INDUSTRY 4.0 IMPLICATIONS IN THE AUTOMOTIVE AFTERSALES SECTOR IN SOUTH AFRICA: A LITERATURE REVIEW

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ABSTRACT

Industry 4.0 is currently a hot topic that has gained swift momentum across various industries and disciplines in recent years. It is therefore not surprising that several transformation frameworks have been developed for specific industries, to assist organisations to prepare and align themselves adequately for the change management required to usher them into the next era of Industrial Revolution. This paper provides a literature review of Industry 4.0 in general, where after the implications thereof in the automotive industry, and more specifically the automotive aftersales sector, are discussed. After considering existing Industry 4.0 transformation frameworks, the author proposes a transformation framework for the South African automotive aftersales sector.
1. INTRODUCTION

The fourth industrial revolution, also referred to as Industry 4.0, is a subject that has been gaining increasing focus in recent years. See Figure 1 for a Google search trends analysis for the terms “Industrie 4.0”, “Industry 4.0” and “Fourth industrial revolution”, which indicates a rapid increase in interest since 2013.

![Google Trends progression for the terms “Industrie 4.0”, “Industry 4.0” and “Fourth industrial revolution” for the period January 2011 to February 2018; a score of 100 relates to the peak in popularity for a specific term.](image)

The preceding industrial revolutions marked periods in history where a significant technological advancement drastically altered the way in which we manufacture product, and ultimately the way we as humans do business. The first industrial revolution was ushered in with the advent of mechanisation mainly through steam power, which spanned the period from the mid-18th century to mid-19th century [1]. The revolution changed the economy from being agricultural and handcraft based, to an economy based on manufacturing and industry [1]. The second industrial revolution is attributed to mass production, assembly lines and electricity. This revolution spanned from about the mid-19th century to early 20th century. The third industrial revolution commenced as a result of automation and the development of computers, which started mid-20th century. The fourth industrial revolution, which is the focus of this paper, is currently gaining momentum across most industries; the implication of which will be discussed in more detail.

There is a general cautiousness and uncertainty in established organisations regarding Industry 4.0, which hinders investment and ultimately the transitioning into an Industry 4.0 organisation. This uncertainty stems from the high complexity of the topic, as well as a lack of guidance via roadmaps, frameworks or models [2][3]. This paper aims to shed some light on the complexities surrounding Industry 4.0, as well as provide a theoretical Industry 4.0 transformation framework for the South African automotive aftersales sector.

As we are currently in the transitional period between the third and fourth industrial revolution, this paper will provide an overview of Industry 4.0 developments in context of the automotive sector, and also specifically examine the factors influencing the South African automotive aftersales sector. From the literature review, an Industry 4.0 transformation framework is formulated and proposed for the automotive aftersales sector in South Africa.

1. OVERVIEW OF INDUSTRY 4.0

As indicated in Figure 1, the term “Industrie 4.0” was the first to gain popularity. This makes sense as the term was first used in the Hannover Fair in 2011, whereafter the concept was finalised in 2013 by a German task team led by Siegfried Dais, from Robert Bosch GmbH, and Henning Kagerman, from the German Academy of Science and Technology [4]. The task team defined Industrie 4.0 as “a collective term for technologies and concepts of
value chain organisation which draws together Cyber-Physical Systems, the Internet of Things, and the Internet of Services [4][5]. McKinsey’s formulated a definition specifically related to manufacturing as “digitization of the manufacturing sector, with embedded sensors in virtually all product components and manufacturing equipment, ubiquitous Cyber-Physical systems, and analysis of all relevant data [6].”

McKinsey & Company have asserted that the imminent era of digital transformation will yield an assortment of new technologies that would change the way things are made. They believe that to gain most of Industry 4.0, organisations will have to invest in the following four dimensions; (1) Data, computational power, and connectivity; (2) Analytics and intelligence; (3) Human-machine interaction; and (4) Conversion of the digital to physical world. Even though it is becoming increasingly difficult to distinguish between these four dimensions due to interdisciplinary development, we will briefly look at these dimensions individually [7].

