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Artificial Intelligence Platforms:

NEW RESEARCH AGENDA FOR DIGITAL PLATFORM ECONOMY

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Abstract

Three out of nine of S&P500 digital platform companies stand out as building own artificial intelligence (AI) platforms. There is overwhelming empirical evidence of AI technologies are being central to running a digital platform business. However, the current research agenda is not directing researchers to study AI technologies in the context of digital platforms.

We have divided the proposed AI platforms research agenda as follows: The first set of questions we propose relates to an overall conceptualization of AI platforms. Thereafter, we recognize specific aspects of AI platforms, which need to be investigated in detail to gain understanding that is more complete. The second set of questions we propose relates to understanding the dynamics between AI platforms and the broader socio-economic context. This topic might be particularly relevant to economies of countries without indigenous AI platforms. Our paper builds on the proposition that AI is a general-purpose technology, which by itself carries properties of a digital platform.

Tiivistelmä

Uudet tekoälyalustat – Digitaalisten alustojen uusi tutkimusagenda

Kolme yhdeksästä S&P500 digitaalisen alustatalouden yrityksestä on rakentamassa tekoälyalustoja. On olemassa vahvaa empiiristä näyttöä, että tekoälyteknologioilla on keskeinen asema digitaalisen alustaliiketoiminnan operoinnissa ja johtamisessa. Tutkijat ovat kuitenkin tarkastelleen tekoälyteknologioita ja digitaalisia alustoja kahtena erillisenä ilmiönä, ja niillä ei ole toistaiseksi yhtenäistävää tutkimusagendaa.

Jaamme tässä paperissa esitetyn tutkimusagendan seuraavasti: Ensimmäisten ehdottamiemme kysymysten joukko liittyy tekoälyalustojen yleiseen käsitteellistämiseen. Eri käsitteiden määrittäminen auttaa meitä ymmärtämään tekoälyalustoja ja niiden toimintalogiikoita yksityiskohtaisemmin. Toinen ehdottamiemme kysymysten joukko liittyy tekoälyalustojen välisen dynamiikan ymmärtämiseen ja niiden laajempiin sosioekonomisiin vaikutuksiin, joilla saattaa olla erityinen merkitys, niin Euroopalle kuin kehittyville talouksille. Lähtöoletuksena tutkimusagendalla on, että tekoälyalustoilla on oleellisia digitaalisten alustojen ominaisuuksia ja että yksittäiset tekoälyteknologiat ovat ns. yleiskäyttöisiä.

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Keywords: Platforms, Digital Platform Economy, Artificial Intelligence, AI platforms, Research agenda

Asiasanat: Alustat, Digitaalinen alustatalous, Tekoäly, Tekoälyalustat, Tutkimusagenda

JEL: M1, M21, O3, O33

1. The rise of AI technologies and their use by digital platforms

Long before battles for mobile platform domination were fought, many digital platform companies were already using machine learning algorithms in their internal business processes or as part of customer offering. iPhone AppStore was launched in mid-2008 (Ghazawneh & Henfridsson, 2013). Microsoft introduced spam filtering based on machine learning in 2003 (Buderi, 2005). eBay leveraged machine learning to categorize and search products since at least 2006[1]. After a series of breakthroughs in modern artificial intelligence (AI) and performance improvements of deep neural networks, these technologies became omnipresent and platform companies are the key providers (see, for example Nilsson, 2009, Chapter 33; Schmidhuber, 2017).

As noted by (Brock & Von Wangenheim, 2019), there appears to be no commonly accepted definition of AI. Nevertheless, an inclusive definition as follows, "Artificial Intelligence . . . is intended to make computers do things, that when done by people, are described as having indicated intelligence" (Brooks, 1991, p. 1) captures not only present day deep neural networks and, more broadly, machine learning, but also many diverse views present in AI discussions. Despite the lack of definitional clarity, both symbolic and probabilistic generations of technologies falling broadly under the umbrella of artificial intelligence have been the target of substantial development efforts by the computer science research community and by companies. Leading digital platform corporations are among the most resourceful and active developers of these technologies.

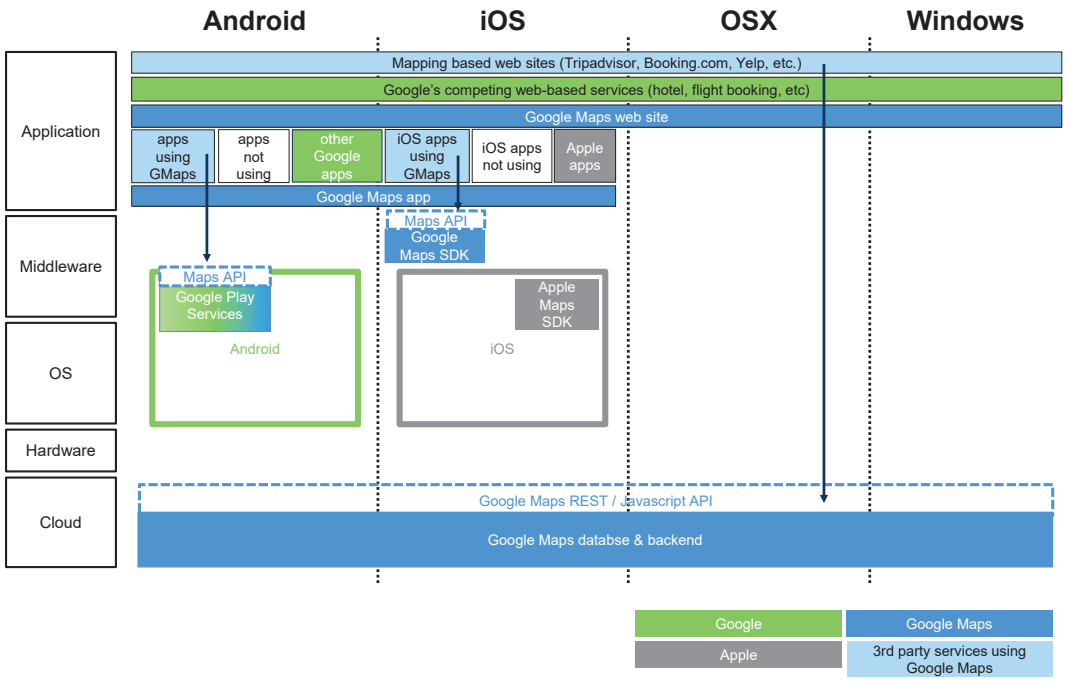
Together with the increasing capabilities and performance of AI technologies, their application areas and the role they play for digital platforms have evolved. Starting from automating specific tasks in internal business processes and offering capabilities to deliver new services that previously required human involvement, these technologies have enriched the repertoire of things that digital platforms can do to improve their business incrementally. However, proliferation of AI technologies has also enabled platformization of this new middleware layer in digital platform technology stack, thus effectively creating a platform inside a platform.

