Are products striking back? The rise of smart products in business markets

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1. Introduction

In recent years, the business world has been experiencing two types of changes that are based on a fundamental trend towards virtualization or dematerialization. On the one hand, we observe a shift away from the classical focus on the physical. This encompasses trends such as the ubiquitous growth of the service sector (Palmer, 2017), the emergence of new service business models (Cusumano et al., 2015; Kujala et al. 2010), the move of manufacturing companies towards servitization or service infusion (Forkman et al., 2017; Kowalkowski et al. 2017; Vendrell-Herrero et al., 2017), and the adoption of a customer experience perspective (Lemon & Verhoef, 2016; Zolkiewski et al., 2017). In many ways, immateriality (or intangibility) is increasingly replacing physicality.

At the same time, technology-based phenomena such as the Internet of Things (IoT) and Artificial Intelligence (AI) are potentially adding new value and repositioning traditional physical products within a larger ecosystem. Smart (and hence *physical*) products, equipped with sensors, embedded artificial intelligence and information technology, are at the centre of this transformation. In this context, Porter and Heppelmann (2014) posit: "What makes smart, connected products fundamentally different is not the Internet, but the changing nature of the 'things'" (p.4). Thus, although a fundamental transformation is currently occurring, this doesn't imply the end of physical objects. Indeed, in 2016, John Roese from Dell Technologies observed that the specificity of IoT lies in the fact that this technology was "essentially built for the *bridging* of the digital and physical world".[1]

The purpose of our research is to contribute to a deeper understanding of the transformation process of traditional physical products. More specifically, we study how a product comes to be a smart product. We focus on specific smart products in business markets (Daley, 2017)

[1] https://www.i-scoop.eu/internet-of-things-guide/industrial-internet-things-iiot-saving-costs-innovation/industrial-iot-revolution/

such as smart cranes, smart tires, smart valves, and so on. They are designed and manufactured by one company to be sold and used by another company or organization (such as hospitals, schools, or administrations). Following the lead of various scholars, we define smart products as being made of a 'physical part' and a 'digital part' (Abramovici et al., 2016; Eddy & Oussama, 2018; Gonzales-Garcia et al., 2017). In addition to their mechatronic parts, smart products also consist of information technology driven parts (Abramovici et al., 2016). For clarity, it should be noted that we consider as equivalent the following alternative terms used in the literature: smart products (Abramovici, 2014), smart things (Puschel et al., 2016); smart objects (Kortuem et al., 2010; López et al., 2011); smart connected products (Porter & Heppelmann, 2014, 2015), but also cyber-physical systems (Lee, 2008; Monostori et al., 2016; Park et al., 2012) and digitized products (Yoo, 2010; Yoo et. al, 2010, 2012).

We focus on how the current transformation is affecting the products themselves within the surrounding ecosystem of products and human users, and the resulting issues for business to business marketing managers. We argue that to understand the transformation, we need to renew our conceptual view of what a product is. We propose, discuss and illustrate several dimensions that allow a redefinition of the nature of 'products' in inter-organizational exchanges when they are transformed through IoT or AI applications and become smart products. For this purpose, we adopt a perspective that sees products as embedded in relationships (Wathne et al., 2001). This perspective is distinct from alternative approaches that focus either on the 'supplier side' (discussing how smart products and IoT are a means to optimize customer-directed processes or support innovation) or the 'customer side' (discussing how smart objects enhance customer journeys and experiences).

The remainder of this paper is structured as follows: First, we provide a view of how 'the product' is defined and discussed in the extant industrial marketing literature. Next, we discuss the characteristics of smart products and identify several theoretical lenses that help

understand the change in the status of the business product when becoming a smart product. We then present twelve business cases involving smart products in business markets. We discuss these cases in order to emphasize the business-to-business marketing issues that these smart products raise and to provide a typology of different ways in which products can be transformed by technology.

2. The status of the product[2] in the marketing literature

Spring and Araujo (2017) provide an insightful short review of how the product has been taken into account in the marketing literature, whether from the Kotler perspective (a product is a bundle of attributes solving a problem for a user) or in the service marketing literature (the product is contrasted with the service.

2.1. A product that is only recognized through interaction with the customer…

Until the mid-1950s, when marketing was still focusing on products (rather than customers) the conceptualization was not very sophisticated, and the product concept was taken for granted. The product was "what the factory was currently producing" and what the "sales force had to sell" (Webster, 1988, p. 31). It was with the turn towards general management responsibility for marketing that the product became "a variable" that had "to be tailored and modified in response to changing customer needs" (Webster, 1988, p. 32). Thus, the product became something that "is defined by each interaction the customer has with any company representative" (p. 39). Mattson and Johanson (2006), tracing the history of "markets as networks", mention the works of Ames, (1968, 1970) and Corey (1962, 1976) in defending a

[2] Given the diversity of use that is made of the terms products, goods, objects, and things, we chose to use the term 'product' in this research without giving the term a specific meaning beyond the idea of physicality. Callon et al. (2002) look closely at the distinction between 'goods' and 'products'. For the authors, talking about *goods* is a way to emphasize '*the fact that the aim of any economic activity is to satisfy needs (what is good, sought after, wanted)*' (Callon et al., 2002, p. 197). On the other hand, talking about a *product* is talking about a good but seen '*from the point of view of its production, circulation and consumption*'. The product is thus a *process*, whereas the good represents a state, a result or, more precisely, a moment in that never-ending process. Spring and Araujo (2017) follow Callon et al. (2002) to posit that a product is always undergoing operations (design, production, circulation, use) that 'transform its characteristics'. The good (or object) on the other hand is the *stabilization* of the characteristics associated with the product, which allows it to be traded. Products are '*goods with a career'* (Appadurai, 1986). Conversely, goods are (temporarily) stabilized products.

similar view of products that "should be regarded as a variable, not as a given" (Mattson & Johanson, 2006, p. 267).

In Kotler's perspective, the product has no value by itself, but only through "its contribution to what a customer wants to achieve" (Kotler, 2017a, p. 171). Hakansson and Waluszewski (2004), digging deeper into the notion of the role of the product, consider the product as a resource whose 'features' are not given, but created through interaction between actors. That is, the features of a product depend on how this product is combined with other resources. The authors insist on the idea of a product being seen through its "dynamic features (i.e., the opportunities, restrictions, and tensions it carries with it or is exposed to)" (p. 255).

From this perspective, what becomes central is the contribution of the product to the value creation mechanism. The idea of a product existing solely through what it 'does to the customer' has regularly been promoted by Kotler from the 1960's onwards, with a product initially described as "a bundle of physical, service and symbolic particulars expected to yield satisfaction or benefits to the buyer" (Kotler, 1967, p. 289) and more recently as "a tool for producing a valued service that will produce a valued outcome" (Kotler, 2017a, p. 170).

However, seeing a product as a 'mechanism for service' doesn't say much about its tangibility or physicality. For instance, Vargo and Lusch's perspective of the product both reduces the product to its role in the value co-creation process and minimizes the meaning of its physicality: "Tangible products can be viewed as embodied knowledge or activities" (Vargo & Lusch, 2004a, p. 9). The product 'per se' has no interest for Vargo and Lusch (2004a), for whom "The focus is shifting away from tangibles and toward intangibles, such as skills, information, and knowledge" (p. 15). As such, it is not really central in their analysis: "The appropriate unit of exchange is no longer the static and discrete tangible good" (p. 15). The product is only of interest for its 'direct service provision' and also as a support for 'experiences' (this is what Vargo and Lusch refer to as 'higher-order needs'). Slightly

different is the position expressed by Ford et al. (2006) who acknowledge the physical dimension of the product. They describe the product as a part of the supplier's offering: it is the "physical part of an offering" (p. 165). Thereafter, the product, per se, is considered of limited importance: "A physical product has little intrinsic value itself, except perhaps for the purpose of display. Its only real value is as part of a solution to a problem" (p. 165). As Kotler puts it, the physical facet of the product has no interest per se: "We must replace the idea of a physical product with the idea of a 'total product' that includes a whole set of services." (Kotler, 2017, p. 171).

2.2. The product in an ecosystem

The above idea of a product 'being a variable' has led to significant borrowing from social science in order to develop a complementary concept of the product as the result of different value layers deriving from a network of relationships. This perspective has a lot to do with the practice-based approach of marketing initiated by certain scholars (see: Azimont & Araujo, 2007; Kjellberg, 2007; Araujo & Spring, 2006; Araujo, 2007; Kjellberg & Helgesson 2006; 2007a; 2007b; Rinallo & Golfetto, 2006; Sjögren & Helgesson, 2007). For instance, Araujo and Spring (2006), building on Callon, support the idea that "products do not just circulate as independent intermediaries in pre-established networks but define and describe a network of actors connected to their design, production and use" Araujo & Spring, 2006, p. 801). From the same perspective, Mol et al (2005) have identified products or services as resulting from a collection of value-contributing parties who settle on a division of spoils that keeps each party willing to participate. Finch and Geiger (2011) borrow the notion of 'market object' from Slater (2002) and the idea of 'pacified object' from Çalişkan and Callon (2010) to build their view of objects as resulting from an 'objectification' work. Because of its variable nature at a given moment, an object has to be "'cut out' from 'different potential shapes and relationships' to 'be imbued with property rights'" (Finch & Geiger, 2011, p.

900), and will eventually be exchanged. Recently, Spring and Araujo (2017) have developed a similar perspective, defining products as "open-ended propositions subject to constant redefinition and re-valuation as they are attached to and detached from successive contexts and networks" (p. 127). Very recently, Kopalle et al. (2019) have emphasized the role played by sensor-equipped products in connecting production and consumption ecosystems, thus becoming platforms (Lusch & Nambisan; 2015; Perks et al.; 2017).

3. When the business product gets smart

3.1. The physicality of smart products

Due to the data they generate, smart products result from being embedded in a larger ecosystem (Iansiti & Levien, 2004) and they can co-create value by interacting with companies belonging to different networks and then integrating new value layers. Smart products are previously non-digital business devices that are at some point equipped with different additional features (sensors, microprocessors, software, connectivity components, etc.) that will allow them to communicate and interact with their environment (other smart products or humans) (Abramovici et al., 2017; Monostori et al., 2016; Puschel et al., 2016; Woodside and Sood; 2017). Therefore, as Kees et al. (2015) emphasize, there is a part of the smart product that "exists independent of IoT technology" (Kees et al., 2015, p. 3). It could therefore be considered as an "IoT-enabled object" (Kees et al., 2015, p. 3). A similar idea is developed by Niu et al. (2016) for whom smart products also exist as "a non-computational physical entity with established purpose, appearance and use in everyday experience" (p. 5). Consequently, even when they get smart, the smart product's "original appearance and functions remain uncompromised" (Niu et al., 2016, p. 5; Beigl et al., 2001).

Therefore, the smart product is first and foremost a physical product and this means that it has to address usage on its own. But at the same time, it is also a connected object, which

means that its value is also created and defined by additional features such as the ability to communicate with humans, with other products, and to feed an information system (sociable product). The importance of 'physical objects' is widely acknowledged in the various definitions of the IoT. For Rakotonirainy et al. (2016), the "Internet of Things (IoT) is the network of physical objects, devices, vehicles, buildings, and other items, which are embedded with electronics, software, sensors, and network connectivity enabling them to collect and exchange data" (p. 78). For Guo et al. (2013) "The Internet of Things (IoT) refers to the emerging trend of augmenting physical objects and devices with sensing, computing, and communication capabilities, connecting them to form a network and making use of the collective effect of the networked objects" (p. 400).

