Using 3D Printing Technology for Manufacturing Interior Aesthetic Components for Customisation in the Automotive Industry

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DECLARATION

I, ***Ms Nondumiso Mbambo***, declare that this business venture proposal is my work except as indicated in the references and acknowledgements sections. It is submitted in partial fulfilment of the requirements for the degree of Master of Business Administration in the Graduate School of Business Administration, under the Faculty of Commerce, Law and Management at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in this or any other university.

Nondumiso Mbambo

Signed at Scottburgh, KZN

On the 29th day of May 2024

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DEDICATIONS

I would like to dedicate this research to a beautiful person who was born during this strenuous time of completing the research, my daughter Her Royal Highness Princess Sibani Zelizwi. As your name means *Light*, you were the light that carried me through the long days and nights of research and your birth brought about it a new meaning to my final work. I hope that one day you will read this piece of work and allow it to inspire you to rise above me and achieve a higher level of intellectual curiosity.

I would like to also dedicate this work to my mother, Aurelia Noziyalo Mbambo, who was supportive of this quest from the onset and even co-funded my studies. Throughout the journey, you prayed day and night, not sparing a single day and you assured me you would only cease this prayer item the day I submitted the final work.

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SUPPLEMENTARY INFORMATION

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ABSTRACT

The research is a business venture proposal focusing on exploring the concept of automobile interior customisation through a 3D printing. The research gap of inclusivity in the current offering of the automobile interior was articulated. Theories of digital transformation, digital maturity, innovation, lean innovation and entrepreneurship were used to inform this study. The conceptual framework was developed using the variables of age, gender, customisation, connectedness and purchasing intent.

The qualitative research strategy was adopted for the research and probability sampling was used to sample random respondents. Reliability and validity were determined using CFA and SEM. The findings of the study revealed that the concept of customisation is not dependent on age and gender therefore an inference drawn was that market segmentation ought to be done by needs and preferences as opposed to demographics.

The findings further revealed that there is a need for this customisation offering as both customisation and connectedness were found to be drivers of purchasing intent. The business case for Mageza 3D printing was advised by the findings of the study where the target market was identified. The business strategy focused on the market penetration, the staggered approach in the operations rollout to 2035 as well as the marketing plan for the concept of customisation. The business showed profitability of 15% from the first year reaching 26% by the fifth year.

The main limitation of the study was in the research methodology adopted whereby the inclusion of a qualitative research strategy would have offered a more holistic understanding of concept buy-in across the value chain. In this regard, future research was recommended to assist in solidifying this business case.

Keywords: customisation, connectedness, 3D printing, vehicle interior, components manufacturing, digital transformation, 4IR technology

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CHAPTER 1 - INTRODUCTION TO THE RESEARCH

1.1. Background

This research serves to gain insight into the drivers of automobile interior customisation for aesthetic appeal as well as the drivers for purchasing intent in order to justify a business case for customisation using flexible and cost-effective means of production, namely three-dimensional (3D) printing. The interior of a standard automobile presents itself in black, grey, or woody brown colours, which are colours that may not appeal to varying customer profiles (Helander et al., 2013).

The face of the automobile driver has evolved since the introduction of the first automobile to South Africa in 1896. Drivers now span across all segments of society; across gender, age and geographical location (W. Saleh & Malibari, 2021). Customers are heterogeneous and interior automobile designs do not cater to this variability in preference thereby underestimating the importance of emotional attachment and connectedness which may influence consumer purchasing decisions (O'Cass, 2000). With 4IR technologies being widely adopted, it is now possible to achieve personal or customised solutions that are aimed at catering to the face of the modern driver as an appreciation of customer heterogeneity (Eckes, 2016).

Historically, automobiles were made to be driven by men in many countries around the world with Saudi Arabia being the last country, in 2018, to permit women to drive automobiles (W. Saleh & Malibari, 2021). Furthermore, most automobile manufacturers (OEMs) originate from Western countries thus an inference to vehicle interior designs having a Western influence and those designs in turn making their way into countries such as South Africa, where the assembly is handled (Humphrey & Memedovic, 2003). One can therefore infer that original automobile designs were, to a large extent, centred around male and western preferences, with little or no aesthetic modifications over the decades to appeal to other automobile owner or driver profiles.

1.2. Conceptualisation

1.2.1 Research problem

A few research gaps exist within the local automotive industry as it pertains to manufacturing of interior components. These include the exploitation of 4IR technologies to create manufacturing flexibility and a customised product offering within the industry, the active participation of local and previously disadvantaged groups in manufacturing within the industry, the theoretical implications of policy advancements within the South African automotive industry as well as the barriers to entry challenges faced by new entrants in this industry.