1.1 The evolution of digital platforms

The range of technologies considered ripe for being a core of a digital platform has been expanding over time. Digital platforms themselves have grown out of product platforms (Gawer, 2009; Henfridsson et al., 2018). While both are distinct forms of platforms (Constantinides et al., 2018), the earliest forms of platforms moving towards digitalization were microprocessors (Gawer & Cusumano, 2002).

Operating system (OS) platforms are digital platforms, which include, most notably, PC OSs and mobile OSs. Particularly the latter ones have taken the central stage of the discussion around digital

Figure 1. Google Maps integration to personal computer and mobile operating systems.
(Special thanks to Kimmo Karhu for drafting this picture with us.)



[1] eBay, Inc., eBay Analyst Day, 4 May 2006

platforms. This was driven by the fact that the research community started paying more attention to platforms around the same time as mobile ecosystem wars were waged by Apple, Google, Microsoft, Nokia and other companies (Kenney & Pon, 2011; Pon et al., 2014).

Operating systems, however, are not the only form of digital platforms. Digital platforms, such as Airbnb, have emerged without explicit OS linkage (Hagiu & Wright, 2015; G. G. Parker & Van Alstyne, 2005). The core of such platform consists of interactions between platform participants, thus creating value without directly holding physical assets and without product sales (Constantinides et al., 2018). Furthermore, OS type platforms have been expanding by converting to modules and adjunct layers (new middleware) in the technology stack into platforms themselves (Constantinides et al., 2018; Kenney & Pon, 2011; Yoo et al., 2010). Google Maps is a good illustration of a new middleware layer in this technology stack. This layer is being integrated both to PC and mobile OSs (see Figure 1). Overall, platforms, such as Google Maps, offer new rich technological features and boundary resources, thus not only generating vast amounts of data suitable for AI algorithms, but also providing entry points for AI utilization.

1.2. The evolution of AI use by digital platforms

In the early days of AI use by digital platforms, these technologies were just one of the tools in the toolbox. Very small fractions of processes could be handed over to AI applications, yet even then, their use could provide tangible business benefits. This is illustrated well with the following quote from May 2006 eBay Analyst Day.

"To provide the highest quality product-based search, what we do at Shopping.com is structure the unstructured. […] [I]t is a key part of our competitive advantage. We combine the best of human and artificial intelligence. First, we start with human intelligence, to structure and group the data. Then we apply machine learning technologies and algorithms which enhance the quality and ensure cost scalability."

Lorrie Norrington, eBay, Inc. – President of Shopping.com, eBay Analyst Day, 4 May 2006

Such narrow applications of AI, which are focused on efficiency and scalability, continue to be a vital part of digital platform companies' operations today. In 2016 letter to shareholders, CEO of Amazon, Jeff Bezos revealed that machine learning drove Amazon's algorithms for "demand forecasting, product search ranking, product and deals recommendations, merchandising placements, fraud detection, translations" (Bezos, 2017).

After the initial wave of internal efficiency focused applications of AI, platform companies explored the possibilities for employing these (and other) innovations to new business opportunities. Machine learning clearly entered on the research and innovation agendas of these companies.

"This is why we send the Neil Armstrongs of our company, our world-class engineers, psychologists, ethnographers, physicists, chemists, vision specialists, and design gurus to the farthest realms of the sci-fi world to think and apply rigorous science to computer vision, machine learning, user interfaces, and language processing. These inventors are creating technologies that have a 10-year horizon or more."

Robbie Bach, Microsoft Corporation – President Entertainment and Devices Division, Microsoft at CEA International Consumer Electronics Show - Pre-show Keynote Address, 6 January 2010

The scale of AI applications and workloads has been increasing continuously. Particularly, machine learning was used, for example, by Google to optimize ad auctions and detect fraudulent clicks on ads. Later, for example, building contour and road sign recognition, both powered by image recognition and used to enrich Google Maps, were added. Furthermore, Google and Microsoft have shifted to machine learning as an important element of search engines ranking algorithms. All these applications of AI on a large-scale elevated machine learning to be a significant part of application portfolio, thus driving infrastructure of these companies. This was a significant step, since infrastructure-as-a-service later will become one of the core elements of AI platform offering.

"The fact that we have a very diverse set of first party workloads [including machine learning] is what keeps us honest in terms of the infrastructure that we need to build to service our own, and then make that available as a third-party infrastructure."

Satya Nadella, Microsoft Corporation – President, Server and Tools, Microsoft at Citi Technology Conference, 5 September 2012

Detailed account of key events goes beyond the scope of this paper. However, it is important to recognize that many digital platform companies not only invested in research, development and improving internal operations, but also looked for ways to productize AI. Relatively soon after or in parallel with major announcements regarding internal developments, product launches followed. Facebook set up an AI team (Simonite, 2013) and hired NYU's Professor Yann LeCun in 2013 (Constine, 2013). Soon after that, Google acquired DeepMind for $500M in 2014 (Shu, 2014). In terms of product launches, Apple (2011), Google (2012), Amazon

(2014) and Microsoft (2014) offered voice assistants. Automatic ad placement, which is powered with machine learning algorithms, is available to advertisers placing ads via, for example, Google, Microsoft, Facebook, Twitter, Amazon and LinkedIn. eBay is offering automatic translation to increase the international reach of internet auctions (Brynjolfsson et al., 2019). These are just some example of offering provided by digital platforms, which leverages AI technologies.

What is central to the discussion regarding AI platform is that at least three digital platform companies, Amazon, Google and Microsoft, go beyond offering stand-alone AI-powered products and services. By bundling data storage, compute resources and algorithms or tools for their development, these platform companies provide a core of a new middleware platform. This constitutes technological core of their AI platforms. All these companies are actively training and converting developers and data scientists to feed both the supply and demand side of their platforms. In 2017 letter to shareholders, Jeff Bezos states that "AWS announced […] Amazon SageMaker, which radically changes the accessibility and ease of use for everyday developers to build sophisticated machine learning models. Tens of thousands of customers are also using a broad range of AWS machine learning services […]." (Bezos, 2018)

It appears that these platforms have succeeded in reaching critical mass, which unlocks economies of scope and network effects. In a manner similar to how Windows operating system (OS), iOS, and Android OS have facilitated value creation and exchange between application developers and users, AI platforms already now mediate value exchange.

Furthermore, all three companies have vast experience in running app stores in their other franchises. Based on this experience, they appear to gradually transition their AI platforms to app store model or, at least, add app store logic there. Currently, machine learning model and algorithm packages in Amazon SageMaker can be listed and sold on AWS Marketplace[2]. Google Cloud Platform Marketplace[3] and Microsoft's Azure Marketplace[4] provide similar opportunities for AI model and algorithm monetization. Thus, AI offering of these companies is enriched by that of third-party developers. Consequently, it appears that AI platforms are sufficiently advanced in their development to warrant a deeper investigation of their business and economic implications. The remainder of this paper sets out a research agenda for such investigation.

