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Industrial Policy 4.0
Promoting Transformation in the Digital Economy

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Abstract

The rise of the fourth industrial revolution (IR) is deeply embedded in a wider context of privatization of knowledge, rising costs of innovation and uneven distribution of capacity between countries. But debates on a 'balanced' policy framework to tackle these issues have until now floundered to address some of the fundamental dilemmas of our times. Will the fourth IR render the manufacturing-led model of economic development a thing of the past? Are there new boundaries for innovation and industry in the fourth IR? What should policy do in such an uncertain technological era? This paper addresses these crucial questions and makes a case for comprehensive digital industrial policies that are differentiated and rooted in the broader reality of development and globalization in the fourth IR. The paper maps the new boundaries for innovation and industrialization, after which, it elaborates in detail the market and institution failures in the platform economy that arise from the highly complex nature of technological change and a lack of effective policy oversight. It offers evidence to the effect that although manufacturing as we knew it – with its effects on low and unskilled labour and employment creation - might not continue to exist, it will continue to thrive using high technology skills and R&D, within a new model of industrialization where the knowledge-component of all sectors – agriculture, manufacturing and services – will be on the rise. Countries therefore, need a more nuanced and differentiated industrial policy 4.0 framework that can: (a) sustain overall industrial performance, (b) in a way that helps close the gap to the frontier in a constantly evolving technological landscape, (c) while mitigating the adverse consequences for society, in terms of employment, privacy and latent social fabric. The paper proposes the components of such an industrial policy 4.0 in detail in its concluding section.

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1. Introduction

As technological progress continues to lead the global economy into the folds of the fourth industrial revolution (fourth IR), the physical and digital realities that surround us are coalescing into one.[1] Key digital technologies promoting these transitions, especially, big data analytics, 3D printing, robotics and process automation (RPA), artificial intelligence (AI), internet of things (IoT) and blockchains, position the internet as the most important building block for innovation in the future. A number of studies have argued therefore, that the fourth IR will be a *tour de force* for the future, increasing productivity and pioneering discoveries in new domains such as quantum computing, AI and machine learning (McKinsey Institute, 2017; AfDB et al, 2018).[2] Changes in several sectors, ranging from health care, education, environment and energy, are already underway, signaling the immense potential of these technologies in shaping a better and prosperous future.

The development and deployment of digital technologies, however, raise two deep seated questions for countries that are currently not at the technological frontier. First of all, these technologies are deeply embedded in a wider global context of expanding privatization of knowledge, rising costs of innovation and uneven distribution of capacity amongst countries. Whether this will undermine the capacity of harnessing the potential of these technologies for the scientific advance of all, and what kinds of strategies will be required to arrest the widening technological divides, while assuring the provision of essential global public goods in the fourth IR and beyond remains unclear.

A second related question is whether, in light of the fourth IR technologies, the manufacturing-led development model that has been at the heart of classical developmental discourse still holds good. In the past, manufacturing has been considered the engine of sustained economic growth, which through its capacity to generate and combine a series of linkages, complementarities and external economies, could trigger a virtuous circle of resource mobilisation, rising productivity growth, increasing incomes and expanding market demand (Ocampo, Rada and Taylor, 2009). The expansion of manufacturing activities leads to what is termed the process of "cumulative causation" (Myrdal 1957; Kaldor 1957, 1958), in which demand and supply factors interact: the expansion of manufacturing activities creates employment, rising incomes leads to greater demand, on the one hand, and allows for faster increases in productivity, on the other, which, in turn allow reinforce further income and demand growth (Myrdal, 1957; Reinert 2007).

However, the fourth IR is shepherding new kinds of production thus blurring the lines between agriculture, manufacturing and services as we knew them. It affects those very features of manufacturing that lent themselves to producing scale effects on employment, wages and demand (Hallward-Driemeier and Nayyar 2017; Fernández-Macías, 2018; Cimoli, 2018). By

[1] The term Industry 4.0 was first coined by the German Academy for Technical Sciences in 2011 (Acatech) for promoting competitiveness in light of computerisation of manufacturing. See Kirchberger (2017) for a discussion on the evolution of industry 4.0 concepts in Europe following 2011.

[2] The African Development bank estimates that AI can generate revenues up to 47 USD billion by 2020 (from the current USD 8 billion), while the wider adoption of cloud technologies is estimated to have already increased GDP by $120 billion (AfDB et al, 2018). At the national economic level, for the USA alone, the US Bureau of Economic Activity (BEA) estimates that real value added in the digital grew at an average annual rate of 5.6 percent, outpacing the average annual rate of growth for the overall economy of 1.5 percent between 2006 and 2016. In 2016, the digital economy was a critical contributor to the overall economic performance of the American economy, accounting for 6.5 percent of current-dollar GDP, 6.2 percent of current-dollar gross output, 3.9 percent of employment, and 6.7 percent of employee compensation (Barefoot et al, 2018, p.2).

making manufacturing scale-independent and customized, the fourth IR is expected to lead to a re-shoring of industrial activities to headquarter locations. This will eventually diminish the incentives for production offshoring to cheaper locations in developing countries, which until now has been a developmental trajectory for the South.[3] Moreover, in the future, manufacturing will depend on greater R&D and high-tech services, calling upon a highly skilled task force, as opposed to large scale employment for the unskilled and semi-skilled masses. This trend, in addition to greater automatization of production, will challenge the nature of cumulative causation that one can expect from manufacturing. Forewarning these effects, the World Bank (2016) estimates that 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. These forecasts are similar to those by Cadena et al (2017), which warn that half of the current worktime (76.4 million full-time jobs) can potentially be automatized by ongoing changes.

Even if only some of these forecasts eventually materialize, it still calls into question how developing countries can ensure participation and benefit-sharing in the fourth IR, and whether 'manufacturing as the engine of economic growth' remains the right framing for industrialization of those countries that still need to catch-up with the technological frontier (Stiglitz, 2018).[4] Heated debates on how countries can industrialize in the light of the changes being brought about in the fourth IR have until now focused on digitization as a separate phenomenon, and argued that developing countries should use policy making – especially in the form of digital industrial policies – to ensure industrial upgrading. Broadly speaking, these studies either emphasize the need to build digital infrastructure, expand cloud capacity, manage and protect data and promote digital technology transfers,[5] or propose the transition from already well-structured manufacturing sectors in advanced economies to those that integrate fourth IR technologies.[6]

But both narratives overlook the most relevant questions for policy, which call for a more fundamental framing. Can we use traditional approaches to industrial policy if the industries themselves rapidly merge together, and if competition shifts in ways that make new competencies critical to economic survival? Are there new boundaries for innovation and industry in the fourth IR? Is the traditional model for economic development itself at risk, and if so, do the policy challenges remain the same? What should policy do in such an uncertain technological era? This paper addresses these crucial questions and make a case for comprehensive digital industrial policies that are differentiated and rooted in the broader reality of development and globalization in the fourth IR. The paper proposes that to resuscitate and support industrial sectors in the fourth IR, we first need to identify the new boundaries for innovation and industrialization, identify the policy challenges this poses, and then devise appropriate policy that can: (a) sustain industrial performance, (b) in a way that helps close the

[3] Reiterating these effects in the history of economic catch-up, Rodrik (2017) for instance, notes that manufacturing became a powerful escalator of economic development for low-income countries for three reasons. First, it was relatively easy to absorb technology from abroad and generate high-productivity jobs. Second, manufacturing jobs did not require much skill: farmers could be turned into production workers in factories with little investment in additional training. And, third, manufacturing demand was not constrained by low domestic incomes: production could expand virtually without limit, through exports.

