Using Real-time Simulation in Company Value Chains and Business Models for Value Creation

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Abstract:

This chapter discusses the field of real-time simulation and its uses in a value chain's different processes, how it can affect business models, and share its benefits with various stakeholders. The primary objective is to explain how real-time simulation tools can increasingly represent real-world functionality in today's businesses and emerging industries. Different value chain activities are being discussed and examples of value creation, based on real-time simulation, are given starting from product development and continuing to when the product is already in the customer's hands.

1. Introduction

In today's rapidly changing global markets, industries are becoming not only interconnected, but also interdependent on each other. Further, the digitalization and globalization of our century is increasing the pressure on companies to stay competitive and therefore in the market. Merely adapting technology is not enough, as companies must also understand technology's complexity and business trends. Digitalization especially has caused rapid development and new complexity in electronics, challenging upper and middle management to understand the new and emerging needs of their business. They must then adjust accordingly by innovating and updating their business models to ensure they are capable of attaining full benefits and extending value to customers. Only a small percentage of companies nowadays believe that their current business model is able to remain profitable and economically

viable as their industries continue digitalizing their course and speed (Bughin et al., 2018).

New revolutions have evolved due to the global market's increasing innovation and competitiveness, giving birth to advanced technologies that grant great benefits to different industries. The introduction of water- and steam-powered mechanical manufacturing at the end of the 18th century (i.e. the 'first wave' or industrial revolution), the division of labor in the beginning of the 20th century (i.e. the 'second wave'), and the appearance of programmable logic controllers for automation purposes during the production process in the 1970s (i.e. the 'third wave') were the main influencers of such revolutions (Brettel et al., 2014). Such transformations have introduced the business world to a whole new possibility of interactions between humans and machines in a cyber-physical world through a large network, which have eventually created the 'fourth wave'. Industry 4.0, coined in this century, refers to the emergence and diffusion of a range of new digital industrial technologies, e.g. in relation to automation and data exchange in manufacturing technologies (Strange and Zucchella, 2017; Hannibal and Knight, 2018). In addition to technological innovations, companies have also had to undergo a huge shift in their organizational structure to cope with the market's complexity. Scholars have also recognized a shift from mass production to customized production, moving toward the co-creation of products with customers and that transformation's potential effects on value propositions and business models. This chapter examines real-time simulation as a result of the fourth wave of industrial revolution that was triggered by the internet.

Real-time simulation is a great result of this latest revolution. It is a technology that is evolving rapidly and finding its way into specific industrial applications, as real-time simulation and its accurate physics-based representation resolve real-time problems by producing meaningful and timely data on product behavior (Mevea (a), 2018; Jaiswal et al., 2019). It can predict accurate — in real time — the dynamic behaviors of complex mechanical systems, such as mobile machinery (Khamim et al., 2018). Real-time simulation techniques are being applied to develop advanced operator training simulators (Mevea, 2018a). Further, several manufacturing companies use real-time simulation to improve their production processes, and real-time simulations can be serving as a vehicle to demonstrate technical features of a product to customers. Consequently, new applications in product development and beyond are

emerging that account for the needs and wants of both customers and operators throughout the whole value chain process, a critically important benefit. The possible next step is taking simulator-driven design methodologies to the new level by developing real-time simulator-driven processes. This development will provide visibility and accessibility to multiple stakeholders in every part of the product lifecycle, thus enhancing new business model potential and driving increased competitiveness. However, this new field of technology is not fully matured and is exploited only for limited uses, so there are many benefits yet to be discovered and proven.

This chapter discusses the field of real-time simulation and its uses in a value chain's different processes, how it can affect business models, and share its benefits with various stakeholders. The primary objective is to explain how real-time simulation tools can increasingly represent real-world functionality in today's businesses and emerging industries. This innovation has increased global competition in product quality and production costs and ensured real-time access to relevant product and production data for the involved parties. Therefore, companies are weakening their boundaries for multiple parties to gain access to data by exchanging it through autonomous systems embedded throughout the entire value chain (Brettel et al., 2014). To cope with these technological changes, industries have had to evolve and face the changing market, creating industrial revolution, and also firms need to think how to create value based on real time simulation in this new environment.

