Parker et al. (2016) to conclude that "When a platform enters a pipeline firm's market, the platform almost always wins." Given that the most valuable assets of digital platforms are the intangible data and algorithms on which their business models are built, the oft superiority of digital platforms as against pipeline producers inspired Andreessen (2011) to coin the phrase "software is eating the world." In a memorable passage, Andreessen (2011) described what he meant by this:

> "Today, the world's largest bookseller, Amazon, is a software company—its core capability is its amazing software engine for selling virtually everything online, no retail stores necessary [. . .] Today's largest video service by number of subscribers is a software company: Netflix. How Netflix eviscerated Blockbuster is an old story, but now other traditional entertainment providers are facing the same threat [. . .] Today's dominant music companies are software companies, too: Apple's iTunes, Spotify and Pandora. Traditional record labels increasingly exist only to provide those software companies with content [. . .] Photography, of course, was eaten by software long ago. . . Companies like Shutterfly, Snapfish and Flickr have stepped into Kodak's place [. . .] Software is also

> eating much of the value chain of industries that are widely viewed as primarily existing in the physical world. In today's cars, software runs the engines, controls safety features, entertains passengers, guides drivers to destinations and connects each car to mobile, satellite and GPS networks."

With network effects leading to the capture and domination of markets by one or a few incumbent firms, there is a significant advantage to being a first-mover: first movers, therefore, tend to capture markets and may be challenging to compete against by later established firms. The literature on the economics of digital platforms as leveraging transactions on multiple sides has emphasised their strategies to increase the number of users on the platform (Rysman, 2009). Rochet & Tirole (2003) explain how a platform can use differential pricing to subsidise users on the one side of the market, to make the platform more attractive to users on the other side (for example, charging merchants, and not consumers, a fee for the use of credit cards to increase the number of users of credit cards, making it more attractive for merchants to accept credit cards). With data enabling them to provide better quality services and products, digital platforms aim their technology and business model innovations more effectively away from the needs of businesses and governments towards the need of the consumer, a trend that has been labelled the "consumerisation of technologies" (Sundararajan, 2014, p.4).

In this type of competition and consumer-oriented innovation, digital platforms often enjoy an advantage in being supported by *patient* finance, that is, the commitment of substantial financial resources even as these platforms may not be making any profits for an extended period. Patient finance has the objective of establishing long-term dominance in a market. Thus, given the presence of network effects and first-mover advantages, it is willing to absorb losses during the expansionary phase (Foster & Azmeh, 2020). Amazon, for instance, established in 1994, made its first annual profit in 2003. Patient finance has been essential to support the rise of digital platforms in the USA and China. In the latter, it had been both western Venture Capital (VC) funds as well as state finance that supported the rise of Chinese digital platforms, such as Baidu, Alibaba and Tencent (the BATs) (Foster & Azmeh, 2020).

In addition to efficiency, first-mover, and network effects from harnessing big data, and the support of patient finance, digital platforms are also difficult to compete against for traditional firms, as they often engage in "shapeshifting", which refers to platforms moving into markets non-related to their original core-business. Examples are Apple competing against the watch industry with its Apple Watch, Google venturing into the market for autonomous vehicles and Facebook planning to launch a currency, the Libra.

As a result of the competitive dangers posed by digital platform firms, they spur traditional non-platform firms to significantly adapt their corporate strategies to be able to compete more effectively- raising the complexity of doing business for developing country firms. Traditional firms typically react in three ways. One, they will implement significant cost-saving measures; two, they will try to make their business model more flexible and customer

oriented – adopting features of platforms; and three, they may start joint businesses with digital platform firms (Parente et al., 2018). An example in the latter regard is the 2019 announced strategic partnership between Volkswagen and Amazon Web Services (AWS), which follows Volkswagen's partnerships with Microsoft Azure, and which created the Volkswagen Auto motive Cloud (Butollo, 2019).

3.2 Goliath *and* Goliath

Irrespective of the type of digital platform, their business models are set up around a digital artefact or artefacts[22]. A digital artefact is "a product or service either embodied in information and communication technologies or enabled by them" (Briel et al., 2018, p.278). Digital artifacts22 are delivered through a modular architecture and as mentioned, the utilisation of large volumes of data, i.e., other digital artefacts.

The modular architecture of digital platforms consists typically of four layers, namely a content layer, a service layer, a network layer, and a device layer (Yoo et al., 2010). Ojala et al. (2018) use Netflix as an example to illustrate this modular architecture, where the content layer is provided by film studios, the service layer the streaming of content provided by Netflix, the network layer by the providers of internet access, and the device layer provided by the hardware devices required on which to watch Netflix.

This example illustrates that digital platform firms need to coordinate the activities of many potentially unrelated services providers across their platform - in effect, it needs to achieve synergies between various prominent role players, a "Goliath and Goliath" cooperation and coordination. This requirement presents a complex challenge even in the most advanced economies (Ojala et al., 2018).

Even if a Goliath and Goliath cooperation can be coordinated by a digital platform, it would still require a Goliath digital institution to underpin this cooperation. Digital institutions that underpin platform capitalism are evolving but already include reputation systems, digital rights management technologies, digital identity verification, reputation and credit scoring systems, distributed ledger technologies, cryptocurrencies, non-fungible tokens - amongst others. These digital institutions, most often than not, are "de facto, subsuming government-mediated intellectual property laws" (Sundararajan, 2014, p.4) and even to an extent "putting the nation-state model under serious strain in all sorts of ways" (Bartlett, 2017, p.297). The Goliath and Goliath cooperation and underpinning required for the rise of digital platforms are therefore considerable and still outside the scope and perhaps even the desire of most late industrialising countries.

[22]The revolutionary nature of digital artifacts as the core of value creation in the digital economy is that artifacts are editable, interactive, accessible, distributed, non-rival in use, and can thus be reproduced and recombined at very low marginal cost (Kallinikos et al., 2013).