[4] Stiglitz (2018) notes in this context, how 'manufacturing is a victim of its own success' (p. 2).

[5] See for example Azmeh and Foster (2016) for a discussion on policy options for developing including, including through data localization and mandatory disclosure of source code.

[6] Gruber (2017) proposes a digital industrial policy framework for Europe, whereas the World Economic Forum (2018) suggests a four-point agenda for the transition of manufacturing into the fourth IR competitively. See also Cimoli, (2018) for example, who argues for a highly interconnected industrial policy in the digital economy.

gap to the frontier in a constantly evolving technological landscape, (c) while mitigating the adverse consequences for society, in terms of employment, privacy and latent social fabric.

Section 2 of the paper elaborates on the nature of innovation in the platform economy – that embodies all the changes of the fourth IR - to show how many of the conventional assumptions of industrialization, investment and technological change may no longer hold good. The choice is not as much one of manufacturing or services, but one of how to cope with the blurred boundaries of manufacturing and services, in a highly technologically complex industrial landscape. The real challenge for policy, in this context, is to identify and address both the market and institution failures of this model of technology and industrial change. These failures are discussed in Section 3. Section 4 presents policy elements of an industrial policy 4.0 framework that developing countries should consider in order to approach tackle these challenges and Section 5 concludes.

2. Understanding the Fourth IR and the Platform Economy

In recent years, digital innovation, spreading widely through the platform economy,[7] has been incremental and disruptive at the same time. By displacing well-established sectors, vertical chains of productions and legacy organizations of the non-digital eras, digital innovation has brought about a new ordering of economic activities at a global level. The term 'platform' is widely used to describe the expansion of fourth IR marketplace, can generically denote a product, technology or a service (Gillespie, 2010:351). A smart phone, for example is a product platform, while as a technology, platforms can be the foundational base/layer on which entire sets of firms build business ecosystems (Gawer, 2009; Gawer and Kusumano, 2014).[8] As a service, platforms can create new market places where different kinds of users – producers, suppliers, customers, distributors – interact, or even build their own market places (Gawer, 2009).

Platforms build on the wisdom that technology in the information space tends to be layered on each other (Zittrain, 2018).[9] Thus, in the most general sense, platforms build on one another, offering consecutive possibilities for the provision of newer and newer products/services/ technologies. As an example, think of a smart phone that can access the internet, upon which google search engine or amazon marketplace can be operated upon. The same smart phone can provide a medium for a number of other platforms such as uber, zipcar, lyft, uber eats, and so on, each of which is a platform economy firm. In many cases, platform markets usually have a 'platform leader' (Gawer, 2017) or a 'keystone firm' (Iansiti and Levien, 2004) such as Apple, Facebook or Google, which serves as the base on which several other platforms are built or layered.

[7] See Kenney and Zysman (2016) who analyse how the platform economy is the best and most direct manifestation of new digital technologies. See also Cusumano, Gawer and Evans (2015).
[8] Example of a platform within a platform is a microprocessor within a computer, or a smart phone that connects to the internet and allows access to Uber.
[9] According to Zittrain (2018) the layering goes from the Physical -> Logical -> App -> Content. In this layering, the world wide web is an application, and like all other applications, it builds upon the other layers and takes their functionality as a given attribute of the system.

2.1. New boundaries of value creation

Innovation in the platform economy is different because it does not need the creation of new knowledge *per se* but can simply rely on new business models that create new markets (Rochet and Tirole, 2003) or can be a combination of new knowledge and new markets. Just taking the examples of well-known platforms, four models of value creation can be identified.[10] A first category of platform firms are those that operate at the technological frontier to offer products/ services in the fourth IR. Good examples are Amazon Web Services or Microsoft Azure, which are product platforms that cater to the growing cloud computing demands of the fourth IR, or Jupyter Notebook, a data science platform allows people to experiment with machine learning. Manufacturing firms that offer new sensor-embedded products, as part of the 'smart' manufacturing drive, are some other examples of this trend.

A second category of platforms capture value by introducing new markets where there was no market or where there were dysfunctional markets before. Firms like Uber, AirB&B, Lyft and Zipcars that cater to private transport, or firms like Alibaba or Ebay, which provide regional or global online market places are good examples of this. These firms do not create products or own car fleets but connect existing suppliers of these services/ products with users and eliminate intermediaries. A third category of firms are those that expand and serve markets using online services, but still produce conventional product/ run warehouses and rely on physical transportation of their goods to users (as opposed to digital transmission), such as Amazon or Zipcars.

A fourth category of platform firms create new mediums of expression and networking ranging from message boards to large social networking sites, such as Facebook and Twitter or those that offer streaming services like Netflix or Amazon Prime. Given that social, cultural and economic capital is now dependent on our capacity to connect and communicate (Stubbs, 2014, p.12), people interact in a much more comprehensive way with one another on social media platforms, thus revealing much more information about them and their preferences that can be used in several industries.

2.2. Mapping data-driven innovation

Although data confers unfathomable advantages to innovation in the fourth IR, data's precise role in innovation in the fourth IR remains relatively obscure. In reality, data and computation jointly account for a fundamental alteration of the traditional contours of the innovation ecosystem in the fourth IR, blurring many of the traditional lines between knowledge creation, use and economic production. In fact, now, every new step toward the technological frontier is not necessarily a fundamental breakthrough but is often just an incremental progression in a longer technological trajectory, building on several previous inventions, thus standing on the shoulders of giants.

The starting point is, of course, big data – the composite of all individual information generated on the internet – which comes in all forms. It can be structured in the form of numeric data or just contain unstructured data such as text, images, or videos (Kayser, Nehrke, & Zubovic, 2018). But what makes big data highly valuable is the growth of other fourth IR technologies

[10] Srnicek (2017) classifies them into five categories to show the differentiated economic characteristics. In the classification here, I merge them into four for expediency.

that rely on big data to create advantages, including IoT, machine learning (where computers learn from existing data), RPA and AI, and allow for data mining and use at several levels. These technologies enable the use and application of big data across a spectrum of manufacturing and services activities, and in recent times, are spreading into agriculture and commodities as well. Brown (2017) notes, for instance, that venture-capital investments in the agricultural sector rose to USD $560 million globally in 2016 from USD $201 million in 2015, and that these are not just investments into precision agriculture (based on data forecasting), but include new target areas, such as robotics-driven farm equipment and genetic editing of plants.

