# Implementation of Pay-Per-Output Business Models and Advanced Automation Systems in Capital Goods Manufacturing SMEs

Mikko Uuskoski(✉), Hannu Kärkkäinen, and Karan Menon

Tampere University, Tampere, Finland
{mikko.uuskoski,hannu.karkkainen,karan.menon}@tuni.fi

**Abstract.** Manufacturing small and medium enterprises (SMEs) are recognized as a major driving force in European Union (EU) and elsewhere both economically as well as technologically in this ever-changing manufacturing paradigm. SMEs have major difficulties in implementing digital technologies such as the industrial internet enabled technologies that can lead towards a change in the business models, especially towards pay-per-output type business models. In this paper, we have studied pioneering manufacturing SMEs that have implemented pay-per-output business models as well as the related advanced automation systems. Both case companies were able to demonstrate the benefits and difficulties that they faced because of the size (SME) during the implementation process of both the pay-per-output business model and the related advanced automation system.

**Keywords:** Industry 4.0 · Business models · Nonownership business model · Pay-per-output · Capital goods · IIoT · Automation system · SME

## 1 Introduction

Manufacturing industry - like many other industries - are facing a new era which is caused by digitalization of processes. This change is affecting both products and services, as well as production lines, and increases the need for their interaction. For example, the German initiative Industry 4.0 is defining the changes very well in different operation levels. Manufacturing Small and Medium-sized Enterprises (SMEs) are recognized as a major driving force in EU and elsewhere both economically as well as technologically in this manufacturing paradigm change. However, SMEs have major difficulties in digitalization, Industrial Internet of Things (IIoT)/Industry 4.0 and the implementation of novel business models, such as pay-per-output type business models enabled significantly by the afore-mentioned technologies. This is partly due to the fact that SMEs have different types of challenges, barriers and also benefits related to business decision making compared to large companies. While it is known that existing academic research concentrates almost solely on large companies in the topics of digitalization, IIoT and Industry 4.0 [1], this research cannot be used as such, or can be used only marginally by SMEs due to the special characteristics of SMEs.


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There are few studies that focus on the SME perspective and supporting the SME's in their implementation of Industry 4.0/IIoT and Smart Manufacturing [2]. Furthermore, the actual implementation of IIoT and advanced Automation Systems (AS), as well as related pay-per-output type business models especially in SME-companies are very little studied and reported in academic literature. There are existing recent studies for instance on novel advanced automation and IIoT supported or enabled services and advanced non-ownership business models, including pay-per-use (PPU) and pay-per-performance (pay-per-output/outcome (PPO)) business models (BMs). However, these studies do not consider how the relatively small SME company size matters in the implementation process. Furthermore, the advanced PPU/PPO type-of models are still extremely little adopted and made use of in SMEs: for instance, in the survey [3] of European capital goods manufacturing companies (54% of respondents were SMEs or smaller companies), only as few as 0,2% of studied machinery and 0,1% of automation companies' turnover was derived from PPU or PPO contracts. Thus, there seems to be a strong need for SME-oriented research particularly in IIoT/Industry 4.0 and advanced pay-per-use, pay-per-output and pay-per-outcome BM context. Accordingly, our research questions were defined as follows:

RQ1 "How were the pay-per-output business models and automation system implemented in the studied pioneering capital goods manufacturing SMEs?"
RQ2 "How did the business model and the automation system interact in the implementation process?"
RQ3 "How did the SME size matter in the implementation process?"

The studied two capital goods manufacturing companies can be considered as pioneering companies in their own capital goods businesses in making use of pay-per-output business models in the SME company category. The structure of this study is as follows: we first review existing research and the research gap in more detail. Second, we introduce the methodology of this paper, describe the cases and explain the questionnaire themes. Third, we present the results, and discuss them, leading finally into the conclusions and managerial implications.

## 2 Theoretical Background

### 2.1 IIoT Based Technologies and Advanced Automation Systems

High level topics concerning today's production of goods and services include sustainability, flexibility, efficiency and competitiveness [4]. Many companies are currently fighting high costs to make small changes to their ISA-95-based production automation systems and thus are calling for new models and architectures for dynamic and digitized production [5]. Several current technological trends that are receiving substantial attention include the following: internet of things (IoT), system of systems (SoS), cyber physical systems (CPS), clouds, big data and service oriented architecture (SOA) [4]. Delsing [4] and Porter et al. [6] show the need to extend the ISA-95 framework, and we decided to select the technology stack from [6] as one base for our interview framework, when discussing the changes in Automation Systems. The former ISA-95 standard

doesn't include IIoT (Industrial internet of things) - enabled extended connectivity to the cloud and other systems [5].