1.1 Digitalization's Effect on the Market

Digitalization has had different impacts on the ways that companies do business and also started new trends. To understand these trends, we need to first understand digitalization. Some managers view digitalization as an upgraded term of what their IT functions do for the company, while others are interested in digital marketing and sales. As for Bughin et al. (2018), they defined digitalization as "the nearly instant, free, and flawless ability to connect people, devices, and physical objects anywhere." I-SCOOP (2019) referred to digitalization in business as "enabling, improving and/or transforming business operations and/or business functions and/or business models/processes and/or activities, by leveraging digital technologies and a broader use and context of digitized data, turned into actionable knowledge, with a

specific benefit in mind." This definition takes into consideration the importance of data gathered from different means of digitalization. Other definitions have included the environmental aspect of digitalization and the adoption of digital technologies across all possible societal and human activities concept, but we focus on the previous definitions proposed by Bughin et al. (2018) and I-SCOOP (2019) for the purpose of this chapter.

CIMdata (2018), an eBook about digital twins, or "digital innovation of a simulation twin that accompanies its real-world companion through its lifecycle, being changed in tandem with the physical version," introduced four different trends that digitalization has led in today's businesses. The first is complexity, whether in product or ecosystem[1]. Product complexity does not only come from the increased number of assemblies, but also from customers' current expectations when using electronics, software, and embedded systems, all of which are taken for granted (ibid). In addition to the fact that these technologies need to be connected with each other, ordering and manufacturing are challenged to meet sustainability conditions. As for ecosystem complexity, this phenomenon is shown in digitalization covering the entire product lifecycle process. Companies' environmental responsibility is on one side and on the other is social responsibility as the companies manufacture products that are increasingly connected to meet society's needs.

The second trend is giving the customer choice, as nowadays customers demand flexibility and are given a wide range of choices to choose from, if not a customized product or service. Since companies are gaining access to trendy and much better means, materials, and solutions, customers expect reliable products of superior quality that have been tested well before their launch CIMdata, 2018). Customers are also participating more in the feedback process and co-creating products with their ideas on how to improve them to match their needs (ibid). Thus, companies are expected to provide such treatment and involvement from their customers.

The third trend is digitalization competitiveness, where companies not only focus on bringing improved and well-tested products to the market, but also the need to do it quickly and in fast response to market changes to stay competitive in their field. To do

[1] A business ecosystem can be defined as the "organisms of the business world – including stakeholders, organizations, and countries – involved in exchanges, production, business functions, and… …trade through both marketplace competition and cooperation" (see Hult et al., 2020, p. 44).

so, CIMdata (2018) explained that all stages of the engineering process's virtual capabilities need to be applied, from inception through product development to manufacturing to service. This requires data and process management, visualization, collaboration, and predictive capabilities. When the company achieves digitalization, that does not mean it has everything in digital form, but rather that it is capable of capturing data, analyzing it, and using it for decision-making.

The fourth and final trend is sustainable innovation, which is achieved through a virtual environment. Virtuality has an impact on companies' competitiveness and profitability, resulting in value proposition and business model transformations. CIMdata (2018) noted some of the virtual engineering practices in businesses, including system modeling and simulation (SMS), BigData, IoT (Internet of Things), digital twins, IIoT (Industrial Internet of Things), and more. The increased use of advanced technologies has brought up these trends to where industries must constantly keep up with them. Thus comes the need for further research on each of these technologies and their impacts. Real-time simulations are already operating in some companies, but not all their benefits have been fully employed throughout the whole value chain. Indeed, real-time simulation is mostly found as part of product development and not used in other value creating activities. This chapter therefore focuses on real-time simulation and its potential benefits.

1.2 Real-time Simulation Models and How they Create Value for Customers

A complete real-time simulation model integrates the appropriate elements, including the models of environment, mechanics, control system, and user input, and predicts their interaction to simulate the dynamics of an entire system (Mevea, 2018b). The user's main role is to provide input signals via the control console to direct the control system. The control system is where most of the input/output data is processed and synchronized with other subsystems. The actuators produce the forces needed to actuate the mechanical subsystem.

For example, hydraulic actuators output the required forces to the mechanical system, which respond by moving within their motion constraints. Multibody system dynamics is the basis of the mechanical subsystem modeling and it includes description of the bodies, joint, contacts and tires, for example. In a multibody approach, the set of position coordinates can be defined using generalized global or relative coordinates

(Jalon and Eduardo, 2012). A selected set of coordinates is also used to define the bodies' velocity and acceleration in the system. To express the equations of motion, the system's dynamic equilibrium must be defined. This equilibrium can be obtained by employing an approach such as the principle of Virtual Work. A multibody system is a constraint system, so the constraints must be considered when defining the equations of motion. There are several ways to express the equation of motion such as coordinate partitioning, the penalty method, and the augmented Lagrangian method (Bayo and Ledesma, 1996), the collision response model, (Korkealaakso et al., 2007), and a lumped LuGre friction model (Astrom and Canudas-De-Wit, 2008). Further, the hydraulic system model describes the actuators and is often based on lumped fluid theory, where the hydraulic circuit is divided into discrete volumes with the assumption that the pressure is distributed equally (Watton, 1989).