At the simplest level, big data trends allow firms in all these industries to better understand their customers, their preferences and expand markets. Firms, therefore, can create value by incrementally changing their product design or service portfolios to suit consumer needs, or even focus on reducing labour costs by reorganizing the work force (Kusaik, 2017). At the next level, data collected systematically is highly valuable to understand and reconstruct histories, and to understand use parameters, intensity, evolution of personal preferences or limitations, which, in turn, pave the way for incremental or personalized innovations across several manufacturing sectors, but also pave the way for innovative health care and education. This synergy between big data sets and new fourth IR innovation trajectories creates a drive amongst platform economy firms to collect more data, wherever possible, by encroaching on personal activities in social medial websites, or by embedding sensors into various equipment, etc.

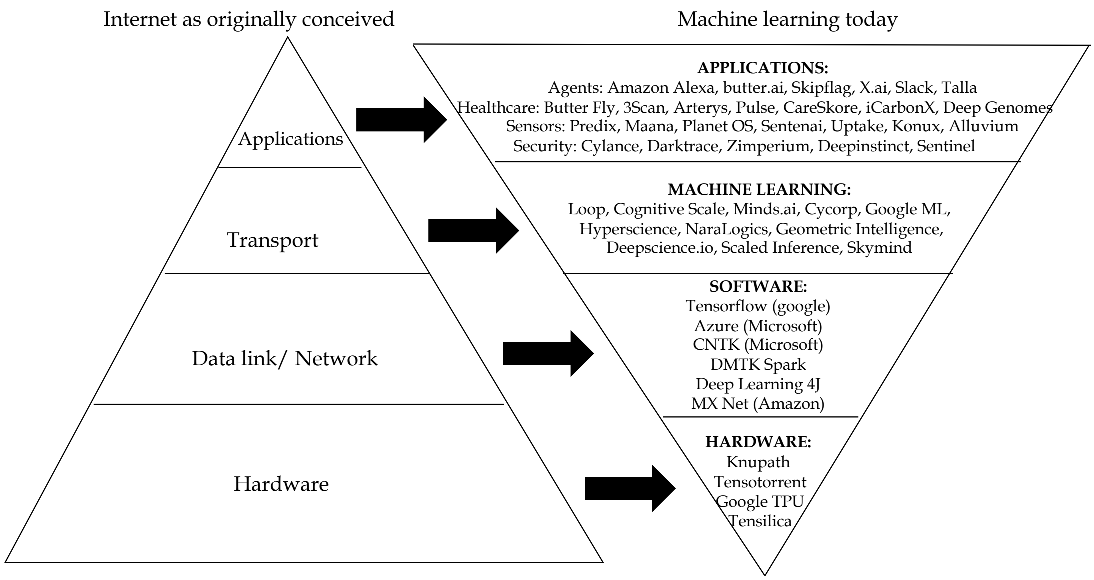
However, beyond all these kinds of synergistic innovation advantages, big data serves as the lifeblood for AI; the newest frontier in the fourth IR. AI, broadly used to describe the demonstration of deep learning in machines, has several different levels of applications today. The design of better and more focused AI applications depends on the availability of larger (and diverse) data sets that can be used to test and retrofit models that guide continuous learning through accumulated experiences, thus furthering the demand for big data.

Thus, in reality, innovation in the platform economy is not only non-linear, but is highly interconnected, with several feedback loops between big data and the different technologies that are leading to transitions of traditional sectors. Mapping the emergent platform economy landscape in which these different technologies stack up incrementally on each other using big data is a highly complex, if not an entirely impossible, undertaking. Many new platforms are not just an amalgam of several digital technologies – but the fact that these innovations are ‘smart’ implies that they are now being applied in every aspect of manufacturing, and while these are in use, they collect data that then feeds into data analytics and AI to create new forms of products that might even be unintended originally. A good example of this is connected driving, which combines several digital technologies and builds on vast data sets that guide autonomous or advanced driver assistance systems. But while in use, the car generates a vast amount of new data through embedded sensors that are valuable from several perspectives – new technological breakthroughs, changes and modifications for safety and quality, public service provision for traffic control and routing, provision of parking, and more broadly, city planning in management (see Kerber and Frank, 2017).

This incremental yet fundamentally important role played by data in innovation has led to the increasing privatization of the internet in recent years. Recent efforts to map the emerging technological landscape in some platform technologies, particularly machine learning and cyber physical systems (popularly known as IoTs) find that these technologies are fundamentally transforming the internet, by introducing new structures and protection mechanisms (both technological and legal) according to levels of technological complexity (see Zillis and Cham, 2016; Zillis, 2018). Thus, the real platform economy of today is a competitive industrial landscape where each of the fourth IR technology is a domain of privatized technology in the internet space.

This is at once, contrary to the open system that the internet was conceived and set up to be, unveiling a new era of centralized governance in the platform economy where the knowledge, skills and power are dispersed amongst a few. Figure 1 below provides a graphical illustration of this phenomenon by mapping the competitive landscape of the platform economy in the case of one technology - machine learning.[11] It shows how, based on hardware that can be easily run on most systems, the machine learning landscape has applications that span across manufacturing, health care, services, finance, security systems, agriculture, education and many other such areas.[12] But more importantly, it shows how the internet space has been evolving from the original idea of having most of its components in the public domain (with few applications), to a new context where the hardware enables an increasing and pervasive privatization of all components that layer upon it.

Figure 1: Privatization of the internet: from its initiation conception to machine learning today



Source: Author.

DeNardis and Raymond (2017) conduct a similar analysis of the IoT sector, making the point that as cyber physical systems or IoTs underlie all industrial sectors, ranging from transport and shipping, to medical systems, to manufacturing. Noting that the new IoT product ecosystems being introduced are highly centralizing in nature; they show how there is little or no aspiration to implement the competition-enabling open standards. They conclude that contrary to the underlying traditions of the Internet, which based on the principle of inter-operability and the capacity for standards-based mutual exchange of information, there is now a "…resurgence of market approaches in opposition to interoperability and competition" (at p. 493).

[11] Zillis and Cham (2016) and Zillis (2018) present a taxonomy of the competitive landscape of machine learning, a slightly simpler version of which is presented in Table 1.
[12] Only some of these are covered in table 1, for more see Zillis and Cham (2016).