1.1 Data, Computational Power and Connectivity

Under the domain of data, computational power, and connectivity, technological developments such as big data, Internet of Things (IoT), open data and, cloud technology are featured. In simple terms big data refers to datasets that are too large for traditional data-processing, analytics programs and systems [8]. A new branch of science referred to as data science (including machine learning and data mining) was born as a result thereof. Open data on the other hand refers to data(sets) that is freely available online and which can be used for a host of applications, such as academic research, private sector use, etc., but ultimately for interoperability. According to the Open Data Handbook “Interoperability denotes the ability of diverse systems and organizations to work together (inter-operate). In this case, it is the ability to interoperate - or intermix - different datasets [9].” The Institute of Electrical and Electronics Engineers (IEEE) define the IoT on their website as:

“a self-configuring and adaptive system consisting of networks of sensors and smart objects whose purpose is to interconnect “all” things, including every day and industrial objects, in such a way as to make them intelligent, programmable and more capable of interacting with humans.[10][11]” Cloud technology is the delivery of Information Technology (IT) services over the internet rather than a direct connection to a server [12]. The internet in this sense is referred to as “the cloud”. These services include storage of data, servers, networking, software, and analytics, to name but a few [12].

1.2 Analytics and intelligence

With the significant advances in artificial intelligence and robotics in recent years, automation of increasingly complex tasks has become possible. With the latest computers able to process larger datasets at a quicker rate than ever before, machine learning algorithms have been implemented to perform a myriad of everyday tasks [8]. Examples of applications where such algorithms are being used are; online personal retail recommendations (such as Amazon.com and Takealot.com), Google Maps route calculator, Uber, Spotify, Siri and Cortana.

1.3 Human-machine interaction

Human - machine interaction (HMI) refers to the interaction between the cyber and physical worlds. HMI have evolved from a point where it was initially primarily used in the industrial sector, to control machinery, robotics, etc., to a point where it is not uncommon to be used in our homes. Examples of HMI include; virtual reality, augmented reality and touch screen devices. An example of the advancement of HMI is the Festo Exohand [13], which is a pneumatic exoskeleton that can be worn similarly to a glove. The exoskeleton enhances the strength and movement of the human hand from the outside, and the possibilities of applications are vast; ranging from medical to industrial applications. As with Festo’s Exohand, there exist a myriad of possible HMI applications which can enhance and simplify strenuous and hazardous tasks for humans.

1.4 Conversion of digital to physical world

In today’s world there exist many interfaces between the physical world and digital domain. Examples of such interfaces are provided in Section 2.3. It addition to the increased interface to the digital world, it is now becoming progressively simpler to bring about changes to the physical world through digital means. Examples include Additive Manufacturing (AM), advanced robotics and, energy storage and harvesting [7]. In their research, Dimitrov and de Beer [14] found that 3-D printing is the most extensively used AM method in the professional world.

Another example of digital to physical conversion is advanced robotics whereby there is collaboration between robots and humans [7]. Examples include robotic surgery [15] and collaborative robots [16]. Collaborative robots can assist humans to perform strenuous or even hazardous tasks, which can reduce risk associated with health and safety, as well as increase the wellbeing of the human operator.
Energy harvesting techniques and the storage thereof is of particular importance to the IoT realm, as this provides a way of sustainably powering low-power IoT devices. Energy harvesting can be accomplished through the use of piezoelectric devices (where an applied stress will yield an electrical potential), thermoelectric devices (where a temperature difference will yield a related electrical potential), triboelectric devices (where an electrical charge is produced as a result of friction applied to the material), pyroelectric devices (where an electrical potential is generated by heating or cooling the device) and photovoltaic devices (where solar radiation is converted into direct current through the photovoltaic effect) [17]. Together with the development of light-weight efficient batteries, energy harvesting and storage systems, development and production of self-powered IoT devices are increasing.

An overview of these four dimensions relating to digital transformation provided a brief introduction to Industry 4.0 developments and the most prominent associated technologies. The next section will delve into Industry 4.0 developments in the Automotive industry, aptly termed Automotive 4.0.

2. INDUSTRY 4.0 IN AN AUTOMOTIVE CONTEXT

Section 2 provided an overview of Industry 4.0 in general. This section will discuss some of the implications of Industry 4.0 specific to the automotive sector. The automotive industry is one of the industries that have made significant strides in terms of implementing and developing Industry 4.0 technologies within manufacturing as well as in its products.

