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Big Tech, knowledge predation and the implications for development

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Abstract

This paper focuses on tech giants as active drivers of a phase of globalisation characterized by growth in digital services trade combined with a general shift to intangible assets. By analysing how Google, Amazon and Microsoft organize their innovation activities, we show that they continuously monopolize knowledge while outsourcing innovation steps to other firms and research institutions. The paper compares science and technology collaborations with patent co-ownership suggesting knowledge predation from those other organizations. We also highlight that selected tech giants combine the collection of innovation rents with rents from exclusive access to data. We therefore refer to tech giants as *data-driven intellectual monopolies*, each organizing and controlling a global *corporate innovation system (CIS).* Intellectual monopolies predate knowledge (including data when they are data-driven) from their CIS that they turn into intangible assets. The paper ends with reflections on the implications for innovation and development.

Keywords: Intellectual Monopolies; Corporate Innovation System; Data-driven rents; Rentier capitalism; Knowledge predation; Economic development

JEL Codes: O30; O38; F23.

1. Introduction

Since 2008, albeit Global Value Chains' trade stagnation (Shin 2019; World Bank 2020, 19), there has been an acceleration of digital services trade (WTO 2019). Core countries -in particular the United States- concentrate large surpluses in intangible trade (Fu and Ghauri 2020).

This context has led several authors to reflect on how the rise of intangible over tangible assets changes capitalism. In particular, it has been shown that investments in intangibles have become crucial for economic concentration (Calligaris, Criscuolo, and Marcolin 2018; Chen et al. 2017; Crouzet and Eberly 2018; Haskel and Westlake 2018). To capture this trend, Pagano (2014) has coined the concept intellectual monopoly capitalism.

An apparent feature of the rise of intangibles is the skyrocketing growth in the market value of data-driven big tech companies such as Google, Amazon, Facebook, Apple and Microsoft (GAFAM). In this article, we conceptualize GAFAM companies as paradigmatic examples of intellectual monopolies and ask what is new about intellectual monopolies in comparison with previous leader corporations, such as GVC leaders and flagship firms. By analysing how Google, Amazon and Microsoft organize their innovation activities, this paper shows that intellectual monopolies continuously monopolize knowledge while outsourcing innovation steps to other firms and research institutions. The paper compares science and technology collaborations with patent co-ownership to argue that tech giants predate knowledge from those organizations. We also show that selected tech giants combine the collection of innovation rents with rents from exclusive access to data. We refer to them as data-driven *intellectual monopolies*.

In order to capture knowledge predation through the interplay between outsourced production and innovation by intellectual monopolies, we suggest that each of them builds, redesigns and leads a *Corporate Innovation System (CIS)*. We define a CIS as a system organized and controlled by a dominant firm but constituted also by a multitude of more or less subordinate firms and knowledge institutions that participate in multiple production and innovation processes. Unlike other productive and innovation structures, in CIS not only the resulting value but also the collectively created knowledge is mostly appropriated by the dominant firm acting like a predatory intellectual monopoly. We argue that knowledge (including data) predation by global intellectual monopolies has particularly harmful effects on development. The article also explains that alternative conceptualizations -such as global value chains, flagship firm, industrial architecture, strategic centre, and global innovation networks- fall short when it comes to explaining that, by organizing outsourced production *and* innovation, leader corporations predate knowledge expanding their intellectual rents. This is at the core of our CIS concept.

The rest of this article is organized as follows. In section 2 we argue that existing concepts have overlooked both knowledge (including data) predation and the interplay between production and innovation, which we argue are characteristic of big tech companies. To fill this gap, section 3 introduces the concept CIS, while section 4 looks into the specificities of data-driven intellectual monopolies, such as GAFAM companies. Section 5 draws on our conceptual contributions showing that Amazon, Microsoft and Google[1] predate knowledge (including data) from their CIS. Section 6 presents reflections on implications for public policy in emerging economies, while section 7 concludes with questions for further research.

[1] In fact, we analyze Alphabet, Google's parent company. However, since the company is still known after its main business, Google, we use Google to refer to the overall holding.

2. Why do we need a new concept? Revisiting the literature

Different approaches have focused on how leader corporations organize productive structures. The flagship firm theory analyses how multinational corporations organize and set the strategy of multiple value chains (Rugman & D'Cruz, 1997). Likewise, the strategic centre approach emphasizes that networks that are strategically guided by a firm grow faster and generate greater benefits for all the participants (Lorenzoni and Baden-Fuller 1995). A shared shortfall of these approaches is that they neglect how the distribution of value (and knowledge) may not reflect each participating organization's contribution. As Strange and Humphrey (2018) note for the case of the flagship firm theory, albeit recognizing the strategic position of certain firms, this framework does not account for asymmetric relations or flagship firm's value appropriation.

The recognition of unequal relations within value chains organized by leader corporations has been a contribution of the Global Value Chain (GVC) literature. The chain represents a single commodity production process that takes place in different firms and geographies that is organized and governed by a leader corporation (Gereffi 2014; Gereffi, Humphrey, and Sturgeon 2005; Gereffi, Korzeniewicz, and Korzeniewicz 1994; Ponte and Sturgeon 2014; Sturgeon 2009). Hierarchical relations between leader firms and partners, and contestation over value creation and distribution are considered as explicit possibilities, and leader corporations can exercise behaviour control due to power asymmetries (Gereffi, Humphrey, and Sturgeon 2005; Strange and Humphrey 2018). Power is not only exercised directly in a one-to-one relationship but also in more diffuse ways, such as by setting industry standards (Dallas, Ponte, and Sturgeon 2017).

Besides GVCs, the industrial architecture concept also considers how value is created and distributed within productive structures (Jacobides, Knudsen, and Augier 2006). Unlike GVCs, industry architectures are not circumscribed to a single commodity. Jacobides et al. (2006) argue that firms can create architectural advantages by innovating, which results in greater chances to appropriate more value from the industrial architecture. However, they do not delve into how that innovation was achieved in the first place.

Similarly, it has been pointed out that GVCs do not sufficiently analyse innovation processes (Chaminade et al. 2016; Jurowetzki, Lema, and Lundvall 2018). Most of the value chain literature assumes that knowledge-intensive activities remain internalized by the leader firm, while manufacturing and other non-core activities are generally outsourced (or offshored) (Serfati 2008). The same distinction was made by authors studying outsourcing and offshoring from the related 'global factory' approach (Buckley and Strange 2015). Rugman and Cruz (1997) also stated that the flagship firm sets the direction of innovations, but the actual innovation process, how it takes place, is overlooked.

This shortfall becomes all the more important in a context where, as Gereffi (2014) recognizes, current GVCs dynamics are increasingly relying on intangible assets. Beyond GVCs, this is an epoch where capital accumulation is more and more driven by the systematic concentration of knowledge in a small number of firms. Intellectual monopolies emerge from the capacity of certain individual capitals to monopolize knowledge and data, transforming them into intangible assets (Durand and Milberg 2020; Pagano 2014; Schwartz 2016; Rikap 2018). Intellectual monopolies must continuously renew their innovation leadership to stay in the lead (Rikap 2018).

An important implication of overlooking innovation processes is that these approaches (flagship firm, strategic centre, GVC, industrial architecture and global factory) have not delved into leader corporations' outsourcing of innovation modules or steps. To some extent, the lack of focus on the innovation process as distributed among firms has been filled by the Global Innovation Networks approach (Chaminade et al. 2016; Ernst 2008; 2009; Liu, Chaminade, and Asheim 2013; Parrilli, Nadvi, and Yeung 2013) as well as innovation and platform ecosystems literature (Adner and Kapoor 2016; Cennamo and Santalo 2013; Gawer and Cusumano 2014; Jacobides, Cennamo, and Gawer 2018; Stallkamp and Schotter 2019).

Within the ecosystems' literature, Jacobides et al. (2018) explain that innovation ecosystems include all the actors around a particular innovation, while platform ecosystems study actors' organizations around a platform. Overall, ecosystems are integrated by firms with unique or supermodular complementarities (Jacobides, Cennamo, and Gawer 2018). GAFAM companies organize these types of structures as well as other platform companies. Albeit useful for analysing multilateral, non-generic complementarities, the ecosystem concept does not focus on the distribution of value and knowledge within participating actors, which is the main focus of our contribution. Furthermore, tech giants organize multiple interrelated platforms going beyond organizing a single platform ecosystem. They also establish traditional collaborations with universities and other research institutions not based on such complementarities. Unlike ecosystems' literature, the innovation systems approach has concentrated on the interlinks between different types of actors within the innovation process regardless of their degree of complementarity, given a central place to universities and the state.

However, this approach shares with the ecosystem's literature that most contributions have overlooked power asymmetries (Chaminade, Lundvall, and Haneef 2018; Jurowetzki, Lema, and Lundvall 2018; Lundvall 2002) and knowledge predation.