3.2. Smart products as sociable objects

Mitew (2014) introduces the notion of a sociable object as a sub-category of smart products. We consider this additional feature as a characteristic in line with the ecosystemic perspective (Iansiti & Levien, 2004) that considers smart products in terms of their relationship with other stakeholders. Objects become sociable when they "acquire the agencies to spill semantically distinct traces onto the material world and detour their human interlocutors into an object-mediated entanglement" (Mitew, 2014, p. 7). This definition focuses our attention on several aspects of the smart product. First, the smart product can *do* things. It has the "ability of an actuator" (Mitew, 2014) which is a type of agency that has nothing to do with "intentionality, subjectivity, or thing-ness" (Mitew, 2014, p. 7). Second, so as to *act* (exchange data with other sociable objects, and possibly, carry out actions in accordance with data generated or received) sociable objects do not need any kind of human intervention: "The ontological problematic is underlined by the capacity of IoT embedded objects to completely dispense with humans as intermediaries" (Mitew, 2014, page 10). Third, this agency is visible. Contrary to 'discrete desktop/ mobile computers', IoT is about 'trivial

material artefacts' being 'permeated' by 'connectivity' (Mitew, 2014, p. 5), "therefore granting them agency visible to humans" (Sterling, 2005, quoted by Mitew, 2014, p. 5). Fourth, according to Mitew (2014), by 'acting', smart products build "anticipatory materiality acting as a host to human interlocutors" (p. 10). As a matter of fact, due to the enormous amount of data smart products can stock, aggregate, and process, the objects can adapt and react – "they are able to share, augment and 'understand' all the context information they acquire" (Mitew, 2014, p. 9). They thus propose a permanently updated environment in a way that leads humans to adapt in turn.

4. Methodology

4.1. Data collection

Based on our theoretical background (sections 2 and 3) and in connection with our research question - how a product comes to be a smart product - our methodology will be guided by the aim to discover and describe the physical aspects of smart products. We selected a convenience sample of 12 cases of smart products in B2B contexts. These cases were chosen following three simple rules. First, smart products described in these cases are 'business products', which means that they are used in business contexts and not consumer contexts. Second, all of them are based on a core of 'dumb' products. For instance, case 8 presents robots used in an industrial context (collaborative robots) and not robots as they are used in service relationships with consumers (service robots). Third, each case should offer enough description of the smart product as a 'physical artefact'. To ensure this, we have used multiple secondary sources of information (see Appendix 1) to build our cases (see Appendix 2). For instance, in the case of smart vehicles or equipment (forklifts, tires, cranes, etc.) we collected additional information to check precisely how the products were modified to become smart products, for instance by checking the size and where sensors were fixed. This

also led us to supply pictures in order to better capture the 'physicality' of the smart product analysed.

In addition we carried out in depth-interviews with 2 engineers with strong IoT expertise; with 5 managers of companies active in the IoT field and with several companies during the international 2019 Smart Industries[3] show. These interviews with experts of the field were conducted with the objective not to miss an important dimension of the analysis of smart business products. The length of these interviews varied from 30 minutes to 2 hours and a half. Certain of these interviews were audio recorded. During these interviews, three mains topics were dealt with: 1/ What is a smart product? (*Is the term 'smart products' used in your company? Which other terms are used? Why did you develop products with smartness? What were the main stages of this project? Would you say that a smart product is a normal product to which something has been added? If yes, how to define this 'something'?*) 2/ with smartness being added to products, which changes occur in interactions? (*We proposed the interviewees to consider several interactions: Between products and user; between the supplier and the customer (for instance are the interactions more continuous? Are they more routinized (they do not only concern "incidents"); with other machines and products? With other actors - humans or non-humans),* And 3/ What are the main challenges created by smartness being added to products and machines?

4.2. Data analysis

Our purpose in this research was to understand how a business product becomes a smart product. We have used the notion of the sociable object – presented in the previous section – to guide our analysis of the cases. This conceptual input helped us to structure our research

[3] The Smart Industries show was held in Paris in 2018, Lyon in 2019 and Paris again in 2020. It is an international show for connected, collaborative and efficient industry. It is considered a must for professionals.

purpose and guided us to consider changes to the product whether at the level of the product characteristics themselves or the product's connections with other products and humans. To assess the trustworthiness of the research, we considered four key components: credibility (linking research findings to reality), transferability (ability to generalize from research findings), dependability, and confirmability (Lincoln & Guba, 1985).

In our analyses of cases, we were thus attentive to:

1/ How much the product was modified when becoming a smart product (in terms of features and production process). This was inspired by the notion of the sociable product, as developed by Mitew (2014), where the notion of 'visible agency' is emphasized. For instance, we considered that a product is *moderately* modified when the 'smartness' is obtained through the fixation of a sensor on an unchanged product. The production process of the product does not have to be changed. This is observed, for instance, in case 3, where beacons are fixed on seals or valves. We considered the product to be *partially* modified when the 'smartness' modifies the product features *and* requires a modification of its production process (for instance, in case 2, in smart tires, the sensor has to be integrated into the inner liner) or when the sensors are particularly numerous (as in case 10, connected wind turbines, on which more than 1000 sensors could be installed). In case 8 (industrial robotics) we can consider the change to be *total* (if we consider that 'cobots' are not a modified production line but an additional part of the production line) or at least *major* if we consider the 'cobot' as a very sophisticated part of a production line. In case 1 – smart farming - the assessment is a little bit more difficult in the sense that it is rather a system of connected products.

2/ We were also concerned with the ecosystem directly surrounding the smart product, paying attention to the additional products made necessary by this smartness (for instance, in the case of smart tires, a smart 'reader station' had to be installed); to the

possible connected products the focal smart product can interact with (for instance, in the case of smart forklifts, the vehicles can interact with other forklifts or other vehicles within the warehouse), and finally, human entities involved in the flow of information / decisions created by the smart product.

3/ Finally, we tried to assess the level of autonomy the smart product has. This aspect is in line with the sociable object conceptualization in the sense that the latter refers to the question of product agency. We have cases where the smart products are relatively low in autonomy (for instance, case 3, with sensors only signalling failures on business equipment but unable to carry out corrective action) and others where smart products have higher levels of autonomy (in case 12, the forklift decides autonomously on its working sequence), including cases where autonomy could be thought of as total (the automated farming project in case 1 is an illustration of this autonomy).

Below, Table 1 offers a brief presentation of the 12 cases we analysed. A detailed presentation of each case is available in Appendix 1.

Insert Table 1 about here

5. Findings

5.1. Changes in status and surrounding changes …

Based on the 12 cases presented (table 1), it is possible to identify various dimensions along which smart products in business markets may vary. These dimensions were derived from the concepts of physicality of the product (degree of smartness, visibility of smartness) and the ecosystemic nature of the product (degree of 'systemness', degree of autonomy) described in the literature review:

— *Degree of smartness.* Here we are assessing how much smartness gives the product new functions or capabilities. In ten cases out of the twelve analysed, the smart business product is an 'augmented' product which means that the product has a utility outside of its smartness. Take for instance case 5 - the smart helmet is primarily used to protect the employees' heads before (or whilst) also offering to warn employees (and/or staff) of environmental dangers and possible resulting injury. Two exceptions should be discussed - case 1 and case 8. Case 8 relates to cobots, and their value 'outside' their smart dimension is difficult, if not impossible to grasp. The cobot is smart (in the sense defined in previous sections) by nature and cannot be thought to exist in a 'dumb'[4] version. Case 1 is rather about a system of connected smart products. If we consider the sensors as the core of the system and the business object to be analysed, here again, the sensor is by nature smart. Both cobots and field sensors, rather than being smart products, are in fact adding a smart layer to a 'dumb' system. In the case of cobots, a production line or production process is enhanced by a smart dimension. In the case of smart farming and tractors, the sensors give the fields a smart dimension too. But in all cases, a 'dumb' aspect of the activity remains.

— *Visibility of smartness.* Here we focus on how much the physicality of the product is changed by smartness by assessing the visibility of the sensors and other smart parts. In case 3, sensors on seals, valves, and motors are visible. Conversely, in case 2, sensors are mounted on the inner liner and are thus not visible. In cases 4 and 7, cranes use additional devices that consist of a sensor, a beacon and a control unit in the cabin. The smartness is thus visible but not prominent. In case 11, most of the 400 sensors that may equip an industrial vehicle are fixed to internal parts and not directly visible. The same goes for case 10, where wind turbines of 160 meters high are

[4] We use the term 'dumb' to designate non-smart products. The term dumb, in this sense, has already been used by several scholars. See, for instance, Meyer et al. (2009), Verhoef et al. (2017).

equipped with 10-centimetre sensors that are not very visible. The cobots in case 8 are smart. The helmet of case 5 is visibly smart, with a prominent module for monitoring visible on the side (on future versions of the helmet it will disappear because it is occupying a part of the hardhat that is usually used by workers to wear ear protectors).

— *Degree of 'systemness'*. Here we look at the range of the stakeholders being connected by the smart product and the resulting system that is created. In all the cases we analyse, the smart product is an entity to which information coming from different parts converges, and from which information is disseminated to different parts. Case 1, for instance, describes the tractor as both receiving information from other parts (sensors for soil composition, or irrigation systems) and communicating information to other parts (other vehicles, the farming system). Forklifts described in case 6 and case 12 receive information from other vehicles, ERP systems, and employees, and send information to other vehicles, automated doors, etc. The number of connected entities that send information to the smart products and to which the smart products send information may vary. For instance, in case 2, the smart tire only sends information on temperature and pressure but does not receive information. The same goes for case 3, where the smart valves only send information on vibration, flow rate, etc. In case 10, wind turbines both send and receive information which is used to judge whether to adapt the speed of their blades, for example. The cobots of case 8 receive information from different parts of their environment, including from humans (who move around them).

— *Degree of autonomy.* Here we are assessing the extent to which smart products can act autonomously (without human intervention). The smart helmet in case 5 has a certain degree of autonomy. When the body temperature or heartrate of the wearer rises above a particular level, it can emit a warning sound and vibrations. No human

intervention is necessary for this action to take place. This autonomny is however limited. The smart forklift in case 12 can prioritize orders *itself* and make decisions to optimally manage its movements. The crane in case 4 is stopped if the sensor detects an incorrect rope angle. But in case 7, all information gathered is transmitted to the crane owner. No indication of an automatic reaction to what the sensor detects is mentioned. Case 1 aims for total autonomy in farming: tractors, harvesters, planters, tillers... move and work based on information sent by surrounding systems.

5.2. Towards a typology

Based on the potential status-related characteristics of a business product when it becomes smart, as described in the previous section (degree of smartness, visibility of smartness; systemness, and autonomy), we classify the different cases analysed along two dimensions (see Table 2) and propose a typology (Weber, 1949; Bailey, 1994) of smart products (see Figure 1).

Insert Table 2 about here

The first dimension, '*Product Internal Characteristics',* reflects to what degree the smart transformation of the business product results in additional functions (occasions of use) for the product. The product can either continue to offer the same core functions, or its new 'smartness' implies the creation of new functions. For instance, a smart valve such as the one described in case 3 still has the same core functionality as before it became smart. On the other hand, the smart helmet presented in case 5 has a new 'warning function'. Hence, we propose classifying a smart product along a first dimension that focuses on the functional enrichment of the smart product. Note that this distinction is not trivial in the sense that the assessment of whether a smart product offers new additional functions depends on the user's

vantage point. For instance, in case 3, the 'smart valve' continues to fulfil the same function for the 'pump' but it is now also a source of information for the site manager. Thus, we consider additional functions to go 'beyond' the simple communication of information, as this is a common characteristic allowed by IoT products or AI embedded interfaces. We focus more on the new functions that a smart product may carry out.

