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ABSTRACT

The digital economy has been growing exponentially in recent years thanks to new technologies that are promoting a global transformation. Key technologies responsible for this transformation have become the subject of intense discussions under the umbrella term 'fourth industrial revolution'. This paper offers a discussion on the differentiated impact of digital technologies on unemployment, capabilities building and technological catch-up for developing countries. It articulates some of the key issues and tradeoffs for developing countries that should be considered in policy discussions and deliberations.

Two important conclusions for policy stand out from the analysis in this paper. Firstly, new digital markets introduce a range of market failures throughout the process of knowledge creation, knowledge mediation, value creation, value capture and trade in the digital economy. The new technology-mediated economy is imperfect, riddled with information asymmetries, monopolies, algorithmic intransparencies and 'winner-takes-all' effects. Secondly, these market failures intensify all existing government or institutional failures that have held back development in developing countries. Any pre-existing binding constraint – such as the lack of coordination for innovation, lack of ability to mobilize domestic resources, inability to create linkages, low resilience of the domestic entrepreneurship sector, tax avoidance, and the failure to regulate competition – will have a direct bearing on how the gains of the fourth industrial revolution can be secured. The real challenge for developing country policy makers, therefore, is to be able to articulate their own industrialization and developmental goals as part of the transition to the digital era and to enact policies that enable it. The paper also warns against technological determinism; an approach that simply focuses on widely applying existing digital technologies for the broader good of mankind without a discussion of its public policy implications.

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I. INTRODUCTION

The digital economy has been growing exponentially in recent years thanks to new technologies that are promoting a global transformation. The key technologies responsible for this transformation - big data analytics, robotics process automation (RPA), artificial intelligence (AI), cyber-physical systems (also known as Internet of Things), 3D manufacturing and blockchains - upend global trade and production patterns in three ways: they blur the boundaries of manufacturing and services as we traditionally understand them; they shift the emphasis of global trade and global production to the digital medium; and they introduce a whole new set of products, processes and ways of doing business.

A number of studies capture these effects under the umbrella term 'fourth industrial revolution' forecasting productivity gains and noting the wide-ranging impact of these technologies on industry and society (See Schwab, 2016; Acatech, 2013; AfDB et al, 2018). Recent scholarship on the topic is widely in agreement that the fourth industrial revolution is somewhat different from the third revolution (which was characterized by the rise of the computers and the digital age), the second revolution (which was led by an increased degree of automation and mass production due to electricity) and the first industrial revolution (as characterized by the invention of the steam engine, roads and mechanical production). In the current era, the expansion of communication and broadband networks have led to the emergence of a new, entirely co-dependent technological ecosystem, where the massive accumulation of big data drives new technologies and related innovations (e.g. robotics and process automation (RPA), cyber-physical systems, artificial intelligence (AI), advanced manufacturing (3D) technologies) and new business models.

But these technologies are not just creating a new technological ecosystem; they are supporting the economic capture of trade, production, knowledge creation and market formation in new ways. A glaring question is whether, and if so how, the digital economy will impact jobs, re-organize industry and affect employment trends in countries globally. Not far behind is the question: whether and to what extent these new technologies aggravate the distance between industrialized countries that have the capabilities and developing countries that do not. Finally, what kind of regulatory and policy regime is best suited to promote the emergence of a fairer digital economy?

These questions are crucially important for all countries because digital technology is not just expanding on an unprecedented scale to implicate every sphere of human activity but is also shifting the scientific frontier on a continuous basis by introducing newer and newer advancements such as quantum computing, semi-autonomous vehicles, and new medical techniques. Despite a wider acknowledgement that policy has a role to play, the debate on the role of policy in the fourth industrial revolution has tended to either revolve around generalities or become highly divisive. There are a few reasons why. To begin with, there are no clear definitions of the digital economy, as a result of which policy discussions do not capture its value appropriately or assign it in any meaningful way. Secondly, many policy discussions oscillate between being too specific by focusing just on e-commerce, which despite its rising importance, is only a part of the digital economy, or are largely generic, either lauding or forewarning against the fourth industrial revolution without delving deep into the specific technologies in question, their industrial capacity, and potential for application in different sectors/ regions/ countries. Lastly, alongside the expansion of digital trade, there has been a proliferation of free trade agreements (FTAs) and other national regulations, which seek to provide regulatory regimes to fully/ partially liberalize digital trade. Broadly speaking, existing FTAs shift the normative basis in favour of extreme digital liberalization, facilitating not just a growing reliance on ownership of knowledge-based capital in new digital technologies (Okediji, 2018; Baldwin, 2018)[1] but helping to concentrate data flows in the hands of a few.[2] Other national regulations - such as those on data localization – seek to promote more national control over what is increasingly becoming an uncertain innovation and production landscape. While much can be said and disputed about both sets of rules, unfortunately, neither focus on comprehensively capturing the key issues in the interface of trade, personal privacy and development that the digital economy creates.