3. Market and Institution Failures in Knowledge Creation and Governance

The previous section shows how the boundaries of innovation and industrialization have changed in the platform economy, with an emphasis on data generation, use and new business models that are modernizing activities across agriculture, manufacturing and services sectors. But given the highly complex nature of this technological change, policy making has been slow, lax and often even complacent, leading to the emergence of a new form of technocracy in the fourth IR. As a result, what began with a 'wait and see' approach by regulators for matters related to the internet, in the hope that "most problems confronting a network can be solved later, or by others", has now snowballed into a full-fledged privatization of public policy by corporate interests.[13] This results in several market and institutional failures in value capture, linkage building, competition and innovation, which are discussed in this section.

3.1. Value creation and capture: The problem with platform business

To be successful in the platform economy, a firm can produce new products/ services and engage in the sale and digital interface these products with the online world, or these two activities can be broken up and conducted in several combinations (see section 2). The task of creating value depends on how a firm can eliminate intermediaries and realize network-wide effects while offering a service/ product. The emphasis therefore is not just on production, but on the ability to devise business models that create network effects. This is a critical challenge that is best accomplished when the business model allows for most costs to be shifted or outsourced, so that it appears cheap or 'free-of-cost' to the user. Secondly, the firm should be able to seal off markets and market rents by promoting brand allegiance through internet 'apps'.

In the absence of effective regulatory oversight, platform economy firms determine what becomes a paid service, and what remains unpaid in their quest for broader networks of users (Scrinek 2017:45), with severe consequences for public welfare. For example, google mail is a free service, but the costs of providing this service to entice users are recouped from advertising firms that tailor ads for you based on the preferences your data reveals.

Such practices can allow firms to reorganize suppliers in advertising markets or have severe consequences for competition depending on the size of the market but go unnoticed because customer loyalties are split between different 'apps', obscuring the underlying firms, their practices and business models. Closer analysis reveals a surge in new but fluid market parameters that serve as the basis for user-courting and loyalty retention, including the appearance of the platform or the chattiness and cleanliness of drivers, or the broader network community is associated with the 'app'. Important issues such as which firms get to advertise where, on what basis, and how such businesses proliferate themselves, and what the consequences are for competition, are mostly unknown parameters, which in fact need to be transparent if markets should function properly.

The fact that value capture is not geographically constrained or accounted for in the platform economy creates additional issues for policy, especially in developing countries. Local firms end up competing with services provided by a platform economy firm that has no presence

[13] Zittrain (2008: 31). See Chander (2017) who contrasts the 'wait and see' approach to regulation in the digital economy with the precautionary principle that advocates pre-emptive regulation to avert unforeseen consequences.

domestically and does not play by the local rules, since what goes on through the 'app' is currently neither taxed nor accountable to local employment and social welfare regulations. Uber's overseas activities, while offering an important service alongside employment (albeit precariously), are a great example of how value generated in any developing economy can be siphoned offshore elsewhere with little legal obligations. Although drivers who are the providers of this service find employment, there is little or no employment and social security over the long term (Calo and Rosenblat, 2017). The same is true of microtask crowdsourcing platforms that operate based on the notion of per-task payments. Ikeda and Bernstein (2016) conduct an empirical analysis of crowdsourcing work platforms such as Crowdflower, mClerk and Clickworker to show that such platforms do not deliver on both the rapidity of employment (i.e. the promise of offering tasks that maximize expected earnings) and accuracy (where online platforms offer quick and efficient payment), which are, in fact, their main selling points.

3.2. Data's impact on competition and innovation

Issues of value capture in the gig economy are smaller (accounting for less than 5% of the total economic share in most countries) when compared to the larger conundrum of big data and how it can impact on innovation and competition. Data ownership distorts the emergence of competitive rents in the fourth IR simply because first party data confers an undue advantage to those firms that were able to capture it first (OECD, 2015). Theoretically, data can be reused by other firms, and if such data re-use creates economies of scope and scale, this may not be such a problem.[14] But when data is concentrated in a few hands, there is an absence of such competitive effects, and the powers that data ownership confers to incumbent firms is similar to patent fencing of upstream research with important effects on market structures and competition (Bessen and Maurer, 2008; Miller and Tabarrok, 2014).

The absence of data is a significant barrier to entry because unless a new entrant obtains data of comparable size and diversity, it cannot pose a threat to incumbent market players (see Shelanski, 2013; Vestager, 2016; Monopolkommission, 2015). Also, upstream innovators or upstream data holders can re-organise markets by selectively handpicking firms that can participate in several sectors and diverting economic gains in main and supplementary markets, with severe distortionary effects on competition. The Qualcomm case, first in South Korea and then China, shed light on how licensing practices can induce differential market competition (Brachmann, 2017). The recent European Union (EU) case against Google's Alphabet also shows how a dominant firm can alter the main and supplementary technological markets. In this particular case, the EU fined Google USD 5.1 billion for abuse of its power in the mobile phone market,[15] on grounds that the company was using its android platform that runs more than three quarters of all smart phones worldwide to promote and entrench the company's search engine. Promoting the google search engine over other options on all android smart phones (over 2 billion in use worldwide) ensured huge returns to the company's advertising businesses worth billions of dollars annually, by tightening its grip over search queries and all other digital habits revealed by what people just type into their smart phones, which the company used to influence advertising (Schechner and MacMillan, 2018).

[14] For example, in Case No COMP/M 5727 Microsoft/ Yahoo Search Business in 2009, the European Commission held that the deal between Microsoft and Yahoo whereby the latter would use Microsoft's Bing search engine can create competitive rents simply by offering competition to Google's search engine.
[15] EU Fines Google 5.1 USD Billion in Android AntiTrust Case, New York Times, July 18, 2018.

3.3. Data's economic attributes: Who owns data?

Data is unlike other industrial inputs because the more you mine it, the more valuable it gets. This at once, sets it apart from other exhaustible factors of production. There have been arguments that data is similar to information in its economic attributes and should be considered a pure public good (which by definition is non-excludable and non-exhaustive), but this raises legal and economic questions of a different nature.[16] While data is in fact non-excludable and non-exhaustive, there is little basis to use the classical economic argument that a property right on data is required to enable its production because data is being generated both actively and passively by users, in quantities that are increasing exponentially each day based solely on the numbers of people who use such products/ services.[17] Beliz (2017, p. 18), for example, estimates that in 2016, around 6.4 billion devices were online globally, but the global internet traffic set to rise by 23% each year to reach a level by 2019 that will be 64 times greater than what it was in 2005.

