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THE INFLUENCE OF GENERATIVITY ON VALUE CREATION – A STUDY OF DIGITIZED PRODUCTS

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ABSTRACT
The advancement of digital technologies is driving traditional product oriented businesses to move from selling products to selling solutions. In order to exploit business potentials from technology, it is important to understand the potential of the technology and how it influences the value creation in a digital environment where it is developed and to be deployed. To understand this changing environment, I have studied remote diagnostics as an example of digital technology within the vehicle industry as a source of new value for business. The findings show that digitized products not only helps to solve existing problems in providing services but also provides potential to generate value for new products and services in the networked environment. An implication from the findings for product oriented firms is that value creation with digitized products requires new business processes. Based on the findings, a discussion is presented about how generativity influences value creation via value in design, governance and networking in a digital ecosystem.

KEYWORDS
Value creation, generativity, digitization, digital innovation, digital ecosystem, 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' (Chesbrough and Rosenbloom 2002, Davies, Brady et al. 2006, Nenonen and Storbacka 2010). During the change, there is an increasing research interest in exploring innovative ways for value creation, especially in digital innovation literature. It has been argued that digital technology creates new opportunities for value creation and helps a company to gain agility (Sambamurthy, Bharadwaj et al. 2003). These opportunities suggest that locus of value creation resides within the networks in digital ecosystems rather than within an organization’s boundaries (Åkesson 2009, Nenonen and Storbacka 2010). This requires organizations to develop and maintain multiple parallel business models within a digital ecosystem to increase exploitation of the technology (Chesbrough 2007, Jonsson, Westergren et al. 2008, Nenonen and Storbacka 2010). Further, (Henfridsson and Lindgren 2010) argue that to create value from digital innovation, firms should consider the generativity aspect and how it changes the existing value creation structures. Generativity refers to the ability or power to generate or produce something. Like other manufacturing industries, this phenomenon can be observed within the vehicle industry with business oriented on to selling products and new efforts are taken to expand the business with services from digitized products (Jonsson, Westergren et al. 2008).

Previous research has addressed the role of information technology (IT), in general, in creating business value and building sustainable competitive advantage (Kohli and Grover 2008, Avital and Te'eni 2009, Nevo and Wade 2010) and strategic positioning of firms. In information systems (IS), researchers have studied the role of digital technology (especially in digital innovation which is open in nature e.g. (Morgan, Feller et al. 2013). Further, value creation has been studied in ubiquitous computing environment in the vehicle industry where remote diagnostics serves as underlying technology (Jonsson, Westergren et al. 2008). But the digital technology’s influence on digitized products has not been addressed in the IS literature on larger scale (Lee, DeLone et al. 2014). To consider this, (Henfridsson and Lindgren 2010) emphasize the importance of new digital strategy frameworks that identify new sources of value creation such as generativity. This paper represents an example of the study where generativity of digital technology is being explored and
conceptualized together with other actors or stakeholders while the technology is being developed. To cope with this, we concur with (Lyytinen and Yoo 2002) who emphasize that IS researchers should be actively involved in studies during the development of technologies rather than after their introduction in the market. Hence the research question is How does generative capacity influence value creation of services of digitized products?

The aim of the paper is to contribute to an understanding of value creation with digitized products in the vehicle industry. In the next section, I provide a review of literature on value creation and generativity. This is followed by research approach and method section along with data collection and analysis strategy. Then I presented the findings from empirical material from the project. After that discussion and conclusion section concluded the paper.

2. DIGITAL INNOVATION AND VALUE CREATION

Digital innovation is defined as “the carrying out of new combinations of digital and physical components to produce novel products”(Yoo, Henfridsson et al. 2010) p.725. 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 digitization is embedding digital technology such as remote diagnostics systems in vehicles. Furthermore, the digitization, in turn, makes physical products programmable, addressable, sensible, communicable, memorable, traceable, and associable (Yoo 2010). The focus of such innovation is based on product innovation and is different from existing digital innovation which is mostly concerned with process innovation (Swanson and Ramiller 2004). In this paper, I refer to the services enabled by digitization as digital services and innovation related to such services is called digital service innovation. Driven by advanced development of digital technology digital services differ from conventional services and inherit properties from digitized products as well as from services, hence possessing the hybrid nature (Yoo, Henfridsson et al. 2010). The advantage of using digitized artifacts include new dimensions to service relationship as embedded sensors can become eye and ear of remote service provider (Yoo 2010) who can access real-time data and in turn can provide seamless services to customers.

