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Progress of Digital Platforms and their Impact on Japan's Industrial Competitiveness[1]

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Abstract

Digitalization has a transformative impact on innovation in firms and markets, and new business models based on digital platforms are disrupting traditional industries. However, understanding the impact of digital platforms on the supply side of manufacturing industries, where Japan's industrial competitiveness is based, is insufficient. This paper conducts and discusses a review of existing studies on digital platforms and the relationship between digitalization and Japan's industrial competitiveness. A platform business can be categorized into three groups, type 1 (internet platformer type), type 2 (producer ecosystem type) and type 3 (IoT data-use type), depending on the existence of direct and/or indirect network effects on the producer and consumer sides of the platform. We have compared these three types of platforms together with "pipeline businesses" (with a traditional supply chain model) regarding the impact of digitalization on each business model. Our analysis found that digitalization does not directly affect the existing pipeline model, as is shown in the automotive industry, for example. However, the convergence of virtual and physical environments (CPS: Cyber-Physical System) redefines the boundaries of existing markets, which introduces a chance of existing pipeline models being displaced by new integrated services, based on platform models.

Keywords: Digital platform; Monozukuri; Network Effect; Industrial Competitiveness; Japan
JEL classification: L14, O36

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１． Introduction

The information gathered by IoT devices and sensors are further enlarging the volume of data on a daily basis. According to a July 2019 IDC survey, there are more than 20 billion IoT devices now in operation. It is predicted that by 2025 this number will have risen to more than 40 billion devices with a data production volume of 80 trillion gigabytes. Data will be produced by IoT devices that number more than 10 times the global population and are forecasted to greatly expand the possible uses of big data. This includes using artificial intelligence (AI) technology that increasingly serves as a "brain" in fields such as internet advertising, e-commerce, manufacturing, production, autonomous vehicles, home electronics, financial transactions, and personnel systems. Furthermore, it is widening the scope of information technology as a general-purpose technology. Thus innovation (IoT application) is rapidly expanding thanks to extensive data collection from people and things, and advancements in technology (AI) that uses this data (Motohashi, 2020).

As the possibilities for innovation expand from the foundation of big data, internet platformers are rising to the fore and growing their businesses through high-volume internet information and customer data. The "GAFA" American companies (Google, Apple, Facebook, Amazon) have a market capitalization rising to more than one trillion US$, placing them in the top 10 global market capitalization rankings. This is remarkable not only in size, but also in the speed of growth. The market capitalization of Google and Apple, which hold the top positions, have more than quintupled in the last decade. In addition, China is seeing rapid growth in the "BAT" companies (Baidu, Alibaba, Tencent), stemming from their massive domestic mobile network data.

GAFA and BAT are growing their internet-related businesses based on a huge amount of personal information and historical customer purchase information drawn from search engines and social networking services (SNS). Also, the increasing introduction of IoT sensors and applications are allowing platform business to spread to diverse industries using big data. Big data activity is rising throughout all stages of manufacturing, from pre-production design and development, through mass production, to post-production maintenance (Motohashi, 2016). For example, Komatsu has been collecting data on the operation of its construction machinery on a global scale and then using it for semi-automated driving functions (among other value-added services). The automobile industry has demonstrated a new wave of interest in using digital technology in the CASE (Connect, Autonomous, Share, Electric) trend. In particular, internet platforms like Google and Baidu have gotten involved in the self-driving (autonomous) field, signaling a change in the traditional structure of automotive industry.

So, how is Japan's industrial competitiveness fairing amid these data-driven innovations in the business environment? Just in terms of market capitalization, the Toyota Motor Corporation, which is Japan's top performer, has less than half the market capitalization of Google or Apple. However, GAFA and BAT revenues mostly depend upon very specific areas of business, namely internet advertisement and e-commerce. Platform strategies based upon personal data, such as SNS websites and purchasing history, have proven to be highly scalable (i.e., increasing in value as data volume increases). On one hand, the IoT applications spreading to various industries are largely dependent upon the characteristics of individual industries, making horizontal cross-industrial development difficult. For example, Komatsu's high value-added services are specifically for the construction industry. On the other hand, the U.S. General Electric (GE) company has applied its Predix concept to the horizontal development of its superior aircraft and implemented power facility data analysis technology in other manufacturing fields. However, GE's data business has remained unprofitable. Its CEO, H. Lawrence Culp, assumed his position on October 1, 2018 and has set forth a policy of narrowing its focus to fields in which GE is performing well (aircraft and power generation).[1] In the business-to-business (B2B) world, platform strategies like GAFA's have proven difficult.

In this paper, we analyze the advancing digitization of the economy, rise in platform business, and Japan's industrial competitiveness. First, in Section 2, we discuss the categories of platform business and their characteristics. Platforms are defined as shared management resources and governance rules tying together producers and customers (van Alstyne et al., 2016). Although their positive feedback is characterized by respective network effects on the producer and consumer, we shall categorize platform models according to economic externality and organize their individual characteristics. In Section 3, we use an economic model of platforms with the two-sided market of producers and consumers to describe the features of platformer monopoly prices and their advantages over conventional supply chain models. In Section 4, we show that, depending on the characteristics of the goods and services handled by the platform (product architecture) and inter-network competition, platforms are not superior in all cases. In Section 5, we shall use these theoretical studies as a basis for examining the validity of the logic behind economic digitization leading to the rise of the platform model and the decrease in manufacturing competitiveness. In conclusion, we will summarize and describe potential future research agenda.

２． Platform functions and their characteristics

The "platform" indicates a shared functional space in which multiple producers provide goods or services to multiple consumers (Gawer and Cusumano, 2013; van Alstyne et al., 2016). For example, iOS and Android smartphones serve as platforms mediating between general users (consumers), and the providers (producers) of various applications for e-commerce, financial management, SNS, games, and other functions. Similar platforms brought together producers and consumers prior to the advent of the digital economy. For example, newspapers and magazines are platforms connecting advertisers with consumers. However, the rise of the internet has allowed the construction of digital platforms that

1 https://xtech.nikkei.com/atcl/nxt/column/18/00065/00128/

have dramatically improved business scalability.

As shown in Fig. 1, producers and consumers both appear in a platform-based business model (van Alstyne et al., 2016). Explained with the example of iOS and Android smartphones, the first platform owners were Apple (iOS) and Google (Android). However, the customer value of a smartphone is greatly enhanced by producers who develop applications that run on either operating systems (OSs). Some applications, such as Amazon, Facebook, and Uber, create their own separate platforms. However, smartphones are immensely effective as an aggregate platform. Smartphones also have a large swath of consumers (users). In the case of Apple and Google, this large size comes from smartphone use. They are able to obtain a wide variety of data (for example, location information from mapping software, and audio information from speech recognition software), and then apply it to their services.