In the case of Global Innovation Networks, authors are ambivalent when it comes to the role of leader corporations. Distinguishing innovation from productive structures such as GVCs, some authors conceived global innovation networks as structures that are not necessarily subjected to hierarchical relations (Chaminade et al. 2016; Liu, Chaminade, and Asheim 2013). On the contrary, for Ernst (2008; 2009), global innovation networks are hierarchically organized by leader firms.

A common shortfall of ecosystems, innovation systems, and global innovation networks literature is that, albeit focusing on innovation processes as conducted by multiple organizations, they have overlooked the resulting distribution of intellectual rents. From a Marxian tradition, Foley (2013, 259) conceptualizes this distinction as the difference between "value creation, surplus value generation, and surplus value appropriation". He argues that the specificity of the dubbed information economy does not lay in how value is created but in the introduction of new modes of surplus-value appropriation. Similarly, Yeung and Coe (2015) argued that what matters is who captures the value created from research and development (R&D).

This distinction between who collaborates in R&D and who turns resulting knowledge into intangible assets is all the more important considering some of the specific economic properties of intangible investments, as described by Haskel and Westlake (2018). Intangible investments generate spillovers. Hence, an organization making an intangible investment will not receive all or perhaps any of the returns. Intangible assets are harder to protect, which can be considered as one of the reasons why Google, Amazon and Microsoft combine multiple strategies to predate knowledge, as we refer to in section 5. Overall, considering their capacity "to create, deploy and protect intangible assets" tech giants can be considered as corporations with strong dynamic capabilities (Teece 2009, 17). Another economic property, as defined by Haskel and Westlake (2018), is that jointly used intangible assets tend to generate radical and often unpredictable synergies. By concentrating intangible assets, intellectual monopolies enjoy this type of synergies.

Overall, innovation is produced collectively by multiple organizations -as shown by global innovation network, innovation systems and ecosystem approaches. However, we argue that the capacity to turn resulting knowledge into an intangible asset, and thus to extract (intellectual) rents, lays mostly in the hands of a few leader corporations. These firms plan and control outsourced innovation processes.

They establish collaborations through predatory relationships with other organizations. Knowledge predation contributes to expanding leader corporations' intellectual rents, thus reinforcing their economic power.

Existing concepts do not focus on knowledge predation from outsourced innovation processes (see Table 1). Moreover, by focusing on specific structures, such as the productive structure, the platform or the innovation network or ecosystem, they overlook the interplay between multiple platforms, production *and* innovation processes organized and controlled by intangible-intensive leader corporations. Therefore, in order to contribute to overcoming these limitations, in the next section, we introduce an alternative concept.

Table 1 should be placed here.

3. Corporate Innovation Systems

We build on an analysis of innovations as outcomes of learning processes. The starting point is that innovation is a cumulative process where innovations as outcomes are new combinations of elements of existing heterogeneous knowledge (Dosi 1988; Antonelli 1999). At the actor level, innovations are outcomes of a process where heterogeneous individuals and organisations engage in interactive learning. This theoretical micro-foundation of the innovation system concept may be further developed through an analysis of user-producer interaction in connection with product innovation (Lundvall 1985; 1988). We take inspiration from Schumpeter's (1934) classical definition of innovation as encompassing the introduction of new products, new processes as well as new natural resources, new forms of organizations and new markets. As we shall see, these different forms of innovation are at the core of the new digital revolution. At the same time, these concepts need to be adapted to the new digital context. For instance, social network platforms are organizational innovation aiming at creating markets for attention. Data takes the form of a new strategic resource and together with machine learning they introduce a new kind of endogenous permanent or dynamic innovation. New algorithms can be seen both as product and process innovations.

We also follow the innovation systems approach in assuming that innovation is a prerequisite for (national and corporate) economic performance. This stands in contrast with the GVC-approach where innovation is seen as one of several sources of 'upgrading' (Barrientos, Gereffi, and Rossi 2011; Coe and Yeung 2015; 2015; Dedrick and Kraemer 2015; Gereffi 2014; Humphrey and Schmitz

2002; Lee and Gereffi 2015). We follow the GVC-approach when it comes to introducing power and hierarchical relationships between the lead firm and other participants in the CIS.[2]

We propose that each intellectual monopoly organizes a CIS from which it extracts not only value from suppliers, but also predates knowledge from other firms and research institutions. This knowledge is assetisized by the intellectual monopoly reinforcing its accumulation of rents. The CIS is, therefore, constituted by all the organizations that participate in an intellectual monopoly's innovation and production processes.

The Corporate Innovation System concept was originally presented by Granstrand (2000). There are less than a handful of academic contributions that make use of this concept and most of them define it focusing on how in-house activities are organized. An example close to our interest is the analysis of Google as a CIS in Steiber and Alänge (2013). The authors do consider it as an open system, but they do not include external organizations in it. This stands in contrast to Granstrand's (2000, 13) original definition:

> ***A 'corporate innovation system'*** *is the set of actors, activities, resources and institutions and the causal interrelations that are in some sense important for the innovative performance of a corporation or groups of collaborating companies and other actors (e.g. universities, institutes, agencies).*

In this paper, we depart from this definition in two respects. First, we focus on CIS organized around one single firm –disregarding those organized around a group of firms. Second, we add to the analysis a focus on vertical dominance by the firm around which the system is established. As we will argue next, intellectual monopolies simultaneously control and orient their CIS to preserve their dominant position. The CIS is designed and organized by a dominant firm capable of appropriating knowledge from other participants. It turns this knowledge into intangible assets, augmenting its intellectual rents. Regarding our second revision, we emphasize that by organizing CIS, intellectual monopolies provide the general orientations and desired results to other participants, of course without being able to anticipate every necessary step to achieve those results. Results remain uncertain, but the associated economic risk is diverted to other participants (Rikap 2018).

3.1. Different organizational structures conform CIS

Intellectual monopolies selectively share knowledge and information with the organizations that participate in their systems. For each particular innovation, when some steps are outsourced, we build

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[2] The article takes inspiration from recent attempts to integrate insights from the innovation system literature and the global value chain literature (Fagerberg, Lundvall, and Srholec 2018; Jurowetzki, Lema, and Lundvall 2018; Lema, Pietrobelli, and Rabellotti 2019).

on Levín (1977) to say that a specific *innovation circuit* is organized by the intellectual monopoly. It engages all the institutions involved *in a specific* innovation process, from basic research and discovery to the adoption and use of the innovation.

As the intellectual monopoly regularly engages certain institutions in a series of innovation circuits, these organizations become part of that Intellectual Monopoly's *innovation network*. We draw here on global innovation network literature (Ernst 2009; Liu, Chaminade, and Asheim 2013) highlighting the institutionalization of innovation relationships and how certain actors become regular participants in a leader's innovation outsourcing.

An intellectual monopoly will typically conduct innovations for multiple technologies simultaneously. For each technology, it develops an evolving/dynamic innovation network. All innovation networks together, as well as its in-house R&D departments, constitute the intellectual monopoly's CIS. Table 2 summarizes how these three structures are related to each other.

Table 2 should be placed here

Corporate innovation systems do not only encompass private knowledge production. Some innovation circuits may be organized as drawing upon knowledge commons and open science initiatives. As we contribute to show in section 5, Google, Amazon and Microsoft have developed the capacity to integrate multiple open source projects into their CIS. They extract rents from these initiatives by integrating specific results into their broader innovation circuits.

For certain steps of different innovation circuits -typically general-purpose innovations- intellectual monopolies cooperate with each other (Rikap 2019). This is certainly true for Google, Amazon and Microsoft, as we illustrate in section 5. In these cases, their (global) CIS intersect. Technological cooperation between intellectual monopolies makes it possible to undertake big and costly R&D projects. One way to track technological cooperation is to analyse scientific publications' co-authorship (Rikap 2019), which is done in section 5.2 for the three chosen tech giants.

As a result of its constant flux of innovations, each intellectual monopoly's innovation system constantly feeds and reconfigures diverse value chains, many of those dominated by the same intellectual monopoly. These transformations may range from the overall reconversion of an industry to minor adjustments. Thus, the permanently on-going innovative activity becomes intertwined with the transformation of production activities. The next sub-section conceptualizes this interrelation.

3.2 Combining the corporate innovation system with the corporate production system

One difficulty with defining 'production' in connection with intellectual monopolies is that intangibles constitute essential elements of input as well as output. Production is intertwined with innovation. CIS are multi-technology leading to multi-product production systems. By organizing both structures, intellectual monopolies capture knowledge (augmenting rents) and value from participating organizations. The production system concerns the reproduction and exchange of commodities within the planning scope of an intellectual monopoly, whereas the innovation system refers to the interlinkages between all the organizations that collaborate in continuous innovation.

