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Industrial B2B platforms: The race Europe cannot afford to lose

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Summary

Digital platforms like Facebook, Instagram, Netflix, Amazon, Uber, AirBnB are everywhere today. There are many types of these so called B2C platforms such as: social platforms, markets and e-commerce platforms and service platforms (Airbnb, Uber), etc. Industrial B2B platforms are relative new and are changing the manufacturing ecosystem by introducing new business roles and impacting others. Industrial B2B platforms can be defined as as *a collection of shared infrastructures, systems and processes, where the value of the platform is based on data sharing and data exploitation*[1]. Such Industrial B2B platforms are often based on underlying technologies and platforms for data exchange (e.g. AI, block chain, aggregators), which enable connectivity, data flows, data storage, etc. Furthermore, to set-up the required collaborations several business networks have decided to set-up (digital) innovation hubs and other private or public-private collaborations to develop novel business and technological approaches and to find-out how such innovations can be best adopted by everyone involved.

Industrial B2B platforms are to play an increasingly important role in integrating production (within companies - e.g. digital factories) and between companies, linking organisations along the value chain. In this report 3 platform types are distinguished: Innovations hubs, Business platforms and Data platforms. We also focus on the potential interrelationship between those three types of platforms.

When comparing developments between Europe and the U.S. and Asia we see that:

- European Industrial B2B platforms are often developed in cooperation and via European projects. While Industrial B2B platforms in the U.S. are often initiated via start-ups.
- Value information providers (e.g. in supply chain collaboration) and data provisioning platforms (focusing on the process of creating, preparing, and enabling data to its users) are often present in Europe.
- In Europe there is an increasing focus on ‘data sovereignty’: enabling organizations to retain full control over the access and usage of their own data. This results in several initiatives to develop decentralized platform architectures. In the U.S. there is more emphasis on centralized architectures based on large cloud platforms, such as Amazon Web Services (AWS) and Microsoft Azure. These platforms are gaining market share in Europe as well.
- Especially in the U.S. and Asia there is a tendency towards platforms focusing on ‘Manufacturing as a service’: integrating manufacturing capabilities through a digital platform, often without owning the actual manufacturing assets (‘Alibaba’ for manufacturing).

Many B2C platforms have become extremely powerful monopolies in a short period. By comparison the current landscape of Industrial B2B platforms is much more fragmented and the different aspects of data generation, processing and analytics are run by different players. In this situation the emergence of a ‘winner takes all scenario’ for Industrial B2B platforms can still be avoided. But this may change in the future and it is important to monitor developments and assess mitigation strategies.

[1] Parker G., Van Alstyne, M., Choudary, S. P., & Foster, J. (2016). *Platform revolution: How networked markets are transforming the economy and how to make them work for you*. New York: WW Norton

Contents

1 Introduction

Digital platforms are everywhere today. They have become so prominent that we are talking about the platform economy as a new model of economic governance.[2] The most visible platforms are those that dominate the social media, consumer products and services. Facebook, Instagram, Netflix, Amazon, Uber, AirBnB etc. have become household names. These companies have become extremely wealthy and powerful monopolies in a short period of time. Less visible, but not less important than these Business-to-Consumer platforms (B2C) are Business-to Business platforms (B2B) that play an increasingly important role in integrating production (within companies - e.g. digital factories) and between companies, linking organisations along the value chain.

This report addresses a number of key issues in relation to B2B platforms in the industrial sector. First, digitalisation of factories and value chains are key developments underlying concepts such as Industry 4.0. Digital platforms play a crucial role in the future of European and Dutch industry. Second, it is important to review and assess developments in Industrial B2B platforms because of changing international trade regimes and more broadly geopolitical developments. Protectionist tendencies are becoming stronger (e.g. the America First policy of the U.S.). Third, an important question is whether the current U.S. dominance in B2C platforms will be extended to Industrial B2B platforms – which would have major implications for Dutch and European industries.

To answer these questions this report addresses a number topics related to the types of digital platform for industry and especially Smart Industry, current platform initiatives and state-of -play, problems and issues in the development of platforms for the industrial sector, the role of standards, the role of (data) infrastructures, possible scenarios for platform development - especially in relation to the European industry, and an outlook and options for platforms in the EU industrial sector.

[2] Kenney, M. and J. Zysman (2016) The rise of the platform economy. In: *Issues in science and technology,* Spring 2016, pp 61-69.

2 Scope of the research

The concept of the *platform economy* is frequently used in the public debate and in academic research as the driving force behind a broad restructuring of businesses, services and production. Despite such a broad awareness of the rise of digital platforms as new way of organizing business models and market places, a clear definition is lacking on what is meant by a digital platform.

The fact that there are several models to structure a platform makes it difficult to generalize and produce models or archetypes that many stakeholders agree on. The focus in this report is on digital Industrial B2B platforms further referred to as Industrial B2B platforms. But we compare them to B2C platforms. The primary reason is that B2C platforms are somehow serving as models that inspire the level of ambition of B2B platforms in an industrial context. The analysis of the main contours of the competitive strategies of B2C platforms provide some lessons the Industrial B2B platforms can learn from.

In the literature there is relatively more information about the development, operation and business models of B2C platforms compared to Industrial B2B models. Both literature on B2C and Industrial B2B platforms indicates that there is a lot of information about data on consumers or data generated about industrial processes that needs to be accessed and analyzed. [3,4]
At the same time there is little or no information about the platforms themselves, their governance and inner workings. There is partially data available on the number of platforms, the geographic distribution, and market powers of B2C platforms but not about Industrial B2B platforms.[5]

There are many types of B2C platforms such as: social platforms (e.g. Instagram, Facebook), markets and e-commerce platforms (E-bay, Alibaba, Bol.com), service platforms (Airbnb, Uber), etc. Industrial B2B platforms are relative new.

Figure 1 provides a partial indication of market dominance, capitalization and worldwide distribution of B2C platforms.[6] There are clearly three large blocks (the U.S., Europe and Asia) which show large asymmetry in market power, with Europe lagging behind. Well-known companies with global dominance include Apple, Google's Alphabet, Microsoft, Facebook, Amazon and PayPal from the U.S. These are followed in size by the Asian Alibaba, Tencent, and Samsung. Europe wages a small piece of the global market power where the largest platforms like SAP, Spotify, Zalando and Yandex are dwarfed by the U.S. and Asian giants in market capitalization by several hundred billion dollars.

[3] Radanliev, P., De Roure, D., Nurse, J. R., Nicolescu, R., Huth, M., Cannady, S., & Montalvo, R. M. (2019). New developments in Cyber Physical Systems, the Internet of Things and the Digital Economy–discussion on future developments in the Industrial Internet of Things and Industry 4.0.
[4] Lee, M., Yun, J., Pyka, A., Won, D., Kodama, F., Schiuma, G., ... & Yan, M. R. (2018). How to respond to the Fourth Industrial Revolution, or the Second Information Technology Revolution? Dynamic new combinations between technology, market, and society through open innovation. *Journal of Open Innovation: Technology, Market, and Complexity*, *4*(3), 21.
[5] Ibid
[6] Tu Darmstadt: Platform economyc.om

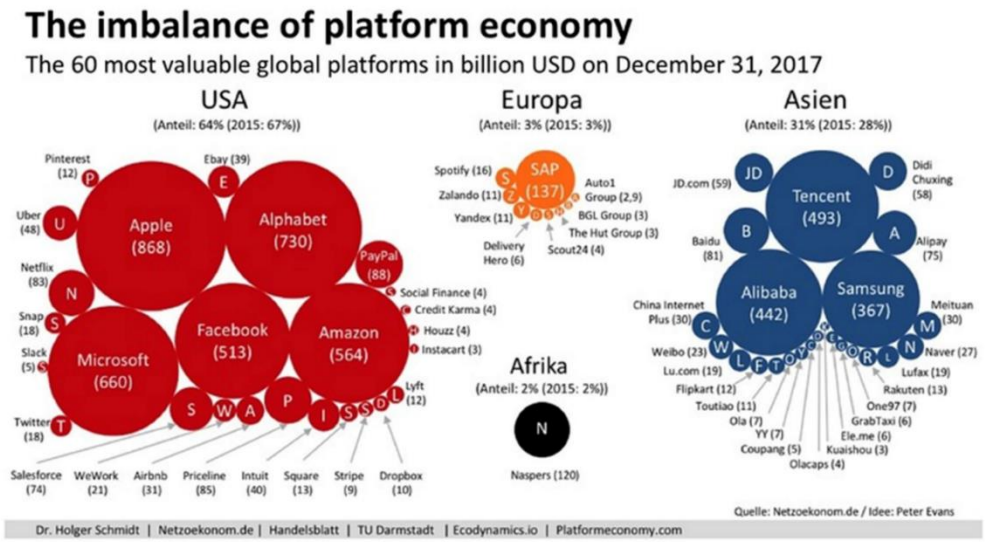

Figure 1 The imbalance of the B2C platform economy[7]

At this moment this imbalance does not exist for Industrial B2B platforms. The current level of consolidation in Industrial B2B platforms is very low. This might be related to the fact that many Industrial B2B platforms are in a very early development stage. Consolidation may be limited by the large heterogeneity across and within sectors.

Figure 2 gives an overview of standardisation initiatives and alliances for the Industrial Internet of Things (IoT). This provides a first indication of the large number of players that appear across several sectors. So far, the market power of individual players appears to be very limited because of the high fragmentation of operations required to enable and operate an Industrial B2B platform.

[7] Ibid

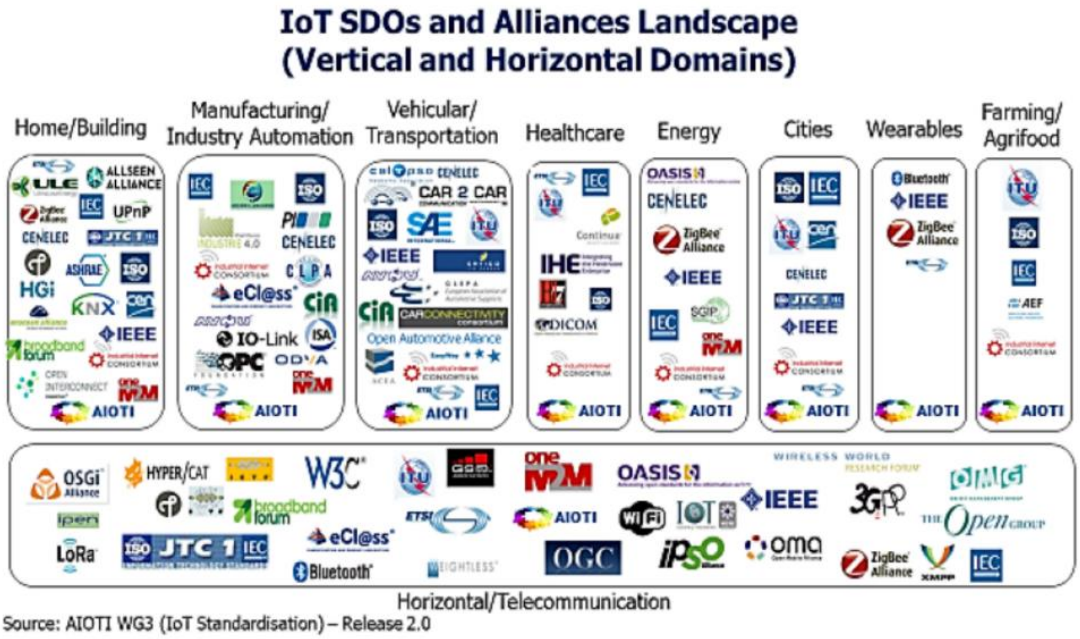

Figure 2 IoT SDOs and Alliances landscape[8]

2.1 Definitions of platforms

Digital platforms can be defined as[9]:
"Evolving 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 modular technological architecture composed of a core and a periphery."

Digital platform like B2C and Industrial B2B platforms contain a set of shared techniques, standards, and interfaces that are open for interaction with a broad set of users who can build what they want on a stable substrate.[10]

Defining B2C platforms

B2C platforms enable the transactions conducted directly between a company and consumers who are the end-users of its products or services. The platform can take the characteristic of an aggregator of products (e.g. Amazon) or services (e.g. Uber, Airbnb, Spotify, etc.). The digital platform serves as aggregator and interface that organises and validates commercial transactions in a secure form, for both the suppliers and the respective consumers.

[8] Source: AIOTI (IoT Standardisation)
[9] Gawer, A. (2014)"Bridging differing perspectives on technological platforms: toward an integrative framework". Research Policy, 43(7), p.1240.
[10] Kenny and Zysman, op cit.

Defining B2B platforms

An Industrial B2B platform can be defined as a collection of shared infrastructures, systems and processes, where the value of the platform is based on data sharing and data exploitation.[11] These platforms are enabled by systems which enable connectivity, data flows and data storage (AI technologies, blockchains, IoT-data aggregators, etc.). Data from industrial production processes, product usage and operations - the 'data footprint' of manufacturing, logistics and aftersales services - play an important role in Industrial B2B platforms.