2) The second dimension describes the functions performed relative to the system of connected entities that it is a part of. The product can either be a 'node' in the connected network, thus capturing a limited amount of information and/or communicating information to a limited number of entities as well as receiving information from a limited number of entities. On the other hand, the product can behave as a sort of hub, receiving various types of information from different entities and communicating information to various entities. Embedded technology enables a new way to create and capture value. In order to make the distinction, the three authors carried out an intercoder reliability based on the extent to which two or more independent coders agree on the coding of the content of interest when applying the same coding scheme (Porter and Heppelmann, 2014, 2015). For instance, in case 9, a smart light in the meeting room can be considered a 'node' (sending limited information, and only capturing information about the presence or not of an employee in the room), but the meeting room itself (as a system of different smart products like lights, heaters, air conditioning, etc.) becomes a hub receiving information from many different sensors or external systems and communicating in return with different products.

Considering these two different dimensions together, we propose the following possible taxonomical representation of different types of smart products (Figure 1) defined in the B2B context.

Insert Figure 1 about here

More Efficient Products (MEPs) are business products that only become more efficient with the new ability to communicate information (point-to-point). At the same time, these smart products do not offer a new function and only capture and send limited information to a limited number of connected entities (i.e., smart truck tires, smart pumping).

Augmented Products (APs) are those business products for which smartness brings new additional functions but maintains them in a rather isolated position from other products (as is the case with smart helmets or smart forklifts).

Products as a Node (PN) are products that do not change in terms of functions, but they capture information from or send information to a large number of entities at the same time (i.e., smart industrial vehicles or collaborative robots).

Finally, *Products as a Hub* (PH), are products that become central in a system. Not only do they offer new functions, but they communicate with many different entities (i.e., smart meeting rooms or smart wind firms).

6. Discussion

Based on the analysis of the 12 cases and the typology described in the previous section, it is now possible to provide a differentiated answer to the research question 'What happens to a product when it becomes a smart business product?'. We identify three possible modifications in the status of a business product when it becomes smart; 1) increased digital enhancement, 2) increased embeddedness, and 3) increased interconnectedness with humans. These three modifications may not cover all possible product status changes, but they are particularly pronounced and developed in the cases described in this study. Hereafter, we first discuss the three modifications identified through this research, and, second, we discuss the

impacts of these modifications on the sales and marketing of such products, emphasizing how smartness may influence the value proposition process.

6.1. Modifications in the status of the business product when becoming smart

Based on the four types of smart products described in our typology (Figure 1) we can propose three key attributes that products acquire when they become smart:

- *Products become 'Thick'*. This notion emphasizes the idea that smart products, in a majority of cases, appear via, and can be used for, one or the other of their 'dumb' and 'smart' dimensions, or both. Digital enhancement refers to the idea that any smart product has something not 'physical' but 'informational' that is a constitutive part of its identity in addition to its dumb / physical nature.

- *Products become 'Deep'*. Smart products act as doors leading to other entities. Every smart product connects with other entities. Connections imply that information gathered by the smart product can be transferred to another entity (a device, another object, another system, a human), but also that the object can receive information from another entity (a device, an object, a system, a human). This means that the boundaries of the product, when 'plugged in' to a system, are pushed back, and what was considered to be the 'product' becomes a 'component' in a broader conceptualization whereby we now see a sort of 'higher order' product or system of systems (Porter & Heppelmann, 2014).

- *Products become transformative.* We define 'transformativeness' as the capacity of a smart product to transform any user - including humans - into data. Sensors only capture 'data'. They do not capture 'the real world' but a quantification of this world. Smart products collect data about how they work, their environment and also how they are used (by humans). The smartness of the product thus creates situations that expand the classical user-product relationship in which the user only 'uses' the product. Usage becomes reciprocal in the sense

that humans use smart products for specific purposes, but at the same time, smart products (in certain cases) use humans as sources of data.

6.2. When the smart product redefines value and value propositions

Digital enhancement raises interesting questions for business-to-business marketing and the value propositions formulated.

One issue emerges in terms of the balance between 'value of the smartness' vs. 'value of the dumbness'. Take, for instance, case 5: the smart helmet is a vehicle of value co-creation both through its 'dumb' dimension (the material of the hard top protects the employee's head) and its 'smart' dimension (it warns the employee of excessive body temperature). It thus multiplies the possibility of value co-creation for the traditional user (in the case of the helmet, the employee is protected both against head injuries and heat-related problems) but also for new users (a site manager can withdraw an employee from too hot an area). From a marketing perspective, the value proposition is then impacted by the smartness. What 'points' (or elements), such as points of parity, points of difference, and so on (Anderson & al., 2006) should be developed in the value proposition? Only those related to the smart capabilities of the helmet? Those related to the 'classic' protection role of the 'dumb' helmet? A mix of both? From the point of view of suppliers this may raise the question of how these dimensions define the product (positioning issue). On the supplier side this could be both an opportunity (e.g., when the product supports different value co-creation processes) or a constraint if the balance of the two dimensions is problematic (when confronted with the design of the value proposition, for instance). On the user side, the same trade-off exists. When buying or using a smart product, what is the customer doing exactly? A possible ambiguity can characterize the buyer/user relationship to the smart product. Am I wearing a helmet to protect my head or to avoid heat stroke? For a customer, it assumes that he/she considers his/her behaviour in a different way. Head protection and heat stroke prevention

become a similar group of behaviours that the smart helmet can address. In a similar way, a smart forklift combines the activity of moving goods in a warehouse with saving energy and improving safety.

The embeddedness of smart products, too, raises interesting questions for business-to-business marketing. How should the extended network, created by the smart product's multiple connections, be conceptualized and communicated (if it is to be communicated) to customers? Should the smart product always be presented as offering 'potential' value? (in accordance with the view of the product as a variable). From a customer perspective, the embeddedness of the smart product raises the question of the identity of the supplier. When considering a smart product, what exactly is considered? The supplier of the 'dumb' product? Or the many suppliers of information that are connected to the smart product?

The embeddedness also raises the question of operating shutdown. Of course, a smart product can fail because of its 'dumb' characteristics. But due to its smartness - providing data on product usage, technical aspects, and also addressing remote corrections… operating shutdowns are likely to diminish. But other operating shutdowns must be considered - the ones potentially generated by the product, the device, or the system the smart product is connected to. For the user, the smart product appears no longer controlled by its direct environment.

Finally, *transformativeness* (here defined as the capacity of a smart product to transform any user - including humans - into data) raises the question of the nature and role of information for business marketers. We will not discuss here the aspects of privacy or security that are linked to the IoT. Those aspects constitute a far too complex issue that goes beyond the scope of this article (see Chin et al., 2019; Dabbagh & Rayes, 2019; Sadeghi et al., 2015). We rather focus here on the changes brought about by the existence of a smart product in a particular business context. By transforming any user into data, the smart product only

captures a 'digital twin' of the user it is interacting with. Of course, this information capture could be considered to be particularly optimized. A sensor can gather a huge amount of information on the functioning of the product or the surrounding environment. It can do that with regularity and accuracy. On the other hand, one may imagine that beyond the data represented by a user, other information could be useful that risks never being captured. For instance, when a smart truck collects data on 'how the driver drives', sensors may capture only 'objective' information such as, for instance, whether the speed limit and the maximum load capacity are respected, … but what about other aspects like 'driving comfort' or 'driving pleasure'? In other words, a risk may exist that business marketers rely too much on data gathered by a smart product at the expense of other types of information that represent the user experience.

7. Implications and avenues for further research

The purpose of this paper is to conceptualize how a business product happens to become a *smart* business product. We propose conceptualizing this change along two dimensions. The first dimension, *'Product Attributes',* reflects to what degree the smart transformation of the business product results in physical change and additional functions (occasions of use) for the product. The second dimension describes the ecosystem of connected entities surrounding the smart product. Such a conceptualization leads us to describe four categories of smart products: *More Efficient Products* (MEPs), *Augmented Products* (APs), *Products as a Node* (PN), *Products as a Hub* (PH).

Our analysis discusses how, in each category of our typology, a product acquires a certain degree of 'digital enhancement', 'embeddedness' and 'transformativeness', and we emphasise the impact on the value proposition process. Below, we suggest possible implications of our work both at the theoretical and managerial levels.

7.1. Theoretical implications

The *first* theoretical implication of our work is that it offers a new view of products in the B2B context when the technology embedded in the product itself transforms it into a smart business product. The emerging typology allows us to identify four different resulting patterns and suggests implications in terms of related business models (Ehret & Wirtz, 2017). Since the value proposition concept is at the heart of any business model, the business model concept is closely related to a smart product, as analysed in our research in relation to value propositions. In addition to the different perspectives of a product as a variable, or as a 'vehicle' for the value co-creation process that have already been developed in the marketing literature, our paper adds a new perspective of the business product reconnecting to its physicality. We contend that in an era of rapidly intensifying digital transformation, it is not just relationships between actors that have to be reconsidered, but *actants* in these exchanges also have to be precisely analysed. Although products have always been present in conceptualizations of marketing exchanges, they have rarely been central in research works. While, in recent years, several new paradigms – such as the service-dominant logic – have tended to stress the importance of services as opposed to tangible products, our work suggests that the physical product remains important for the creation of value in many B2B settings. For perspectives such as those seen in the business model literature, this also implies that digitalisation is not only an element reflected in the resource dimension included in frameworks such as the business model canvas. Our work highlights that through its concrete manifestation in business products, digitalisation also materializes in the value proposition element of a business model and, in turn, through the *actant* dimension, in the relationships between direct and indirect business customers, suppliers, partners, and other stakeholders.

Second, in addition to renewing the way we see products, our work contributes to reactivating (or simply activating?) debate on the meaning of the physicality/tangibility of products in business marketing. In the services literature, several authors discuss the fact that intangibility can't and shouldn't be used as a criterion to differentiate services from goods (Bateson 1991, Gummesson 1995, Riddle 1986), stressing that instead of buying objects customers buy benefits, and that customers derive value from the function an object performs, not from its materiality. Our study doesn't contradict these important observations. Other authors have narrowed the intangibility discussion around distinctions between services and goods down to a matter of substitution between human work and services rendered by machines. For instance, Vargo and Lusch (2004b) argue that "a stamping machine in a factory is a substitute for labor services. (…)" and that "tangible goods are merely platforms for the performance of human functions" (Vargo & Lusch 2004b, p. 328). Against this background, our work suggests that the digital capabilities of smart products go far beyond the suggested equifinality of human labour and machines. In fact, in many ways, smart products outperform by far the value creation that could be achieved through human work alone; they create new kinds of value that humans could not produce, and they establish new relationships between humans and tangible objects in actor networks in which humans may but needn't play an active role. The typology developed in this study allows us to specify the different ways smart products create additional – and sometimes complex - value by combining tangible and intangible digital components.

Third, in addition to offering a renewed perspective of the 'product itself', our work proposes widening our vision of the smart product to the area of smart business products. By moving the setting from consumer situations to business situations, our work allows us to deal with new situations of smartness that transform the product itself and open it up to a larger business ecosystem. While we don't suggest that 'business situations' are radically different

from ‘consumer situations’, the focus on business products at least obliges the observer to consider new impacts of smartness (new business models, new functions, new markets addressed). By conceptualizing the ideas of the *embeddedness*, *digital enhancement* and *transformativeness* of smart products, we propose new dimensions to capture aspects of digitalisation on business markets.

Finally, to strengthen the previous point, our work proposes a typology of smart business products that, to our knowledge, is one of the first attempts in the marketing literature to give an account of product transformation due to additional smart capacities. This typology could be of use for scholars to go on investigating digitalization in companies with a view to distinguishing between different situations. Moreover, it allows categorization of the differential impact of digitalization via smart products. At the same time, this typology suggests that there is not one standard effect of digitalization on business products, while also showing that certain typical forms of smart products can be identified. While reality may be more complex than our typology, we believe it helps us to understand business markets and products better in times of radical change through digitalization.

7.2. Managerial implications

A *first* managerial implication of our work is linked to the renewed perspective on value co-creation and value propositions that managers might exploit. In this paper, we agree with the logic of value, which breaks down the distinction between products and services and combines them into activity-based ‘offerings’ from which customers can create value for themselves. We encourage managers to carefully explore the diversity of value co-creation made possible by additional layers of smartness created by embedding digital technologies in business products.