Planning allows intellectual monopolies to organize the productive and innovative avenues to be followed within both their production and innovation systems. As a result, intellectual monopolies reduce risks and increase value extraction. This behaviour can be summarized as predation through planning. Companies owning platforms are an illustrative example of this behaviour. As Montalbán et al. (2019, 14) pointed out, platform integrators get their share of rent through intermediation and redistribution, i.e. through value extraction, rather than through creating value.

Overall, intellectual monopolies organize production systems and CIS using at their convenience outsourcing and offshoring. Within the GVC literature, the decision on internalization or outsourcing depends on the degree of power asymmetry between the leader and the rest of the chain. It also depends on the degree of codifiability of the information needed to assure successful results from outsourcing (Strange and Humphrey 2018). We add that outsourcing is also subjected to what is considered to be a core activity.

Core activities for lead corporations have been defined as research, development, design, technology and business intelligence (Serfati 2008), but what should be regarded as core activity cannot be universally defined. We have already argued that intellectual monopolies outsource innovation steps and, as they keep innovating, outsourcing decisions may be reconsidered. For instance, the emergence of new technologies such as 3D printers and robotics may result in reshoring and/or resourcing certain production stages.

4. Data-driven intellectual monopolies

In this section, we focus on a special type of intellectual monopoly characterized by monopolizing constant streams of big data. Durand and Milberg (2020) proposed a taxonomy of rents from intangible assets: legal monopoly rents, vertical natural monopoly rents, intangibles-differential rents, and data-driven innovation rents. Legal monopoly rents correspond to Pagano's (2014) definition of intellectual rents as derived from intellectual property rights (IPRs). Vertical natural monopoly rents refer to the GVC leader's capacity to monopolize knowledge over the whole chain. GVC leaders have monopolized the know-how and know-who (Johnson and Lundvall 1994) in the supply chain. They have exclusive knowledge covering the whole chain and, thus, the capacity to integrate it, assuring network complementarities. Rikap (2020) has pointed out that this type of rent is also garnered by intellectual monopolies when they organize global innovation networks. Another form of rent from intangible assets, continue Durand and Milberg (2020), arises from the different scale economies between intangible and tangible assets. Those relying mostly on the former and outsourcing the latter will have greater valorisation capabilities. Finally, data-driven dynamic innovation rents are inspired by Foley's (2013) concept of informational rents. Intellectual monopolies garner one, some, or even all these types of rents.

Data-driven innovation rents are characteristic of the digital economy. UNCTAD (2019) presents an analysis of 'data value chains' as spanning from data acquisition (to provide new sources of data) to data storage and warehousing, to respectively data modelling and analysis, and data visualization. All the latter can be called digital intelligence because they rely on machine learning algorithms and it is digital intelligence that can be monetized. It is not the access to data itself that raises entry barriers and gains market power (Nuccio and Guerzoni 2019). Big data needs to be centralized and processed in such a way that its use triggers multiple successive innovations (Fourcade and Healy 2016). As Cockburn et al. (2018) explain, machine learning algorithms learn as they process data, which means the development of a new method for inventing, a general-purpose method of invention that is transforming how innovations take place. Within machine learning, deep learning and neural networks have the potential to speed up the process of innovation using algorithms to locate the most promising new combinations of the existing elements of knowledge. These artificial intelligence approaches are changing the innovation process itself, with digital intelligence offering potentially unlimited applications. The monetization of digital intelligence turns data into an intangible asset. Data-driven innovation rents were defined by Durand and Milberg (2020, 421) as "benefits accruing from the enhancement of innovation capabilities derived from data centralization". As big data are increasingly gathered and processed, machine learning techniques self-improve algorithms, thus continuously augmenting data management proficiency. Digital intelligence gives direction to sales, take-overs and innovation.

For Birch et al. (2020, 3), data rentiership is defined as “the pursuit of innovation strategies designed to capture or extract value through ownership and control of data as an asset”. The latter is the case of Google, Amazon and Microsoft. These companies create new ways to extract (new) data (Dolata 2020; Kenney and Zysman 2019; Rikap 2020; Srnicek 2017). However, it is Durand and Milberg’s (2020) definition of data rentiership that interests us the most because it is related to the data value chain as a general-purpose method of invention, in line with Cockburn et al. (2018). In this sense, as certain companies monopolize data centralization, they trigger potentially always expanding rents. Even if they garner other types of intellectual rents, we dub these companies data-driven intellectual monopolies to give an account of their innovation and rentiership potential. These are companies that innovate on the basis of their digital intelligence, which is based on predating data from individuals and other organizations.

Therefore, there are synergies between big data and continuous innovations. On the one hand, the creation and renewal of a platform where data is freely and voluntarily shared is in itself the outcome of a series of innovations. On the other hand, the data gathered through the control of platforms are transformed into valuable information for directing sales, take-overs and further innovations.[3]

Tech giants enjoy multiple and diverse sources of big data from organizations and individuals all around the world. These data are crucial to improve their deep learning and neural network algorithms continuously. They also use processed data to increase their current profits by orienting their businesses and finding new innovation paths within and beyond the data value chain. Albeit being intangible capital intensive, remaining as a data-driven intellectual monopoly requires tangible capital expenditures in datacentres and cable. In this respect, the intertwined functioning of tangible and intangible capital in the data value chain is specific of data-driven intellectual monopolies. Other leaders garnering intangible rents, such as GVC leaders, typically outsource most of the tangible capital required in their value chain.

In the next section, we give brief comparative sketches of Google, Amazon and Microsoft’s CIS, suggesting that these companies predate knowledge that contributes to expanding their intellectual rents. We also elaborate on their status as data-driven intellectual monopolies, which further

[3] There is a growing literature that refers to these developments as reflecting a move toward a platform economy or platform capitalism (see for instance Cusumano, Gawer, and Yoffie 2019; Montalban, Frigant, and Jullien 2019; Srnicek 2017). The ownership of digital platform is important for GAFAM dominance. But the basis of their lead position goes beyond. For instance, it draws upon tight collaboration with academic research institutions, and in some cases with US government agencies. And some of their products follow the typical GVC structure. This is the case of iPhone for Apple and in general for the handsets offered by GAFAM as well as Kindle for Amazon. Finally, these companies’ innovation strategies and success also rely on IPR and strategic acquisitions.

reinforces intellectual rentiership, and identify the place of research institutions and developers from peripheral countries in their CIS.

5. Google, Amazon and Microsoft as data-driven intellectual monopolies predating knowledge from their CIS

Google, Amazon and Microsoft (GAM) are among the world's biggest corporations (see Table 3). In this section, we analyse them and their CIS based on secondary sources as well as on business, scientific publications and patent data, retrieved respectively from Compustat, Web of Science and Derwent Innovation. We provide insights on their condition as data-driven intellectual monopolies and of knowledge predation from their CIS.

Table 3 should be placed here

5.1. GAM as data-driven intellectual monopolies

GAM stand out in terms of innovation inputs –they are among the top 5 companies in the world in Business Expenditure in R&D (European Commission 2019) and have shares of R&D investment over net sales above 10%. Together with Apple and Facebook, they are the most valuable brands in the world.[4] Data harvesting and artificial intelligence are at the basis of every GAM product. This provides constant business opportunities opening new markets for directly selling their technologies. We argue that these companies are leaders of data value chains, collecting data-driven intellectual rents.

Every Amazon business relies on data and is a source of data for Amazon, from Kindle[5] to Amazon Prime Video. Digital intelligence has contributed to make its e-commerce platform a marketplace that is attractive to third-party sellers. Digital intelligence also contributes to strategic decision making processes regarding acquiring or entering successful businesses of third-party sellers (Galloway 2017; Lan, Liu, and Dong 2019; Zhu and Liu 2018).

Microsoft became a leader corporation during last century's ICT revolution. Its intellectual monopoly historically relied on legal rents based on the authorization to patent or claim copyrights for software (Arthur 2012). 2014 was a turning point as the company changed from an intellectual monopoly mostly based on legal monopoly rents, towards becoming a data-driven intellectual monopoly. The new Microsoft deprioritized Windows and gave top priority to mobile and cloud businesses based on

[4] Retrieved from: https://www.forbes.com/powerful-brands/list/ last access November 28, 2019.
[5] https://www.theguardian.com/technology/2020/feb/03/amazon-kindle-data-reading-tracking-privacy

big data and artificial intelligence as sources of continuous innovations (Ibarra and Rattan 2018). Indeed, Microsoft has the second largest artificial intelligence patent portfolio, only surpassed by IBM (World Intellectual Property Organization 2019).