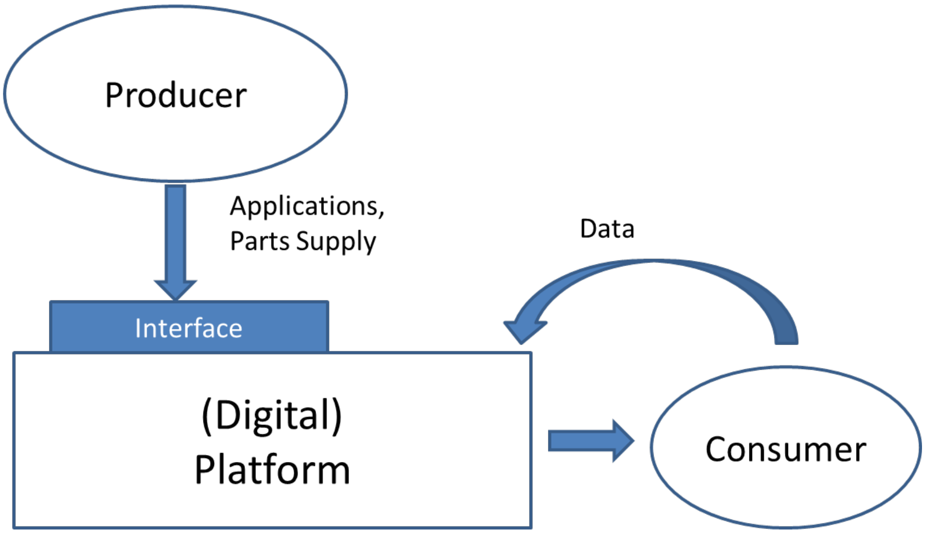

Figure 1. Platform conceptual diagram

The key characteristic of platforms is that they share functions between producers or customers. The aforementioned smartphone OS provide a shared space for producers (application developers) to open an API (Application Programming Interface) and provide various applications. Additionally, smartphone users not only use these services, but provide information to OS owners (Apple and Google) or producers (application owners). This includes deliberately provided information (i.e., posts to SNS websites) and unconsciously provided data (i.e., location information from smartphone GPS functions and information portal search keywords); information sharing can be limited by privacy functions. This information (data) plays a critical role in the development of services by OS owners. This is typical of smartphone OS platforms that provide two- sided producer and consumer side functions.

Platform types include those that are exclusively for producers and those exclusively for consumers. An example of a producer-only platform is the partnership program in which SAP brings together software companies that develop applications on its Enterprise Resource Planning (ERP) system (Ceccagnoli et al., 2002). ERP is a core software that can integrate various business administration functions, such as production, procurement, financial affairs, accounting, and human resources. However, multiple options are available depending on company conditions and size. SAP does not develop each application on its own, but provides ones developed by third parties (on an integrated company system). SAP provides a System Development Kit (SDK) to third parties in order to create this producer-side ecosystem. Similar programs are also available from Microsoft (Azure Technology Partner) and IBM (IBM Cloud Business Partners). Here, the foundation is to provide common resources to SDK and cloud environment partners; the aim is to increase the customer value of entire systems by incorporating various applications of partner companies into platforms. However, consumers (customers) of producer-side platforms developed by SAP and Microsoft are business customers using ERP and cloud services. No direct network effects parallel smartphone platforms, which generate new users (consumers).

On the other hand, KOMTRAX by the construction machinery manufacturer Komatsu may be considered a consumer-side platform. KOMTRAX has installed a semi-automatic driving function for energy-saving in construction machinery. Specifically, it has a P (power) mode and an E (economy) mode when using construction machinery. It displays suggestions on which mode is best to use depending on user circumstances (Kinukawa, et al., 2015). As the number of users increases and the amount of data related to usage increases, it becomes possible to provide a variety of highly-precise value-added services. However, this system-building is entirely within the control of Komatsu, and no platform functions are found on the producer side. Consequently, it may be considered a consumer-only platform model. Nissan has a similar operation that collects driving data from its Leaf electric vehicles and relays it to insurance services according to the driving distance.

The value of a platform comes from multiple producers (application developers and smartphone manufactures) and having a large customer base; the drawing power of a specific platform for producers and customers represents its network effects (externality). Utilizing platform functions gives rise to two-sided (producer side and customer side) networks. This results in two types of indirect effects between the sides (indirect network effects), which is different from the direct effects within the same side (direct network effects) (Gawer and Cusumano, 2013). Typical examples of direct effects are the classic network effects seen on SNS websites, like Facebook, and in communication services, which increase convenience for individual users as the user base grows. This represents a positive feedback loop that results in attracting more users[2]. Network effects

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[2] An economist joke goes, who is the most capable salesman in the world? The answer is a person who first sold a telephone.

between similar customers can also be observed in Komatsu's KOMTRAX. The more users there are, the more data can be collected, which makes it more precise prediction and more value added services prediction possible.

Separate from these direct effects, there are also indirect network effects from the interaction of the producer side and customer side mediated by platforms. It is possible to use diverse applications on smartphone platforms, but from the producer (application developer) side, it is more appealing if platforms themselves carry many applications. In cases such as this, a feedback loop is at work. Many application developers gather together, thus raising the efficacy of smartphone platforms and attracting more customers. An example of a producer-side platform is the SAP partnership program, which is a model that mainly utilizes indirect network effects, since the motivation of SAP partners to join this program is the size of potential consumers. However, direct network effect (on producer side) may not be observed in this case. When the number of producers increases, there is a greater possibility of increased competition between companies on platforms.[3] Rather, the purpose of producer platformization is to widen the diversity of applications in a company's ERP package and raise its benefits to customers. The result is that if the number of customers increases, then the platform becomes more appealing to producers (partners). On the other hand, in the case of Komatsu, there is a controlled situation (similar to the relationship between automobile and parts manufacturers) in system creation (producer side), and thus such indirect effects are not seen.

Foregoing discussion leads us to the Fig. 2, describing the typology of platforms, depending on the existence of direct and/or indirect network effects. First is their use of both direct and indirect effects, as seen with smartphone OS (type 1). When such platforms are formed, in addition to the positive feedback of consumers attracting other consumers, there are also interactions between producers and consumers, which may lead to rapid network growth. The rapid growth in corporate value of the GAFA and BAT internet platformers is due to the successful launching of this positive cycle.

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[3]Therefore, it is important that producer-side platform owners (keystones of the ecosystem) maintain the complementary diversity of producers (niche players of the ecosystem) for platform model success (ecosystem growth) (Iansiti and Levien, 2004).