Value creation, in general, has been discussed even before the advent of digital technology. For example, it has been discussed as value-in-use (or use value also called value perception) (Priem 2007); exchange value – both tangible and intangible (Allee 2000, Bowman and Ambrosini 2000, Lepak, Smith et al. 2007); value in co-creation (Prahalad and Ramaswamy 2004). The theoretical frameworks used for explaining value creation include value chain (Porter and Millar 1985, Peppard and Rylander 2006, Vanhaverbeke, Van de Vrande et al. 2008); transaction cost economies (Zajac and Olsen 1993, Moran and Ghoshal 1996, Vanhaverbeke, Van de Vrande et al. 2008); dynamic capabilities (Chesbrough and Crowther 2006, Wang and Ahmed 2007); and Schumpeterian innovation (Amit and Zott 2001).

Value creation in digital ecosystems where innovation is at the core has been discussed in extant literature. The use of digital technology can create value for firms when developing innovative ways of doing business (Porter and Millar 1985). If innovation of products and services increases customers’ satisfaction during use, new value is created (Lepak, Smith et al. 2007, Priem 2007). But satisfying customers is not sufficient and also requires a firm’s ability to innovate. It has also been observed in the past that innovative information technology helped firms in transforming their business and changing customer relationships (Brynjolfsson and Hitt 2000). Moreover, over the past few decades, digital innovations depict positive impact in various business sectors such as banking sector, chemical industry, tourism, insurance industry (Muller and Zimmermann 2003) and aircraft maintenance (Lampe, Strassner et al. 2004). Although the previous studies shows that digital innovation enables new value creation opportunities for businesses opportunities (Fleisch and Tellkamp 2003), there is need for more research on influence of digital technology on value creation.

3. GENERATIVITY

Existing research on the concept of generativity can be described along three dimensions: (i) Technological; (ii) organization; and (iii) business. Along the technological dimension, 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 (Zittrain 2009). Some researchers refer to this as an attribute of a system and call it ‘generative fit’ (Avital and Te’eni 2009). It has been defined as “a system's capacity to produce unanticipated change through unfiltered contributions from broad and varied audiences” (Zittrain 2009). Since the introduction of the term with respect to digital technology, there have been studies that try to explain it as a concept in different contexts ranging from internet to embedded devices. In case of embedded devices, one of the themes related to digital technologies argue for a new kind of architecture for digitized products. This architecture consists of a continuum having modular architecture at one end and layered modular architecture on the other end (Yoo, Henfridsson et al. 2010). Generativity in digitized products is achieved through agility on modular side (Brusoni, Prencipe et al. 2001, Sambarurthy, Bharadwaj et al. 2003), and through loose coupling across layers and multiple design hierarchies on layered modular side. However, achieving generativity in digital innovation of incumbent firms is not easy due to even rate of advancement in underlying technological interdependencies (Sambarurthy, Bharadwaj et al. 2003, Henfridsson, Mathiassen et al. 2009). Still, unpredictable product interdependencies give rise to generativity in such architectures in the vehicle automotive industry which depicts modular architecture (Brusoni, Prencipe et al. 2001).

The second dimension regarding generativity or ‘generative capacity’ argues along the social lines. This line states that it is an attribute of a person (or organization) in terms of one’s ability to rethink existing structures and to produce something innovative in general or at least in a particular concept (Brusoni, Prencipe et al. 2001, Avital and Te’eni 2009). In the business context, generativity is referred to as the ability of a business model or value network that can inform about new technological solution (Chesbrough 2007).

Recent literature emphasize on the role of intangibles (on top of tangibles) to create value from digital technology (Allee 2000). However, these dimensions require in depth analysis of the value creation for digitized products.

In order to understand the influence of generativity on value creation, an integrative framework is presented in Figure 1 to address the transformation it brings in digital ecosystem. The framework considers three different dimension of generative capacity that influences value creation of digital services. In a manufacturing industry (such as vehicle), new value proposals from firms providing such services and perceptions by customers and other stakeholders are affected by digitized products. Hence, this paper will use this framework to explore the influence from a generative perspective.

4. RESEARCH APPROACH AND METHOD

This paper reports on three years research at GlobalAlpha (pseudonym of organization), a manufacturer of buses, construction equipment and trucks in the vehicle industry. In addition to researchers from academics, the project is carried out in collaboration among manufacturing firms, public transport authority and bus operating customers (customers of GlobalAlpha) that share common interest in remote diagnostics technology. The project aimed to explore and design the services or solutions based on remote monitoring based on remote diagnostics technology. The project was divided into two main parts: technology development and service development. Both parts of the projects were running in parallel and information was shared from the researchers and practitioners on regularly and on-demand basis. Different stakeholders from the industry such as vehicle manufacturers, customers, users, and public transport companies were involved in the research activities.
With the help of remote diagnostics technology, GlobalAlpha is looking forward to provide innovative digital services to its customers to expand its existing business. At present, the main business of the organization is based on selling vehicles in three distinct business areas (BAs). A little share of revenue is obtained by providing maintenance services through contracts. These contracts provide maintenance services according to fixed schedule of time. However, the customers (transport operating companies -TOC) are bearing extra cost and unexpected breakdowns. So, GlobalAlpha decided to develop the technology to reduce breakdown risks and costs. The company is also looking for new business opportunities from the technology.