There is no doubt that technological transformation of countries will take place at different speeds in the fourth industrial revolution much like it did in the previous eras, given the already polarized and uneven nature industrialization in the global context, and the already ongoing scramble for digital gains. Digital technologies rely on *pre-existing* industrial capacity for use and profit generation, thereby exacerbating the already existing technological divides. As a result, new rules being introduced as part of FTAs secure export markets in digital trade for a wide variety of knowledge goods in which industrialized countries hold a competitive advantage, much like it has been doing for the past two decades in conventional trade of goods and services (Correa, 2000; Kur, 2014). The real challenge for developing country policy makers, in this context, is to be able to articulate their own industrialization and developmental goals as part of the transition to the digital era and to enact policies that enable it. This calls for a comprehensive assessment of new digital technologies, how they will unfold in the immediate future, which sectors they will affect most, and how they will interact with the pre-existing industrial strengths and capabilities in different parts of the developing world.

This paper offers a discussion on the differentiated impact of digital technologies on unemployment, capabilities building and technological catch-up for developing countries. It articulates some of the key issues and tradeoffs for developing countries that should be considered in policy discussions and deliberations. Section 2 of the paper starts out by discussing the six key digital technologies that fall under the umbrella term fourth industrial revolution currently, namely, big data analytics, cyber-physical systems, artificial intelligence (AI) and robotics and process automation (RPA), advanced (3D) manufacturing and blockchains. This section presents the viability of these technologies globally and for developing countries, offering a discussion on how they will change production, innovation and business. Section 3 discusses the complexity of these technological changes, showing how the ongoing rise of the digital economy and digital trade, marginalize development concerns. Section 4 contains a discussion of the key issues that confront developing countries in promoting employment, technological access and capabilities. Section 5 of the paper concludes.

[1] As accompanied by a rising trend in IP filings at the World Intellectual Property Organization and other apex intellectual property organizations such as the European Patent Office. A recent EPO study (2017) notes not only that fourth industrial revolution technologies are on the rise, it also shows how incumbent players are branching out into other sectors to secure an edge on data-driven innovation.

[2] See Wu (2017) who notes that as of September 2017, over 90 FTAs had specific e-commerce provisions of which 57 FTAs contained dedicated e-commerce chapters or detailed provisions related to e-commerce, covering over two thirds of global digital trade. A one-on-one mapping of the countries that have signed e-commerce related FTAs with just e-commerce revenues shows that 88 percent of the global market is already covered by at least one FTA of this nature. See also Chander and Le (2015) for a discussion on data localization.

II. THE DIGITAL ECONOMY AND NEW DIGITAL TECHNOLOGIES

Despite its relevance, there is no universally accepted definition of the term digital economy. A study of the European Parliament on the topic notes that a wide spectrum of definitions for digital economy that have arisen over time although many of them simply do not delve into specifics, calling it "…a "complex structure" (European Parliament, 2015) or "less as a concept and more as a way of doing things" (Elmsary et al, 2016)".[3]

More closely, the digital economy is a maze of complex innovations, applications and new technologies that emerge from transactions on the internet no doubt but are fueled by extreme connectivity and the gigantic expansion of cloud computing, AI and process automation. Despite its fast expansion, different digital technologies are at different stages of maturity right now. Big data analytics, cyber-physical systems, RPA and AI are already fully mature for industrial application at a wide scale, pioneering new applications (apps), platforms, products and processes that have now become routine to production, communication and everyday life, including the IoTs. 3D printing and block chains, although largely hyped about, are not yet fully available on an industrial scale,[4] and cloud computing, currently at its infancy, is projected to grow exponentially in the coming years. This section discusses these technologies at length.

II.1. Big data analytics

Big data is a term that "…[d]escribes large volumes of high velocity, complex and variable data that require advanced techniques and technologies to enable the capture, storage, distribution, management, and analysis of the information" (Gandomi and Hyder, 2015:138). Data has since long been available widely, but it is cloud computing that has transformed the big data situation drastically because now, platform vendors make it possible now to set up data clusters in the cloud that can be accessed by users[5] with a user-based pricing system that often does not require software licenses.[6]

The term ‘big data’ generally represents data from any source, ranging from social media accounts, visits to web pages, online purchases, all of which generate information on likes and dislikes that can be used to tailor products, processes or even advertisements according to consumer tastes.