The World Economic Forum, in collaboration with Accenture [18], has identified three digital themes that will have an increasing influence and effect on the automotive industry. These three themes are the connected traveller, autonomous driving and digital enterprise. These themes, as they paint a holistic picture of Automotive 4.0 developments, are discussed in more detail below.

2.1 Connected traveller

The automobile has evolved from what was mostly a mechanical and analogue transportation machine into a complex computer operated vehicle which is becoming a mobile digital communications hub [18]. In-vehicle Infotainment (IVI) systems convey entertainment and information content to drivers and passengers within the vehicle. These systems are moving towards open-source systems that are more focussed on connectedness with mobile devices. IVIs are evolving into condition and location based service, where customers will have access to services and systems on a need to have basis, similar to mobile applications today. Usage based insurance also becomes a reality where the increase of connected vehicles and telematics will enable insurers to monitor individual driver behaviour and adapt policies accordingly.

In Accenture’s World Economic Forum white paper, multimodal integration is comprehensively defined: “Multimodal connected transportation links all forms of road, rail and ferry travel, walking, cycling, all manner of automobile driving, public transit and the seamless connectivity among the modes. It brings together Original Equipment Manufacturers (OEMs), automotive and non-automotive suppliers, and government planning, tax and regulatory entities. Full-scale multimodal integration would create significant social and environmental benefits [18].” Multimodal integration is something that will not materialise in the short term, but rather the medium to long term future. The benefits of integration will lead to lower transportation costs for everyone, and ultimately lower cost of goods due to a more efficient supply-chain network.

2.2 Autonomous driving

In the truest sense of the word, autonomous driving refers to a vehicle being piloted by Artificial Intelligence (AI) without the need for human intervention. The level of autonomy of a vehicle is rated on a scale from 0 to 5, where 0 means the vehicle has no assistance systems in the form of automation, and 5 refers to vehicles that can navigate through all types of terrain and conditions, without the need for steering wheels or pedals [19]. Amongst companies currently testing fully autonomous vehicles in society is the company that was founded as a result of Google’s self-driving car project, Waymo [20-21]. Tesla states on their website that all their vehicles currently produced at their manufacturing facility have the required built-in hardware to enable the vehicle for full autonomous driving, at a more advanced safety level than that of a human driver [22]. Audi unveiled their A8 model in 2017 that will have the necessary hardware and AI ability to allow autonomous driving in slow-moving traffic conditions up to 60km/h [19]. Although the before-mentioned, as well as other major vehicle manufacturers either have the ability, or are busy developing the ability for full autonomous driving, legislation still needs to be developed for local authorities to deal with technicalities surrounding fully autonomous vehicles operating on public roads. One of the greatest threats of fully automated vehicles that are connected to the internet is cybersecurity [18]. Although fully autonomous vehicles are not yet that common in society, vehicles
have been manufactured with increasing levels of assisted driving systems, such as adaptive cruise control, adaptive light control, automatic braking, automatic parking, blind-spot assist, collision avoidance systems, driver drowsiness detection, GPS navigation, hill descent control, tyre pressure monitoring and, lane departure warning systems.

2.3 Digital enterprise

Digitisation has driven significant improvements throughout existing value chains through optimised processes, increased efficiencies, reduced costs, increased collaboration and innovation [18]. With increased innovation and new ways of doing business, organisations will shift their strategies from simply selling products to customers to customer-centric value offerings. With increased levels of available customer data and ever evolving data science methods, businesses will be able to present customer specific offerings based on their purchasing preferences, lifestyle habits, etc. For the automotive industry to remain relevant during and after the Industry 4.0 transformation, some key areas in the automotive sector will see significant changes in the short to medium term.

A connected supply chain will lead to increased transparency and ultimately increased quality of products being produced. Increased data capturing through IoT devices will enable enhanced quality control which will in turn reduce defects, shorten the component design time, as well increase the efficiency of the manufacturing and logistics processes. In the longer term, 3D printing of parts on demand could significantly change the supply chain landscape, as the lead time will be reduced and the quality of the product will increase.

