**A Big Data Framework for Facilitating Product Innovation Processes**

**Abstract**

**Purpose:** This paper suggests how firms could use big data to facilitate product innovation processes, by shortening the time to market, improving customers’ product adoption and reducing costs.

**Design/methodology/approach:** The research is based on a two-step approach. First, this research identifies four potential key success factors for organisations to integrate big data in accelerating their product innovation processes. The proposed factors are further examined and developed by conducting interviews with different organisation experts and academic researchers. Then a framework is developed based on the interview outputs. The framework sets out the key success factors involved in leveraging big data to reduce lead times and costs in product innovation processes.

**Findings:** The three determined key success factors are: a) accelerated innovation process; b) customer connection; and c) an ecosystem of innovation. We believe that the developed framework based on big data represents a paradigm shift. It can help firms to make new product development dramatically faster and less costly.

**Research limitations/implications:** The proposed accelerated innovation processes demands a shift in traditional organisational culture and practices. It is, though, meaningful only for products and services with short life cycles. Moreover, the framework has not yet been widely tested.

**Practical implications:** This paper points to the vital role of big data in helping firms to accelerate product innovation processes. First of all, it allows organisations to launch new products to market as quickly as possible. Second, it helps organisations to determine the weaknesses of the product earlier in the development cycle. Third, it allows functionalities to be added to a product that customers are willing to pay a premium for, while eliminating features they do not want. Last, but not least, it identifies and then prioritises customer needs for specific markets.

**Originality/value:** The research shows that firms could harvest external knowledge and import ideas across organisational boundaries. An accelerated innovation process based on big data is characterised by a multidimensional process involving intelligence efforts, relentless data collection and flexible working relationships with team members.

**Key words:** Big data, accelerated innovation, product innovation processes, key success factors, rapid innovation.

**Paper type:** Research paper.

**1.0 INTRODUCTION**

Big data is attracting considerable attention worldwide. According to Davenport (2013), the effective use of big data has underlying benefits in bringing about dramatic cost reductions and substantial improvements in the time required to perform a computing task, or in new product innovation and service offerings. Taking advantage of valuable knowledge beyond big data will become the basis for competition for today’s enterprises (Barton and Court, 2012; Wamba, 2015; Li et al., 2015). Several researchers have pointed out that big data can enhance firms’ innovation capabilities in many respects (Manyika et al., 2011; Gobble, 2013; Tan et al., 2015). For example, Manyika et al. (2011) report that predictive modelling using big data can cut three to five years off the approximately thirteen years that pharmaceutical companies generally need to bring a new drug to market. Capgemini (2012) estimates that the process improvements enabled by big data may lead to an average 26% performance improvement over a three-year period. What is more, the analysis of big data may have huge operational and strategic impact on business process innovation at the firm and supply chain levels (Trkman et al., 2012; Dubey et al., 2015), and therefore allow firms that adopt it to achieve competitive advantage.

Today, the global market is in a product ‘war’ and management of innovation is the strategic weapon. According to Cooper (1990), product innovation – the development of new and improved products – is crucial to the survival and prosperity of the modern business. A new product is usually defined as one that has been on the market for three years or less and that, in the customer’s view, is visibly different from previous offerings, with new features, functionality or performance characteristics (Cooper and Kleinschmidt, 2011). A company’s development of new products can be much more quickly and efficiently helped with a bit of planning before development starts (Copper, 1990). Facing increased competition from home and abroad, maturing markets and the heightened pace of technological change, corporations look to new products and business for sustained growth and competitive advantage. Reports and surveys identify that most companies count heavily on new product development for growth and profitability (LaValle et al., 2011). However, an empirical study has in fact shown that fully commercialised new products have a remarkable failure rate of 40–50%, and this performance has not changed much over the past 20 years(Cierpicki et al., 2000). Therefore, the need for effective product innovation in organisations demands immediate attention. Ortt and Duin (2008) point out that current systematic innovation approaches are lacking in enough market focus and some are becoming too complex to manage efficiently and effectively. Some researchers also argue that current innovation approaches are too time-consuming; as well as having too many time wasters and too much cost ineffectiveness, some of them are bureaucratic and have no provision for focus (Cooper, 1994). Researchers believe that a good product innovation process should be adaptable, provide companies with a much more efficient roadmap, bring products to market faster and improve the use of scarce resources(Sheu and Lee, 2011; Wooder and Baker, 2012). Clearly, there is a lack of an effective way to support organisations to utilise big data and drive new product innovation from idea through to launch. With big data, firms can extract new ideas or understanding about their products, customers and markets, which are crucial to innovation. However, how could organisations use big data to better facilitate their product innovation? Product innovation is a process. And like other processes, innovation can be managed(Cooper 1990; Ortt and Duin, 2008). The first and most important step is to first understand the key success factors – those factors that make the difference between winning and losing at product innovation.