The internet, consequently, is generating staggeringly large amounts of data each second and companies often find themselves flooded by data generated from the various services offered on the internet, such as search engines, other websites, landing pages, online platforms and social media (Newman, 2017). These data flows can help to systematically map customer behaviour, competition trends, price comparisons (thereby showing ways to cut

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[3] See Bukht and Heeks (2017) for a summary of existing definitions of the digital economy.
[4] Lakhani and Iansiti (2017) forecast that despite its potential, a true blockchain revolution may be years away.
[5] Typically, through big data tools like Hadook or Spark.
[6] Amazon, for instance, offers cloud services through Amazon Web Services. Some applications although available on cloud require user licenses, such as word-editing or other such process software that can be downloaded for use. Such data is usually governed by the terms of the cloud services provider that one chooses.

costs), among others,[7] thereby serving as the backbone for a large number of new activities, including the generation of new business models that rely on matching products to customers' better thereby increasing firm-level profits, technology forecasts (what the consumers might be interested in, what are becoming trendsetters) that help firms tweak product pipelines or change R&D strategies, and other forms of business analysis and insights.[8] In a wide variety of sectors such as healthcare firms that can use and own big data stand to have certain advantages, including stocking product pipelines appropriately or planning better on where to invest their R&D or devising new personalised innovations using the IoT (See Raghupati and Raghupati, 2014).

But all data are not equal, and the value of data is dependent on how it is created, which have an impact on how versatile it is and how much it can be mined, and on the presence of data-mining capabilities (Gandomi and Hyder, 2015).[9] Breaking down the current data deluge into data typologies is a first step in understanding the key differences in big data. Studies on data typology break down data into structured and unstructured data (Secundo et al, 2017), and then create further sub-categories of these two kinds of data to differentiate between the kinds of data sets and their applications.

Structured data broadly refers to data generated by machines, such as IoT applications, sensors, machine logs, among others, which can be accumulated over time to create large data sets (Hurwitz et al, 2013). Unstructured data, in contrast, is created by humans transacting or using the internet. Unstructured data can be further broken down into other sub-categories. For instance, data on surfing history that enables online companies to trigger consumer needs based on their surfing history is different from data that is collected on social media or online trading accounts where customers leave a longer term, consistent trace of personal choices, purchases (showing ability to pay), and preferences on the basis of which their income, lifestyle and personal status (including family category) can be constructed. These data are different in nature, revealing intricate information on individuals, making it possible to construct individual behaviour using relatively large historical datasets that contain their actions, likes and dislikes and other such personal details.

The large data sets created through structured data by machines, and unstructured data mining when individuals transact on online platforms and social media accounts are critical inputs for artificial intelligence (see next section).

II.2. Robotics Process Automation and Artificial Intelligence

RPA and AI are generally used to denote a variety of algorithmic techniques that make it possible for computers and machines embodying computers to mimic human actions (Stankovic et al, 2017). RPA can help streamline a large number of tasks that are routine but extremely essential in the information technology sector, such as updating customer profiles, filling out timesheets and other such administrative tasks that were needed for upkeep and

[7] Tesco, the UK supermarket chain, for instance, is well known for data mining to decipher customer purchase patterns to suggest new products.

[8] For example, a large number of supermarkets or online platforms have big data sets collected from store cards or customer accounts that can be used to understand and track consumer behavior. This not only helps to create better sales strategies, it also provides insights into what other forms of products can be suitable, what the fears, preferences, and likes of customers generally are, apart from shedding light on the general lifestyles.

[9] Velocity, variability, and volume are three challenges aspects of big data management, and it is well acknowledged that issues of such unreliability of data are also a big problem (Gandomi and Hyder, 2015).

maintenance. RPA software can be programmed to deal with such tasks automatically thereby eliminating the need for human intervention, within and beyond the IT industry.

Big data provides fodder for AI, where learning is based on information on interactions, preferences and a history of repeated actions that allow for the tracing of historical behaviour. This helps to create machines that perform routine tasks, or even mimic ‘learning’ or ‘problem solving’, in ways that can augment human capabilities (Stankovic et al, 2017:6). As highlighted in the previous sub-section, the kinds of data that are useful for AI are those that are machine generated, or available through user-created online accounts on various e-commerce platforms or what reveals strong personal preferences along with other data on the individuals (such as in social media). Algorithms built using such data allow for several variations of AI innovations, such as assisted intelligence (when you are involved to a large extent, but the machine conducts the activity) or autonomous intelligence (when the machine can function on its own, learn and systematically store the learned actions to inform future behaviour). Important examples of autonomous intelligence are driverless cars, or services such as IBM Watson Software, which is an AI platform for business that provides a variety of solutions – from the creation of virtual agents to conduct business to developing more intelligent irrigation systems for vineyards.[10]

AI is expected to drive growth in the future in at least three ways: by creating a virtual workforce, by augmenting existing skills and workforce in the economy and through newer innovations that use AI (Purdy and Daugherty, 2016: 13; Agrawal et al, 2018). AI’s use extends beyond production to distribution as well. It is already in use quite extensively in the retail business, by generating learning algorithms for instance, that forecast a week before what any business can expect its customers to order (Economist, 2017b).