3.3 Goliath *vs* Goliath

The third way platform capitalism complicates industrialisation is that, even if late industrialising countries establish home-grown digital platforms, adopt features of digital platforms, or build appropriate digital institutions, they will have to engage in platform-to-platform competition. Here, they are far behind in experience and lessons learned. In advanced economies and China, digital platforms often compete against one another. The competition of the large global digital platforms has been described as "Goliath vs Goliath." An example is Amazon and Google competing for advertising revenue or Apple taking legal action against alleged intellectual property appropriation by Google (Foroohar, 2019).

Often large incumbent digital platforms will compete against newly established, growing digital platforms that try to unsettle them from their dominant position. One strategy that new digital platforms will use to try and oust an incumbent is to try and provide a better service to attract the users of the incumbent platform to switch. Eisenmann et al. (2011) discuss the example is of Sony's PlayStation which out-competed Nintendo's Super Nintendo Entertainment System (SNES) by offering users a 32-bit processor and 3D graphics, which was better than SNES 2D-graphics and 16-bit processor. The implication though is that the new entrant platform needs to have access to significant financial and human resources to provide a superior product or service. For developing countries this, as well as the requirement to coordinate and put in place a modular architecture dependent on the inputs of many other firms present significant obstacles in competing with the large incumbent firms.

Another strategy that one platform will use against another is "platform envelopment." This is defined as "entry by one platform provider into another's market by bundling its own platform's functionality with that of the targets to leverage shared user relationships and common components" (Eisenmann et al., 2011, p.1271). An example is of Google "that has entered many platform markets by linking new products to its search platform, including online payment services (Google Checkout), productivity software (Google Docs), Web browser software (Chrome), and mobile phone operating systems (Android)" (Eisenmann et al., 2011, p.1271).

3.4 Five-star Bombs and Other Dirty Tricks

The fourth way platform capitalism complicates industrialisation is the competition that digital platforms create between third-party entrepreneurs, such as app developers or online retailers, using its digital infrastructure (and paying the platform a share of their revenue). Examples are app developers on the Apple Store, retailers on Amazon Market Place and Facebook's Marketplace.

The platforms set the terms of this competition, including, importantly for sellers, how high up in online search rankings their product or service will appear. This has lead in practice to

many complications, most often to the detriment of small firms[23] or freelancers operating on the platform. These complications have arisen from the platform both making the rules and competing with other users, thus not being a neutral arbiter, and from the manipulation and misuse of the rules by users against each other. In an article entitled "Dirty Dealing in the US$175 billion Amazon Marketplace", Dzieza (2018) describes the troubles that small businesses and freelancers may encounter by competing on a large digital platform such as Amazon. These have even been given labels such as "the five-star bomb," "hijacking," "defacement," and "phoney fire." A "five-star bomb", for instance happens when "a seller pays someone to write obviously fraudulent five-star reviews for a competitor's listings and hopes Amazon cracks down" (Dzieza, 2018).

If Amazon "cracks down" an entrepreneur may suddenly find their account suspended and their business unable to operate. Small firms do not have effective recourse if, in the case of such a "five-star bomb" or other dirty trick Amazon unfairly shuts its business down, as they agree to an arbitration procedure when signing up to the platform. This arbitration procedure however has been found to be biased in favour of Amazon "by discouraging sellers who lack the money, time and energy to take on the company" (Soper, 2021).

Moreover, Amazon may be inclined to crack down more fiercely on 3rd party sellers on its platform if those sellers are offering products that compete with one of Amazon's own (Weise, 2019). And there are cases reported where Amazon copied the products of successful 3rd party sellers and sold them at a discount on the platform to steal its business or avoid competition (Addady, 2016).

There is nothing inherently wrong with a competitive online marketplace, and indeed many freelancers and entrepreneurs run successful businesses on such platforms. Increasingly, given the spread of digital platforms to developing countries and the development of more home-grown digital platforms in these countries (see sections 4.1 and 4.3 below), more and more businesses, including new ventures supporting industrialisation, will be doing business on a digital platform. Their ultimate lack of control over their business and the inequities of platform competition, however, implies a large degree of dependence on foreign platform owners, which may not be the best approach to sustainable industrialisation.

3.5 Kill Zones

The fifth way platform capitalism complicates industrialisation is that local business dynamism tends to taper off where there are large digital platforms firms present. Two mechanisms at work here are one, the lack of competitiveness of local firms against the more effective and customer-oriented platform model with its network economies. And two, that

[23]Worldwide, more than 2 million small businesses operated as 3rd party sellers on Amazon in 2020, the most - around 300,000 - from the USA (in 2018) (Danziger, 2018). Sellers from 188 countries can at the time of writing sell directly on Amazon Marketplace, including sellers from 42 Sub-Saharan African countries.

the start-up of new firms, the engine of innovation-driven growth, declines in the presence of large digital platforms.

The lack of competitiveness of traditional local firms against platforms has been discussed in section 3.1. In the case of late industrialising countries should digital platforms enter more into these markets and become more prominent in future, they may out-compete local small businesses, as they have done in advanced economies. This will be not only due to the data network effects as discussed in section 3.1 but also because platforms may be able to fill gaps in developing economies and may even do so better and more cheaply than traditional local businesses. Platforms, particularly peer-to-peer (P2P) platforms may be able to overcome cultural barriers through the internet, establishing trust through rating and feedback systems, and bringing down the cost of matching buyers and sellers significantly. As described by Parente et al. (2018, p.56):

> "Since emerging markets usually have institutional and informational voids and high levels of bureaucracy and doing business costs, sharing economy services become very appealing to individual providers and become legitimated in the market [...] Firms like Go-jek, an Indonesian Uber for motorcycles, Airbnb entrepreneurial hosts from slums in Rio de Janeiro, and PrepClass, a Nigerian educational platform, together with crowdfunding platforms have created thousands of jobs and fomented many new ventures in these emerging markets."