Such software technologies helped decrease cost and increase simulation's performance to model and predict real world, and as a result, real-time simulation's ability to solve problems increased. In addition to the reduction in real time simulation modelling cost, the techniques have been made more available and accessible to a large number of users for multiple applications (Bélanger and Paquin, 2011). The need for real-time simulation has emerged from the importance of properly understanding the needs and wants of customers during the product design process, thus involving customers in the actual process through a virtual prototyping experience with real-time simulation tools.

During real-time simulation, the amount of real time required to compute equations or the system's functions needs to be synchronized, shorter, or faster than the simulation time-step so the real-time simulator performs with an acceptable resemblance to its physical counterpart in the same expected performance (if the equation or state of the simulated system is solved accurately (cf. Bélanger and Paquin, 2011). For each time-step, the simulator takes certain actions that are the same for each, as follows (Bélanger and Paquin, 2011):

1) Reading inputs and generating outputs

2) Solving model equations

3) Exchanging results with other simulation crossing

4) Waiting for the start of the next step

As implied in the previous steps, all the output data can be exchanged and shared. This potential creates another form of communication between stakeholders, which could include current or potential customers; other dealers involved in the sales action, such as sub-retailers and wholesalers; partners and investors; or any other party that makes use of the simulator-gathered real-time data.

Traditionally, product and service development decisions are made, for the most part, by the few experts tasked with directly addressing development issues and questions (Mohr et al., 2010; a certain approach could be even paternalistic, see e.g. Baden-Fuller and Haefliger, 2013). In this approach, if asked, often customer needs and wants are solicited via verbal or written interviews. For a completely new product, this approach is challenging, as it is tricky to describe a concept-level product to customers and equally difficult for customers to fully understand the advantages or disadvantages of the resulting product. Furthermore, if the product contains a radical innovation, customers may not even be able to articulate what their specific needs related to the product would be (Mohr et al., 2010).

This problem can be alleviated by developing real-time simulation-driven processes, which can be accomplished, in practice, by developing a toolset that allows the multiple stakeholders access to machine research and development, production planning, and customer services through virtual worksites, providing fully configurable, real-time, virtual prototyping. To this end, it is critical to employ server-based virtual environments, as described in Figure 1. With a server-based virtual environment, any number of stakeholders can simultaneously work with the virtual machine; the environment also allows setting up and modifying models within it. All in all, these processes can function as tools for open innovation and crowdsourcing (Füller et al. 2013).