2.2 Industrial B2B platforms change the industrial landscape

First insights into the logic of operation of Industrial B2B platforms indicate that we might be about to face a radical transformation of the current industrial landscape. This is likely to be enabled by an increasing flow and importance of data exchanges between industrial stakeholders but also by new ways of creating innovations and economies of scale and scope.

Most of the current industrial landscape of production, innovation, and distribution has been conceptualized and operated around linear value chains that are organized under one roof, within one company, based on a silo operation with some connections to suppliers and customers. Through digitalisation such linear operations are becoming more dynamic, resulting in medium and large frontrunning companies. These frontrunners start to cooperate in networks where the suppliers are not only delivering semi-finished products (or final goods), but also become partners in the innovation process of the frontrunners. In such a scheme the frontrunners return data to the suppliers, data that -ideally - will help to continuously improve the products. In this network logic (in which data sharing plays a large role), stakeholders dealing with logistics are interacting in the same way as the aforementioned suppliers.

This network approach requires a move from a linear system of transactions into platforms that aggregate data and share information across firms, systems and products. The aim is to create a better customer experience and intimacy around industrial products with lower costs, as well as to leverage external resources in a more efficient and flexible manner.

New technologies (e.g. AI, Cloud computing and storage, block chain, HPC, etc.) promise large gains in productivity and production flexibility. This creates opportunities and pressures for industry to rush towards a rapid digitalisation shift and the use of Industrial B2B platforms.

Most supply chains continue to be driven by the urgency to reduce costs (i.e., increase profit margins). But currently due to digitalisation customers for both final products and intermediate products are demanding more customized and flexible products and services. Whether we are talking of a car, complex tooling, expensive equipment or machinery for production and processing, costumers want their machines to be customized more appropriately to their needs than before. This is promoting and driving a knock-on effect into supply chains, whereby suppliers of

[11] Parker G., Van Alstyne, M., Choudary, S. P., & Foster, J. (2016). *Platform revolution: How networked markets are transforming the economy and how to make them work for you*. New York: WW Norton

equipment and machinery (capital goods) need to work on their product and services portfolio around modularity and bring their respective suppliers to co-innovate with them to meet the new customer expectations and above all share innovation risks. The focus is no longer on cost efficiency only, also time to market and above all the creation of better customer intimacy and experience are becoming more and more important. How Industrial B2B platforms provide faster response capacity to-customer demand and result in more supply chain cooperation is illustrated by examples like Open Automotive Alliance[12], INTEL[13],TOYOTA[14], etc..

2.3 Industrial B2B platforms stimulate supply chain cooperation

Two detailed examples of the usage of Industrial B2B platforms that stimulate the cooperation between supply chain partners are provided by the Joint venture of Airbus and the German automotive association.

Airbus

Airbus uses a supplier management system that operates in the Cloud to manage all supplier relationships around building an Airbus. An Airbus plane is a highly complex product, every plane despite having the same product platform is different, in color, seats and seating arrangements, alleys, toilets located in different places. Airbus is a conglomerate of many companies that are aggregated in an ecosystem with locations in many different places. Thus, it is important that when a component or subsystem arrives at a given Airbus assembly plant (production is distributed across Toulouse, France; Hamburg, Germany; Seville, Spain; Tianjin, China, and Mobile, Alabama, United States) that the components and subsystems arrive for final assembly with the right specification as required by an Airbus. It was more difficult in the previous non-digital paradigm that uses EDA[15] or EXML[16] to make or trigger any change. Once the company had a layout design (seating or toilets location) it was difficult to reconfigure it through a transactional system with large time lags. Currently, this is all done in real time (in the cloud), Airbus has instant time requests coming, demanding much faster reaction but also enabling co-innovation and co-design in the cloud interacting internally and with its network of suppliers.

This enables the supplier to contribute to faster supply of components and spare parts, but also to participate in the co-design in any component like wings or turbines. This affects linear aspects of the supply chain by replacing them with a continuous space of interaction that is using a digital infrastructure to share data, share systems and a cloud platform to aggregate the right components for the right Airbus as ordered by the client.

Automotive industry (German VDA)

A similar example is provided by the automotive industry with a production platform for automotive products (Daimler, Audi, BMW, Volkswagen, etc.). The platform is

[12] https://www.openautoalliance.net/#about
[13] *https://www.intel.com/content/www/us/en/supplier/overview.html*
[14] https://toyotasupplier.com/
[15] EDA, Exploratory Data Analysis. EDA is the practice of describing the data by means of statistical and visualization techniques to bring important aspects of that data into focus for further analysis.
[16] Extensible Markup Language (XML) is a markup language that defines a set of rules for encoding documents in a format that is both human-readable and machine-readable.

owned by the German Association of Automotive Industry. The participants allow interaction with the platform but keep ownership of some aspects of the data to protect their respective brands, IP and security. The requirements for marketing are conducted through governance based on contract agreements.[17] This is due to the usage of common components. Platform often brings very similar architectural modularities in final products. According to Parker et al., (2016) the issue of participation and competition revolves around agreed "differentiation". [18] The participating brands use the shared supply chain to drive scalability and flexibility to have a faster time to market. Differentiation in this automotive industry is based on how individual brands assemble components and subsystems adapted to the differences of their market segments, this is done in their respective final assembly factories.

The car now has become a platform as well, it gathers data on car performance, user preferences, or uses geo-mapping. What is happening here is that those two platforms (Airbus and VDA) are converging. In the production system for consumer products "mass customization" is the name of the game, companies must be able to produce series of one. Companies must now compete based on cost efficiency but also around a customizing ecosystem encompassing suppliers of all parts and components, thus increasing agility and flexibility of manufacturing operations directly links to design and marketing. There is now a *faster and more direct link between the operational side of manufacturing and the customer side* that without the scalability of involving the whole supply chain via a digital platform would not be able to produce.[19] Customer feedback in B2B relations for manufacturing occurs through post sale services but also through social media like Twitter.[20] There is no more separation between manufacturing and front desk sales since there is now a sort of closed loop that did not exist before.

2.4 The shift towards Industrial B2B platforms requires heavy investments

The new paradigm shift towards Industrial B2B platforms requires heavy investments in the manufacturing, logistics and aftersales services side. This new paradigm is driven and tried by large organisations but not necessarily by smaller companies. A rapid change is occurring where companies are moving from producing things to a situation highly dominated by software and data analytics and firms that concentrate on providing services or solutions. Firms like Siemens or Bosch are all building IoT platforms in their ecosystems these days and General Electric moved to a large extent from manufacturing to software and data analytics.

General Electric

As illustrated in Figure 3 - showing the case of GE Edge system - they are selling not only the service of connecting hardware, sensors and machinery in systems and processes, but also the service of security together with the cloud services. They have created alliances or acquired software companies to cater to the software needs of their IoT services.

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[17] www.vda.de/en.html

[18] Parker G., Van Alstyne, M., Choudary, S. P., & Foster, J. (2016). *Platform revolution: How networked markets are transforming the economy and how to make them work for you*. New York: WW Norton

[19] Scalability is the new source of network effects in scope and scale of flexible production in digital platforms. The cost of flexibility and innovation to a large extent is passed on to suppliers.

[20] Andersson, S., & Wikström, N. (2017). Why and how are social media used in a B2B context, and which stakeholders are involved?. *Journal of Business & Industrial Marketing*, *32*(8), 1098-1108.

Figure 3 GEs Edge to cloud ecosystem

In the Edge to Cloud Ecosystem (ECE) environment the data sensors, equipment, machines, and entire systems are to be connected via and "edge device" integrating information from the traditional PLC[21] used to control machines and equipment linked to the IoT. In turn, Edge devices interact and feed information to the Edge manager that is part of an ecosystem of applications in the GE App Store, where the triad AppStore-GE Certification-App Development is similar to the logic and structure displayed by Apple and Android Platforms running in mobile devises for B2C operations and data flows. In the GE ECE the same functions of the current B2C platforms are conceptualized for the Industrial B2B platform in the following way:[22]

- *Edge device* – Connects, enables updates of non-embedded and non-embedded software and execute commands;
- *Edge Manager* – Monitors, manages and deploys connectivity across systems in the factory/company;
- *GE App store* – Opens a market for sales and purchases of apps, license apps and expose apps to market evaluation and feedback from customers;
- *GE Certification* – Secured gateway, secure access for clients and data, apps certification and evaluation;
- *App Development* – Assembly of apps, testing functionalities in field of application (beta versions) and packaging for customers.

Given the structure of the GE concept it is very likely that a similar business model to Apple and Android in mobile smart devises environments might apply here. However, such a logic is not likely to be applicable for companies developing digital platforms to integrate suppliers of a production network as described for the cases of Airbus or the automotive alliance.

[21] Programmable Logic Controller
[22] https://www.ge.com/digital/blog/what-edge-computing

2.5 Potential resistance to move towards the Industrial B2B platform paradigm

Resistance may exist in some businesses to this paradigm shift. To move towards a platform approach, firms need to lower walls in factories and across suppliers to make the silo culture disappear, within factories and across factories. Most likely CEOs will be struggling to move from an approach driven by cost efficiency and quality towards agility and enhanced customer experience. Most companies are still trying to produce the highest quality product so that once the product is out of the factory there will be little or no need for aftersales service. Their current idea is to sell reliability and high quality without the need for constant contact with the client, which is supposed to happen in the new production paradigm of customer intimacy. Companies moving toward a new paradigm are moving to sell services rather than products. Often, they are not buying the product but just renting it for a short period.

Airbnb and Uber are seen as B2C examples for Industrial B2B platforms. These B2C platforms are already involving their clients in getting feedback that affect business and innovation process, aggregating customer data and preferences to generate new businesses. In a similar fashion companies on the B2B market aggregate data and search patterns based on data about the use of sensors, machines, robots, assembly times and quality, inventories, turnover, logistics, products usage and efficiency, maintenance and aftersales service, etc. Companies organize their suppliers and customers around a digital platform and are trying to replicate the network effects that B2C platforms achieve. It is expected that companies entering early in the Industrial B2B platform development and focus on the identification of patterns and trends based on the data generated by industrial applications and operations are able to develop new business models and generate revenue streams.

The aforementioned definition of a digital platform[23] indicates that a digital platform is a collection of infrastructures, systems and processes that are shared where the value and coordination of economic agents within the platform revolves around data flows. That means that companies need to initially invest heavily in modifications in systems that enable connectivity and data flows, data storage, AI, blockchain, aggregators, etc. Data flows concern amongst others product usage (clients) and operations (manufacture, logistics, aftersales services) connecting both the consumption and production side of the platform. Costumer involvement in the data generation providing real time feedback is changing the game initiated by B2C platforms and now emulated by Industrial B2B platforms.

In B2C platforms consumers receive services or use end products, in Industrial B2B platforms companies purchase or lease machinery. Tools and systems are now more and more connected to the internet and often run on (mobile) software applications (so called apps). This has already created B2B services. An early example was Rolls-Royce plc leasing out its aircraft engines under the concept of “Power by the Hour”. Companies that purchase or lease new systems and machines are now expecting to get information about performance and maintenance on their computers and mobile apps, having information in real time at their fingertips, and have the aftersales service attached to the machine. The logic and expectations of success created by large companies using digital platforms creates a very attractive reference model to replicate. Large companies find it

[23] Parker et al. 2017 op cit.

difficult to change direction but once they realise the need to change, commit and start changing, they move with them their ecosystems of suppliers. In this sense the aggregated macro-economic and industrial restructuring effects of Industrial B2B platforms are expected to be larger than the effects of B2C platforms.

The platform is the aggregator and integrator of an ecosystem of actors that produces and shares data. In addition, the platform aggregates unstructured contextual data generated during the operations of the factories and users to create interpretations for maintenance, services, reparations, insurances, governance and many other aims. This is likely to create tensions concerning the ownership of the data, the monetary value of the data, and who is fundamentally responsible for securing the data. The digital platform is an extension of a systems integration that already occurs with many large brands like Airbus that integrate an ecosystem of suppliers for complex products or services. The operation of the platform is likely to be supported by a number of “contractual agreements” negotiated in bilateral or multilateral fashion between the aggregator and the participants of the platform. Once the platform is legitimized it often dictates or at least influences the behaviours of the users of the platform in the virtual environment that is extended to the production and businesses.

2.6 Industrial restructuring and platform versus a non-platform business model

This section discusses the differences between the competitive model of a B2C platform and those that operate outside the platform model. It also illustrates some rationales as to why the platform model in B2C platforms might serve as example enticing or inducing traditional manufacturing industries into the digital platform model.