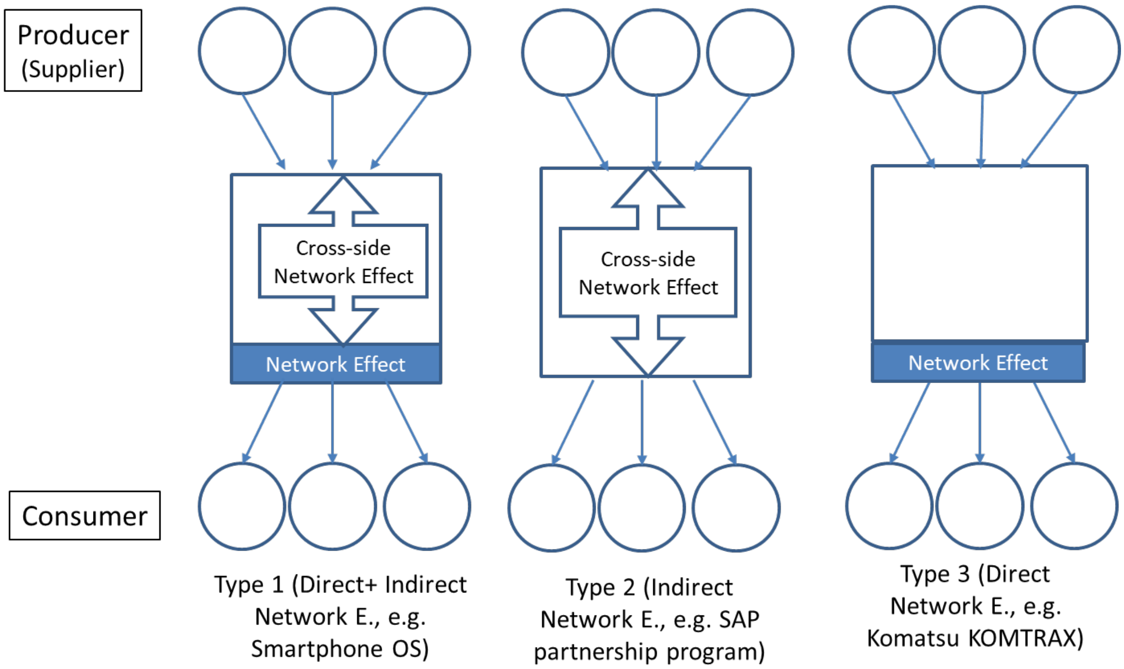

Figure 2. Platform typology

Second, typical producer-side platforms mainly use indirect network effects, but not so much for the direct network effects on producer side (type 2). Finally, there are those classified as type 3, which are seen in customer data-using business models (those mainly using consumer-side direct network effects). Furthermore, in regular supply chains (for example, the relationship between automobile and parts manufacturers), parts development and specification by producers (parts manufacturers) are completely controlled by integrated companies (automobile manufacturers). This is different from the way producers are allowed to freely act on shared interfaces on SAP and other producer-developed platforms. Consequently, there are no producer-to-consumer effects in which product functions improved by an increase in producers also increases consumer utility. Indirect network effects show positive feedback involving both directional positive impact between producer and consumer. However, in case of automotive industry, there is little observed the positive effect from producer to consumer side, while a large consumer base attracts producer's involvement in such platform. Off course, current trend of digital transformation may lead to the platform model weeding out certain pipelines (van Alstyne et al., 2016). As yet, there are no examples of the platform model being applied to automobile parts procurement. Rather, platform business success stories have been limited to software and certain digital content, such as publications and music. Thus, discussions may lack generality. We come back to this issue in section 4.

3. Economic analysis of network external effects

In the previous section, we classified three platform types, depending upon whether they were (mainly consumer side) direct networks or two-sided producer-consumer indirect networks. In direct networks, the utility of a service increases the more users there are. Thus, a “Winner Take All” or “Tipping” phenomenon arises in competitions between services of the same quality. In pursuit of economies of scale, platformers strategize to increase the number of users. Or, if this is difficult (when there are already dominant players), they attempt to diversify services and target niche markets (specific users).

On the other hand, if indirect network effects are produced as in type 1 and type 2, they will make corporate competition strategies more difficult. The implications of such cases for corporate pricing strategies and competitiveness policies have been subject to various two-sided market economic analyses (Rysman, 2009). Here, we organize the characteristics of price action in a two-sided market based upon Parker and Van Alstyne (2005).

A two-sided (or multi-sided) market refers to those that provide products and services to markets that are in a dual (or more) complementary relationship (e.g., between platform producers and consumers). For example, credit card companies connect two sides: merchants (producer side) and card users (consumer side). Demand functions on the consumer side (c) and producer side (j) may be respectively formulated (as shown below), since there are indirect network effects in which increasing the number of card users attracts merchant demand and further enhances utility for card users.

$$q_c = D_c(p_c) + E_{jc} * D_j(p_j) \quad (1)$$
$$q_j = D_j(p_j) + E_{cj} * D_c(p_c)$$

Here, Dx (p) is the demand function for a single consumer side (x=c) or producer side (x=j) market. According to indirect network effects, demand is calculated by multiplying either demand function by Exy.[4] All credit card companies collect fees from merchants (Pj>0), but while some collect membership fees from card users, others do not. This means that, in terms of card operation costs, the latter heavily subsidize the customer side. Thus, a negative price could be set on either side (Pc <0 here). In a two-sided market, price action may be formulated to maximize (assuming cost 0) the total profits from both sides ($\pi = P_c * q_c + P_j * q_j$). However, depending on the indirect network effects on production from the consumer side, even if consumer-side profits ($P_c * q_c$) are negative, greater profits ($P_j * q_j$) could be obtained from the producer side.

Parker and Van Alstyne (2005) have modeled the pricing strategy of companies in a monopolistic

[4] Although indirect network effects are treated additively here, variations (i.e., adding or multiplying E * qj (Pj) instead of multiplication type or recursive type (E * Dj (Pj))) are conceivable functional types. Parker and Van Alstyne (2005) show that similar price actions can be seen with these functional types.

position in both markets. The indirect network effect $(\partial q_y/\partial p_x)$ in Expression (1) on market y from market x is referred as a spillover effect, and the ratio r of the spillover effects of C->P to P->C (relative spillover effects), as follows.

$$r \equiv \frac{(\partial q_j/\partial p_c)}{(\partial q_c/\partial p_j)} = \frac{E_{cj} * D_c'(P_c)}{E_{jc} * D_j'(P_j)} \quad (2)$$

When we compare monopoly prices (p*) in two-sided markets and monopoly prices (p^) in single markets, if r=1 (relative spillover effect is equal), both prices match (Px*=Px^). If r>1 (spillover effect from consumer markets onto producer markets is relatively large), the optimum two-sided market price in consumer markets is lower than single-market prices (Pc*<Pc^), and greater than single market monopoly prices in producer markets (Pj*>Pj^) (the reverse if r<1).

