Value Creation in Digital Ecosystem – A Study of Remote Diagnostics

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Abstract. The advancement of digital technologies is driving traditional product oriented businesses to move from selling product to selling solutions. In order to exploit business potentials from technology, it is necessary to understand the technological capacity and how it influences the value creation in the environment where it is deployed. I study remote diagnostics as an example of digital technology within the vehicle industry. I found that this technology provides potential to generate new value. To create this value, traditional product oriented organizations are required to create value in different way than traditional mode of creating value. In this paper, I show that how generative capacity of remote diagnostics technology creates value in digital ecosystem.

Keywords: Value creation, digital innovation, generativity, digital ecosystem, layered modular architecture, remote diagnostics

1 Introduction

With advancement in digital technologies, there are increasing trends in traditional product oriented business to move 'from selling products to selling solution' or 'system selling' ([1][2][3]). Like other manufacturing industries, this phenomenon can be observed within the vehicle industry. Further, there is an increasing interest in finding innovative ways for value creation, especially in digital innovation literature. It has been argued that digital services create new opportunities for value creation and help a company to gain agility [5]. These opportunities suggest that locus of value creation resides within the network rather than within an organization's boundaries [3], [6]. This requires organizations to develop and maintain multiple parallel business models within a digital ecosystem to increase exploitation from the technology [3], [4]. Further, [7] argue that to create value out of digital technology in digital ecosystem firms should constantly asked which layer to close and which layer to open in layered modular architecture. A layered modular architecture emerges when physical products are embedded with digital capabilities. An example of such architectures in the vehicle industry is when subsystems of a vehicle are becoming digitized and connected through vehicle-based software architectures. A vehicle has

become a computing platform on which other firms outside the vehicle industry can develop and integrate new devices, networks, services, and content [8].
There is research describing the role of information technology (IT), in general, in creating business value and building sustainable competitive advantage [9], [10], [11]. In information systems (IS), researchers have studied remote diagnostics as a value creating technology in manufacturing industry. But the digital technology's influence on physical products has not been addressed in the IS literature on larger scale [7]. To consider this, researchers (such as [12]) emphasize that IS researchers should be actively involved in studies during the development of technologies rather than after their introduction in the market. Finally, [7] argued that IS scholars should identify new sources of value creation such as generativity. They state that "IS scholars must imagine new digital strategy frameworks that identify new sources of value creation such as generativity, heterogeneity, digital product platforms, and meaning-making capability." Hence the research question is *How does the generative capacity influence value creation in digital ecosystem?*
The aim of the paper is to inform managers that build strategy in changing business environment within the vehicle industry. Moreover, the paper will contribute to an understanding of value creation in changing business environment in the vehicle industry.

2 Literature Review

The following sub-sections provide review of the literature on value creation digital innovation in ecosystem and on the concept of generativity.

2.1 Value Creation and Digital Innovation Ecosystem

Digital innovation is defined as "the carrying out of new combinations of digital and physical components to produce novel products" [7]. In their earlier work they showed that digitization (i.e. encoding of analog information into digital information) is an important stimulus of digital innovation. An example of digitalization is embedding digital technology such as remote diagnostics systems in vehicles. Furthermore, the digitalization, in turn, makes physical products programmable, addressable, sensible, communicable, memorable, traceable, and associable [13]. The focus of such innovation is based on product innovation and is different from existing IT innovation which is mostly concerned with process innovation [14]. The services enabled by digitalization are called digital services [7], [13] and innovation in services is called digital service innovation. Driven by advanced development of digital technology digital services differ from conventional services and inherit properties from digitalized products as well as from services, hence possessing the hybrid nature [7].
The embedded digital technology have three key features that differentiate this new technology from earlier ones are *(i)* re-programmability that relates to the ability of devices to be re-programmable enable separation of semiotic functional logic of device from physical embodiment; *(ii)* the homogenization of data which refers to the

binary representation of data and together with emergence of new media separate the content from medium; and *(iii)* the self-reliance nature of digital technology means it requires the use of digital technology [7]. The advantage of using digitalized artifacts include new dimensions to service relationship as embedded sensors can become eye and ear of remote service provider [13] who can access real-time data and in turn can provide seamless services to customers.