The research gap that was explored for this study is that of the exploitation of 4IR technologies to create manufacturing flexibility and a customised product offering within the automotive industry. This was done in a way which unpacks the drivers of the concept of customisation for the vehicle interior as a means of promoting aesthetic appeal. The reason behind exploring this gap is that it presents an innovative and flexible means of providing customisation which challenges traditional manufacturing within the industry. When it comes to the research gap, what one scholar may deem to be a gap may be found by another scholar to not be as such therefore it is important to substantiate why a certain area of study is identified as a research gap (Miles, 2017).

For this study, the research problem identified is that of unmet needs of inclusivity and personalisation as presented by current automobile interior designs. These unmet needs do not take into cognisance the concept of customer heterogeneity and that customers have varying preferences in relation to vehicle interior aesthetics. The research problem generally arises from issues, problems, difficulties, personal experiences or deductions made from existing theories (Onen, 2016). It is therefore defined as the unifying thread or the axis on which the research revolves around.

There is a need for the provision of interior aesthetic finishes that have the potential to create a personal connection between the consumer and the automobile within the automotive industry. Khalid and Helander (2006) argue that product success is mainly attributed to how it appeals to individuals as well as the feelings of satisfaction it brings with it. This statement emphasises the emotional attachment that customers have with their intended products of purchase. Currently, the main differentiator in vehicles is vehicle performance and technology, whilst the interior finishes are found in standard black or grey colours in lower-end vehicle models and standard beige or red colours in premium vehicle models. This rigid approach to vehicle interior design is limiting in the context of customer diversity. It is important to note that for effective value in servicing customers, a deeper appreciation of the varying needs of the ever-changing customer journey is required. By building in customer preferences for the finished products, automobile manufacturers may be able to improve their customer value propositions (CVPs) thereby increasing their competitive advantage.

1.2.2 Research purpose

The purpose of this study is to investigate the viability of introducing an innovative solution for the customisation of interior aesthetic components within the automotive industry using 3D printing technology. The study seeks to ascertain the interest and acceptance levels of customisation from the ordinary driver and vehicle owner as the targeted end-users for this business venture. This is in cognisance of the view that customer need, customer buy-in and value creation are key deciding factors for business success. Lastly, the study seeks to draw inferences that certain criteria drive the intent to purchase vehicles with customised interiors.

1.2.3 Research questions

The study serves to address five research questions to ascertain the viability of this business venture and they are stated below:

Research Question 1 – To what extent does age have an effect on the view of 3D printing for customization?

Research Question 2 – To what extent does gender have an effect on the view of 3D printing for customization?

Research Question 3 - What relationship exists between vehicle interior customisation and connectedness?

Research Question 4 - What impact does connectedness have on purchasing intent?

Research Question 5 – Does customisation influence purchasing intent?

1.3. Significance of the study

The study evaluates the relationship amongst the variables of age, gender customisation, connectedness and purchasing intent to assess interest from the vehicle owners into the customisation of vehicle interior components. It enables an understanding of the influence that gender and age have on the concept of vehicle interior customisation using 3D printing. The findings serve to inform policy makers around the exploitation of 4IR technologies in the manufacturing sector. Insight into the variables of age and gender as drivers for purchasing of customised vehicles assists marketing practitioners into target-driven marketing. The study helps practitioners and new entrants gain insight into the variables that drive purchasing intent from a business perspective.

1.4. Delimitations and assumptions of the research

Delimitations of the research concern parameters within the researcher’s control and seek to set boundaries of the study area (Theofanidis & Fountouki, 2018). The study focuses on automobile owners, drivers and potential owners of any gender and age group within the geographical location of South Africa. These respondents were assessed on their interest in the concept of a customised automobile interior and whether their sense of emotional attachment or connectedness to a vehicle has any potential influence in their purchasing decisions. The assumption made is that the research questions have relevance to the research problem being addressed and together with existing theory, bring about insightful contribution to the study.

1.5. Preface of the research

Chapter 1 begins with laying the background of the research and details the aspects that inform the concept of introducing customisation of automobile interior components. The conceptualisation section presents the research problem, the research purpose and research questions. The significance of the study presents how the study serves to give insight to various groups with notable interest within the automotive industry whilst the delimitations of the research set the boundaries of the study area.

