The impact of the Internet of Things on revenue in supply chains

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ABSTRACT

The Internet of Things is increasingly used to enhance supply chains by providing additional information and making decisions based on this information. This research analyses the benefits the Internet of Things has on supply chains through a literature study, and looks how these benefits can increase revenue within a supply chain. The goal of increased revenue is competitive advantage. The Internet of Things allows existing business models to change and allows new business models to emerge. The results from literature research are placed in business reality by interviewing people with different functions related to the Internet of Things and supply chains. The results of this research are twofold. Firstly, this research provides five benefits that can be used to increase revenue in a supply chain, of which each its applicability is confirmed by results from interviews. Secondly, this research has found five business models that are able to emerge because of the existence of the Internet of Things. The results of this research allow a business to increase revenues from a supply chain and to utilize new business models the Internet of Things makes room for.

Keywords

Internet of Things, Supply Chain, Business Model

1. INTRODUCTION

Our society is integrated with a growing amount of computing devices. Where computers at first were several meters in diameter, new technology allowed a higher density of chips, making computers smaller and increasing the utilization [20]. We are now entering an age where virtually every physical object can be turned into a so-called ‘smart object’ by enhancing it with a small computer. This age is called ‘The Internet of Things’. Haller et al. [13] define the Internet of Things as “a world where physical objects are seamlessly integrated into the information network and where physical objects can become active participants in business processes”. The Internet of Things offers new possibilities for supply chains, by making use of smart objects. A supply chain is defined as a set of organizations (actors) that exchange products, services, finances and/or information, according to Mentzer [19]. López et al. [17] define smart objects as follows: A “smart object” is any object or product that is -by way of embedded technologies- aware of its environment and state, and it may have the ability to make its own decisions about itself and its uses, communicate state information, and achieve actuation under its own control. According to López et al. [17] smart objects can be used to enhance supply chains by improving quality of information and visibility of products, and increasing accuracy and timeliness of information about the business process [13]. The application of the described benefits can potentially increase a business’ competitive advantages, which explains the business need of this research.

1.1 Problem statement

With the ability to equip physical objects with small computers these objects can be turned into smart objects as defined by López et al. [17]. Haller et al. [13] state that additional information supplied by these smart objects, enables a company to better understand what happens in ‘the real world’. This makes the supply chain more transparent. It is likely that the availability of extra information makes it easier to identify inefficiencies in the supply chain. This can increase revenues and competitive advantages. Besides identifying inefficiencies within the processes, the Internet of Things can simplify monitoring and auditing the supply chain and the Internet of Things can allow smart objects a degree of freedom in decision making [15], which allows an object to adjust processes within the supply chain based on information it possesses. The main question this research addresses is how a supply chain can benefit from the Internet of Things.

The introduction of the Internet of Things can potentially influence a company’s business model, which is commonly based on today’s largely static information architecture [6]. Future companies will heavily rely on information from smart objects [13], and new business models will emerge. This makes it interesting to research the influence the Internet of Things has on existing business models and how new business models will emerge.

The concepts introduced in recent literature provide different visions on the application of the Internet of Things in supply chains and how the supply chain can benefit from the Internet of Things. The actual application and benefits in business reality however, can be different. How literature conclusions match business reality is a question that arises.

The following questions will be addressed:

- How can supply chains benefit from the Internet of Things?
- How can the Internet of Things influence new and
existing business models?

- How does the business reality match with the literature conclusions?

In order to assure these topics are not already researched, the method of Wolfsink et al. [25] has been used to systematically review current literature. The search criteria that outline the scope of this paper are “internet of things”, “supply chain”, “smart object” and “business model”. Since the base of this paper is the “internet of things”, this has been the keyword was used in all queries. The following search queries were formulated:

1. “internet of things”
2. “internet of things” and (“supply chain” or “supply chains”) or (“business model” or “business models”) or (“smart object” or “smart objects”)

The intention of the first query is to provide general background information on the Internet of Things and due to a large amount of results the selection was narrowed down to articles from 2008 and younger, with at least 10 citations. The results were refined by title and abstract. The second query is more specific. All results (139) were subjected to refinement by title and abstract.