Since the remote diagnostics technology provides potential benefits to business by addressing customers’ problems, it is important to identify and develop the services based on the customer needs. To gain stakeholders views workshop, interviews with the traffic managers, service technicians and the drivers of were conducted with personnel from different companies. The purpose was to gain a deep understanding so that digital services can be explored and designed with the help of remote diagnostics technology. Participants of this project include three informatics researchers, three technical researchers, two service developers from GlobalAlpha, three technology developers from GlobalAlpha, and a project manager from GlobalAlpha. Other participants in the study include service technicians, business manager, bus drivers from customers’ side. The author of this paper is one of the informatics researchers who actively took part in different activities. Number of activities including meetings, workshops, interviews, observations, and e-mail correspondences were used as data sources. The following Table 1 shows the activities and participants:

<table>
<thead>
<tr>
<th>Type</th>
<th>Activities and sources with numbers</th>
<th>Participants</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Meetings</td>
<td>30 Service development meetings</td>
<td>Service developer, business developer, informatics researchers</td>
<td>2-3 hours</td>
</tr>
<tr>
<td></td>
<td>20 Monthly project meetings</td>
<td>Project manager; Service developer; Business developer; Technology developer; technology researchers</td>
<td>2-3 hours</td>
</tr>
<tr>
<td>Workshops</td>
<td>3 Value network workshops with representatives from BA1 of GlobalAlpha, 2 &amp; 3</td>
<td>Business area manager; service developers</td>
<td>4 hours</td>
</tr>
<tr>
<td></td>
<td>1 Future workshops with TOC</td>
<td>Business manager, service manager, bus drivers, service developer</td>
<td>4 hours</td>
</tr>
<tr>
<td>Interviews</td>
<td>3 Semi-structured interview from BA 1, 2 &amp;3 of GlobalAlpha</td>
<td>Business area managers</td>
<td>1-2 hours</td>
</tr>
<tr>
<td></td>
<td>1 Semi-structured interview BA1 of GlobalAlpha maintenance workshop</td>
<td>Service manager</td>
<td>1-2 hours</td>
</tr>
<tr>
<td></td>
<td>1 Semi-structured interview with representative from GlobalTech</td>
<td>Technology development manager</td>
<td>2 hours</td>
</tr>
<tr>
<td></td>
<td>3 Semi-structured interview with GlobalTech</td>
<td>Project manager; technology developers</td>
<td>1-2 hours</td>
</tr>
<tr>
<td></td>
<td>1 Semi-structured interview with public transport authority</td>
<td>Manager</td>
<td>2 hours</td>
</tr>
<tr>
<td></td>
<td>11 semi-structured interviews with TOC (existing and potential customers of Alpha 1)</td>
<td>Managers; assistant managers; drivers</td>
<td>1-2 hours</td>
</tr>
<tr>
<td></td>
<td>1 semi-structured interview from GlobalAlpha</td>
<td>Global business manager; service concept developer</td>
<td>1-2 hours</td>
</tr>
<tr>
<td>Docs</td>
<td>54 Weekly project newsletters</td>
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<tr>
<td></td>
<td>50 Meeting notes and minutes</td>
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<td>---</td>
</tr>
<tr>
<td></td>
<td>4 Project reports (including scenarios and service concepts etc.)</td>
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</tr>
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</table>

In the data analysis process, meeting notes from service development meetings and monthly project meetings, the transcription of interviews and workshops and the other documents were used. This process consisted of two stages: first stage consisted of coding, and, second stage consisted of looking at the material from technological, human and business dimensions of generativity concept. The materials are coded using the qualitative coding types described by (Richards 2009). 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
three topics discussed in the literature section i.e. along technology, organization and business dimensions. The examples of such topics include repair, cost, time, and maintenance when the texts are coded. Finally, analytic coding helped to identify themes that are related to remote diagnostics technology, organization and business of manufacturing firms. Then I proceed with next stage of analysis by using the concept of generativity related to remote diagnostics technology. This part provided the three value systems that can be enabled by remote diagnostics technology. In addition to interviews, the results also represent findings from the overall empirical base such as value networks, workshops and other documents.