Chapter 2 focuses on providing theory around the evolution of the manufacturing sector and the automotive industry, 3D printing technology, digital transformation, lean innovation and entrepreneurship. In this section, the study constructs or variables of age, gender customisation, connectedness and purchasing intent were introduced. Using these variables, the conceptual framework was developed to indicate the hypotheses driving the research.

Chapter 3 elaborates on the methodology used in the research, commencing with the research strategy, followed by the research design, the description of the population and sample, the research instrument, the data collection procedure, the data analysis procedure, the ethical considerations and lastly, the methodological limitations to the study.

Chapter 4 focuses on the presentation of results obtained from the data collection. This chapter details the analysis of the data using confirmatory factor analysis for reliability testing as well as structural equation modelling (SEM), a combination of factor analysis and multiple regression analysis to measure the structural relationships between the variables and their latent constructs. Each statistical test is explained in together with its relevance to the study in this chapter.

In Chapter 5, the discussion of the findings from the analyses conducted is laid out. The section delves into making associations between the findings of the study and previous studies in support of the findings as well as those opposing the findings.

Chapter 6 focuses on the business case by incorporating the findings. An alignment of the research objectives and the business need is presented in this chapter to highlight the synergy that exists between the research and the business case. The key steps of a business plan are presented, which detail the funding of the business, the financials relating to the profitability of the business as well as the timelines for the rolling out of full-scale operations.

In Chapter 7, the conclusion of the research is made with reference to the research process and content summary, the contribution of the findings to the knowledge gap and the parallels drawn from other similar studies. The limitations to the study are stated in this section as well as the recommendations to inform policy makers in the industry, marketing practitioners, new entrants to the components manufacturing space and the academic fraternity at large.

CHAPTER 2 - LITERATURE REVIEW

2.1 Introduction

This chapter introduces the theories underpinning the concept of a 3D printing business emanating from the need for inclusivity in the automobile interior offering through customisation. The background into the evolution of manufacturing, of which the automotive industry form part of, is laid out. The theory looks into the applications of 3D printing as well as other technologies in use within the automotive industry. The theories covered are digital transformation and digital maturity of the automotive industry, innovation adoption and lean innovation as well as entrepreneurship. This section introduces the study constructs or variables pertinent to the study from which conceptual framework and hypotheses are derived. The conceptual framework and hypothesis are developed.

2.2 Evolution of manufacturing and the South African automotive industry

Industrial revolutions have been embraced by societies, over the decades, as significant eras of new technologies aimed at broadening transformation and improving the quality of life. To date, three industrial revolutions have been attributed to productivity since the 18th century. The first industrial revolution emerged in the United Kingdom through the introduction of steam power and mechanized production which drove output and productivity levels. Although this increase in productivity resulted in the formation of global economies, urbanisation and the middle class (Philbeck & Davis, 2018), it was also responsible for the factory politics that excluded females in the manufacturing sector by favouring a male-dominated workforce (Purvis, 2013). This revolution thus did not drive gender inclusivity.

The second industrial revolution occurred between the latter decades of the 19th century and around 1914, this revolution was driven by science and technology thereby giving birth to manufacturing, mass production and standardisation. This era introduced several concepts and technologies that are still in use today. One concept that was introduced during this era and is still in use today in the manufacturing sector is that of economies of scale. From an invention point, this era introduced most of the technologies that exist today such as electricity production, cheaper forms of steel, gas turbines, diesel engines, the telephone, artificial fertiliser, and chemicals.

A notable effect of the third world war was a dented global economy whereby a new political order and ecosystem were needed. The adoption of systems and processes led to an era of information technology and data, termed the third industrial revolution. This revolution was biased towards skills-sets which meant an advantage for those individuals with skills over those who were illiterate (Liu & Grusky, 2013). This meant that the former group could actively participate in the economy compared to the latter which is the reason for the large disparities created over the years, especially in countries that could not actively participate in the economy due to oppression. South Africa is such a country and is recorded to have the highest levels of inequality in income globally, ranking at number one with a Gini coefficient of 63 (World Population Review, 2021).

2.3 The applications of 3D printing within the automotive industry

Additive manufacturing or 3D printing is reported to have existed for around 20 years in the automotive industry where the primary focus has been for prototyping given its flexibility for rapid design and production (Sarvankar & Yewale, 2019). According to Wohlers & Campbell (2016), additive manufacturing accounts for approximately 16% of the global manufacturing industry, with revenue projections of $ 8.8bn as far back as 2017. In another study by (Savastano et al., 2016), citing Wohlers & Campbell (2016), the automotive industry was recorded as the second-highest user of additive manufacturing at 19% which was mainly for rapid prototyping. In a highly competitive environment where time-to-market is a significant factor, additive manufacturing can provide the necessary agility through production speed and flexibility.