2. AI platform research agenda

The role of AI has changed from being one of many minuscule building blocks in the technology of platform companies to an important layer in the stack, and a platform by itself. There is overwhelming evidence of AI technologies and platforms are being central to running a digital platform business (Brynjolfsson et al., 2018; Brynjolfsson & Mcafee, 2017; Varian, 2014). Despite this trend, it appears that economists, as well as strategy and information systems scholars have failed to recognize the importance of this development. A recently published "The Economics of Artificial Intelligence: An Agenda" (Agrawal et al., 2019) mentions platforms only a few times in passing and misses the concept of AI as a digital platform. Similarly, recent literature setting a research agenda for digital platforms (Constantinides et al., 2018; de Reuver et al., 2018; Kenney et al., 2019) is impoverished. It is not directing researchers to study AI in the context of platforms. We do not imply that the link between AI and digital platforms is completely absent from ongoing research efforts and practical publications. However, economists, strategy and information systems scholars appear to find disproportionately less interest in this topic, when compared with efforts excreted by digital platform companies. This is particularly the case for AI as platforms, which is the topic we address in this paper.

In the remainder of this paper, we outline a research agenda that complements that of economists and digital platform scholars. Summary of the themes and questions for further research are presented in Table 1. We break the agenda into two perspectives. These perspectives represent distinct levels of analysis. Micro perspective on AI platforms deals with dynamics within the limit of a single AI platform and its ecosystem. Macro perspective is concerned with the dynamics between AI platforms and the broader socio-economic context.

2.1. Micro perspective on AI platforms

There are many types of digital platforms (Kenney & Zysman, 2016). Each type has own defining characteristics. We believe that AI platforms do not fall squarely within any of the existing categories. While stand-alone AI technologies can be considered as tools for building other platforms, AI platforms are more than that. They span across not only applications, but also stretch vertically between hardware infrastructure and end users. Furthermore, different level of openness compared with for example mobile OS platforms distinguishes AI platforms from OS platforms.

[2] https://docs.aws.amazon.com/sagemaker/latest/dg/sagemaker-marketplace-sell.html (information retrieved 3.2.2020)
[3] https://cloud.google.com/marketplace/sell (information retrieved 3.2.2020)
[4] https://docs.microsoft.com/en-us/azure/marketplace/marketplace-publishers-guide (information retrieved 3.2.2020)

Table 1. Themes and questions for further research on AI platforms.

Level of Analysis	Theme	Research questions
Micro perspective on AI platforms	1. Conceptualization of AI platform	… Who are the agents participating in AI platform and its ecosystem? … What constitutes core and periphery of an AI platform? … What is the overall AI platform architecture?
	2. AI platform openness and boundary resources	… How open are AI platforms? … What are the boundary resources used in controlling and facilitating AI platforms?
	3. Value creation and capture in AI platforms	… How value is created and distributed within AI platforms? … What are the AI platform externalities?
	4. AI platform strategy, ownership and control	… What are the building blocks of AI platform strategy? … What are the governance models of AI platforms?
	5. Sustainability of AI platforms	… What are the operating costs / operating cost models of AI platforms? … Is the future of AI platforms sustainable?
Macro perspective on AI platforms	6. AI platforms as (quasi) utility companies	… Do AI platforms resemble utility companies? To what extent? … What level of AI platform concentration/ competition is optimal for the economy? … What role should regulation play in relation to AI platforms?
	7. Expansion/integration of AI platforms with other digital platforms and industrial sectors	… What are the mechanisms and consequences of AI platform expansion/integration with other digital platforms? … What are the mechanisms and consequences of AI platform expansion/integration with different industrial sectors?
	8. Impact of AI platforms on national economies and geopolitical relationships	… What are the AI platform related economic synergies and conflicts of interests between regions and nations? … What are the AI platform related economic implications for Europe, with no indigenous AI platform offering? … What are the AI platform related economic implications for the developing economies?

To understand the degree of these differences, gain more insight into how AI platforms work and generate value, we propose the following micro-level topics for exploration.

The first set of questions we propose relates to an overall conceptualization of AI platforms. Thereafter, we recognize specific aspects of AI platforms, which need to be investigated in detail to gain understanding that is more complete. These are openness and boundary resources, value creation and capture, strategy, ownership and control, and sustainability of AI platforms. Insights from research addressing questions pertaining to these topics will lead us towards understanding AI platforms on a micro level.

2.1.1. Conceptualization of AI platform

Conceptual clarity is a prerequisite for an informed discussion. To our understanding, academic literature has not recognized AI platforms as a distinct concept. Therefore, it is an imperative to address the following questions to build the foundations for further enquiry. For the purpose of this paper, we rely on Gawer's (2014, p. 1245) definition of platforms as "evolving organizations or meta-organizations that: (1) federate and coordinate constitutive agents who can innovate and compete; (2) create value by generating and harnessing economies of scope in supply or/and in demand; and (3) entail a technological architecture that is modular and composed of a core and a periphery." This definition leads us to proposing specific questions for future research.

Who are the agents participating in AI platform and its ecosystem? These agents include not only platform owner, users, and AI application developers. In the context of AI platforms, it is possible that other actors have a vital role to play as well. Research community can be considered an important actor, as AI research drives advancement of the technology. Unlike for other digital platforms, it appears that companies take also much more active role in driving research (Constine, 2013; Shu, 2014). Due to source code opening for some of the core platform elements, there are also participants contributing to platform's core codebase. Data collection and labeling, which is unique to AI platforms, is done in not only an automated fashion, but also utilizing human input. Furthermore, AI platforms are interlinked with other digital platforms, often controlled by the same agent. Thus, range of actors with roles important for AI platform vitality might be wider than for other digital platforms.

What constitutes core and periphery of an AI platform? A wide range of technologies is used in the AI application technology stack (for platform technology stack discussion see e.g. Constantinides et al., 2018; Kenney & Pon, 2011; Yoo et al., 2010). Both, software and hardware can be considered part of platform core. Peripheral modules might include a broader spectrum, than for other types of digital platforms. For example, iOS apps or Airbnb offering are both confined to their specific context – Apple product use and real estate renting, respectively. AI technologies are not tight to any context and their use is not bounded in the same manner.

What is the overall AI platform architecture? Architecture of a platform is "a conceptual blueprint that describes how the ecosystem is partitioned into a relatively stable platform and a complementary set of modules that are encouraged to vary, and the design rules binding on both" (Tiwana et al., 2010; see also Chapter 5 of Tiwana, 2013). It is not clear whether a single AI platform architecture dominates or whether each AI platform is substantially distinct in this respect. Also, comparison of AI platform architecture with that of other types of digital platforms could reveal new insights. Furthermore, the presence of complementarities has been considered as one of the key characteristics of platforms (Tiwana, 2015). Goods and services are said to be complementary to one another if the utility offered by one greatly depends on the consumption of the other (Gawer & Henderson, 2007). It is not clear whether and how some AI platform architectures create superior complementarities.