An IIoT system connects and integrates industrial control systems with enterprise systems, business processes and analytics [7]. Related automation control systems contain sensors and actuators, and systems are typically large and complicated (Fig. 1).

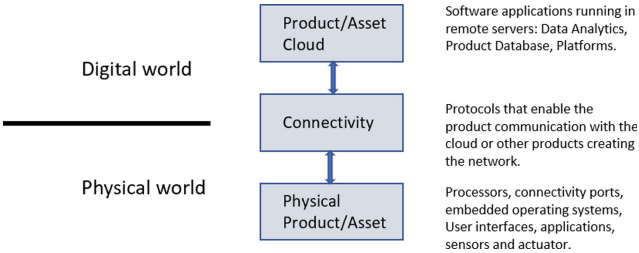


**Fig. 1.** Industrial Internet technology stack [6]

Into this stack, we can place all hardware and software components needed to realize modern and connected automation system required by Pay-per-output. In the physical product/platform software level, we included controller parameters, fieldbus technologies and programming, and runtime software as well as that at the sensor level. At the connectivity level, we were interested in used hardware connection types and used protocols. The cloud level gave us information about used cloud/server types and tools used in the cloud.

### 2.2 Pay-Per-Output Business Model in Manufacturing Companies

In the manufacturing sector, Nonownership model can be defined as *"service in which customers acquire some property rights to an asset and are offered a certain degree of freedom in using this asset for a specified period of time while the burdens of ownership remain with the owner"* [8].

The above definition describes the concept of nonownership in a clear manner from the customers point of view as it talks about how a customer can use the asset but not own it, by keeping the ownership with the manufacturer. In order to take the manufacturer's point of view into consideration, the earning logic of nonownership business models has to be described. This can be done by dividing the nonownership model into pay-per-use, pay-per-output and pay-per-outcome models.

Literature has covered the nonownership models from various different sectors; such as, software industry [9], B2C product manufacturers such as washing machine manufacturers [10], manufactured products such as the copier and printer [11]. The above-mentioned product ranges are easy to scale because the economies of scale work very well for software products, B2C products and use intensive copiers and printers. B2B manufacturers that make equipment's or machines that are critical in the customers process, such as the air-compressors or jet engines (critical components for an airplane manufacturer) have a very different risk profile when it comes to these nonownership

models when compared to the above-mentioned products. There are some authors that discuss the risk profile for these kind of manufacturing companies [12, 13].

In order to understand the implementation of the pay-per-output model, we follow the implementation process described by [14] where the business model implementation is divided into four phases or 4I's, Initiation, Ideation, Integration and Implementation. Initiation, ideation and integration belong to the design part of the business model innovation process whereas implementation belongs to the realisation part. All these phases are intertwined and require iteration at different times in order to create a near perfect business model for the customers [14].

### 2.3 Manufacturing SMEs and IIoT Enabled Pay-Per-Output Business Model

According to the OECD and European Union definitions, SMEs are defined as the enterprises with less than 250 employees, and with an annual turnover of 50 million euros or less or an annual balance sheet not exceeding EUR 43 million[1]. In this section, we discuss in more detail the overall SME specific characteristics that differentiate SME-related operations and business from larger companies' operation and business. Furthermore, we discuss the significance of SME-related research in IIoT and automation, and related novel business models, as well as the research gap of this study.

Manufacturing SMEs are recognized as a major driving force of many economies. For instance, in Germany, as well as in the EU, ca. 99% of all companies are SMEs, and only 1% are large companies [1]. In addition, it is found that SME's can have a significant impact on the Fourth Industrial Revolution, which is related to the rise in the role of IIoT in the manufacturing sector [2]. However, SMEs have different types of challenges, barriers and also benefits related to business decision making, compared to large companies [2, 15]. For this reason, the Smart manufacturing and IIoT research carried out from the perspective of large companies, which forms a very extensive part of all related research, cannot be directly applied and is not considered credible in most cases in SMEs. According to [2], only a few studies focus on supporting SME's in their implementation of Industry 4.0/IIoT and Smart Manufacturing.

Many studies have listed major differences between SMEs and large companies or (Large) Multi-National Enterprises (MNEs). Mittal et al. [2] provides a good condensed description of main SME characteristics compared to large MNEs: they sum up these to include 8 overall clusters of characteristics, including the following: finance, technical resource availability, product specialization, standards, organizational culture, employee participation, alliances and collaboration. Various studies, e.g. [1] demonstrate that academic research on Industry 4.0/IIoT focuses strongly on large enterprises [16], and only marginally on SMEs [17]. Also, a recent review study by Mittal et al. [2] recognized a few studies to have at least some focus on SME-specific needs in the field of Smart manufacturing and Industry 4.0. Thus, there seems to be a strong need for SME-oriented research, in general, in manufacturing, as well as in the IIoT/Industry 4.0 context in particular.