5. FINDINGS: VALUE CREATION AND REMOTE DIAGNOSTICS AT GLOBALALPHA

GlobalAlpha is a manufacturer of different types of vehicles used mainly in the transport industry. 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 maintenance were identified. These problems serve as a base in understanding how remote diagnostic technology can affect the way services are designed and value is created.

5.1 Generativity from Technological Dimension – Value in Design

The analysis of the material collected from the data sources reveals important findings about RDS. The architecture of RDS consist of (i) sensors embedded in different parts of vehicles; (ii) a device placed in vehicles (called VACT) to process real time signals from the bus (on-board signals); (iii) a wireless transmission system to send on-board signals to a remote station; and (iv) back office – a remote station where on-board signals are received and combined with service records for further analysis (via the COSMO algorithm) to find the status of a vehicle in the fleet. Any deviation from other vehicles’ patterns in the fleet is marked and further probed for specific faults. The information is later sent to different stakeholders interested in using this information. RDS can thus provide value not only for GlobalAlpha and its customers (TOC), but also for other stakeholders such as public transport authorities and production unit.

The main goal of the maintenance is to minimize the cost and number of breakdowns of vehicles so that operations of the public transport company are not put on hold. By minimizing upholds and keeping uptime high, value can be created for customers (Armistead and Clark 1993). Some of the values that this technology provides to different stakeholders are described below:

Diagnosing the fault using existing traditional ways (i.e. without remote diagnostics) is a trivial job as narrated by one of the service planners:

“Sometimes, it becomes really difficult and time consuming in detecting faults. The existing procedure has limitations in detecting faults.”

An interview with technology developers further highlights that the design of remote diagnostics system is based on a physical device specific algorithm which is patented itself. From that point of view, the device is specifically programmed for GlobalAlpha vehicles. About the design of the technology, a technology developer further added:

“The device is only applicable for the buses of our company. It cannot be used in other brands.”

This feature of the technology can be leveraged by other companies’ diagnostics tools but other advantages that this technology offers is described by one of the technology developers as:

“Most existing diagnostics or error detection systems are not on-board diagnostics tools. There is a requirement for analysis of the error codes by some experts. We are implementing a system where the diagnostics will be done by the main device in the bus and it will send an analyzed signal about the irregularity. No more expert analysis will be required”.

The information from remote diagnostics technology is combined with the existing service records at the service workshops. These service records contain the history of maintenance activities for each vehicle over specified period of time. Hence, an idea about frequent and critical faults was obtained in order to start working with critical problems. The information gained from the remote diagnostics can be helpful to develop services that the company can use to build customer relationships. They will not only be able to
control the digital information but also decide what services they should provide. A service developer
mentioned this during a meeting:

“The back office will be able to see the signals coming from the buses and based on the signals we shall
see the condition of the buses. Any irregularity can be informed to the bus owners so that their buses can be
saved from any possible breakdown.”

Findings from empirical material reflects value in design i.e. value that the architecture of remote
diagnostics technology offers to various stakeholders. For example, the architecture of remote diagnostics
system enabled an improved design for diagnosing and error notification system. This design creates value
for various stakeholders at the same time. Furthermore, information about frequent as well as critical
problems can be sent to product development for improvement in design.

5.2 Generativity from Business and Organization Dimensions – Value in
Networking and Value in Effective Governance

In the assessment of digital technology’s potentials, GlobalAlpha envisioned three different technological
solutions where data flows in different ways. Each solution results in a distinct value proposal and perception
for value creation. Value network, future workshops, and business model workshops together with reports
served as main sources of data collection (see Table 1) to identify the following value systems:

5.2.1 Value System 1

In the first solution, the customers are passive receivers of the services – the customers in this case have
signed contracts with GlobalAlpha and rely on the company for all kind of services i.e. to diagnose the faults
and repair parts. One way of creating new business value is to incorporate it into existing service contracts,
which GlobalAlpha provides to its customers. The other way is to offer new service contracts, for example
extended warranty if GlobalAlpha take care of all maintenance. However, in both value proposal customers
receive both services i.e. diagnostics and repair. For GlobalAlpha it will save time, address skilled workers’
shortage, record previously unreported errors, and provide information about usage for GlobalAlpha service
department. With this solution, the TOCs are exchanging knowledge by providing access to the information
about use of vehicle, service records and feedback from drivers. TOCs having this value system also
participate by providing customer needs. In return, value for customers is reduced numbers of unplanned
halts during their business operations (i.e. better quality of service). This also provides customers with more
flexibility in planning and scheduling their transport as well as related to maintenance, well in advance.