This paper seeks to develop a big data framework which can facilitate organisations’ product innovation processes. To assist our understanding of harvesting big data to facilitate product innovation, this study is structured into three parts. First of all, this paper investigates how big data can be used to transform the development of new products, by shortening the time to market, improving customers’ product adoption and reducing costs. Then, drawing on a systematic literature review, this research identifies key success factors that help broaden the understanding of the most significant success factors in product innovation. Secondly, a series of interviews with leading academics and subject matter experts from a number of industries and disciplines are conducted to improve and examine the key factors. Thirdly, based on the literature and interview output, a big data innovation framework is developed and demonstrated. Finally, the implications for practitioners and academia are discussed and conclusions drawn.

## 2.0 LITERATURE REVIEW

## 2.1 Big Data Transforming Product Innovation

Tan et al. (2015) define big data as a holistic approach to managing process; they analyse the 3Vs (volume, variety, velocity) in order to create actionable insights for sustained value delivery, measuring performance and establishing competitive advantages. In 2000, only 800,000 petabytes (PB) of data were stored in the world (IBM, 2013). It is expected this number will reach 35 zettabytes (ZB) by 2020 (Wong, 2012). The explosion of data is a natural tendency and, if harvested properly, can provide companies with better product innovation. For example, Dell initiated the development of a database that includes 1.5 million records related to sales and advertisements (Davenport, 2006) and Tesco generates more than 1.5 billion new items of data every month to support their new product development (Manyika et al., 2011). Thus, product innovation can be facilitated by acquiring amounts of information from different sources to develop better innovation processes, and to quickly find out the market acceptance of new products, customers’ needs or even competitors’ market movements. It also provides organisations with big ideas which could lead to big concepts and big solutions – the growth engines of the future (Li et al., 2015; Wamba, 2015). In short, it helps organisations to generate valuable insights, better decision making and finally achieve competitive advantage co-creation and realisation.

Moreover, there are many different types of data, such as texts, weblogs, GPS location information, sensor data, graphs, videos, audio data and more online data. Besides, data has become complex because the variety has shifted from traditional structured data to more semi-structured and unstructured data – from search indexes, emails, log files, social media forums, sensor data from systems, and so on (Zikopoulos and Eaton, 2012). In the digital economy, a firm’s success will rely on its ability to draw insights from the various kinds of data available to it, which includes both traditional and non-traditional. The ability to analyse all types of data will create more opportunity and more value for an enterprise (Dijcks, 2013; IBM, 2013). Big data analytics can integrate heterogeneous resources and tools from multi-disciplines to gain great advantages; these include increasing operational efficiency, informing strategic direction, developing better customer service, identifying and developing new products and services, identifying new customers and markets, etc. (Zhang et al., 2011; Chen et al., 2012; Lohr, 2012; Demirkan and Delen, 2013). For example, Tata Motors analyse 4 million text messages every month, spanning everything from product complaints to reminders about service appointments to announcements about new models, as well as connecting these with customer satisfaction polling (Agarwal and Weill, 2012); Procter and Gamble created a group consiting of more than 100 analysts from such functions as operations, supply chain, sales, consumer research and marketing to improve total business performance by analysing interrelationships among functional areas (Davenport, 2006). Therefore, big data is pushing traditional operations and product innovation to a higher generation, which can be more adaptable to complex situations, and also self-adjusted to changing conditions and unstable information to satisfy a wide range of customers (Zhong et al., 2015). Instead of collecting customer feedback via formal questionnaires, new product innovation relies more on mobile devices, social media platforms – including YouTube, Facebook and Twitter – and the internet in order to build better customer connections and get feedback quickly at a reduced cost.

In terms of velocity, huge amounts of data are generated every second and increasingly have a very short life (Xu et al., 2013; Zhong et al., 2015). In 2011, about 4 billion mobile phone users were identified worldwide; about 12% of them using smartphones and having the capability of turning themselves into data-streams. Meanwhile, the video platform YouTube received 24 hours of video every 60 seconds (The Economist, 2011). On Facebook alone we send 10 billion messages including photos and videos per day; we click the 'share' button 4.5 billion times and upload 350 million new pictures each and every day (Thibeault and Wadsworth, 2014). In these circumstances, firms can easily track customers’ data, including clickstream data from the Web, and can leverage details from their behavioural analysis to better support their new product innovations. For example, Amazon manages a constant flow of new products, suppliers, customers and promotions without compromising guaranteed delivery dates (Davenport, 2006). The velocity of big data can drive new product development dramatically faster and at less cost through responding to market feedback in a short time. Firms are now capable of gathering users’ feedback in near real time to track changes in customer behaviour and rapidly communicating this to the R&D team to ensure that a newly launched product is sufficiently flexible to incorporate new functionality quickly.