Local business dynamism also tends to taper off where there are large digital platforms firms present due to the presence of so-called "Kill zones." This refers to types of new ventures that are likely to be taken over by digital platforms, or their intellectual property appropriated (Foroohar, 2019; Kamepalli et al., 2021). Global platform giants have indeed been engaging in an active spree of M&A – essentially buying up other firms - the number of firms taken over by the USA based digital platform giants' runs into the hundreds. Likewise, Chinese digital platforms have taken over many firms in China and the East Asian region, an example being Alibaba taking over Indian-based firm PayTm (Foster & Azmeh, 2020). While part of the reason for buying up new start-ups is to gobble up potential competitor firms (e.g., Facebook's acquisitions of Snapchat, Instagram and WhatsApp), it is also done to obtain access to more and diverse data, which allows for recombination and aggregation of data from which new value can be extracted (Li et al., 2019). Many start-ups, aware of these kill zones, accordingly, never plan to establish a long-run, sustainable enterprise but merely aim to enter the market with a product or service that will attract the attention of a digital platform so that they can be bought up even before launching an IPO, such as Instagram (Kamepalli et al., 2021).

3.6 Gatekeepers

The sixth way platform capitalism complicates industrialisation is that digital platform firms have become par excellence the lobbying firms of the present generation – even

outperforming the global financial firms in this regard. Google and Amazon's close relationship to the US Department of Defence had been noted (Sadowski, 2020), and China's BAT's (Baidu, Alibaba and Tencent), although not government-owned, have a close relationship with the Chinese communist party. Given the centrality of data and new technologies based on data to the business models of the large digital platforms, they have a strong interest in weak data and intellectual property protection and engage in extensive and well-coordinated lobbying and legal efforts to influence policymaking (Foroohar, 2019).

One of the practices that digital platform firms want to protect is that of *digital enclosure*. Digital enclosure refers to the creative use of software licenses to obtain control and gain access to users' data. For example, when a factory owner purchases a "smart" machine, they would typically obtain ownership over the physical object, not the embedded software, which through the licensing agreement is leased or rented. This allows the owner of the software access to the use of the machine – even to the extent of shutting it down (Sadowski, 2020).

The influence that digital platforms have over the competitive landscape, and the increasing efforts they exert to gain influence over policy makers is of even greater concern considering that the largest and most predominant of the digital platforms, such as Google, Facebook, Amazon, Apple, Alibaba, and others have in essence become "gatekeeping" intermediaries[24] between consumers and producers (and consumers and consumers). This has made their potential abuse of their position an even graver cause of concern. As such, as is discussed in greater detail below in section 4.2, the new frontier for (digital) industrial policy has become regulation and competition policy since "traditional competition policy approach based on (i) market definition, (ii) assessment of market power and (iii) design, if necessary, of adequate remedies, is difficult and too slow to implement in the digital space" (Cabral et al., 2021, p.3).

3.7 Surveillance Capitalism

Finally, platform capitalism complicates industrialisation as there are many new downsides to an economy in which data is becoming increasingly valuable, and platforms compete for user attention and data. Digital platforms' huge hunger for data, and the high value which data holds for them, has given rise to dubious business models - such as for instance violations of data privacy and data harvesting (gathering data without knowledge and permission of users) and models that foster digital addiction.

Data harvesting and digital addiction are often two sides of the same coin within platforms' business models. For instance, if Google or Facebook's business model depends on selling advertising space (auctioning of space) and data for advertisers, then it has the interest to collect as much data as possible but also to keep users engaged on their platform for as long as possible. This result in a digital architecture that plays in on humans' dopamine centres,

[24]Gatekeeping platforms are defined by the EC as those with "more than 45 million active monthly end users or more than 10,000 active yearly business users" (Cabral et al., 2021, p.9).

causing addiction, resulting in clickbait and false news, in a battle to gain as much as possible of users' attention in a model - where the user of these platforms becomes in effect the product. Thus, given that "showing consumers arousing and sensationalist things [. . .] will make them stay longer than something truthful and useful [. . .] If you let a machine learning algorithm loose in these platforms, it will discover that people click more on this kind of content, and therefore the platform will deliver more of it" (Morton, 2021, p.143).

With the widespread prevalence of data harvesting and digital addiction, digital platform capitalism has been described as surveillance capitalism and as responsible for the emergence of a surveillance state (Zuboff, 2015; Srnicek, 2017a, b; Murakami Wood & Monahan, 2019). Surveillance capitalism includes not only direct surveillance activities by platforms, but "the manifold and often insidious ways that digital platforms fundamentally transform social practices and relations [. . .] and setting the terms upon which individuals, organisations, and governments interact" (Murakami Wood & Monahan, 2019, p.1). Pasquale (2016) contrasts two narratives of digital capitalism, noting that because the technical press is dependent on advertising revenue from "big tech" they tend to provide an over-optimistic narrative of digital capitalism - including hyping the 4IR.

Considering this, industrialisation in late industrialising countries faces a novel set of challenges relating to the value, use and misuse of data. Very few African countries, for instance have at the time of writing for instance signed up to the African Union's Convention on Cyber Security and Personal Data Protection. And more and more are resorting to utilising new digital technologies to spy on their citizens and restrict access to the Internet. This situation creates uncertainty, distrust, and vulnerabilities, limiting the absorption and use of new digital technologies for domestic industrialisation.

4. Implications for Industrial Policy

Industrial policy refers to "any type of selective government intervention or policy that attempts to alter the structure of production in favour of sectors that are expected to offer better prospects for economic growth that would not occur in the absence of such intervention" (Pack & Saggi, 2006, p.1-2). Digital industrial policy refers to industrial policy where the emphasis is on "new approaches that are relevant to digital technologies and the new business models that are common in the digital economy" (Foster & Azmeh, 2020, p.1248). Digital industrial policy should thus not only be concerned with the nature and implications of new digital technologies but also with the business models that they give rise to. More attention is needed in the literature on late industrialisation on this latter aspect.

Late industrialising countries require very deliberate digital industrial policies to deal with business models such as the digital platform firm, which underpin digital platform capitalism. Such policies need to deal with at least three issues: (i) avoid being marginalised or captured by other countries' digital platform strategies; (ii) appropriately regulate digital platforms; and

(iii) create a supportive environment for home-grown digital platforms. These requirements will be discussed in greater detail in the following sub-sections.