Value creation in digital ecosystem where innovation is at the core has been discussed in extant literature. The use of new technology can create value for firms when they develop innovative ways of doing things [15]. If innovation of products and services increases customers' satisfaction during its use, new value is created [16], [17]. It also relies on a firm's ability to innovate [18]. Value creation through digital innovation is facilitated by the protection of property rights, use of dominant design and complementary assets [19]. It has also been observed in the past that innovative information technology helped firms in transforming their business and changing customer relationships [20]. Moreover, over the past few decades, digital innovations depict positive impact in various business sectors such as banking sector, chemical industry, tourism, insurance industry [21] and aircraft maintenance [22].

Although the previous studies shows that digital innovation enables new business opportunities [23], there is need for more research on influence of digital technology on value creation and customer relationship [21].

2.2 Generativity

Generativity or generative capacity refers to the ability or power to generate of produce something. It has been defined as "a system's capacity to produce unanticipated change through unfiltered contributions from broad and varied audiences" [24]. The concept of generativity has multiple meanings in various disciplines such as psychology, linguistics, organization science, social psychology, architecture, computer science and social studies. Although the term has been around since 1950 but in terms of technology and products it was used by Zittrain. In terms of digital innovation, generativity is defined as "a technology's overall capacity to produce unprompted change driven by large, varied, and uncoordinated audiences" [25]. According to [25] generativity is a function of a technology's capacity for leverage across a range of tasks, adaptability to a range of different tasks, ease of mastery, and accessibility.

Since the introduction of the term with respect to digital technology, there have been studies that try to explain it as concept in different contexts. For example, one of the themes related to digital technologies argue for kind of architecture for digital products. This new architecture consists of a continuum having modular architecture at one end and layered modular architecture on the other end [8]. Generativity in a layered modular architecture is accomplished through loose coupling across layers whereby innovations can spring up independently at any layer leading to cascading effects on other layers [26], [27]. It further inherits multiple design hierarchies,

produces differences in kind rather than differences of degrees, and is constrained by characteristics of physical components of products.

Table 1. Generativity in Modular and Layered Modular Architecture [8]

Generativity in Modular Architecture	*Generativity in Layered-Modular Architecture*
	Accomplished through loose coupling
Single design hierarchy	Multiple design hierarchies
Flexibility of the architecture produces differences in degree	Generativity of a layered modular architecture produces differences in kind.
Generativity is not constrained by characteristics of physical components of the product	Unlike layered architecture, the generativity of layered modular architecture is constrained by characteristics of physical components of the product (e.g. forms factors and availability of certain physical components)

The generativity of layered modular architecture comes from a firm's ability to design a product platform that can attract a large number of heterogeneous and unexpected components that belong to different design hierarchies [8].

3 Research Approach and Method

This paper reports on three years research study at GlobalAlpha (pseudo name of organization), a manufacturer of vehicles (buses). The research project is carried out in collaboration among our research group and number of organizations that share common interest in remote diagnostics technology. From a research perspective, I are interested in studying the system in practical setting, while the organizations are interested in looking to deploy it in their business setting. The project was aimed to explore and design the services or solutions based on remote monitoring and predictive diagnostics. Different stakeholders from the industry such as vehicle manufacturers, customers, users, and public transport companies were involved in during the research activities. The project was organized in such a collaborative way that it can be termed as action research [28], [29].

With the development of remote diagnostics technology, GlobalAlpha is expecting to expand its business by providing innovative services to its customers. At present, the major business of the organization is based on selling vehicles. Although some of the maintenance services are provided to the customers with the help of signed contracts. These contracts require maintenance services according to fixed schedule of time. Despite these regular and fixed maintenance services, the customers (bus operating companies) are still experiencing unexpected breakdowns. Hence, GlobalAlpha decided to introduce the technology in order to minimize unexpected stoppages because of these breakdowns. The company also see a business opportunity out of the

remote diagnostics technology. The aims with the technology are not only to implement technology that enables remote monitoring and diagnostics of the vehicles but also to predict the faults in advance. The remaining aim with the technology is to explore and develop services out of this new technology.