Google concentrates 90% of the internet search market (UNCTAD 2019), providing it with massive streams of data that further improve the quality of its artificial intelligence algorithms contributing to sustaining its search engine superiority (Dolata 2017). Google's data are monetized by producing digital intelligence that results in targeted ads. Its multi-product portfolio also includes other sources of big data such as YouTube, Gmail, Google Maps, mobile payments, and even healthcare ventures like Verily and Calico. All these ventures are not only product innovations but also innovations on how to collect new sources of data, in line with Birch et al.'s (2020, 3) definition of data rentiership. These innovative sources keep feeding Google's business and lead to larger profits. This gives another reason why –besides contributing to its advertising business- many Google products are free for users. They produce massive amounts of data for Google.

Besides all the mentioned types of big data, to some extent specific of each of these tech giants, Amazon, Microsoft and Google, in this order, are the undisputed leaders of the cloud computing business, which relies on artificial intelligence as core technology while they innovate in data sources and data storage. Ubiquitous algorithms are provided so that a wide variety of more targeted developments can apply them. A whole set of ICT services is offered online, saving customers development time and money.

The cloud computing market potential is huge: CBInsights (2018a) estimates that by 2022 cloud computing will be a $513B market and cloud storage $90B. Amazon, Microsoft, Google, IBM and Alibaba (in this order) concentrate over 75% of the cloud computing market. Amazon Web Services (AWS) alone has more than a third of the market. And the degree of concentration in this world-wide market is increasing. With the exception of IBM, all those companies increased their market share in 2018 (Synergy Research Group 2019). The dominant market position of Amazon explains why its profits mostly come from AWS, while most of its revenues still come from its e-commerce activity (Amazon 2019).

Microsoft includes in its intelligent cloud exclusive solutions and datacentres for the US government.[6] It became selected to become the US Department of Defense cloud computing provider, although the contract was postponed until Amazon's appeal is solved.[7]

Google applies the same business model used for its advertising business to capture a niche market within cloud servicing. By focusing on small players it captures rents from a market not yet exploited by Amazon and Microsoft (CBInsights 2018b).

Clients pay according to what they use, a system called "pay as you go". Amazon claims that this payment system is convenient for clients because it makes it easier for them to "adapt to changing business needs".[8] Clients save tangible capital investment, while GAM's enjoy economies of scale and scope. Since the reproduction costs of those services tend to zero, as these companies expand their client base, profits increase exponentially.

Cloud computing provides new sources of data by allowing GAM companies to kee training their algorithms and identify the services used by each type of company as well as which companies are increasing their consumption of web services, therefore signalling potentially promising businesses and technologies. Hence, cloud services feed and direct innovation and acquisitions. For instance, through AWS, Amazon spotted start-ups like Yieldex, Sonian, Engine Yard and Animoto. They all received seed money and may eventually be acquired.[9]

Cloud computing is not only about providing cloud services based on artificial intelligence. This business is also intensive in tangible capital expenditure contributing to high entry barriers. It requires bandwidth cable distributed around the world and datacentres with powerful computers (machine learning processors and accelerators) to process artificial intelligence algorithms and store data. Tangible capital expenditure over revenues grew in recent years for all three companies (see Figure 1).

Figure 1 should be placed here

[6] https://www.microsoft.com/en-us/microsoft-365/government
[7] https://www.nytimes.com/2020/02/13/technology/amazon-jedi-pentagon-contract-microsoft.html
[8] https://aws.amazon.com/pricing/
[9] Retrieved from: https://www.reuters.com/article/amazon-cloud-idUSN1E7A727Q20111109 last access February 27, 2019.

GAFAM companies (excepting Apple) own more than half of the world's undersea bandwidth.[10] Furthermore, 40% of the world's datacentres are located in the United States and 80% in developed countries.[11]

Summing up, Microsoft's business data, Amazon's market and business data and Google's personal and business data are indispensable raw materials for their businesses. Furthermore, the three companies have used their leadership in the data value chain to develop a profitable cloud servicing business. All in all, by processing monopolized data, digital intelligence becomes a source of continuous and eventually also radical innovations that provide dynamic data-driven or informational rents (Durand and Milberg 2020; Foley 2013). As explained by Durand and Milberg (2020), data has become the key ingredient for innovating and beating rivals. Yet, as we explain next, their knowledge monopolies are not only based on internal R&D and data harvesting.

5.2. Predatory innovation by GAM: discrepancy between collaboration and patenting

In Google, Amazon and Microsoft's CIS, in-house innovation is complemented with the outsourcing of modules or steps in transnational innovation networks and by acquiring promising start-ups. These companies have in common predatory practices of rent-seeking and subordination of the companies and research institutions that participate in their CIS. They engage broadly in scientific collaboration, both with other companies and with public research organisations. However, they generally patent alone or with employees as co-owners.

Veblen (2017) conceptualized predation as a direct manifestation of superior force. Mobilizing this concept in the intellectual monopoly context, Rikap (2020) reconceived predation as a direct production relation of spoliation where a corporation exercises its superiority by planning the activities of other organizations. Different authors have provided evidence of leader corporations' capacity to appropriate value within production networks (Selwyn 2019; Smith 2016; Bergvall-Kareborn and Howcroft 2013; Kraemer, Linden, and Dedrick 2011). What has been overlooked, and we contribute to uncovering, is that leader corporations also predate knowledge from the innovation networks they dominate. Overall, we argue that these companies not only organize production and

[10] https://www.nytimes.com/interactive/2019/03/10/technology/internet-cables-oceans.html

[11] Retrieved from: https://wikileaks.org/amazon-atlas/map/ https://azure.microsoft.com/en-us/global-infrastructure/locations/ and https://www.google.com/about/datacenters/locations/

innovation within their CIS but also predate value -as the literature has shown- and knowledge. In this section, we focus on the latter for the cases of Google, Amazon and Microsoft.

Amazon owned over 10,000 patents by the beginning of 2018 of which it only shared 13 (0.13%) with other companies and none with universities. Nevertheless, Amazon organizes multiple innovation networks with companies and universities, as evidenced by its scientific publications. It has co-authored papers with more than 750 organisations.

Microsoft has developed an even wider network of research collaborations publishing with more than 4,000 organizations. Between 2014 and 2019, 15 of its top 100 co-authors were Chinese organizations with three additional institutions from Hong Kong on the list. Yet, with more than 76,000 patents until 2017, Microsoft only co-owns 150 with other companies and 11 patents with universities.

Google's 6,447 scientific publications until 2019 were co-authored with almost 2,400 organizations. However, none of them is among Google's top 100 patent co-owners. In fact, until 2017, it had only shared 3 patents with a university (Stanford).

Table 4 summarizes this information. It also provides an indicator of the degree of asymmetry between scientific publications' co-authorship versus patent co-ownership. This indicator is below 1 when the share of co-owned patents exceeds the share of co-authored papers. It equals 1 if co-authorship and co-ownership shares are equal, and above 1 when the share of co-publications surpasses the share of co-ownership. It is, therefore, an indicator of the asymmetry between R&D collaborations (proxied with the percentage of co-authored papers) *vis-à-vis* the percentage of co-owned patents.

Table 4 should be placed here

Additionally, Table 5 presents each company's top 10 co-authors between 2014 and 2019. It provides evidence of technological cooperation between GAM companies as well as with IBM for the cases of Amazon and Google. Moreover, the three corporations rely in part on the same US universities as most frequent co-authors, with the University of California as their top co-author. Microsoft has a more diverse network of privileged partners, including two Chinese and two European universities.

Table 5 should be placed here.

The inclusion of Chinese and an Indian institution among top co-authors point to knowledge and rent extraction from emerging and developing countries. Furthermore, among other co-authors, Amazon has scientific publications on big data analysis with different Brazilian universities (such as the

Universidade Estadual de Campinas and the Universidade Federal Fluminense). Microsoft also co-authored with Brazilian universities (such as the Universidad de São Paulo and the Universidade Estadual de Campinas), while Google co-authored with Argentina's National Research Council (CONICET).

Our results are in line with the examples presented by Popkin (2019). The author interviewed academic researchers receiving funding from tech giants. He observes that these companies generally launch an open call for projects once a year, usually providing small grants that are still meaningful for academic researchers. Amazon's last call received over 800 applications but funded only 49. Contacts with employees, such as previous professional connections or networking at a conference, are important for accessing funds from most tech giants. They are even a precondition for receiving a grant from Microsoft. In his interviews, it was pointed out that companies avoid discussing new products with funded researchers. They are not usually included when it comes to sharing the profits of a product based on their research. Furthermore, tech giants do not "provide access to any internal or proprietary data" (Popkin 2019, 666).

This type of calls for projects save tech giants' time because researchers apply themselves, thus there is no need to seek out who is working on what. They also save money because providing small grants to researchers is cheaper than expanding in-house R&D teams, which not only implies paying for the research project itself but also for the people. Additionally, this mechanism assures that the tech giant will have expert researchers for a wide diversity of projects. Sustaining themselves as multi-technology and multi-product companies would be way more expensive if done in-house.