4.1 Avoid marginalization or capture

As a first requirement to bring digital platforms within the purview of digital industrial policy, developing countries should formulate appropriate responses to the industrial policy responses of leading manufacturing countries, e.g., the USA, Germany, and China. These countries have all, in recent years, in response to the digital revolution, developed new industrial strategies. These will either close policy space and opportunities in late industrialising countries or create more opportunities – or a mix of both.

In the West, the USA is essentially developing smart manufacturing to re-shore jobs outsourced to China and other Asian countries during the latter's rise. Germany, with its Industrie 4.0 strategy, is aiming at the digitisation of its manufacturing sector, including promoting new business models for manufacturing that would likewise re-shore jobs and shorten value chains. The digital revolution enables manufacturing to be more agile, to be less dependent on low-wage labour, and through the consumerisation of digital technologies, brings firms closer to consumers (Balsmeier & Woerter, 2019). Banga & te Velde (2018) reckon that African countries where low digital intensity sectors with low wage labour still dominate may have around 15 years until they lose their wage advantages because of these reshoring strategies in the advanced economies.

Germany, and the EU more generally, has also started to pay much more attention to the regulation of USA-based digital platforms and their potential negative consequences for European industries[25], for instance, through initiatives such as the General Data Protection Regulation (GDPR), more aggressively bringing anti-competitive actions against the large USA digital platforms, and formulating its own Digital Strategy (Europe's Digital Decade).

In China, the state is using existing large digital platforms - the BATs – deliberately as an industrial policy tool to support less innovative regional firms to modernise, such as in transport, small scale manufacturing and regional retail (Foster & Azmeh, 2020). An example of this is the creation of "Taobao-villages" which is an consumer-to-consumer (C2C) digital platform owned by Alibaba that sells products made locally in regional areas by small scale producers (Butollo, 2019).

China's digital industrialisation ambitions may be consequential for late industrialising countries such as those in Sub-Saharan Africa, as the region is explicitly targeted. China's vision for global industrial leadership is based on a comprehensive digitisation strategy to attain digital sovereignty and digital dominance. The establishment and promotion of digital platform giants and their spread into emerging markets like Africa is a central plank of this

[25]Chinese firms are also not exempt from EU scrutiny and legislative measures, see for instance the case of Huawei and the provision of 5G telephone networks in Europe.

strategy. The digital giants will cement their leading positions not only through the network economies from the large domestic Chinese market, but through locking in the economies of emerging economies into their technology hardware, standards, and cyber governance systems. China's industrial policies follow from its Made in China 2025 strategy, which has the ambition to position China as the world's leading high-tech manufacturing hub. Made in China 2025 (MiC2025) has several components with implications for African industrialisation, such as the Belt and Road Initiative (BRI) with its digital counterparts, the Digital Silk Road (DSR), the Internet Plus initiative, and the China Standards 2035 plan (Dekker et al., 2020). As a result of these, China's most prominent digital platforms are expanding into Africa. Anwar (2017) discusses the case of Alibaba[26], one of China's most prominent digital platforms, and how it is expanding into foreign markets - including those in Sub-Sahara Africa.

Since 2017 Alibaba has expanded its global reach into Sub-Sahara Africa, aiming to create a "pan-African eco-system based on the Alibaba model" and several interlinked initiatives to gain rapid market share across the continent. These include the rolling out of the Electronic World Trade Platform (eWTP) to link African consumers and firms to those in China (it is part of the Digital Silk Road), the Africa Netpreneur Prize (ANPI) to identify promising new businesses for Alibaba to invest in, and the cultivation of close ties to African political leaders (Velluet, 2020). The Alipay mobile payment platform has entered into collaboration agreements with virtually all of Africa's main payment infrastructures and services, including M-Pesa, Vodacom, Ecobank's RapidTransfer, Flutterwave and Vodacom (Velluet, 2020).

Whereas Western digital industrial strategies are likely to leave African countries more excluded or marginalised through the withdrawal of manufacturing activity through re-shoring and automation in the west, and through the restrictions imposed by the GDPR and other privacy-oriented legislative responses, China's industrial strategy aims to dominate African economies by locking their economies into China's technology hardware, standards, and cyber governance systems.

4.2 Appropriately regulate digital platforms

A second requirement for digitally relevant industrial policies in late industrialising countries is to regulate global digital platforms so that developing countries could benefit from their presence but avoid their many dangers. Global digital platforms pose risks, but they also have

[26]Alibaba, which was established in 1999 by Chinese entrepreneur Jack Ma, has grown to become one of the largest, if not the largest, business-to-business (B2B) platform in the world. It has also created a large business to-consumer (B2C) platform, Taobao, and a financial services platform for small businesses, Ant Financial Services (Alipay) - amongst other intermediation services connecting consumers and small businesses across the world. Since 2009 the platform has expanded globally – mainly to the USA, India, Japan, and Europe – and engaged in acquisition of various companies as well as building alliances with other large platform and ICT companies including Microsoft, Baidu, Tencent, CTrip, Sohu.com, Netease, eBay, and Yahoo (Anwar, 2017).

many potential benefits, as illustrated during the COVID-19 pandemic (Kenney & Zysman, 2020).

The various ways in which digital platforms complicates industrialisation, as set out in section 3 of this paper, suggest that how they compete, and in particular, their first-mover advantages and dominance of markets may pose the most severe obstacles or dangers for late industrialising countries. The monopoly power that these digital platforms obtain because of data network effects, on the one hand generate benefits in the form of more efficient products and services for consumers and users of their platform, but on the other brings with it possible misuses and abuses of this power - such as stifling competition and engaging privacy-eroding surveillance practices. The challenge for regulators in the age of platform capitalism is how to preserve dynamic competition, i.e. prevent the misuse and abuse of digital platform monopoly power and gatekeeper function (Cabral et al., 2021). A lack of dynamic competition could harm social welfare and thus call for appropriate intervention (?). Misuses, abuses the resulting harms to social welfare may create a very uneven and unfair playing field for late industrialising countries. The EU's grappling with this challenge indicates the complexity of the matter.