Second, as potential offerings grow more complex, so do the relationships necessary to create them. We encourage managers to update their ‘network picture’. With smart products, *actors*

in a business network are ‘traditional’ actors who were previously using the dumb version of a business product. Actors might also be ‘new ones’ and because of the smartness of the product could be integrated into the value creation process (this is the case of all new actors that could benefit from the data generated by the smart product). Moreover, managers should also consider the *nature* of the value proposition by analysing carefully which ‘layer’ of the smart product is creating value for the user - whether the dumb layer, the smart layer, or both. This will prevent the marketing manager from misunderstanding what the product does exactly for the user by over- emphasising its smart aspect.

Third, with this work, we also want managers to understand that data collected and used by smart products is only part of the environmental information available in a given situation. In other words, managers have to be aware that the data does not give the whole picture and should be integrated and combined with other analytics. For instance, when sensors on a truck capture information about how the equipment is used, this is only one insight into the working situation. Other elements, not captured by the sensors, could also be useful when carrying out a thorough analysis of the situation.

Finally, new managerial implications emerge concerning how smart, connected products affect rivalry, industry structure, industry boundaries, and strategy. Hence, firms need to define their digital business strategy and understand how it is related to their market performance (Leischnig et al. 2016). Our typology suggests that the smartness and digitalization of business products affect central concepts of competition in different ways, depending on which one of the four quadrants of our typology a product falls into. As a consequence, managers may want to differentiate their strategic analyses and attempt to predict the evolution of their industry depending on the mix of smart products competing on their specific market.

7.3. Future research

This article represents a potential starting point for several types of research. We focus on five possible avenues for future research but are convinced that others exist.

A *first* research question we see as flowing directly from our analyses concerns the performance effects of business product digitalization. While we identify different types of smart products, it would be interesting to gain a better understanding of whether some types in our typology produce better economic performance outcomes as compared to others. While we lack empirical evidence, we would speculate that the performance of different types of smart products is contingent on contextual factors, some of which may be related to the kind of value customer firms are looking for. Hence, we would welcome studies that analyse the performance of new smart products, that is, the outcomes, drivers (or success factors) and potential moderators or mediators the move towards smart business products.

Second, several actors (Akaka & Vargo, 2014; Nambisan, 2013; Lusch & Nambisan, 2015; Sklyar et al., 2019), have discussed the idea that technology is both an operand resource (facilitator or enabler) and an operant resource (initiator or actor) in value creation. Our findings suggest that not only technology but also products themselves, once they become smart, can be considered operant resources, because – thanks to their characteristics – they are able to initiate action. Given the fact that, traditionally, non-material entities (skills, knowledge…) are considered to constitute operant resources, this is a new perspective that calls for a broader scholarly exploration. Along with research that puts forward the idea that the consumer as a co-creator should also be seen as an operant resource (Kjellberg et al., 2018), this new vantage point may trigger further research on both the distinction between operand and operant resources and on which items or entities qualify as operand and which ones as operant resources.

Third, among current mega trends (such as digitalization), sustainability and corporate social responsibility play key roles (Chakrabarti et al., 2020). There are several conceptual links between both types of trends, that is, digitalization on the one hand and sustainability/CSR on the other. Future research may analyse if and how smart products produce positive and/or negative effects on relevant sustainability outcomes (such as improved water or carbon footprints, resource usage, recycling/refurbishing rates, etc.) or CSR outcomes (such as the respect of employee rights or guaranteeing healthy work conditions). In a similar vein, future research may study servitization (Baynes 2000) which considers the innovation of an organisation's capabilities and processes to better create mutual value together with customers through a shift from selling products to selling Product Service Systems (PSS). A variety of concepts, such as predictive maintenance or the circular economy approach will need to be included in such a discussion, and the effects may be different depending on the sustainability concept one chooses to focus on. Many service-based business models (car-sharing, etc.) explicitly or implicitly also address the issue of sustainability/circularity and their performance may depend on the level of smartness of the products around which they are built. In any case, the interplay between digitalisation and smartness on the one hand and sustainability on the other certainly deserves much more detailed attention than it has hitherto received.

Fourth, smart products, such as the ones this article discusses, may operate in a certain type of isolation (although their smartness connects them to other entities without which they couldn't create value), but they may also be combined into broader solutions. New product bundles may be comprised of connected objects of a similar nature (a higher order smart product), or of connected "dumb" objects of different types (a smart system of some kind), or there may be mixed bundles. Indeed, products are moving towards a system-of-system future in which increased value will be generated by integrating smart products and less smart

products in larger networks of objects which, in turn, need to be integrated with human or organizational networks of actors. Studying the nature and types of such systems-of-systems (SoS) represents, we believe, a major field of research for the future in different disciplines, including sales and marketing management. It points to several challenges that are, of course, physical or technological in nature, but also very much related to human life and human destiny. For example, while today we most often ask the question what additional value smartness or digitalization create for us humans, the future question may be: "What value do human beings, human intelligence, and human work create for the larger system of digital and human systems?". Given the speed at which product smartness advances, academic answers to such questions are needed sooner rather than later in time.

Finally, digitalization – and hence smartness – are often presented as culture-free phenomena. However, business markets and business products are subject to cultural influences. For example, the interaction and negotiation behaviours of actors from different cultural backgrounds vary strongly, sometimes provoking crises or at least tensions in business relationships. More specifically, concerning the value propositions of smart products, it is unclear whether business customers from different regions around the world converge in terms of value perceptions. Extant research on perspectives on new technologies suggests that cultural effects exist (Fleischmann & Ivens, 2019) Future research could dig deeper into the question of whether smart products are culture-free or whether cultural factors influence individual attitudes and perceptions across business markets around the world.

Apendix 1 – Presentation of secondary data for the 12 cases

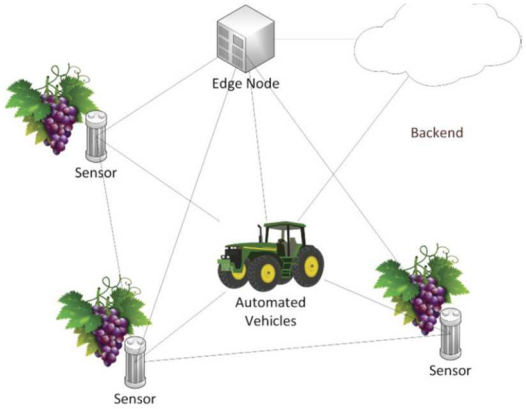
		Secondary data used	Examples of documents, websites, videos consulted
Case 1	**AfarCloud** Smart farming	• Description of the Afarcloud project partially funded by the EC Horizon 2020 Programme. The project is coordinated by José-Fernán Martínez-Ortega from Universidad Politécnica de Madrid. • Description of the different products, machines, actors involved in the project	• https://www.ecsel.eu/projects/afarcloud • https://ercim-news.ercim.eu/en113/special/smart-farming-from-automated-machinery-to-the-cloud
Case 2	**Continental** Smart truck tyres	• Description of Continental ContiConnect, a new digital tyre monitoring platform for commercial fleets. • Several pictures of sensors mounted on the inner liner of the tyre.	• https://internetofbusiness.com/reinventing-the-wheel-smart-tyres-and-the-iot/
Case 3	**Flowserve** Smart pumping	• Article of the blog by Michelle Hopkins, Managing Editor of Product Lifecycle Report. Description of the functioning of a smart pump • An 8-page document describing the solution provided by Flowserve. • Diagrams explaining how the smart valves are integrated into a global system. • Pictures of Flowerve pumps equipped with sensors	• https://www.ptc.com/en/product-lifecycle-report/iot-data-reducing-unplanned-downtime-with-predictive-analytics • https://www.flowserve.com/sites/default/files/literature/marketing/ps-90-11-a4.pdf
Case 4	**Konecrane** Smart cranes	• Description of the different types of cranes. • Technical features precisely described. • Pictures, diagrams.	• https://www.konecranes.com/sites/default/files/2018-10/konecranes_brochure_smart_features_en_2015.pdf
Case 5	**Laing O'Rourke** Smart Helmets	• Description of Laing O'Rourke smart helmets along with the surrounding technical network. • Interview of Laing O'Rourke CIO Ryan Macnamee: description of what the helmet 'does' to prevent heatstroke • Interview of Rob Shepherd, in charge of Laing O'Rourke engineering excellence group: description of the sweatband sensor, the accelerometer the GPS • Pictures.	• https://www.iothub.com.au/news/laing-orourke-brings-iot-to-hard-hats-412008 • https://internetofbusiness.com/australian-construction-firm-uses-iot-for-smart-helmets-which-keep-workers-safe/
Case 6	**Linde** Smart forklifts	• Technical description and pictures of Linde forklifts • Precise description of the functioning of forklifts. • Interview of Melonee Wise, CEO of Fetch Robotics. • Interview of Tobias Zierhurt, vice president of product management and industrial warehouse trucks at Linde Material Handling.	• https://www.linde-mh.com/en/Products/Automated-Trucks/K-Matic/ • https://www.supplychaindive.com/news/4-types-of-autonomous-mobile-robots-and-their-warehouse-use-cases/529548/ • https://www.linde-mh.com/en/Products/Automated-Trucks/

Case 7	**Manitowoc** Smart cranes	• Presentation of smart cranes. • Description & diagrams of CraneStar functioning • Description of CraneStar technical features • Pictures of smart cranes.	• https://vertikal.net/ • https://www.manitowoccranes.com/en/Tools/CraneSTAR/about-CraneSTAR/features
Case 8	**Rethink Robotics** Industrial cobots	• Precise description of Sawyer. • Interview with Chris Budnick, president of Vanguard Plastics using Baxter Cobots. • Pictures of Baxter and Sawyer	• http://www.rethinkrobotics.com/baxter/; • https://en.wikipedia.org/wiki/Baxter_(robot)#cite_note-2; • http://www.bcone.com/smart-machine-enabled-services-future-technology/ • https://www.technologyreview.com/s/429248/this-robot-could-transform-manufacturing • https://singularityhub.com/2015/09/24/learning-to-speak-robot-the-mainstreaming-of-robotics/#sm.000080511jy2kfbupco142a7sandm • https://i.ytimg.com/vi/AgCerYgmq_w/maxresdefault.jpg
Case 9	**Schneider** Smart meeting rooms	• 74-slide presentation of the smart grid by Schneider Electric with diagrams describing the different elements of a smart building or smart plant. • Pictures of controllers, sensors, cameras…	• https://download.schneiderelectric.com/files?p_enDocType=White+Paper&p_File_Name=998-2095-05-14-15AR0_EN.pdf&p_Doc_Ref=998-2095-05-14-15AR0_EN • https://www.schneider-electric.co.in/en/work/insights/every-thing-connected-iot-the-internet-of-transformation.jsp • https://www.slideshare.net/seindia/schneider-electric-smart-energy-presentation-smart-gird-domains
Case 10	**Siemens** Smart wind farms	• Pictures • A case study by the Industrial Internet Consortium describing a Siemens project of a wind farm • Precise description of sensors within the nacelle of a wind turbine A 12-page slideshow providing diagrams of sensors used in wind turbines	• https://phys.org/news/2014-03-automatic-self-optimization-turbines.html; https://www.iotone.com/casestudy/siemens-wind-power/c430 • https://www.iiconsortium.org/case-studies/RTI_Siemens_Wind_Power_case_study.pdf • https://www.mouser.fr/applications/tiny-Sensors-Role-in-Wind-Turbines/ • https://www.slideshare.net/Aquibhamid17/storyboard-for-wind-x
Case 11	**Volvo Construction Equipment** Smart industrial vehicles	• A video of N*iels Haverkorn, vice president connected solutions at Volvo Construction Equipment (CE), presenting how Volvo is using IoT* • *Description of how a truck is equipped with sensors.*	• https://internetofbusiness.com/video-volvo-benefiting-iot/ • https://www.scimag.news/en/2018/09/19/construction-telematics-the-power-of-the-network/
Case 12	**ZF** Smart forklifts	• A 3:11 minutes video showing a ZF forklift in action: situations of man / machines contacts; autonomy… • Presentation of the product. • Interview of ZF's CEO Wolf-Henning Schneider : description of high automation level of ZF forklift	• https://drivetribe.com/p/see-think-act-TWUQg4-uS4m3aRjTv2eVOQ?iid=buErFkilT-azEwJ15zcnwQ • https://www.ivtinternational.com/videos/zf-demonstrates-the-capabilities-of-its-smart-forklift.html