We found one very recent paper [1] which discusses specifically IIoT/Industry 4.0 - facilitated business models and business model innovations from the specific angle

[1] https://stats.oecd.org/glossary/detail.asp?ID=3123.

of SMEs. It discusses Industry 4.0 implementation and related business model implementation from the perspective of interviewed SMEs. They also discuss the impact of Industry 4.0 on the business model elements of manufacturing SMEs. However, it does not address the advanced NOBMs and their implementation process from SME perspective. Our study will go further than the above study in analysing the PPO BMs and their implementation and impacts to AS from an SME perspective in more detail. We used also recent literature reviews in confirming the research gap (e.g. reviews on links of IoT and BM: [18, 19], and academic studies discussing advanced automation and IIoT technologies' various roles in novel business models: [11, 20–22]), revealing no other studies considering the SME company size in the context of BM (and AS) implementation. To the best of our knowledge, our study is the first to consider SME company size, as a central focus of the study, in understanding its impact in the BM and AS implementation, as well as the BM and AS interaction in the case of PPO NOBMs.

## 3 Research Methodology

The aim of this research is to understand the implementation process of pay-per-output business model and IIoT enabled automation systems for capital goods manufacturing SMEs. To study this, we have used the case study methodology, by selecting pioneering SME capital goods manufacturing companies that have implemented the pay-per-output business model and have implemented the related IIoT enabled automation systems. In order to answer the research questions appropriately, we designed a selection criterion, under which we selected companies that were capital goods manufacturing SMEs, pioneering in their business, B2B businesses, companies that had already implemented the pay-per-output business model, companies that had implemented the IIoT enabled automation system.

Based on the above selection criteria, we selected two companies, Company A and Company B from Finland. We have signed a confidentiality agreement with the companies, that does not allow us to mention their names and details of their businesses. On a broader level, they are B2B capital goods manufacturing SMEs, pioneering in their business and have implemented the pay-per-output business model as well as IIoT enabled automation system with many of their customers.

We conducted a qualitative interview session with both the companies that lasted for about 2 h each. In both companies, we interviewed R&D managers who were responsible for strategizing the implementation of both the business model (pay-per-output) as well as the IIoT enabled automation system. Due to the lack of space, we are not able to attach the entire interview questionnaire, but we will describe the major interview themes in the following paragraph. We designed a semi-structured questionnaire with a few open questions and some specific structured questions. All the questions are categorized under the following five categories:

1. Background questions
2. Planning of the business model implementation and main drivers
3. Business model implementation process
4. Automation system implementation process

We recorded the interview and then transcribed it manually in order to extract the data for the result section.

# 4 Results

## 4.1 Drivers and Motivation for Implementation of PPO Business Model and Automation System (See Tables 1 and 2)

Both studied SME-companies explained that internal motivation to develop new business models came from strategic needs to develop new sources of income. According to the interviews, one of the main external drivers to the implementation of the PPO BM in both companies was the needed transparency to the real created value from their products to the customers. In the starting phase, company A had large technological limitations to implement the PPO BM, while e.g. industrial internet and automation data collection and analysis technologies were not too developed from PPO perspective. For company B, technological readiness was good.

Pay-per-output (PPO) business model was experienced in the interviews as significantly important for the business of both the interviewed companies A and B in many ways, which were not only about the proportion of turnover from PPO to the whole turnover. As far as company A was concerned, the traditional business, where they sell the machine and later on in the lifecycle of the machine sell spare parts and components of the machine, was not enough to generate profits. Hence, company A implemented the PPO based optimization service. Company B has a product which is unique when compared to the competitor's product but very expensive. Hence, company B designed a PPO model where the customer can use the entire product and related system and pay under the PPO model (i.e. pay as per output of the machine and the related system). In the last couple of years, this has led to a situation where 20% of their overall business is now under PPO business model. Company B expects that it will be almost 100% of their business under the PPO model in near future. Table 1 describes the advantages and the disadvantages of being an SME that company A experienced while implementing the PPO business model and the advanced automation system, and Table 2 company B's experiences.