2.1.2. AI platform openness and boundary resources

How open are AI platforms? Platform openness is inherently linked with the issue of platform control and boundary resources (Tiwana et al., 2010). Even more encompassing impact of governance and technical interface design decisions is evidenced in these decisions having "an effect on the platform agents' incentives to collaborate, to innovate, and/or to compete" (Gawer, 2014). AI platforms' economic viability is likely to rely on their ability to thrive in a broader ecosystem. Therefore, openness with respect to AI platform architecture and, specifically, data, algorithms and compute resources are key topics for investigation. Studies investigating this topic could examine to what extent AI platforms open through other ways than just interfaces (such as licensing of core technology to complementors). One such alternative, which appears to be used by AI platforms includes "platform's sole sponsor inviting other parties to jointly develop the platform's core technology" (Eisenmann et al., 2009, p. 141).

What are the boundary resources used in controlling and facilitating AI platforms? Boundary resources play a key role in a digital platform growth and long-term existence. They strike a balance between allowing platform owner to maintain control and encouraging third parties to contribute to the platform ecosystem (Gawer, 2009; Ghazawneh & Henfridsson, 2013). Investigation of the nature of social and technical boundary resources used in AI platforms is, thus, of high importance to understanding the AI platforms themselves, irrespectively of whether we take information systems, strategy or economics perspective. This analysis cannot be removed, however, from broader context of ecosystem, in which AI platforms are positioned. For example, Google's launch of an end-to-end AI platform (Lardinois, 2019) sparked discussion in developer circles (*Google launches an end-to-end AI platform | Hacker News*, 2019) regarding limitations of service's use for cars, TVs and appliances, which was included in Google's service terms. Overall, analysis of boundary resources used in AI platforms could benefit from comparison with those used in other digital platforms.

2.1.3. Value creation and capture in AI platforms

How value is created and distributed within AI platforms? Marketplaces, which are part of AI platforms, are not very mature yet. Unlike mobile (iOS or Android) or service-providing (Airbnb or Uber) platforms, AI platform owners do not appear to extract value directly from mediating exchange on a marketplace. This does not mean that AI platform owners must defer value capture until higher volume of marketplace transactions takes place. Instead, there are multiple ways in which AI platforms, which are a form of digital innovation, can lead to value creation and capture (Henfridsson et al., 2018). Similarly, AI platform actors can also restore to recombination as design or recombination in use to create and capture their share of value. Both, AI platform owner and

other actors' value creation require deeper investigation.

What are the AI platform externalities? Externalities have been mentioned as one of the key characteristics of a platform. A platform is said to create externalities, if more than one platform actor is crucial to the outcomes of interest, and the platforms actors exhibit network-effects between them (Katz & Shapiro, 1994; Mattila & Seppälä, 2018; G. G. Parker & Van Alstyne, 2005; Rochet & Tirole, 2003). Network-effects for AI platform appear to have a potentially unique feature, which requires further investigation. An AI platform benefits from externalities not only because of the value of actors engaged in it, but also because many AI models and algorithms have ability to learn and improve performance over time. This latter effect has been popularly labeled as "virtuous cycle of AI" (Ng, 2017) or "data flywheel". The extent to which both effects are additive and where the eventual limits of these effects lays remains currently unexplored.

2.1.4. AI platform strategy, ownership and control

What are the building blocks of AI platform strategy? AI platforms are currently emerging. Amazon, Google and Microsoft are among the most prominent companies developing such platforms. It is not clear how these companies or their potential contenders approach establishment, growth and protection of their AI platforms from a strategic perspective. It seems that their approach to platformizing AI products/services follows the recommendations of Van Alstyne and colleagues (2016), as well as that of Zhu and Furr's (2016). However, more detailed investigation is needed. For example, do platform dynamics related to winner-take-all and differentiation strategies (Cennamo & Santalo, 2013) hold for AI platforms? How important is the development of AI platforms in tandem with the existing other digital platforms and whether these provide significant entry barriers to incumbents? While it is likely that there is no single recipe for a successful AI platform, explication of AI platform strategy and identification of its key building blocks might reveal new insights to scholars investigating digital platforms and practitioners devising such strategies.

What are the governance models of AI platforms? On a general level, the definition of platform governance refers to the interaction between the platform provider and any platform actor who contribute to the product and/or service offering of the platform externally, from outside of the platform provider itself. We propose further studies on AI platform governance to complement the existing studies on the platform literature: What are the mechanisms through which an AI platform owner exerts influence over any platform actors participating in the platform's ecosystem?; What are the business rules and contract terms in AI platforms that platforms typically regulate with an interest of controlling prices, access and interactions on the platform; What the set of rules concerning who gets access to an ecosystem, how to divide the value, and how to resolve conflicts. The motivation for this research agenda is to see whether AI platforms are being governed in a same way as platforms or differently (for comparison see: Boudreau & Hagiu, 2009; Constantinides et al., 2018; Mattila & Seppälä, 2018; G. Parker & Van Alstyne, 2018; Schilling, 2010; Tiwana, 2013, Chapter 6; Tiwana et al., 2010).

2.1.5. Sustainability of AI platforms

What are the operating costs / operating cost models of AI platforms? The cost of operating a platform, artificial intelligence systems and their applications has not received wide attention in research lately. It has been noted that ever since the 1980s, information technology systems have not been mainly evaluated by their operating costs, but rather by their enhanced market access, product differentiation, strategic benefit and competitive advantage (Hukkinen et al., 2019; Ives & Learmonth, 1984, pp. 1193–1201). These current platforms and artificial intelligence are also expected to produce some novel theoretical models on pricing, revenues, and resource utilization. The advent of platforms and artificial intelligence have changed the long-term investment-based view to a short-term utility-based one

Is the future of AI platforms sustainable? ICT-related activities have had significant environmental impacts due to rare raw materials required to build new hardware as well as energy to power the digital infrastructure (Rajala et al., 2018). Lately, it has become questionable whether the contemporary AI-related resource abundance is sustainable. These new AI platforms require a new way of thinking with the society, meticulous attention to resources and energy efficiencies from the larger perspective that we call digital ecology. The perspective of digital ecology focuses our attention on sustainability in the use of natural resources for information processing (Seppälä et al., 2019). Present research concerned with the impact of digital technologies on a biophysical environment (for example Hukkinen et al., 2019) has not comprehensively considered AI platforms. Thus, understanding of AI platform sustainability presents many opportunities for timely and important research.