II.3. Cyber-physical systems

Known more colloquially as the Internet of Things (IoT), this is a term that refers to ‘smart’ innovations and ‘smart’ manufacturing that rely on the embedding of sensors and computing platforms into products and processes. As opposed to popular perception that applies IoT mainly to consumer appliances, we are in an age where all large industrial sectors are entirely dependency on cyber-physical systems, including gas and oil, global shipping, medical systems, manufacturing and even local city traffic control systems (De Nardis and Raymond, 2017). This technology not just allows for different factories and production systems to be interconnected, it also allows for customization, which drives 3D manufacturing (next section).

II.4. Additive and direct digital manufacturing

Additive manufacturing, or more popularly rapid manufacturing or 3D printing (3DP) relies on two main kinds of software: a 3D computer-aided design (CAD) or any other 3D software that creates the digital model and a ‘slicing software’ that cuts the product into numerous cross-sectional layers that are each less than a millimetre thick (Barnatt, 2014). Once the digital model is ready, the final product can be fabricated by adding different materials, on a layer-by-layer basis, with the help of a 3D printer (Kommerskollegium, 2016). Products can

[10] See the IBM Watson Website: https://www.ibm.com/watson/ai-stories/index.html

be produced in several ways, such as polymerisation, use of a bonding agent, melting and laminating making transmission of data the main issue in 3D printing as opposed to the transportation of goods in conventional manufacturing.

3D printing shortens several stages of manufacturing (such as design, prototyping and product layout, all of which are created digitally) and also enables production to be tailored to individual design specifications. Since the cost of printing one additional unit is little or nothing once the digital model is ready to be fabricated, 3D printing can fundamentally change manufacturing by making it scale independent. When additive-manufacturing technologies can also be used for the large-scale manufacture of end-use components they are called direct digital manufacturing (although term 3D printing is used to denote all such variations in common parlance) (Gibson et al, 2015: 375). Direct digital manufacturing provides for tailor-made solutions with higher or even low volume production loads. What will become important in this context for the future is that digital manufacturing enables digital archiving of the design and manufacturing information associated with any particular spare-part or machine, which can be transferred electronically anywhere in the world for part production, and therefore has important implications for global enterprises.

II.5. Blockchains

Blockchain is an internet-based, peer-to-peer network that was originally created for the bitcoin currency in 2008 to allow for the issuance and record keeping of online currency transactions. But the technology has uses that go far beyond that given its capacity to store and distribute digital information without the risk of copying. It can be programmed to create a digital ledger of all economic transactions of any value of any kind and can work across any number of digital devices connected to a network. Any system based on blockchains will allow for the digital ledger to be replicated in a large number of identical databases, each hosted and maintained by an interested party. All information serves as a kind of a digital spreadsheet of transactions on the common database that is automatically updated in a way that is impossible to edit or forge.

Blockchains are predicted to replace normal contracting mechanisms, allowing them to be concluded and monitored digitally and stored in transparent databases that cannot be edited or tampered with (Lakhani and Iansiti, 2017). The potential for expansion of this technology is immense: since every digital transaction has a signature, the technology can help eliminate all intermediary functions offered by lawyers, bankers and other kinds of brokers.

III. FORECASTED IMPACTS ON INDUSTRIAL TRANSFORMATION

As of 2016, it was estimated that global e-commerce website sales were above USD 22 trillion, with projections that it will expand to USD 27 trillion by 2020 due to a 're-boom' in online transacting (Gfluence, 2017). But the e-commerce story is just a small part of what is at stake; new digital technologies are thriving by eliminating intermediaries, changing GVC structures, introducing smart manufacturing and smart services, and promoting new business models (Gehl Sampath, 2018; Scrineck, 2017). Even in the case of Amazon, the largest e-commerce giant, Amazon Web Services, its cloud computing arm, accounted for 74% of its operating income (Economist, 2017a). The company also expects Amazon Dash (which is an IoT) are expected to bring in new streams of profits. The rapid proliferation of these technologies and the ongoing economic expansion of large companies in the digital economy not only introduce several uncertainties with respect to who benefits and how in the present context, but also create substantial ambiguity on how the future will unfold, especially for developing countries.

III.1. Job creation or job elimination?

In years to come, the widespread use of 3D printing is forecasted to fundamentally change the way the manufacturing sector works in at least in three important ways. Firstly, 3 D printing will make manufacturing scale-independent, i.e.., even small quantities of any good can be produced profitably, thereby leading to re-shoring of many industrial activities to the developed world which are currently located in developing countries because of considerations of lower costs of production. Secondly, the expansion of 3D printing will lead to a reduction in the trade of manufactured goods in favour of the export of raw materials only, and an increase in trade in services, because 3D printing moves the design and engineering of the products from a typical manufacturing activity to a services activity (Kommerskollegium, 2016:20). Finally, it could also signify a decrease in the volume of total trade eventually because apart from the design and engineering components, 3D printing also eliminates several stages of intermediary trade operations that are common to traditional manufacturing, such as the supply of spare parts, transport, assembly, and so on, which can all be potentially integrated into the main process directly now.

