Exploring Accidental Digital Servitization in an Industrial Context

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3 authors:

Matthew Anderson
Sulzer

Shaun West
Lucerne University of Applied Sciences and Arts

D.K. Harrison
Glasgow Caledonian University

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Matthew Anderson[1](✉), Shaun West[2], and David Harrison[1]

[1] Glasgow Caledonian University, Glasgow G4 0BA, Scotland
mander237@caledonian.ac.uk, D.K.Harrison@gcu.ac.uk
[2] Lucerne University of Applied Sciences and Arts, 6002 Luzern, Switzerland
shaun.west@hslu.ch

Abstract. Recent advances in the Industrial Internet of Things (IIoT) and 'Smart Products' within manufacturing industries have promoted a shift to service-related offerings [1], often inadvertently and without the prerequisite foundations in place, in terms of operating models, impact upon revenue streams, and business strategy. This paper endeavors to investigate this by reviewing three distinct examples of 'smart innovations' for medium-sized industrial businesses and considers the impact upon the business when a service becomes 'smart.' We further review the impact and suggest mitigation approaches relevant to Servitization, and the key factors to enable a more effective digital transformation. Findings indicate that 'Accidental Servitization' can occur within industrial firms, irrespective of their digital experience. Also, that these firms need to ensure an underpinning organizational change is established to support new, disruptive business.

Keywords: Product service systems · Digital servitization · Smart products

1 Introduction

Evidence suggests increasing activities within industrial businesses where 'smart products' are a catalyst for digital transformation, with the potential to reshape business. Most notable is a shift to Cyber-Physical Systems (CPS) [2], where an industrial asset is augmented with monitoring or control functionality as part of a complex eco-system [3]. This leads to ongoing data generation via sensors, which industry is leveraging for data-driven insights at a lower cost. The CPS removes a gap between customer and supplier and provides new insights into product performance.

The motivation for the study is that these new smart product innovations can unexpectedly generate new services, particularly for CPS efforts that combine an IoT element with an asset. This asset may have an effective lifespan of many decades [4] and complex lifecycle management, from initial tender through to support and aftersales. To ensure repeatable quality and minimize risks, a stage-gate methodology is the norm, leading to extended quality assurance and predictable consistency [5].

This is an area that deserves more research. Failure to plan for this shift from product to service reduces the financial benefit gained from such a disruption and impedes

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establishing a sustainable service. To date, most studies have focused on technology transformation aspects and not the day-to-day impact on operational or business processes. Considering three use case examples, this paper aims to highlight instances of this inadvertent servitization, and answer the following question: "*what is the impact of smart product innovations upon the established business value?*".

2 Literature Review

Porter and Heppelmann's [2, 6] articles give an overview of the nature of 'smart products' and their impact upon business transformation. Porter defined these as physical products with some degree of technological augmentation to allow connectivity, plus a 'smart component' focused on data generation/capture and analysis. Porter highlights the potential of these products to drive substantial business transformation due to the greater insights gained throughout the value chain. The articles reference the consequent change needed to business organization and skillsets; however, the focus remains on product impact, rather than the shift to service.

Numerous scholars, according to Baines et al. [7], have researched the move from products to integrated service, particularly in manufacturing. Baines et al. [7] describes a comprehensive overview of servitization within industry from the perspective of leveraging unexploited value. They observe the lack of applicable frameworks available to assist successful implementations. However, the importance of offering service as a series of options to drive value from the customer's perspective is well established. Lay [8] provides a selection of studies on the adoption of servitization in different sectors, plus barriers for adoption, and highlights the need to adapt processes. However, there is limited research regarding applying these learnings to servitization resulting from a digital catalyst. Marjanovic et al. [9], raise the importance of this research, employing a statistical analysis of industrial firms, while considering the potential impact on business strategy. Rymaszewska et al. [1], give a case-based overview of the value-driven impact of a digital servitization shift, but with a focus limited to successful projects. Of note, there is limited analysis of the barriers faced, possible mitigation steps, or what changes were required within the companies to fully leverage a new offering. Likewise, there is limited study of the need to re-engineer business processes to fully enable new opportunities. However, significant focus is afforded to potential value propositions. Freitag and Hämmerle [10] recognize the need to address how to manage the shift from product to service focus, particularly in industry, but also across firms of all sizes. They apply a novel, 'design thinking' approach to understand the problem scope which merits further study, this same approach is leveraged by Keiser [11] for a case study on Manufacturing Execution System implementation. Leminen et al. [12], reflect upon current knowledge, stating: "*existing literature lacks understanding… On what IoT business models are and how they are connected to the underlying eco-system*", and the need for new business models is a theme across the literature.