Beyond funding academic researchers, another mechanism that enables collaborations is hiring academic researchers that keep ties with former colleagues. In 2015, the US top mental health researcher left the National Institute of Mental Health to work for Alphabet (Google).[12] Tech companies have data and money, which are major reasons why several researchers in the US have changed their path from public life sciences departments to work for tech giants.[13]

All these mechanisms contribute to shaping CIS led by Google, Amazon and Microsoft, respectively. Seen together, publications' co-authorship and patents' co-ownership indicate that these companies garner intellectual rents from their CIS that are not shared with their most frequent co-authors. Building on Durand and Milberg's (2020) typology, these companies combine data-driven innovation

[12] https://www.technologyreview.com/2015/09/21/10487/why-americas-top-mental-health-researcher-joined-alphabet/
[13] https://www.nature.com/news/why-biomedical-superstars-are-signing-on-with-google-1.18600

rents with legal monopoly rents. Indeed, as Jacobides et al. (2006) had argued, and other more recent analyses have reaffirmed (Comino, Manenti, and Thumm 2019; Sampat 2018), IPR does not necessarily capture all the returns to innovation. However, the fact that these companies concentrate IPR that at least in part derive from R&D conducted with other organizations suggests a capacity to predate knowledge from their CIS. Moreover, we overview next other strategies followed by tech giants to profit from outsourced or open innovation.

5.2.1. Profiting from Open Source Software

Even if IPR have mushroomed in the high-tech sector, GAFAM also extract benefits from open-source software (OSS). On the one hand, they own platforms that were put in open source for the development of applications. Android is the paradigmatic example with 3.3 million applications available on GooglePlay by August 2020.[14] On the other hand, they open some of their projects to the OSS community by placing them on developer platforms such as GitHub. In the former, developers do not contribute to the core infrastructure of the platform but create complementary products and keep the property of the result, thus partially profit from it (part goes to platform owners as a fee for using the platform). In the latter, the result is OSS, thus potentially useful for anyone. However, it is monetized only once it is integrated into more complex systems. In the case of big tech companies, those other parts remain as privately owned software.

Embracing OSS has historically been part of Google's success. Android is an open-source platform for mobile phone development. Individuals or small companies cover all the production costs, while Google decides which apps will be sold and when without paying any direct remuneration to developers (Bergvall-Kareborn and Howcroft 2013). Amazon also outsources innovation modules for app development for Alexa, its virtual assistant, with more than 700,000 developers building Alexa skills by August 2020 (Amazon 2020). Developers assume all the risks and, if successful, must share revenues with the tech giant owning the platform.

Arthur (2012) explains that by offering Android for free to handset makers, Google took a decisive move to assure its advertising business because Android came with Google search as the default setting. Through the Open Handset Alliance Google assured that every handset producer (but Apple) introduced its operating system in every mobile phone.

Amazon has not been a big player in the OSS environment but still harvests code by remaining close to –and even funding- OSS initiatives such as the Linux Foundation (Schrape 2018). Meanwhile, in

[14] https://www.businessofapps.com/guide/app-stores-list/

2018, Microsoft made clear its turn to OSS by acquiring GitHub for USD 7.5 billion[15], a leading software development platform for developers. It provided Microsoft with professional data of millions of developers that have a user account and their associated projects stored in GitHub.

By October 2018, GitHub's top three open-source projects ranked by the number of developers participating belonged to Microsoft, Facebook and Google: Microsoft/vscode (19,000 developers), facebook/react-native (10,000 developers), tensorflow/tensorflow[16] (9,300 developers). This demonstrates that they are profiting from developers beyond their own workforce because Microsoft had, by the same date, 7,700 registered developers, Google 5,500, and Facebook 1,700 (https://octoverse.github.com/).

Google has also moved to open source Kubernetes, a container system for running multiple programs on demand and simultaneously in a more efficient way than virtual servers. Its website says "Kubernetes builds upon a decade and a half of experience that Google has with running production workloads at scale, combined with best-of-breed ideas and practices from the community"[17], thus explicitly recognizing the unpaid contribution of external developers. Kubernetes is also an open window for offering cloud services to those smaller companies.

Overall, US tech giants profit from open source innovation in multiple and complementary ways:

1. They get access to code that they can reuse for their private innovations. As Lan et al. (2019) explained, OSS attracts large numbers of developers and complementors worldwide, thus the amount of code that can be privately reused is countless. Microsoft included a Linux kernel in Windows 10 so that it can now profit from OSS Linux developments.[18]
2. It provides valuable information on the type of recurrent problems faced by smaller companies, therefore providing valuable inputs for new services to be offered in their clouds.
3. By placing modules of their in-house innovation in open source platforms, they profit from developers' free work (Schrape 2018).
4. They get potential users' feedback in advance since open source developers are usually employees of companies that will afterwards buy cloud services.

[15] https://news.microsoft.com/2018/06/04/microsoft-to-acquire-github-for-7-5-billion/
[16] Tensorflow is a huge machine-learning library put in open source by Google (https://www.tensorflow.org/).
[17] Retrieved from https://kubernetes.io/docs/concepts/overview/what-is-kubernetes/ last access January 13, 2020.
[18] Retrieved from https://www.theverge.com/2019/5/6/18534687/microsoft-windows-10-linux-kernel-feature last access on December 21, 2019.

5. Standard setting. By releasing libraries to open source (such as Tensor Flow and PyTorch), standards are set, and thus small companies can be easily integrated into GAFAM business in case they are acquired.

While the biggest projects in GitHub are led by Microsoft, Google and Facebook, the highest rates of growth of individual developers' take place in emerging countries (China, India, Russia and Brazil). In terms of the creation of repositories per continent, Africa grew 40% between October 2018 and September 2019, becoming the continent with the highest percentage growth. Within African countries with the largest developer communities, those growing faster are Morocco, Kenya and Nigeria, each growing 50% or more in that year (https://octoverse.github.com/). These figures contribute to thinking that GAFAM profit from OSS communities in less developed countries, something that favours their rentiership.

Another strategy to avoid risks in connection with transformative innovations is the acquisition of start-ups to acquire their technologies.

5.2.2. Expansion through acquisitions focusing on cloud computing and artificial intelligence

Amazon has acquired more than 100 companies. While some acquisitions were driven by concentration aims, others responded to its knowledge management strategy, such as Amiato inc; a pioneering cloud start-up, Audible inc. and the robotics start-up Kiva Systems inc.

Microsoft also acquires technology through acquisitions. Lopez Giron and Vialle (2017) trace 178 acquisitions until 2016 included. Since 2010, when Azure was launched, Microsoft has been actively acquiring both cloud computing and mobile platform firms (15 and 8 until 2016 included). Cloud-related acquisitions dealt first with internalizing R&D capabilities and, since 2014, they are focused on artificial intelligence (AI). Cloudyn (for managing cloud costs) and Bonsai (an AI training platform) are illustrative examples. Acquiring big patent portfolios through acquisitions in artificial intelligence was observed by WIPO (2019) as a particular characteristic of Microsoft.

According to WIPO (2019), Microsoft has acquired 9 artificial intelligence companies, making it the third AI-related acquirer until May 2018. The first one was Google, who until that date had acquired 18 artificial intelligence companies, including the forerunner DeepMind in 2014. Overall, Google has acquired more than 200 companies.

Although most of the acquired companies are US firms, they also buy promising start-ups from other regions, including developing and emerging countries, thus further limiting their chances for digital catching-up. Google has acquired companies from India (Sigmoid Labs and Halli Labs), Brazil (Akwan Information Technologies Inc) and Ukraine (Viewdle). Amazon acquired Ivona from Poland, which was a voice recognition company, and then Emvantage and Tapzo, two Indian online payment start-ups.[19]

All in all, through different channels that include outsourcing R&D modules, OSS and acquiring start-ups, Google, Amazon and Microsoft find new businesses, reduce capital commitments (including R&D investments) and innovation risks, while predating knowledge from other organizations, increasing their knowledge monopolies.

6. How to understand and cope with the GAFAM-phenomenon

Who benefits from data-driven intellectual monopolies and what are the consequences for the rest of the world?

6.1. Who benefits from GAM's data-driven intellectual monopolies?

In financial terms, it seems that the main beneficiaries have been shareholders, which include tech giants' top managers and founders. Bezos, Amazon's founder and CEO, is the richest person in the world owning around 11% of Amazon's stocks. Amazon shares' third and fourth individual owners are AWS CEO and Amazon's e-commerce business CEO[20]. GAFAM have the highest market values of all companies worldwide. Haskel and Westlake (2018) argue that the market value of today's leaders is determined mainly by their intangibles. Such a pattern can be discerned for Google, Amazon and Microsoft (see Figures 2, 3 and 4 in Appendix).