But these predictions on how 3D printing will affect manufacturing jobs may not be as urgent as many suggest at this point of time. Currently, 3D printing is in use in some sectors such as medical devices, but widespread optimism on the use of the technology has been dropping in the past two years given that existing 3D technologies that are now freely available in the market are rather outdated (Hornick, 2015) and the 3D printing market that employs new technology is rather concentrated with 3D Systems Corp (NYSE: DDD) and Exone (NASDAQ: Xone) in the lead.[11] What matters more for industrial application is the estimated cost of professional industrial 3D systems, which can cost anything up to 1 million USD (Ernst and Young, 2016:15). These high costs have been a deterrent for wide-scale industrial use until recently. A recent survey conducted in 900 companies in 12 countries based in Western Europe, USA, China and South Korea concluded that 40% of all companies considered high costs to be a deciding factor while investing in industrial scale-3D production

[11] Hornick (2015) notes that around 16 patents on core 3D printing technologies, particularly those related to Material Extrusion, Powder Bed Fusion and Vat Photopolymerization expired in 2013-14, but this only means that 3 D printing that is 20 years older is now widely available for use.

systems (Ernst and Young, 2016:15). The survey found that Chinese and South Korean manufacturers were the most active in applying the technology for end production on a mass scale, with one in every two Chinese companies expected to use 3D printing for production by 2021 (Ernst and Young, 2016:11).

In contrast, the changes introduced by RPA and AI, which are already being widely being exploited in the industry, are more relevant to assess employment scenarios in the near future. AI is widely considered to be the biggest transformative technology in the years to come, with current estimates forecasting that AI alone can generate revenues up to 47 USD billion by 2020 (from the current USD 8 billion), and the wider adoption of cloud technologies is estimated to have already increased GDP by $120 billion (AfDB et al, 2018). On the global scale, these and other forecasts suggest that while jobs will be destroyed, many new employment niches will be created arguing that, on the whole robotics, cloud computing, AI and other new technologies have a job creating potential that is underestimated (Purdy and Daughtery, 2017; Accenture, 2017; Ford, 2015).

In reality, it is more likely that in the short term, the quest for greater productivity, efficiency, and profits across sectors will be accompanied by rendering some kinds of job redundant (PWC, 2016; 2017). For example, if a global company is able to create an RPA platform that addresses all its maintenance issues, it will eliminate the need for certain kinds of human-operated call-centre functions. These kinds of consolidation functions that will reduce the employment base of companies, but at the same time, allow companies to thrive on machine-run operations that are not restricted to a 40-hour work week, are a large part of the greater efficiency gains being forecasted.

In the longer term, new jobs will be created in occupations such as those focusing on data analytics, robotics engineers and other forms of technology specialists that will support increased digitization. There will also be jobs in new and emerging technologies, such as cloud computing. But these job gains will in no way compare to the job creation potential of traditional manufacturing as we knew it, and in the longer term, labour productivity growth is expected to go down even further (see discussion in section 3.4; see also West, 2018).

Finally, in the case of block chains, a potential job eliminating effect is anticipated in occupations such as brokers, banking intermediaries and other such agencies that perform the task of mediating transactions including lawyers. However, analysts studying technological innovation in the digital space believe that a blockchain revolution may still be several years away.[12]

III.2. Market competition or market concentration?

Booms in digital technologies have already created a new class of millionaires and billionaires worldwide over the past two decades. Bitcoin, the cryptocurrency is a timely example of this phenomenon, where the price of a single bitcoin rose from USD 100 to USD 4880 between 2016 and 2017 (Shen, 2017). Companies such as Apple, Alphabet (Google), Amazon, Facebook, Microsoft, have all profited immensely over the past two decades creating a great amount of corporate value for their shareholders and are top companies in the sector. Other new kinds of companies providing important social platforms or sectoral services are also on

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[12] The authors note that given the foundational nature of this technology, the process of adoption is likely to be slower.

the winning spree: Whatsapp, Twitter, Snapchat, and companies such as OnceLogix (a company that created online mental health records software) are making great profits and are expected to become the next global leaders (Forbes, 2014).

While concentration may in itself not be anti-competitive, certain kinds of concentration of technologies and related value raise serious issues. In the particular context of digital technologies, technological advantages (that firms might have when they are pioneers in markets such as 3 D printing provide first mover advantages, that can be used in numerous ways to structure/ segment markets. Information advantages confer a new kind of power that can also distort competition (Gehl Sampath and Park, 2019; UNCTAD, 2017).