The automotive industry is one of the most aggressive industries when it comes to digitalisation and automation of processes. A combination of AI, robotics and IoT in manufacturing plants have led to increased flexibility in processes, shortened cycle times and increased productivity by reducing defects. The concept of a ‘smart factory’ is considered an important outcome of Industry 4.0. Deloitte [23][24] defines a smart factory as “a flexible system that can self-optimize performance across a broader network, self-adapt to and learn from new conditions in real or near-real time, and autonomously run entire production processes”.

The biggest cause for disrupted retail is customers whom are increasingly expecting a seamless customer experience through digital and physical touchpoints. With more and more customers thoroughly researching the products online before going to a bricks and mortar dealership, dealers of the future will most likely have smaller retail showrooms where the retail experience will be strengthened by augmented reality, virtual reality, digital showrooms, etc.

The traditional method of servicing and maintenance of a vehicle will also change as more vehicles become connected to the cloud. With the development of sophisticated in-vehicle diagnostic systems, smart components and ubiquitous vehicle connectivity, the vehicle will be able to proactively detect whether a component will require maintenance or replacement. With this level of predictive maintenance, bigger failures which result as a consequence of smaller component failures will drastically reduce. OEMs will also be able to utilise the connectivity of vehicles to send software updates directly to a specific vehicle, which will allow the owner to either accept or reject the update, as is currently the case with mobile devices, PCs and even smart televisions [18].

Vehicle lifespans are increasing as a result of increased manufacturing quality. Customers are therefore on average keeping their vehicles longer than in the past. As the automotive aftersales sector primarily earned revenue by selling parts and labour, increase digitisation, electrification and improved quality of vehicles will naturally lead to a significant decrease in revenue for traditional aftersales businesses. It is therefore imperative that this sector transforms into a digital aftermarket, where OEMs and aftersales providers will be able to offer software and hardware upgrades for infotainment and navigation systems [18].

Organisations in the automotive sector have and are collected large amounts of data on existing and past customers. This data is becoming valuable in its own right, as it can be analysed by data science methods to predict customer purchase preferences, behaviour, etc. This data is therefore valuable for the creation of new business models in an automotive data marketplace [18].

Another significant outcome of Industry 4.0 would be a connected infrastructure. Vehicle to infrastructure (V2I) and vehicle to vehicle (V2V) communication are key enablers towards intelligent transport. Through communication between connected devices such as vehicles, traffic lights, parking lots, RFID readers on road, and even bridges, an integrated communication network will increasingly be established that will continuously utilise data to increase the flow of traffic and increase road safety [18].
The first three sections of this paper provided an overview of Industry 4.0 and Automotive 4.0 developments and opportunities. It is clear from the complexity and extent of Industry 4.0 disruptions that it can present a daunting challenge to organisations to figure out how to ready itself for this revolution. Prior research has been done to formulate transformation frameworks for organisations to successfully navigate into this revolution. This will be the topic of the next session.

3. EXISTING INDUSTRY 4.0 RELATED TRANSFORMATION FRAMEWORKS

This section will discuss three frameworks from literature, focussing on Industry 4.0 and digital transformation. This section will conclude by looking at pros and cons of the presented frameworks.

In a report published by Massachussets Institute of Technology (MIT) and Capgemini Consulting [25], Digital Transformation was defined as “the use of technology to radically improve performance or reach of enterprises”. In their report they endeavoured to find out how senior executives could successfully bring about digital transformation within their organisations. Their conclusion based on a study of 50 large traditional companies (exceeding annual turnovers of $1 Billion on average), which included 157 executives, was a digital transformation framework consisting of 9 elements. The nine elements of this framework are contained within 3 fundamental pillars, namely customer experience, operational processes and business models [25] as illustrated in Figure 2.