2. METHOD OF RESEARCH

The first question requires research in recent literature. The effects of transparency in supply chains is described by Haller et al. [13] and is called “Real-World Visibility”. The article of Bo et al. [3] explains the way information attached to smart objects can be shared between multiple entities within a supply chain and how the “bullwhip effect” can be prevented using this information. Haller et al. [13] explain the concept of Business Process Decomposition, which decentralizes decisions within a business process. By doing this, data and services are propagated to potentially underutilized run time environments. The found benefits are explained in section 4.

The second question can partially be answered using literature. By comparing differences between the static environments of the past with the future ones, we can analyze differences in business models [6]. Besides changes to existing business models, new business models will emerge as effect of the introduction of the Internet of Things: which opportunities exist according to literature, is described. The new and changed business models found in literature can be found in section 5.

The third question addresses the applicability of the results found in the previous research questions. The literature conclusions are matched with business reality by interviewing D. Otter, operation manager at CTT, an intermodal transporting company, E. de Jong, managing director at Antaris Solutions, a supplier of Internet of Things-enabling technology and J.C. den Ouden, proposition manager of project IBOR at Logica, an IT and management consulting company and applies the Internet of Things to articles related to specific parts of the Internet of Things. The following general articles with at least 10 citations are used to provide general context on the subject: Chui et al. [6] provide an explanation of the Internet of Things and mention examples of application and implications for process optimization; Atzori et al. [2] explain how the Internet of Things can be applied in supply chains; Haller et al. [13] explain the effect of real world visibility on supply chains and the effect of business process decomposition on business processes. The other articles mentioned in table 1 and the business model part of this research provide a more specific vision on the subject they are mentioned in. Several contributions on supply chain management are provided by Mentzer et al. [19]. This is useful for answering the questions because it creates a greater understanding of the issues addressed.

4. BENEFITS OF THE INTERNET OF THINGS

The new technology the Internet of Things offers can add value for actors in the supply chain. There are different ways the Internet of Things can add value. The literature research that has been conducted, shows that many articles mention the same beneficial concepts as others. Table 1 shows the different beneficial concepts of different articles, then for each beneficial concept it is explained how it can influence the supply chain and how the supply chain profits from the concept.

The current research also addresses the business reality the Internet of Things in supply chains, the results acquired using interviews are placed in a subsection after each beneficial concept.

<table>
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<tr>
<th>Article</th>
<th>Improved inventory management</th>
<th>Real-time SCM</th>
<th>Increased logistic transparency</th>
<th>Business process optimization</th>
<th>Resource saving</th>
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4.1 Improved Inventory Management

Business of all kinds use inventories to store objects such as raw materials and finished products for further use. Inventories exist because there is a difference in the timing or rate of supply and demand [24]. Inventories work as a buffer: when demand is high and can provide materials when suppliers cannot supply quick enough and are therefore useful. Keeping an inventory is also expensive: not only the value of the stored products can be high but
maintaining a large building for the sole purpose of keeping inventory is expensive. By using the technology of the Internet of Things, stock can be monitored in real time which can save from over stocking and over production [1]. The application of the Internet of Things can decrease the reaction time of a traditional enterprise from the customer's requirements to the supply of commodity from 120 days to a few days [2], which allows a significant decrease in stock size thus saving costs. Other advantages include theft and loss prevention, reduced turnaround times and avoidance of unnecessary handling [8].

4.3 Increased Logistic Transparency
The Internet of Things can add value to inventory management because more information is available. This allows CTT to improve the positioning of payload (containers) before the arrival of a barge [22]. This way a barge can be unloaded and loaded more efficient.

4.2 Real time SCM
Supply chain management (SCM) manages to optimize processes and collaboration with other companies in the supply chain (suppliers and customers) in order to create more value. While SCM is already heavily supported by various IT solutions, the Internet of Things can be of great value by providing additional information. One of the major challenges in SCM is reducing the bullwhip effect. A major cause of the bullwhip effect is information distortion [16]. For a better information flow, the Internet of Things is able to trigger all relevant actors in the supply chain upon the sale of a product [14]. In traditional processes, information on demand was only passed to one's direct downstream partner instead of sharing this information with the whole chain.