What are the most important success factors for harvesting big data in product innovation? Although big data can offer much more useful production innovation and can gain great competitive advantages, there are no success factors for managers to support organisations’ product innovation from idea through launch based on the values captured from big data. Therefore, instead of just generating vast amounts of information from big data, managers need success factors as guidelines to structure and utilise the information captured from big data to support their product innovation systematically, so that a better insight into the issue being analysed could be gained. Previous research shows that there are many existing success factors that organisations could implement to support product innovation (Cooper, 1990; 2014; Cooper and Kleinschmidt, 2011; Balbontin et al., 1999). However, these traditional success factors are limited and not necessarily optimised for big data harvesting tasks due to their general purposes. With big data, firms can gain a better understanding of their products, customers and markets – and this is crucial to innovation (Manyika et al., 2011; Wong, 2012). The main challenge for firms is how to use big data to dramatically hasten the development of new products and to make them less costly.

**2.2 Key Success Factors in Product Innovation**

According to Cooper and Kleinschmidt (1996), product innovation can potentially be more successful if a number of factors are improved and implemented. Failing to do so can have disastrous results for a firm. In order to determine the key success factors for product innovation – based on values harvested from big data – this research draws on different researchers who have systematically and comprehensively summarised such key success factors for successful product innovation. A series of interviews with leading academics and big data experts from a number of industries and disciplines were then conducted to further develop and examine the key factors.

As determined by previous research, the most important recognised factors in organisations to support product innovation are: pre-development research; an accelerated innovation process; customer connection; and an ecosystem of innovation (see Table 1).

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| Table 1: Success factors for product innovation |
| Key Success Factors | **Essential Elements** | **Literature Support\*** |
| Pre-development research | Idea generation | 1, 3, 5, 7, 8, 11, 12, 13, 15, 16, 17, 18, 19, 20, 22, 25 |
| Initial screening |
| Preliminary market assessment |
| Detailed market study |
| Financial analysis |
| Well-defined product |
| Accelerated innovation process | Systematic innovation process | 1, 2, 3, 4, 5, 8, 9, 10, 13, 14, 15, 18, 20, 21, 24, 26, 27 |
| Autonomy management |
| Cross-functional teams |
| Simultaneous development |
| Customer connection | Market orientation | 1,, 3, 4, 5, 6, 7, 9, 13, 16, 17, 18, 19, 20, 22, 24, 25, 26, 27, 28, 29 |
| Customer communication |
| Understanding of customers |
| Good relationship with customers |
| Ecosystem of innovation | Connection with customers and partners | 1, 2, 3, 4, 7, 11, 14, 15, 16, 18, 19, 23, 24, 26, 27, 29 |
| Proficiency of marketing test |
| Fast development and launch |
| Quick response to market |
| Market and partner tests |

\*Notes: 1. Cooper (1980; 1996); 2. Mann and Jones (2002); 3. Lovelace et al. (2001); 4. Sethi et al. (2001); 5. Cooper and Kleinschmidt (2011); 6. Atuahene-Gima (1995); 7. Balbontin et al. (1999); 8. Barczak (1995); 9. De Brentani (1989); 10. Calantone and Di Benedetto (1988); 11. Calantone et al. (1997); 12. Dwyer and Mellor (1991); 13. Griffin (1997); 14. Al-Mashari and Zairi (1999); 15, Quesada and Gazo (2007); 16, Maidique and Zirger (1984); 17, Mishra et al., (1996); 18, Parry and Song (1994); 19. Rothwell et al. (1974); 20. Rubenstein et al. (1976); 21. Liao and Barnes (2015); 22. Song and Parry (1997); 23. Souder and Chakrabarti (1978); 24. Souder et al. (1997); 25. Utterback et al. (1976); 26. Evanschitzky et al. (2012); 27. Williamson and Yin (2014); 28. Lin et al. (2010); 29. Rese and Baier (2011).

In terms of the pre-development research, Cooper (1994) points out that the seeds of success or failure are sown in the first few steps of the process (the pre-development stage). The pre-development activities are important because they qualify and define the project. Many projects are poorly defined when they enter the development phase. This is often the result of weak pre-development activities: the target user is not well understood, user needs and wants are vaguely defined and required product features and attributes are fuzzy. Those in R&D and design engineers are not mind readers. With a poorly defined project, they waste considerable time seeking definition, often recycling back several times to get the product right. Better project definition, the result of sound pre-development research, actually speeds up the development process. What is more, pre-development research up front encourages changes to occur earlier in the process rather than later, when they are more costly. The result is considerable savings in time and money at the back end of the project and a more efficient new product process.