Notwithstanding, traditional manufacturing will still hold a dominant position in the industry given that this industry produces annual volumes exceeding 100,000 units and traditional manufacturing has the benefits of dimensional accuracy and mass production. In recent years, 3D printing has shown to be gaining traction in the printing of aesthetic parts such as side mirrors, steering wheels, interior dashboards, and centre consoles (Sarvankar & Yewale, 2019). Furthermore, the addition of colour is also possible given the various materials used in the 3D printing process.

Various automobile manufacturers have adopted additive manufacturing into their production chain. In 2017, Audi formed an alliance with SLM Solution Group AG, a leading supplier of industrial metal 3D printing machines, to produce spare parts as well as prototypes for research and development (Savastano et al., 2016). At BMW and Honda, 3D printing has been embraced for the printing of hand tools used in the assembly process (Savastano et al., 2016; Shahrubudin et. al., 2019). A closer look into the Audi automobile manufacturer showed that the printing of 3D parts is taking place for commercial purposes which is a clear indication of the traction that the technology is gaining in the automotive industry thereby contributing to the overall value chain (Savastano et al., 2016). At Mercedes Benz, the trucks division is said to be using 3D printing technology for the printing of spare parts (Lecklider, 2017). One other automobile manufacturer Bugatti, operating under the Volkswagen Group, has managed to use 3D printing to successfully produce the brake calliper, a considerably complex structure (Sarvankar & Yewale, 2019)

An area where 3D printing is argumentatively impacting the automotive industry is inventory management. Whilst most automobile manufacturers are aligning to a lean operations model in the production of their latest models, there is still a need to support the previous generation models in terms of parts (Savastano et al., 2016). This can be seamlessly achieved through the incorporation of 3D printing for on-demand parts orders thereby reducing the necessity for maintaining high inventory levels, mainly because these are older models. This could reduce consumer frustration for those customers that keep automobiles for longer periods thereby driving customer retention. 3D printing in the automobile industry may not have matured yet (Savastano et al., 2016) however, there is a perception that this market is filled with potential for embracing the technology given benefits such as cost reduction, waste minimisation, complex customisation ability and production speed.

2.4 Other technologies adopted in the automotive industry

Apart from 3D printing, the automotive industry has adopted other 4IR technologies to advance manufacturing processes. The next section introduces these sections as the following: modern-day smart systems such as artificial intelligence (AI), augmented reality, cobots, the smart-eye (also known as Machine Vision) in the production processes, the Internet of Things (IoT), cloud computing and big data.

2.4.1 Internet of things (IoT) and artificial intelligence (AI)

The interconnectedness of automobiles, through IoT, was designed to reach beyond just smartphone connections, remote emergency assistance such as panic buttons or live traffic alerts but to go as far as having self-driving automobiles with little or no human intervention. The combination of IoT and AI has led to the introduction of autonomous or self-driving automobiles (Hatani, 2020). In 2016, it was predicted that there would be approximately 10 million autonomous or driverless vehicles (Krasniqi, 2016), and to date, there are no more than 1,400 self-driving vehicles on the road (Kopestinsky, 2021) in the United States alone. These predicted numbers strongly indicate how IoT and AI had been perceived to be the biggest disrupters to the current driving methodology of human intervention. However, this has not taken shape as well as predicted due to the safety concerns and reported crashes of autonomous vehicles.

2.4.2 Robotics

Robotics is still the most common technology employed in the automotive industry from a manufacturing perspective. Collaborative robots or cobots as they are commonly known, are automated robots that assist human technicians by handling a large amount of the assembly work (Plant Automation Technology, 2021). They work collaboratively with humans in the assembly process and are intelligent enough to sense when a human takes over. This technology focuses on the vehicle assembly process in the automotive industry.

2.4.3 Machine vision

Another technology used in the automotive industry is Machine Vision, a tool for conducting multi-imaging in the production process. Considered to perform the role of an "overall eye", it assists with diagnostics during the production process to ensure the highest degree of quality (Plant Automation Technology, 2021)

2.5 Theories reviewed

2.5.1 Digital transformation within the automotive industry

This section contributes to the broader understanding of the extent of digital transformation within the automotive industry. Digital transformation is the process of using digital technologies to either create new or modify existing business processes, business culture, and customer experiences to align with evolving business and market needs (Llopis-Albert et al., 2021; Riasanow et al., 2017). Digital transformation makes use of 4IR technologies for creating enhanced value for the customer thereby driving sustainable value proposition (Pech & Vrchota, 2022).