2.2. Macro perspective on AI platforms

AI technologies and, thus platforms built around these technologies, have the potential to profoundly impact multiple sectors of economy, play a role in international economic relationships and contribute to the establishment of a new innovation system (*Air Force releases 2019 Artificial Intelligence Strategy*,

2019; Li & Etchemendy, 2019; Plastino & Purdy, 2018). These impacts have not materialized thus far, and it is not certain they ever will. However, the presence of such potential is, in our view, enough to warrant investigation of topics falling under this perspective. Understanding the dynamics between AI platforms and the broader socio-economic context might be particularly relevant for economies of countries without indigenous AI platforms. This macro perspective on AI platforms builds on the proposition that AI is a general-purpose technology (Brynjolfsson et al., 2018; Cockburn et al., 2018; Goldfarb et al., 2019; Trajtenberg, 2018), which by itself carries properties of a platform technology (Carr, 2009, p. 15).

Each set of questions for research listed under macro perspective considers impact of AI platforms on the economy from an increasingly broad perspective. The first set of questions is concerned with AI platforms as utilities and potential implications from such role in the economy. These questions are predominantly relevant on the national economy level. The next set of questions relates to the interaction of AI platforms with other digital platforms and other industries. These issues are no longer limited by national borders and the implications potentially reach international economy level. Finally, the last set of questions included under macro perspective deals with potential implications of AI platforms on geopolitical balance and international economics.

It appears that the discussions regarding AI technologies and their impact on macroeconomics and geopolitics is largely taking place in media, government and its agencies. This is paralleled by our references pointing much more to these sources, rather than to academic journals. At the same time, this is a sign that academia has an opportunity to contribute to this discussion. Therefore, research questions listed under macro perspective provide a fertile ground for scholars interested not only in questions of importance to the society, but also in timely questions.

2.2.1. AI platforms as (quasi) utility companies

Do AI platforms resemble utility companies? To what extent? Nicholas Carr (2009, p. 15) claims that "General-purpose technologies, or GPTs, are best thought of not as discrete tools but as platforms on which many different tools, or applications, can be constructed. … GPTs offer the potential for huge economies of scale – if their supply can be consolidated." Hence, there is a strong economic reasoning for consolidating AI technologies under one roof, which belongs to companies controlling AI platforms (Lee, 2018, pp. 94–95). However, there are limitations to comparing AI and utilities. Brynjolfsson and colleagues (2010), in their discussion regarding cloud computing as a utility business, raise several points, which are also relevant when considering AI platforms as utilities. They stress that high pace of innovation, limits to scale and latency differentiate cloud computing from, for example, electrical utilities. Given that utilities have a special role to play in the economy, potential resemblance of AI platforms to utilities might carry implications for both, the economy and companies controlling AI platforms. This is the case even if AI platforms only partially resemble utilities.

What level of AI platform concentration/ competition is optimal for the economy? Many countries have addressed lock-in issues related to utility companies by creating special market structures or legally separating parts of utility business, such as electricity generation and transmission (Brynjolfsson et al., 2010). It is not clear whether AI platforms could feasibly be subjected to such interventions and whether these could be beneficial for the economy. Another aspect related to this question is the level of competition between AI platforms. In what conditions multiple AI platforms can co-exist. What are the economic consequences of high or low levels of competition and/or concentration of AI platforms? What is the interaction between the level of AI platform competition and rate innovation, which is complementary to AI?

What role should regulation play in relation to AI platforms? The development of different technologies interacts with legislation and other regulations. This interaction influences technology development paths and commercial success of individual technologies (Ailisto et al., 2018; see also the ongoing work *Regulatory reform—OECD*, 2020). AI technologies are not an exception and AI regulation is an active area of interest, discussion and research (for example, see: Etzioni, 2018; House of Commons Science and Technology Committee, 2018; Koulu et al., 2019; O'Sullivan & Thierer, 2018). Notably, White House has released a guidance for regulating AI applications (Heckman, 2020). However, this ongoing discussion appears to center on specific (narrow) use cases of AI, rather than more encompassing view on AI platforms. If AI platforms are to face similar response to monopolistic situations as utilities do (Brynjolfsson et al., 2010), then regulation on this level is also an important topic to investigate.

2.2.2. Expansion/integration of AI platforms with other digital platforms and industrial sectors

What are the mechanisms and consequences of AI platform expansion/integration with other digital platforms? AI platforms closely integrate with other digital platforms controlled by the same companies, for example Android mobile operating system integrates with Google's AI platform and Amazon marketplace leverages AWS machine learning. This close relationship between AI platform and other platforms from the same house might have

implications for competitive dynamics. Furthermore, what is less obvious is that AI platforms expand also into digital platforms controlled by other companies. Netflix uses Amazon Web Services, among others, to run recommendation engines (*Netflix & Amazon Kinesis Streams Case Study*, 2017). Uber uses Microsoft Cognitive Services to verify if drivers' faces match profiles of the respective drivers' accounts on file (*Uber boosts platform security with the Face API, part of Microsoft Cognitive Services*, 2019). eBay uses Google Cloud to innovate in image search, improve customer experiences, and train translation models (*Disrupting eCommerce*, 2018). This phenomenon of multiple digital platforms interlocking with each other in new ways presents an area for further investigation with potential for significant new insights related to digital economy.

What are the mechanisms and consequences of AI platform expansion/integration with different industrial sectors? Global Value Chain (GVC) governance models have been an initial concept in understanding industrial sectors and respective supply chains (Gereffi et al., 2005). Clarifying the different constellations of AI platforms and their current and potential future role in reorganizing GVCs has become crucial, since different AI platforms continue to increase integration with companies across various sectors. To name just a few examples, we refer to Shell (oil and gas), Ryanair (airline) and Grant Thornton (professional services, tax, accounting and financial advisory). All these companies are leveraging AI platforms. Shell is using machine vision to improve safety on its gas stations (*Shell invests in safety with Azure, AI, and machine vision to better protect customers and service champions*, 2018). Ryanair is automating customer service with a chatbot (*Ryanair Case Study – Amazon Web Services (AWS)*, 2019). Grant Thornton is optimizing sales efforts to close more sales opportunities and increase share of successfully closed deals (*Grant Thornton looks to AI to close new opportunities faster, win more deals*, 2020). Thus, AI platforms seem to infiltrate to a wide range of industries, in the same ways as utilities did in the past. Unlike utilities, AI platforms are delivered as a service, not as a commodity. What are the economic implications of these developments? Are value creation, capture and distribution logics in GVCs going to change due to AI platforms?