The accelerated innovation process aims to use systematic methods to speed up the innovation process as much as possible. Speed yields competitive advantages: being the first on the market can result in a quicker realisation of profit, and there will be a lower risk that the competitive situation or market would have changed before the new product can be launched (Steinfeld and Beltoft, 2014). Systematic innovation is significant in the product innovation process; it can create value and secure competitive advantage for organisations by generating a series of innovations, rather than unplanned or haphazard activities (Mann and Jones, 2002; Sheu and Lee, 2011). Autonomy management is based on guaranteeing the freedom of the individual groups of employees to decide on basic issues; it can improve efficiency and increase the effects of employee job satisfaction and motivation to work. Cross-functional teams can improve integration and coordination, span organisational boundaries, and reduce the production cycle time in new product development (Cooper and Kleinschmidt, 2011). What is more, bringing people together from different disciplines can improve problem solving and lead to more thorough decision making, which makes it easier to achieve corporate goals and customer satisfaction at the same time (Sethi et al., 2001). Simultaneous development is a method of designing and developing products, in which the different stages run simultaneously, rather than consecutively. Applying such a method can result in great benefits for organisations, such as reduced overall programme costs, lower manpower requirements, reduced potential risks, improved high-quality products and flexibility (Lovelace et al., 2001).

In terms of customer connection, a thorough connection with and understanding of customers is significant: the more the customer is understood, and the more that understanding is implemented in product design, the more positive the impact will be on market share, revenues and margins (Evanschitzky et al., 2012; Bohlmann et al., 2013). Therefore, a strong customer connection is critical to success in product innovation. With regard to customer connection, in terms of firms’ value creation in product innovation, this research identified four essential elements from literature (as Table 1 shows): market orientation; customer communication; understanding of customers; and keeping good relationship with customers. According to Chesbrough (2003), companies are increasingly rethinking the fundamental ways in which they generate ideas and bring them to market. Because R&D has long been a costly and inexact process (Anders and Ali, 2004), customer connection has been widely acclaimed in management rhetoric as a means to tighten the feedback loop between the cycles of consumption and production (Lundkvist and Yakhlef, 2004). Underlying most such views is the assumption that customers are sources of information and knowledge (Lacity and Willcocks, 2014) and that customer connection can enhance product concept effectiveness (Anders and Ali, 2004).

Adner (2006) defines an ecosystem of innovation as the collaborative arrangements through which organisations combine their individual offerings into a coherent, customer-facing solution. As one of the determined key success factors in product innovation, an ecosystem of innovation refers to building an innovative and market-testing environment that can support organisations to develop new products at dramatically fast speeds and with lower expenses. There are five essential elements identified in this factor, as Table 1 shows: connection with customers and partners; proficiency of marketing tests; fast development and launch; quick response to markets; and market and partner tests. Bogel et al. (2014) point out that the ecosystem allows organisations to generate a greater value that no single firm could have generated alone. It also bridges the gap between the need for new product definitions and the changeable market conditions as development proceeds (Gupta, 2013). For each project, instead of focusing on R&D internally, allocating resources externally from partners (e.g. with customers, universities or companies) can be far more effective because critical bottlenecks may reside outside the company (Lacity and Willcocks, 2014). Especially when enabled by information technologies that have drastically reduced the costs of coordination, innovation ecosystems have become a significant success factor in the growth strategies of organisations in a wide range of industries (Adner, 2006).

**3.0 METHODOLOGY**

So far, this research has presented a normative research approach to determine the key success factors for enhancing product innovation in a big data context. Starting from a systematic literature review, five key success factors were identified to support organisations in gaining competitive advantages by implementing product innovation successfully. In a second step, this research conducted qualitative research using semi-structured interviews (Hansen, et al., 2009; Silverman, 2008) to validate the key success factors and develop a model based on the determined factors.

Using multiple interviews brought a richer portrait of each case (Yin, 1994) and also aided in mitigating bias in historical data interpretation. As previous research in the area of product innovation suggested addressing high-level corporate officers to gain the most accurate information (Hansen et al., 2009), this research conducted interviews with fifteen high-level experts from leading organisations between May and September 2015. As Tables 2 and 3 show, these experts belong to two groups: corporate experts (eight executives) and research experts (seven senior researchers).

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| Table 2: Summary of interviewed organisations  |
| Executive | **Industry** | **Turnover (£)** | **Interviewee Position** |
| *Firm A* | Family apparatus | 1.3b | General manager |
| *Firm B* | E-commerce | 2.1b | Analytics engineer  |
| *Firm C* | Electronics  | 12b | Project leader |
| *Firm D* | Computer hardware | 30b | Data analyst |
| *Firm E* | Consumer goods | 35b | Innovation manager |
| *Firm F* | Chemical & manufacturing | 1.2b | CEO |
| *Firm G* | Automotive | 9b | General manager |
| *Firm H* | Logistics | 13b | Open innovation R&D |

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| Table 3: Summary of interviewed researchers |
| Researcher | **Institute** | **Professional Area** | **Location** |
| *RSR A* | Cambridge University | Open innovation and innovation strategy | UK |
| *RSR B* | Imperial College London | Big data, software development, etc. | UK |
| *RSR C* | University of Nevada | Supply chain innovation management, operations, etc. | USA |
| *RSR D* | National Chiao Tung University | Systematic innovation management | Taiwan |
| *RSR E* | University College London | Data analytics, manufacturing management, etc. | UK |
| *RSR F* | Iwate Prefectural University | Information science and software | Japan |
| *RSR G* | South China University of Technology | Innovative manufacturing research | China |
| *RSR = Researcher* |

These organisations reflect a variety of different industry sectors (e.g. electronics, manufacturing, automotive, family apparatus). The diverse selection of interview partners guarantees a holistic perspective on the topic and uses very different experiences and opinions in the field of big data and product innovation. Each interview took approximately one and half hours and was recorded. The questionnaire itself was extensively pretested via personal interviews. Parts of the interview were translated into English, and then transcribed and analysed with qualitative data analysis.