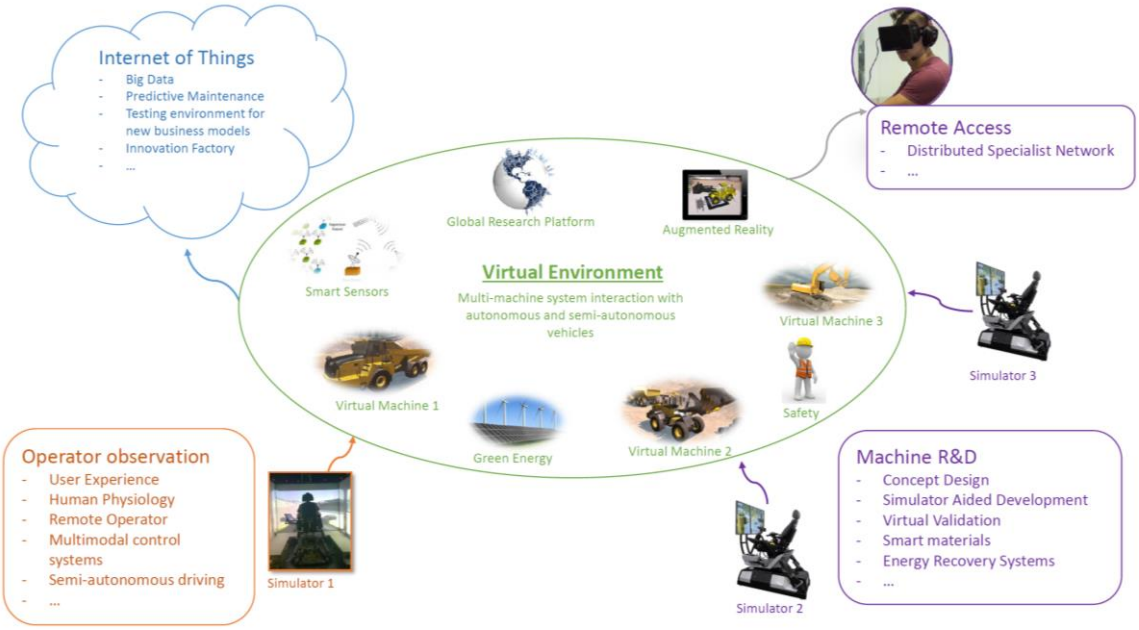

Figure 1: Virtual Environment (Mevea, 2018a, b and c). Courtesy of Mevea.

2. Business Model Canvas as a Tool to Analyze Value Chain

As mentioned above, it is challenging for upper and middle management to understand the new and emerging needs of their businesses and adjust to them by innovating and updating their business models. However, it is of great importance to innovate and update business models to ensure that they can fully benefit from the new technologies introduced to the industry and that their value reaches customers.

Studying the benefits of real-time simulation helps companies better capture their full potential value and use it extensively. With this use comes the need to adjust the business model to provide customers and other players in the value chain technological value. This can be done by considering and applying real-time simulation to different actions along the value chain. However, first, we need to clarify the business model canvas to identify exactly where this technology functions best.

As Osterwalder (2010) described, “The business model describes the rationale of how an organization creates, delivers, and captures value”. His idea also identified nine building blocks (forming the business model canvas), as follows:

Value proposition represents what the company is offering and makes customers consider buying. It shows the bundle of services and products that create value.

Channels are the way the company intends to reach its customers and deliver its products or services by different means of communication, distribution, and sales.

Customer relationships comprise the connections that a company establishes with each of its customers. These relationships could be automated or personal to create a customer base, retrieve customers, or increase sales.

Customer segments are the people that the organization is creating value for, that is, its most important customers. The company can serve one or more customer segments.

Revenue streams form how the company makes money. Here, managers have to determine what customers value and what they are willing to pay for.

Key resources are the most important assets in the company that could be owned by the company, rented from partners, or rented to other companies. These assets are important to offer value to customers, build relationships, and gain revenue.

Key activities serve as the most important activities for the company to deliver value, maintain customer relationships, and make revenue. They vary depending on the type of business model.

Key partnerships constitute the partnership network of suppliers and partners. These partnerships take the shape of cooperation, joint ventures, alliances, and buyer-supplier relationships. The partnership network is especially important, as it optimizes and creates economy of scale, reducing the risk of uncertainty and granting the privilege of acquiring a particular resource or activity the company needs.

Cost structure is understanding what the company must pay to create and deliver the value proposition. Cost structure has an effect over different blocks in the business model, including value proposition, revenue streams, and customer relationships in the long run.

This business model canvas has made previous assumptions regarding one coherent and understandable business model, which has made it easier for companies to follow these steps and compare themselves to other companies' models (Osterwalder and Euchner, 2019).

Innovating business models seems to be a method for companies to commercialize innovative ideas and technologies, but also complements other forms of innovation, including process, product, and organizational innovation, allowing new possibilities for collaborations. Chesbrough and Rosenbloom (2000) wrote that it is important to have a proper business model that works with a company's new technology to create value from it and manage not only technological uncertainties, but also economic and market uncertainties. Chesbrough and Rosenbloom (2000) also explained that learning and searching for effective business models makes it more likely to successfully adopt technology. This search ensures that market needs are discovered and customers receive the full value from it. Zott et al. (2011) came to the conclusion that the business model has an important role in unlocking the potential values of using technologies and converting them to potential outcomes. That is why we believe companies can benefit from modifying their own business models to use real-time simulation. This way, they are able to compete and fully benefit from it and reflect values to their customers as will be explained in the following section.