During the mid-80’s and throughout the 90’s there was a wave of industrial restructuring based on international subcontracting (off-shoring). This wave gave birth to what we know now as “the globalisation of manufacturing and services” and the so called “global innovation networks”. This process had a significant effect on the industrial landscape affecting the distribution of labour across countries.[24],[25] Competitiveness was based on labour cost and quality such that firms that relocated their manufacturing operations to lower labour cost countries gained a competitive edge. The competitive game has shifted towards the inclusion of an additional organisation layer of innovation (in the form of networks) to remain competitive. This happened especially over the last decade whereby labour in forerunner companies is less of a determinant and innovation networks are considered important to differentiate products and services.[26],[27] The outsourcing of manufacturing operations reduced the risk of unionised staff and sunk costs in machinery and equipment in case of unfavourable demand fluctuations. The new trend in the world of internet and digital platforms takes the practice of leveraging

[24] Pietrobelli, C., & Rabelotti, R. (2008). The Global Dimension of Innovation Systems and Enterprise Upgrading-Linking Innovation Systems and Global Value Chains.
[25] Blinder, A. S. (2006). Offshoring: the next industrial revolution?. *Foreign affairs*, 113-128.
[26] Montalvo, C. (2014). Global innovation and production networks: new rationales and policy challenges. *Can policy follow the dynamics of global innovation platforms?*, 125.
[27] Kinkel, S., & Maloca, S. (2009). Drivers and antecedents of manufacturing offshoring and backshoring—A German perspective. *Journal of Purchasing and Supply Management*, *15*(3), 154-165.

external resources into a new dimension that is transforming the industry in such a way that it creates some dominant digital platforms, mainly in B2C brands.

Currently some dominant digital platforms in B2C markets are partly operating as software driven companies. They are showing the way on how to leverage external resources and create economies of scale and scope that are demand driven. Such companies respond to the question whether they should produce their own output or orchestrate the output of others by increasingly favouring the latter. [28] Table 1 shows some examples of companies operating within the paradigm of non-platform versus platform driven business models. The level of capitalization achieved by digital platforms in less than a decade rivals that of those achieved in the course of a century by traditional non-platform companies.

Table 1 Non-platform company and platform company[29]

Company	**Year founded**	**No. Employees**	**Capitalisation (billion)**
Traditional structure and strategy			
Digital Platform structure and strategy			
BMW	1916	116,000	$53
Uber	2009	5,000[30]	$60
Marriot	1927	200,000	$17
Airbnb	2008	3,000	$21
Walt Disney	1923	185,000	$165
Facebook	2004	12,691	$315
Kodak	1888	145,000	$30
Instagram	2010	13	$1

The limited amount of staff employed by digital platforms to achieve capitalisation is impressive compared to conventional non-platform companies. Such logic revolves around the decision by companies to favour orchestration and outsourcing over production. According to Parker et al. (2017) Apple, Google and Microsoft became the most valuable companies in the world in 2015 [31] due to their platform strategy.

The digital platform based competitive strategy is based on a different principle than the non-platform strategy, since it enable features like offering products or services for free as data exploitation creates business revenues that out-weight the marginal costs of companies operating in the new competitive model. Table 2 presents seven principles on which competitive strategies of non-platform companies and platform companies differ from each other.

[28] Parker, G., Van Alstyne, M., & Jiang, X. (2017). Platform ecosystems: How developers invert the firm. MIS Quarterly, 41, 1, 255-266.
[29] @InfoEcon Data on capitalization and employees 2017.
[30] in the case of Uber 'employees' is a highly controversial topic. See Dudley, G., Banister, D., & Schwanen, T. (2017). The rise of Uber and regulating the disruptive innovator. *The political quarterly*, *88*(3), 492-499.
[31] Parker, G., Van Alstyne, M., & Jiang, X. (2017). Platform ecosystems: How developers invert the firm. MIS Quarterly, 41, 1, 255-266.

Table 2 Non-platform and Platform Competitive strategies [32, 33]

Non-platform	Principles	Digital Platform
Distinct: Buyers, suppliers, substitutes, entrants, rivals	**Market forces**	**Overlap**: consumers-Producers-competitors-complementors
Inhouse *core competences*	**Focus**	**Outside** *core interactions* (partners and customers)
Supply side	**Scale economies**	Demand side
Own inimitable resources	**Assets**	Community and network as asset
Cost leadership/product differentiation	**Goals/Metrics**	Engagement, positive spillovers, just governance (balance platform ecosystem)
Barriers to entry, boulevards for exit	**Access**	Low or non-barriers to entry, open around, key control points
Typically by firm	**Innovation**	Open-By firm and ecosystem

Each of these principles can be explained in the following way[34,35]:

1. Market forces

Traditional competitive strategies of non-platform companies are based on the principle of responding to market forces with clear differentiation between consumers, suppliers, competitors and entrants in existing market segments. In the digital world there is a large degree of overlap between consumers, producers, competitors. For example, new manufacturing technologies like 3D printing creates the opportunity for specialised 3D printing manufacturing equipment to ship away lucrative markets of batches of one in specialised engineering for equipment. The cases of Materialise and Shapeways are typical examples of companies shipping ways for example areas of rapid prototyping. [36] In this way it is increasingly likely that both customers and suppliers can become a companies' competitor and new entrants can quickly impact market share and operating margins.

2. Focus

The focus on the core competences in the non-platform competition remain within the company (e.g., preproduction, specific components, integration, etc.), in the platform context competences (and risks of maintaining them) are coming from key partners outside the company. This represent a shift *from core competences to core interactions* with key partners and customers.

3. Scale economies

[32] Kazan, E., Tan, C. W., Lim, E. T., Sørensen, C., & Damsgaard, J. (2018). Disentangling digital platform competition: The case of UK mobile payment platforms. *Journal of Management Information Systems*, *35*(1), 180-219.
[33] Parker G., Van Alstyne, M., Choudary, S. P., & Foster, J. (2016). *Platform revolution: How networked markets are transforming the economy and how to make them work for you*. New York: WW Norton.
[34] Kazan, E., Tan, C. W., Lim, E. T., Sørensen, C., & Damsgaard, J. (2018). Disentangling digital platform competition: The case of UK mobile payment platforms. *Journal of Management Information Systems*, *35*(1), 180-219.
[35] Parker G., Van Alstyne, M., Choudary, S. P., & Foster, J. (2016). *Platform revolution: How networked markets are transforming the economy and how to make them work for you*. New York: WW Norton
[36] https://www.materialise.com/ ; https://www.shapeways.com/

The way to achieve scale economies shifts from minimising marginal costs for mastering changes from the supply side (e.g., inputs large bulk purchase, labour cost, etc.) for non-platform companies towards changes to the demand side by leveraging data assets and interaction with customers and suppliers for digital platforms.

4. Assets

The orchestrator of the digital platform, being one company or a consortium of companies, will choose to run the platform leveraging open external resources via contracts (to innovate for example) in preference to closed vertical integration or subcontracting. Here according to Parker et al.[37], the locus of value creation and risk bearing moves from inside the firm to outside, focusing on the community and network assets instead of the own imitable resources of the non-platform company.

5. Goals / metrics

Traditional non-platform companies compete based on product leadership and product differentiation, while digital platforms optimize spillovers by creating network effects. In the case of Industrial B2B platforms, the network effects created by the digital platform will be dependent on the number of competing suppliers for the same contracts and the extent to which the orchestrator can replicate the same type of relation in most if not all areas that are related to the actual operations of manufacturing.

6. Access

Access to established markets in the non-platform world have high barriers, while in digital platforms that create substitutes, built on existent infrastructure and excess capacity, there are low or no-barriers to entry.

7. Innovation

In the non-platform world innovation is conducted primarily within a company. In the platform world this is done via the platform ecosystem participants and the risks of innovation is outside the platform realm.

2.7 Comparison between Industrial B2B platforms and the inverted firm

At this point we make a comparison between an *Industrial B2B platform* and *the inverted firm*. An inverted firm can be defined as a firm that dematerializes assets and externalizes core competences into core interactions with partners. Inverted companies organize their business model around an Industrial B2B platform, given the competitive strategy of Industrial B2B platforms, and behave like a software company. The firm has very few capital assets and direct labor under its direct payroll, it primarily leverages external resources.

Up to this point we were still referring to manufacturing companies engaged in the production of physical things, products or capital goods that enable services and how manufacturing firms are likely to be affected by Industrial B2B platforms. For conventional manufacturing firms inverting the firm could be difficult if not impossible. The opportunities to gain network effects and economies of scale changes for companies operating on the logic of the Industrial B2B platforms: their

[37] Parker et al., Op. cit.

business model is increasingly about trading with knowledge, data and the data flows. The marginal cost of scaling up is becoming close to zero, especially for aggregator companies. The rules of competition in the market follow the logic of the Digital Platform as described and summarized in Table 2 above.

Industrial B2B platforms if adopted across leading brands and across sectors, have the capacity to radically transform the landscape of industrial B2B relations for the longer term. Especially for manufacturing in a supply chain network where relationships with specialized suppliers are slowly built up. Such relations require the trust on, reliability and quality of inputs to final products and also supplier's investment must meet standards and certifications required by the client. Once a certified and trusted supplier base is established the ecosystems of the Industrial B2B platform is relatively stable for the long term (e.g. suppliers are able to meet standards, time lags, quality, quantity, and often even finance their clients, etc.). In a way from the perspective of the platform orchestrator the loyalty of suppliers participating in the platform, once formalized in contracts, is difficult to lose.

2.8 Industrial B2B platforms: benefits, costs and risks for companies

A recent survey presents information as to why industrial companies are engaging in digitalisation of their business operation. [38] The survey analyzed the yearly corporate reports of about one hundred large companies regarding their strategic outlook on digitalisation and the reasons for engagement. The reasons for engaging, their priority and significance are listed below in diminishing ranking order along a scale of efficiency-growth[39]:

- Efficiency, productivity and cost optimization (70% of respondents);
- Regulation compliance and management (10% of respondents);
- Experience enhancement (48% of respondents);
- Connected ecosystem (20% of respondents);
- Business model innovation (30% of respondents);
- Strategic digitalisation of enterprise (10% of respondents).

Despite the enthusiasm reported in some instances the reality is that there seems to be precaution in the investment and engagement in Industrial B2B platforms. The level of priority given to digitalisation of the enterprise in reference to growth points out the low relevance to be part of a digitally connected ecosystem and corresponding lack of strategic outlook of digitalisation for a large majority of the companies surveyed. Such outlook is related to the mix and pay-off of expected benefits, costs and risks involved in the digitalisation process. Some of these are outlined below.

The outlook of benefits, costs and risks associated with the participation of manufacturing companies in Industrial B2B platforms is contingent upon a number of developments:

1. First, the deployment of deep digitalisation in the medium and long term by dominant large firms in the manufacturing sector generates pressure and

[38] Infosys (2018). *The new champions of digital disruption: incumbent organisations*. Bangaluru: Infosys Limited,
[39] Ibid

demands in the manufacturing B2B trade of intermediate, consumer and capital goods;

2. Second, as the process of industrial B2B platform deployment is pushed by companies delivering large complex products integrators (e.g., automotive, logistics, aviation, consumer electronics, maritime, specialized health equipment, military and security, etc.), their respective tiers of suppliers are likely to be pulled into the trend as well. Those suppliers most likely have interest to participate and benefit by securing a place in the next wave of industrial change. We assume then that those companies lagging behind in the uptake of the digital transformation will be marginalised and perhaps benefiting less from the industrial transformation promised by industry 4.0.
3. Third, the process is seen by industry leaders, policy makers as an ongoing and accelerating process enabled by new technologies and industrial geopolitical competition. This is seen in some instances by industry and policy making as a race that Europe's manufacturing sector cannot afford to lose.

3 Typology of Industrial B2B platforms

This report makes a distinction between 3 interrelated Industrial B2B platform types: *Innovation hub, Business platform* and *Data platform* (see Figure 4).

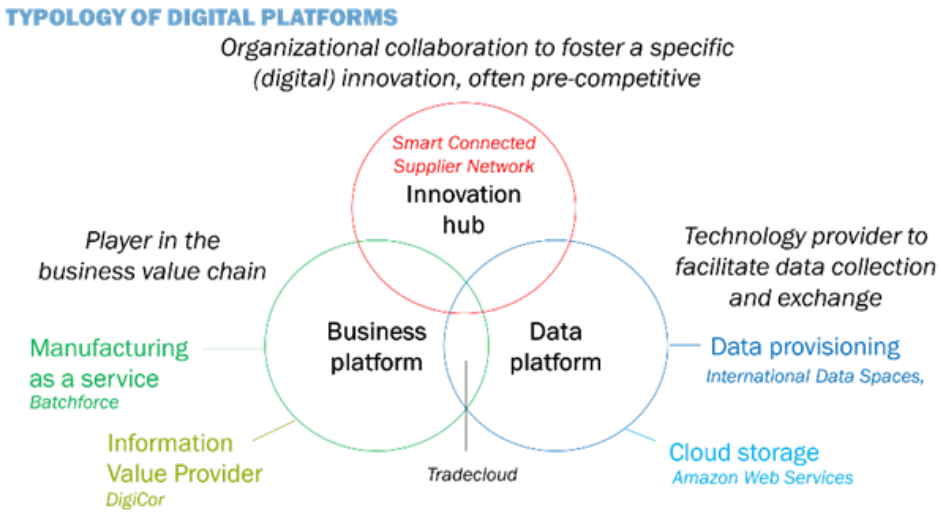


Figure 4 Typology of industrial B2B platforms

The typology is based on the core activities of the initiative, whereby it should be noted that many platforms share characteristics of multiple types.