**4.0 RESULTS**

During the interviews we received a vast amount of feedback on the identified key success factors and their potential implementation in product innovation in a big data context. We recorded both broad agreements and controversial opinions toward the discussions. Table 4 summarises the feedback obtained from the interviews of different organisation executives and research experts about the identified key success factors in using big data to support product innovation.

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| Table 4: Summary of the interview results  |
|  | **Pre-development Research** | **Accelerated Innovation Process** | **Customer Connection** | **Ecosystem of Innovation** |
| Firm A | √ |  | √ | √ |
| Firm B |  | √ | √ | √ |
| Firm C | √ | √ | √ |  |
| Firm D |  | √ | √ | √ |
| Firm E |  | √ | √ | √ |
| Firm F | √ | √ | √ | √ |
| Firm G |  | √ | √ | √ |
| Firm H |  | √ | √ | √ |
| RSR A | √ | √ | √ | √ |
| RSR B |  | √ | √ |  |
| RSR C | √ | √ | √ | √ |
| RSR D |  | √ | √ | √ |
| RSR E | √ |  | √ | √ |
| RSR F | √  | √ | √ |  |
| RSR G |  | √ | √ | √ |

 (√ = Agree with the element; RSR = Researcher)

**4.1 Accelerated Innovation Process**

Overall, the managers and researchers felt that the key success factors are conceptually accurate in capturing the essence of product innovation in a big data environment. For the accelerated innovation process, we observed broad acceptance among organisations and research experts. By applying this concept, self-directed teams emerge as the way to drive innovation and deliver great products, and we observed that it can create high velocity in product innovation projects. Most interviewees commend autonomous teams as being more effective for addressing projects with high technological novelty or radical innovation, especially in a big data environment. Also, some interviewees found the cross-functional teams and simultaneous management to be very “new to its [produce development’s] culture”, and can help communication more broadly, gain alignment more easily and build better products in a short time. It was highlighted that this factor can provide a better big data-supported product innovation approach:

*By implementing the accelerated innovation process, people from different function departments are grouped together to work actively. It cuts across boundaries of different departments and there is no more marketing team or production team. Instead, every team member becomes involved in marketing, engineering, design, production or R&D*. *This movement can save us a lot of time and eliminated vast number of unnecessary double communication within various teams.*

This observation adds to the fact that the elements of the accelerated innovation process are commonly known and integrated in numerous business and theoretical concepts.

**4.2 Customer Connection**

Most of the organisation experts and researchers concurred with the customer connection factor. They referred to various examples of their current projects addressing the importance of customer connection in product innovation. One organisation’s marketing manager pointed out that the proposed customer connection factor provides more than merely an idea for product innovation. It supplies the firm with information on market needs or existing problems, product-related specifications or even a complete product design. It is generally believed by the interviewees that as one of the most important factors in product innovation, organisations need a process in place to pay close attention to their customers in every phase of the product innovation value chain, from idea generation to product development to marketing. According to Firm F’s CEO:

*Normally, companies just determine their main customers and potential customers, but big data will allow them to investigate more detailed aspects such as where they are, what problem they face, what they need, how they want to be contacted and when.*

Therefore, the observation shows that customer connection is significant for every organisation for product innovation, and it can be further enhanced by harvesting values from big data.

**4.3 Ecosystem of Innovation**

There was broad agreement on the innovation ecosystem concept among business executives and researchers, which underlines this concept’s high diffusion and acceptance. As a result, it costs the companies less time and money than would ordinarily be required, by concentrating on new product research and development rather than other non-value adding processes. According to the interviewees, by building a stable and diverse ecosystem of innovation, organisations can provide new products to meet their customers’ requirements in a much more efficient and effective way. One organisation executive outlined the ecosystem of innovation as a major business opportunity:

*The company is already spending about a million dollars in cooperating with desirable partners among the entire supply chain to support its product development ecosystem and it helps the company gain an outsized competitive advantage such as offering the consumer a greater value than the competitors, as well as providing better products and services.*

However, a few academic experts criticised the innovation ecosystem concept as being too simple. For example, it was argued that the concept is based on successful examples of agglomeration, whether in industrial, entrepreneurial, economic or geographic terms. As such, there is relatively little new about the innovation ecosystem compared with earlier concepts like development clusters or blocks. These diverse and sometimes controversial viewpoints underline the difficulties when trying to operationalise the concept of innovation ecosystem.