It could be said that these companies also contribute to job creation in host countries but, unlike big corporations from the past, Google and Microsoft do not seem to be increasing employment in line with their increase in revenues. Amazon does create jobs as its revenues grow but especially in its fulfilment centres (Figure 5 in Appendix). These are, on average, low wage and low-quality jobs.[21]

[19] Retrieved from https://www.economist.com/business/2018/07/07/chinese-and-us-tech-giants-go-at-it-in-emerging-markets last access April 19, 2020.
[20] Retrieved from https://www.investopedia.com/articles/insights/052816/top-4-amazon-shareholders-amzn.asp last access April 24, 2020.
[21] See for instance: https://www.theverge.com/2018/4/16/17243026/amazon-warehouse-jobs-worker-conditions-bathroom-breaks and http://inthesetimes.com/article/22413/supply-chain-crisis-nationalize-amazon-coronavirus-covid-19

Moreover, these companies' contribution to job creation should be weighed against the number of jobs destroyed worldwide. For instance, Amazon expansion undermines employment in retail, logistics and entertainment, while Google undermines employment in advertising and entertainment.

Overall, some GAFAM activities have a direct negative impact on specific existing industries in host countries. Through their control of platforms, they are monopolistic as well as monopsonistic, leaving local customers and suppliers with smaller margins. This context results in pressing salaries and diminishing working conditions among suppliers, customers, and rivals.

Neither do these companies pay taxes in proportion to their extraction of value. They have developed strategies to minimize their declared earnings in the United States. They profit from tax loopholes and allocate IPR and profits in tax havens. To pay dividends to shareholders while avoiding paying US taxes, these companies issue debt in the US (Pozsar 2018). They are major players in financial markets with significant investments in corporate bonds and US treasury and agency debt. But they also hoard cash abroad used to acquire foreign firms. This was the case when Microsoft acquired Skype in 2011.[22] Amazon has its own strategy. It has privileged a low-profile strategy with low profits allowing rapid expansion of production and data centralization. Amazon does not pile offshored retained earnings but still minimizes paid taxes (Rikap 2020).

As UNCTAD (2019) argues, this scenario accentuates global inequalities both in financial terms and in terms of digital and innovation divides. A combination of concentration and centralization of capital takes place, and entry barriers grow and become more or less prohibitive. Network effects expand data-driven monopolies' businesses, and their control of IPR gives them dominance when it comes to orienting innovation. Required R&D investments and the minimum scale of tangible capital expenditure make it even harder to enter. Digital catching-up is completely curtailed in this context.

The US Government could take anti-trust action and recent events seem to be moving in that direction, considering the US big tech Congress investigation initiated in 2019 which might signal the beginning of an attempt to regulate these companies. However, it is not obvious that it is in its interest as a global hegemon to substantially limit GAFAM's power. Actually, the US government and legal authorities have historically moved in the opposite direction, reinforcing and broadening IPR while reducing anti-trust action.[23] Furthermore, it is not only market concentration but also knowledge concentration

[22] https://www.wsj.com/articles/SB10001424052748703730804576314854222820260
[23] Retrieved from https://www.ft.com/content/1fad936e-38a3-11ea-a6d3-9a26f8c3cba4 last access April 23, 2020.

that antitrust offices should regulate. It is also noteworthy that Microsoft was excluded from the US investigation.

In other countries, the room for and efficiency of antitrust action against GAFAM looks narrow. So far, China has been successful in reducing US tech giants' dominance through blocking their access to domestic markets and data while simultaneously creating its own intellectual monopolies (Baidu, Alibaba, Tencent and Huawei) (Azmeh, Foster, and Echavarri 2020; UNCTAD 2019). The European Union has engaged in antitrust sanctions, but it is still an open question how far it can go in this direction, given that the US could punish European governments trying to limit GAFAM's freedom of action.

6.2. IPR and the knowledge commons. Throwing away the ladder

From the perspective of developing economies, a major problem with GAFAM is that they hoard IPR and that the US government has succeeded in imposing wide and strong legal protection through TRIPS and bilateral trade agreements (Dreyfuss and Frankel 2014). New global initiatives to loosen IPR may be difficult to realize since China has become a major intellectual property owner and Europe hosts major pharma companies, highly dependent on strong IPR.

The fact that GAFAM extracts rents from their collaboration with universities in developing countries weakens the incentives to build a strong knowledge base that is a prerequisite for economic development. At the same time, GAFAM are engaged in sowing and harvesting from the knowledge commons. While, in principle, everyone has equal access to knowledge commons, GAFAM have specialized in infrastructure and ubiquitous technologies that enhance their capacity to transform shared scientific and technological knowledge into intangible assets.

Overall, GAFAM exercise a major influence on the direction of innovations in digital and, more broadly, ICT technologies. It is less obvious how they affect the rate of innovation in different parts of the world but the results of our analysis contribute to thinking that their CIS are mostly -but not exclusively- based in core countries, that tech giants concentrate most of the benefits of their CIS innovation and that global knowledge governance is favouring them.

6.3. What place is left for developing countries in the GAFAM-dominated digital economy?

UNCTAD (2019) is a systematic attempt to clarify policy options for developing countries, given that GAFAM and their Chinese counterparts are key players in the digital economy. While this report is useful in listing challenges and existing policy responses, it does not take into account the complexity of data-driven intellectual monopolies' CIS.

The report points to surveillance and data privacy, suggesting EU-regulations as an exemplary response(UNCTAD 2019). But there are also issues related to espionage and national security to be considered. The US has used national security arguments as motivation for attempts to block the rest of the world from using 5G-solutions from Huawei. Similarly, GAFAM contributed to the US National Security Agency (NSA) global surveillance. The PRISM program has provided the NSA access to data from Google, Apple, Facebook and other US internet companies.[24]

UNCTAD (2019) also argues that uneven access to digital services and platforms (many individuals in developing countries do not have access to the internet, and datacentres are concentrated in the rich countries) widens the current digital divide. Here the recommendations go mainly in the direction of investing in education and in infrastructure, promoting digital entrepreneurship and life-long learning. These policies might be necessary for developing local capabilities to develop and use digital services. However, standing alone, they deepen dependency and potentially increase rent extraction.

Another problem is that, so far, the emergence of data-driven intellectual monopolies from the global south like Jumia or MercadoLibre neither have created significant quality jobs, nor escaped from the rentier logic that characterises other data-driven intellectual monopolies. Furthermore, these platforms generally copy existing businesses from core countries, thus failing in the transition from early adopters to developers of new technologies.

Most developing countries provide data to intellectual monopolies without significantly participating in other steps of their innovation systems. To analyse their options, UNCTAD (2019) takes inspiration from the GVC-perspective and raises issues of 'upgrading' –making local attempts to refine data in order to appropriate value locally. It also raises the issue of tax reform, forcing GAFAM-type companies to pay taxes where they operate. Here, the limited enforcement capacity of emerging and developing states and the readiness of the US to use sanctions against countries trying to limit GAFAM's power is a serious shortfall. Eliminating tax havens and loopholes requires a globally coordinated initiative.

Given the reflections presented in this section and considering the results of our contribution, the next section concludes by focusing on challenges for policy and research.

[24] https://www.theguardian.com/world/2013/jun/06/us-tech-giants-nsa-data

7. Challenges for Policy and Research

In this article, we have focused on how a handful of giant intellectual monopolies build and organize global CIS. We provided evidence of how Google, Amazon, and Microsoft predate knowledge (including data) from these systems that are transformed into intangible assets expanding these companies' intellectual rents. They establish scientific collaborations with universities and other research institutions but seldom share intellectual property. They also profit from open source communities and acquire technology by acquiring promising start-ups. We also argued that selected tech giants are data-driven intellectual monopolies, providing insights on how they harvest and analyse data with machine learning algorithms that produce digital intelligence. The latter is used to orient business and keep innovating. In this context, we end with brief reflections on policy perspective and research questions.

The growing dominance of big tech companies points to the need for efforts to develop a coherent set of complementary and feasible policies in this new stage of globalisation. The fact that China has been the only country that has successfully built competitors to GAFAM indicates that fostering firms that could challenge them would require a combination of long-term planning, entrepreneurial state intervention and big markets, particularly relevant when it comes to harvesting data. Could India with its huge and growing domestic market replicate some of the elements of China's strategy? In the case of Europe, Latin America and Africa it would require a closer integration in terms of transnational and technological cooperation than what national governments have been ready to accept so far. Neither is it probable that individual countries or regions could succeed in regulating data-driven intellectual monopolies. A huge coordination effort between third countries would be required.

Yet, an open question remains, would this be enough when it comes to tackle inequalities and contribute to development? Given the penetration of the digital economy in every respect of our lives, is it possible to regulate data-driven intellectual monopolies (in particular GAFAM) without rethinking global capitalism's overall governance, laws and policy? At the core of a more radical agenda would be new forms of international cooperation, massive investments in knowledge and equal and common access to knowledge. The ultimate vision is a global knowledge commons with an equal and fair distribution of the tools to access and use knowledge both within and across national borders.