3. Applying Real-time Simulation in Different Value Chain Activities

3.1 Applying Real-time Simulators in R&D and Product Development

Real-time simulation is being applied in many fields, including traffic, movies, gamification, and HVAC (heating, ventilation, and air-conditioning) systems (Pell et al., 2016; Jaiswal et al., 2018; Trcka and Hensen, 2010). Companies are thus gaining awareness of the advantages of using simulation to improve their businesses. For that reason, we see more companies, such as Siemens and other German machine tool vendors, developing simulation procedures that use data from real physical machines (Rubmann et al., 2015). According to Rubmann and others (2015) this procedure has allowed operators to test and optimize the machine's settings for upcoming products in the virtual world before completing the actual makeover in real life, thereby lowering the setup time for the real machining process by as much as 80% and increasing production quality.

Product development is essential because it can influence organizations' competitive success, adaptation, and renewal (Brown and Eisenhardt, 1995). The vast amount of literature focusing on product development has described numerous reasons for

successful new product introductions, as well as reasons for failure. A few of these reasons are addressed here. Ancona and Caldwell (1992) discovered that the most successful product development teams engaged in a wide-ranging external communication strategy, combining so-called ambassador and task coordination behaviors, that helped them secure resources, gain task-related information, and eventually enhance their performance. This type of communication strategy connects product development to various stakeholders, and in our opinion, there is analogy between Ancona and Caldwell's (1992) ideas and the use of real-time simulation in product development. Von Hippel (1982) showed that a real-time simulation process makes it easier for a company to make customers an important resource for their product development efforts. Djelassi and Decoopman (2013) reported that crowdsourcing can be helpful in mobilizing selected customers. Crowdsourcing can be defined as "the act of a company or institution taking a job traditionally performed by employees and outsourcing it to an undefined, generally large group of people in the form of an open call" (Howe, 2006a, 2006b). Crowdsourcing is a form of user-driven innovation and value co-creation through which companies can apply individual innovation (Hopkins, 2011). Real-time simulation can be used as platform which fosters crowdsourcing based outsourcing.

One example of using a "virtual machine" in product development might be its application in the development of new car models. Taking a simulator-driven approach would enable the recruitment of a large number of test drivers who could then test-drive several (virtual) prototypes or beta versions. This approach combines the classic idea of testing various product versions with customer-driven innovation. If this virtual machine approach is well-executed, test users can experience virtual driving under assorted conditions and with different vehicle features over a substantially shortened schedule.

Receiving customer feedback effectively during the early phases of product development is an important benefit of a simulator-driven process, as it enables the involvement of a large group of potential users in the development process. To better involve potential users, though, game-like elements can be added to the testing platform. Indeed, gamification can boost test users' commitment and even encourage the participation of yet a larger number of participants (Hamari et al., 2014).

The R&D real-time simulator approach offers benefits for both the product development cycle and the product itself: for example, better concept design and material savings for the final design, which are optimized based on data from a larger pool of potential users than would be available using classic marketing research methods.

This real-time simulation benefit type could be very common in companies that have a complex and expensive production process (cf. Bélanger et al., 2010; Jaiswal et al., 2019). Factories that are responsible for developing agriculture machines, for instance, require a lot of effort and resources during the model development process, so a tool that can minimize risks and test machine settings before producing the actual model is much welcomed. This is how the real-time simulation can be utilized during the R&D process. It has proven to be an effective tool for machinery design, as the simulation model makes it possible to quickly understand how a machine's dynamic behaviors are affected by changing design variables. It can replace experimentation and consequently accelerate product development. Mevea (2018b) discussed that virtual prototyping in real-time simulation achieves significantly shorter lead times and decreases the cost of prototyping by reducing the need for numerous physical prototypes. It also tests the individual components of the product, how it works together in the environment, and the task it was designed to operate on. Operator experience is critical when considering machinery's dynamic performance as well. In real-time simulation, a machine operator can actively engage with the machine's dynamic performance, so the training simulator should feel and behave as realistically as possible. This is only possible if the real-time simulation model accurately accounts for the mechanical components' multiphysical behaviors in response to actuations and contact behaviors in accordance with control algorithm instructions.

3.2 Applying Real-time Simulators in Training

Real-time simulation techniques are also being used to develop advanced operator training simulators, as they could perform in place of real machines. Compared to traditional training methodologies, simulation-based user training provides a number of advantages. Mevea (2018a) indicated that simulation could be used to generate training data, as well as test solutions that can be used after training in various

scenarios. For example, while training operators, real-time simulation gives them experience in likely operating environments subject to a variety of adverse environmental conditions, such as wind, rain, or fog. In each case, the simulator can teach the operator how the machine “feels.”