2.2.3. Impact of AI platforms on national economies and geopolitical relationships

What are the AI platform related economic synergies and conflicts of interests between regions and nations? "Whoever becomes the leader in this [artificial intelligence] sphere will become the ruler of the world" – these are words of Vladimir Putin in his address to Russian students (Vincent, 2017). The potential for AI technologies to disrupt the global balance of power are universally recognized. A report from US Center for New American Security states "as a critical enabler of future economic success, leadership in AI thus is likely to be critical to the macro balance of power and international competition" (Horowitz et al., 2018). China seconds that opinion by stating in their national AI strategy that (translated) "the Chinese leadership sees technological innovation, particularly in AI, as a core aspect of international competition" (Webster et al., 2017). These adversarial views have also been connected with explicit measures, for example US administration blacklisting Chinese AI startups (Xu Elegant, 2019). Another aspect of rivalry between countries, which requires investigation, relates to designing and building custom hardware for running AI algorithms. While in 2017 China acknowledged being "far behind world leaders" (Webster et al., 2017) in this respect, already in late 2019 Alibaba's Hanguang AI chip appeared to outperform Intel or Nvidia chips (The Economist, 2020). These tensions, however, are not present across the whole AI ecosystem. Openness and collaboration are still recognized as important drivers of progress by the research community. Investigation of economic and geopolitical implications of these developments is an important topic, as it potentially has far-reaching business and societal consequences.

What are the AI platform related economic implications for Europe, with no indigenous AI platform offering? In its scoping document on the European AI landscape (Stix, 2018, p. 3), the European Commission acknowledged that European AI resources are scattered, and the international competition is fierce. In response, the European Commission has launched multiple activities and deployed funding. For example, under the Digital Single Market strategy, the European AI Alliance was formed (European Commission, 2018b) and a High-Level Expert Group on Artificial Intelligence created (European Commission, 2018a). In terms of funding, one notable project is AI4EU consortium, which "was established to build the first European Artificial Intelligence On-Demand Platform and Ecosystem with the support of the European Commission under the H2020 programme" (AI4EU consortium, 2019). In our view, however, Europe currently lacks sufficiently advanced AI platform companies to present a scalable and compelling alternative to US or Chinese ones. Considering economic vitality of the continent and competitiveness of local companies, it is important to investigate multiple questions. Can Europe develop indigenous AI platforms, which could be viable alternatives to US or Chinese ones? What are the economic benefits and costs of doing that? How indigenous AI platforms can be fostered/matured? What are the economically viable approaches to growth without indigenous AI platforms?

What are the AI platform related economic implications for the developing economies? Unlike the European community jointly or European countries on stand-alone basis, developing countries do not have research or funding capabilities to approach AI platform emergence in the same way. "Developing countries may stand to gain the most from emerging digital technologies because they face the highest trade costs and biggest distortions" (World Bank, 2019, p. 137). However, they are also exposed the most to abuse due to market power concentration elsewhere or discrimination stemming from prevalent biases (World Bank, 2019, p. 137). Considering economic impact of AI platforms on the developing economies beyond the impact of stand-alone AI technologies might involve the following questions. How AI platforms influence dependencies between developing and developed countries? For example, facial recognition and surveillance technologies based on Chinese or US AI platforms are being supplied to the developing world, thus increasing cross-border dependencies (Kharpal, 2019; Yang & Murgia, 2019). How AI platforms influence distribution of value, which is created in the developing countries?

3. Summary and outlook

We are at the beginning of a research effort to understand the role of AI platforms in the economy. This new and versatile middleware layer platform integrates not only with both PC and mobile operating systems, but also with other digital platforms and traditional industries. Based on the current magnitude of AI platform adaptation into PC and mobile platforms, it is evident that this new, next generation, platform economy will affect our current understanding of the platforms themselves. Furthermore, increasing infiltration of AI platforms into traditional industries might have consequences reaching beyond national economies, thus expanding the range of topics within the scope of digital economy research.

Our research agenda raises multiple fruitful areas for future inquiry in AI platforms. We believe that this agenda not only complements the individual agendas for research on platforms and on AI, but also integrates them. While the research questions we proposed are concerned with economic and business impact of AI platforms, we recognize that research on these topics is multidisciplinary. Apart from economics and business strategy perspectives, information systems, sociology, political sciences and environmental sciences are some of the examples of disciplines, which could bring valuable insights and advance our understanding of AI platforms and their role in the society.

AI platforms exert impact on our society already now. Yet, we can expect further developments that might be as, or even more, transformative than the ones we have already seen. The role AI platforms play in the operational and business models of companies throughout the economy is increasing. This means that the way in which value is being created, capture and distributed might change. Profound changes of this type are difficult to predict. Nevertheless, the research community needs to be vigilant about such potential. This is especially the case, because AI platforms are a middleware layer in the technology stack. They can be ubiquitous without their presence being obvious to the end users. Consequently, AI platforms might allow companies to create superb customer experiences. But at the same time, they can carry competitive risks or environmental consequences of which end users or decision makers are unaware.

Overall, we believe that AI platforms are likely to become a powerful organizing principle for economic and social activity over the next decade. Scholars interested in contemporary digital and platform economy must consider how AI platforms interact with the economy on different levels and how they foster economic activity. We foresee an influx of further studies related to AI platform topic.

4. References

Agrawal, A., Gans, J., & Goldfarb, A. (2019). *The Economics of Artificial Intelligence: An Agenda*. University of Chicago Press. https://doi.org/10.7208/chicago/9780226613475.001.0001

AI4EU consortium. (2019, January). *About the project | AI4EU*. https://www.ai4eu.eu/about-project

Ailisto, H., Heikkilä, E., Helaakoski, H., Neuvonen, A., & Seppälä, T. (2018). *Artificial intelligence and its capability assessment. 46*. http://julkaisut.valtioneuvosto.fi/handle/10024/160925

Air Force releases 2019 Artificial Intelligence Strategy. (2019, September 12). U.S. Air Force. https://www.af.mil/News/Article-Display/Article/1959225/air-force-releases-2019-artificial-intelligence-strategy/

Bezos, J. (2017, April 17). *2016 Letter to Shareholders*. US Day One Blog. https://blog.aboutamazon.com/company-news/2016-letter-to-shareholders

Bezos, J. (2018, April 18). *2017 Letter to Shareholders*. US Day One Blog. https://blog.aboutamazon.com/company-news/2017-letter-to-shareholders/

Boudreau, K. J., & Hagiu, A. (2009). Platform Rules: Multi-Sided Platforms as Regulators. In *Platforms, Markets and Innovation*. Edward Elgar Publishing. https://EconPapers.repec.org/RePEc:elg:eechap:13257_7

Brock, J. K.-U., & Von Wangenheim, F. (2019). Demystifying AI: What Digital Transformation Leaders Can Teach You about Realistic Artificial Intelligence. *California Management Review*, *61*(4), 110–134.

Brooks, R. A. (1991). *Intelligence without reason*. https://people.csail.mit.edu/brooks/papers/AIM-1293.pdf

Brynjolfsson, E., Hofmann, P., & Jordan, J. (2010). Cloud computing and electricity: Beyond the utility model. *Communications of the ACM*, *53*(5), 32–34.

Brynjolfsson, E., Hui, X., & Liu, M. (2019). Does machine translation affect international trade? Evidence from a large digital platform. *Management Science*, *65*(12), 5449–5460.