As a result, the main issue with data is not its creation, but its transfer, storage and use. Data, created in a most decentralized and personalized manner, concentrates in private hands enabling a shift of power from labour to capital in modern day economies. From a business perspective, the dependency on data and the incremental nature of innovation jointly trigger a self-reinforcing cycle of economic advantage for firms that are able to capture it. Gadgets, products, cyber physical systems (IoTs) and social media platforms are storehouses of data generation for future use, but obfuscate the primary question: who created it? Is data information or is it knowledge? If it is information, then is it the user who first created the "socially useful information" which has been the most defensible argument in social sciences to defend rights on inventions, [18] or is the firm/ individual/ computer that now owns the data and has been able to accumulate expertise to mine it across different spheres of activities or over larger periods of time that should be credited with the rights on the information? Although data mining requires investments into skills that enable the conduct of data science, can the firm's contribution be isolated, or does it still leave open the question of what kinds of skills were called for, in any particular instance, or how data can be used to create innovative applications unbeknownst to the user who created it? In a Marxist perspective, any activity that generates surplus is labour, and so if these activities are labour, then does the fourth IR open up a new horizon of exploited labour (Scrinek, 2017: 55; Gehl, 2014)?

3.4. Data, market concentration and intellectual property

The age of big data has in no way stemmed the rising tide of intellectual property protection, but instead, laid bare a number of problematic issues that relate to the application of existing

[16] In classical economics, information is a pure public good and suffers from the threat of being under-provided in nature because it is non-rivalrous (because one more person using the good does not affect its availability to others) and non-excludable (because the use of information would result in the automatic divulgence, at least partially, to others).

[17] Passive data generation refers to instances whereby people simply provide data by activities such as walking into shops with their mobile phones.

[18] Kenneth Arrow (1962) argued that creating incentives for "socially useful information" was the one of the key goals of society, when he propounded what became the most convincing justification for the grant of intellectual property in the 21st century.

legal systems to new technological changes (Okediji, 2018).[19] Scholars have for some time now, cautioned that there might be a need to separate the technological rigour of the innovation that sustains performance and puts the firm to the top ranks in high tech sectors from what might be simply anti-competitive dynamics or market rents that accrue from a strategic use of dominant positions (Autor et al, 2017; Furman, 2018). These studies, while noting that the rise of 'super star' firms may be a technological phenomenon, also confirm that this is not necessarily the case for all firms that reign globally across many sectors, and that a number of factors, including intellectual property might be leading to market concentration (Gehl Sampath and Park, 2018).[20] Such effects are expected to worsen as we head into a future of AI, and therefore the role of intellectual property in these markets, and its relation to technological innovation, needs to be revisited if we are to create competitive outcomes.[21]

Such a revisiting of the role of intellectual property should address two of the core issues in big data and AI-based inventions. Firstly, when new big data-based innovations, either alone or in combination with one other, act as incremental building blocks for newer and newer discoveries, how does one acknowledge and reward new knowledge? Secondly, if a computer was responsible for the creation of the new knowledge, does it still fall under the same category as those applicable to humans? Can "a computer could and should be an inventor for the purposes of patent law as well as whether computational inventions could and should be patentable"? (Abbott, 2016: 1, see also Abbott, 2017; Gehl Sampath and Bouhia, 2018).

A final issue that calls for some scrutiny in this regard is the enforcement of intellectual property by fourth IR firms using new technologies. Several content providers on the internet (e.g. YouTube) already filter all online content they feature for infringing material. Such a notice and takedown regime is gradually becoming an algorithmic enforcement regime with robotic enforcement. This confluence of data control, control over users and IPRs enforcement in and through private parties is not a well-studied area of legal and economic scholarship and will require more analysis, especially in the context of provision of important public goods in developing countries.

3.5. Machine learning, AI and inequality

Although machine learning has been in use for decades, new techniques of deep learning and reinforcement learning that use neural networks have transformed the possibility frontiers of AI. These techniques use bottom up learning methods, where the computer is presented with several thousand examples to identify patterns, and can often also be complemented through top down Baysian techniques that set certain hypotheses (Gopnik, 2017). Deep learning from large data sets – ranging from Instagram images, emails, voice recordings, online posts and so on – have made possible the creation of recent image and voice recognition software, while other forms of AI applications employed for decision-making in education, employment,

[19] Okediji (2018:1) notes the strong trends in IP filings: not only were over 3 million patent applications filed in 2015, it was the most ever filed in any single year up until now, recording an 8.3% growth over the previous year, and trademark applications similarly grew a reported 13.7% also in 2015.

[20] The 'winner takes all' dynamic is well studied in economic literature, starting out with the concept of 'superstar firms' first introduced by Rosen (1981), arguing that in markets where quality advantages exist, a small number of suppliers dominate the market and command most of the returns.

[21] Furman (2016) singles out AI noting that it will have significant implications for innovation, employment and market concentration in the global economy, worsening the effects we have seen up until now.

insurance and health care, are often a combination of Baysian hypothesis and deep learning methods.

AI's broader use in industry and society is currently being supported by arguments of greater efficiency, consistency, and reliable monitoring, with forecasts routinely predicting a rise in AI-related productivity in all countries. An associated reality that does not get highlighted is that algorithmic decision making is not fair. In fact, contrary to the popular belief that computations are mathematical, they actually propagate offline inequality and systemic prejudices to an online environment (Hardt, 2014; Noble, 2018). There are several reasons why this happens. Firstly, the efficacy of any learning algorithm depends on the historical instances (the so-called training data) that it has been exposed to, which it then uses to model future responses. So, if there are social biases in the data set used to retrofit the model for the algorithm, it will continue to replicate them while in use. Examples abound, including Amazon's facial recognition software 'Rekognition' that mistakenly associated the facial profiles of 28 members of the US Congress with criminal mugshots (Snow, 2018) in which there was a disproportionate error rate for people of colour, or Wikipedia's recently revealed gender bias (See Economist, 2018), or Amazon's use of AI in employment shortlisting which revealed that the AI in question in fact replicated traditional gender profiling in favour of male applicants. Such biases continue to proliferate when predictive policing techniques get perfected in suburbs of Los Angeles or other US cities, which tend to racially profile non-Caucasians as offenders, which is problematic when applied anywhere in the world, but especially in the developing world.

Secondly, algorithms have embedded values, which while not being that relevant in industrial use, become extremely significant in governance and selection of societal outcomes. When used for governance and selection in society, it is important to note that AI, while being good at analysis and targeting, is limited in capacity for interpretation of rules, regulations or events that are essential to pool and select outcomes. Or AI, while being good at execution and meeting targets, is limited in its ability to consider consequences and factor them into decision making. These shortcomings explain the accidental failures arising from AI applications which prioritize targets over potential consequences. For instance, in the area of energy, AI applications programed to optimize energy use have been found to simply cut off energy access to parts of the grid in situations of overload.

The issue therefore is not how machines learn, but what they learn (since computers can tap into multiple domains to sequence and replicate learning), and to make sure that unnecessary accidents do not occur during use. Microsoft's TAY bot, for example, expected to mimic a 19-year-old girl in 2016, managed to learn and release sexually and racially charged messages, even after a second release. Scientists lobbying for responsible and ethical AI believe that safeguards, in this context, are not just related to specifying directions (Arnold and Schentz, 2018) or providing better data sets, but are about ensuring social accountability of AI, which remains the real challenge.