Appendix 2 – Cases

Case 1 – AfarCloud – Smart farming

AfarCloud (Aggregate FARming in the CLOUD) is an E.U. project bringing together 59 organizations in 14 countries. AFarCloud addresses the urgent need for a holistic and systematic approach in smart farming. It will provide a distributed platform for autonomous farming, which will allow the integration and cooperation of Cyber Physical Systems in real-time for increased agricultural efficiency, productivity, animal health, food quality, and reduced farm labour costs. IoT sensor networks in the field will detect pests and environmental conditions and a range of other factors affecting plant health. Communicating this information via secured edge nodes with the AfarCloud middleware, and storing them in a backend, enables fast reaction and adaptation and simultaneously charters and monitors long term trends to compare production and conditions over time. Automated vehicles compensate for the shrinking labour force and enable precision farming by closing the feedback loop between sensing, control, and actuation. Automated farming vehicles, working in combination with a distributed sensor network, can apply pesticides and fertilizer based on the measured needs of small patches of the complete agricultural production unit.



Source
https://ercim-news.ercim.eu/en113/special/smart-farming-from-automated-machinery-to-the-cloud
https://www.ecsel.eu/projects/afarcloud

Case 2 – Continental / Smart Tyre

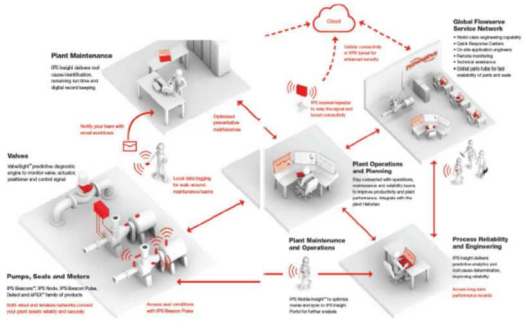
Continental is a leading German automotive manufacturing company specializing in brake systems, interior electronics, automotive safety, powertrain tyres and other parts for the automotive and transportation industries. ContiConnect is the digital tyre monitoring platform developed by Continental for commercial fleets. There are three elements to ContiConnect. First is a tyre sensor, mounted on the inner liner of the tyre in order to measure tyre pressure and temperature. 'Intelligent tyres' are available to buy from Continental for trucks, buses, and earth-moving vehicles with the sensor pre-fitted, but it can also be retrofitted to existing tyres. The second part of the system is a yard reader station – a 'gateway' installed on a company's premises that its commercial vehicles have to pass regularly. For example, it could be positioned close to the washing bay, petrol pumps, or a security checkpoint. The yard reader station is the connecting component between the tyre sensor and Continental's software platform, reading data off the sensors as a vehicle passes and sending it to the back end for analysis. Third, there is the underlying software. This includes a web portal, which employees at the fleet operator use to monitor tyres. It shows them, for example, the history of a particular tyre and enables them to perform retrospective analyses. But the system also sends out notifications, by email or SMS, to fleet managers when particular issues are identified, and maintenance work is needed. According to Continental's executive vice president of commercial vehicle tyres in the Americas, Paul Williams, this means higher vehicle uptime and less general maintenance. "Fleets no longer have to rely on performing tyre pressure checks on tens, hundreds, or even thousands of tyres on their vehicles", he says. "With ContiConnect, they will know

immediately upon returning to the fleet terminal whether any tyres have low pressure. Leveraging the IoT saves fleets time and money by protecting their tyres and improves safety for everyone who drives on the roadway."

Source
https://internetofbusiness.com/reinventing-the-wheel-smart-tyres-and-the-iot/

Case 3 - FlowServe / Smart pumping

Flowserve is an American multinational company. It is one of the largest suppliers of industrial and environmental machinery such as pumps, valves, seals, automation, as well as a range of related flow management services to the power, oil and gas, chemical and other industries. Flowserve is a recognized global leader. The company operates in more than 55 countries. Reducing downtime of critical assets and keeping manufacturing plants up and running is FlowServe's mission. In manufacturing, unplanned downtime leads to billions of dollars lost each year. But with data coming from connected industrial assets, downtime can be minimized. Flowserve offers a range of IPS (indoor positioning systems) products. Those sensors can be installed on valves, motors, pumps, seals... and they continuously collect and/or transmit specified performance data on vibration, pressure, temperature, flow rate, even the presence of fluids. A software understands pumps, valves, and seals: how to diagnose their problems, learn from their life cycles, predict their future working life and, uniquely, prescribe the steps to take to fix them. Flowserve experts can be called upon when needed and can help the customer fix the problem.



Source
https://www.ptc.com/en/product-lifecycle-report/iot-data-reducing-unplanned-downtime-with-predictive-analytics
https://www.flowserve.com/sites/default/files/2017-08/ps-90-11-ea4.pdf

Case 4 – Konecrane / Smart crane

Konecreane is a Finnish company, which specialises in the manufacture and service of cranes and lifting equipment. Konecranes products are made for industries handling heavy loads like ports, intermodal terminals, shipyards, and bulk material terminals. Konecranes' remote services represent top technology. Remote services make it possible to monitor crane use, determine the need to replace worn parts, and diagnose possible fault situations. One of the biggest advances in smart crane technology is active sway control, which takes sway

control to the next level of crane safety. Traditionally, sway control has been algorithm-driven. It factors in hook height, predicting how much a load will swing, based on how fast the crane is moving. Active sway control incorporates rope angle measurement, which uses an infrared sensor that detects a beacon attached to the hook block. Instead of being on the back end of the sway like traditional sway control, calculating what we think the sway will be, this technology monitors the actual angle of the hook block in relation to the trolley. It then adjusts the motors to compensate for and eliminate the sway. Rope angle measurement is especially helpful in detecting and compensating for outside influences, unrelated to the crane itself, and supports two smart crane features. First, hook centering, which prevents dangerous sway that can occur when a trolley or bridge is not lined up perfectly over a load before lifting it. Off-center lifts are particularly hazardous in heavy lifting applications such as handling large dies in auto plants. Hook centering uses the rope angle measurement to ensure that the trolley is perfectly centered over the load to prevent sway. Second, 'Snag prevention', which automatically stops crane motion when the rope hoist or hook bumps into equipment or building structures—and the rope angle measurement technology detects a variance in rope angle. Without this feature, cranes plough on through, potentially leading to damage and injury.

SWAY CONTROL limits load swing by controlling the bridge and trolley acceleration and deceleration. Sway Control allows faster load handling and more precise positioning. This feature also reduces the risk of damage to the load, crane and surrounding area. **ACTIVE SWAY CONTROL** is designed to dampen also the existing load sway.

SNAG PREVENTION is designed to stop all crane movement if the hook, sling or load accidentally gets caught on something. This safety function reduces the risk of hazardous situations while moving loads and helps to prevent damage to the load, crane and surrounding area.

Source
https://www.konecranesusa.com/resources/lifting-viewpoints/what-makes-smart-crane-smart
https://en.konecranes.ca/sites/default/files/download/konecranes_brochure_smart_features_en_2015.pdf

Case 5 – Laing O'Rourke / Smart helmets

Laing O'Rourke is an English multinational construction company. It is the largest privately-owned construction company in the United Kingdom. Working in construction is dangerous at the best of times, but the safety risks to employees increase exponentially when taking on projects in the remote, baking deserts of Australia's outback. Heat stroke is a constant threat, made all the more dangerous by its unpredictability and sudden onset. Laing O'Rourke has developed smart safety helmets fitted with IoT technologies. The 'connected' helmet is a smart hard-hat that looks rather conventional but is fitted with a number of sensors for data collection purposes. These sensors can monitor both the temperature and heartrate of the wearer, as well as the external temperature and humidity. The data these devices collect is uploaded to the cloud for analysis. The data is scanned for the patterns that show an employee is close to heatstroke. If the wearer is at risk, the hard-hat will emit a warning sound and vibration – something along the lines of "Cool it! Head to safety!". The safety system can also report directly to site managers, warning them of teams at risk and in need of a break from the heat.

Source
https://internetofbusiness.com/australian-construction-firm-uses-iot-for-smart-helmets-which-keep-workers-safe/
https://www.iothub.com.au/news/laing-orourke-brings-iot-to-hard-hats-412008

Case 6 – Linde / Smart forklifts

Linde Material Handling is one of the world's largest manufacturers of forklift trucks and warehouse equipment. Linde's automated forklifts feature a navigation laser, front and rear scanners, a 3D camera and visual and acoustic warning indicators that enable it to safely move around a warehouse in the vicinity of human workers. The company claims it can detect obstacles in real-time and adjust the course when needed. Many of Linde's machines are being used to transport pallets and trailers in warehouses at distances up to several hundred meters. These automated trucks operate in fleets from just a few to 30 and are usually used together with manually-operated trucks for certain duties. Linde autonomous logistics trucks are controlled via a geo-navigation system. The forklifts sense their surroundings down to the finest details, allowing them to work safely together with people as cooperative robots, or "cobots." The standard version of the system consists of four optical laser sensors that scan the surroundings in all directions up to a distance of 30 meters. What is going on around the truck is also monitored by a 3D camera that is mounted on the highest point of the chassis.
The data streams of both detection systems are processed, allowing each truck to be coordinated with any other autonomous trucks and move safely in even the most restricted of spaces. External equipment, such as guide rails laid in the floor or light reflectors, are not necessary for orientation and control. In new surroundings, such as a different warehouse than usual, the forklifts completely remap their operating area. They can also communicate via data interfaces with warehouse doors or roller tracks, and with business applications, such as warehouse management or ERP systems.

Source
https://www.linde-mh.com/en/Products/Automated-Trucks/
https://www.supplychaindive.com/news/4-types-of-autonomous-mobile-robots-and-their-warehouse-use-cases/529548/
https://www.linde-mh.com/en/Products/Automated-Trucks/K-Matic/

Case 7 – Manitowoc / Smart cranes

Manitowoc is an American manufacturer of cranes. CraneSTAR is a remote asset management system that uses a secure, Web-based application to display the operating data CraneSTAR collects. CraneSTAR is the term given to the Manitowoc telematic device as well as to the complete system. Manitowoc Cranes are equipped with a Manitowoc-engineered Telematics Control Unit that monitors major crane functions and provides operational data. Once gathered, the information is transmitted to a secure database linked to a web server, allowing the crane owner to access the information online, from any web-connected computer or handheld device. In addition to the usual tracking and geo-fencing applications owners can monitor fuel consumption, service intervals, load chart utilization. For example, contractors can monitor the percentage of the load chart or boom length used for specific repetitive applications, possibly leading to replacement with a smaller or more appropriate crane. The crane owner can agree to provide limited access to Manitowoc, so that staff at its CraneCare call centers can help the owner's service engineers with troubleshooting. The system has no impact on crane operations and requires no intervention by the crane operator.
And what about being able to disable a crane or restrict its operation? Manitowoc reports that the subject had been discussed at length and the decision made not to include such a feature, referring to the fact that in the highly unlikely event that a hacker ever managed to penetrate the data center, the risk of a shutdown of Manitowoc cranes all over the world was just too high.