**4.4 Pre-development Research**

Most of the interviewees were not satisfied by the pre-development research factor toward product innovation in a big data environment. Although many researchers argued that pre-development research is key to success, most of the organisation experts in particular commented that it can be achieved in the early stage of customer connection via harvesting information from big data. As an R&D manager points out:

*Companies should not spend too much time on pre-development research because people don’t know what they want until you show it to them.*

Instead of spending a lot of time and resources on conducting pre-development research, big data can be used as the most important source in generating new ideas, capturing useful information, assessing target markets, introducing new product concepts and gathering feedback. Therefore, as pre-development research can be included as part of customer connection, it was removed from the identified key success factors.

**4.5 Implementation in Product Innovation Management**

All interviewees outlined the advantage of the determined key success factors as an orientation framework for supporting product innovation in a big data context. Often, the key success factors were considered particularly helpful in organisations when employees needed to be introduced or sensitised to the concepts, such as autonomy and innovation ecosystem. Organisation experts initially criticised the lack of possibilities for quantitative methods/techniques to harvest big data, but later acknowledged the proposed key success factors’ role as a meta-method (Paterson et al., 2001). These observations underscore two facts. On the one hand, businesses seek accurate amounts of valuable information from big data as a basis to support their product innovation. On the other hand, large organisations may have already built up their big data toolbox of analytic techniques and methods to support product innovation, and hence they may not necessarily take advantage of the key success factors as a meta-method. Small- and medium-sized enterprises (SMEs), conversely, might not have enough resources to engage in the field of big data analytics. Here, the developed key success factors as a meta-method could significantly support organisations in providing guidelines for appropriate product innovation processes by harvesting values from big data. However, the particular value of the developed key success factors for SMEs is beyond the scope of this paper and is a suitable subject for further research.

To summarise, the developed key success factors are: accelerated innovation process, customer connection and innovation ecosystem, which gained significant support in all major elements of successful product innovation implementation in a big data context. These factors can be seen as an orientation framework and introduction to the field of big data, adding value to both big data and product innovation management.

**5.0 DEVELOPMENT OF THE FRAMEWORK**

Based on the above research, a framework can be further developed to assist firms in product innovation through harvesting big data to shorten the lead time to market, improve customers’ product adoption and reduce costs (see Figure 1). It is termed the ACE framework because it is based on the principles of accelerated innovation process (A), customer connection (C), and ecosystem of innovation (E). We believe the proposed framework represents a paradigm shift. It can provide guidelines to firms in harvesting big data to better support their product innovation.

Accelerated Process (A)

Connection (C)

Ecosystem (E)

Figure 1: ACE Framework for Product Innovation

**5.1 Accelerated Process**

One of the principles of the ACE framework is accelerated innovation process. Figure 2 shows the most important elements in achieving this.



According to Wynen et al. (2014), autonomy is the mother of motivation and creativity. The first principle in the proposed ACE framework is to give autonomy to the innovation teams. This means allowing R&D team members a high level of freedom to make decisions by themselves in their workplace. Autonomy here also implies that project teams work in parallel, rather than sequentially. At each stage of a project, many activities take place concurrently and involve different functions of the firm. Under autonomy management, a group leader is allocated to supervise the output of the project. The project approach begins with dividing the innovation process into many small elements. After that, the divided project activities are undertaken by cross-function teams (which mean a team of people from different functional areas) who work on different elements in parallel. By doing this, the so-called innovation ‘assembly line’ can be accelerated and results can be delivered quickly (Davenport, 2013). Autonomy does not mean being separate: project teams need alignment with the core, using big data to share innovation portfolios as well as to cultivate a network of peers and relationships, to facilitate innovation (Chen et al., 2015).

In this situation, the innovation process is industrialised by assigning more people to the many small steps and project activities (Williamson and Yin, 2014). The total outlays for a given project can nonetheless be reduced, as these people are less highly trained than traditional R&D staff and are generally therefore paid less (McNeish and Hazra, 2014). For example, Lenovo overcomes the usual problems of implementation by: breaking down its product designs into separate modules linked by standardised interfaces; redesigning its software to be compatible across all activities associated with the new product; establishing short lines of communication where each team member can represent his or her respective functional department; and introducing open design processes where information is shared with the entire team as early as possible.

Big data plays a significant role. In terms of traditional innovation approaches, many companies have found it hard to implement the autonomy principle, because of barriers such as unwillingness by engineers to release information early and difficulties in coordinating multidisciplinary teams (Berglund and Sandström, 2013). Companies now can rely directly on big data to gather the latest information; team members are now working and living in a big data environment, which ensures their communication and knowledge sharing are both effective and efficient.

**5.2 Customer Connection**

Barwise and Meehan (2012) believe that Apple built its success not as a pioneer, but as a good follower of its customers. The second cornerstone of the ACE framework is customer connection, i.e. a focus on building a close relationship with customers via big data (see Figure 3).