Since the remote diagnostics technology provides potential business by addressing customers' problems, hence it is important to identify and develop the services based on the customer needs. Neither of the members from GlobalAlpha can identify all the customer needs. So, I find it necessary to talk not only with the people from the company (GlobalAlpha), but also with the potential customers as well as other stakeholders. The purpose was to gain a deep understanding so that maximum possible services can be developed with the help of the technology.

Participants of this project include three informatics researcher, three technical researchers, two service developers, three technology developers, and a project manager from GlobalAlpha. While other participants include service technicians, business manager, bus drivers from customers' side. The authors of this paper are among the informatics researchers who actively take part in different activities. I conducted number of various activities in order to collect data together with different participants from the vehicle industry. These activities include meetings, workshops, interviews, observations, and e-mail correspondences.
Public transport operating companies are among the customers of GlobalAlpha. To gain customer perspectives, I conducted workshop, interviews with the traffic managers, service technicians and the drivers of these companies. The following table shows the activities and participants:

Table 2: List of activities

Activities	*Participants (Numbers)*
Service development meetings (Biweekly and on-demand)	• Service Developers (2) • Project Manager (1) • Technical Researcher (1) • Informatics Researchers (3)
Workshops	• Business Area Representative (3) • Informatics Researchers (3) • Traffic manager (1) • Drivers (2) • Service technician (1)
Monthly Project Meetings	• Service Developers (2) • Project Manager (1) • Informatics Researchers (3) • Technical Developers (2) • Technical Researchers (3)
Interviews	• Business Area Representatives (3) • Maintenance Manager (1) • Service Developers (2)

	• Traffic managers (4) • Drivers (5)
Documents (Meeting notes, weekly Project reports, mail correspondence)	• Service Developers (2) • Project Manager (1) • Technical Researcher (1) • Informatics Researchers (3)

In the data analysis process, as data analysis materials, meeting notes from service development meetings and monthly project meetings, the transcription of interviews and workshops and the documents are used. This process consists of two stages: first stage consists of coding, and, second stage consists of looking at material from generativity concept. The materials are coded using the qualitative coding types described by [30]. I used three types of coding: descriptive coding, topic coding and analytical Descriptive coding allowed me to store the information about the interviewee (for example, a traffic manager in a public transport operating company). Topic coding allowed me to code the topic that is being discussed in the text. The examples of such topics include repair, cost, time, and maintenance when the texts are coded. Finally, analytic coding helped to identify what's going on in a passage of text, i.e. identifying several themes that are worth noting and not known before. Then I proceed with next stage of analysis by using the concept of generativity related to remote diagnostics technology. This part provides the two value systems that can be enabled by the technology. Although examples are provided with the specific quotations from the interviews, the material also presents the findings from the overall findings from the empirical base.

5 Research Findings

GlobalAlpha is a manufacturer of different types of vehicles used mainly in transport industry. The company is a part of larger manufacturers of buses, trucks, cranes etc. Maintenance and other vehicle related services are among the biggest business in after-sale sector of the company. It provides the services to customers in such a way that they can concentrate on their core operations, knowing that their fleets are receiving attentions from the specialists. By adding remote diagnostics technology, GlobalAlpha envisions to provide efficient and effective service with improved quality and uptime.

During the project, a number of problems related to after-sales business were identified.

5.1 Problems Identified

The service business is done by selling spare parts and upgrades, as well as providing maintenance and other services. The main goal of the service department is to reduce the number of breakdowns of vehicles so that operations of the public transport company are not put on holds. By minimizing upholds and keeping uptime high, value can be created for customers (Armistead and Clark, 1991). On the basis of material collected during different activities, a number of problems are identified.