3 Methodology

This study used qualitative techniques to analyze a cross-case analysis and reflection of three distinct case studies from industrial companies operating in the B2B sector. The case companies are at the earlier stages of digital adoption but have shifted from product to servitization models due to these innovations. Each case will be reviewed to highlight specific aspects relevant to identifying the impact of smart product innovation upon a business and the subsequent shift to servitization, according to the IMPULS model for Industrie 4.0 Readiness [13].

The key characteristics of each case are compared in a cross-case analysis, Table 1 provides the scoring rational using a five-point Likert scale for each of the characteristics. The characteristics are group based on the four major dimensions, which have been taken from the literature [14]. The lead author built up the cases and then scored the cases, these were then moderated by the second author to support the remove of bias.

Table 1. Cross case analysis review framework

Major dimension	Key characteristic	1 – low	5 – high
New service opportunity	Service evolution	Not embraced	Growth into new areas
	New service in adjacent area	Not embraced	New services
	Complementor service	Not embraced	Add-on services offered
Value proposition	New business opportunity	Not embraced	New service offerings
	Improved relationship with customer	Not embraced	New relationship dynamic/improved feedback
	Improved insights	Limited	Data feedback used
	Value co-creation for all parties	Limited	opportunities established
Impact on operating model	Process re-engineered	None	Services redefined
	Focus on product lifecycle	None	Holistic approach adopted
	Specialist roles assigned	None	Multiple assigned
Impact on business model	Shift from product to service	None	Recognized and embraced
	Cannibalization of existing business	Avoided/ ignored	Recognized and embraced
	Shift to data driven company	N/A	Strategic view clearly defined

4 Results

Three examples used for this analysis are: light industrial hand tools; digital optimization service from a product test service; and, an industrial sensor.

4.1 Case Study 1. Light Industrial Hand Tools

A handheld tool manufacturer produces various battery-operated machine tools used in light industrial work, where key business drivers are quality and safety. This firm is at the 'beginner' stage of digital transformation, and this is one of their earliest 'smart product' ventures. They are an OEM provider to resellers/redistributors, so interaction with the end-user is limited to warranty and repair issues. Feedback from resellers and warranty claims showed end-users had supply chain issues with non-OEM consumable materials, reducing output quality and damaging tools. This reduced the tool's availability and introduced 3rd party involvement into the warranty process. Another issue was that the tools are not connected to shop floor data collection systems, so their location and status is not tracked, and neither is operators' exposure to vibration in adherence to safety regulations.

The firm added a variety of sensors and remote monitoring capabilities to a range of tools to counter these gaps. The IIoT components were mounted to existing devices cost-effectively in a simple 'sleeve'. An RFID reader confirmed the provenance of consumables and read/write material-specific metadata for tool usage, while a range of sensors measured usage and ambient parameters such as vibration. Bluetooth Low Energy was used for data transfer to an end-user smartphone, and to the cloud. These technology choices drove new functionality for the resulting smart product. Using a smartphone for data transfer from the hand tool simplified the connection into IT/OT environments, and also created the opportunity to send configuration data to the device, allowing greater control and the recording of usage macros to automate operator efforts.