Innovation can be facilitated by evolving ideas while listening to the voice of customers; the product is better when potential customers can be identified and their needs satisfied (Prahalad and Ramaswamy, 2013; Steinfeld and Beltoft, 2014; Cooper, 2014). Many projects have poor customer connections, which results in a series of problems: customer requirements and problems are vaguely defined; the product’s functions and features are fuzzy; and the target customers are not well understood (Dunn and Dahl, 2012). Engineers and R&D teams are not mind readers. With poor customer connections, they often have to back-track to make the product right. Thus, they waste considerable time in defining projects appropriately. This development process can be speeded up by building better customer connections. What is more, instead of making changes late in the project, customer connection encourages changes to occur earlier, when they are less expensive (Williamson and Yin, 2014). For example, the MIUI system developed by Xiaomi (now the world’s third largest manufacturer of smartphones) and the Talend big data platform by Lenovo (the largest personal computer vendor in China and the second largest in the world) are both good ways to build a close connection to customers. Additionally, Didi Dache (a young Chinese taxi service company, selected as one of China’s thirteen most valuable start-ups) spent a lot of time building various platforms to connect to its users as well as the market (including using big data to clarify its product definition and to identify its main competitors, market size and customers’ problems and needs).

The involvement of customers is an emerging trend (Cooper, 2014; Dunn and Dahl, 2012; Steinfeld and Beltoft, 2014). The innovation process can be dramatically accelerated by using big data in the form of, for example, usage information, which is much more rapidly available than, say, the results of market surveys (Williamson and Yin, 2014). Big data in the form of feedback can be an important source of useful information and new ideas. Key questions need to be focused at this stage, such as: Who exactly is the target customer? What functionalities and features should be developed to give the product a differential advantage? What exactly should the product be to make it a winner? How should the product be positioned? By answering such questions, companies can gain a better understanding of their customers, markets and products.

**5.3 Fast Launch-and-Improve Ecosystem**

The third cornerstone of the ACE framework is an innovation and market-testing environment to develop new products at dramatically fast speeds and lower costs. Adner (2006) argues that innovation ecosystems have become a core element in the growth strategies of organisations in a wide range of industries. The ecosystem element of the ACE framework indicates that the company network is used to acquire new requirements and components of product development processes externally or from intermediaries, in order to create a fast launch-and-improve environment that is able to launch a product quickly with less cost. A fast launch-and-improve ecosystem involves the concept of autonomy and customer connection. It helps the product team to move quickly to a market-winning product through a series of iterations: new product ideas, fast launch, feedback gathering, fast improvement and re-launch (see Figure 4).



The emergence of big data and the internet allow for the combination of organisations’ business strategies and those of outside suppliers within an ecosystem (Shih, 2014). For example, in order to further enhance its smartphone ecosystem and take ownership of its future products roadmap, Lenovo Group in 2014 acquired world-renowned Motorola Mobility from Google Company, including the Motorola brand and Motorola Mobility’s portfolio of innovative smartphones. The acquisition of such an iconic brand immediately made Lenovo a powerful global competitor in smartphones, through scaling Motorola Mobility into a major player within its existing Android ecosystem and facilitating product innovation across the new Android ecosystem (Google, 2015).

Enormous cost advantages can be acquired from the ecosystem and companies should identify the key competencies of their components and focus on them, and acquire the less important components from the ecosystem (Horn, 2005). For example, owing to its supportive ecosystem, Xiaomi is able to sell its products and a wide range of accessories at near-production cost to keep prices competitive and sell a large volume of goods. By integrating a range of key components and technologies, many high-class products can be invented and created. Producing such products in an open innovation ecosystem depends on contributions from across the network of suppliers and creates value for the eventual buyer (Boer et al., 2001).

The core competitive advantage of this ecosystem arises from the use of big data to attract and connect to a wide range of networks in each step of product development (McAfee and Brynjolfsson, 2012). This might be through the presentation of mock-ups, images or videos of the new product to customers and thus the gathering of feedback early in the process of product development (Tuulenmäki and [Välikangas](https://scholar.google.co.uk/citations?user=YYD2_XEAAAAJ&hl=en&oi=sra), 2011). For example, rather than spending time on internal R&D to make the product perfect, Didi Dache and Xiaomi tend to launch their new product ideas on the market quickly (and are able to do so through implementation of the autonomy principle) and then improve them through extremely fast and continuous rounds of commercial realisation and testing within their ecosystems. Hence, companies can earn a premium by staying abreast of competitors’ innovations and by having up-to-date products available in volume at affordable prices (Williamson and Yin, 2014). Moreover, nurturing interactions in the proposed ecosystem improves efficiency and creativity, and also makes innovation a cycle of continuous improvement and information transformation (Gupta, 2013). In the ecosystem, innovations are made from interrelated networks (Nieto and Santamaria, 2006) and these empower organisations to rapidly integrate useful feedback from customers and partners. Through repeated accelerated innovation cycles, project teams can iterate the product in sync with evolving market requirements and stay ahead of the competition. With innovation ecosystems, firms are better able to respond to today’s fluid, changeable information and evolving market conditions.