3.1 Innovation hubs

'Innovation hubs' concern partnerships, in which companies knowledge and / or education institutes or the government work together on developments to digitalise the manufacturing sector (Smart Industry, Industry 4.0) or other sectors.[40] *"The innovation hubs are based upon technology infrastructure (competence centre) and provide access to the latest knowledge, expertise and technology to support their customers with piloting, testing and experimenting with digital innovations."*[41] An example of an Innovation hub is the Smart Connected Supplier Network.[42]

The innovation hub Smart Connected Supplier Network[43] focuses *"on the development of a networked high-tech supply chain for easier data sharing, to provide quick access to product and design data. The involved partners collaborate on the following topics: easy data sharing, reliable data sharing, and interpretation of shared data. The objective of this innovation hub is to enable an improved collaboration in the supply network of high-tech OEMs, making them more efficient and reliable as well as improving the time-to-market. This should increase the*

[40] van der Zee, F., Goetheer A., and Gijsbers G. (2016), Staat van Nederland Innovatieland, https://www.tno.nl/media/8806/de_staat_van_nederland_innovatieland_2016.pdf.
[41] http://s3platform.jrc.ec.europa.eu/digital-innovation-hubs
[42] https://smartindustry.nl/8-smart-connected-supplier-network/
[43] https://www.smartindustry.nl/wp-content/uploads/2018/06/TNO-2018-R10453-OECD-report-Going-Digtal-Smart-Industry-field-labs-final-May-31-2018-final.pdf

overall attractiveness of the Dutch high-tech supply cluster for high-complexity, high-mix, low volume manufacturing."

3.2 Business platform

A business platform may be part of an innovation hub. 'Business platforms' are typically multisided platforms that bring together supply and demand in different forms; they are often referred to as 'marketplaces'. Multisided platforms *create value* primarily by enabling direct interactions between two (or more) distinct types of affiliated customers[44]. In the B2C-domain these include platforms such as Uber, AirBnB, etc. In the literature this always refers to the aforementioned platform economy (e.g. Zysman and Kenny, 2015[45], Zysman and Kenny, 2016[46], Langley and Leyshon 2017[47]). Many of these platforms are driven by digital techniques and digital techniques also ensure a changing structure of these platforms.

Batchforce and Tradecloud are examples of business platforms that are linked to the innovation hub Smart Connected Supplier Network (see Figure 5). Tradecloud aims to streamline procurement processes, by enabling data sharing of orders and invoices between customers and suppliers and by providing value-added services.

Next to these platforms Smart Connected Supplier Network also cooperates with business platform Batchforce in the European project Market 4.0[48]. Batchforce[49] is an example of an online platform providing third party manufacturing capacities to industrial customers. This platform has a focus on CNC machining and 3D printing which it provides based on the principle of 'manufacturing-as-a-service'; it leverages production assets of third parties with spare CNC/3D printing capabilities.

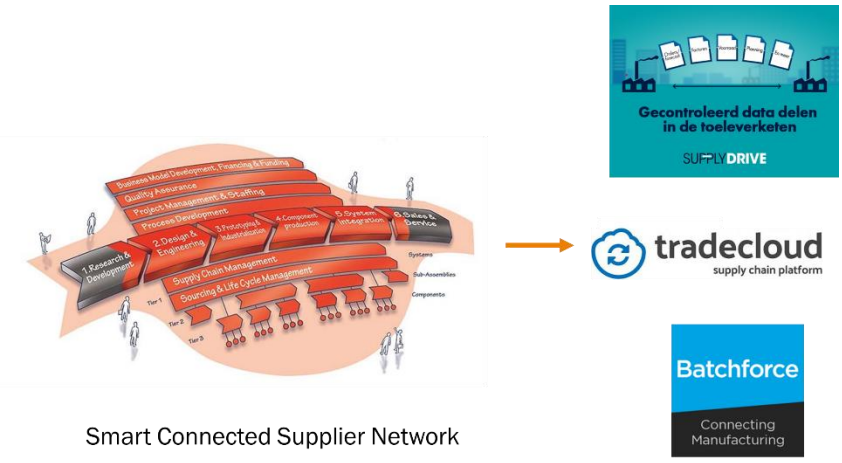


Figure 5 Example of business platforms being part of an innovation hub

[44] Hagiu A., and Wright J., (2011), Multisided Platforms, Working Paper 12-024, Havard Business School, http://www.hbs.edu/faculty/Publication%20Files/15-037_cb5afe51-6150-4be9-ace2-39c6a8ace6d4.pdf
[45] *John Zysman*, Martin Kenney (2015). "*Choosing a Future in the Platform Economy:The Implications and Consequences of Digital Platforms"* (PDF). UC Berkeley.
[46] Kenney M., Zysman J. (2016) "The Rise of the Platform Economy". *Issues in Science and Technology, https://issues.org/the-rise-of-the-platform-economy/*
[47] Langley, P. and Leyshon, A. (2017) 'Platform capitalism : the intermediation and capitalisation of digital economic circulation.', *Finance and society.*, 3 (1). pp. 11-31.
[48] For more details about Market 4.0 see http://futuring2030.eu/
[49] https://www.batchforce.com/nl/

As is shown in this example, business platforms can be divided in two types:

1. **Manufacturing as a service platform:** With this platform we refer to platforms that bring together customers searching for a specific manufacturing service and suppliers providing them.[50] Such platforms help for instance product designers and engineers to find the fastest and most price competitive manufacturing solution nearby, like 3D printed and CNC parts. Examples of such platforms are the aforementioned platforms Batchforce and 3D Hubs.[51]

   3D Hubs is a platform for 3-D printing for the B2B market. Before October 2018 the platform was also active on the B2C market.[52] The platform currently offers 3D printing services in more than 140 countries. [53] In an increasing number of countries, 3D Hubs is inviting a select group of top-performing B2B suppliers to become Manufacturing Partners. These partners adhere to the quality standards of 3D Hubs, enabling 3D Hubs to support customers.[54] Other examples of platforms providing Manufacturing as a service are presented in the left hand side of Figure 6.

2. **Information value providing platform that provides value added data services:** this type of platform refers to platforms that offer data sharing services.[55] For instance for orders and invoices, planning and control (e.g. Tradecloud,) or to provide a 'yellow pages' type of service so that customers are able to find the supplier they are looking for. An example of a platform that provides a 'yellow pages' type of service is Digicor. Digicor supports the integration of SMEs into the complex supply chain of large OEMs.[56] Other examples of Value added data service platforms are provided on the right hand side of Figure 6.

[50] Fisher O., et al., (2018), Cloud manufacturing as a sustainable process manufacturing route, *Journal of Manufacturing Systems*, 47 (2018) 53–68
[51] https://www.3dhubs.com/
[52] https://tweakers.net/nieuws/143317/3d-hubs-laat-particulieren-met-3d-printer-niet-meer-toe.html
[53] https://www.3dhubs.com/jobs
[54] https://www.3dhubs.com/blog/3d-hubs-from-3d-printing-to-manufacturing/
[55] Jay Lee*, Hung-An Kao, Shanhu Yang (2014), Service innovation and smart analytics for Industry 4.0 and big data environment, *Procedia CIRP* 16, 3 – 8 https://ac.els-cdn.com/S2212827114000857/1-s2.0-S2212827114000857-main.pdf?_tid=fb047de8-19d0-41e8-9403-8bd01a9c620f&acdnat=1551454246_ebf2506e4617b2c736aa61b9f48f4e13
[56] https://www.digicor-project.eu/

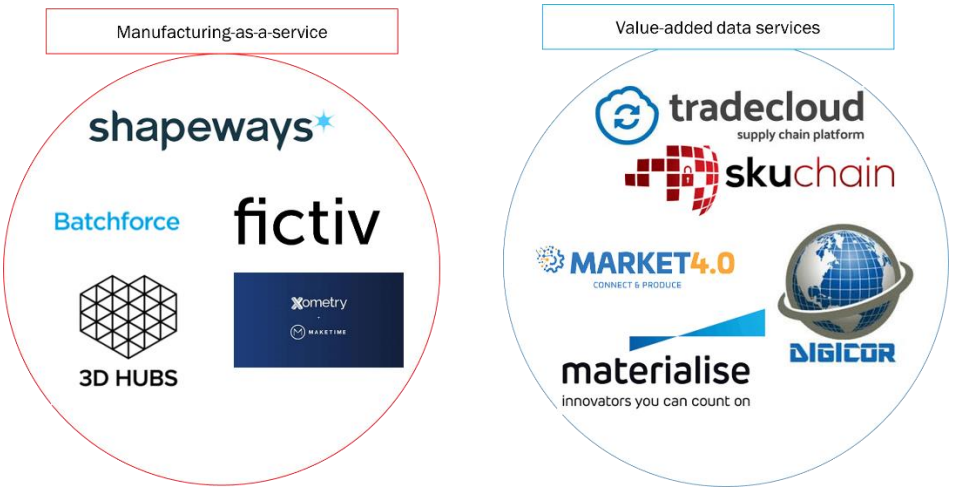


Figure 6 Examples of Manufacturing as a service platforms and Value-added data service platforms

3.3 Data platform

'Data platforms' involve all kinds of architectures for data exchange. Their core focus is to facilitate date exchange and its constituents provide software and services. An example is the Industrial Internet Reference Architecture.[57] "*The Industrial Internet Reference Architecture is a comprehensive architectural template to help developers and software architects design and build their industrial IoT systems based on industry recommended approaches.*"[58] Other examples include the International Data Spaces[59] and MindSphere (see Figure 7).

A distinction can be made between **reference architectures** and actual **data services platforms.** implementing such architectures (connectors, brokers, connectivity services, etc.). Providers of data services often play a role in the definition of reference architectures.

Standards play an important role in this type of platforms. On one hand to achieve interoperability, on the other hand to create network effects to support the business of its constituents. Data platforms are often linked to one or more specific domain-specific business platforms (e.g. Uber, which is a business platform for personal transport with an underlying data platform). This is where business and data platforms come together and their business models interact. If a business platform is based on a decentralized data platform, based on the principles of data sovereignty, it is likely that this puts the position of the traditional intermediary under pressure ('Uber concept' without 'Uber Inc.', but with a better market position and profit margin for the individual taxi operator).

[57] https://www.iiconsortium.org/IIRA.htm
[58] https://blogs.grammatech.com/the-industrial-internet-reference-architecture-and-security-framework
[59] For more details about the Industrial Data Spaces see the white paper: https://www.fraunhofer.de/content/dam/zv/en/fields-of-research/industrial-data-space/whitepaper-industrial-data-space-eng.pdf

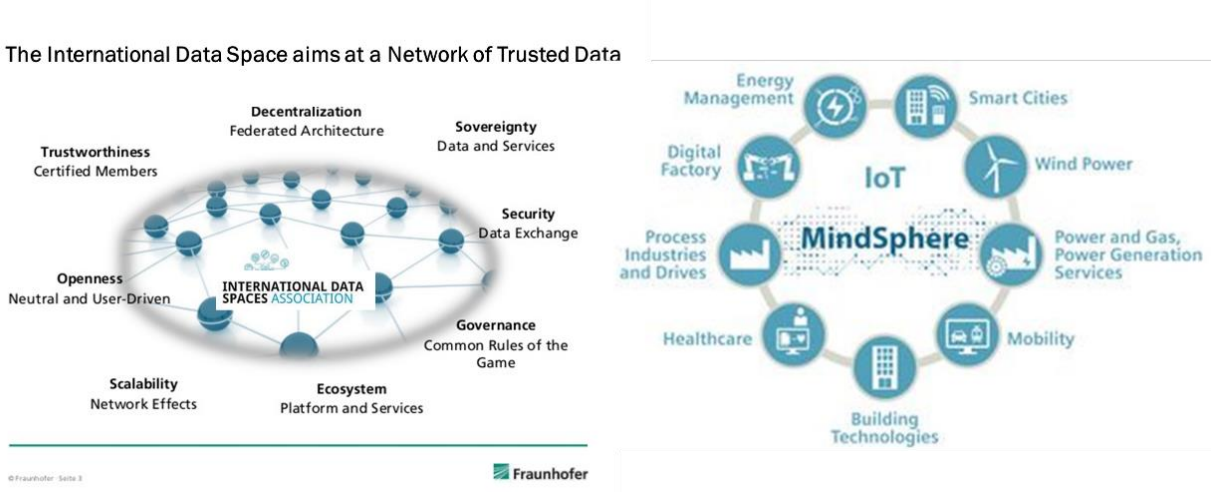


Figure 7 Examples of dataplatforms

International Data Spaces (IDS) aims to create a decentralized "*virtual data space in which partners in business ecosystems can securely exchange and easily link their data assets. The main goal of the International Data Spaces is to facilitate the exchange of data between Data Providers and Data Users"*.[60] The German government took the initiative for this platform in 2014, together with representatives from business, politics, and research. The aim of the platform is to accelerate the digital transformation in all sectors by providing them 'data sovereignty'. IDS can be characterized as a reference architecture, implemented by multiple software companies.