There was a notable change with the relationship dynamic, shifting from the sequential 'OEM, reseller, end-user' pattern to a 'three-way' relationship. The reseller gained insight into application patterns, gaining the option to shift their service to tool and material usage, and to automate replenishment There were also notable changes with the warranty service. The tool manufacturer was previously constrained by lack of access to end-user and complications in the service support model. Gaining operational data, and limiting potential causes of damage to the tool, makes the service more transparent and collaborative for the three parties. Table 2 summarizes.

Table 2. Case 1: light industrial hand tools

Industry 4.0 attributes	IoT sensors for monitoring and control Smartphone app, cloud reporting
Target markets	Reseller ecosystem End users in light industry
Resulting product service system	Product improvement feedback Reseller service improvement from usage patterns Replenishment service model
Impact	Improved feedback from end-users, but notable reluctance from resellers to change
Comments	Suggest joint workshops with all parties to establish needs

4.2 Case Study 2. Digital Optimization Service from a Product Test Service

An industrial asset producer manufactures bespoke engineered-to-order (ETO) products for use in heavy industries. Key business drivers vary but cover performance, efficiency, and availability. The firm is established in this market and is usually approached by the customer for tenders. This customer can be a system integrator or the end-user. The firm has a strong relationship with its user-base due to the close collaboration required for ETO projects and a range of aftersales service (i.e., spare parts, repairs, and retrofit). The digital maturity of the firm would be classified as 'intermediate'. Performance tests in the firm's test facilities are typically required before shipment, simulating the customers' environment as closely as possible, although with higher instrumentation and monitoring. The firm created in-house software to perform the test calculations on real-time data and found that the in-house test tool created a demand for a similar offering for customers to use at their facilities for ongoing monitoring. The firm started to sell a cut-down version of the service via a cloud-based dashboard. This gained the firm the flexibility of a centralized environment to support and manage while safeguarding their intellectual property in a secure cloud environment.

This raised new opportunities: gaining access to anonymized data across a range of customers, assets, and failure modes allowed the firm to go beyond its initial offering. Using this centralized data source and employing more advanced analytics, new insights allowed them to provide predictive support with estimating the remaining useful lifespan of assets and guiding targeted maintenance activities. This benefited both parties, as the provider gains real-world asset application knowledge, and the customer experiences a more tailored service. Providing this information is helpful, but the customer needs guidance in applying the insights. The firm employed equipment specialists to liaise with the customers to interpret the data and guide operational improvements, using the service as 'intelligence augmentation' for decision support. The outcome was some cannibalization of existing aftermarket services, improved customer experience, and improved customer operational challenges. A short summary is given in Table 3.

4.3 Case Study 3. An Industrial Sensor

The third case study considers an industrial asset producer that manufactures and assembles configured-to-order products. These are used throughout process industries such as water treatment and food production, which focus on availability, reliability, cost efficiency and safety. With regards to their digital maturity, this case firm would be considered 'experienced' according to the IMPULS model. They have a well-established e-commerce platform, and several digital innovations underway. The firm sells a wide range of configured industrial assets, which the customer orders via a sales representative or via an online configurator. The cost of automation for asset monitoring is too high to justify its use, resulting in manual measurements that do not identify problems early enough to avoid unplanned downtime. Access to equipment can be restricted, leaving snapshot data collation to be made on an ad hoc basis, losing opportunities to see underlying patterns that would allow more reliable predictions to be made.

A low-cost IoT sensor system for automated measurement of temperature and vibration at critical areas that connects to the Internet via a smartphone app was developed

Table 3. Case 2: digital optimization service from a product test service

Industry 4.0 attributes	Data transport and ingestion to cloud machine learning, advanced analytics
Target markets	Engineer-to-order asset operators in heavy industry
Resulting product service system	Asset optimization and benchmarking Detection of anomalous behavior Targeted maintenance activities R&D feedback
Impact	Initial gaps with leveraging the data and customer communication Opportunities beyond the initial requirement identified and leveraged Better customer relationship
Comments	Gap addressed by hire of specialist resource, and customer training

to overcome these challenges. Equipment data is collected from the ERP system and recombined in an e-commerce platform, extending the offering to include monitoring. Using a web dashboard, customers can see the asset's condition, set thresholds for alerts, receive event notifications and reports, and export data for their analytics. Lastly, the firm manages the sensors and gateway's product lifecycle, scheduling updates for sensors and gateways and remote troubleshooting. The customer gained 24/7 monitoring coupled with trending, enabling them to adopt a risk-based maintenance approach.