![Figure 2: Graphical representation of MIT and Capgemini's digital transformation model](image)

McKinsey and Company [6] also formulated a roadmap for the manufacturing industry to successfully transition into the fourth industrial revolution. Their research comprised a survey of 300 participants from companies in Japan, USA and Germany. The surveys were then supplemented by industry interviews and further research with critically-acclaimed individuals in terms of the fourth industrial revolution. The resultant framework from their enquiry is shown in Figure 3 [6].
Erol, Schumacher and Sihn [26] proposes a three stage transformation model for a company to evolve into an Industry 4.0 ready one, as seen in Figure 4. The three stages are Envision, Enable and Enact [26]. Where the first two frameworks discussed in this section are focussed on organisations in general, and not a specific industry, this model rather focusses on the manufacturing industry. It is however considered in this paper due to the technical nature of the service dimension of the automotive after sales industry. As the service department in the automotive after sales business share many similarities to a manufacturing environment, this model is deemed useful for the sake of completeness.

One of the biggest advantages of the discussed frameworks are the large aggregated amount of resources in terms of research hours and budget to conduct research by means of surveys and, personal interviews with industry leaders and subject matter experts. It is also noteworthy that the individual resultant frameworks, although originating through different research design methodologies, share a large proportion of common elements and themes. In light of this study it however lacks consideration of the sector and country (or market) in question. Although the before mentioned frameworks are the results of extensive research conducted by
experts in their respective fields, the multidisciplinary nature of the automotive aftersales sector demands a transformation framework that is distinctive and ordered to the sector’s unique characteristics. It is therefore necessary to consider the South African landscape relative to the automotive aftersales sector to determine these distinctives, which is the focus of the next section.

4. SOUTH AFRICAN AUTOMOTIVE AFTERSALES SECTOR

Industry 4.0 brings a host of opportunities, albeit at times in the form of disruption, to almost every industry. It is important to consider the impact thereof on the automotive aftersales sector separately.

To visualise some of the future challenges and disruptions brought about as a result of Industry 4.0, in the context of a South African automotive dealership, an environmental scanning diagram is employed (see Figure 5). In the visual representation, the contextual environment includes the elements which are outside of the control or influence of the organisation, but which has an indirect impact on the organisation’s goals and performance. The transactional environment on the other hand includes the elements which the organisation interacts with directly and which has a direct influence on the organisation’s goals [27]. PESTLE analysis is the tool which was used to consider the influences in the contextual environment which include Political, Economic, Social, Technological, Legal and Environmental aspects [28]. The McKinsey 7Ss analysis [29] is used to consider the strategy, structure, systems, shared values, skills, styles and staff, which fall under the ambit of the transactional environment.

![Environmental scanning of a generic South African automotive dealership in context of Industry 4.0](image-url)
As seen in Figure 5, the traditional South African automotive dealership consists of various departments, of which the Parts and Service departments cumulatively constitutes the Aftersales department. In this regard it is important to note that role and magnitude of the individual departments in the current model will differ drastically from the automotive dealership of the future, in terms of physical size, structure and profit contributions.

Not only does the automotive aftersales sector have unique challenges to other industries, likewise South Africa is atypical to other countries in many other areas, which may present its own challenges for Industry 4.0 transformation. South Africa has an act protecting personal information of individuals called the Protection of Personal Information (POPI) act of 2013 [30]. This requires business to take special consideration when collecting, accessing and using personal information of individuals for the purposes of offering an omni-brand customer experience and customer specific offerings by using personal information in ML algorithms.

Some of the areas outside of the control of the automotive aftersales sector that are being adopted at a slower rate in South Africa than other markets include, electrical vehicles, hybrid vehicles, focus on reduction of GHG emissions, multinodal integration, digital showrooms and autonomous driving [31][32][33]. On the one hand this is not necessarily negative, as it provides the industry the opportunity to ensure it is ready for the Industry 4.0 and Automotive 4.0 expectations. To assist the automotive aftersales sector in assuring readiness, the next session will propose a transformational framework.

5. PROPOSED INDUSTRY 4.0 AUTOMOTIVE SERVICE SECTOR TRANSFORMATION FRAMEWORK

As the Google Scholar catchphrase asserts, “Stand on the shoulders of giants”1, similarly this paper draws on the expertise of thought leaders in their respective fields of research to address a certain gap in literature; both academic and industrial. Therefore in this section, the author considers the literature presented, as well as the three existing Industry 4.0 transformation frameworks covered in this paper, to formulate a generic automotive aftersales sector transformation framework. The goal is for the proposed framework to be used as a generic theoretical framework for aftersales departments within the automotive sector, as well as a foundation for further research into Industry 4.0 transformation in this particular sector.