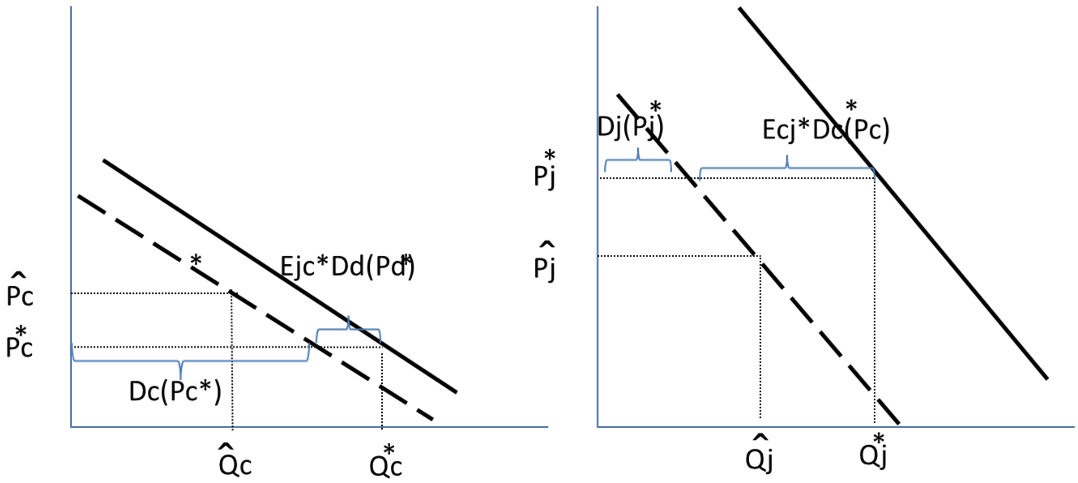

Figure 3. Pricing in a two-sided market (in case of r>1)

In each respective market, the dotted line shows a single-market demand curve (Dx (Px), indirect network effects are 0), and the solid line shows the (inverted) demand curve for two-sided markets, which have the addition of Exy*Dx (Px) indirect network effects. Single market monopoly prices are conferred by Px^ (=-Dx/D'x), maximizing profits (Px＊Qx=Px*Dx (Px), assuming costs are 0) along the dotted line section. On the other hand, two-sided market monopolistic enterprises take price action maximizing as the following (which is the total of profits in both markets):

$$\pi = p_c * \left(D_c(p_c) + E_{jc} * D_j(p_j)\right) + p_j * \left(D_j(p_j) + E_{cj} * D_c(p_c)\right) \quad (3)$$

When we arrange this from first-order conditions ($\partial \pi/\partial p_c$=0) for consumer prices (Pc) to maximize profits, it yields the following:

$$p_c^* = {}^{-\ (D_c + E_{jc} * D_j)} \Big/ {}_{D_c'} - E_{cj} * p_j^* \quad (4)$$

Pc* and Pj* are derived together with the expression for Pj* derived from first-order conditions for producer prices (Pj).

Here, if r>1, then Ecj＊ (-D’c) >Ejc* (-D’j) (note that D’x is negative). As said in Fig. 3, the coefficient of external effects (Ecj) on producer markets from consumer markets is relatively large. Therefore, consumer market price elasticity (-D’c) becomes relatively large (the dotted line has a flatter slope). In which case, lowering consumer market prices results in larger consumer demand (Dc). Furthermore, depending on how large the coefficient of external effects (Ecj), there may be a large demand even if prices increase in producer markets. That is, by lowering consumer prices, even if profits (πc) from consumer markets are sacrificed, a higher rise in profits (πj) from producer markets may be expected. Consequently, if r is sufficiently large, then Pc* becomes to be negative. This corresponds to the case of credit card companies targeting price sensitive consumers (with large price elasticity), where they offer credit card services without any card holding fees. In contrast, companies (e.g., American Express) that collect card fees from users target higher-income groups that are not sensitive to card-holding costs.

When we compare one-sided and two-sided market monopoly profits, the profits of two-sided market players are sometimes smaller in either market (and could be negative), but the sum total of profits from two markets is higher for monopoly players in two-sided markets (which have indirect network effects). Obviously, profits are increased from indirect network effects under monopoly prices Pc ^, Pj ^ in individual independent markets. Consequently, if other conditions are constant, then type 2 platformers are in a more advantageous position than regular supply chain players.

When direct network effects on the consumers side are added as in case 1, the spillover effects from the consumer side to the producer side will work even more. When we assume the direct network effects (Ye) are added on the equation (1) (Katz and Shapiro, 1985), then the consumer market demand function becomes as follows:

$$q_c = D_c(p_c) + v(y^e) + E_{jc} * D_j(p_j) \quad (5)$$

In case that Ye is unaffected by Pc, then ($\partial y^e / \partial p_c = 0$), and consumer-side monopoly prices (Expression (6)) are as follows:

$$p_c^{**} = {}^{-\ (D_c + v\ (y^e)\ + E_{jc} * D_j)} \Big/ {}_{D_c'} - E_{cj} * p_j^{**} \quad (6)$$

The following is a comparison of monopoly prices with direct network effects and monopoly prices without direct network effects (together with first-order conditions for Pj):

$$p_c^{**} - p_c^* = -M * {}^{v\ (y^e)}\ /_{Dc'}$$

$$p_j^{**} - p_j^* = M * E_{cj} * {}^{v\ (y^e)}\ /_{Dc'}$$

Here $M = \frac{1}{1-E_{cj}*E_{jc}}$, and when this is positive, then (Exy<1), direct network effects and Pc rise, and Pj falls. Furthermore, when direct network effects are entered, their share of total profits increases even if there is no change in Pc or Pj (optimum pricing for type 2). Therefore, it is possible for type 1 monopolistic enterprises to earn greater profits than type 2. Consequently, the monopolistic enterprise profits (producer surplus) of type 1 platforms (direct + indirect network effects) are greater than those of type 2 platforms (indirect network effects only), which are greater than those of normal supply chains (pipelines).

4． Conditions for platform model formation

While the economic model in the previous chapter suggests superiority of platform over pipeline, those that have adopted the platform model make up a rather minority in real world. Producer-side ecosystems use shared platform interfaces platforms (API, System Development Kit, SDK) to freely develop applications (permission-less innovation (Cerf, 2012)). In contrast, regular supply chain (pipeline), supplier (producer) products are supplied via customer firm's approvals (permission). For example, in the automobile industry, original equipment manufacturers (OEM) control the product specifications of parts manufacturers, release only the interfaces for interconnecting parts, and limit parts manufacturers from freely designing products.

Focusing on the supply side of type 1 and type 2 platforms, they are structured so producers are attracted to shared management resources (iOS provided by Apple, SDK provided by SAP) provided by platform owners. Consequently, platformers need to modularize product and service structures, and share component interfaces with (potential) producers. However, the product architecture (design concept) of automobiles is integrally structured with a high degree of interdependence between individual parts. This is because the overall product performance of automobiles cannot be realized unless all parts function normally. When developing new parts, automobile companies must control overall product design concepts and ensure that no problems arise in any individual part. If a problem arises due to permission-less innovation in just one part, an overall product loses value (for example, economic loss and decreased brand value from part recalls). Consequently, it makes sense that they stick with the pipeline model, and do not aim for platforms governed by parts manufacturer ecosystems.

In contrast to such integrated products, modular products like personal computers have overall standardized interfaces for hard disks and memory chip parts, and thus have structures that allow for interchangeability (Fujimoto, 2012). In addition, parts manufacturers can make independent improvements to functions (i.e., in the case of personal computers (PCs), there are independent makers of display and memory devices). Since there are no difficulties replacing parts and competitive parts offer new functions, overall technological innovation for products is accelerated. Thus, it is possible for products to incorporate parts from companies that have successfully made risky technological developments. As a result, the overall value of a product is expressed as the sum total of their various parts options (Baldwin and Clark, 2001).