Source
https://www.manitowoccranes.com/en/Tools/CraneSTAR/about-CraneSTAR/features
https://vertikal.net/en/cranes-and-access

Case 8 – Rethink Robotics

Rethink Robotics (now integrated into the HAHN Group's robotic division) is a robotics specialist. Baxter and Sawyer are the industrial robots built by Rethink Robotics. Baxter has two arms and can help with packaging and material handling tasks. The single-arm Sawyer is designed for tasks that require more precision, including machine tending and circuit board testing. Sawyer and Baxter are considered adaptive robots. This means that they can adapt to their environment. Baxter and Sawyer are easy to program (or rather… to teach). To recognize something, you just hold the object in front of one of their cameras (in the head, the chest, at the end of each arm). To make it do something, you just have to mimic the task, guiding his arm. Baxter and Sawyer are used by General Electric Lighting, Steelcase, and DHL. They are equipped with sensors that allow them to sense people nearby and a potential collision. They come with a 360-degree sonar sensor and a force-sensing system. The combination freezes the robot motion the moment it comes into contact with a human body.

Source
http://www.rethinkrobotics.com/baxter/;
https://en.wikipedia.org/wiki/Baxter_(robot)#cite_note-2;
http://www.bcone.com/smart-machine-enabled-services-future-technology/
https://www.technologyreview.com/s/429248/this-robot-could-transform-manufacturing
https://singularityhub.com/2015/09/24/learning-to-speak-robot-the-mainstreaming-of-robotics/#sm.000080511jy2kfbupco142a7sandm
https://i.ytimg.com/vi/AgCerYgmq_w/maxresdefault.jpg

Case 9 – Schneider – Smart meeting rooms

Schneider Electric is a French multinational company in the field of energy management, automation solutions, and services. It offers its customer companies WPE (Work Place Efficiency) solutions. These solutions aim to reduce the energy consumption of buildings while assuring workplace comfort to their residents. A sensor in a meeting room can determine occupancy and tell the building management system to turn off lights and heat/cool accordingly to save energy. That impact can be further magnified by connecting it with weather information to shape and inform environmental controls for tomorrow's workday. New and existing office buildings can thus be equipped with smart, integrated room controllers. These devices provide monitoring and control of individual

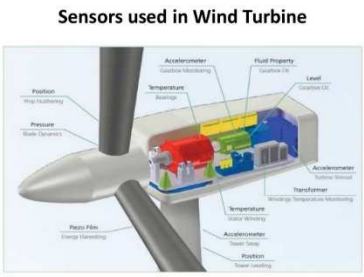
rooms and improve overall building management. These room controllers are occupancy sensors that use infrared, ultrasonic, or microwave technology to detect motion in a room, and then adjust the heating or air conditioning accordingly. Controllers can also be door/window sensors (that can detect when doors and windows are open), lighting control, CO2 ventilation control, etc. The most basic energy management approach is to deploy room controls as a standalone system, using presence detection sensors and door/window contact sensors. It is estimated that simply turning off lights when not needed—something that can be controlled automatically with occupancy sensors—can reduce lighting expenses by as much as 40 percent. The systems can also be integrated with a building management system (BMS), a software platform designed to provide integrated monitoring, control, and management of energy, lighting, fire safety, and HVAC. A BMS provides facility managers with centralized control and promotes a facility-wide approach to managing energy and occupant comfort.

Source
https://download.schneiderelectric.com/files?p_enDocType=White+Paper&p_File_Name=998-2095-05-14-15AR0_EN.pdf&p_Doc_Ref=998-2095-05-14-15AR0_EN
https://www.schneider-electric.co.in/en/work/insights/every-thing-connected-iot-the-internet-of-transformation.jsp
https://www.slideshare.net/seindia/schneider-electric-smart-energy-presentation-smart-gird-domains

Case 10 – Siemens – Smart wind farms

Siemens Wind Power is a wind turbine manufacturer. It is a separate division of Siemens. Each turbine is equipped with up to 1,000 sensors and actuators. There are many different types of electrical and optical sensors used in wind turbines. In general, they: 1/ Detect, monitor, and communicate information about parameters such as changes in the distance between two components near each other; 2/ Monitor levels of vibration that, if excessive, can cause major damage. 3/ Monitor changes in temperature, pressure, and mechanical stresses. One major challenge when managing wind farms is to be able to provide consistent power generation while wind conditions are fast varying. In its wind farms, Siemens manages hundreds of wind power generators. Sensors and actuators that equip wind turbines allow capturing information about the wind and control blade speed and power generation by altering the blade pitch and power extraction. The challenge is to integrate these turbines so that they work together which means balancing the loading and generation across the wide geography of the wind farm to generate constant power while avoiding damage to a half-billion-dollar installed asset! The IoT solution used allows generator-to-generator communication that ensures rapid response to wind gusts and optimal turbine settings for changing wind conditions.
Siemens is also "teaching" wind turbines on how to automatically optimize their operation in line with weather conditions. The turbines are learning to use sensor data on parameters such as wind speed to make changes to their settings. These changes ensure the turbines can optimally exploit the prevailing conditions. The solution combines reinforcement learning techniques with special neural networks. The software programs learn from historical data, which also enables them to forecast the future behaviour of a system. A model can thus be created that predicts the electrical output of a wind turbine under specific weather conditions.
The system thus learns to change certain wind turbine settings in a manner that ensures the maximum possible amount of electricity is generated in a given situation. After just a few weeks, the system can define and store the optimal settings for common weather occurrences. After an additional extended period of training, it can

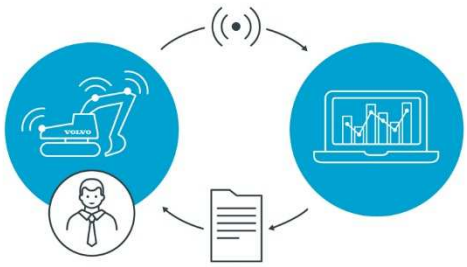
even regulate electrical output under rare and exceptional weather conditions. The technology was successfully tested at a Spanish wind farm in recent years.



Source
https://phys.org/news/2014-03-automatic-self-optimization-turbines.html;
https://www.iotone.com/casestudy/siemens-wind-power/c430
https://www.iiconsortium.org/case-studies/RTI_Siemens_Wind_Power_case_study.pdf
https://www.mouser.fr/applications/tiny-Sensors-Role-in-Wind-Turbines/
https://www.slideshare.net/Aquibhamid17/storyboard-for-wind-x

Case 11 – Volvo Construction Equipment / Smart industrial vehicles

Volvo Construction Equipment (Volvo CE) is a leading international manufacturer of premium construction equipment. It proposes a wide range of products and services for the construction, mining, agriculture or any other industry. Products are haulers, excavators, compactors, etc. Volvo CE is connecting all of its construction equipment thanks to an average of 400 sensors per machine, plus GPS ports and communication gateways. All data are sent on an off-board solution that its team can build IoT services and solutions on top of. The services Volvo CE is looking at are focused on avoiding unplanned downtime for machines, otherwise known as predictive maintenance. Through IoT, the company will monitor its equipment on a real-time basis and send out an engineer to repair a machine before the failure happens. Once that has been achieved, the company aims to move to a more prescriptive maintenance model whereby a machine will predict failure and send out an engineer automatically, without human interaction.

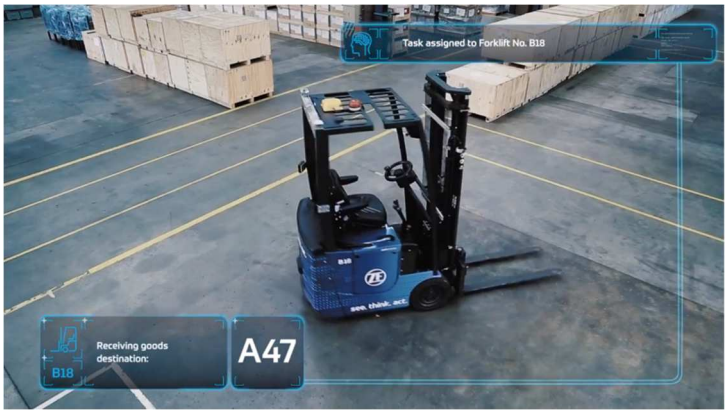


Source
https://internetofbusiness.com/video-volvo-benefiting-iot/
https://www.scimag.news/en/2018/09/19/construction-telematics-the-power-of-the-network/

Case 12 – ZF – Smart forklifts

ZF is a German car parts maker and also a specialist in plant equipment. It has developed the ZF Innovation Forklift. It is a fully networked electric forklift truck with highly automated driving functions equipped with camera and radar systems that enable it to see its surrounding environment. The data that these systems generate are analysed by the ZF ProAI central computer, which is based on an artificial intelligence software that has already been proven in other prototype vehicles modelled on passenger cars and tractors.

Intelligent actuating elements – such as the ZF electric rear-axle steering for forklift trucks – and the electric single-wheel drive carry out the control unit's given commands. This highly automated forklift truck completes work orders by independently going to the storage location, picking up the goods and delivering them to the customer. The vehicle can prioritize orders itself and thus make decisions regarding the optimal sequence and route. An essential factor in this is how the ZF Innovation Forklift is networked. It can operate in a digitalised production network and there communicate both with the materials management system, infrastructure, and other vehicles. The cloud-based, dynamic fleet management allows the data from the individual forklift trucks to be efficiently managed and analysed. The system takes into account, for example, the current battery charge status during all driving operations and schedules the recharge time at which the forklift truck should independently head toward the charging station.



Source
https://drivetribe.com/p/see-think-act-TWUQg4-uS4m3aRjTv2eVOQ?iid=buErFkilT-azEwJ15zcnwQ
https://www.ivtinternational.com/videos/zf-demonstrates-the-capabilities-of-its-smart-forklift.html

References:

Abramovici, M. (2014). Smart products. *CIRP Encyclopedia of Production Engineering*, 1-5.

Abramovici, M., Göbel, J. C., & Dang, H. B. (2016). Semantic data management for the development and continuous reconfiguration of smart products and systems. *CIRP Annals*, *65*(1), 185-188.

Abramovici, M., Göbel, J. C., & Savarino, P. (2017). Reconfiguration of smart products during their use phase based on virtual product twins. *CIRP Annals-Manufacturing Technology*.

Akaka, M.A. and Vargo, S.L. (2014), "Technology as an operant resource in service (eco)systems", Information Systems and E-Business Management, Vol. 12 No. 3,pp. 367–384

Ames, B.C. (1968). Marketing planning for industrial products. *Harvard Business Review*, *46* (5), 100-11.

Ames, B.C. (1970). Trappings vs substance in industrial marketing. *Harvard Business Review*, *48*(4), 93-102.

Anderson, J. C., Narus, J. A., & Van Rossum, W. (2006). Customer value propositions in business markets. *Harvard business review*, *84*, 1-4.

Appadurai, A. (Ed.). (1988). *The social life of things: Commodities in cultural perspective*. Cambridge University Press.

Araujo, L. & Spring, M. (2006). Services, Products, and the Institutional Structure of Production. *Industrial Marketing Management 35*(7), 797–805.

Araujo, L. (2007). Markets, market-making and marketing. *Marketing theory*, *7*(3), 211-226.

Azimont, F., & Araujo, L. (2007). Category reviews as market-shaping events. *Industrial Marketing Management*, *36*(7), 849-860.

Bailey, K. D. (1994). *Typologies and taxonomies: an introduction to classification techniques* (Vol. 102). Sage.

Bateson, J.E.G. (1991). *Managing Services Marketing*. Fort Worth : Dryden.

Beigl, M., Gellersen, H.W., and Schmidt, A. (2001). Mediacups: experience with design and use of computer-augmented everyday artefacts. *Computer Networks*, 35(4), 401-409.