This article leaves us with a series of questions for further research. How to analyse the impact of intellectual monopoly on growth and income distribution at the global level? How does the Chinese counterparts' mode of operation differ from GAFAM's? Under what circumstances could participation in CIS by developing country firms contribute to economic development?

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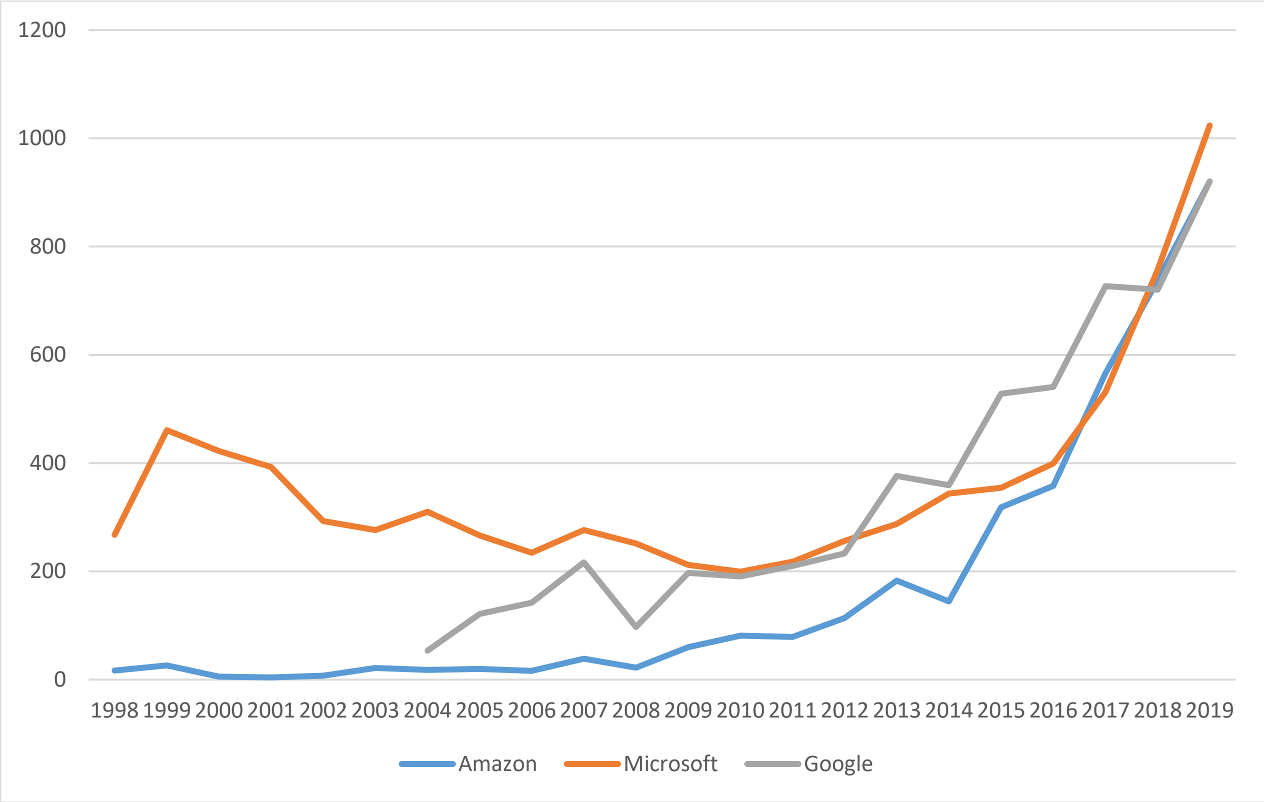
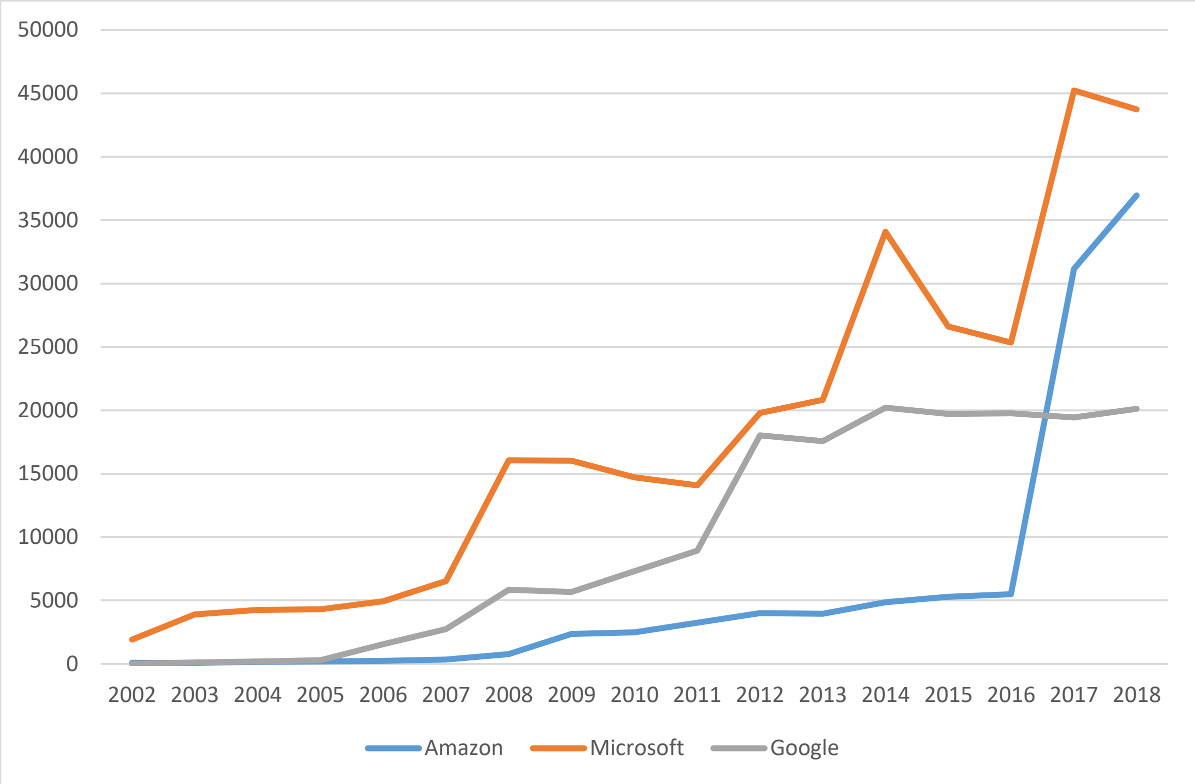
Appendix

Figure 2. GAM's market value



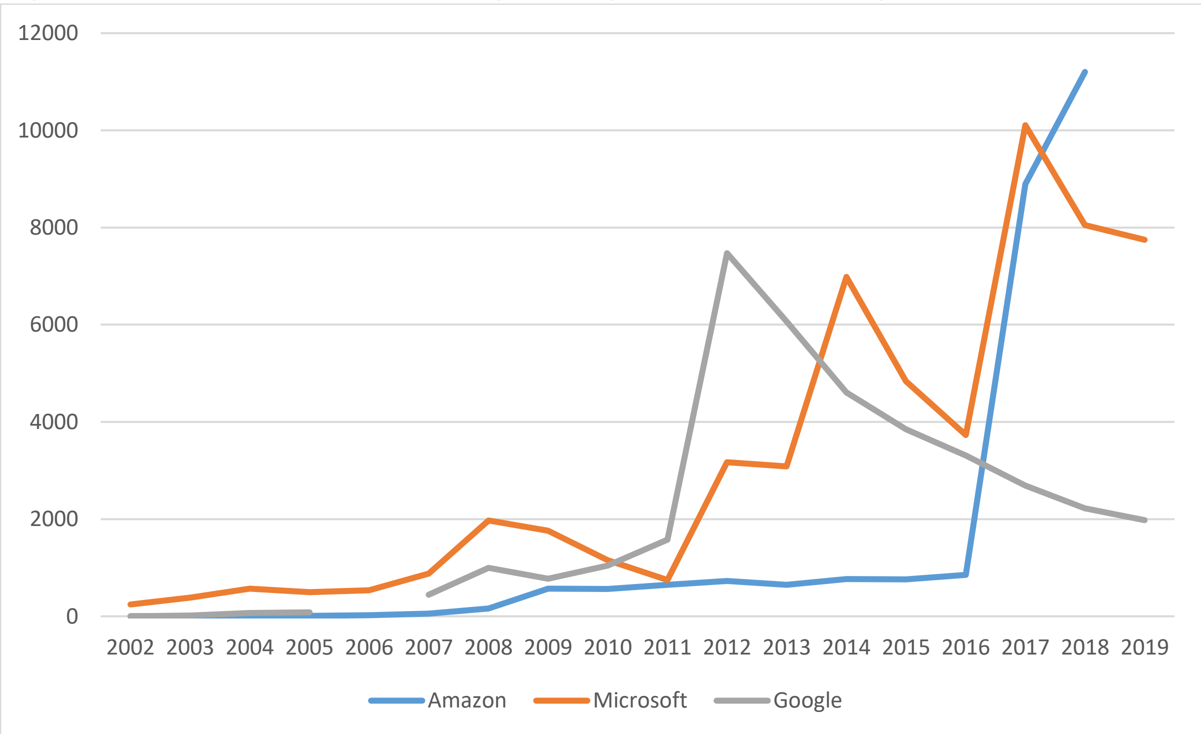
Source: Compustat.