The EU, like late industrialising countries in the developing world, is marginalised as far as global digital platforms are concerned: Europe has no comparable digital platforms to compete with those of the USA and China. As a result, Europe's digital industrial strategy is to regulate (US and Chinese) platforms. The EU has, for instance, in recent years, in addition to the GDPR which concerns the use of data, adopted its EU Platform-to-Business (P2B) Regulation (2019), and proposed a Digital Markets Act (DMA) and Digital Services Act (DSA) in December 2020 (Cabral et al., 2021). And it has brought an increasing number of punitive legal cases against global digital platforms - for example between 2017 and 2019 the EU imposed almost €9 billion in antitrust fines on Google.

For late industrialising countries the EU's regulatory approaches and antitrust fines against global digital platforms, and China's efforts to impose its standards and governance systems on the worldwide economy, signal that digital industrial policy in the age of platforms capitalism will ultimately be concerned with regulations and standards (Li et al., 2019). Herein, regulations and standards about data will be paramount, as data is the "oil" that fuels the business models of digital platforms. Regulations and standards about data will have to deal with its ownership, sharing, exchange, and privacy protection issues.

From a digital industrial policy point of view, the governance of data poses challenges. Hence, the fact that data is non-rival in consumption or usage and non-material complicates simple policies to prevent data from being harvested by foreign firms. The problem is the existence of cross-border spillovers in data analysis (Bergemann et al., 2019; Rubinfeld & Gal, 2017). Data spill overs mean that because consumers tend to be roughly similar in their make-up and psychology across jurisdictions, data from consumers in one country may be helpful in

another protected jurisdiction[27]. This gives an advantage to digital platforms operating in several countries. Thus, for example, Chinese-based digital platform firms may use data harvested in Kenya to design products and sell data to businesses targeting South African consumers without access to data of South African origin. Moreover, because data about one consumer helps to understand another consumer, the social value of data will exceed the private value of data. Hence, the cost of acquiring the private data will be much less than the value of the data to the platform (Bergemann et al., 2019).

While this complexity of regulating data, given its nature, remains an obstacle in late industrialisation and an open challenge for digital industrial policy, there is, however, also an upside, namely that there is sat the time of writing still policy space for novel digital industrial policies relating to data regulation and governance. As pointed out by Foster & Azmeh (2020, p.1257) "binding rules are relatively limited at the moment, there are significant grey areas in current rules, and slow progress at present within digital trade at the WTO and within RTAs". This creates scope - and urgency - for digital industrial policy in late industrialising countries.

4.3 Create a supportive environment for home grown digital platforms

The third requirement for digitally relevant industrial policies in late industrialising countries is that it should help create a supportive environment for the emergence and growth of home-grown digital platforms -and of course regulate these appropriately. This will require a focus on digital entrepreneurship, skills, infrastructure, and finance to develop digital entrepreneurial ecosystems. The purpose of such digital entrepreneurial ecosystems should be to nurture the growth of new ventures based on business models wherein data and consumer orientation are more centrally embedded than in traditional models. Such policies will require more research on the current state, drivers, and obstacles of the emerging digital platform landscape in developing regions.

The literature on industrialisation in developing countries has focused largely on the nature and potential of the new digital technologies, and the requirements for late industrialising countries to benefit from these. It has neglected digital platforms. Nevertheless this literature makes useful industrial policy recommendations that are also relevant for creating a supportive environment for home-grown digital platforms. These include policies to promote ("21st century") skills, digital entrepreneurship, complementary infrastructure, and global value chain integration (Matthess & Kunkel, 2020; UNCTAD, 2019; OECD, 2017). As far as skills are concerned, Andreoni et al. (2021) stress that digital technologies are characterised by the "merging and overlapping of technologies" ("technology fusion") which requires a premium on "foundational capabilities" to be able to absorb and implement new technologies. They argue against industrial policies that try to achieve some sort of technology leapfrogging, or policies that try to bypass manufacturing by trying to promote high productivity services

[27]Bergemann et al. (2019) describes this spill over effect of data as the social dimension of data.

sectors (e.g., business, financial and transport services, and tourism) because these policies would require first that foundational capabilities are present.

As far as supporting infrastructure is concerned, there is a general and established recognition that the digital divide - reflected for example in low internet penetration rates, lack of significant broadband access – is one of the basic bottlenecks in the digitalisation of SSA industry. Cariolle (2021, p.14-14) identifies the most serious shortcomings in African countries' ICT / digital infrastructure to be high costs for internet usage[28], underdeveloped backbone backhaul and last-mile mobile networks, internet exchange points and data centres[29], lagging in terms of SMC rollout, and lack of affordable and stable electricity[30].

When one considers the digital platform landscape, then mere internet access is not enough anymore: what matters for industrial competitiveness is bandwidth. The digital bandwidth gap between high-income countries as the rest of the world, measured in terms of the difference in average kilobits per second (kbps) bandwidth installed was 45 kbps in 2000, has grown to over 15,000 kbps by 2014 (Hilbert, 2016). This reflects that bandwidth expansion has underpinned the growth of digital platform firms in advanced economies and that a new digital divide is opening up between advanced economies and late industrialising countries.

While the USA and China dominate the global digital platform economy, there has been growth in Africa in the number of local (homegrown) digital platform firms, despite the skill and infrastructural bottlenecks mentioned in the previous paragraphs. Johnson et al. (2020) documents the number and growth of digital platforms in several countries Africa in 2019. They list 365 digital platforms across eight countries with an average of 92,000 users per month and found that across Africa the average user base is growing by 18% per annum. Around 82% of platforms are "homegrown" (i.e., originating in the country) and 20% are foreign – although foreign platforms were found are capturing an increasing size of the market - as one would expect given the discussion in section 3. Johnson et al. (2020) also found that homegrown platforms tend to focus largely on the local market – few are expanding into other African countries, and the number of platforms is growing faster than the user base, which the authors see as a reflection of the fragmented nature of homegrown digital platforms. In contrast to this profile of emerging but somewhat struggling homegrown platforms, Johnson et al. (2020) found that

> "scale-of-usage data suggests that the average number of users per platform is three times larger on platforms originating from outside of Africa's borders, than on homegrown platforms [...] foreign platforms on average have launched operations five years earlier than homegrown platforms. This may have resulted in a first-mover

[28]The cost of internet use in SSA is high due monopolistic and oligopolistic market conditions and relatively high tax rates being levied on telecommunications operators (Cariolle, 2021).
[29]Most African websites are hosted on European and American data centres (Cariolle, 2021).
[30]The extent to which unreliable energy – for example power outages - negatively impact firms in Africa are described in Cole et al. (2018).