MindSphere, driven by Siemens, "*is a distributed two-sided open platform to connect the IoT and leverage its combined power through services and Apps. MindSphere is the cloud-based, open IoT operating system from Siemens that connects products, plants, systems, and machines, enabling to analyze data generated by the Internet of Things (IoT) with advanced analytics. MindSphere collects and analyzes all kinds of sensor data in real time"*.[61] It can be characterized as a data services platform. The commercial version was launched in 2014. The company seeks active collaboration with other providers of services and platform initiatives.

[60] https://www.fraunhofer.de/content/dam/zv/en/fields-of-research/industrial-data-space/whitepaper-industrial-data-space-eng.pdf
[61] https://www.siemens.com/global/en/home/products/software/mindsphere.html

4 Current situation of Industrial B2B platforms

In this chapter we compare examples of industrial B2B platforms in Europe one hand and the U.S. and Asia on the other hand (see Table 4). The Annex contains a more comprehensive list of examples.

4.1 Industrial B2B platforms in Europe

Innovation hubs to set up a data platform or business platform
Industrial B2B platforms in Europe are often developed in cooperation between businesses, sector organizations and academia. Complementary partners come together to co-create data platforms such as FIWARE[62] and International Data Spaces .

FIWARE is an initiative to provide a data platform and a set of standardized APIs to support the creation of Smart Applications in various sectors. It initially started in 2011 as an EU's Seventh Framework Programme.[63] FIWARE is actually a technical interface description for sharing 'real-time' open data. It started in the Smart City domain but is currently also available for other domains like manufacturing. In many European projects they have taken part in a blue print and in use cases. For the parts in the blueprint, reference implementations took place.

Such co-creating activities are often initiated by public-private partnerships or innovation hubs like the aforementioned Smart Connected Supplier Network focusing on supply chain collaboration for high-tech manufacturing. Another example, in a different domain, is the public private partnership of SmartFactoryKL[64] in Kaiserslautern (Germany), an innovation hub of more than 45 member organizations from industry and research. These partners cooperate in research and development projects related to the factory of the future and data sharing within the factory.

In all these instances the innovation hub was used to set-up a data platform or business platform.

Platforms are often initiated via European projects
European Industrial B2B platforms like IDS[65], FIWARE[66], Far-Edge[67] and ARROWHEAD[68] are often (co-) funded by public parties like the German government (e.g. IDS) or via projects (partly) funded by the European Commission (e.g. FIWARE).

FAR-EDGE is a data platform which provides a blueprint solution for industrial automation based on edge computing, which uses blockchain technologies to

[62] https://www.fiware.org/about-us/
[63] https://scholarspace.manoa.hawaii.edu/bitstream/10125/50615/paper0728.pdf
[64] https://smartfactory.de/
[65] https://www.internationaldataspaces.org
[66] https://www.fiware.org/about-us/
[67] https://www.edge4industry.eu/
[68] http://www.arrowhead.eu/about/general-overview/

synchronize digital information models with the actual status of the factory.[69] It has been initiated via a European H2020 project. [70, 71]

ARROWHEAD is a data platform that was initiated via a FP7 project.[72] It provides an IoT Framework for factory automation that addresses interoperability across multiple Service Oriented Architecture (SOA) technologies. With these features, the Arrowhead Framework enables the design, engineering, and operation of large automation systems for a wide range of applications utilizing IoT and CPS (Cyber Physical System) technologies.

Information value providers
Industrial B2B platforms that can be characterized as value information providers (e.g. sharing of invoices and orders) occur a lot in Europe. Examples of these platforms are the aforementioned Digicor[73], and Tradecloud[74]. Such platforms can be distinguished from platforms providing manufacturing-as-a-service and leave more room to play for individual manufacturing companies. Initiatives such as Market 4.0[75] have similar aims.

Data platforms: reference architectures and decentralized approaches
Several architectures for data provisioning have emerged in Europe, focusing on creating, preparing, and enabling data to its user. Examples of these platforms are the aforementioned International Data Spaces[76,] and FIWARE[77].

In many cases these architectures provide a decentralized approach: using distributed data architectures. They enable users the opportunity keep full control over their own data. This differs from approaches in which data is stored on a central cloud platform, with a centralized architecture like Amazon Web Services (AWS).[78] AWS will be further discussed in the section about cloud platforms later in this chapter. Nevertheless, decentralized approaches are not unique to Europe alone. An example of a business platform with a decentralized architecture in the U.S. is SKUchain. SKUchain is a private initiative that empowers stakeholders in a global value chain based on blockchain.[79] They store supply chain data on a blockchain.[80]

[69] https://www.edge4industry.eu/knowledge-base/articles/digital-twin-digital-modelling/
[70] http://www.faredge.eu/#/
[71] https://www.edge4industry.eu/2018/02/15/h2020-far-edge-project-factory-automation-meets-edge-computing-blockchain-technology/
[72]https://webcache.googleusercontent.com/search?q=cache:gmZSsAaPmnIJ:https://cordis.europa.eu/project/rcn/111279_en.html+&cd=3&hl=nl&ct=clnk&gl=nl
[73] https://www.digicor-project.eu/
[74] https://www.tradecloud1.com/en/
[75] https://www.market40.eu
[76] https://www.fraunhofer.de/content/dam/zv/en/fields-of-research/industrial-data-space/whitepaper-industrial-data-space-eng.pdf
[77] https://www.fiware.org/foundation/
[78] https://aws.amazon.com/
[79] www.skuchain.com
[80] Ibid

Table 4 Differences between platforms in Europe, the U.S. and Asia

	Europe	US	Asia
Public initiatives	Mainly in Europe often via EU projects (FIWARE, IDS, Crystal, FarEdge, ARROWHEAD, DigiCor)		
Private initiatives	(MindSphere, SAP hana)	Mainly in the VS via start-ups (Xometry, MakeTime, Fictiv)	
Manufacturing as a service	(BatchForce, 3dHubs)	Mainly in the VS via start-ups that focus on Manufacturing as service (Xometry, MakeTime, Fictiv)	(3ERP)
Information value provider	Mainly in Europe (is a new role) (DigiCor, TradeCloud)	(SkuChain)	
Data provisioning	Mainly in Europe (IDS, FIWARE, Tradecloud)	(SkuChian)	
Cloud platform	(SAP hana, Axoom of Trumpf)	Mainly in the US (AWS, Microsoft Azure)	(Alibaba cloud)
Centralized architecture	Used in Europe, for manufacturing as a service and for data provisioning via cloud platforms	Used in the VS, for manufacturing as a service and for data provisioning via cloudplatforms	
Decentralized architecture	Often in Europe and mainly for data provisioning (IDS)	(SkuChian (based on blockchain))	
Innovation hubs that initiate platforms	Mainly in Europe (SCSN, SBF, SDF)		
Business model	Various solutions App store, percentage of the orders, selling services	Various solutions App store, percentage of the orders, selling services	

4.2 Industrial B2B platforms in the U.S. and Asia

Initiated via start-ups
Industrial B2B platforms in the U.S. are often private initiatives. They are often funded and initiated by start-ups and based on investments of venture capitalists. Examples of these platforms are Xometry[81], MakeTime[82] and Fictiv[83].

Xometry[84] is an Industrial B2B platform that connects industrial parts, manufacturers and buyers in a system similar to Uber, Amazon and other (B2C) platforms. It allows buyers to upload their 3D models, specify the materials, features and components. They will also receive feedback on pricing, lead times and the best manufacturing processes. Buyers can review manufacturer profiles and rankings and make purchase decisions. Manufacturers, especially mid-market companies engaged in sheet metal fabrication, 3D printing and urethane casting, can join the partner network to serve as a seller of the platform.

MakeTime[85] is an Industrial B2B platform that enables companies to produce machined components quickly and more efficiently. MakeTime does this by collecting unused CNC machine time from qualified machine shops across the United States. MakeTime's software helps customers streamline time-wasting processes, gives insight and transparency in the process, overcomes capacity shortages, and gives insights in the pricing. Their goal is to make CNC machining production straightforward. MakeTime is in 2018 acquired by Xometry.

Fictiv's manufacturing platform[86] pairs intelligent workflow and collaboration software with Fictiv's global network of manufacturers. From prototype to production, Fictiv helps hardware teams work and bring products to the market faster. Fictiv created a two sided platform that is used by machine shops and designers. Machine shops upload availability and designers upload CAD files. Fictiv aggregates orders and routes designs to open machines.

Platforms focusing on Manufacturing as a service
In the US there are many examples of platforms with a servitization role. They focus for instance on manufacturing as service (e.g. platforms that support product designers and engineers to find the fastest and most price competitive manufacturing solution nearby, like 3D printed and CNC parts), like the aforementioned Xometry[87], MakeTime[88], Fictiv[89] or Protolabs[90].

[81] https://www.xometry.com/
[82] https://www.maketime.io/
[83] https://www.fictiv.com/
[84] https://www.xometry.com/
[85] https://www.maketime.io/
[86] https://www.fictiv.com/
[87] https://www.xometry.com/
[88] https://www.maketime.io/
[89] https://www.fictiv.com/
[90] https://www.shapeways.com/

However, there are also some examples of Manufacturing-as-a-Service platforms in Europe like the aforementioned Batchforce and 3DHubs. Shapeways[91] is a platform example based in the U.S. but founded in the Netherlands. In Asia there are also similar Manufacturing- as-a-Service platforms like **3ERP**, (which focuses among others on 3D Printing, CNC tooling)). [92]

Cloud platforms

Large cloud platforms like Amazon Web Services (AWS) and Microsoft Azure are initiated in the US and Asia (Alibaba).[93] AWS, Microsoft Azure, and Google Cloud are dominating the cloud field and became more dominant over the last years. [94] These cloud platforms enable many Manufacturing-as-a-service platforms like 3D Hubs and Batchforce, which use them to store their data on a central cloud location. This dependency has recently raised concern on a political level whether the current technological and legal frameworks for data protection are sufficient in the long run (as this dependency increases) and what role Europe can play itself in this competitive landscape.[95]

AWS [96] is the world's largest cloud services platform. AWS is the basis of the success of companies such as AirBnB, NetFlix, Pinterest, Spotify and others. It offers a huge range of services and APIs. AWS is even used by the public sector in the U.K..[97] The AWS cloud platform is being used to host part of the Cabinet Office's Crown Marketplace portal in the U.K..[98]

Microsoft Azure[99] is a cloud computing service created by Microsoft for building, testing, deploying, and managing applications and services through a global network of Microsoft-managed data centers. It provides software as a service (SaaS), platform as a service (PaaS), infrastructure as a service (IaaS) and supports many different programming languages, tools and frameworks, including both Microsoft-specific and third-party software and systems.

Alibaba[100] is one of the biggest companies in China that provides consumer-to-consumer, business-to-consumer and business-to-business sales and various other services via e-commerce web as well as offline portals. The major revenue earning services include electronic payment services, marketplace, and data-centric cloud computing.

[91] https://www.shapeways.com/
[92] https://www.3erp.com/services/3d-printing/, https://www.aniwaa.com/best-of/3d-printers/best-3d-printing-services/
[93] https://solutionsreview.com/cloud-platforms/gartner-magic-quadrant-public-cloud-infrastructure/
[94] Ibid
[95] https://www.faz.net/aktuell/wirtschaft/diginomics/altmaier-plan-europa-soll-seine-eigene-cloud-gaia-x-bekommen-16346646.html
[96] https://aws.amazon.com/
[97] https://www.computerweekly.com/news/252455417/AWS-secures-cloud-hosting-role-in-UK-government-Crown-Marketplace-programme
[98] Ibid
[99] https://azure.microsoft.com/nl-nl/
[100] https://www.alibabagroup.com/en/global/home

An example of a European cloud platform is SAP HANA[101]. Which is a small player on the global cloud platform market compared to giants like AWS and Google cloud.[102]

4.3 Industrial B2B platforms covering different parts of the factory or the supply chain

An analysis of the existing Industrial B2B platforms indicates that the Industrial B2B platform landscape is scattered. This means that most platforms have their own niche and most of them are covering a very specific part of the automation pyramid within the factory or the supply chain (see Figure 8 for some examples).
Building further on the European Connected Factories study a distinction can been made between[103]:

1. **Autonomous Smart Factories:** This concerns digital platforms inside the factory, with a focus on intra-factory automation and optimization.
2. **Hyper Connected Factories:** This concerns digital platforms within the supply chain, with a focus on networked enterprises and data sharing within the supply chain.