Accidents or injuries to personnel or property that might otherwise occur as an inexperienced operator learns on an actual machine can also be avoided. Moreover, the simulator can be used to take operators through various accident scenarios and instruct them on the most appropriate responses. This application is most beneficial for high-risk jobs. For example, Finnair Flight Academy uses real-life simulation to train its pilots and crew members, who carry the risk of harming theirs and their passengers’ lives (Finnair Flying Academy, 2018). With this technology, they are able to simulate physics, the flying process, the flying system, and the environment. Thus, training that has zero possibilities of any negative consequences is necessary, and that is where real-time simulation is needed the most, as it provides actual experience with genuine real-time data to prevent accidents.

Further, the traditional training process requires the use of real machines, so the machine is extracted from real usage in producing outcomes. Therefore, another reason to use real-time simulation in the training process is so real machines are still in full capacity and do not take from revenue-generating work. Thus, simulation-based user training frees up existing machine capacity, making it available to carry out productive revenue-generating work while simultaneously saving costs and environmental damage.

3.3 Applying Real-time Simulators to Predict Faults

In the extant literature, most real-time simulation-related articles focus on the computational aspects of the subject, or for computational purposes, such as developing systems and software algorithms, while only a little attention is given to problem-solving aspects (De Souza et al., 2014). Some researchers have even discussed the use of simulation to conduct real-time tests. De Souza et al. (2014) explained that these tests are to develop new embedded algorithms and control techniques for dynamic systems: for example, motors, industrial processes, automobiles, and aircrafts. On the other hand, real-time simulations can also solve

problems in different value chain processes, including design, production, and even aftersales services while the machine is already operating.

Trcka and Hensen (2010) mentioned how real-time simulation can also be applied to make the production processes more flexible, as they were able to prove that real-time simulation tools can be used during building operations to predict and monitor performance and detect and identify abnormalities in system behavior. Real-time simulation enabled the system to predict machine errors, so this capability can be benefitted from in the R&D stage, as explained earlier, or while using the machine. For instance, when real-time simulation is used on an operating machine, its faults could be tracked to predict when the machine will break down. To stop such an accident before it happens, the machine could be fixed in a short time after contacting the service provider for preventive maintenance. This process would save time and effort, and most importantly, the machine will not be extracted from productive revenue-generating work for a long time. The company will not be exposed to a panic situation as if the machine were to suddenly break down, and that is why companies are moving toward predictive maintenance based on the real-time simulation (cf. CIMData, 2018).

Mattera et al. (2018) explained how simulation can be used to reduce buildings' energy consumption by predicting faults as well. The simulation in this case would be used to predict the optimal amount of used energy during different environmental conditions so that any deviation from the optimal case would be noted to maintain sustainable and environmentally friendly consumption.

3.4 Applying Real-time Simulators in Services

Outsourcing is a growing trend that began with the outsourcing of elements of the manufacturing process (Hatonen and Eriksson, 2009). The trend has continued to include other business functions, such as human resource management and R&D. Many multinational enterprises, such as PC manufacturers, outsource all their major technology requirements, implying that technology is not seen as key to their success or a necessary core competency (Buckley, 2011); more value can created in other activities like branding. The market research agency Research & Markets (2015) actually forecasted an 8.1% annual growth in R&D outsourcing from 2015 to 2019. Another key reason for this outsourcing development trend is virtual R&D, which offers

benefits such as cost efficiency and reduces heavy internal R&D investment risks. However, virtual R&D is also specialized activity. As a result, there is room for R&D- and innovation-shrewd companies to provide virtual environments and simulator-driven processes to their customers. An R&D company can collaborate with an actual machinery producer and provide the necessary user data collection and testing. Additionally, it may not be cost-efficient for every company to develop expertise in market research or integrate product development processes because their new product releases may be infrequent. A company specializing in providing these services could thus benefit from economies of scale and more-established knowledge bases, making this business model a tempting option. Real-time simulation methods could be used for marketing research as several test users can try virtual models efficiently.

One example of outsourced R&D is the pharmaceutical testing for Food and Drug Administration (FDA) approval in India by Indian firms. Due to lower costs and an abundant educated workforce, many firms have started in India that offer services to Western pharmaceutical companies (Manavalan and Sinfield, 2017). Information technology and protocol standardization allow drug testing to be performed in a much more cost-optimized way than before. This has given rise to a multitude of companies that specialize in a particular phase of the drug development R&D process. Similarly, by focusing on real-time simulation technologies, companies can offer outsourcing services in a particular segment, such as heavy vehicles and machinery, to services to include customers and users in the development process. From these events, the manufacturer can receive market data and valuable knowledge regarding potential customers' preferences.