> advantage for foreign platforms [...] local platform players are not yet able to scale their operations in a sustainable manner."

The need for industrial policies to create a supportive environment for the emergence and growth of homegrown digital platforms is thus clear.

5. Conclusion

Given diminished expectations of the digital revolution / 4th Industrial Revolution for late industrialising countries, and given the rise of digital platform capitalism, industrial policy is becoming a battle for technological supremacy and control over fundamental digital assets – both tangible and intangible. Regulations, standards, intellectual property, legislative measures are becoming more than ever crucial industrial policy tools. In this, the policy and political processes in late industrialisers cannot remain behind. According to (Kenney & Zysman, 2016, p.69), digital platform capitalism can lead to social and political upheaval, as was the case during earlier forms of capitalism. As they put it, "*The reality is that the winners and losers in markets depend on who can participate and on what terms. There are no markets, and no market platforms, without rules, but what happens to the politics if important market rules are made unchallenged by the platform owners? Many political struggles will be waged over these rules, and those fights will be part of defining the market and society in a platform era*." Late industrialising countries need digital industrial to ensure that they get a say in establishing and policing the market rules for platform capitalism.

References

Addady, M. (2016). Merchants Say Amazon is Copying their Products. Fortune, 20 April.

Anderson, C. (2012). Makers: The New Industrial Revolution. London: Random House.

Andreessen, M. (2011). Why Software Is Eating the World. The Wall Street Journal, 20 August.

Andreoni, A., Chang, H., & Labrunie, M. (2021). Natura Non Facit Saltus: Challenges and Opportunities for Digital Industrialisation Across Developing Countries. The European Journal of Development Research, 33, 330–370.

Andreoni, A. & Tregenna, F. (2020). Escaping the Middle-Income Technology Trap: A Comparative Analysis of Industrial Policies in China, Brazil and South Africa. Structural Change and Economic Dynamics, 54, 324–340.

Anwar, S. (2017). Alibaba: Entrepreneurial Growth and Global Expansion in B2B/B2C Markets. Journal of International Entrepreneurship, 15, 366–389.

Astebro, T., Braguinsky, S., & Ding, Y. (2020). Declining Business Dynamism among our Best Opportunities: The Role of the Burden of Knowledge. NBER Working Paper no. 27787, National Bureau of Economic Research.

Balsmeier, B. & Woerter, M. (2019). Is This Time Different? How Digitalization Influences Job Creation and Destruction. Research Policy, 48(8), 103765.

Banga, K. & te Velde, D. (2018). Skill Needs for the Future. Pathways for Prosperity Commission Background Paper Series; no. 10. Oxford, United Kingdom. Bartlett, J. (2017). Radicals: Outsiders Changing the World. London: Windmill Books.

Bergemann, D., Bonatti, A., & Gan, T. (2019). The Economics of Social Data. Cowles Foundation Discussion Paper No. 2203R, September.

Bergstein, B. (2019). This is Why AI has Yet to Reshape Most Businesses. MIT Technology Review, 13 February.

Berman, B. (2012). 3-D Printing: The New Industrial Revolution. Business Horizons, 55(2), 155–162.

Bloom, N., Jones, C., van Reenen, J., & Webb, M. (2017). Are Ideas Getting Harder to Find? NBER Working Paper no. 23782, National Burea for Economic Research.

Bostrom, N. (2014). Superintelligence: Paths, Dangers, Strategies. Oxford: Oxford University Press.

Briel, F. V., Recker, J., & Davidsson, P. (2018). Not All Digital Venture Ideas are Created Equal: Implications for Venture Creation Processes. The Journal of Strategic Information Systems, 27(4), 278–295.

Broekhuizen, T., Broekhuis, M., Gijsenberg, M., & Wieringa, J. (2021). Introduction to the Special Issue - Digital Business Models: A Multi-Disciplinary and Multi-Stakeholder Perspective. Journal of Business Research, 122, 847–852.

Brynjolfsson, E. & McAfee, A. (2016). The Second Machine Age. New York: W.W. Norton.

Brynjolfsson, E. & McElheran, K. (2019). Data in Action: Data-Driven Decision Making and Predictive Analytics in U.S. Manufacturing. Rotman School of Management Working Paper No. 3422397.

Brynjolfsson, E., Rock, D., & Syverson, C. (2017). Artificial Intelligence and the Modern Productivity Paradox: A Clash of Expectations and Statistics. NBER Working Paper no. 24001. National Bureau for Economic Research.

Butollo, F. (2019). Data, Artificial Intelligence (AI) and Industrial Platforms in Global Value Chains. Paper presented at the Annual Meeting of the Society for Socioeconomics (SASE), New York, 27-29 June.

Byrne, D., Corrado, C., & Sichel, D. (2018). The Rise of Cloud Computing: Minding Your Ps, Qs, and Ks. NBER Working Paper No. 25188, National Bureau of Economic Research.

Cabral, L., Haucap, J., Parker, G., Petropoulos, G., Valletti, T., & Van Alstyne, M. (2021). The EU Digital Markets Act. Publications Office of the European Union, Luxembourg.

Calvino, F., Criscuolo, C., Marcolin, L., & Squicciarini, M. (2018). A Taxonomy of Digital Intensive Sectors. OECD Science, Technology and Industry Working Papers no. 2018/14, OECD Publishing, Paris.

Cano, A. (2017). A Survey on Graphic Processing Unit Computing for Large-Scale Data Mining. WIREs Data Mining and Knowledge Discovery, 8(1), e1232. Cariolle, J. (2021). International Connectivity and the Digital Divide in Sub-Saharan Africa. Information Economics and Policy, 55, 100901.