Brynjolfsson, E., & Mcafee, A. (2017). The business of artificial intelligence. *Harvard Business Review*, 1–20.

Brynjolfsson, E., Rock, D., & Syverson, C. (2018). Artificial Intelligence and the Modern Productivity Paradox: A Clash of Expectations and Statistics. In *The Economics of Artificial Intelligence: An Agenda* (pp. 23–57). University of Chicago Press. http://www.nber.org/chapters/c14007

Buderi, R. (2005). Microsoft Declares War on Spam. *Technology Review*, *108*(2), 22–23. bth.

Carr, N. (2009). *The big switch: Rewiring the world, from Edison to Google*. WW Norton & Company.

Cennamo, C., & Santalo, J. (2013). Platform competition: Strategic trade-offs in platform markets. *Strategic Management Journal*, *34*(11), 1331–1350.

Cockburn, I. M., Henderson, R., & Stern, S. (2018). The Impact of Artificial Intelligence on Innovation: An Exploratory Analysis. In *The Economics of Artificial Intelligence: An Agenda* (pp. 115–146). University of Chicago Press. http://www.nber.org/chapters/c14006

Constantinides, P., Henfridsson, O., & Parker, G. G. (2018). *Introduction—Platforms and infrastructures in the digital age*. INFORMS.

Constine, J. (2013, December 9). NYU "Deep Learning" Professor LeCun Will Head Facebook's New Artificial Intelligence Lab. *TechCrunch*. http://social.techcrunch.com/2013/12/09/facebook-artificial-intelligence-lab-lecun/

de Reuver, M., Sørensen, C., & Basole, R. C. (2018). The digital platform: A research agenda. *Journal of Information Technology*, *33*(2), 124–135.

Disrupting eCommerce. (2018, September 10). https://www.youtube.com/watch?v=OWvbeEEq14k

Eisenmann, T. R., Parker, G., & Van Alstyne, M. (2009). Opening platforms: How, when and why? *Platforms, Markets and Innovation*, *6*, 131–162.

Etzioni, O. (2018). Point: Should AI technology be regulated? Yes, and here's how. *Communications of the ACM*, *61*(12), 30–32.

European Commission. (2018a, June 14). *High-Level Expert Group on Artificial Intelligence* [Text]. Digital Single Market - European Commission. https://ec.europa.eu/digital-single-market/en/high-level-expert-group-artificial-intelligence

European Commission. (2018b, June 14). *The European AI Alliance* [Text]. Digital Single Market - European Commission. https://ec.europa.eu/digital-single-market/en/european-ai-alliance

Gawer, A. (2009). *Platforms, Markets and Innovation*. Edward Elgar. https://books.google.fi/books?id=aQJdmAEACAAJ

Gawer, A. (2014). Bridging differing perspectives on technological platforms: Toward an integrative framework. *Research Policy*, *43*(7), 1239–1249.

Gawer, A., & Cusumano, M. A. (2002). *Platform leadership: How Intel, Microsoft, and Cisco drive industry innovation* (Vol. 5). Harvard Business School Press Boston, MA.

Gawer, A., & Henderson, R. (2007). Platform owner entry and innovation in complementary markets: Evidence from Intel. *Journal of Economics & Management Strategy*, *16*(1), 1–34.

Gereffi, G., Humphrey, J., & Sturgeon, T. (2005). The governance of global value chains. *Review of International Political Economy*, *12*(1), 78–104.

Ghazawneh, A., & Henfridsson, O. (2013). Balancing platform control and external contribution in third-party development: The boundary resources model. *Information Systems Journal*, *23*(2), 173–192.

Goldfarb, A., Taska, B., & Teodoridis, F. (2019). Could Machine Learning Be a General-Purpose Technology? Evidence from Online Job Postings. *Evidence from Online Job Postings (October 12, 2019)*.

Google launches an end-to-end AI platform | Hacker News. (2019, April). https://news.ycombinator.com/item?id=19626275

Grant Thornton looks to AI to close new opportunities faster, win more deals. (2020, January 10). Microsoft Customers Stories. https://customers.microsoft.com/en-

us/story/754855-grant-thornton-professional-services-dynamics-365

Hagiu, A., & Wright, J. (2015). Multi-sided platforms. *International Journal of Industrial Organization*, *43*, 162–174.

Heckman, J. (2020, January 7). *White House releases 'first of its kind' set of binding AI principles for agency regulators*. Federal News Network. https://federalnewsnetwork.com/artificial-intelligence/2020/01/white-house-releases-first-of-its-kind-set-of-binding-ai-principles-for-agency-regulators/

Henfridsson, O., Nandhakumar, J., Scarbrough, H., & Panourgias, N. (2018). Recombination in the open-ended value landscape of digital innovation. *Information and Organization*, *28*(2), 89–100.

Horowitz, M. C., Allen, G. C., Kania, E. B., & Scharre, P. (2018). Strategic competition in an era of artificial intelligence. *Center for New American Security (Washington, DC: Center for New American Security, 2018)*, *8*.

House of Commons Science and Technology Committee. (2018). Algorithms in decision-making. *UK Parliament House of Commons*, *36*.

Hukkinen, T., Mattila, J., Smolander, K., Seppala, T., & Goodden, T. (2019). Skimping on Gas–Reducing Ethereum Transaction Costs in a Blockchain Electricity Market Application. *Proceedings of the 52nd Hawaii International Conference on System Sciences*.

Ives, B., & Learmonth, G. P. (1984). The information system as a competitive weapon. *Communications of the ACM*, *27*(12), 1193–1201.

Katz, M. L., & Shapiro, C. (1994). Systems competition and network effects. *Journal of Economic Perspectives*, *8*(2), 93–115.

Kenney, M., & Pon, B. (2011). Structuring the smartphone industry: Is the mobile internet OS platform the key? *Journal of Industry, Competition and Trade*, *11*(3), 239–261.

Kenney, M., Rouvinen, P., Seppälä, T., & Zysman, J. (2019). Platforms and industrial change. *Industry and Innovation*, 1–9.

Kenney, M., & Zysman, J. (2016). The rise of the platform economy. *Issues in Science and Technology*, *32*(3), 61.

Kharpal, A. (2019, October 8). *China's surveillance tech is spreading globally, raising concerns about Beijing's influence*. CNBC. https://www.cnbc.com/2019/10/08/china-is-exporting-surveillance-tech-like-facial-recognition-globally.html

Koulu, R., Mäihäniemi, B., Kyyrönen, V., Hakkarainen, J., & Markkanen, K. (2019). *Algorithm as a decision-maker? The possibilities and challenges of artificial intelligence in the national regulatory environment*. http://urn.fi/URN:ISBN: 978-952-287-764-2

Lardinois, F. (2019, April 10). Google launches an end-to-end AI platform. *TechCrunch*. http://social.techcrunch.com/2019/04/10/google-expands-its-ai-services/

Lee, K.-F. (2018). *AI superpowers: China, Silicon Valley, and the new world order*. Houghton Mifflin Harcourt.