However, it should be noted that platforms (ecosystems) are in an intermediate position between the supply chains (pipelines), where a large degree of control is seen for integrated products, such as automobiles and the market where interfaces that are openly available and have parts markets, such as PC (Jacobides et al., 2018). With PCs, there is little incentive for parts manufacturers (producers) to utilize specific PC manufacturers. This is because there is little value-added during assembly of the final product. End users can individually procure parts from product markets and freely assemble them. On the other hand, in the case of SAP, its ERP (core software) system is required to install partner company applications. Although SAP provides an SDK (software development kit) to partner companies, it is primarily for SAP's ERP system. Although free application development (permissionless innovation) is allowed on the platform, the platform is still largely controlled by SAP. That is, platform (ecosystem) models are not simply a matter of being able to assemble modules (parts) into products, but they may exist in a situation of complementarity. The platform model requires modularity between producers and platforms, but they are not completely modular; they are conditioned on two-way complementarity (Distributed Super Modular Complementarity) (Baldwin, 2019).

In addition, a certain number of producers are required for the network effects that underlie the platform model. When the number of network participants has exceeded a certain threshold, positive feedback kicks into action. A tipping phenomenon is seen in which numbers attract more numbers. In the economic model in the previous section, we analyzed the price behavior of monopolistic enterprises that have network effects. However, businesses are forced to decide whether the cost of developing a platform business (design change to modularization, anticipatory investment to trigger tipping, etc.) outweighs the benefits. The condition for platform model becomes more complicated where there is a (potential) competition among multiple platforms.

The decision of whether to develop a platform business requires exploration of diverse variants. However, here, we would like to consider the differences between B2B (consumers are corporations, such as SAP or Komatsu) and B2C (consumers are individuals, such as in the case of smartphone OS), as platform business types. The major differences between the two are the number of (potential) consumers (B2B: small, B2C: large) and differences in price elasticity. The number of potential consumers (target market size) differs depending on the type of goods and services provided, but business customers tend to be segmented into multiple markets and heterogeneous in terms of industry types and company size. Related to this, individual B2B markets are small, and transactions are more likely to emphasize function over cost (small price elasticity). Therefore, in B2B transactions, potential indirect network effects ($E_{cj} * D_c(p_c)$) are smaller in the producer markets in Expression (1), which are small consumer markets. Furthermore, as price elasticity is small, the relative spillover effects (the numerator in Expression (2) r) from consumer markets onto producer markets is also small. Producer prices for maximizing profits are low compared to B2C markets. That is, the large profits from producer markets seen in Fig. 3 (indirect network effects) are not foreseen; the tipping required for a platform is unlikely to occur.

The SAP ERP system aims at the overall optimization of various internal company activities. It is a fundamental system integral to a wide variety of industries. Consequently, even B2B businesses can engage in platform businesses using indirect network effects with the anticipation of relatively large markets. However, since the consumer (corporate user) price elasticity is small, the situation is the reverse of that in Fig. 3, which envisions a B2C market supplementing the producer market side (distributes SDK to developers) and drawing revenue from the consumer side. Komatsu's KOMTRAX is a system targeting the construction industry. Therefore, the size of its user base cannot be expanded as is the case in SAP. Consequently, there is little benefit in transitioning from a type 3 platform using user data to the type 1 utilized in producer-based ecosystems as well.

If there is competition between producers and networks, the tipping phenomenon is even more unlikely. In the case of inter-network competition, it is difficult to establish a model like SAP that lowers producer prices and brings in revenue on the consumer side. SAP is quasi dominating the world ERP market, so it is an exceptional case with this regard. When producer-side competition tightens, there is less incentive to participate in platform ecosystems from the producer point of view. Platform owners need to provide major incentives (reduce and open platform control) to producers to compensate for this (Parker et al., 2018). Or platform owner is required to ensure greater diversity of platform services, in order to avoid too much competition among producer firms. Consequently, it is important for platform owners (keystone companies) to maintain producer (niche company) diversity so that platform ecosystems can function effectively (Iansiti and Levine, 2004).

The following is a summary necessary conditions of platform models in foregoing discussion.

- Product architecture of goods and services provided to consumers is of an intermediate nature between an integrated (vertical integration, pipeline) and modular (parts market trading) type (super modular type splits between parts and platforms that have mutual complementarity).
- The presence of a sufficient consumer market to demonstrate indirect network effects. Consequently, in general B2B businesses are not suited to the platform model (generally pipeline model).
- When there is tighter completion between platforms or between producers, the establishment of a platform based on indirect network effects (type 2) is less likely.

- To alleviate producer competition, it is important to construct platforms as ecosystems consisting of diverse producers. In addition, the construction of platforms in which wide-ranging services are provided on a flexible basis in response to consumer needs will also lead to wider consumer markets and positive feedback from indirect network effects.

５． Impacts of digitalization on platform dynamics

According to Moore's Law of semiconductors, computer capabilities have explosively improved. Information and data can now be transmitted instantaneously through the internet. Especially in recent years, the collection of device sensor information via the internet and the spread of the internet of things (IoT) means that the use of digitization and big data induces transformation of manufacturing processes (Motohashi, 2016). Furthermore, the machine learning (artificial intelligence (AI)) model has developed and spread. AI can now out-perform humans in various applications, such as image recognition and speech and language processing. This information technology can now be used in various realms of economic activity, loosening the conditions restricting the establishment of the platform model. Consequently, the platform model is increasingly pushing the conventional pipeline to the edge (Van Alstyne et al., 2016).

On one hand, the size of Japan's economy in terms of nominal GDP has not changed since before the burst of the bubble economy in 1990. On the other hand, developing countries, such as China and India, saw rapid growth from the year 2000. In contrast, Japan's share of the global economy shrank from 15% in 2000 to 9% in 2010. As Japan's global economic standing dropped, valuation of its industrial competitiveness also tightened. According to the IMD, Japan was first place in global competitiveness in the WCY (World Competitiveness Yearbook) until the mid-90s but started to decline in the latter half of the decade. Recently, Japan has hovered between 20th and 30th place (Motohashi, 2014). Early 90s Japanese corporate competitiveness definitely lay in the high productivity of its manufacturing industry, which was able to deliver high-quality, low-cost products to international markets. Is the retreat in the international competitiveness of Japan's manufacturing industry, which had been supported by strong local manufacturing, related to advancements in economic digitization and the platform business model? Here, we would like to focus on the supply of goods and services (competitiveness, productivity), and discuss digitization, the relative advantage of the platform model over the pipeline model.

First, among digital products (the switch from newspapers to online advertising, video rental to video on demand, etc.) and O2O (Online to Online) platforms (the switch from physical stores to e-commerce, taxis to ride hailing services, hotels to private lodging businesses, etc.), there are many cases of digitization accelerating platforms and conventional business disruption (McAffee and Brynjolfsson, 2017). Most of these are B2C businesses that may be considered examples of thoroughly exploiting indirect network effects (spillover effects) from the potential demand of a massive consumer side. In addition, consumer-side direct network effects are also seen when these services increase users. Thereafter, service level is improved by word-of-mouth. Consequently, there is a succession of direct and indirect two-sided network effects. If a certain size can be secured on the consumer side, then the tipping phenomenon can rapidly expand usage (type 1 platform).