Chan, H., Griffin, J., Lim, J., Zeng, F., & Chiu, A. (2018). The Impact of 3D Printing Technology on the Supply Chain: Manufacturing and Legal Perspectives. International Journal of Production Economics, 205, 156–162.

Cole, M., Elliott, R., Occhiali, G., & Strobl, E. (2018). Power Outages and Firm Performance in Sub-Saharan Africa. Journal of Development Economics, 134, 150–159. Danziger, P. (2018). Thinking of Selling on Amazon Marketplace? Here are the pros and cons.

Forbes, 27 April. Deichmann, U., Goyal, A., & Mishra, D. (2016). Will Digital Technologies Transform Agriculture in Developing Countries? Agricultural Economics, 47, 21–33.

Dekker, B., Okano-Heijmans, M., & Zhang, E. (2020). Unpacking China's Digital Silk Road. Clingendael Report, The Hague, July.

Dzieza, J. (2018). Prime and Punishment. The Verge, 19 Dec.

Eisenmann, T., Parker, G., & Alstyne, M. V. (2011). Platform Envelopment. Strategic Management Journal, 32(12), 1270–1285.

Farboodi, M., Mihet, R., Philippon, T., & Veldkamp, L. (2019). Big Data and Firm Dynamics. NBER Working Paper no. 25515, National Bureau of Economic Research.

Feldstein, S. (2019). The Global Expansion of AI Surveillance. Working Paper, Carnegie Endowment for International Peace, Sept.

Foroohar, R. (2019). Don't be Evil: The Case Against Big Tech. London: Penguin. Foster, C. & Azmeh, S. (2020). Latecomer Economies and National Digital Policy: An Industrial Policy Perspective. The Journal of Development Studies, 56(7), 1247–1262. Frey, C. &

Osborne, M. (2017). The Future of Employment: How Susceptible are Jobs to Computerization? Technological Forecasting and Social Change, 114, 254–280.

Friedman, T. (2016). Thank You for Being Late: An Optimist's Guide to Thriving in the Age of Accelerations. New York: Picador.

Gandomi, A. & Haider, M. (2015). Beyond the Hype: Big Data Concepts, Methods, and Analytics. International Journal of Information Management, 35(2), 137–144. 31

Gordon, R. & Sayed, H. (2020). Transatlantic Technologies: The Role of ICT in the Evolution of U.S. and European Productivity Growth. International Productivity Monitor, 38, 50–80.

Grabher, G. & van Tuijl, E. (2020). Uber-Production: From Global Networks to Digital Platforms. EPA: Economy and Space, 52(5), 1005–1016.

Graham, M., Ojanpera, S., Anwar, M., & Friederici., N. (2017). Digital Connectivity and African Knowledge Economies. Questions de Communication, 32, 345–360.

Gries, T. & Naudé, W. (2010). Entrepreneurship and Structural Economic Transformation. Small Business Economics Journal, (34), 13–29.

Hatton, M. & Webb, W. (2020). The Internet of Things Myth. Transforma Insights, UK.

Hess, B. (2017). What Is CNC Machining? An Overview of the CNC Machining Process. https://astromachineworks.com/what-is-cnc-machining/, 22 May.

Hilbert, M. (2016). The Bad News is that the Digital Access Divide is Here to Stay: Domestically Installed Bandwidths Among 172 Countries for 1986-2014. Telecommunications Policy, 40(6), 567–581.

Hinton, G., Osindero, S., & Teh, T.-W. (2006). A Fast Learning Algorithm for Deep Belief Nets. Neural Computation, 18, 1527–1554.

Hinton, G. & Salakhutdinov, R. (2006). Reducing the Dimensionality of Data with Neural Networks. Science, 313, 504507.

Hirsch-Kreinsen, H. (2016). Digitization of Industrial Work: Development Paths and Prospects. Journal for Labour Market Research, 49(1), 1–14. HUBS (2020). 3D-PrintingTrends 2020: Industry Insights and Market Trends.

Amsterdam. Johnson, C., Bester, H., van Vuuren, P. J., & Dunn, M. (2020). Africa's Digital Platforms: An Overview of Emerging Trends in the Market. insight2impact.

Kallinikos, J., Aaltonen, A., & Marton, A. (2013). The Ambivalent Ontology of Digital Artifacts. MIS Quarterly, 37(2), 357–370.

Kamepalli, S., Rajan, R., & Zingales, L. (2021). Kill Zone. NBER Working Paper No. 27146, National Bureau of Economic Research.

Karlgraad, R. (2011). 3D Printing will Revive American Manufacturing. Forbes, 23 June.

Kenney, M. & Zysman, J. (2020). COVID-19 and the Increasing Centrality and Power of Platforms in China, the US, and Beyond. Management and Organization Review, 16(4), 747–752.

Kenney, M. & Zysman, M. (2016). The Rise of the Platform Economy. Issues in Science and Technology, Spring, 61–69.

Korinek, A. & Stiglitz, J. (2017). Artificial Intelligence and its Implications for Income Distribution and Unemployment. NBER Working Paper no. 24174. National Bureau for Economic Research.

Langley, P. & Leyshon, A. (2017). Platform Capitalism: The Intermediation and Capitalisation of Digital Economic Circulation. Finance and Society, 3(1), 11–31.

Lawrence, R. (2017). Recent US Manufacturing Employment: The Exception that Proves the Rule. Peterson Institute for International Economics Working Paper 12-17.

LeCun, Y., Bengio, Y., & Hinton, G. (2015). Deep Learning. Nature, 521, 436–444.

Li, W., Nirei, M., & Yamana, K. (2019). Value of Data: There's No Such Thing as a Free Lunch in the Digital Economy. RIETI Discussion Paper Series 19-E-022.

Maffei, A., Grahn, A., & Nuur, C. (2019). Characterization of the Impact of Digitalization on the Adoption of Sustainable Business Models in Manufacturing. Procedia CIRP, 81, 765–770.