Li, F.-F., & Etchemendy, J. (2019, October 22). *We Need a National Vision for AI*. Stanford Institute for Human-Centered Artificial Intelligence. https://hai.stanford.edu/news/we-need-national-vision-ai

Mattila, J., & Seppälä, T. (2018). Distributed Governance in Multi-sided Platforms: A Conceptual Framework from Case: Bitcoin. In *Collaborative Value Co-creation in the Platform Economy* (pp. 183–205). Springer.

Netflix & Amazon Kinesis Streams Case Study. (2017). Amazon Web Services, Inc. https://aws.amazon.com/solutions/case-studies/netflix-kinesis-streams/

Ng, A. (2017, April 28). *Artificial Intelligence is the New Electricity—Andrew Ng*. Medium. https://medium.com/syncedreview/artificial-intelligence-is-the-new-electricity-andrew-ng-cc132ea6264

Nilsson, N. J. (2009). *The quest for artificial intelligence*. Cambridge University Press.

O'Sullivan, A., & Thierer, A. (2018). Counterpoint: Regulators should allow the greatest space for AI innovation. *Communications of the ACM*, *61*(12), 33–35.

Parker, G. G., & Van Alstyne, M. W. (2005). Two-sided network effects: A theory of information product design. *Management Science*, *51*(10), 1494–1504.

Parker, G., & Van Alstyne, M. (2018). Innovation, openness, and platform control. *Management Science*, *64*(7), 3015–3032.

Plastino, E., & Purdy, M. (2018). Game changing value from artificial intelligence: Eight strategies. *Strategy & Leadership*, *46*(1), 16–22.

Pon, B., Seppälä, T., & Kenney, M. (2014). Android and the demise of operating system-based power: Firm strategy and platform control in the post-PC world. *Telecommunications Policy*, *38*(11), 979–991.

Rajala, R., Hakanen, E., Mattila, J., Seppälä, T., & Westerlund, M. (2018). How do intelligent goods shape closed-loop systems? *California Management Review*, *60*(3), 20–44.

Regulatory reform—OECD. (2020). https://www.oecd.org/regreform/

Rochet, J.-C., & Tirole, J. (2003). Platform competition in two-sided markets. *Journal of the European Economic Association*, *1*(4), 990–1029.

Ryanair Case Study – Amazon Web Services (AWS). (2019). Amazon Web Services, Inc. https://aws.amazon.com/solutions/case-studies/ryanair/

Schilling, M. A. (2010). *Strategic management of technological innovation*. Tata McGraw-Hill Education.

Schmidhuber, J. (2017, August). *Our impact on the world's most valuable public companies (Google, Apple, Microsoft, Amazon, etc)*. http://people.idsia.ch/~juergen/impact-on-most-valuable-companies.html

Seppälä, T., Mattila, J., & Rajala, R. (2019). *Is the Digital Future Sustainable?* The Research Institute of the Finnish Economy.

Shell invests in safety with Azure, AI, and machine vision to better protect customers and service champions. (2018, September 24). Microsoft Customers Stories. https://customers.microsoft.com/en-us/story/shell-mining-oil-gas-azure-databricks

Shu, C. (2014, January 27). Google Acquires Artificial Intelligence Startup DeepMind For More Than $500M. *TechCrunch*. http://social.techcrunch.com/2014/01/26/google-deepmind/

Simonite, T. (2013, September 20). *Facebook Chases Google's Deep Learning with New Research Group*. MIT Technology Review. https://www.technologyreview.com/s/519411/facebook-launches-advanced-ai-effort-to-find-meaning-in-your-posts/

Stix, C. (2018). *The European AI Landscape: Workshop Report* [Workshop Report]. The European Commission. http://ec.europa.eu/newsroom/dae/document.cfm?doc_id=51262

The Economist. (2020, January 4). China is slowly moving up the microprocessing value chain. *The Economist*. https://www.economist.com/technology-quarterly/2020/01/02/china-is-slowly-moving-up-the-microprocessing-value-chain

Tiwana, A. (2013). *Platform ecosystems: Aligning architecture, governance, and strategy*. Newnes.

Tiwana, A. (2015). Evolutionary competition in platform ecosystems. *Information Systems Research*, *26*(2), 266–281.

Tiwana, A., Konsynski, B., & Bush, A. A. (2010). Research commentary—Platform evolution: Coevolution of platform architecture, governance, and environmental dynamics. *Information Systems Research*, *21*(4), 675–687.

Trajtenberg, M. (2018). Artificial Intelligence as the Next GPT: A Political-Economy Perspective. In *The Economics of Artificial Intelligence: An Agenda* (pp. 175–186). University of Chicago Press. http://www.nber.org/chapters/c14025

Uber boosts platform security with the Face API, part of Microsoft Cognitive Services. (2019, June 18). Microsoft Customers Stories. https://customers.microsoft.com/en-us/story/731196-uber

Van Alstyne, M. W., Parker, G. G., & Choudary, S. P. (2016). Pipelines, platforms, and the new rules of strategy. *Harvard Business Review*, *94*(4), 54–62.

Varian, H. R. (2014). Beyond big data. *Business Economics*, *49*(1), 27–31.

Vincent, J. (2017, September 4). *Putin says the nation that leads in AI 'will be the ruler of the world.'* The Verge. https://www.theverge.com/2017/9/4/16251226/russia-ai-putin-rule-the-world

Webster, G., Creemers, R., Triolo, P., & Kania, E. (2017, August 1). *China's Plan to 'Lead' in AI: Purpose, Prospects, and Problems*. New America. https://www.newamerica.org/cybersecurity-initiative/blog/chinas-plan-lead-ai-purpose-prospects-and-problems/

World Bank. (2019). *World Development Report 2020: Trading for Development in the Age of Global Value Chains*. The World Bank. https://doi.org/10.1596/978-1-4648-1457-0

Xu Elegant, N. (2019, October 10). *The Trump Administration Blacklisted Chinese A.I. Startups. But That Might Not Slow Them Down*. Fortune. https://fortune.com/2019/10/10/trump-china-entity-list-ai-blacklist/

Yang, Y., & Murgia, M. (2019, December 6). *Facial recognition: How China cornered the surveillance market*. Financial Times. https://www.ft.com/content/6f1a8f48-1813-11ea-9ee4-11f260415385

Yoo, Y., Henfridsson, O., & Lyytinen, K. (2010). Research commentary—The new organizing logic of digital innovation: An agenda for information systems research. *Information Systems Research*, *21*(4), 724–735.

Zhu, F., & Furr, N. (2016). Products to platforms: Making the leap. *Harvard Business Review*, *94*(4), 72–78.

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