Çalişkan, K., & Callon, M. (2010). Economization, part 2: A research programme for the study of markets. *Economy and Society*, *39*(1), 1–32.

Callon, M., Méadel, C., & Rabeharisoa, V. (2002). The economy of qualities. *Economy and society*, *31*(2), 194-217.

Chakrabarti, R., Henneberg, S., & Ivens, B. (2020). Open Sustainability: Conceptualization and Considerations. *Industrial Marketing Management.* (forthcoming)

Chin, J., Callaghan, V., & Allouch, S. B. (2019). The Internet-of-Things: Reflections on the past, present and future from a user-centered and smart environment perspective. *Journal of Ambient Intelligence and Smart Environments*, *11*(1), 45-69.

Corey, R. (1962). *Industrial Marketing: Cases and Concepts*. Englewood Cliffs, NJ : Prentice-Hall.

Corey, R. (1976). *Industrial Marketing: Cases and Concepts, 2nd ed*. Englewood : Prentice-Hall.

Cusumano, M. A., Kahl, S. J., & Suarez, F. F. (2015). Services, industry evolution, and the competitive strategies of product firms. *Strategic management journal*, *36*(4), 559-575.

Dabbagh, M., & Rayes, A. (2019). Internet of things security and privacy. In *Internet of Things From Hype to Reality* (pp. 211-238). Springer, Cham.

Daley, J. (2017). Insecure Software is Eating The World: Promoting Cybersecurity in an age of Ubiquitous Software-Embedded Systems. *Stanford Technology Law Review*, *19*(3), 533-546.

Eddy, B., & Oussama, H. (2018). Social relationship paradigm applied to object interactions in industrial IoT. *IFAC-PapersOnLine*, *51*(11), 1391-1396.

Ehret, M., & Wirtz, J. (2017). Unlocking value from machines: business models and the industrial internet of things. *Journal of Marketing Management*, *33*(1-2), 111-130.

Finch, J., & Geiger, S. (2011). Constructing and contesting markets through the market object. *Industrial Marketing Management*, *40*(6), 899-906.

Fleischmann, M., & Ivens, B. (2019). Exploring the role of trust in blockchain adoption: an inductive approach. In *Proceedings of the 52nd Hawaii International Conference on System Sciences,* p.6845.

Ford, D., Gadde, L. E., Håkansson, H., & Snehota, I. (2006). *The business marketing course: Managing in complex networks*, 2nd Edition. Chichester: John Wiley & Sons

Forkmann, S., Ramos, C., Henneberg, S. C., & Naudé, P. (2017). Understanding the service infusion process as a business model reconfiguration. *Industrial Marketing Management*, *60*, 151-166.

González García, C., Meana Llorián, D., Pelayo García-Bustelo, B. C., & Cueva Lovelle, J. M. (2017). A review about smart objects, sensors, and actuators. *International Journal of Interactive Multimedia and Artificial Intelligence*.

Gummesson, E. (1995). Relationship Marketing: Its Role in the Service Economy, in *Understanding Services Management*, W.J. Glynn and J.G. Barns, New York : Wiley, 224-268.

Guo, B., Zhang, D., Yu, Z., Liang, Y., Wang, Z., & Zhou, X. (2013). From the internet of things to embedded intelligence. *World Wide Web*, *16*(4), 399-420.

Håkansson, H & A. Waluszewski, A. (2004). Conclusions: Reinterpreting the four Ps. In Hakan Håkansson, *et al.* (Eds.), *Rethinking marketing: Developing a new understanding of markets* (pp. 249-262). John Wiley & Sons: Chichester.

Iansiti, M., & Levien, R. (2004). *The keystone advantage: what the new dynamics of business ecosystems mean for strategy, innovation, and sustainability*. Harvard Business Press.

Kees, A., Oberländer, A. M., Röglinger, M., & Rosemann, M. (2015, May). Understanding the Internet of Things: A Conceptualisation of Business-to-Thing (B2T) Interactions. In *ECIS*.

Kjellberg, H., & Helgesson, C. F. (2006). Multiple versions of markets: Multiplicity and performativity in market practice. *Industrial Marketing Management*, *35*(7), 839-855.

Kjellberg, H., & Helgesson, C. F. (2007a). On the nature of markets and their practices. *Marketing theory*, *7*(2), 137-162.

Kjellberg, H., & Helgesson, C. F. (2007b). The mode of exchange and shaping of markets: Distributor influence in the Swedish post-war food industry. *Industrial Marketing Management*, *36*(7), 861-878.

Kjellberg, H., Nenonen, S., & Thomé, K. M. (2018). Analyzing service processes at the micro level: actors and practices. *The SAGE Handbook of Service-Dominant Logic*, 411.

Kopalle, P. K., Kumar, V., & Subramaniam, M. (2019). How legacy firms can embrace the digital ecosystem via digital customer orientation. *Journal of the Academy of Marketing Science*, 1-18.

Kortuem, G., Kawsar, F., Sundramoorthy, V., & Fitton, D. (2010). Smart objects as building blocks for the internet of things. *IEEE Internet Computing*, *14*(1), 44-51.

Kotler, P. (1967). Marketing management: analysis, planning and control. Englewood Cliffs. NJ: Prentice-Hall.

Kotler, P. (2017). Customer value management. *Journal of Creating Value*, *3*(2), 170-172.

Kowalkowski, C., Gebauer, H., Kamp, B., & Parry, G. (2017). Servitization and deservitization: Overview, concepts, and definitions. *Industrial Marketing Management*, *60*, 4-10.

Kujala, S., Artto, K., Aaltonen, P., & Turkulainen, V. (2010). Business models in project-based firms–Towards a typology of solution-specific business models. *International Journal of Project Management*, *28*(2), 96-106.

Lee, E. A. (2008). Cyber physical systems: Design challenges. In *2008 11th IEEE International Symposium on Object and Component-Oriented Real-Time Distributed Computing (ISORC)* (pp. 363-369). IEEE.

Leischnig, A., Woelfl, S., & S Ivens, B. (2016). When Does Digital Business Strategy Matter to Market Performance?. In *International Conference On Information (ICIS)*. Association For Information System.

Lemon, K. N., & Verhoef, P. C. (2016). Understanding customer experience throughout the customer journey. *Journal of Marketing*, *80*(6), 69-96.

Lincoln, Y.S. and Guba, EG (1985). *Naturalistic inquiry.* Sage: Newbury Park, CA.

López, T. S., Ranasinghe, D. C., Patkai, B., & McFarlane, D. (2011). Taxonomy, technology and applications of smart objects. *Information Systems Frontiers*, *13*(2), 281-300.

Lusch, R. F., & Nambisan, S. (2015). Service innovation: A service-dominant logic perspective. *MIS quarterly*, *39*(1).

Lusch, R.F. and Nambisan, S. (2015), "Service Innovation: A Service-Dominant-Logic perspective", MIS Quarterly, Vol. 39 No. 1, pp. 155–175.

Mattsson, L. G., & Johanson, J. (2006). Discovering market networks. *European Journal of Marketing*, *40*(3/4), 259-274.

Mitew, T. (2014). Do objects dream of an internet of things. *The Fibreculture Journal*. *23*, 3-26.

Mol, JM., Wijnberg, NM., & Carroll, C. (2005). Value Chain Envy: Explaining New Entry and Vertical Integration in Popular Music. *Journal of Management Studies* 42(March): 251-276.

Monostori, L., Kádár, B., Bauernhansl, T., Kondoh, S., Kumara, S., Reinhart, G., ... & Ueda, K. (2016). Cyber-physical systems in manufacturing. *CIRP Annals*, *65*(2), 621-641.

Nambisan, S. (2013). Information technology and product/service innovation: A brief assessment and some suggestions for future research. *Journal of the Association for Information Systems*, *14*(4), 1.

Niu, Y., Lu, W., Chen, K., Huang, G. G., & Anumba, C. (2015). Smart construction objects. *Journal of Computing in Civil Engineering*, *30*(4), 04015070.

Palmer, A. (2017). The dematerialization of marketing in a global economy. In T.C. Melewar and Suraksha Gupta (Eds.), *Strategic International Marketing: An Advanced Perspective*. New York: Palgrave Millman.

Perks, H., Kowalkowski, C., Witell, L., & Gustafsson, A. (2017). Network orchestration for value platform development. *Industrial Marketing Management,* 67, 106-121.

Porter, M. E., & Heppelmann, J. E. (2014). How smart, connected products are transforming competition. *Harvard Business Review*, *92*(11), 64-88.

Porter, M. E., & Heppelmann, J. E. (2015). How smart, connected products are transforming companies. *Harvard Business Review*, *93*(10), 96-114.

Püschel, L., Röglinger, M., & Schlott, H. (2016). What's in a Smart Thing? Development of a Multi-layer Taxonomy. Communication presented at the 37th International Conference on Information Systems (ICIS), Dublin, Ireland.

Rakotonirainy, A., Orfila, O., & Gruyer, D. (2016). Reducing driver's behavioural uncertainties using an interdisciplinary approach: Convergence of Quantified Self, Automated Vehicles, Internet Of Things and Artificial Intelligence. *IFAC-PapersOnLine*, *49*(32), 78-82.

Riddle, D.I. (1986), *Service-Led Growth*, New York: Praeger.

Rinallo, D., & Golfetto, F. (2006). Representing markets: The shaping of fashion trends by French and Italian fabric companies. *Industrial marketing management*, *35*(7), 856-869.

Sadeghi, A. R., Wachsmann, C., & Waidner, M. (2015). Security and privacy challenges in industrial internet of things. In *Design Automation Conference (DAC), 2015 52nd ACM/EDAC/IEEE* (pp. 1-6). IEEE.

Sjögren, E., & Helgesson, C. F. (2007). The Q (u) ALYfying hand: health economics and medicine in the shaping of Swedish markets for subsidized pharmaceuticals. *The Sociological Review*, *55*(2_suppl), 215-240.

Sklyar, A., Kowalkowski, C., Sörhammar, D., & Tronvoll, B. (2019). Resource integration through digitalisation: a service ecosystem perspective. *Journal of Marketing Management*, 1-18.

Slater, D. (2002). Markets, materiality and the 'New Economy'. In J. Stanley Metcalfe & Alan Warde (Eds.), *Market relations and the competitive process* (pp. 95–113). Manchester: Manchester University Press.

Spring, M., & Araujo, L. (2017). Product biographies in servitization and the circular economy. *Industrial Marketing Management*, *60*, 126-137.

Sterling, B. (2005). *Shaping Things*. Cambridge, Massachusetts: The MIT Press.

Vargo, S. L., & Lusch, R. F. (2004a). Evolving to a new dominant logic for marketing. *Journal of marketing*, *68*(1), 1-17.

Vargo, S. L., & Lusch, R. F. (2004b). The Four Service Marketing Myths: Remnants of a Goods-Based, Manufacturing Model. *Journal of Service Research*, *6*(4), 324-335.

Vendrell-Herrero, F., Bustinza, O. F., Parry, G., & Georgantzis, N. (2017). Servitization, digitization and supply chain interdependency. *Industrial Marketing Management*, *60*, 69-81.

Wathne K.H., Biong, H., Heide J.B. (2001). Choice of Supplier in Embedded Markets: Relationship and Marketing Program Effects. *Journal of Marketing*, *65*(2), 54-66.

Weber, M. (1949). *The methodology of the social sciences*. New York: Free Press.

Webster Jr, F. E. (1988). The rediscovery of the marketing concept. *Business horizons*, *31*(3), 29-39.

Woodside, A. G., & Sood, S. (2017). Vignettes in the two-step arrival of the internet of things and its reshaping of marketing management's service-dominant logic. *Journal of Marketing Management*, *33*(1-2), 98-110.