5.2.2 Value System 2

In the second solution, the bus in this value system is again embedded with sensors and data is transmitted in
a similar fashion to the previous solution. However, TOCs companies rely on GlobalAlpha for diagnosing the
faults but are not dependent for regular repair services. However, they are still dependent on GlobalAlpha for
critical repair and maintenance services. In this regard, GlobalAlpha also withholds data regarding critical
problems. Hence, this system suggests participation of customers during co-design, knowledge sharing via
customer needs, access to vehicle usage data and service records. An example of customer participation and
knowledge sharing was observed during future workshop where one of the TOCs formed team with project
members. They participated in designing possible digital services based on remote diagnostics technology
keeping their business needs in mind. Although TOC showed their interest in collaborating with
GlobalAlpha, yet reflection from the empirical material showed that TOCs require alignment of objectives to
keep the participation going. The value proposition of GlobalAlpha is selling diagnostics information related
to regular maintenance and repair services. This was mentioned in an interview:

“We now regularly collect data from the vehicles. There is an opportunity to sell the data to customers.
They can use the data and design diagnostics services according to their needs”.

Similar, yet distinct, value proposition of providing diagnostics services exists for the next value system.

5.2.3 Value System 3

As in the first and second solutions, the bus is provided with a number of sensors that register the vehicle’s
health condition. However, the customers in this case own service workshops, so they are not passive
receivers 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, and 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 difference of this setting from previous one is that a control unit is placed at the customers’ place where technicians can use the system to detect faults. Hence, in this case the customers are dependent on the solution providing company for diagnostics only. The customers are equipped with more and better information about their own vehicles, which will be valuable from a learning perspective. GlobalAlpha in this case incorporate the solution to some sort of service contracts in order to maintain their position as maintenance supplier and establish sustainable relationships with their customers. Since customers own the data, GlobalAlpha may or may not get feedback from TOCs and need to establish new ways to establish relationship. This in turn limits knowledge sharing which is essential for networking in a business; hence both stakeholders are required to find new structures for collaboration and participation such as through aligning the objectives. Table 2 below provides the summary of the findings:

6. DISCUSSION AND CONCLUDING REMARKS

In order to explore how the generativity of digit technology influences value creation of digital services in the manufacturing industry, this paper presents a study of remote diagnostic technology as an example of the phenomenon. The paper contributes to an understanding the potentials of digital technology in physical products and how it influences the value creation. On one hand, the findings highlight the role of digital
technology to overcome many of the limitations of the current system. On the other hand, considering generativity along technological, organization and business dimensions provides new insights for the value creation process. It was mentioned in sections 2 and 3 that traditionally value is created through creativity, loose coupling and agility in incumbent manufacturing firms. This study shows that there are some additional values that contribute to the value creation of services related to digitized products. These incorporated values that influence the value creation are: (i) value in design; (ii) value in effective management; and (iii) value in networking. The following model shows the influence of generativity on value creation:

![Figure 2. Influence of generative capacity on value creation of digitized products](image)

Value in design is dependent on the architecture of digital technology embedded in physical products and digital services enabled by it. Value in effective management or governance is relates to new forms of relationships between focal firm providing value and its receivers. This value is based on formal and informal relationships, as well as the control over the ecosystem. Standard interface design of modular products achieved through creativity within incumbent firms also adds value to value creation. Finally, value in networking is achieved through the introduction of intangible exchanges such as knowledge, active participation by customers as well as aligning the objectives with other stakeholders during innovation. The following model presents how the generativity influence overall value created in digital innovation.

Figure 2 shows that beside the architecture of digitized products, key activities regarding networking are important for generativity. Since the digital technology inhibit generative capacity and multilayered, firms need to cope with the design of both architectures for value creation. Considering generativity along technology, business and organization dimensions suggest new value s i.e. value in design, value in effective governance and value in networking with other stakeholders. Findings also show three types of or multiple value systems exist because of generativity of business networks. I concur with (Yoo, Henfridsson et al. 2010) that one of 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 other stakeholders in network. Finally, in managing such a network, a firm needs to develop the capability to create new meanings of its products and services (Verganti 2009). This should be done by constantly redefining the product boundaries through active reshaping of the digital products in the ecosystem (Kusunoki and Aoshima 2010).

The sector (i.e. Vehicle Industry – the context of research) provides the limitations to theorize the implications of the study. However, the study provides insights for researchers who are interested in exploring value creation in digital age. Since, digital ecosystem in the industry is evolving; further studies
can elaborate on more aspects of value creation process with time. More studies can be conducted in other industry and environments, and a comparative analysis can made to generalize the results.

REFERENCES