Manwaring, K. & Clarke, R. (2015). Surfing the Third Wave of Computing: A Framework for Research Into eObjects. Computer Law and Security Review, 31, 586–603.

Matthess, M. & Kunkel, S. (2020). Structural Change and Digitalization in Developing Countries: Conceptually Linking the Two Transformations. Technology in Society, 63, 101428.

McAfee, A. & Brynjolfsson, E. (2017). Machine, Platform, Crowd: Harnessing our Digital Future. New York: W.W. Norton & Company.

MIT (2020). How AI Will Revolutionize Manufacturing. MIT Technology Review, 29th September.

Moor, J. (2006). The Dartmouth College Artificial Intelligence Conference: The Next Fifty Years. AI Magazine, 27(4), 87–91.

Morton, F. (2021). What Should We Do about Big Tech? In Garicano, L. Capitalism after Covid: Conversations with 21 Economists. CEPR Press: Centre for Economic Policy Research, London, (pp. 141–146).

Murakami Wood, D. & Monahan, T. (2019). Editorial: Platform Surveillance. Surveillance & Society, 17(1/2), 1–6.

Naudé, W. (2021). Artificial Intelligence: Neither Utopian nor Apocalyptic Impacts Soon. Economics of Innovation & New Technology, 30(1), 1–23.

OECD (2017). African Economic Outlook 2017: Entrepreneurship and Industrialisation. Paris: OECD Publishing.

Ojala, A., Evers, N., & Rialp, A. (2018). Extending the International New Venture Phenomenon to Digital Platform Providers: A Longitudinal Case Study. Journal of World Business, 53(5), 725–739.

Oqubay, A., Cramer, C., Chang, H.-J., & Kozul-Wright, R. (2020). The Oxford Handbook of Industrial Policy. Oxford: Oxford University Press.

Pack, H. & Saggi, K. (2006). Is There a Case for Industrial Policy? A Critical Survey. World Bank Research Observer, July, 1–31.

Parente, R., Geleilate, J.-M., & Rong, K. (2018). The Sharing Economy Globalization Phenomenon: A Research Agenda. Journal of International Management, 24(1), 52–64.

Parker, G., Van Alstyne, M., & Choudary, S. (2016). Platform Revolution. New York: W.W. Norton & Company.

Pasquale, F. (2016). Two Narratives of Platform Capitalism. Yale Law & Policy Review, 35(1), 309–319.

Patsavellas, J. & Salonitis, K. (2019). The Carbon Footprint of Manufacturing Digitalization: Critical Literature Review and Future Research Agenda. Procedia CIRP, 81, 1354–1359.

Rayna, T., Striukova, L., & Darlington, J. (2015). Co-creation and User Innovation: The Role of Online 3D Printing Platforms. Journal of Engineering and Technology Management, 37, 90–102.

Rochet, J.-C. & Tirole, J. (2003). Platform Competition in Two-Sided Markets. Journal of the European Economic Association, 1(4), 990–1029. 34.

Rodrik, D. (2016). Premature Deindustrialisation . Journal of Economic Growth, 21(1), 1–33. Rubinfeld, D. & Gal, M. (2017). Access Barriers to Big Data. Arizona Law Review, 59, 339–381.

Russel, S., Dewey, D., & Tegmark, M. (2015). Research Priorities for Robust and Beneficial Artificial Intelligence. AI Magazine, Association for the Advancement of Artificial Intelligence, Winter, 105–114.

Rysman, M. (2009). The Economics of Two-Sided Markets. Journal of Economic Perspectives, 23(3), 125–43.

Sadowski, J. (2020). The Internet of Landlords: Digital Platforms and New Mechanisms of Rentier Capitalism. Antipode, 52(2), 562–580.

Schwab, K. (2016). The Fourth Industrial Revolution: What it means, how to respond.

Soper, S. (2021). Amazon Merchant Kicked Off Website Spent $200,000 to Get Justice. Bloomberg Technology, 3 March.

Srnicek, N. (2017a). The Challenges of Platform Capitalism: Understanding the Logic of a New Business Model. Juncture, 23(4), 254–257.

Srnicek, N. (2017b). Platform Capitalism. Malden, MA: Polity.

Sundar, R., Balaji, A., & Kumar, R. (2014). A Review on Lean Manufacturing Implementation Techniques. Procedia Engineering, 97, 1875–1885.

Sundararajan, A. (2014). Peer-to-Peer Businesses and the Sharing (Collaborative) Economy: Overview, Economic Effects and Regulatory Issues. Written testimony to Committee on Small Business of the United States House of Representatives, January 15th.

Thomas, L., Autio, E., & Gann, D. (2014). Architectural Leverage: Putting Platforms in Context. Academy of Management Perspectives, 28(2), 198–219.

UNCTAD (2019). Digital Economy Report 2019: Value Creation and Capture: Implications for Developing Countries. Geneva: United Nations Conference on Trade and Development.

Velluet, Q. (2020). China's Jack Ma: An Africa Strategy of Connect and Influence. The Africa Report, 9 November.

Wade, R. (2016). Industrial Policy in Response to the Middle-Income Trap and the Third Wave of the Digital Revolution.

Global Policy, (7), 469–480. Waldrop, M. (2016). The Chips are Down for Moore's Law. Nature, 530, 144–147.

Weise, K. (2019). Prime Power: How Amazon Squeezes the Businesses Behind its Store. The New York Times, 19 Dec.

Weller, C., Kleer, R., & Piller, F. (2015). Economic Implications of 3D Printing: Market Structure Models in Light of Additive Manufacturing Revisited. International Journal of Production Economics, 164, 43–56.

WIPO (2019). Technology Trends 2019: Artificial Intelligence. Geneva: World Intellectual Property Organization.

Yoo, Y., Henfridsson, O., & Lyytinen, K. (2010). The New Organizing Logic of Digital Innovation: An Agenda for Information Systems Research. Information Systems Research, 21(4), 724735.

Zuboff, S. (2015). Big Other: Surveillance Capitalism and the Prospects of an Information Civilization. Journal of Information Technology, 30(1), 75–89.

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