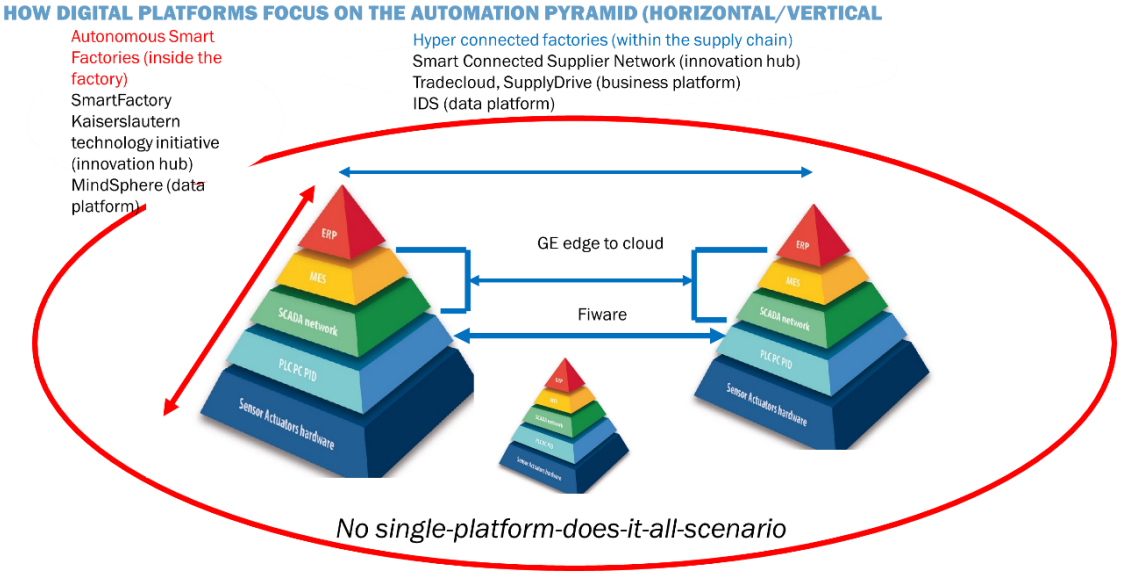


Figure 8 Industrial B2B platforms focusing on the automation pyramid[104]

Examples of Autonomous Smart Factories and Hyper connected Factories are provided in Table 5:

[101] https://www.sap.com/netherlands/products/s4hana-erp-cloud.html
[102] Gartner: https://solutionsreview.com/cloud-platforms/gartner-magic-quadrant-public-cloud-infrastructure/
[103] Connected Factories Study: https://www.effra.eu/pathways-digitalisation-manufacturing
[104] Ibid

Table 5 Examples of Autonomous and Hyperconnected factory platforms

Autonomous Smart Factories (Inside the factory)	
Smart Factory Kaisers-Lautern	*"SmartFactoryKL is a platform of more than 45 member organizations from industry and research. These member organisations perform research and development projects related to Industrie 4.0 and the factory of the future. "*[105]
MindSphere	*"MindSphere is a distributed two-sided open platform to connect IoT and provides services and Apps. MindSphere is the cloud-based, open IoT operating system from Siemens that connects products, plants, systems, and machines, enabling to analyze data generated by the Internet of Things (IoT) with advanced analytics. MindSphere collects and analyzes all kinds of sensor data in real time."*[106]
Amazon AWS (USA)	*"Amazon AWS is a cloud-based data platform that provides data services including compute, storage, databases, analytics, networking, mobile, developer tools, management tools, IoT, security and enterprise applications."*[107]
BOSCH IoT Suite	*"The Bosch IoT Suite is a comprehensive toolbox for IoT developers and offered as a Platform-as-a-Service (PaaS). The platform provides key middleware capabilities needed to build sophisticated IoT applications. Thereby the IoT platform serves as the technical foundation on which Bosch and its customers realize a broad range of solutions and projects."*[108]
BOSCH Rexroth Service	*"Bosch Rexroth provides a set of services for connected automation for Industry 4.0 at the device level. It provides services for modernization, reparation, spare parts, field servicing, product overhaul, servicing agreements, predictive maintenance."*[109]
C-Labs C-DEngine	*C-Labs C-DEngine, a scalable IoT software platform, supports large distributed networks of machines, devices, and 'things.' "C-DEngine can be embedded into machines and devices or run on gateways, hubs, and proxies to bridge between legacy devices and modern infrastructure."*[110]
Celos	*CELOS provides am holistic user interface of shopfloor machines, schedule production operations, as well as integration with ERP, MES, PDM and CAD/CAM systems.*[111]
Hyperconnected Factories (throughout the supply chain)	
GE Edge to cloud	In the Edge to Cloud Ecosystem (ECE) environment the data sensors, equipment, machines, and entire systems are connected via and "edge device" integrating information from the traditional PLC[112] used to control machines and equipment linked to the IoT.[113]
FIWARE	*FIWARE is an initiative to provide a platform and standardized APIs to support the creation of Smart Applications in various sectors. It initially started in 2011 as an EU's Seventh Framework Programme.*[114]
IBM Bluemix	*IBM Bluemix is s cloud platform that spans public, private and hybrid environments. Build with advanced data and AI tools.*[115]
International Data Spaces (IDS)	*"IDS is a virtual data space in which firms can set up protocols for data exchange and linking, while providing policies for managing security and confidentiality."*[116]
MS Azure	*"Microsoft Azure is a cloud computing service created by Microsoft for building, testing, deploying, and managing applications and services through a global network of Microsoft-managed data centers. It provides software as a service (SaaS), platform as a service (PaaS) and infrastructure as a service (IaaS) and supports many different*

[105] https://smartfactory.de/
[106] https://www.siemens.com/global/en/home/products/software/mindsphere.html
[107] https://aws.amazon.com/
[108] https://www.bosch-iot-suite.com/
[109] https://www.boschrexroth.com/en/xc/service/industrial-applications/service-industrial-applications
[110] https://internet-of-things.cioreview.com/vendor/2015/c-labs
[111] https://celos.dmgmori.com/
[112] Programmable Logic Controller
[113] https://www.ge.com/digital/iiot-platform/edge-to-cloud
[114] https://scholarspace.manoa.hawaii.edu/bitstream/10125/50615/paper0728.pdf
[115] https://www.ibm.com/cloud/
[116] http://www.industrialdataspace.org/en/

	programming languages, tools and frameworks, including both Microsoft-specific and third-party software and systems."[117]*:*
Oracle cloud	*Oracle cloud*[118] *provides SaaS enterprise applications for supply chain management, ERP, monitoring, quality assurance, and data analytics*
Plex	*"Plex Manufacturing Cloud provides SaaS enterprise applications for supply chain management, production, inventory, shipping. Plex is created for manufacturing industries, including automotive, aerospace, food & beverage, and life sciences or medical manufacturing.* **"**[119]

The analysis of existing Industrial B2B platform examples, and the discussion with experts indicate that there is currently no single business platform for autonomous Smart Factories that cover the whole automation pyramid. Also, there are no hyper connected factory platforms that connect the whole automation pyramid with the complete automation pyramids of other firms within the supply chain (e.g. by connecting all layers between various automation pyramids).

[117] https://azure.microsoft.com/en-us/
[118] https://www.oracle.com/cloud/index.html
[119] http://www.plex.com/

5 Industrial B2B platform scenario's

5.1 Introduction

In this chapter we will introduce several concepts to assist in the process of finding potential future strategies in the field of industrial B2B platforms.

The development of platforms and what is now known as the platform economy is the result of a combination of two main developments:

1) First the liberalization of the Western economies that started in the 1980s with its emphasis on small government and free markets. Together with the ICT revolution and the emergence of the Internet as a transformative power we are witnessing the rise of new types of markets and market models. The Internet enabled the emergence of online retailers such as Amazon and Bol.com which have grown very rapidly and are wielding increasing market power.

2) Another development is the 'sharing economy' with the Internet enabling peer-to-peer exchanges of goods and services. Everything from second-hand goods to tools to household help can be exchanged directly between users. As such the idea was (in the 1990s and 2000s) that the Internet would have a strong effect of 'disintermediation' i.e. doing away the need for middlemen in transactions. However, what we have seen rather than the disappearance of the middleman is the emergence of a new class of Internet-based intermediaries.[120] Often adopting the language of the sharing economy, e.g. offering vacant rooms (Airbnb) or transportation services (Uber) they have become new global monopolies. Or, if they have not yet become global monopolies their investors are willing to absorb company losses for as long as it takes for the company to establish itself as the global monopoly. The network effects that are key to the platforms ensure that the larger the number of suppliers and users, the more useful it will be to both. In the end this leads to a global monopoly and a winner-takes-all scenario which will reward investors handsomely. In a nutshell this is what occurred in the area of Business-to-Consumer (B2C) networks. The question here is to what extent Industrial B2B platforms, which are Business-to Business (B2B) in nature will follow a similar path, or whether they are so different (in nature or with regard to context) that they will follow different paths.

5.2 The changing international context

This question becomes more relevant in the changing international context that has characterized the world economy since 2010. First there were the effects of the Great Recession which lead to a severe slowdown in economic growth across the world. Protectionist tendencies made themselves more strongly felt as a result and a new wave of populist policies took aim at earlier economic policies of openness, free markets and multilateral trade regimes. The election of Donald Trump as president of the U.S, the Brexit decision in the UK, and the rise of a movement of

[120] Ryan, C. (2000) How disintermediation is changing the rules of marketing, sales and distribution. In: *Interactive Marketing*. Vol. 1 No. 4. PP 368-374. April/June 2000.

yellow jackets in France are all expressions of a changing political environment. At the same time and related to this there is growing resentment against the growing power of China, both economically and politically. Fears of job losses as a result of outsourcing are compounded by worries about 'technological unemployment' caused by rapid automation and robotization. A final factor here is that countries are increasingly seeing technology as a new source of competitive and strategic advantage. Industrial espionage is becoming more prominent. And countries are becoming increasingly aware of the importance of protecting their critical innovation assets. The sale of German company Kuka (a world leader in industrial robotics) to China served as a wake-up call.[121]

Damen[122] sees a shift taking places from a "values based" trade regime to a "reciprocity based" trade regime (see Figure 9). This change which has taken place in quite recent years (between 2015 and 2017) is characterized by a change from multilateral to bilateral agreements, and a shift in attention from social and environmental issues to economic and market issues in global value chains.

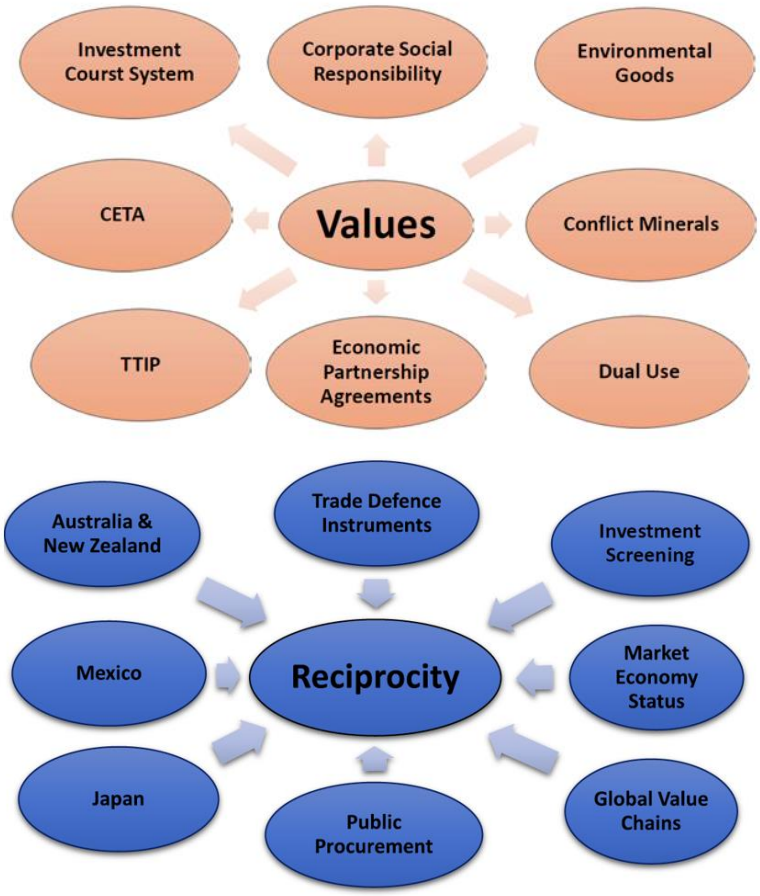


Figure 9 Value based, and reciprocity based trade regimes
Source: Damen 2017

[121] https://www.engineering.com/AdvancedManufacturing/ArticleID/12679/Its-Happened-KUKA-Is-Now-Chinese-Owned.aspx
[122] Damen, M. (2017) Free and fair trade for all? Brussels: European Parliament.

The changing international environment is also reflected in changes in the international innovation environment. Leijten[123] distinguishes three different innovation diplomacy scenarios:

1) The first is the **"indigenous innovation" scenario**, seen as a response to nationalist and protectionist tendencies and the intention to support national champions in both defensive and offensive ways.
2) This recent scenario can be seen as a response to an earlier **"innovation as a global public good" scenario** characterized by international collaboration and an emphasis on solving global challenges.
3) The third **scenario "bottom-up innovation"** stresses the role of networks of public and private actors, including civil society, regions and cities. More detailed characteristics of these scenarios can be found in Figure 10.

[123] Leijten, J. (2018) Three scenarios for innovation diplomacy. Presentation at the conference "Innovation and International Relations, a future-oriented EU-perspective", Brussels, October 4th, 2018.