III.3. Data commercialization or privacy protection?

Given big data's relevance for AI, firms not only need the free flow of data but rely on capabilities for data analysis, which have now become part of investment portfolios of all global firms. In the future, data control is expected become a major driver of business, thereby worsening the existing nature of industry concentration and strengthening the 'superstar' technology firms that have emerged in a variety of sectors globally.[13]

Greater flow of data comes with spam, malware, and cyber-attacks, which call for internet filtering to minimize these risks (Meltzer, 2013). But big data also raises other questions of privacy and personal security, because accumulation of large data sets that reveal personal data on individuals can easily be misused by banks (to deny loans) or companies (to decide on hiring, firing or even to approve insurance applications), raising several legal and policy related questions. There are a number of ownership issues that remain unresolved and are important for the design of policy frameworks. Is the right to data a human right? How does one separate the right to privacy from data use? Should all data be made available for economic activities? Can government collected data be used to further economic activities of private firms? To what extent should users be allowed an absolute right over the data they create and how should such rights be enforced? These questions are equally relevant for government-led collection of big data, such as in the case of the Aadhar Identification Card in India or its concentration in the hands of private companies (See also, Okediji, 2016).

III.4. Technological determinism: panacea or downfall?

The rise of new digital technologies has been accompanied by a technological determinism that focuses almost entirely on the potential of these technologies for future growth, welfare and society, but ignores most of the blatant realities in this context. In reality, as Brynjolfsson et al (2017:5) note, despite the oft-repeated potential of these technologies, they have not had an effect on labour productivity growth in the developed economies which fell in the 2000s and have remained at low levels since then. The probability that this will continue, while concentrating wealth in the hands of large companies, is an extremely likely scenario at the global level.

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[13] On the impacts of market concentration in global markets, see UNCTAD (2017). The concept of 'superstar firms' was first introduced by Rosen (1981), arguing that in markets where quality advantages exist, a small number of suppliers would dominate the market and command most of the returns. This "winner takes all" idea is further explored in the current industrial landscape by Autor et al (2017).

Furthermore, although the overall global estimates and forecasts predicating a revival of the global economy from the use of digital technologies, they will come with many distributional caveats that are currently not part of the story-telling exercises on the digital economy. Accenture, for example, estimates that public cloud computing reached US$70 billion in 2015 alone with a huge capacity for expansion and further growth (Purdy and Daugherty 2017:11). Similarly, it has been estimated that the extensive use of RPA in production can boost global GDP by 14% (or USD 15.7 trillion) by 2030 (PWC, 2016). While China is forecasted as the country most likely to benefit from this GDP boost (26% by 2030), North America is also expected to recover (14% by 2030). Africa, in comparison, is forecasted to derive only 5.6 % if it's GDP through the greater use of AI by 2030, while Latin America is expected to gain 5.4% of GDP (PWC, 2016). In sectoral terms, financial services, healthcare and manufacturing are all expected to be huge drivers of AI-based productivity.

There is even reason to believe that the staggered productivity forecasts may also not materialize to the fullest extent given that there is a lot of technological optimism that accompanies it, and the lack of definition of the term digital economy means that the forecasts are all calculated using different methodologies and are subject to errors (IMF, 2018; Brynjolfsson et al, 2017). They also depend on several other factors materializing (such as increased investment in infrastructure, greater industrial growth and expansion, skills building, stable macroeconomic climate, export markets, and so on, many of which may not materialize for all countries.

Eschewing this technological deterministic view and taking a broader socio-economic and developmental perspective to acknowledge the shortcomings of many of these technologies is needed to form an unbiased picture of the new digital reality. It is not just a situation where automation risks existing jobs and occupations while creating new ones. It is a much more complex scenario where all existing digital technologies have pros and cons as well, as will newer ones that hit the market in years to come. For example, the use of greater AI comes with a large risk of inequality due to the way these algorithmic learning data sets are created (Olson, 2017; Eubanks, 2018). The greater use of cyber-physical systems automatically concentrates data in the hands of companies (DeNardis et al, 2017). These technologies, the associated inter-dependencies and risks call upon a more systemic perspective that speaks to balancing the use of these technologies in a way that benefits society is therefore urgently needed.

IV. IMMEDIATE CONCERNS FOR DEVELOPING COUNTRIES

A large number of developing countries are currently marginalized in all economic gains that arise from the application of digital technologies – those that accrue from developing and pioneering these technologies and related e-commerce applications and those arise from applying them to industrial production. Existing data shows that large parts of RPA, AI, and 3D companies are all located in a handful of countries, namely, countries of Western Europe, USA, China and South Korea. As of 2015, not only were most robotic companies located in the developed world,[14] most companies that use robotics process automation in production were also located in the industrialized countries. This is also supported by estimates of world retail shares in e-commerce, which show that the top 15 markets are almost the same where new digital technologies are concentrated, except for Mexico, Brazil, and India (Gfluence, 2017). In a preeminent strike to safeguard first-mover advantages and related gains, FTAs have no doubt secured liberalization of digital trade to a large extent, with intellectual property rights (IPRs) protection that protect new digital technologies in an extensive way (Okediji, 2018; Gehl Sampath and Bouhia, 2019). This has elaborate implications for economic catch-up.