The new sophisticated RFID chips used in the Internet of Things allow the recording of all kinds of manufacturing information, production date, expiry date, warranty period, after sales details etc. allowing real time and more efficient supply chain management [1].

4.4 Business Process Optimization
Business processes within a company can work more efficiently when making use of the Internet of Things. Fleisch [12] introduces the concept of 'high resolution management', which makes extensive use of real time information made available in the business process by technologies such as RFID. High resolution management emphasizes the shift from 'low resolution management' in a traditional environment to the current environment in which we can embed almost everything within a business process: trucks, forklifts, pallets, work-in-progress bins, consumer products: the result is a more detailed look into business processes, simplifying the detection of conflicts and inefficiencies [12]. Fleisch [12] also states that the use of the Internet of Things often leads to the discovery of problems they were (at first) not looking for, creating new possibilities to optimize a process.

Business processes transformed by the Internet of Things show the decentralization of decision making. Smart objects are given a greater degree of freedom, leading to increased scalability and performance. The decentralization of decision making is what Haller et al. [13] call Business Process Decomposition. Decentralization distributes computing power to the specific area the decision applies to, this saves computing time and reduces computing load [14].

4.5 Resource Saving
As explained in the previous sections, the Internet of Things allows one to look at business processes with more detail.
5. Data storage and analysis

Along with cloud computing, the Internet of Things allows the integration of agent-based autonomous control in logistics. This allows real-world material flows and data flow to be managed with the Internet of Things technology. According to Schuldt et al. [23] the necessary synchronizers for existing companies to change their business model and for new companies to start a new business. Literature describes several new needs that come along with the introduction of the Internet of Things. These needs can provide a fertile basis for new ventures. The ‘output’ of the Internet of Things (data) is not limited to supply chains, but can be of use in new business models. In this research Osterwalder’s [21] definition of a business model is used. A business model is defined as follows.

A business model is a conceptual tool that contains a set of elements and their relationships and allows expressing a company’s logic of earning money. It is a description of the value a company offers to one or several segments of customers and the architecture of the firm and its network of partners for creating, marketing and delivering this value and relationship capital, in order to generate profitable and sustainable revenue streams.

5.1 Fourth party logistics

Fourth party logistics (4PL) is an existing concept to manage comprehensive supply chain solutions. Where the concept of third party logistics (3PL) is the outsourcing of logistic activities within a company, 4PL manages a larger supply chain network which can include several 3PL operators. According to Schuldt et al. [23] the necessary synchronization of real-world material flows and data flow is accomplished with the Internet of Things technology. This allows the integration of agent-based autonomous control in logistics and cloud computing using the Internet of Things. Along with cloud computing, the Internet of Things allows the 4PL business model to emerge.

5.2 Data storage and analysis

With the Internet of Things emerging, a massive amount of sensor data will become available to monitor and store. The phenomenon of this growing amount of data (it doubles every 18 months) is known as ‘big data’ [5]. This allows existing business models to change and new business models to emerge. Current data providers can change their business model to not only store data, but also analyze data and sell results [22]. An example is data stored at Facebook, with which companies can measure the immediate impact of their marketing campaigns [5].

Another way to change a business model is to change pricing strategies dynamically based on the availability of recent and historical data. Bugnin et al. [5] mention supermarkets that change prices daily or even more, based on data from online transactions, consumer service interactions and visits to their website.

New business models can emerge in a different way: data from multiple sources can be aggregated and analyzed or sold. With this information organizations can enhance their strategies because new ideas can be drawn from the aggregated data.

To support big data’s enormous storage and analytical needs, cloud computing can be used [4] and because of flexibility to changes in demand and scalability cloud computing is also used to support 4PL [23].

5.3 Data security

As the Internet of Things consists of a lot of sensors that transmit data wireless, this calls for security and privacy challenges [11]. Due to the relations amongst objects being closer, objects are linked. The need to protect massive amounts of data and privacy of users and to prevent interference of signals arise [18].