## 6.0 DISCUSSION

The core competitive advantage of the proposed framework arises from the use of big data to attract and connect to a wide range of networks in each step of product development. This might be through the presentation of mock-ups, images or videos of the new product to customers and thus the gathering of feedback early in the process of product development (Tuulenmäki and [Välikangas](https://scholar.google.co.uk/citations?user=YYD2_XEAAAAJ&hl=en&oi=sra), 2011). By implementing the framework, innovations are made from interrelated networks and these empower organisations to rapidly integrate useful feedback from customers and partners (Wang 2009). Through repeated accelerated innovation cycles, project teams can iterate the product in sync with evolving market requirements and stay ahead of the competition. With the innovation ecosystems, firms are better able to respond to today’s fluid, changeable information and evolving market conditions (McAfee and Brynjolfsson, 2012).

Traditionally, the new product development process involved inefficient sequential processing of information between functional specialities. The ACE framework allows firms to adapt and respond rapidly to changing market needs and to develop innovative products in such an environment. Rather than spending years to exploit in-house capabilities, the ACE framework can be used to build a network to piece together production according to capabilities. Hence, it ensures the company remains at the cutting edge of product innovation. Proactive assessment of customer needs and behaviours is vital in today’s competitive environment (Brown and Bessant, 2003). The demand for intelligence on product defects, improvements and usage has never been greater, especially in high technology firms in the electronic and manufacturing industries (Salge et al., 2013). The accelerated approach is meaningful for products and services with short product life cycles, notably the consumer electronics industry, where demand is driven mainly by lifestyle trends. Moreover, the case also highlights that achieving innovation and flexibility requires considerable planning and coordination through the various phases of development. Thus, top-level management support through a product champion and tight interfacing with social media and the target market are essential components of accelerated innovation.



Figure 5: Comparison between traditional innovation approach and ACE framework

As Figure 5 shows, compared with traditional innovation approaches, the ACE framework places particular emphasis on efficiency and cost saving. There is no magic formula for innovation. However, firms could expand their existing innovation competence in many ways by tapping into the knowledge afforded by big data. The ACE framework provides a blueprint for using big data to make product innovation dramatically faster and less costly. By using the ACE framework, firms are leveraging big data analytics to embed customer sentiment in product development. This enables firms to move away from product-focused innovation and to turn their attention to innovation around the customer experience. The proposed paradigm-shifting innovation processes enable firms to find ways to innovate – to make new product development dramatically faster and less costly.

## 7.0 CONCLUSION

The ACE framework proposed in this research is based on the key success factors elicited from the literature; these success factors were validated by conducting interviews with eight different leading organisations and seven university researchers. The framework presented in this paper can facilitate better planning and organisation of parallel work teams and groups that may be involved in rapid new product development. This paper extends the accelerated innovation boundaries pointed out by Williamson and Yin (2014), and provides further evidence of the vital role of the innovation ecosystem in new product development.

This paper points also to the vital role of big data in helping firms to accelerate innovation. The incorporation of big data into the fast launch-and-improve ecosystem can be significant. It allows organisations to launch new products to market as quickly as possible. What is more, it helps organisations to determine the weaknesses of the product earlier in the development cycle; and it allows functionalities to be added to a product that customers are willing to pay a premium for, while eliminating features they do not want. Furthermore, it identifies and then prioritises customer needs for specific markets.

However, this study has its limitations. First, since using big data to support accelerated innovation is new, there is little literature to build on. We have had to rely on investigation of some trends of increasing importance in product innovation evolution to identify the key success factors, and use semi-structured interviews with leading industry experts and academic researchers to verify them. Therefore, the issue of whether more industry experts and academic researchers would generate similar results, internationally, needs to be investigated. In addition, in order to better apply the ACE framework to business practice, further research could address how to integrate the framework into real product innovation processes. This implies defining an appropriate search focus, for which the ACE framework might serve as an ideal basis.

Second, developing a high-level framework for such a complicated phenomenon as accelerated innovation may highlight some obvious connections while failing to capture others. Future empirical studies might test the ACE framework across different industries. Also, this research could take a longitudinal approach to analysing ACE implementation in a firm over time. Learning and innovation processes can be properly studied only over a period of time. In particular, it is significant to address the problem of how to apply big data in each cornerstone of the ACE framework in detail. What hardware facilities are required to be constructed and what innovation capabilities are needed to be improved are both worth studying in future research. The findings could have useful implications for future research and policy design and implementation.

Lastly, this qualitative study interviewed industry experts from leading organisations as these organisations are highly engaged in big data harvesting and product innovation management. However, the ACE framework may also add value to SMEs by supporting their efforts in harvesting big data to support their new product development. The implementation of the ACE framework in SMEs may thus be an interesting field for further research.

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