Secondly, even if these intellectual property issues were not taken into account, many developing countries will find it difficult to benefit from the application of these technologies, because the presence of some level of industrial capacities is a pre-condition to benefit from new digital technologies and industry 4.0, given that these are technologies and innovation that automate and connect ***existing*** industrial capacity. This is also largely true for the services sector, where digitization raises the knowledge bar (to high technology services) to benefit from trading in services.

Moving ahead, therefore, economic growth through manufacturing or the services sectors is dependent on how capable countries are in absorbing these technologies and applying to existing industry or upgrade their capacity in the global economy. This is what sets industry 4.0 apart from other previous industrial developments: while previously technologies were inputs to the process of industrialization, industry 4.0 makes industrialization and structural diversification a pre-requisite for countries to participate in, and benefit from, the digital economy. This further implies that:

(a) *The effects of digitization are dependent on the level of development of countries*: For developing countries with some level of industrial capabilities that are engaged in sectors such as automobiles and information technologies, the quest for industrial productivity through RPA and AI at the global level will render certain kinds of outsourced jobs redundant. This is a trend that is ongoing in the IT sector in India[15] and industry consolidation through process automation is expected to continue, with consequences for other emerging countries, predominantly in Asia and Latin America.

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[14] In total, 40 of the companies are situated in the USA, and other countries with some level of robotic industrial capacity were Germany (8 companies), Japan (5), UK (5), China (5), France and Canada (4 each), followed by South Korea (3), Italy (3) and Switzerland (2). See Keisner et al, 2016: 11.

[15] The past two years have seen a tremendous rise in process automation in the IT industry, which is evidenced by the layoffs in the Indian IT sector. Before the end of 2017, seven of the largest Indian companies (Infosys Ltd, Wipro Ltd, Tech Mahindra Ltd, HCL Technologies Ltd, US-based Cognizant Technology Solutions Corp. and DXC Technology Co., and France-based Cap Gemini SA), which account for approximately 1.24 million jobs in the Indian market are expected to let go of 4.5% of their workforce. See Sood (2017).

The gains from these changes introduced by 3D printing, RPA and AI will mostly accrue to the original equipment manufacturers (OEMs) within existing global value chains (Ernst and Young, 2016:45; Eurofound, 2018).

(b) *For countries with little industrial capacity, it is only artificially reassuring that digital technologies are not being applied and jobs will not be displaced in the immediate future*. Although up until now, there has been a focus on some technology-intensive sectors such as automobiles and computer technology where the application potential of emerging digital technologies is immense with astounding returns, digital technologies are also equally being applied to low technology sectors such as ready-made garments and mining (Ramadoo, 2018). Thus, a more balanced account of the ongoing is that countries that do not possess wide-spread industrial capabilities, for example, least developed countries, or do not engage in specific sectors where digital technologies are being widely applied, will not see any effects. A rather longer-term corollary of this is far more critical to note: the absence to apply such technologies excludes countries' from being able to use digitization for economic growth.

Thirdly, developing countries will be hard-pressed to ensure job creation and employment as industries and sectors re-organize in the digital economy. As discussed in the previous section, the job creation potential of manufacturing will eventually shrink in the fourth industrial era. The other job opportunities that are predicted as the use of new digital technologies in industry expand, countries will need to ensure the presence of highly skilled and supple labour that can be moved from firm-level operations that are expected to become redundant to other areas of specialization that will facilitate the industrial transformation to hybrid production systems where machines and humans work side-by-side.

This is not an easy task, especially for many developing countries, where STEM graduates are difficult to find, and labour markets already suffer from extreme uncertainties. Taking these factors into account, more recently, some studies have begun to articulate these differential impacts of RPA and AI technologies for countries at different levels of development (Chandy, 2017). According to the World Bank (2016), for example, 67% of all jobs in developing countries remain at threat due to automatization as opposed to 57% in OECD countries, even after considering lags because of adaption problems.[16] This is confirmed by Cadena et al (2017), where the authors warn that half of the current worktime (76.4 million full-time jobs) can potentially be automatized by ongoing changes. Although some other studies dispute the extent of these findings, they still conclude that on the whole somewhere up to 40% of the total jobs can potentially be affected by automation (McKinsey Institute, 2017; AfDB et al, 2018).