Thirdly, minority data sets – whether in the context of race, gender, or economic parity (developed versus developing) – will continue to remain minority data sets by definition and will not contain the same kind of information for those who are in the 'minority'. Even when the sample set is enlarged to include more observations, it will still not contain as many variables as the majority sample set and therefore give less information than the majority data sets. This is because minorities, as we define them in the social and economic sense, are those segments of the population that do not have access to many important services. This disparity therefore is something that needs to be factored in, while considering AI and its wider use.

Lastly, algorithms mimic majority outcomes, raising the question as to whose knowledge/ worldview it is that gets propagated online. For example, search hits are determined on how many others searched for similar sites. This, by itself, propagates racial, social, and gender biases, reinforcing stereotypical identity issues that have been larger struggles in today's societies.[22] In the very least, it raises important issues in decision-making – is the majority of any population the determining standard? Would that be a good basis for democratic societies? And if so, for which cases, and how do we determine different thresholds in AI based decision making? A good, but limited example of this is Google's flu predictor which consistently over-predicted the incidence of flu in 2011-2012 and 2012-2013, based on the number of people who searched for symptoms.

4. Formulating Industrial Policy 4.0

The market and institution failures highlighted in section 3 raise questions of a fundamental nature, implicating the current economic model. Should businesses profit from people using the Internet to connect with one another (Gillespie, 2018)? Can corporate businesses hoard data simply by virtue of being the suppliers of platforms for business and industry? Who is regulating (or even in the least, monitoring) the introduction of sensors into all forms of products and its effects on privacy of people - and what are the limits to the massive, pervasive intrusions into our daily lives? Where are the limits to privatization of the internet? And finally, what are the boundaries to this kind of profitability and how should citizens be protected/ safeguarded?

The challenge for industrial policy frameworks in these times is not just to identify national priorities or support domestic industry, but much wider. Industrial policy 4.0 has to step up to steer societies and economies into alternative models of growth where business priorities, individual guarantees and societal goals are better aligned. Such an alternate model of regulation is critical to foster what Polyani (1944) called the "great transformation", wherein policy complements market forces to maximize the economy's growth potential, support individual choice and autonomy and reduce the risks associated with digitization.

A starting point would be to acknowledge that going ahead, all manufacturing will be digital manufacturing, which is what led the German government to coin the term industry 4.0 in 2011.[23] This implies that although manufacturing as we knew it – with its effects on low and unskilled labour and employment creation - might not continue to exist, it will continue to flourish with an emphasis on skills and R&D, within a new model of industrialization where the knowledge-component of all sectors – agriculture, manufacturing and services – is on the rise. This is not a radical proposition. But it is one that calls for a nuanced policy framework that goes beyond general discussions on data ownership, technological change, intellectual property and digital infrastructure. Such a policy framework – the industrial policy 4.0 – needs to focus on facilitating the simultaneous industrialization and modernization of all sectors from

[22] See Noble (2018) on how algorithms reinforce racism, and in particular, racial stereotypes about women. See also, Noble and Tynes (2016) for a discussion on how race, gender and cultural stereotypes interact online.
[23] See footnote 1.

agriculture to manufacturing to services, with four essential areas of intervention and priority, as highlighted here.

4.1. Building capabilities for digital industrialization

Technical, digital infrastructure that provides secure networks for seamless transmission of data can help millions of people access new technological innovations in the fourth IR, and cloud infrastructure can promote data storage and application of technologies in local firms, thereby helping them compete. But firms in developing countries need much more support to build domestic skills for production and to access technology.[24] They need better and faster access to finance, information and training on new business models, skills and training, marketing support, and a supportive domestic technological base that is actively engaged in new forms of discovery and science. Therefore, the provision of digital infrastructure needs to be augmented with capabilities building that allow for development of local strengths in manufacturing and services sectors. The expansion of actual internet use should aim to promote the integration of digital technologies into the economy to boost competitiveness of traditional sectors. Governments should focus on the development of digital public services (e-government) that can help create effective data bases for use in social sectors to promote health, education and other social services. Jointly considering these aspects is, for instance, a priority for the EU currently (DESI, 2016). This entails a focus on the following issues.

(a) Capabilities building and reforms of the education system

As automation and other digital technologies fundamentally re-shuffle the global job markets, a good number of jobs will be created alongside many other occupations that will get reduced or even wiped out. Capitalizing on these new job niches, however, calls for a highly skilled and supple labour force that can be moved easily from firm-level operations that will become redundant to other areas of specialization in hybrid production systems where machines and humans co-exist. The real challenge for countries is one of ensuring that their work force is able to transition and make use of these opportunities. If truck and taxi drivers are unemployed by connected driving and jobs are created in high technology production, how do individuals make the leap?

Creating such a job force should address three kinds of capabilities failures that is widely prevalent (to different extents) in developing countries. First of all, there is a need to build digital capabilities, namely, skills, knowledge and technical know-how of particular significance to Industry 4.0. New jobs created in the fourth IR will be in areas such as data analysts, robotics process automation engineers, cloud computing experts, and inter-disciplinary task managers, all of which call for a prioritization of STEM (Science, technology, Engineering and Maths) education, which is expected to play a critical role in enabling such skills creation.[25] Inter-disciplinary skills, that is, those that combine technical expertise with specific plant management expertise required to combine, create and run the hybrid production systems will also become valuable in the years to come. For example, a total of 28% of the 900

[24] Keyser et al (2018: 19) similarly, identify four important prerequisites to analyze big data and reap benefits of which digital infrastructure is only one, accompanied by: the existence of a business need; the availability of data that can be assessed; and the skills and capacity to conduct data analytics,
[25] See for instance: http://www.azcentral.com/story/money/business/jobs/2017/09/04/how-artificial-intelligence-robotics-could-transform-jobs-10-years/574501001/

companies surveyed in the 12 industrialized countries on the viability of 3 D printing as an industrial option reported lack of qualified personnel as the main impediment to their decision making (Ernst and Young 2016: 15).

Secondly, digital production and innovation is not about programming or creating products and processes over the internet, but about interfacing existing physical domains with the internet. Therefore, digital industrial policies should equally focus on creating or strengthening traditional industrial capabilities that create routine skills and know-how in manufacturing. This is relevant to boost e-commerce gains, which in large parts, is creating online markets for traditional goods and services. In the absence of capabilities to produce diverse (and new) forms of industrial outputs, countries will find it difficult to leverage the fourth IR for any kind of transformation.

Thirdly, specific short and midterm capabilities building, and training programs need to be introduced in parallel to deal with the job losses that are already occurring in the developing world. Such programs should target the re-training of existing skilled and semi-skilled workforce to eliminate or bridge the skills mismatch that currently exists in the developing world in the context of the digital economy, which can often be twice as high as in the case of a developed country such as the USA (See McGowan and Andrews, 2015; 2017).