This challenge leaves new opportunities for new business models that ensure the security of smart items in the supply chain in order to protect a company’s assets from cyber attacks or intentional interest of a participating member of the Internet of Things infrastructure [1]. Other opportunities for new business models are anti-counterfeiting services or services that guarantee supply chain integrity by compliance with regulations imposed by external authorities [10].

5.4 Carbon footprint

Sustainability is a hot topic at this point in time and many companies are trying to reduce CO2. The carbon footprint of supply chains is not easy to capture. The Internet of Things can enable the capture process per product by letting each smart component of the product mark its own carbon footprint [14]. The Internet of Things can enable a carbon credit trade history which can ensure environmental regulation compliance. He et al. [14] also states that a supply chain’s carbon source can be matched with carbon demand (i.e. carbonated drinks, baking powder), in order to greatly enhance a green supply chain.

The ideas described above can lead to new business models: there is a place for companies that keep records of carbon footprint and by matching carbon source with demand. Existing business models can change because resources are used in a different way, changing their relationship.

5.5 Infrastructure provider

There are technologies such as RFID that can only be read using special readers. For these technologies to be useful an infrastructure of readers is required. This allows the...
tracking of the object equipped with the sensor every time it passes a reading device. A company that wants to use these technologies, can easily place reading devices on its own part of the supply chain, but when objects leave this part of the supply chain, they can’t be tracked anymore. Because it is useful to monitor objects in the entire supply chain as mentioned in section 4.2 and 4.3, the need for a new business model which is based on the realization and exploitation of a reading infrastructure that covers the entire supply chain is created [7].

6. CONCLUSION
In this paper we have found the following five benefits of the Internet of Things in supply chains.

- Improved inventory management
- Real time SCM
- Increased logistic transparency
- Business process optimization
- Resource saving

These benefits are found in literature and are supported by multiple authors, as is shown in table 1. With the results from interviews, it is confirmed that each of the benefits is beneficial for the supply chain, and can rely on support of business as well. The benefits often lead to cost reduction within processes and the entire chain [9, 7] but also allow a higher throughput rate because processes are more efficient [22]. The aspects of cost reduction especially, is a motivator to shift to the Internet of Things because of the current financial crisis [9].

Yet, when applying the Internet of Things there are challenges an organization has to face. Infrastructure for current technologies is a challenge that has to evolve, because RFID still relies on readers which are not everywhere in the supply chain [7]. Wireless sensor networks that don’t rely on readers but on existing infrastructure (3G/4G/GPRS) have a different challenge: coverage and conflicts with communication technologies in airplanes [7] and they are more expensive and power consuming. Besides technological challenges individuals within an organization will have to face the shift from the current state to the Internet of Things state [7].

The Internet of Things allows organizations to enjoy the benefits introduced in section 4, and brings possible business opportunities. The data produced by the Internet of Things demands for storage, but this data can serve more complex purposes such as the aggregation of multiple data sources and the streaming of multiple logistic operations. As these purposes are moving further away from the core business of typical supply chain companies, the business models introduced in section 5 are a fertile basis for new ventures and for existing companies to expand their activities.

7. FUTURE WORKS
This research focuses on the beneficial aspects of the Internet of Things on supply chains, and how revenue is generated. Introducing new technologies brings disadvantages as well. Especially introducing a technology such as the Internet of Things – which is often seen as ‘the next big thing’ in context of this research – inevitably has disadvantages for companies, employees and other parties. Future work includes a research on the social impact on people, which looks at the change people undergo as effect of shifting to the Internet of Things, and which problems can be expected and the way to deal with these problems.

The technology that enables the Internet of Things is still developing. There are plenty of projects that attempt to introduce a standard for the Internet of Things (Zigbee, WirelessHART, 6LoWPAN, etc.) yet a global standard is required to fulfill part of the definition of the Internet of Things (“a world where physical objects are seamlessly integrated into the information network” [13]). Further research has to focus on the development of a global standard, that allows for seamless integration in every information system.

8. ACKNOWLEDGEMENTS
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9. REFERENCES