To decode the term digital transformation, there ought to be an appreciation that it is multi-faceted. It is the streamlining of the operations of a business in a way that brings the most value to customers. This streamlining is achieved through cultural transformation, business model transformation, process transformation and domain transformation (Matt et al., 2015). Furthermore, changes in customer expectations directly influence a conscious shift in organisations to pursue new business models, new markets and revenue streams through the adoption of digital technologies (Kunonga et al., 2021).

Existing business models are gradually being disrupted in the automotive industry through the investment of OEMs into digitisation (Riasanow et al., 2017) though it is not clear which technologies will be in the leading position given the classification of information by the various manufacturers in maintaining their competitive advantage. Figure 2.1 depicts the digital transformation process.

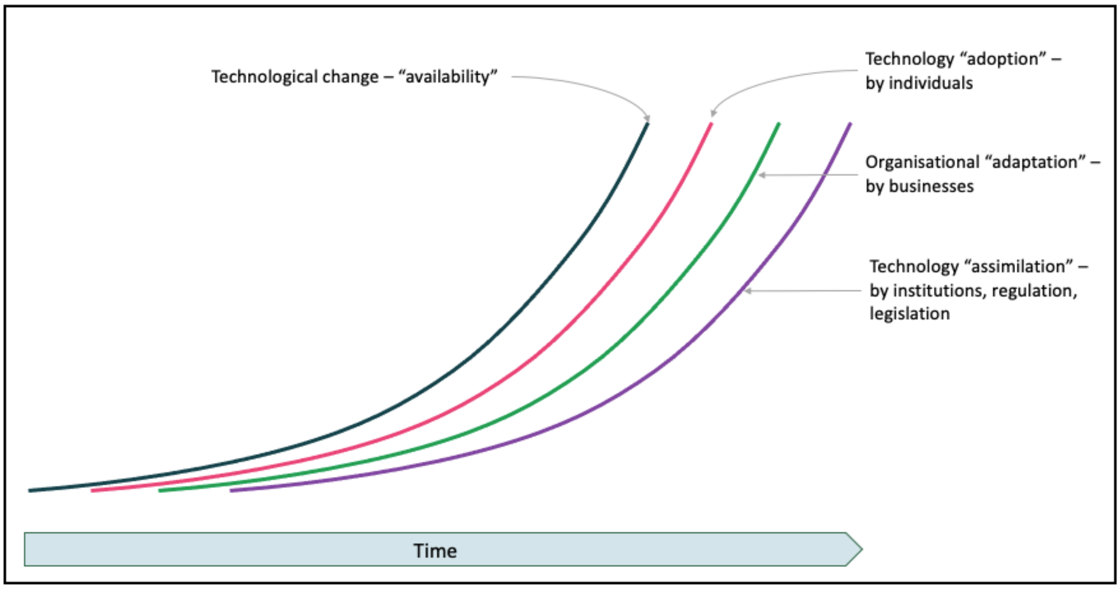


Figure 0.1: Digital transformation process by Armstrong (2020) sourced from Kane et. al. (2019)

The impact of digital transformation on existing business models is the shift from a product-centred approach to an experience-centred approach of the product life cycle (Westerman & Bonnet, 2015). This encourages businesses to create innovative solutions that stretch beyond product functionality by driving consumer experience and satisfaction. This approach could not be more relevant than at a time when consumers are overwhelmed with choices in the market. It is this experience-centred approach that will be the contributor to company success in a competitive environment.

An interesting observation by (Westerman & Bonnet, 2015) was the advancement of custom manufacturing at BMW, allowing a turn-around time of approximately one week for custom orders. Digital transformation has assisted BMW to modify its operations model by incorporating custom orders into its conventional manufacturing stream whilst aggregating demand. The author's (Westerman & Bonnet, 2015) continue to state that advances in 3D printing are fast-changing supply chain models and inventory management which allows for the printing of slow-moving or customised parts however do not explicitly mention that this is how BMW is currently achieving customisation on its automobiles.

The concept of digital transformation by Kane (2019) focuses on technological change and adoption by individuals and businesses, with the conclusion that business adoption is preceded by individual adoption. This has consequences for the application of customisation using 3D printing in the automotive industry as any widespread adoption will be informed by the degree to which individuals embraces the customisation, and hence the new technology.

