# **The Smart Factory:**

# **Exploring an Open Innovation Solution for Manufacturing Ecosystems**

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#### **INTRODUCTION**

Companies, cities, regions and ecosystems are facing increasing challenges due to issues as globalization, competitive pressures, and increased digitalization. At the same time, these issues give rise to an open innovation model that relies on the increased connectivity between various stakeholders to collectively develop better product, services, processes and business models. Such more open models have to support the development of different types of platforms, devices and features that allow for better connectivity, but also create challenges in terms of developing, implementing and understanding such approaches. However, while the emerging literature in open innovation has considered some of these aspects, the notion of openness for process technologies, especially in the context of business ecosystems, is not yet fully understood. With the increasing interest in "smart cities" in the background, we therefore explore how such (combinations of) ecosystems could support a collaborative manufacturing solution—what we may call a "smart factory".

#### **OPEN INNOVATION, ECOSYSTEMS AND SMART CITIES**

Due to shortening lifecycles of the products as well as digitalisation of services it is becoming very difficult to satisfy customer needs. Companies are looking for new ways of how to create the value to the market and still be able to keep up with increasing competition. Innovative products, services or processes, could be the way to go. The shift from closed inhouse R&D to an open model, based on incorporation of external sources of information, is more and more visible in companies as well as discussed by academics. Open innovation is defined as *"a distributed innovation process based on purposively managed knowledge flows across organizational boundaries"* (Chesbrough and Bogers 2014) to support companies and public institutions in their innovation effort. The literature provide wide range of examples of positive influence of open innovation adoption in large multinational companies like IBM,

Lucent or Intel (Chesbrough 2003), DSM (Kirschbaum 2005), P&G (Huston and Sakkab 2006; Dodgson et al. 2006) ItalCementi (Chiaroni et al. 2011) as well as SMEs (van de Vrande et al. 2009; Lee et al. 2010; Bianchi et al. 2010).

The increasing interest in innovation is also strongly connected with research related to various types on external sources of knowledge (Laursen and Salter 2006; West and Bogers 2014) as well as the best way to leverage those into sources of innovation. In this respect also inter-organisational collaboration can be an important driver for innovation performance (Powell et al. 1996). For that reason, firms embedded in various types of networks or clusters can benefit from knowledge present in their external environment to achieve better innovative output (Shan et al. 1994). There are various examples of innovative projects involving many commercial and public partners, however the situation starts to be more complicated if we take into consideration smaller market players. Research shows that open innovation activities are performed differently in SMEs, namely more intensively, than in large companies (Spithoven et al. 2013). What is more, SMEs are also more dependent on open innovation due to significant impact on their revenues. What is interesting, lack of resources, as well as financial issues could be a much bigger stimulus for SMEs to collaborate than to larger market players.

Taking into consideration smart cities as a context of this research, we should take a more holistic perspective, where we do not focus on the company level of large of small companies, but look at the entire business ecosystem (Adner and Kapoor 2010, Rohrbeck et al, 2009; van der Borgh et al. 2012), which relates to the constellation of innovative actors, which forms a structured community (Moore 1993). The literature describes business ecosystems as a community (Iansiti and Levien 2004; Moore 1996), which consists of variety of types of stakeholders, such as suppliers, customers, competitors, universities and other complementors, but at the same time is much bigger and richer than a firm's immediate

customer-supplier network. All those involved actors play a different role in the value creation process (van der Borgh et al. 2012; Iansiti and Levien 2004; Eisenhardt and Galunic 2000; Moore 1996; Adner and Kapoor 2010; West and Bogers 2014; Afuah 2000). A prerequisite of a "membership" in this ecosystem is then a certain level of inter-dependency between participants. In the context of open innovation, knowledge becomes an important medium of interaction between the members of the business ecosystem.

Smart cities in our view consist of many different business ecosystems, in which the interaction with one another depends on the area of interest. This communication or collaboration could be stimulated by local authorities, which are also a very important element of the smart cities. Smart cities in the public view are usually associated with strive to sustainable infrastructure for a better life. This should be provided by advanced solutions for smart homes, more innovative industry, and better infrastructure, resource management, as well as security. The following section will provide our consideration of contemporary technological advancement as well as its future outlook. We will focus on manufacturing, which is the main source of GDP generation as well as the biggest base for future service development (Wadhwa 2012).

# COLLABORATIVE MANUFACTURING PLATFORMS: TOWARDS A "SMART FACTORY"

While the open innovation and business ecosystem literature has offered important insights into the importance of collaborative solutions to innovation—mostly R&D—there is a general focus on new product, and also more recently services (Chesbrough 2003, 2011). However, it has been shown that openness can also be important for the process innovation with an important role for the manufacturing function in a company (Bogers and Lhuillery 2011; Reichstein and Salter 2006). Therefore, a more complete open innovation framework—

also within innovation ecosystem—needs to take the more downstream innovation activities, such as manufacturing, into account (Chesbrough and Bogers, 2014). As such, collaborative efforts in manufacturing play an important part of any collaborative manufacturing platform.