In the absence of reliable data on the topic that corresponds to different regions of the world, three important conclusions can be drawn.

1. In the short term, the focus of industry will be on greater productivity, efficiency and profits, which may be accompanied by rendering some kinds of job redundant. For example, if a global company is able to create a robotics process automation platform that addresses all its maintenance issues, it may eliminate the need for certain kinds of human operated call centre functions. This trend is currently ongoing in the IT sector.

[16] This study uses the methodology in Frey and Osborne (2013), which concludes that 47 percent of all persons employed in the United States were working in jobs that could be performed by computers and algorithms within the next 10 to 20 years (See updated, Frey and Osborne, 2017).

The past two years have seen a tremendous rise in process automation in the IT industry, which is evidenced by the layoffs in the Indian IT sector. Before the end of 2017, seven of the largest Indian companies (Infosys Ltd, Wipro Ltd, Tech Mahindra Ltd, HCL Technologies Ltd, US-based Cognizant Technology Solutions Corp. and DXC Technology Co., and France-based Cap Gemini SA), which account for approximately 1.24 million jobs in the Indian market are expected to let go of 4.5% of their workforce (Sood, 2017).

2. Capitalizing on the jobs that will be created in AI or cloud computing will call on the presence of skilled personnel in categories such as data analytics, robotics engineers, cloud computing experts, and inter-disciplinary task managers, and developing countries will need to strengthen their education base, especially by prioritizing STEM education, which will be critical role in enabling such skills creation.[17]

3. Smart manufacturing – which will become the norm as we head into the fourth industrial era – will not have the capacity to generate the kind of jobs that traditional manufacturing did to promote economic catch-up in the successful developing countries of East Asia, and now, to a large extent in the BRICS countries (see Stiglitz, 2018). This calls for industrial strategies that prioritize industrialization in all sectors – manufacturing, services and agriculture – through digital technologies.

In a widespread scramble for jobs,[18] one of the three scenarios can materialize, all of which call for policy intervention: (a) machines work and people enjoy from benefits that are distributed evenly, (b) machines work, large companies benefit and there are large scale inequalities and (c) economies transition with skills building into the new digital technology by averting large scale job losses (Berenburg, 2015).

[17]See for instance: http://www.azcentral.com/story/money/business/jobs/2017/09/04/how-artificial-intelligence-robotics-could-transform-jobs-10-years/574501001/

[18] Other recent studies find that these changes will not be trivial even for developed countries. Arntz, Gregory and Zierahn (2016) estimate fundamental changes to the nature of employment in all countries and predict that atleast 9% of all jobs are at risk in the OECD countries.

V. CONCLUDING REMARKS

All industrialization will be digital industrialization in the future. The analysis in the paper shows how new digital technologies that enable this transformation are not only at different stages of maturity, they are diverse in their scope and application, they increase the distance for economic and technological catch-up, and also pose important constraints for employment creation, capabilities building and industrial change in the developing world.

Two important conclusions for policy emerge from the detailed discussion of these changes as conducted in this paper. Firstly, new digital markets introduce a range of market failures throughout the process of knowledge creation, knowledge mediation, value creation, value capture and trade in the digital economy. The new technology-mediated economy is imperfect and riddled with information asymmetries, data monopolies, algorithmic intransparencies and the 'winner-takes-all' effects that accompany these changes (Allen, 2017; Banks, 2018). These effects are continuously being aggravated by one-sided rules that liberalize digital trade without much consideration of the social, developmental and personal (privacy) implications of the digital economy. Secondly, these market failures intensify all existing government or institutional failures that have held back development in developing countries. Any pre-existing binding constraint – such as the lack of coordination for innovation, lack of ability to mobilize domestic resources, inability to create linkages, low resilience of the domestic entrepreneurship sector, tax avoidance, and the failure to regulate competition – will have a direct bearing on how the gains of the fourth industrial revolution can be secured.

This makes an immediate and strong case for industrial policy in the digital economy to promote the emergence of free and fair digital markets in the fourth industrial era of the kind that will arrest the unfair consequences for skills creation, job attrition, technological catch-up data sovereignty, and personal privacy. Differentiating between the kinds of data (data typology) will be critical to create a better legal and policy understanding of the economic and personal value of data. This should be articulated as part of detailed frameworks for data ownership that recognize and protect individuals that create the data (Gehl Sampath, 2018).

The paper also warns against technological determinism in the digital economy, which focuses mainly on the application of new digital technologies and does not pay enough attention to the issues that they raise. By showing how a technological deterministic approach – that simply focuses on widely applying digital technologies for the broader good of mankind – may lead to an unfocused, undifferentiated perspective on the digital economy, this paper calls for a more differentiated approach to policy in the digital economy. Such a differentiated approach should design policy to regulate each of these technologies individually, as is underway in a large number of industrialized countries.

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