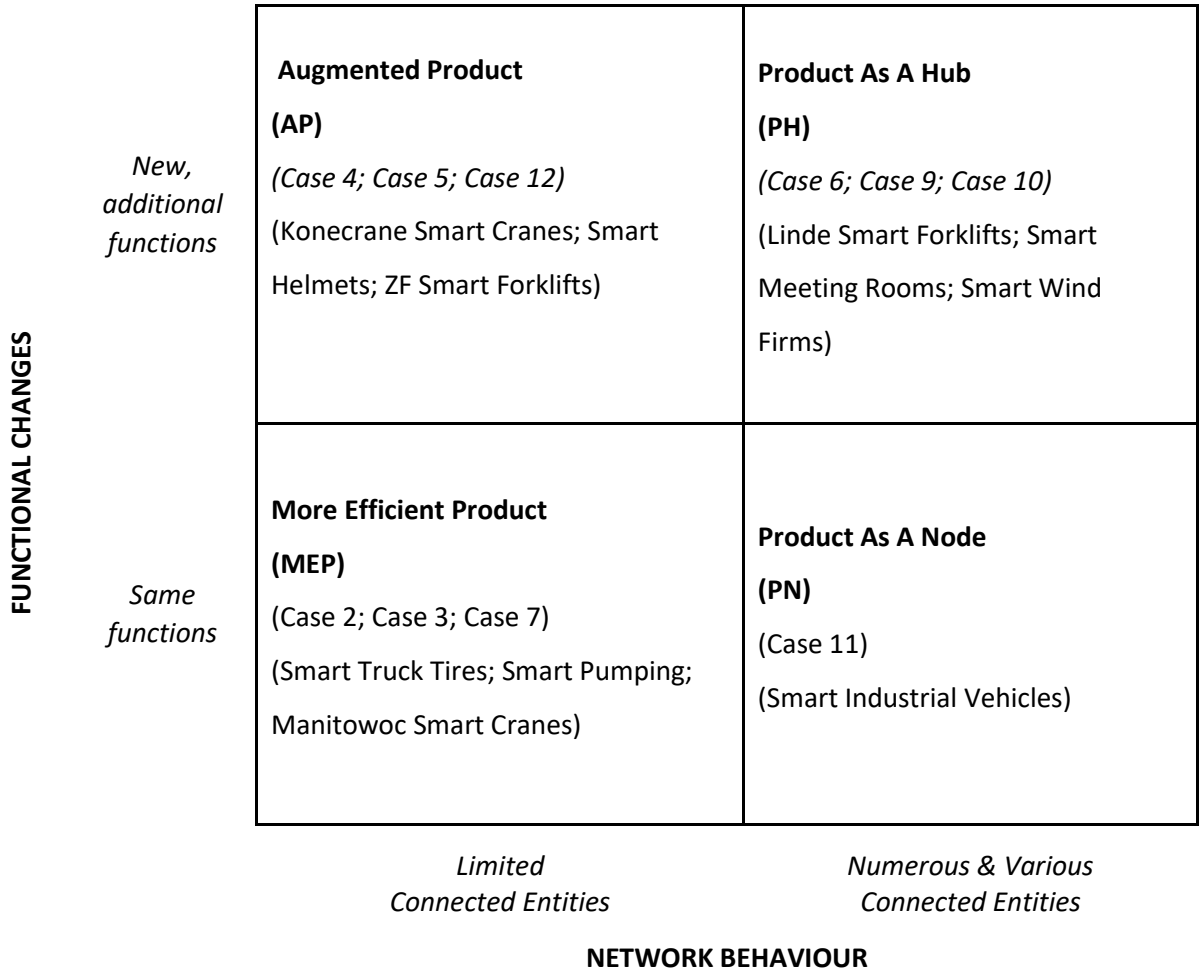
Yoo, Y. (2010). Computing in everyday life: A call for research on experiential computing. *MIS quarterly*, 213-231.

Yoo, Y., Boland Jr, R. J., Lyytinen, K., & Majchrzak, A. (2012). Organizing for innovation in the digitized world. *Organization Science*, *23*(5), 1398-1408.

Yoo, Y., Henfridsson, O., & Lyytinen, K. (2010). Research commentary—the new organizing logic of digital innovation: an agenda for information systems research. *Information systems research*, *21*(4), 724-735.

Zolkiewski, J., Story, V., Burton, J., Chan, P., Gomes, A., Hunter-Jones, P. ... & Robinson, W. (2017). Strategic B2B customer experience management: the importance of outcomes-based measures. *Journal of Services Marketing*, *31*(2), 172-184.

Figure 1 – A Typology of Smart Products



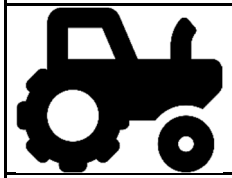
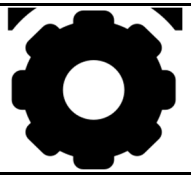
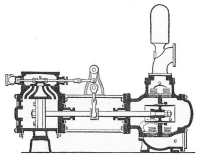
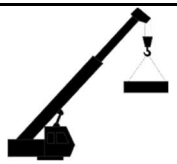
Case 1 AfarCloud	Case 2 Continental	Case 3 Flowserve	Case 4 Konecrane	Case 5 Laing O'Rourke	Case 6 Linde
Smart farming	Smart truck tyres	Smart pumping	Smart cranes	Smart Helmets	Smart forklifts
					
Automated farming vehicles, working in combination with a distributed sensor network.	A sensor is mounted on the inner liner of the tyre to measure tyre pressure and temperature.	Sensors are installed on valves, motors, pumps, seals, etc., and they continuously collect and/or transmit data.	Technology makes it possible to monitor crane use, determine the need to replace worn parts, and diagnose possible breakdown situations.	Helmets are fitted with a number of sensors for data collection purposes.	Forklifts are equipped with a navigation laser, scanners, a 3D camera and visual and acoustic warning indicators.
Case 7 **Manitowoc**	**Case 8** **Rethink Robotics**	**Case 9** **Schneider**	**Case 10** **Siemens**	**Case 11** **Volvo Construction Equipment**	**Case 12** **ZF**
Smart cranes	Industrial cobots	Smart meeting rooms	Smart wind farms	Smart industrial vehicles	Smart forklifts
					
Cranes are equipped with an engineered Telematics Control Unit that monitors major crane functions and provides operational data.	Robots help with packaging, material handling, and testing tasks. Equipped with sensors, they can adapt to their environment.	Diverse devices provide monitoring and control of rooms.	Sensors and actuators that equip wind turbines allow information about the wind to be captured and blade speed to be controlled.	Sensors, GPS portals and communication gateways connect different construction equipment and send data on off-board solutions.	Automated forklift trucks complete work orders by independently going to the storage location, picking up the goods and delivering them to the customer.

Table 2 – Cases classification

		PHYSICALITY OF THE SMART PRODUCT		ECOSYSTEMIC NATURE OF THE SMART PRODUCT			TYPOLOGY DIMENSIONS	
		Degree of smartness	**Visibility of smartness**	**Degree of autonomy**	**Systemness**		Dimension 1 (Vertical axis) Product attributes	Dimension 2 (Horizontal axis) Ecosystem attributes
Case 1	**AfarCloud** Smart farming	High (Data exchanged can link different systems and allow for autonomous behaviours of vehicles)	Moderately visible (Humidity sensors, for instance, are visible)	Potentially high (Potentially, vehicles could be activated autonomously on a given date).	High (Smartness can connect different systems)		Same functions for the soils and vehicles	The tractor receives information from different entities. Soils send limited information
Case 2	**Continental** Smart truck tyres	Low (Sensors 'only' make it easier to measure pressure and temperature)	Invisible (The pressure sensor is fixed in the inner liner of the tyre)	Limited (No autonomous decisions)	Limited (Only the customer ecosystem is involved: fleet operators & fleet managers)		Same functions as the tyre	Limited connected entities
Case 3	**Flowserve** Smart pumping	Low (Sensors 'only' communicate information on vibration, temperature, flow rate, and presence of fluids)	Visible (The vibration sensors are visible)	Limited (No autonomous decisions)	Limited (Only the customer ecosystem is involved: The supplier ecosystem could be involved on customer request)		Same functions as the pump	Limited connected entities
Case 4	**Konecrane** Smart cranes	Medium (Sensors allow them to predict how a load will swing and automatically adjust the motor speed)	Moderately visible (The infrared sensors are visible)	Medium (Automatic adjustment of speed)	Limited (Only the customer ecosystem is involved: operators)		New functions for the crane (For instance: automatic stop or speed adjustment)	Limited connected entities
Case 5	**Laing O'Rourke** Smart Helmets	Medium (Sensors allow them to capture new types of information like the user's heart rate)	Visible (The temperature sensors are visible)	Limited (No autonomous decisions)	Limited (Only the customer ecosystem is involved: wearer and site manager)		New functions for the helmet (For instance: warning function)	Limited connected entities
Case 6	**Linde** Smart forklifts	High (Sensors allow for intelligent moving of forklifts and autonomous decisions)	Moderately visible (The 3D camera and optical laser sensors are visible)	High (Autonomy for remapping the operating area and changing movements)	Medium / High (Only the customer ecosystem is involved, but this includes the equipment (roller tracks, the infrastructure, e.g. doors, the warehouse management system, the ERP, etc.)		Important new functions (Forklifts can autonomously remap their operating area and change their moves accordingly)	The forklift receives information from other different products (conveyors, doors, etc.)

Case 7	**Manitowoc** Smart cranes	Medium (Sensors allow each crane to be geo-located)	Moderately visible (The weight sensors are visible)	Limited (No autonomous decisions)	Medium (Only the customer ecosystem is involved. The supplier ecosystem could be involved if the crane owner agrees)		Same functions (The crane is 'just' giving information about location, fuel consumption, etc.)	Limited connected entities
Case 8	**Rethink Robotics** Industrial cobots	High (Sensors allow for collaboration between humans and cobots, by adapting cobots' behaviour to human behaviour)	Visible (The cobots' design embodies smartness)	High (Autonomy in interfacing with humans)	No information collected		Important new functions (The cobots 'react' to a human presence)	Limited connected entities
Case 9	**Schneider** Smart meeting rooms	Low (Sensors 'only' automate simple actions that were previously carried out by humans)	Moderately visible (The room controllers are visible)	Limited (Sensors first send information to the building management system that takes the decision to turn off heating/cooling system lights)	Limited / Medium (The customer ecosystem is involved and/or a facility manager's ecosystem)		New functions (For instance: automatic lighting)	The room receives information from different products and communicates information to several 'users' (the actuators that open / close windows or switch on /off lights…)
Case 10	**Siemens** Smart wind farms	Medium (Sensors allow consolidation of information coming from different entities in real time; Wind turbines are 'taught' to optimize their operations, etc.)	Moderately visible (The wind captors are visible)	High (Blade speed can be autonomously altered according to data collected)	High (Both the supplier, Siemens, ecosystem and the wind farm owner ecosystem are involved)		New functions (For instance: adaptation to wind direction and strength)	Each turbine sends information to all the others and receives information from many other turbines
Case 11	**Volvo Construction Equipment** Smart industrial vehicles	Medium (Sensors allow for predictive maintenance)	Invisible (Sensors are mainly on internal parts)	Limited (No autonomous decision)	High (Both the supplier, Volvo Construction Equipment, ecosystem and the customer (industrial) ecosystem are involved		Same function (The equipped trucks 'behave' as traditional ones)	Many vehicles communicate with one another
Case 12	**ZF** Smart forklifts	High (Sensors allow for intelligent movement of forklifts and autonomous decisions)	Moderately visible (The cameras and radar systems are visible)	High (Autonomy in prioritizing orders)	Medium / High (Only the customer ecosystem is involved, but this includes the material management system, infrastructure system and the vehicle system)		New functions (For instance: forklifts can autonomously prioritise orders)	Forklifts communicate with various entities (other vehicles, doors, etc.)