2.5.2 Digital maturity process

Digital maturity describes the level at which individuals and businesses embrace digitisation. With new technologies, individuals are the first adopters as they do not have any significant dependent variables to consider in their decision-making. The next group to adopt technologies is the businesses to adapt to new norms as brought about by customer needs. Regulatory institutions are said to be the last adopters of technologies as policymaking is usually a lengthy process.

Westerman et al., (2014) presented a digital maturity model which comprised of four areas for assessing digital maturity of all industries, from beginners to those industries termed digital masters. The four areas of this model are: beginners; conservatives, fashionistas and digital masters as depicted in Figure 2.2. This model was designed to combine two separate but related concepts of digital intensity and transformation management intensity. The former refers to the level of investment in technology initiatives for driving change within a company. The latter, on the other hand, focuses on the investment in leadership capabilities to accelerate digital transformation at the company level.

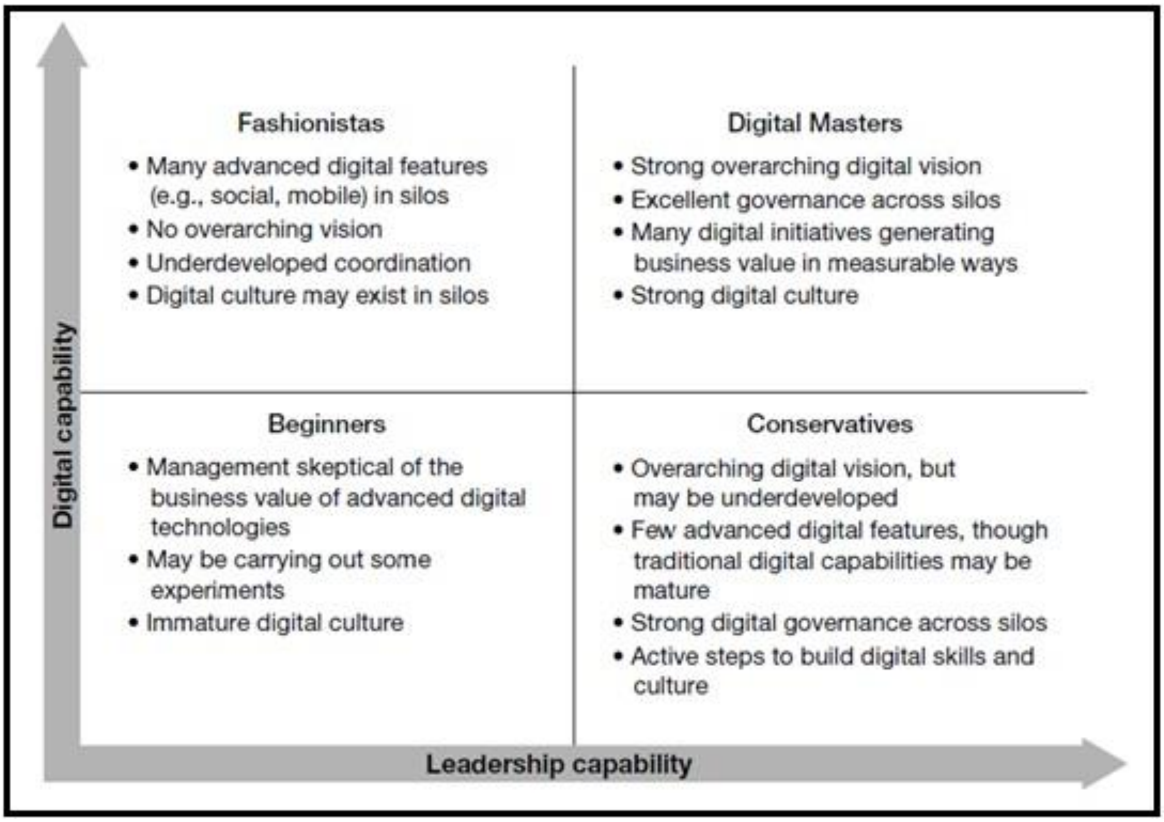


Figure 0.2: Digital Maturity Evaluation Model by Westerman et al. (2014)

Though the definitions of the maturity model are interpreted from a company or individual business level (Westerman et al., 2014) where the model assigns the different industries according to their respective maturity levels. Figure 2.3 is a representation of where the various industries are in terms of digital maturity and it is evident that pharmaceuticals, goods production and manufacturing are in the beginners quadrant meaning the infancy stage of digital transformation. For the automotive industry to enter the domain of digital masters, the OEMs would need to inculcate a strong digital vision, enforce streamlined initiatives as well as a strong digital culture.