Figure 3. Amazon, Microsoft and Google Intangible Assets (in USD millions)



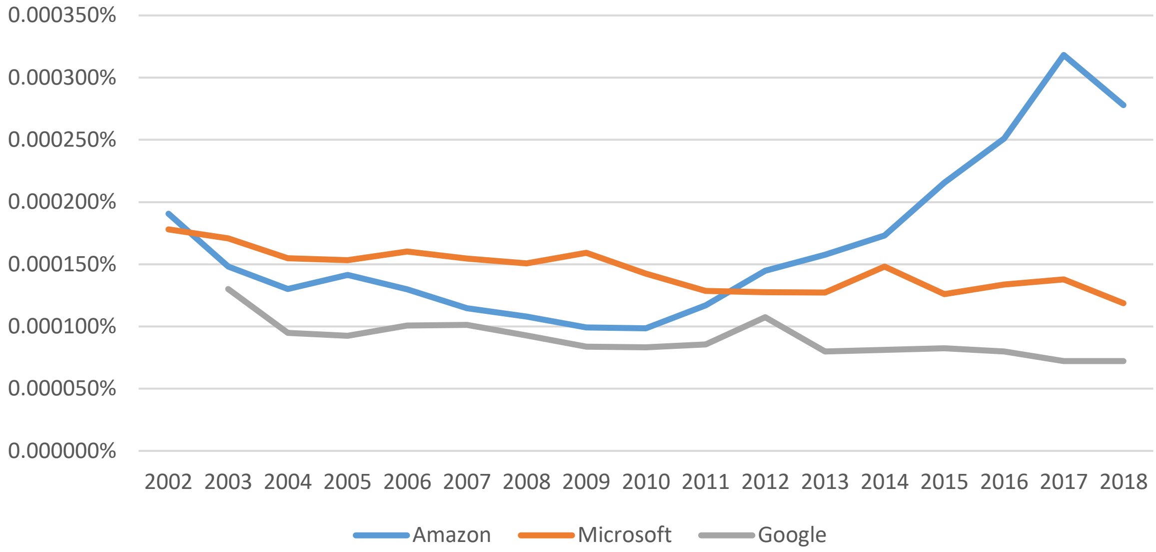
Source: Compustat.

Figure 4. Amazon, Microsoft and Google Intangible Assets without goodwill (in USD millions)



Source: Compustat.

Figure 5. Amazon, Microsoft and Google employees over revenues



Source: Compustat.

Main text tables and figures

Table 1. Summary of discussed frameworks.**Suggested structure led by a big/multinational corporation**	**Focuses on production as a network of system?**	**Focuses on innovation as a network or system?**	**Considers power relations leading to unequal distribution of value?**	**Accounts for knowledge predation in the innovation process?**
Flagship firm theory	Yes	No	No	No
Strategic Centre	Yes	No	No	No
Global Value Chain	Yes	No	Yes	No
Industrial architecture	Yes	No	No	No
Global factory	Yes	No	Yes	No
Global Innovation Network	No	Yes	Only some authors	No
Ecosystems (including platforms)	No	Yes	In general No	No
Corporate Innovation System	Yes	Yes	Yes	Yes

Table 2. How Intellectual Monopolies organize innovation.

	Innovation circuits	**Innovation networks**	**Corporate Innovation System**
Time span	One-time interlocking	Long-term	Long-term
Degree of institutionalization	Low	High	High
Scope	A single (or a single set of) innovation	Multiple (somehow related) innovations within a single technological field.	Multiple innovations that may or may not be related to each other (multi-technology)

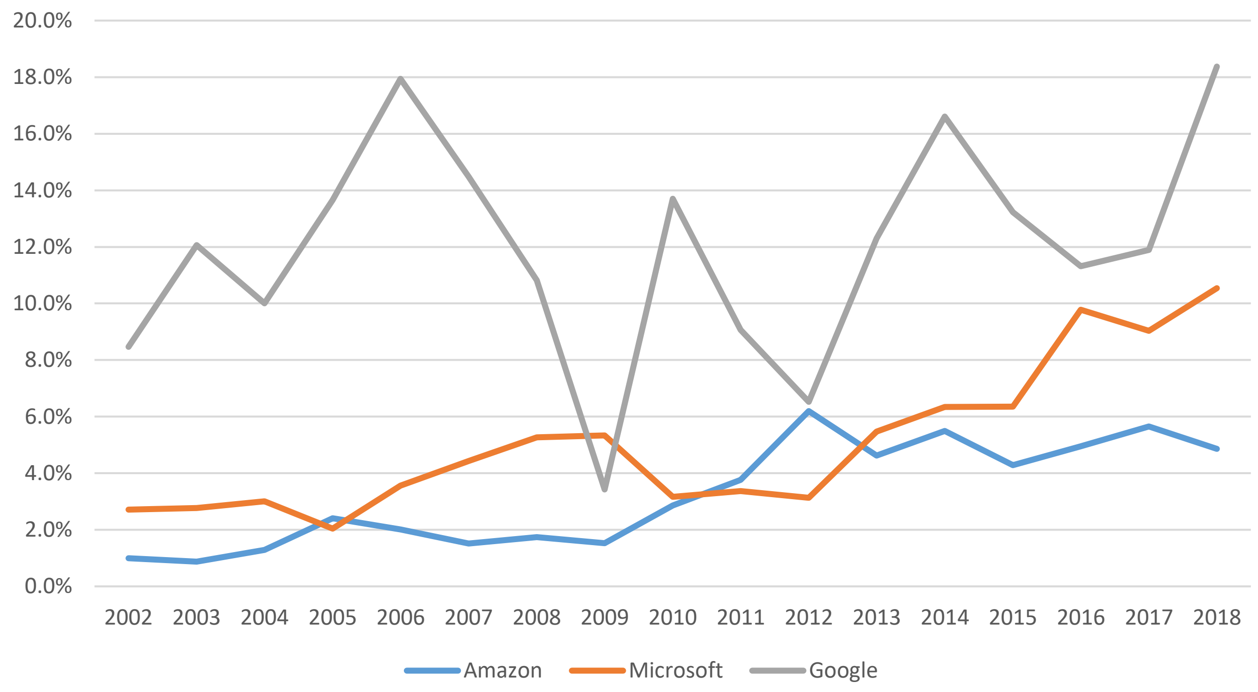
Table 3. Google, Amazon and Microsoft. Selected business and innovation figures (in USD billion unless stated otherwise)

Market capitalization world ranking (Dec 31, 2019)	No 3. Microsoft	No 4. Alphabet (Google)	No 5. Amazon

Market capitalization (Dec 31, 2019)	1,203	923	916
Income 2019	126	162	87
Net Income 2019	39	34	3
R&D in 2019	14.7	18.3	22.6
Granted patents in 2019 by the USPTO	7,350	6,602	1,100

Sources: Compustat and USPTO

Figure 1. GAM Capital expenditure over revenues.



Source: Compustat

Table 4. Co-authorship versus co-patenting as evidence of knowledge predation

Company	Publications (until 2019 included)	Co-authored papers	% Co-authorship	Applied & granted patents (until 2017 included)	% of co-owned patents	Co-authorship versus co-ownership
Amazon	824	719	87.3%	10063	0.1%	87,257
Microsoft	17405	13622	78.3%	76109	0.2%	39,132

Google	6447	5305	82.3%	25538	0.3%	27,429

Source: Authors’ calculation based on Web of Science and Derwent Innovation

Table 5. Microsoft, Google and Amazon’s top co-authors (2014-2019)

Microsoft	**Google**	**Amazon**
University of California	University of California	University of California
University of Washington	Stanford University	Microsoft
University of Science & Technology of China	Microsoft	University of Washington
MIT	MIT	Google
Tsinghua University	Harvard	IBM
University of London	Carnegie Mellon University	Georgia Institute of Technology
Carnegie Mellon University	University of Illinois	Carnegie Mellon University
Google	University of Washington	University of Texas
Stanford University	IBM	MIT
ETH Zurich	New York University	Indian Inst of Technology

Source: Web of Science.