The solution was sold as a one-off investment, priced to cover the sensor production and the R&D costs. An operating model for the sensor lifecycle was not defined, but both sensors and gateway require remote support for implementation and connectivity issues, plus firmware updates and similar factors. Customer feedback identified that the cloud-based solution was complicated, and customers needed help to get the system's value. This was overcome by a specialist team who provided customer training. Installation of sensors to the equipment as part of the standard design and later activation on customer requests has yet to be implemented and could reduce costs and complexity in the medium-term. Table 4 summarizes this.

5 Discussion

The information gathered for the three cases was combined into a cross-case analysis (see Table 5). Leading to several notable managerial implications. Firstly, it is shown that companies make greater profit from services than from products [15]. However, as the studies show, this is often not the focus of smart product innovation. A common theme across all of the cases is the focus solely on the innovation aspect, which is common in industry. Businesses with both a long industrial heritage and well-established product ranges often employ a stage-gate approach to production, and consequently to innovation [5]. This results in a slow but measured approach to what is perceived as 'sustainable

Table 4. Case 3: an industrial sensor

Industry 4.0 attributes	Data generation, transport, cloud storage Analytics and visualization Web API for data extraction
Target markets	Configured-to-order asset operators in process industry
Resulting product service system	Internet-enabled condition monitoring
Impact	Initial gaps with sales effort Lack of target operating model for ongoing support and maintenance of service Ongoing costs and support not considered Complimentary service not considered
Comments	Recruitment of IIoT sales specialists, better explanations to customers Ongoing costs and support to be factored into operating model review service offerings and synergies across the company

innovation', which is at odds with the 'fail fast, fail often, and learn' approach inherent to digital innovation. Also notable was the singular focus on a digital product. More digitally mature companies tend towards 'proof of concepts' being tried and rapidly discarded if not fit for purpose. Service innovation needs this 'start-up mentality'. Such traditional approaches also fail to capitalize on potential smart service opportunities due to business model limitations. A frequent comment was the need to review a process when limitations were met, but this resulted in a considerable reluctance to adapt. Likewise, a change in the structure is required to harness opportunities, but barriers were met with established status quo, particularly with product-centric sales efforts and a focus on immediate return on investment, rather than driving greater customer value and collaboration. However, this need for organizational transformation also includes their partner network and interaction with the customer base. One of the other barriers met was with the skillsets required.

This is an area where medium-sized industrial firms struggle and usually default to buying-in such skills and innovation mindsets. Of note, the first use case firm used the opportunity to identify key skills required and where they existed within different business units, opening those areas of the business, creating opportunities for innovation. In each of the cases a clear pattern emerges of servitization arising unexpectedly from smart products. With the immediate focus being on achieving the technical innovation without consideration of the required underpinning factors to leverage opportunity. A more holistic approach is needed. Firstly, with a systems level thinking, the realization that the smart product does not exist in isolation, but is part of an adapting eco-system that requires ongoing service such as upgrades, and leverage of the insights gained. Likewise, adaptation to existing sales process needs to be embraced. Smart products create a different relationship pattern with customers, upending the traditional dynamic. Shifting from discreet product sales to a data driven solution, results in value co-creation

Table 5. Cross case analysis

Major dimension	Key characteristic	Case 1	Case 2	Case 3
New service opportunity	Service evolution	2	4	3
	New service in adjacent area	2	4	2
	Complementor service	2	3	1
Value proposition	New business opportunity	2	3	3
	Improved relationship with customer	2	4	3
	Improved insights	3	4	3
Impact on operating model	Value co-creation for all parties	2	4	3
	Focus on product lifecycle	2	4	3
	Specialist roles assigned	1	5	3
Impact on business model	Shift from product to service	2	3	3
	Cannibalization of existing business	1	4	2
	Shift to data driven company	2	4	3

for both company and customer, in terms of upgrades and service, often resulting in cannibalization of existing products, and creating a blurred distinction between initial sales and aftersales.