	Indigenous innovation	Innovation as global public good	Bottom-up innovation
1. Entrepreneurial discovery	- Strong focus on national R&D and industry capabilities and collaboration - Protective/defensive against foreign attacks on IPR, markets, human resources, etc.	- Develop international value networks - Develop strong localised eco-systems in international context	- Largely national generic incentives - Eco-system policies - Focus on entrepreneurship
2. Knowledge development	- Focus on science - Training/skills in existing industries	- Strengthening "open science" and international collaborative programs - Seeking complementarities	- Broad skills development strategy
3. Knowledge diffusion (networks)	- Support for diffusion in national industries - Seeking international collaboration in function of national strengths	- Exchange programs - Sharing IPR etc. in collaborative ventures	- Business led diffusion in sectoral or regional ecosystems - International diffusion in function of building markets - Learning by using
4. Guidance of the search	- Nationally defined and supported missions - International intelligence	- Focus on global challenges thinking - Benchmark international competitiveness	- No strong guidance
5. Market formation	- Transactional approach to international access to markets - In regulation and standards too - Nationally oriented public procurement	- Global public and public/private initiatives - Work towards a global "level-playing-field" in business led innovation	- Business led - Allow for experimentation - Focus on international market access
6. Resources mobilisation	- Entirely driven by national interests and policy goals	- International collaboration and pooling of resources - Strengthening of global governance institutions	- No strong national or international directive resources policies
7. Creation of legitimacy; fighting resistance to change	- May range from anti-innovation attitude (reduced innovation policy actions) to aggressive national interest strategy	- Building support for global challenges - Spreading innovation thinking and behaviour (including values and policies)	- Business led (policy focus on boundary conditions) - Actions related to opening markets

Figure 10: Innovation diplomacy scenarios, Source: Leijten 2018

These changes in international context provide the background against which the developments in B2C and Industrial B2B platforms need to be interpreted.

5.3 The role of standards

A key issue in the development of Industrial B2B platforms and B2C platforms relates to the standards used. Relevant related questions are who controls (access to) the standards and to what are extent they open or closed? As the report Industrie 4.0 in a Global Context: Strategies for Cooperating with International Partners" states: "*individual modules, components, devices, production lines, robots, machines, sensors, catalogues, directories, systems, databases and applications should have common standards both for the connections between them and the overall semantics. This would, for instance, make it possible to flexibly build a production facility from components made by different manufacturers."*[124] Without common standards there will be isolated silo solutions which will ensure that companies cannot adopt Industrie 4.0 solutions. "*Ultimately, the only way out is to switch to a solution that is based on international standards and therefore provides greater flexibility and modularity, not least in terms of the extra freedom to choose between functionally identical systems from different suppliers."*[125]

5.4 Scenario's for Industrial B2B platforms

This section presents four scenarios for the development of Industrial B2B platforms. These scenarios aim to present possible and plausible development paths. Based on a review of the literature two different drivers for these scenarios were identified:

1) The first one relates to the question whether **platform standards** are **open or closed**. Open and interoperable standards are seen by different authors as important to avoid user lock-in in relation to specific vendors or software developers. Openness varies between **fully open** (e.g. the International Data Spaces platform that is being developed by a consortium of partners), **semi-open** (often a marketplace type of platform initiated by a company but open to other parties who, want to become suppliers to the company). Then there are **closed platforms** used by a single company or inside a group of companies (BMW is an example).
2) The second scenario driver is formed by the **strength of the network effects** in the platform. Network effects mean that the larger the number of platform users the more useful (or indispensable) the platform becomes to existing and new users alike. Thus the fact that Uber is the biggest platform for taxi services with the largest number of suppliers (drivers) and customers ensures its dominance in the market – its (U.S.) competitor Lyft being only a distant second. As mentioned above, network effects also explain why investors accept many years of financial losses by the platform company. While network effects are always there (otherwise there would be no point in having the platform) they may vary between stronger and weaker effects. There are

[124] Kagermann, H. et.al. Industrie 4.0 in a Global Context: Strategies for Cooperating with International Partners, p.23. Accessed at: https://www.plattform-i40.de/I40/Redaktion/EN/Downloads/Publikation/industrie-40-in-a-global-context.pdf?__blob=publicationFile&v=1
[125] ibid

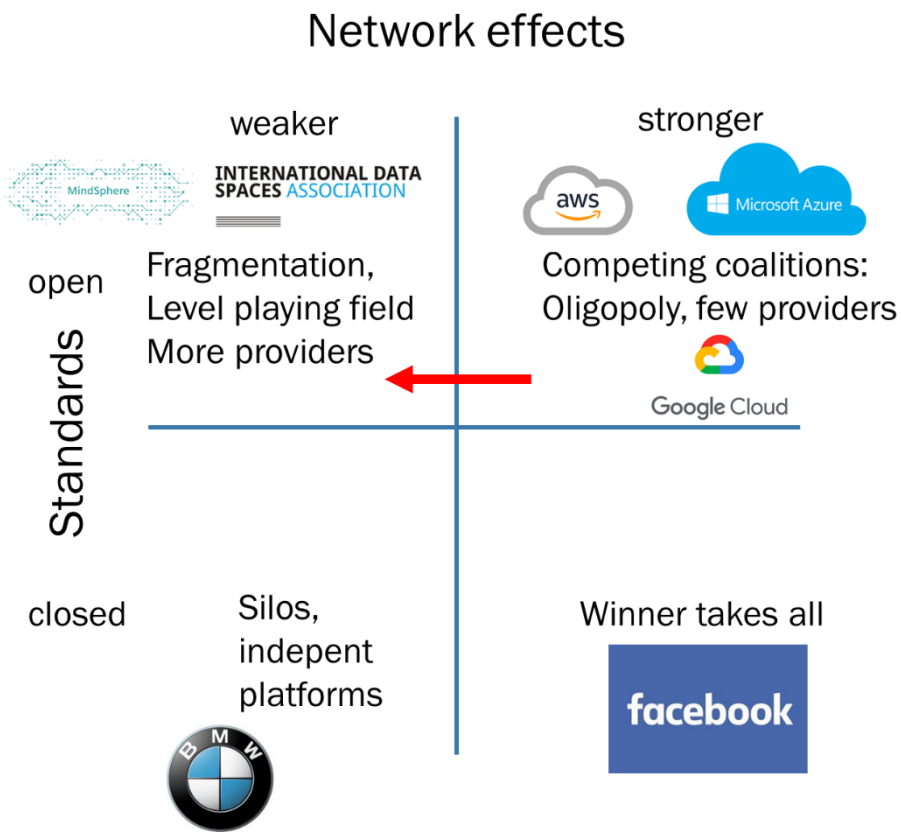
indications that network effects may not be as strong in Industrial B2B platforms as they are in B2C platforms. There are several reasons for this:

- B2C platforms such as Facebook and Uber have very **short and simple value chains**: they are two-sided platforms that link users and producers of a service. In Industrial B2B platforms value chains are much longer and more fragmented involving a variety of partners (with different roles) and links in the chain.
- **User power or influence** differs markedly between B2C and Industrial B2B platforms. For Facebook all 3-4 billion users are the same. In Industrial B2B platforms there is a smaller number of users, most of who contribute something to the platform in which they are participating. Whereas the **users of B2C platforms are essentially powerless** vis-à-vis the platform participants in the more open Industrial B2B platforms, who will be able to exercise some influence (less in the case of company driven platform and more in the case of open platforms).

In combination these two drivers lead to four different scenarios as presented in Figure 11:

1. The **first scenario** (bottom-right quadrant) represent the **Winner-takes-all scenario,** with a monopoly based on closed standards and strong network effects: the big consumer platforms Facebook, Uber and AirBnB have become global household names.
2. At the bottom left we find the **second scenario**, based on **platforms with closed (company-based) standards and weaker network effects** with smaller numbers of users. Company-driven supply chain networks such as those operated by BMW and many other companies for their supply chain management and production are examples. These platforms operate as independent, unconnected silo type of chains.
3. The **third scenario** at the top right quadrant **combines strong network effects with more open standards.** A number of cloud platforms such as Amazon Web Services (AWS) and Microsoft Azure provide a platform that give users an opportunity to run their own web based services. We see a small number (oligopoly) of providers emerging as key players. They are all U.S. companies and many European organisations, other platforms (e.g. the aforementioned 3D Hubs), companies and governments have their data on these U.S. cloud platforms. This leaves them vulnerable as the new U.S. Clarifying Lawful Overseas Use of Data (CLOUD) Act gives the U.S. Government right of access to all information on these cloud service irrespective of the location / jurisdiction of the organization. [126]

[126] https://www.24solutions.com/en/blog/cloud-act-american-law-impact-european-companies/



Source: TNO research

Figure 11: Four platform scenarios

4. **The fourth scenario** at the top left of the figure includes those **Industrial B2B platforms based on more open standards and with weaker network effects.** The degree to which a platform uses open standard differs: a company- driven system such as Mindsphere is open to the extent that others can sign up. But the basic design of the platform has been developed by Siemens. This contrasts with platforms such as International Data Spaces which has, from the beginning, been designed as an open platform with interoperable standards.

5.5 Assessing scenario's for societal outcomes

The scenarios presented above are realistic and plausible as they are based on existing developments and cases. A key trend that can be observed is one of concentration and a trend towards monopolistic and winner-takes-all outcomes. As Figure 12 shows there has been a very rapid consolidation of cloud service providers in recent years. So even though the individual platforms are open in the sense they provide a wide range of possibilities for users, there is also a serious risk of lock-in and dependence on a few oligopolistic providers. The public led initiatives such as International Data Spaces are small by comparison. Yet, these are being developed (and supported by public funding) to ensure open access and a level playing field that will prevent lock-in and the rise of monopolies.

What is the risk of concentration in the Industrial B2B platforms, that will lead to lock-in of users, particularly for SMEs?

The conclusion from interviews and from the literature is that this risk for the short and medium term is not so big. Edzell sees the risk as "relatively low" because " *all major IoT and M2M standards-development activities are supported by a variety of industry groups and corporations, many of which participate in multiple fora to monitor and contribute to development work. A greater risk of lock-in would arise if governments intercede in the IoT marketplace via misguided efforts to minimize business risk through "managed" innovation and competition.*"[127]

One of the experts interviewed was of the opinion that for Industrial B2B platforms there are still good opportunities for European companies: "*For B2B is the competition not yet decided, there is a lot of fragmentation. At this moment there is no standardized digital platform controlling the B2B market for manufacturing. That means that there is in my opinion still a huge opportunity for Germany and the EU."*

Finally, longer term outcomes are uncertain: there could be stronger tendencies of concentration if for example one of the dominant U.S. cloud platforms such as Amazon (AWS) were to put in a major effort to build an Industrial B2B platform that would integrate factory automation and supply chains at a number of different levels.

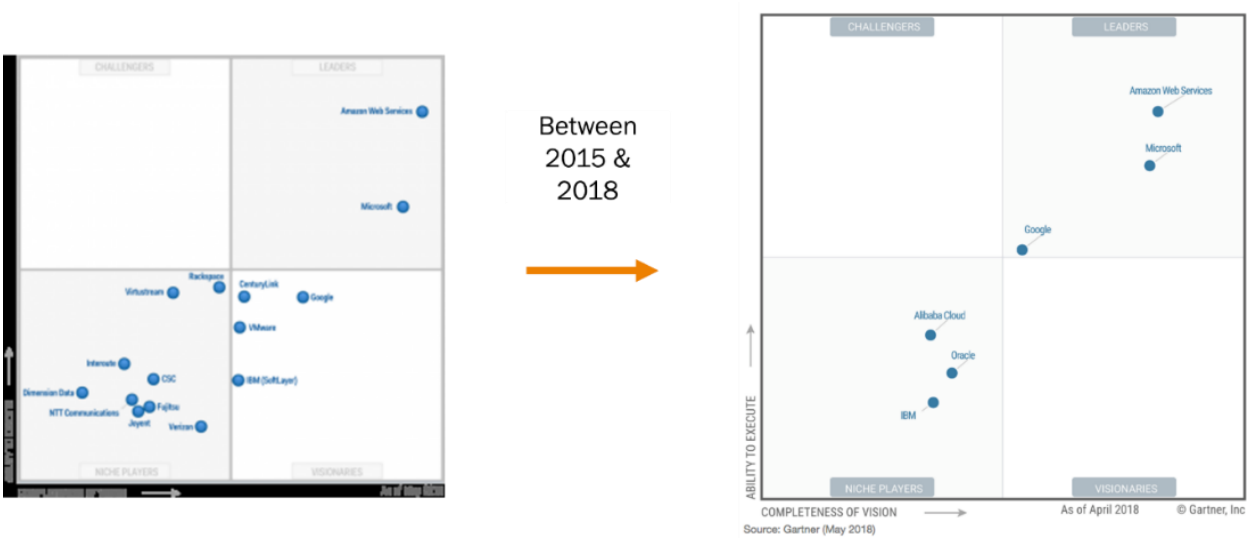


Figure 12 Concentration trends in the cloud services sector[128]

[127] Edzell, S., (2018) Manufacturing Digitalisation: Extent of Adoption and Recommendations for Increasing Penetration in Korea and the U.S. Endnote 178, p. 68. Accessed at: http://www2.itif.org/2018-korean-manufacturingdigitalization.pdf?_ga=2.176348519.317375918.1548327373-936244439.1544446714

[128] Gartner: https://solutionsreview.com/cloud-platforms/gartner-magic-quadrant-public-cloud-infrastructure/

6 Conclusion

The transformative power of digitalisation is currently seen in different spheres of life, enabled by smart products and services that make life, to those with access to such infrastructures, more convenient. Digital platforms are very pervasive and present everywhere. Many B2C platforms have become extremely wealthy and powerful monopolies in a short period. Less visible, but very important are the Industrial B2B platforms that are to play an increasingly important role in integrating production (within companies - e.g. digital factories) and between companies, linking organisations along the value chain.