3.5 Applying Real-time Simulators in Sales and Marketing

Schneider and Hall (2011) reported that the "biggest problem" in a problematic new product launch is "lack of preparation." They suggested that because companies are often so focused on designing and manufacturing new products, they do not put enough effort into marketing them until it is too late. An immediate and more realistic idea of different value drivers becomes available by introducing community-based, real-time tools that simulate real-world functionality for potential customers. Simulation

can substitute real observations and provide expansive realistic data. This information on how potential users may cope with different situations can then help marketers and salespeople optimize products for their intended customer bases.

A product with a catalogue of value-creating features serves as a practical example of using simulation to enhance marketing and sales. For example, a car dealer could use a simulator to give potential customers the opportunity to test the effects of a car's various available options (e.g., more effective engine). The ease with which customers could try out these extras in real-life scenarios may result in more of them being sold, which boosts the bottom line for the dealer. Simulations can also provide information about intangible attributes, such as feel, which are less frequently addressed in customer surveys, for example. This would also lead to cost savings for the car dealer, who would be able to stock fewer cars for test drive purposes.

In general, the advantages for marketers and salespeople can be found in customer value analysis, user training, and product demonstrations. Real-time simulation lets more people participate in the testing phase, as well as in further phases of the product development lifecycle. This provides information for various marketing activities and market research. Simulation data can also be "topped up" with interviews after the simulation itself, where user behavior can be observed in real time by the marketer. Further, marketers may be able to develop their market information capabilities, i.e. the processes by which firms can learn about markets and apply this market knowledge (Vorhies and Morgan, 2005) along the way.

3.6 The Effect of Real-time Simulation on Business Models

The aforementioned effects of real-time simulation on the value chain will cause changes in the overall business model. If real-time simulation is used during the development process, for example, it affects effort and time, as the simulation reduces the need for physical prototypes and thus affects cost and resource demand. The business model's role is to create a way for the business to capture value and deliver it to customers. In this way, we find similarities with the value chain that aim to pinpoint the actions that add value to products.

If a company is using new technologies, it will need more human resources in knowledgeable experts in the given field. This is a way for the company to adapt to

market competitiveness by modifying its human resources, as well as the financial resources needed to apply the simulation. Thus, the enterprise's key resources are affected as well.

The business model would face some changes regarding the company's key activities. When it starts using real-time simulation, more data can be gathered from the machines, leading to a greater possibility to incorporate activities that benefit from this data: for example, providing accurate aftersales services by predicting faults using the machine's real-time data. Another way simulation can affect business activities is providing training services for employees or customers.

Combining the gains of real-time data, some B2B companies could benefit from certain partnerships with other firms that provide services with these data, so real-time simulation provides opportunities to network and cooperate with other partners and increase its activities and the value proposed to its customers.

Value proposition could be the most affected block of the business model, as real-time simulation allows many benefits to transfer to customers. One of these benefits is customers' chance to give feedback and participate in developing products and services so that value can transfer to a wider audience. Predicting faults, training, and maintenance could be used with the help of real-time simulation, thus creating more values to pass on during the aftersales services process, as real-time simulation allows the data to be tracked through the whole product lifecycle, leading to greater customer benefits.

Real-time simulation could affect a company's relationship with customers, as when they are involved during different processes—from R&D to when the product or service is in their hands and being consumed—due to the ability to share real-time data. This may increase customers' trust in and loyalty to the company after being able to track the data through the product lifecycle, which will make them feel safer[2].

Customer segmentation could be divided due to the company's introduction of real-time simulation into those in favor of utilizing such new innovative technology and those who are not. This technology could also add new segmentation according to the

[2] Brettel et al. (2014) point out that one key obstacle to the establishment of close collaborations between companies is the absence of trust: This stems from the fact that many managers are not used to share critical information with other companies.

demand for the services and benefits presented by real-time simulation. If the company targets one of the previously mentioned segments or more, the new technology will generate a new type of customer interested in the benefits that real-time simulation has to offer before and after the buying action: for instance, customers interested in the data collected from their purchased machines and who want to use it for different purposes to achieve their goals in predicting faults, reducing costs, or finding optimal machine usage.