Returning to the research question posed by this paper, there is an impact of Smart Product innovation upon the established business value. This occurs in three ways: first, there is an ongoing cost burden to the supplier for the digital aspects of the product; second, there is a change to the value proposition offered by the supplier as they are moving to a servitized business model predicated on product-service system; finally, the revenue model for value capture can be adapted to better reflect value in use or value in context.

This is an initial study and subject to several limitations. Due to the relatively recent trend of digital servitization, there are a limited number of case studies available for comparison. Another factor is, the firms operate in similar industrial sectors. The authors wish to build upon this and introduce case studies across a range of studies, allowing more quantitative approaches. Future research on digital-driven servitization should address a greater range of business models and impact on value once these initiatives are more commonplace. These studies should eventually lead to a common body of knowledge which can be leveraged as templates for the implementation of digital service across industry.

Of note, some seminal works, such as Porter and Heppelmann [2, 6], were commonly referenced by the firms as providing a vital catalyst for their initial digital transformation. The subsequent barriers these firms met when shifting from product to service would imply a need to revisit such papers and critically review with hindsight.

5.1 Managerial Implications

The critical lesson for management is that Smart Products are similar in many key characteristics to more traditional ones, in that much of the value can be attributed to their application. What differs is that connectivity and data analysis create ongoing costs for the supplier. In effect, the firm has unintentionally created a sophisticated product-service system where value is based upon value-in-use or -in-context, however value capture can be problematic. The challenge is to recognize the change and shift to more advanced servitization-based business models, rather than charge for the product and then provide the digital value for free. The move to Smart Products requires a change in the firm's value proposition, a new revenue model, and modifications to the underlying business model, beyond incremental product development. Without this, sales may find it difficult to attain the full value that Smart Products promise, and the business may build a growing cost base that they cannot cover adequately with their revenue streams. Therefore, when developing new Smart Products, managers should ensure that the cost model for the whole lifecycle is well defined, and the revenue model provides value capture in excess of the ongoing cash requirements. A new value proposition will be required to achieve this, and sales must adapt to sell the solution.

5.2 Theoretical Implications

The three cases illustrate that Smart Products are a 'Trojan Horse' for services and, in effect, should be considered as Service Innovation, leading to a major impact on the supplier business model. This finding is in agreement with servitization literature, Kohtamäki et al. [16] and service science literature, Grönroos and Vargo [17, 18]. The findings highlight that product development with a digital aspect fundamentally changes the underlying supplier business model and value proposition, thus changing customer relationship and experiences, and may need to shift from traditional product development process to one that integrates product and service innovation concurrently.

6 Conclusions

In each of the cases a clear pattern emerges of servitization arising unexpectedly from innovative work related to smart products that are customer oriented. It is clear that in order to establish value, smart products invariably lead to smart services, and yet the firms, irrespective of their perceived digital maturity, seem ill prepared for such an eventuality. Notably, these technology-driven innovations outpace the business transformation required to sustain them, with a delayed response in adaptation to operating models. The organizational transformation required to support these can be a complex and far-reaching endeavor. The firms referenced in the case study have invested heavily over many years into processes that support their 'heritage products' via incremental innovation. Disruptive approaches in these environments are often perceived as a risk, resulting in an understandable inertia. It is a clear necessity to accommodate both operational modes to support core business, starting with a strategic epiphany to embrace far reaching change, otherwise industrial firms' risk relinquishing such opportunities to more organizationally agile upstarts.

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