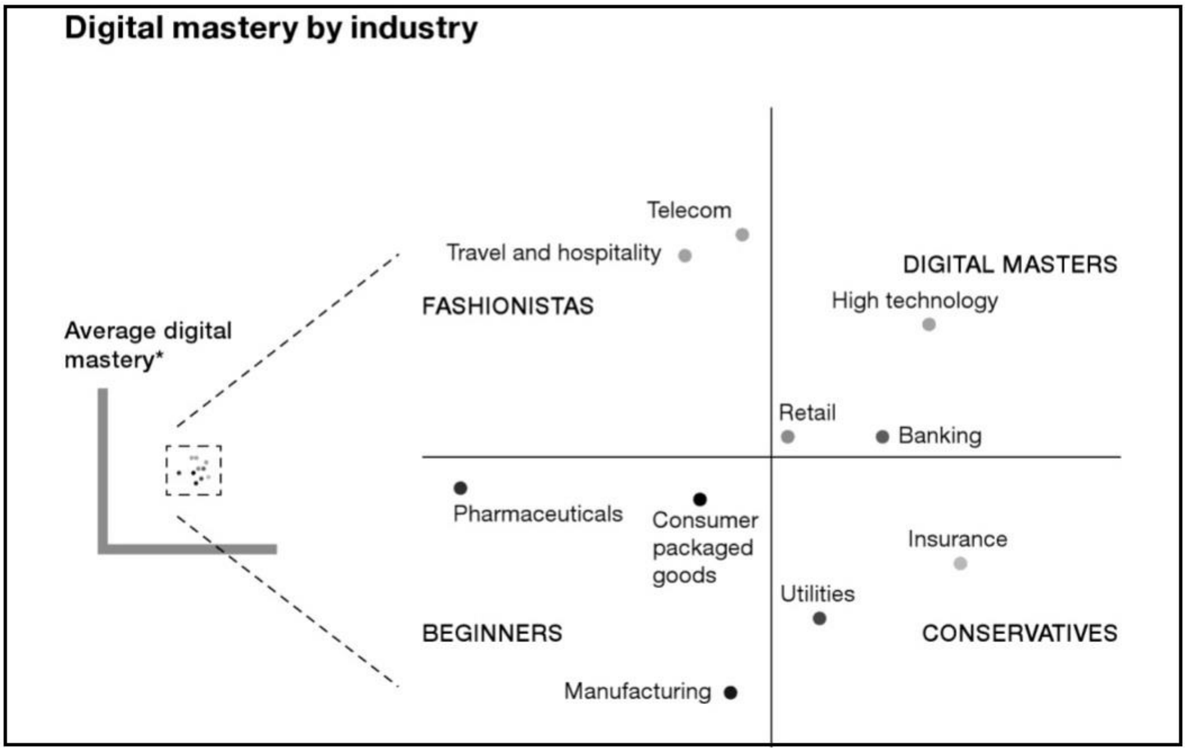


Figure 0.3: Digital Maturity positioning of manufacturing industry against other industries as sourced from Westerman et. al. (2014)

2.5.3 Innovation adoption

The term *innovation* is classified as either incremental, radical, exploratory, or exploitative (Johnson et al., 2017). According to (Johannessen, 2009), innovation is directly linked to economic growth where businesses that innovate have greater potential for survival than those that fail to innovate. This growth is brought about by the progressive innovation in both products and processes over time. The type of innovation likely to be adopted by a business is dependent on the maturity stage of a business or organisation (Johnson et al., 2017).

In developing industries, product innovation tends to thrive given the low competitive forces whereas with maturing industries the focus of innovation is more on processes as competitive rivalry compels differentiation approaches. In ideal conditions, the innovation journey is best described by the technology S-curve (Christensen, 2006; Mazouz et al., 2019), starting with the slow adoption of a product before reaching a tipping point and spiralling on an upwards growth trajectory. As seen in Figure 2.4, rapid market adoption follows this tipping point before resulting in a plateau stage as competition rises. Eventually, a tripping point is reached as a result of declining demand in the market for that particular product or service. However, because innovation is an iterative process, most innovations do not reach the tripping point as the innovation pattern allows for interruptions or pivoting for a new cycle to emerge through the innovation window (Mazouz et al., 2019).