6.1 The role of Industrial B2B platforms in the European and Dutch Industry

Currently there are Industrial B2B platforms operated by large companies in sectors like aeronautics, automotive, house appliances, electronic consumer goods that help coordinate a global network of production. These Industrial B2B platforms are vertically integrated and owned and controlled in a traditional form. They facilitate the flow of information required for procurement, production, distribution and sales services to clients. They have the aim of creating efficiencies for the core company but also for the production ecosystem. With the advent of more intelligent machinery and equipment the work-floor in factories is expected to produce new types of data that would be connected not only to the core companies Enterprise Resource Management systems, but also directly to suppliers of machinery, equipment and supply inputs for production. Such a flow of information would feed other companies besides the company that “owns” the data generating devices.

The reasons for European and Dutch companies in a given manufacturing ecosystem to engage in Industrial B2B platforms are all related to efficiency and growth. Our research indicates that for companies these reasons are (in decreasing order of importance): efficiency, productivity and cost optimization; regulation compliance and management; connected ecosystems, business model innovation, and the strategic digitalisation of enterprise. This indicates that at the individual company level the digitalisation process concerns more the efficiency of day-to-day operations than the long-term strategic orientation of the company.

6.2 The link between geopolitics and the developments in (Industrial B2B) platforms

Relevant geopolitical developments that influenced the (Industrial B2B) platforms are the liberalization of the Western economies and the emergence of the sharing economy. These developments enabled the rise of online wholesalers and retailers such as Amazon, Alibaba and Bol.com and the emergence of a new class of Internet-based intermediaries that have become new global monopolies. The network effects that are key to these platforms ensure that the larger the number of suppliers and users, the more useful it will be to both of them.

6.3 Winner takes all scenario of Industrial B2B platforms

The current landscape of Industrial B2B platforms is rather fragmented whereby the different activities of data generation, processing and analytics are performed by

different players. There are for instance companies producing hardware that enable data generation who are different from companies producing software, data storage and data analytics. This limits the dominance of a large player across industries and countries.

Based on the experience with B2C platforms we currently know that the scale effects of data concentration for individual participants in the platform are not seen at the participant level. The scale effects and sizable profits can be seen only at the aggregated platform level and accrue to the platform owner. Critical mass of data flows is achieved only once there is a wide deployment of digital platforms in different industries where data flows are pervasive. The current structure of the Industrial B2B platform ecosystems does not allow for this yet. This becomes especially clear when we look at the automation pyramid. Each platform is connecting a different element of the automation pyramid (e.g. GE edge to cloud which is focussing on MES and SCADA within the supply chain, FIWARE which is focussing on PLC within the supply chain, while SmartFactoryKL is focussing on the whole automation pyramid within the factory).

Is not clear whether the same dynamics of competition seen in the B2C platform market can and will be replicated in Industrial B2B platforms. In any case the dynamics of competition will favour those that control the platform architecture and data flows. Assets for production become less important and rapid growth of gains for the platform owners are possible as investments, innovation and the risks associated with these are born by platform users. They contribute to the platform with production and services that generate data at no cost for the platform owner. In turn, the accumulation of data from different users may generate new business opportunities for the digital platform owner.

The question whether the current US dominance in B2C platforms will be extended to Industrial B2B platforms has major implications for Dutch and European industries. At the moment fragmentation of the digital world business remains strong but there are potential critical nodes that require strategic attention. Therefore, it will be important to monitor the critical infrastructures that enable agglomeration of Big Data. These are the storage infrastructures or Data Cloud infrastructures. Currently there are few dominant players with the size to provide data storage in a global scale (e.g. Amazon, Google).

6.4 Implications for the European and Dutch Industries

The implications of a potential “winner takes al scenario” of Industrial B2B platforms for Dutch and European industries are at the moment not yet visible, but the early signals are clear enough to foresee the need to develop a strategic outlook and position from companies, branch organisations and policy making to avoid such a situation. It is currently not completely possible to see the competitive implications for individual companies but the new forms of competition in B2C indicates that there could be a rearrangement of the rules of competition that will affect industry intra- and inter- trade outcomes. This requires a type of regulation that creates a level playing field for industry. There is a clear need to ensure data agglomeration into Big Data with a decentralised governance of platform ownership (e.g. like the International Data Spaces, or platforms based on blockchain).

Here the definition of industrial contract agreements that consider the health of the ecosystem and the sector would help a lot. There is an urgent need to make the industry aware of all the benefits as well as the risks (e.g. associated with security and privacy of data) that Industrial B2B platforms have. It is also important to pay attention to the medium to long term strategic outlook of data agglomerations where the data provider has no saying into the usage of Big Data. Business is likely to be very cautious in participating in the formation of formal ecosystems as those that control the algorithms and the architecture of the platform are entrusted and endowed with discretionary power over potentially sensitive information of companies.

7 Research agenda

The advent of the digital economy is creating opportunities to build new value chains in the manufacturing sector. These new opportunities are based on the exploitation of data and data analytics for decision making and provision of services. Such opportunities imply issues of data flow governance (for example data location, security, veracity, ownership, and taxation of revenues generated in the usage and exploitation of data, etc.). The field of research on digitalisation and in particular in digital platforms has focused primarily on B2C platforms producing abundant literature (for reviews on privacy issues[129], business models[130], on B2C platform research approaches[131], on peer-to-peer market places[132], etc.). Such literature sheds little light on the dynamics of Industrial B2B platforms, which is the interest of this study. This report is the result on the exploration of Industrial B2B platforms, that are likely to affect the structure of industrial organisations in the years to come. The outcome of this report indicates gaps that are of relevance for the better understanding of the effects and opportunities of Industrial B2B platforms.

7.1 Research gaps related to Industrial B2B platforms

The research gaps in this nascent area of Industrial B2B platforms are intrinsically large. Currently there are ongoing efforts to compile research insights in knowledge gaps in the field of innovation management[133] and new skills requirements by the digital economy.[134] All gaps indicated below show that the regulatory and policy infrastructures do not match the developments in the technology and markets, where former regulations and policy continue to support the idea of leaving the new markets unregulated. It is known that business requires regulatory certainty. Thus, regulatory gaps are likely to hamper investments by industry, especially by SMEs that are lagging behind in digitalisation.

This study on Industrial B2B platforms shows important topics for *future research*. The gaps identified are primarily of interest for innovation strategy and policy in the context of industrial manufacturing. These refer to:

1. **Existing policy initiatives and policy needs**: Currently all policy initiatives in Europe are oriented to support the development and scale up of Industrial B2B platforms. There is no accepted typology or characterisation of an Industrial B2B platform. Such a typology is the first step to assess the effects of current initiatives. This will enable to focus on what member states are doing to support and regulate platforms.
2. **Development of key Performance Indicators**: KPIs are needed to monitor platform developments and to support evidence-based strategy and policy.

[129] Nelson, B., & Olovsson, T. (2016, December). Security and privacy for big data: A systematic literature review. In *2016 IEEE international conference on big data (big data)* (pp. 3693-3702). IEEE.
[130] Vendrell-Herrero, F., Parry, G., Bustinza, O. F., & Gomes, E. (2018). Digital business models: Taxonomy and future research avenues. *Strategic Change*, *27*(2), 87-90.
[131] de Reuver, M., Sørensen, C., & Basole, R. C. (2018). The digital platform: a research agenda. *Journal of Information Technology*, *33*(2), 124-135.
[132] Hausemer, et al, (2017) Exploratory study of consumer issues in online peer-to-peer platform markets. Study on behalf of Directorate-General for Justice and Consumers, European Commission, Brussels,
[133] Appio, F. P., Frattini, F., Petruzzelli, A. M., & Neirotti, P. Digital Transformation and Innovation Management: Opening Up the Black Box. Forthcoming JPIM Special issue
[134] Massini, S., Tommaso Ciarli, Davide Consoli & Kenney, M. Innovation and skills in the digital economy. Forthcoming special issue in *Research Policy*

There is a need to investigate social, economic, privacy, security and productivity aspects of Industrial B2B platforms.

3. **Standardisation processes**: The creation of a reference platform in several sectors is currently ongoing. A more thorough understanding of the role of standards in platform development, governance and management is crucial.
4. **The contribution of digital technologies and technological infrastructures to Industrial B2B platforms:** There is no clear understanding of the strategic role of supporting technologies like APIs, HPC, Cloud, AI, block chain, sensors, etc. It unclear what the critical technological components are that require prioritization and further specialization. Also the role of critical technological infrastructures requires further development.
5. **Governance and regulation of Industrial B2B platforms:** (market) power, ownership of data and decision making processes are key issues for platforms.
6. **Value creation and appropriation in Industrial B2B platforms** need to be understood. This includes business models for platforms.
7. **Overall macroeconomic effects** in productivity and economic growth and added value of Industrial B2B platforms for participating firms need to be assessed.
8. **Methodological approaches:** Existing studies use different units of analysis this makes comparability of results and generalisation of lessons learned limited. There is the need to define the platform ecosystem boundaries and units of analysis. The challenge here is that currently platform functions are fragmented. Not a single platform covers all the spectrum of the platform functions across the automation pyramid within the supply chain as shown in chapter 4. This for example limits any analysis of market power required for regulatory intervention.
9. **Scoping:** Regarding scoping we have identified the usage of different units and levels of analysis. Studies remain primarily qualitative and this hampers the capacity of comparative analyses. This requires better scoping of the units of analyses at the ecosystem or sectoral level, whereby the notion of geographical boundaries must be dealt with rigour to enable comparability. This has strong implications for studies focusing on regulation, for example in the case of consolidation and market power.

ANNEX Examples of Industrial B2B platforms

This list is not complete since there are coming new platforms every day, but it gives an illustration of the large amount of different platforms.

Name of the platform	Type of platform	Region of foundation
Blue initiatives are not directly related to Industry 4.0 such as initiatives for logistics or market places like OpenBazaar. However, they are added as they are relevant examples of platforms that include characteristics that are useful for Industry 4.0.		
IDS	Data platform	EU
FIWARE	Data platform	EU
CRYSTAL	Data platform	EU
ARROWHEAD	Data platform	EU
FAR-EDGE	Data platform	EU
MindSphere open industry cloud (based on SAP HANA cloud platform) Siemens	Data platform	EU
Cisco Kinetic	Data platform	US
3D Hubs	Business Platform	EU/NL
Xometry (acquired Make Time in 2018)	Business Platform	US
MakeTime (acquired by Xometry in 2018)	Business Platform	US
Fictiv: Virtual manufacturing service	Business Platform	US
Shapeways	Business Platform	EU/VS (Dutch founded, New York-based)
3DExperience platform of Dassault systemes	Data platform	EU/France
Adamos (ADAptive Manufacturing Open Solutions)	Innovation hub (joint venture)/data platform	EU/German
JoinData	Innovation hub / Data platform	EU / NL
Batchforce	Business Platform	EU/NL
SKUChain	Business Platform	US
OpenBazaar (Amazon without central platform)	Business Platform	US
Ariba	Business Platform	US
Transfollow (logistics)	Business Platform	EU/NL
Portbase	Business Platform	EU/NL
Uber freight	Business Platform	US
Alibaba	Business Platform	China
Arcade City	Business Platform	US
Beenest platform	Business Platform	US
STORJ	Data platform	US
Exact Industry Suite	Data platform	EU/NL
Bosch IoT Suite	Data platform	EU
Autoware	Business platform	EU

Name of the platform	Type of platform	Region of foundation
Safire	Business platform	EU
ISRUPT	Business platform	EU
DEADULUS	Data platform	EU
Scalable4.0	Data platform	EU
Cloudifacturing	Data platform	EU
DigiCor	Business platform	EU
Tradecloud	Data and/or business platform	EU
Coupa	Business platform	US
Microsoft Azure	Data platform	US
Salesforce	Data and/or business platform	US
Materialise	Data and / Business platform	US
Deutsche Telekom / IoT Platform	Data platform	EU
Cumulocity / Cumulocity IoT platform	Data platform	EU
AWS IoT (Amazon)	Data platform	US
DataV (Bsquare)	Data platform	US
Datonis (Altizon)	Data/business platform	US
Oracle IoT Cloud Service	Data platform	US
Predix (GE Digital)	Data platform	US
Market 4.0	Business platform	EU