These problems can inform about how remote diagnostics technology can influence service provisions. The problems are as follows:

A poor way to communicate information. The information about bus problems is often reported through bus driver to the manager at bus operating company. Moreover, the drivers have to write information manually in a form which is then transferred to the system. The manager then decides to report the problem or to skip it. This results in heavy communication without precise knowledge about the fault or problem. Further, the driver does not understand the error codes.

Errors go undetected and/or unreported. The driver driving the bus does not have any responsibility over the functionality of the bus. Since the driver does not understand the error codes, he just skips it and do not report.

Time wastage. Most of the time at service workshop is wasted to detect or find accurate reason for problem, waiting for ordered parts (in case of unexpected breakdown). It is also evident that the technicians have direct connections with customers. So the customers call them directly over phone. This kind of relationship does not produce direct income but contribute to the goodwill of the company.

Lack of skilled workers. Service departments at different places also realized that it is very difficult to find workers with the right skills. It takes at least couple of years to learn the basics and even more to master it.

Information about usage. Today, it is difficult for GlobalAlpha to get feedback from the field about the current status of buses and how they are used over time. The information is not only useful in better diagnostics of problems but also is valuable for product development over the long time of period.

Problems with existing knowledge. The existing database is not used in its full potentials since there is no way to extract information and couple it with the information from the field.

Ease of use. Due to highly technical and poor communication of information, it is difficult for the users to use the system properly and efficiently.

5.2 Value creation

The basic architecture in this technological solution is remote diagnostics system where bus is embedded with sensors that register data about the crane and then transfer it to the control system. The control system then transfers data to analytical and processing unit where it is analyzed to find about the current status. Critical problems or otherwise are diagnosed in this way and two value systems are identified: (i) one with users as passive receivers of the services – the customers in this case have signed contracts with GlobalAlpha and rely on the company to diagnose and repair the faults. In this scenario, the technology can provide value to service departments in terms of providing accurate and precise information to the service technicians. It will also save time, address skilled workers' shortage, record previously unreported errors, and provide information about usage for GlobalAlpha service department; and (ii) customers in this case own service workshops, so they are not passive receive of services i.e. they are not dependent on GlobalAlpha for repair services. But they still have the problems of unexpected errors, skilled workers' shortage, poor knowledge about their vehicle usage and so on. Hence, diagnosing the problem and reporting it to the bus operating company is a potential business for GlobalAlpha. The differentiation of this setting is from previous one is that control unit is placed at

customers' place where technicians can use it to detect faults. Hence, in this case the customers are partially dependent on solution providing company i.e. for diagnostics only.

6 Discussion and Concluding Remarks

In order to answer how generative capacity influence value creation in digital ecosystems or networks, I illustrate value creation in these types of situations. It has number of characteristics on which it depends upon.

Since it is generative capacity and multilayered, and it is on the service side and not the other side, I need to cope with both structures in these networks i.e. to cope with the whole span of continuum. Because some structures are on the modular side and some are on the layered modular side. So if the question is how it influences the value creation? Then the answer is that implications suggest that I need to cope with the whole structure for such value creation situations. Findings also show that two types of or multiple value systems exist because of generative capacity. Further, passive customer's value system need to expand with active customers' value system.

I conquer with [7] that the primary source of value creation is the generativity and it is emerged when heterogeneous resources mix-and-match their capabilities in an unbounded manner. Finally, in such digital ecosystems, to maximize generative potential of technological architecture, it is essential for an organization to design digital product platform that can inspire and mobilize others. Finally, in managing such a network, a firm needs to develop the capability to create new meanings of its products and services [31]. This should be done by constantly redefining the product boundaries through active reshaping of the digital products in the ecosystem [32].

The sector (i.e. Vehicle Industry – the context of research) provides the limitations to the study. Moreover, the study is conducted in one of the Nordic countries, hence the cultural aspects about innovation also provides additional limitation when it comes to generalize the results/theoretical contribution in other geographical regions. However, the study provides useful insights on how digital technology provides generative capacity in product oriented business. A similar study can be conducted in other industry and a comparative analysis can help to generalize the results.

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