There is a need to study supply-side characteristics (including the producer side) in order to understand the effects of economic digitization on the industrial competitiveness of manufacturing and other fields. In the previous section, we identified that the costs of platformization (risks to producers from permission-less innovation) outweighed the benefits (speed and diversity of permission-less innovation) for products with integrated product architectures, like automobiles. Nevertheless, movement towards modularization is occurring even with automobiles, such as providing functions, like car navigation or car stereos, to connect with smartphones. However, there has been no movement towards incorporating the type 2 platform model for basic functions, such as driving and navigating functions of a car.

Vehicle technology is becoming increasingly digitized. Cruise control and steering functions are also being managed digitally. There is definitely a high ratio of software to hardware in electronic control units (ECU) (i.e., embedded software and onboard communication systems). Yet, as long as overall vehicle functions are achieved with integrated hardware and software, the costs of type 2 platformization will outweigh the benefits. Some think this might change with electric vehicles. However, even if there is some degree of overall product modularization (combining main parts, such as motors, batteries, and inverters), ecosystems merging platform functions and permission-less innovation are difficult to be foreseen due to the importance of overall product safety and functionality.

In general terms, we shall clarify fundamental differences between virtual digital systems and physical mechanical systems. The features of digital content and digital data are described in ones and zeroes, are completely duplicable, and can be moved instantly at no cost (Economics of free, perfect, and instant) (McAfee and Brynjolfsson, 2017). In addition, software that can covert digital data into information of economic value is described by unambiguous logical processes (Ikeda, 2002). Therefore, it is easy to cut out commonly usable algorithms and to reuse such function as a module. On one hand, in physical machine systems, a final product functions are derived by balancing constituent parts, and the functions sought are multidimensional. For example, in terms of driving, there is running stability, energy saving, downsizing, quieter operation, etc. There are no unambiguous logical processes for improving all of them. Therefore, it is difficult to improve system functions without coordinating individual parts (modules) (Whitney, 1996). Machine systems are being digitized (becoming software-based), but the digital portions are still subordinate to the function of physical components. Thus, there is no real change in the characteristics of the physical machine systems listed above.

The acquisition and accumulation of digital information on things (the possibility of using big data on things) has major effect on expansion to service models that use things (servitization of manufacturing, Vendrell-Herrero et al., 2017). For example, with KOMTRAX, Komatsu collects data on the usage of a capital good (construction machinery) from the consumer side to provide value-added service. A similar approach is taken with durable consumer goods, such as automobiles. For example, Nissan partnered with casualty insurance companies for a service that calculates insurance premiums according to driving distance. The producer side ensures the quality of products (construction machinery or car) within its normal pipeline, but digitalization of economy changes the way that producer's value proposition of its product by using the big data collected from consumer side (type 3 platform).

The movement towards digital service by the manufacturing industry (servitization) rather induces its producer to competition with new entrants in such service market. In the case of automobile manufacturers, ride hailing services become to be a rival. In addition, MaaS (Mobility As A Service) services combining public transportation and ride hailing services are spreading in some countries in Europe. So, there is a need to rework strategies that only consider the product competitiveness of things. In addition, internet platformers, such as Google Group (Waymo), which focus on self-driving, may represent a future threat. Companies with a massive customer base on smartphone platforms can weaponize potent network effects and leverage heavy bargaining power. However, self-driving services are subject to regulatory systems in each country, and they find themselves in a chaotic state of platform competition with diverse companies, including automobile and semiconductor manufacturers. In addition, multi-tiered connectivity (e.g., communication network) is required. As with smartphones, the formation of flat platforms consisting of two-company oligopolies is not likely. However, with automobile manufacturers, there is growing importance for competitive strategies based upon platform models that completely differ from the old, centralized pipeline model.

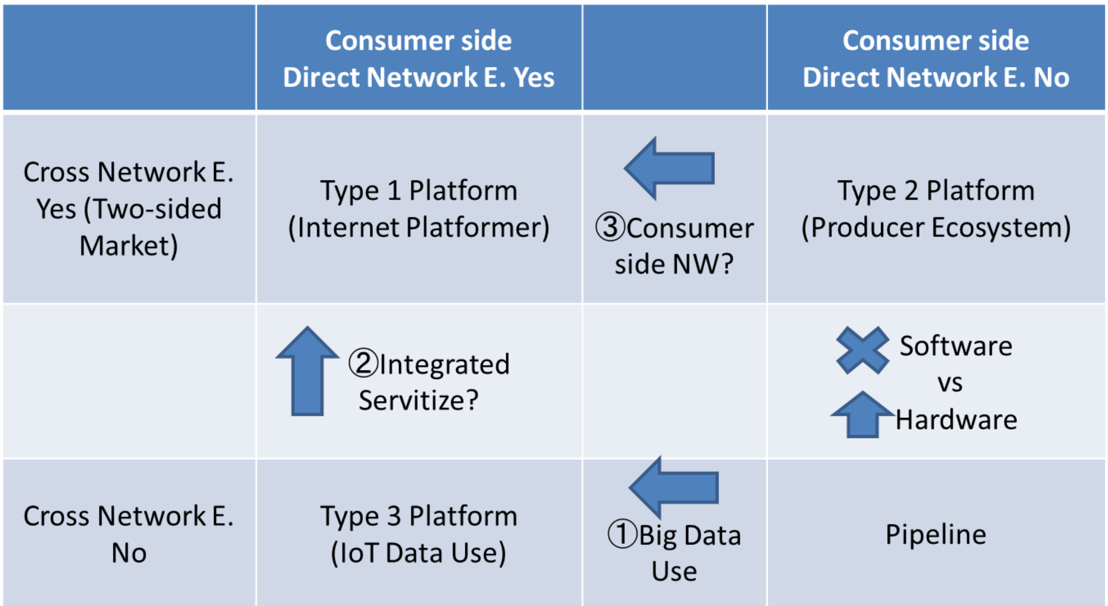

Figure 4. Relationship of digitization and platform dynamics

As a summary of foregoing discussion, the figure 4 is presented to understand the dynamics of platform models with advancement of digital economy. First, we showed that changing from a pipeline model like automobile supply chains to a type 2 platform (producer ecosystem type) is not likely, give that there are no changes to customers' expectation toward hardware characteristics (such as integrity of whole product to ensure safely requirement). Producer ecosystems like the SAP partnership program may be considered models peculiar to software. The pipeline model producer rather move to type 3 platform, by using big data analytics of its user base (movement to the left of the pipeline indicated by ①). This IoT-using platform model is often seen with durable consumer goods (i.e., automobiles) and capital goods (i.e., jet engines); Komatsu is just one example (Motohashi, 2016).

Next, as a development of the type 3 platform (movement upward from Type 3), we described the example of personal mobility service through self-driving technology. This suggests the possibility of upward move from type 3 to type 1. This is referred to as integrated servitization in which individual products are used as an input to integrated services with superior costumer provision (indicated by ②). An interesting case of such advancement is the Predix developed by GE. Predix is their attempt to horizontally apply the data usage model they used for specific industrial equipment (such as wind power machine and jet engine) (model 3) to wider industrial applications ((Keidanren, 2017). To that end, they established GE-Data, a department for handling manufacturing industry data, and took the lead on standardization within the Industrial Internet Consortium (IIC). However, in recent years, they have determined that their business is contracting due to poor performance and they retreated to a conventional application specific model. While we mentioned the difficulties with the type 1 model in B2B business in the previous section, more detailed feasibility research is required.