**Table 1.** SME related advantages and hindrances for company A from BM and AS point of view.

| Company A | Advantages from the size (SME), PPO | Hindrances from the size (SME), PPO | Advantages from the size (SME), AS | Hindrances from the size (SME), AS |
|---|---|---|---|---|
| Initiation<br>– analyzing the ecosystem | Motivation to find niche BM to grow<br>Decision making process was dynamic | Harder to convince customer for novel BMs<br>Limited resources for experimenting with customers | Limited resources forced team to concentrate on relevant, focused tasks | Not possible to collect data about customer needs extensively |

(*continued*)

**Table 1.** (*continued*)

| Company A | Advantages from the size (SME), PPO | Hindrances from the size (SME), PPO | Advantages from the size (SME), AS | Hindrances from the size (SME), AS |
|---|---|---|---|---|
| Ideation<br>– generating new ideas | | Limited resources forced decision making more by gut-feeling. Not clear road map | Good customer knowhow about needs to fulfill requirements to engineer AS | Resources were limited, not possible to explore and test many ideas |
| Integration<br>– building a new business model | Fast decision making<br>Goal was clear<br>Not too much internal resistance | Had to accept customers which were willing for testing. Risk taking capacity was rather small | Clear goal<br>Team motivated and independent for fast decision making<br>Objective supplier selection | |
| Implementation | Management supporting decision making towards new BM. Full commitment from the whole team | Development steps were limited because of the resources, not possible to jump fast towards PPO | Information flow between customer and supplier was better in small organization, better customer insight | Limited resources, which had potential to slow down technology development towards to the technology required by PPO |
| | Found own niche business area, which was enough to fulfill SMEs needs | Limitation to execute larger development projects fast, for example general IT data secure system | New opportunity to sell also hardware to larger customers. Was not be possible without PPO BM | Sales forces and production capacity was limited |

For both companies that are SMEs, the PPO-model was experienced to provide a way to grow their business and compete in a business and market where there are many large companies. For company A, the growth in the business was triggered because of the ability to manage machines that were manufactured by other manufacturers using their optimization system. For company B growth in the business was triggered because even if the machine they manufacture is expensive, under the PPO model the customer just pays for the output. This allowed them to tap into new customers and grow their business. Through experimenting, both companies believed that the output-based BM was leading to improved earnings in the long term.

### 4.2 Implementation Process of PPO Business Model and Automation System (See Tables 1 and 2)

The results from interviews related specifically to the advantages and hindrances from the relatively small (SME) company size perspective towards the different phases of the implementation process of PPO BM and automation system (AS) are shown in Tables 1 and 2.

**Table 2.** SME related advantages and hindrances for company B from BM and AS point of view

| Company B | Advantages from the size (SME), PPO | Hindrances from the company size (SME), PPO | Advantages from the size (SME), AS | Hindrances from the size (SME), AS |
|---|---|---|---|---|
| Initiation<br>– analyzing the ecosystem | Agile. Company sold PPO BM to show performance level | Unknown company and small size (SME) | Team motivation was excellent to develop a good system | |
| Ideation<br>– generating new ideas | | | Good customer knows- how to fulfill requirements of the AS | Resources were limited, takes time to get system ready |
| Integration<br>– building a new business model | Big competitors didn't go to similar PPO model, because it spoiled existing business Fast decision making | To convince customer in different places to believe PPO and measuring of the production, easier in Europe, harder in China and less developed countries | Goal was clear for everyone | Measurement of output was not easy. Took resources to realize measurement system |
| Implementation | Readiness and capabilities to fulfill customer requirements Possibility to use many selling channels and methods | Biggest problem was financing the customer hardware when sold as a PPO BM | Better information flow between customer and supplier resulted in small organization better customer insight | If the company wants to larger scope of supply with additional system components development resources were limited |

Company A mentioned that instead of an intensive pre-study, they started the implementation with experimenting with beta-customers. Company B started implementation at a fast pace from the idea to get new customers faster with PPO BM. In company B, the AS system development towards the PPO BM was not a big step, because the system was already equipped with extensive measurement and data collection system. Only limited modifications were needed to get a reliable AS for PPO based invoicing.

In Company A, the experimentation phase provided a good basis for the BM and AS development. Because of size and its flat organization structure, the companies had freedom to select most suitable AS according to the overall system requirement. Especially company A noticed that it was an important advantage when they compare their success to a larger competitor who selected a system according to internal rules instead of real AS system and PPO BM needs. In company B, the system was selected based on demanding machine control requirements and at the same time, it was serving PPO BM requirements very well.

Company A also told that because of the low hierarchy of the company they were able to take decisions and act quickly. For that reason, the experimentation phase gave

fruitful results to the PPO BM and AS development. The same was true for company B, when they decided to implement the PPO BM. Both companies agreed that the AS technology development with connectivity (IIoT) development is important in enabling implementation of the PPO BM. In both companies, at the time when data security issues cause concerns to move towards more open communication systems, for example that based on cloud systems.