Recently, increasing attention is being put to intelligent factories of the future also called "smart factories". Some conceptualisations (Yoon et al. 2012) propose to shift away from conventional manufacturing paradigms in order to apply ubiquitous computing (Weiser 1991) perceived as a new enabling technology for solving contemporary shop floor problems. In this case, the setup is perceived as "a factory system in which autonomous and sustainable *production takes place by gathering, exchanging and using information transparently anywhere anytime with networked interaction between man, machine, materials and systems, based on ubiquitous technology and manufacturing technology"* (Yoon et al. 2012).

Another stream of literature strongly indicates the role of the conventional manufacturing paradigms (Zuehlke 2010), which, with help of upcoming smart technologies, should lift manufacturing systems into more advanced level. Those smart factory concept are strongly embedded in wireless communication infrastructure and are very much aligned with Internet-of-things (IoT), perceived as an open network of items equipped with ubiquitous intelligence giving them an ability to act independently, without direct human intervention (Gubbi et al. 2013). Prerequisites for this smart factory are: a degree of intelligence embedded in all, even very small, coupled devices, while some of the important functionalities should be provided by RFID technology. A smart factory should not only have a modular structure, but also be interconnected by wireless network, where each device could have its own IP (Internet Protocol) address (Zuehlke 2010). In this literature stream scholars try to interconnect a physical (i.e. position of a tool) and a digital world (i.e. electronic documents) (Lucke et al. 2008). They define a smart factory as "*a factory that context-aware assists people and machines in execution of their tasks [...] by systems working in* 

*background, so-called Calm-systems and context-aware applications*" (Lucke et al. 2008). *Context-awareness* refers to knowledge of position and status of objects of interest, where so-called *Calm-systems* are its hardware and *context-aware applications* are the software (Lucke et al. 2008).

In all above mentioned cases existing technology is not well developed yet, which is why it may still take 5-10 years to be able to create a fully operating system. Additionally, some important challenges of those systems are: lack of a dominant standardized protocol and compatibility to make devices easily work together, and regulations allowing process control. Moreover, before all those devices will constitute to create a smart factory, their safety and reliability needs to be thoroughly tested.

## WHAT IS "SMART" ABOUT A SMART FACTORY?

In today's world, we are surrounded by many things labeled "smart". Local governments are working hard on developing smart cities, which offer connection to a smart grid infrastructure. The latter consist of smart homes, which could be controlled by smartphones and in order to create those smart (eco)systems we use *smart* devices. The label "smart" (or "intelligent" as also used) is however used differently in different contexts, partly because its meaning with regard to the objects is yet not clearly defined. Smart, in some contexts, refers also to an independent device, which usually consists of: a sensor, and/or an actuator, a microcomputer and a transceiver. However, adjective smart is commonly used to characterize an object that was enhanced by implementation of additional features, from the engineering point of view it should introduce multiplatform communication and increase its computational abilities. The intelligence of such device can be revealed by cooperation in a network of other smart devices, which have the ability to check the system state updates and decide whether to act on them or not. What is not surprising, such a network is called a *smart* 

network. One can also find smart objects, presented as items having the ability to store, link related data as well as may offer access to it for a human or machine consumer. There are also smart products, which are defined as those with memory understood as a sort of product diary.

In the context of manufacturing ecosystems, a smart factory could relate to a way to enhance the collective and individual capabilities of manufacturing companies to foster growth and competitiveness by providing integration and alliance between partners and systems when they collaborate in an open innovation ecosystem where competences and technologies are mutually shared. The organization and management of a smart factory should be based of in-depth technological understanding as well as clear rules and procedures regarding knowledge sharing and potential disclosure in this open innovation environment (Bogers et al. 2012). This could be either related to open networks of wireless connected devices operating without direct human interaction, or to an organization where interconnection between different actors chosen to collaborate is more physical. The creation of such an innovation community should generate more opportunities for knowledge sharing where the innovation process is facilitated for each member (Iansiti and Levien 2004; Moore 1996). A prerequisite for such collaboration is an alignment of business models between the participating companies (Chesbrough and Bogers, 2014; West and Bogers, 2014).

## CONCLUSION

In this chapter, we built on the increasing interest in "smart cities" in the background to explore how innovation ecosystems could support a collaborative manufacturing solution, which is an important area in terms of academic research and industrial practice. Building on the notion of ecosystem, we have explored some possible characteristics of a collaborative manufacturing platform, which we may call a "smart factory". We have discussed some

7

aspects of what would make such a platform "smart", which may also give opportunities to relate it back to the notion of smart cities. Future research should therefore further elaborate on the smart factory concept and collaborative approaches to manufacturing more general. It will be of particular importance to better understand how such an open manufacturing approach will allow companies to link to their larger ecosystem, and how such a platform will fit to the "smart city" in which this development takes place. Future research should then also explore other, more or less related conceptualizations of collaborative manufacturing platforms and business ecosystem, and better develop these as parts of the smart cities notion. Smart factories could then become an integral part of this approach. Finally, in order to further develop and understand such notions, empirical research should further develop and validate some of the exploratory themes as they are addressed in this chapter, either through action-based development of smart factories/cities or through retrospective cases and large-scale studies.

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