Finally, there is the possibility of advancing from a type 2 platform (producer ecosystem type) to a type 1 platform (movement to the left from type 2). If the SAP ERP system can encourage user community activity (e.g., sharing of SAP system user experience), and bring forth consumer-side direct network effects (consumer-side networking), then a stronger platform closer to type 1 is possible. Although this example of a type 1 platform will clearly work for internet platformers like GAFA and BAT, whether it can be established for B2B business remains unclear. If the consumer side of a type 2 platform consists of corporate customers (B2B business), corporations might compete with one another, making it difficult to expect consumer-side direct network effects as in B2C business.

６． Implications to Japan’s industrial competitiveness and future research agenda

In this study, we propose the typology of platform models, type 1 (internet platformer type), type 2 (producer ecosystem type) and type 3 (IoT data type), depending on the existence of direct and/or indirect network effects. In addition, we examined the economic advantages of four business models, adding in the conventional supply chain (pipeline model), and their relationship to advancements in the digital economy. From our results, we found that the pipeline model seen in the automobile industry is unlikely to be replaced by a type 2 producer ecosystem through economic digitization. There is rather a chance for a pipeline producer (typical Japanese manufacturer) to further strengthen its competitiveness by moving to the type 3 platform (IoT data use type).

However, we have identified that the risk associated with type 3 model, when it is integrated into a more superordinate concept service model, then it may be exposed to competition with type 1 players (internet platformers such as GAFA and BAT). In addition, there is the possibility of producer ecosystem (type 2) platformer owners upgrading to type 1 by deriving consumer side network effects. The type 1 and type 2 business types greatly differ from B2C and B2B. Yet, there are examples of type 1 players moving into B2B business (for example, Amazon’s logistics business and Tencent’s block chain-based smart contract business), which may cast disruptive changes in the competitive landscape of traditional manufacturing industries.

In this paper, we focused on the relationship between digitization and platform models, describing their relationship to manufacturing competitiveness, but there are other critical problems related to Japan’s industrial competitiveness that are worthy of discussion. We conclude this paper with future research agenda to disentangle a whole question.

The first one is related to questioning the possibility of type 1 platform for B2B business. In current type 1 internet platforms, big data on consumer personal information produces indirect network effects (spillover effects) for producers. Large volumes of personal data can be used for advertising and other forms of marketing. However, if the consumer side consists of business users (for example, users of Komatsu and GE capital goods), then data usage is limited to specific equipment (Komatsu construction machinery and GE jet engines), and there is little benefit to opening up to producers (other businesses) and pursuing ecosystem-based innovation. Other competitor companies would have the industrial domain knowledge needed to use relevant data, and allowing such data access is not a good competitive strategy. GE put out the Predix platform concept, presumably an attempt to move forward with their "industrial internet" type 1 platform concept. What they attempted was not data access, but building an ecosystem connecting the producer side and consumer side, in which an analytical module for analyzing big data on industrial machinery (functions such as asset performance management (APM) for efficiently maintaining heavy equipment and driving support systems) would serve as a shared management resource. However, since producers were not allowed data access in their relationship to data (machinery) owners, indirect network effects were limited and operations ceased before reaching the necessary tipping point.

In the world of AI/Big Data/IoT, is ② in figure 4 (integrated servitization) really impossible? If not, an appropriate strategy would be for capital and durable goods manufacturers to construct a solid type 3 platform to prevent business entry by internet platformers based on type 1 personal information. In Germany, there is movement towards networking and standardization of IoT applications (mobility, smart production systems, smart city, etc.), based upon the CPS (cyber physical system) concept of a system fusing digital and physical things (ACATECH, 2015). There is the possibility that this industry-academia collaboration will convert the B2B world, in which information is split between devices and products, into an integrated and horizontal world like the internet. While keeping in mind the movement of such forth industrial revolution, it is important to pursue research into the possibility of realizing a type 1 platform in the IoT by analyzing indirect network effects and exploring governance structures.

To study the above problem, there needs to be a theoretical framework of balancing two factor, (A) incentives to attract diverse producers on the producer side (supply side), and (B) the appeal (reservation prices) of consumer side goods and services in a diverse ecosystem. Regarding (A), the relative size of platform function added-value to producer added-value has an impact on overall ecosystems. A team lead by prof. Gawer of UCL conducted a comprehensive survey of global platform businesses, and divided them into three categories: (1) asset heavy types in which producer management resources are a major contributor (GE's Predix, Samsung's Tizen, etc.), (2) contrasting asset light types in which shared platform management resources are important (Google, Uber, etc.), and (3) mixed types that fall in between (Apple, Amazon, etc.) (Evans and Gawer 2015). The heavier the producer side assets, the less the centripetal pull of platform functions, and the less likelihood of forming type 1 or type 2 platforms. These differences between platform types lead to the question of how shared management resources can be separated (modularized) from the supply structure of a platform business. Furthermore, they interrogate what needs to be studied, particularly regarding product architecture and related industrial architecture.

In addition, the platform openness in (A) also has an impact. For example, Bourdreau (2010) defines the openness of mobile data devices (handheld computers) according to the OS intellectual property license policy of platform owners to device manufacturers, e.g., no external licensing (in-house device development), licensing only to specific partners, and unspecified and indiscriminate licensing), and shows product development (innovation) and performance as being an inverted U-shaped relationship. In addition, there are also examples of defining openness by the ratio of sharing profits from overall ecosystems of platforms and producers, and conducting model analysis of the relationship between openness and innovation performance (Parker et al., 2017; Parker and Van Alstyne, 2018). Increasing openness (producer share) benefits producers in that they have an increased incentive for development. However, increasing the number of producers creates greater competition between producers, which may impair development. Consequently, an optimal level of openness (intermediate openness that is not completely open or closed) is being derived from model analysis.

Furthermore, the root question in (B) is how much the profits expected from goods and services supplied in an ecosystem can be raised through development competition between diverse producers as seen above. This point is closely related to research into manufacturing servitization through digitization. As seen with GE's Predix and Komatsu's KOMTRAX, there is the possibility of a platform model with B2B manufacturing by adding value-added service using digital data to products themselves. While using the above findings, work needs to be done to answer the question of whether there is a business model balancing both (A) and (B) like type 1 and typ2 platform models (manifesting positive feedback effects through indirect network effects).