(b) Re-conceptualizing the triple helix

The traditional triple helix of innovation – university-government-industry – needs a new boost, with a clear elaboration of, and incentives for, new forms of collaboration. Government agencies and data collected by the government can become a huge source of innovation for the future, provided that this data is collected, stored and stewarded appropriately. Existing studies suggest that government data is prone to (a) inconsistency; (b) incompleteness; (c) insufficiency of metadata; (d) lack of technical and semantic interoperability and; (e) fragmentation due to lack of technical ability (Jetzek et al, 2014). Policy therefore, should set out guidelines for how data can be collected in governmental agencies or public research institutes, and to what extent it should be used by the private sector for innovation, and what kinds of benefit-sharing arrangements should prevail to protect the data creators (that is, individuals).[26] Greater attention is also required to understanding and elaborating the new roles of universities and public research institutes as brokers of innovation in the digital economy, in both traditional and new, high technology sectors, along with greater investment to promote high skilled research in STEM areas.

Moreover, many of the kinds of innovation that the digital economy thrives on are the kinds of innovation that are under-served or under-regarded in developing countries. The disconnect between universities that are conventional ivory towers with academics who look down on ‘apps’, ‘platforms’ or technological applications based on the internet is a phenomenon that impedes the creation of innovation linkages. This disconnect needs to be addressed actively through policy, by creating new forms of industrial and innovation hubs that support the fourth IR.

[26] Okediji (2017) looks at how government data can become the basis for innovation of private firms and looks at the questions of benefit sharing.

(c) How to 'smart' manufacture when we don't manufacture much?

Alongside creation of skills and capabilities, sufficient efforts should be put into enabling industry transition to incorporate and use digitization for smart manufacturing into all existing production systems so that they can compete. For example, if Siemens offers sensor embedded washing machines and the local competitors do not, this puts the local firms at a new kind of disadvantage since Siemens over time can collect new forms of data over use and consumption patterns. Although questions of this nature seem minor, they reflect the broader parameter of support for manufacturing sector firms to upgrade and use digital technologies in production, which should particularly embrace small and medium sized firms (Kusaik, 2017). In Germany, the emphasis of the Industry 4.0 framework has been to create projects with and for the small and middle manufacturing firms to enable them to introduce new business models that integrate the internet of things into existing products (Dowling, 2018).[27] This has included training and support for the creation of digitally charged products, sensor systems, the use of pay and use versus traditional production models, among others, to enable the firms to transition to new ways of value creation and capture in the digital economy. In China, similarly, such a government strategy has extended to supporting local firms in creating capabilities in local technological platforms of a highly modular nature and in the mobile telephone sector (see Humprey et al, 2018).

(d) Enabling local firms to compete

As the data wars continue, local companies will be up against large conglomerates in all sectors. As e-commerce continues to offer platforms for smaller companies from developing countries, it will also enable greater and often disproportionate gains for global giants, such as Amazon or Ebay. Even in the gig economy, the odds are stacked against local companies to a large extent. For example, Uber's second largest market globally is Brazil (AfdB et al, 2018), which will be a significant obstacle for any local company to overcome, including a successful one like Brazil's 99 taxis, which has now been acquired by China's rising power, Didi Chuxing, in January 2018 (Culpan, 2018). The relative mismatch in market power between a local company and a global incumbent can be a result of many factors, as discussed earlier in section 3. While some factors may be competitive, such as sheer volume of transactions or supply discounts, efficacy of algorithms used in predicting customer reactions, many factors can be anti - competitive, such as existing connections with local supply chains, collusion and selective licensing, or data control in primary and secondary markets. Ensuring level playing ground calls for active and informed competition authorities at the national level, whose objectives would be to measure and benchmark market power and market concentration with an oversight function in all sectors of the economy.

4.2. Making data a developmental asset

Discussions on big data need to move beyond data localization (rules that ensure storage of all data generated in the country on national servers), in order to fully capture data's primary role in the fourth IR. Data localization could help impose restrictions to data amassing by large companies in the big tech domain, promote the assertion of national sovereignty on data created by citizens, offer access to data generated by users in the country to national governments and

[27] See for more details: http://www.platform-i40.de

can enhance the efficacy of national agencies and promote national security (Chander and Le, 2015; Cory, 2017). Data localization can also be imposed partially in that, for example, governments can include restrictions that compel firms who collect this data to seek 'prior consent' from individuals before such information is used. Governments can also enact additional restrictions for international firms from using the data for any further commercial activities, among others.

Data localization will entail large costs both for provision of digital infrastructure and monitoring, and by itself, will not be enough to transform big data into a developmental asset. In other words, localizing data will not automatically make domestic companies competitive or enhance privacy of citizens or promote national security. The alleged leak of India's biometric scheme containing a billion identities as part of the Unique Identification Authority of India (UIDAI) project shows how data safety and security issues can arise from any centralized collection of data (Somanchi, 2018). Big data needs to be addressed through an effective regulatory framework that balances privacy, use and safety in tandem.

(a) Data ownership and stewardship: Key issues

Creating a balanced data regime at the national level hangs between two extremes. At one extreme is a purely free data economy, either at the global level, or within countries (with data localization), which in the longer term can become a drag on productivity growth and put individual security at risk (Byrne et al., 2016; Ibarra et al, 2018) although some studies suggest that an open data economy could promote private and public sector innovation (Zuidewijk et al, 2014).[28] At the other extreme is the option of heavily regulating data with strong incentives for the users (that is, the creators of the data) such as a sui generis intellectual property right on data (Drexl, 2016 and 2017) or a data protection right as suggested by the European Commission (2017). This, while serving to be protectionist, can be equally problematic because in unequal bargaining situations, these rights would be bargained away in contracts between large companies and individuals without a consideration of the social ramifications (Kreber and Frank, 2017). Such regimes could also stifle innovation because in the digital economy, several domains including those on IoT, depend on multi-stakeholder collaborations (Determan, 2018).

In the EU, these options are being widely discussed in the context of the recently promulgated General Data Protection Regulation (GDPR). Legal discussions on the topic are split between those that seek to frame the issue as a human right or an exclusive property right on personal data[29] or a right to be informed before the data is used. The GDPR mandates prior consent for the use personal data in Article 13 and recognizes the right of the user to their personal data without any risk of use in automated individual decision making and profiling in Article 22. The GDPR also recognizes in its Preamble, "the protection of natural persons in relation to the processing of personal data is a fundamental right" (para 1), but there is a general consensus amongst EU lawyers that this does not create an exclusive property right in personal data (See Schweitzer, 2017). But at the same time, several legal scholars in Germany have proposed a *sui generis* data right which has also led to a discussion on the data producer right in the

[28] Ibarra et al (2018) make the case that the fundamental problem in the discourse is the treatment of data as capital, and not as labour.
[29] These discussions can be traced back to Article 2 of the German Constitution, which provides for personal freedom of every citizen to freely develop his personality without any unfair encumbrances or influences.