The three frameworks discussed in Section 4, namely (1) MIT and Capgemini’s digital transformation model, (2) McKinsey and Company’s roadmap to the fourth industrial revolution, and (3) Erol, Schumacher and Sihn’s three stage Industry 4.0 transformation model, were used to formulate a base framework for the automotive service sector. The frameworks were broken down to its’ individual elements and classified in tiers. The elements of each tier were individually considered in light of the literature review as well as the conditions of the environmental scanning diagram displayed in Figure 5. The elements which were not considered pertinent to the automotive aftersales sector were discarded, while the relevant elements were recorded. Similar elements in each tier were combined, whereafter the framework was formulated in a logical order of progression. The proposed framework, named the Automotive Aftersales 4.0 Transformation Framework is illustrated in Figure 6. The framework consists of three subdivisions, which are again broken down into individual framework steps. The three subdivisions are customer centric experience, foundation for digital operations and digitally integrated business models. These subdivisions are discussed in more detail below.

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1 https://scholar.google.co.za/
5.1 Customer centric experience

The customer’s service experience in the automotive aftersales department influences their loyalty to that department, dealership and brand, as well as their future purchasing decisions pertaining to the particular brand. Therefore, delivering customer centric experiences to each and every customer are of the utmost importance. With the wealth of available data at both OEM and dealer levels, it is possible to deliver customised service experiences to individual customers. As far as the digital customer is concerned, they want to experience a seamless, consistent and continuous process that transcends digital and physical platforms. The OEM and
dealerships need to ensure they can provide this Omni-channel experience to customers. Another potential aftersales service that will enhance the customer centric experience is the offering of a shared mobility service to customers.

5.2 Foundation for digital operations

Before aftersales departments can digitise their business processes, it needs to ensure it has the requisite internal digital capabilities in terms of hardware and human resources. Once the aftersales department is digitally ready, the business can start integrating their internal and customer facing processes with digital platforms and devices. There exists great opportunity for elimination of wastes when migrating to digital solutions, which will lead to cost savings, as well as an improved and streamlined customer centric process. Once the digital foundation has been set in the aftersales department, areas such as augmented and virtual reality can be explored, which falls under the ambit of digitally modified businesses. Lastly, the fuel for the digital economy is data. It is therefore important for the business to be prepared to store large amounts of data, which are in formats which can easily be imported into data science tools, such as R, Python, SAS, SQL, Hadoop, etc.

5.3 Digitally integrated business models

As every organisation is unique, with different internal and external factors, each organisation will need to create its own Industry 4.0 specific roadmap. The organisation can consider their unique situations by utilising tools such as the environmental scanning, PESTLE analysis and McKinsey 7S analysis tools, as described in Section 5 in this paper. From these tools they will be able to determine their internal and external success factors. Once all the previously mentioned framework steps have been implemented, the business is digitally ready for effective digital marketing. Digital marketing can be pursued before the other framework steps are implemented, however it may not be as effective because the marketing strategy will be less driven by analytical decisions based on the available data, as it is by traditional marketing decisions.

6. CONCLUSION

This paper provided a literature overview pertaining to the foreseen implications of Industry 4.0 in general, as well as in the automotive industry in particular. The universal Industry 4.0 topics were discussed under four focus areas, namely (1) data, computational power and connectivity, (2) analytics and intelligence, (3) HMI and (4) conversion of digital to physical world. The three major themes discussed under Automotive 4.0 were the (1) connected traveller, (2) autonomous driving and (3) digital enterprise. Existing transformation frameworks relating to Industry 4.0 and the digital revolution were then presented. It was noted that these frameworks, however pertinent in a general sense, were not adequate to be used in the South African automotive aftersales sector, which are affected by its own unique challenges. The author therefore proceeded to consider some of the topics in the South African environment that will influence the automotive aftersales sector and how it relates to Industry 4.0 and Automotive 4.0 developments.

The framework elements were then individually considered in light of the South African Automotive Aftersales sector and the beforementioned assessment thereof. This culminated into a theoretical Industry 4.0 transformation model, named the Automotive Aftersales 4.0 Transformation Framework.

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