The second research topic is related to the Japan's economic and innovation systems in relation to the advancement of digital platforms. The Japanese economic system is described as one in which non-market mechanisms, such as long-term business relationships between companies and stable labor relations, hold greater importance than market mechanisms, such as product and labor markets (Hall and Soskice, 2001). The result has generally been a relative advantage in cumulative innovation, yet weakness in dealing with disruptive innovation (Motohashi, 2014; Kwon and Motohashi, 2017). In the world of type 1 internet platformers, which have been rapidly growing through the use of personal data, Japanese companies have been completely left behind. Substantial network effects by GAFA are substantiated already, which may be irreversible unfortunately. However, Japanese companies have managed to be relatively competitive due to type 3 platforms that utilize data for manufacturing industries, such as automobiles and machine tools. Thus, the focus of future research should be to identify strategies for exploiting the strengths of the Japanese system amid continued digital and physical advancements, and to identify the system innovations needed to overcome its weaknesses.

If we assume continued standardization towards CPS, then there is a greater chance that the platform model will materialize in the B2B field as well. In the platform model, portions that can manifest from a core of shared management resources and producer ecosystems need to be separated. However, this separation requires an environment in which interfaces are open but not completely modular. Platform owners should maintain a certain amount of control, while producers engage in permission-less innovation. Integration capability is required to create business models that coordinate ecosystems (Helfat and Raubitschek, 2018). Japanese companies have excellent integration capability for developing complex machine systems. However, they may have many deficiencies in their capability to generate ecosystem dynamism among different industry players. In addition, there is the question of whether they can keep up with the speed at which manufacturing platformization proceeds through CPS.

Furthermore, compared to American companies that have been moving ahead thanks to the rise of internet platformers and digitization, and German companies fusing cyber and physical aspects in manufacturing, Japanese companies are unfortunately still behind in digital transformation. The aforementioned RIETI survey of digitization and open innovation in small and mid-sized manufacturing companies comparatively analyzed Japan and Germany with the cooperation of the German Leibniz Centre for European Economic Research (Leibniz-Zentrum für Europäische Wirtschaftsforschung: ZEW), and found that Japanese company efforts towards digitization fall short of those of their German counterparts (Motohashi and Rammer, 2020). However, simultaneously, Japanese companies were found to be slightly ahead of German companies in co-innovation with suppliers and other business partners. In the current Japanese economic system, further research is needed to understand the strong fundamental bonds in network structures underlying economic transactions, how to utilize them within platform models that fall between market transactions and pipelines, and whether innovation is needed to overcome these obstacles.

References

Acatech (2015), Living in a network world: Integrated research agenda, Cyber-Physical-System, Eva Geisberger and Manfred Broy ed, Acatech Study March 2015, Germany

Asanuma, B. (1997), *Innovative adaption mechanisms in Japanese corporate organization – structure and function of long-term business relationships*, Toyo Keizai Inc., June 1997

Baldwin, C. Y. (2019) “Platform Systems vs. Step Processes—The Value of Options and the Power of Modularity,” HBS Working Paper (January 2019)

Baldwin, C. and Clark, K. (2001), *Design Rule: The Power of Modularity*, MIT Press, Cambridge MA

Boudreau, K. (2010), Open Platform Strategies and Innovation: Granting Access vs. Devolving Control, Management Science, 56 (10), 1849–1872.

Ceccagnoli, M., Forman, C., Huang, P. and D. J. Wu (2012), Cocreation of Value in Platform Ecosystem: The Case of Enterprise Software, MIS Quarterly, 36 (1), 263-290.

Cerf, V. (2012), Keep the Internet Open, New York Times, May 24, 2012

Evans, P. and Gawer, A. (2015), The Rise of the Platform Enterprise: A Global Survey, The Emerging Platform Economy Series No. 1, The Center for Global Enterprise

Gawer, A. and M. Cusumano (2013), Industry Platforms and Ecosystem Innovation, Journal of Production Innovation Management, 31 (3): 417-433.

Hall, P. and Soskice, D. (2001), *Varieties of Capitalism: The Institutional Foundations of Comparative Advantage*. Oxford University Press.

Helfat, C. and R. Raubitschek (2018), Dynamic and integrative capabilities for profiting from innovation in digital platform-based ecosystems, Research Policy, 47, 1391-1399.

Iansiti, M. and R. Levien (2004), The Keystone Advantage: What the New Dynamics of Business Ecosystems Mean for Strategy, Innovation, and Sustainability, Harvard Business School Press, Boston, MA

Ikeda, N. (2002), Digitization and Modularization, *Modularization: Essence of new industrial architecture*, Chapter 4 (Masahiko, A., Ando, H., eds.), Toyo Keizai Inc., March 2002

Jacobides, M., Cennamo, C. and A. Gawer (2018), Towards a theory of ecosystem, Strategic Management Journal, 39, 2255-2276.

Katz, M. and C. Shapiro (1985), Network Externalities, Competition and Compatibility, American Economic Journal, 75 (3), 424-440.

Keidanren, The 21st Century Public Policy Institute (2017), *Innovation ecosystems research: How to make money from open innovation*, 21st Century Policy Research Report, February 2017

Kinukawa, S., Tanaka, T., Nishio, K. and Motohashi, K. (2015), "Innovation trends and case studies using big data," RIETI Policy Discussion Paper Series 15-P-015

Kwon, S. and K. Motohashi (2017), How institutional arrangements in the National Innovation System affect industrial competitiveness: A study of Japan and the U.S. with multiagent simulation", Technological Forecasting and Social Change, 115, 221–235.

Mayer-Schonberger, V. and K. Cukier (2013), *Big Data: A revolution that will transform how we live, work and think*, John Murray Publisher, Great Britain

McAfee, A. and E. Brynjolfsson (2017), *Harnessing our Digital Future: Machine, Platform and Crowd*, W. W. Norton & Company, New York

Milgrom, P. and J. Roberts (1990), Rationalizability and learning in games with strategic complementarity, Econometrica, 58 (6), 1255-1278.

Motohashi, K. (2014), *The sun rises again: Revitalizing industrial competitiveness*, Nikkei Publishing, Inc., February 2014

Motohashi, K. (2016), "Actual state of big data activity and innovation in the Japanese manufacturing industry," RIETI Policy Discussion Paper Series 16-P-012

Motohashi, K. and Rammer, C. (2020), Digitization and New Product Development in Manufacturing SMEs: A Comparative Study of Germany and Japan, RIETI Policy

Discussion Paper 20-P-007.
Parker, G. and M. Alstyne (2018), Innovation, Openness and Platform Control, Management Science 64 (7): 3015-3022.
Parker, G. and M. Alstyne (2005), Two sided Network Effects: A Theory of Information Product Design, Management Science, 51 (10), 1494-1504.
Parker, G., M. Alstyne and X. Jiang (2017), Platform Ecosystems: How Developers Invert the Firm, MIS Quarterly, 41 (1), 255-266.
Rysman, M. (2009), The Economics of Two sided Markets, Journal of Economic Perspectives, 23 (3), 125–143.
van Alstyne, M., Parker, G. G. and Choudary, S. P. (2016), Pipelines, Platforms and the New Rules of Strategy, *Harvard Business Review*, April 2016
Vendrell-Herrero, F., Bustinza O., Parry, G. and N. Georgantzis (2017), Servitization, digitization and supply chain interdependency, *International Marketing Management*, 60 (2011) 69-81.
Whitney, D. (1996), Why Mechanical Design Cannot be like VLSI Design, Research in Engineering Design, 8, 125-138.