European Union.[30] Outside the EU, the recent Supreme Court judgement in India (of 2017)[31] has upheld the fundamental right to privacy and circumscribed several of the uses of the data collected by the government as part of its national identification card scheme, but has not elaborated on its implementation.

Going ahead, what is needed is the consideration of a balanced data governance regime, with clear principles that differentiate between informational privacy (where personal information that is revealed in online transactions is protected) and autonomy privacy (which refers to the freedom of doing things without being observed) (Borgman, 2018). Autonomy privacy is equally important because unbeknownst to most of us, our online profiles are continuously being enriched and can become the first point of reference for a number of national, government-based decisions. Governance principles therefore need to be clear right from the start in specifying the nature and extent of data protection, with guidelines on how it interacts with an individual right to privacy, which is much broader than just the protection of online data.

(b) Data governance

At least three layers of data governance should be secured by national data regulations as part of industrial policy 4.0: provision of secure infrastructure, data management and the elaboration of governance principles and processes (Borgman, 2018):

(i) Secure infrastructure is important to maintain control over data, and also to ensure that it is reusable (in different applications over time) and interoperable.

(ii) Data management i.e., the processes whereby companies, users or government agencies can collect, use and store data that is being generated. A number of open questions needs to be answered by the data management regime – where is data stored, how often and how many people can make use of the data, how long will individual data be stored (what is the term limit), when does data become inadmissible for decision making, and how can individuals be protected against data misuse?

(iii) Data governance principles and processes: Data governance should outlines the right over data produced or collected at each stage, as well as rules for contractual arrangements, benefit sharing, the storing and processing of data, the analyzing of data, e.g. also through combination with other data, limitations to the use of data (for what kind of purposes), granting access to data for others through sharing, transfer or licensing, and the protection of data against destruction, compromising, copying, or misappropriation (Kreber and Frank, 2017: 9). Promoting access to already accumulated data by big technology companies should also form part of such data governance regime, in order to create level playing fields in industry.

[30] See Kerber (2016), Drexl (2017). Also see the proposal for an exclusive "data producer right" in the EU (EU, 2017).
[31] Justice K.S Puttaswamy (Retd) and Another v. Union of India and Others, Writ Petition (Civil) no. 494 of 2012.

4.3. Promoting effective regulation of digital technologies

Each of the fourth IR technology – from cloud computing, machine learning and AI, RPA, and the internet of things – is a separate technological domain with complex questions for adoption, use and technological learning in countries. Hence, the tradeoffs of costs and benefits will not only depend on the technological characteristics of these technologies; but also, on how the institutional frameworks for these technologies are carefully calibrated, designed and implemented to promote the balance between technology and society.

Industrial policy 4.0 therefore needs to introduce tailored incentives and regulations for each digital domain recognizing its differentiated impacts, geared to correct market failures in all fourth IR markets ranging from cloud computing (Newman, 2016), internet of things (Kreber and Frank, 2017), cyber security and AI (Erzachi and Stucke, 2015; Vessozo, 2017).

For instance, a national AI strategy should not just be about promoting the use of AI or developing AI but about laying out rules for the responsible use of AI. Such an AI regime should institute algorithmic accountability by revisiting existing laws or creating entirely new ones, to ensure that liability rules regarding the failure of AI is in place for citizens and businesses/organizations alike. This supports AI development as much as its acceptance. Social oversight over AI will also call for measures that might specify the disclosure of underlying algorithms, discussions with scientists on how to best build safeguards for control and learning focus within machines, and national governments will need to play a key role in stewarding these debates.

4.4. Protecting and preserving employment

Capabilities formation is a first step in creating employment. But protecting and preserving employment and ensuring wage growth will call on governments to address the question of value capture and value generation in the digital economy in a systematic manner. The real issue, as highlighted in section 3, is one where successful 'apps' have the capacity to create large global/ regional/ national companies, but in the absence of regulation that classifies and extracts accountability from these providers in a manner akin to traditional companies, these gains are extracted by firms to the detriment of those employed nationally and the national economy.

To prevent such capital flight, there is a need to introduce legislation that mandates the registration of such providers and monitors their activities with taxation and other obligations on revenues earned in the local market. States themselves will be faced with financial difficulties in industry 4.0 as industries transition to robot led production systems. Determining taxation of robotic production will be crucial, failing which states can find themselves in a situation of having to dole out universal basic income or other social protection benefits to individuals in the face of unemployment while large companies amass greater profits, enjoy greater efficiency and production surpluses without paying taxes on employee (robotic) revenues (Abbott and Bogenschneider, 2018; OECD, 2018).

The European Commission, for instance, has proposed two new draft EU Directives as of March 2018 on the question of taxation of digital revenues. The first Directive proposes that Member States can tax profits that are generated in their territory, even in cases of companies that are not *physically* based there. The second directive proposes to introduce a Digital Services Tax at EU level at a rate of 3% on gross revenue from digital services.[32]

Other industrial policy incentives should aim to protect individual job safety and security by:

- Generating reliable forecasts of job market changes across sectors.
- Promoting on the job-training facilities for near-job transitions in a number of occupations that are expected to be affected.
- Providing for additional social protection and training breaks as individuals face risks of job losses and look for alternate working domains.
- Ensure the provision of social security and welfare while individuals and families undergo unfair transitions.
- Consider the universal basic income solution.

5. Concluding Remarks

This paper makes a series of important contributions to the ongoing debate on development in the fourth IR. It highlights the new boundaries to innovation and industrialization in the fourth IR, with a detailed enumeration of the various market and institution failures that impact upon the way countries can channel these technologies for the overall development of their sectors and economies. It argues that the critical issue in the wake of the fourth IR is not whether manufacturing is the next engine of growth or not, but rather to understand how the changes to manufacturing and industry (more broadly), will affect all countries. The analysis suggests that in this new context, all sectors will be affected, ranging from manufacturing to services, and developing countries will need a balanced developmental strategy focusing on raising the knowledge and skills component of each of these sectors. It proposes an industrial policy 4.0 that is not just comprised of defensive measures, but one that is based on a genuine, well-articulated national vision of how to promote digital innovation and its benefits for the local economy, while taming market forces and big tech fallouts of the kind that we witness in the global economy today. Such an industrial policy 4.0 should have at least four key pillars: capabilities for digital transformation, guidelines to make data a developmental asset, effective regulation of all digital technologies, and protection and preservation of employment. These measures need to be well coordinated with investment, technology transfer, trade, export promotion and most of all, competition policy, in order to promote positive transformation in the fourth IR.

[32] https://ec.europa.eu/info/law/better-regulation/initiatives/ares-2017-5253058_en

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