Concerning the AS, in Company A I/O-quantity had increased 2–3 times from the beginning. Data was processed and collected at the Physical product/Asset level [6] as well as the Product/Asset cloud level [6]. Because of larger data collection and more advanced analysis also, the calculation capacity of the system was huge compared to the original system. They have basic technical readiness to use real cloud-based system, but because of the customer prejudices about IT-secures issue, it is still marginal. Company B started the automation system development with machine development and additional features was added when they decided to have PPO BM. They have developed a full automation system to collect data from the Machine. I/O-quantity per system is 50-100 points. The current situation is that most of the systems are connected with 3G modem to the company own server. The user interface is playing a major role in opening the critical information for the system operator to optimize the process and create saving or higher performance. The current system is very precise with measurements and enabling PPO invoicing. Company B could also offer connectivity to customer systems with OPC-UA.

### 4.3 Interaction of PPO Business Model and aS

Both companies A and B noticed that the business model development and automation system development seemed to be strongly interdependent. The AS impacted the PPO BM by enabling the more credible (A and B), more accurate (A and B) and real-time measurement (A and B) of the output. It also enabled invoicing (A and B).

The PPO BMs output results in both companies were related with savings and process optimization to get more output. All value to generate savings or better performance was conveyed by automation system capabilities. That is why automation system played a major role in execution of the PPO BM successfully.

There was no internal resistance, for that reason both BM and AS development were really customer and system based. Motivation to the PPO BM in both companies is transparency to real created value (saving or performance improvements). To enabled PPO BM AS has to fulfil technical requirements for data collection, analysing and measurement and all that should be synchronized with BM. Connectivity to different directions is extremely important for running PPO BM. Both companies have realized online connectivity to the machine. Security concerns and customer prejudice are still limiting larger cloud-based system implementation.

## 5 Discussion and Conclusions

This study contributed to the academic understanding of the implementation of advanced BMs, especially the very little studied PPO models, in the context of SMEs in particular.

Both studied companies agreed that small size is both advantageous and brings limitations in the implementation process of BM. As for the advantages, both companies due their small size were able to recognize a new niche market, making use of the PPO BM, which were interesting and significant for their SME company, but probably would not have been interesting for larger companies. Secondly, internal small and flat organization of the SME was enabling fast adapting to the BM requirements. Due to the limited size both companies didn't have all needed expertise to implement the PPO BM in a structured and preplanned way, and for that reason they had to take relatively large risks in BM implementation.

Furthermore, their company size seemed to matter in all phases of PPO implementation process: initiation, ideation, integration and implementation (See Tables 1 and 2). The SME company size seemed also to impact in a manner that there was no clear roadmap and no before-planned separate implementation process phases in the PPO implementation, e.g. initiation and implementation were very iterative and intertwined.

Both companies faced that small size is both advantageous and brings limitations in the implementation process of AS. Because of relatively small organization size and freedom from internal strict supplier policies, both companies were able to select most suitable advanced AS parameters according to the system requirement.

Major strategic benefits from PPO BM were access to new markets, better profitability and overall growth opportunities. For both of these two SME companies PPO BM and advanced AS have given opportunities to succeed and differentiate their business from large competitors. In company A, open-minded BM and AS experimentation led them to a new business, relatively free from competition, and at least partly without precise planning, opened to them new markets to sell hardware, both as an investment product as well as a PPO service. In company B, PPO BM enabled the sales of a totally new type of expensive technology to customers which were not able to trust the promised performance of produced machine, sold in the form of an investment product. In both companies there was clear interaction of BM and AS development.

This study brings forth some important managerial implications for manufacturing SMEs, especially those dealing with B2B capital goods. First, we demonstrate that PPO BMs are possible to be achieved also by SMEs, and that there can even be important small size-related benefits enabling SMEs to make use of such advanced PPO BMs that large companies cannot make use of. Among these are that the studied novel type of business models offer these SMEs new possibilities to compete with even larger companies that have e.g. the advantage of economies of scale compared to SMEs, by enabling SMEs for instance to enter interesting niche markets created by pay-per-output services and related BMs.

This study is limited by its approach to studying two case companies, and as such, it does not allow the direct generalization of the results to other companies. The results and conclusions are important, however, already in this case study format, because there are very few studies that focus on SMEs in the field of advanced BMs (such as PPU and PPO models) and advanced automation. It seems viable, however, to make the claim that also other SMEs will very probably find both similar types of benefits and also limitations in their attempts to make use of advanced business models like PPO models. Future

research should attempt to include further SMEs, including different types of industries, to enable a more extensive generalization of the conclusions.

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