Company stakeholders could communicate and share real-time data as well. Thus comes the need for new and effective communication channels to distribute information between HQ and dealers, for instance. As for physical channels, simulation could optimize distribution channels to cover as much area as possible with the right timing and amount of products where needed. If real-time storage and vehicle status data is available, the company could further optimize its distribution channels as accurate input data will help the simulation to model the situation in a more detailed manner.

All these real-time simulation benefits would eventually affect company revenue both directly by adding more activities and services to the business model or more value to propositions and optimizing offerings (which could increase sales), and indirectly by decreasing costs during R&D, marketing, and other value chain processes.

4. Discussion and Conclusions

Real-time simulation is a complicated concept for non-specialized managers. Thus, they have to properly understand its functions and applications to correctly employ it throughout the business process model and reap full benefits. This chapter presented some of these applications in different value chain activities such as R&D, product development and marketing. Notably, advanced simulation technologies make it possible to describe increasingly complex mechanical systems, so these technologies' potential benefits and uses should be considered. When R&D and in-house product development function is using real-time simulation techniques, which seems to be a starting point for many companies, it may also mean that manufacturing companies could proactively begin to enhance their market research and customer interface management competencies alongside real-time simulation skills in the future.

In our opinion, real-time simulation has clearly advantages. We believe that simulations can lead to better success rates in new product launches, as well as cost savings; still, this type of R&D operation model and product development requires “capability upgrading” from manufacturers, as they require new skills to manage various stakeholders, for example. Required marketing capabilities may also relate to the product development processes, for instance, by which firms develop and manage product and service offerings and market information management (Vorhies and Morgan, 2005).

Marketing and sales can also benefit from virtual environments. In a survey focusing on the success factors of Israeli high-tech start-ups, the respondents gave high importance to product perceived utility, comprehensive market knowledge, reliable marketing plans, and the marketing and R&D relationship (Chorev and Anderson, 2006). Real-time simulation, when used properly in marketing and sales activities, is able to enhance all these factors. As customers are able to test the product in virtual environments, they are able to experience the different utility benefits of the given product. At the same time, marketing and sales personnel are able to learn about the market, that is, their existing and potential customers. This learning should lead to more reliable marketing plans that match targeting, segmentation, and unique selling propositions. Training as a value-added service may also become more integral in product offerings, which would increase sales. Furthermore, if this information, stemming both from simulation and face-to-face interactions with users, can be communicated to R&D via functioning market information management systems, the added value from marketing and sales activities can be used to enhance the whole R&D and product development process. Therefore, we still need to distinguish the required marketing and sales tactics for various customer segments, as their experience and usage needs may differ.

The use of real time simulations for various purposes can also be a challenge for companies. For example, the large pool of data stemming from simulation users may also be difficult to digest. Hence, outsourcing of simulation activities might be a viable option for many manufacturing firms, which provides opportunities for companies to master this part of the product development process in the value chain. For R&D firms which may get the contracts, though, there may be a need for capability upgrading in relationship management.

This chapter presented the possible uses of real-time simulation in different aspects of the value chain, starting from product development and continuing to when the product is already in the customer's hands. Mevea (2018c) told that the possibility of analyzing machines uses data with digital twins to gain valuable insight into product behavior. This enables operators and consulting companies to find ways to improve machine use. Training as a part of the companies' customer service or for its own employees could benefit from simulated scenarios in different environments as well. Predicting faults is another benefit that real-time simulation can provide, whether it is during R&D or while operating machines, which can save time and resources. This chapter also mentioned the use of this technology during the R&D, sales, and marketing phases, as well as in the service field, aiming to guide managers and bring awareness to this innovation's use and how it affects business models. Ultimately, real-time simulation was found to have an impact on the business model canvas's nine blocks. Still, changes in business models may differ depending on the industry and the market in which the company operates. This chapter accordingly displayed a general idea that can be adjusted to match a company's situation at hand.

As for future research, it would be beneficial to further explore the benefits of the data gathered by real-time simulation and how it may affect machine learning, and how real-time simulation in the value chain can affect different business model blocks. Artificial intelligence is being used on a larger scale as well, therefore influencing more research on the subject. According to Gartner (2018), 14.2 billion connected things will be in used in 2019, though that total will reach 25 billion by 2021, producing an immense volume of data. Thus, this data is driving growth in artificial intelligence, leading to a greater possibility of the use of real-time simulation to teach smart machines that are capable of learning. Another possibility for further research would be to specify the effect and use of real-time simulation in certain industries to explore how it benefits variety or stabilizes in relation to the industry employing this technology.

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