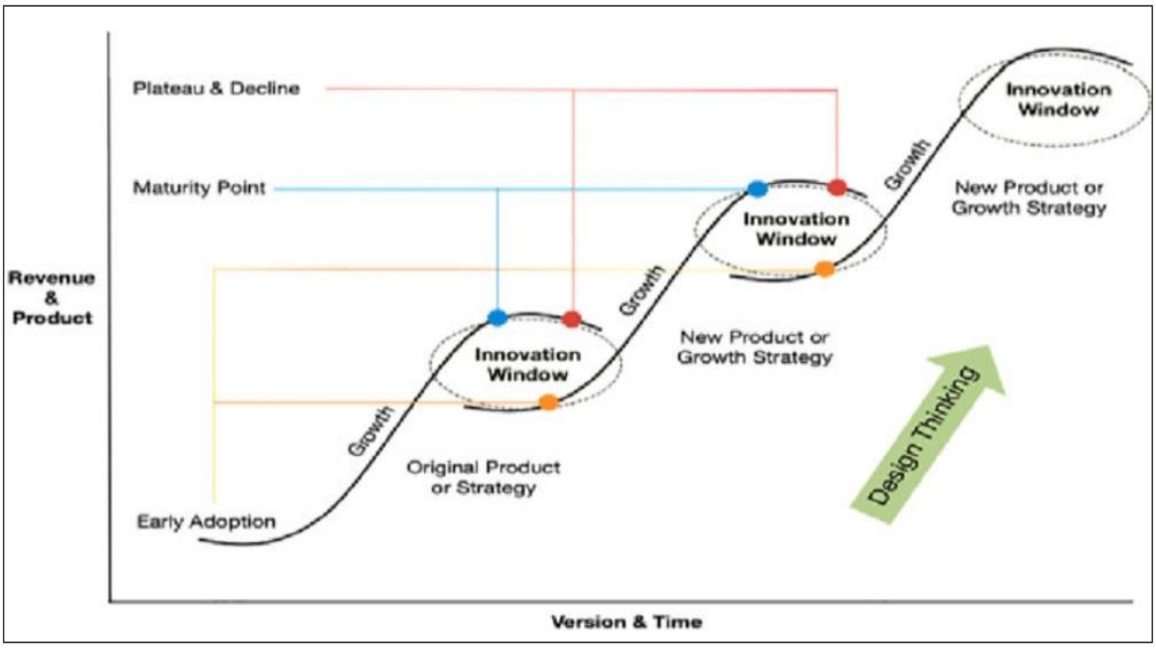


Figure 0.4: Innovation S-Curve depicting cyclical innovation windows sourced from Mazouz et. al (2019)

A decision that businesses or organisations need to consider is whether they want to be leaders or followers in innovation. Both have their own advantages and disadvantages. Waymo, a car technology manufacturer under Alphabet, decided to push their innovation to a point where they were the first to market with a level 4 autonomous automobile, outcompeting the likes of Tesla, Audi, Volvo, Mercedes Benz (Raviteja & Vedaraj, 2020).

Disruptive innovations are more prevalent in the current digital era. Businesses that embrace radical innovation are best positioned to outcompete their counterparts who in most instances are limited by their resources and capabilities. Though radical innovation may result in a first-mover advantage for a business, investing in this approach does have its risks. From a study by Johannessen (2009), innovation leaders are said to have approximately five years to leverage off their lead advantage before their innovations are fully copied by competitors. The author further states the advantage of being a follower is that the innovation adoption costs are reduced by 35% compared with the leaders' costs.

A question that most businesses would grapple with is how innovation can be cultivated without interfering with existing operations. Strategies of innovation that businesses can adopt are corporate venturing and intrapreneurship. BMW, for instance, adopted the former strategy wherein they opened up a new business unit for the mass production of the electric "i-series" automobile (Elmcrona & Persson, 2014). With intrapreneurship, some businesses are averse to this concept however with companies such as IBM and Google, their respective successes are attributed to its adoption (Johnson et al., 2017). Innovation adoption ought not to be considered only from the perspective of the business but should also be considered from the customer perspective as customers are the ones that authenticate innovation success.

In a study by Awan et al. (2019), the journey of innovation adoption is said to take a bell-curved shape comprising five groups, namely: the innovators, the early adopters, the early majority, the late majority and finally the laggards. The full spectrum of the adoption phases of innovation is depicted in Figure 2.5 where the innovators and early adopters contribute towards the early market before the "chasm" or the start of participation from the mainstream market.

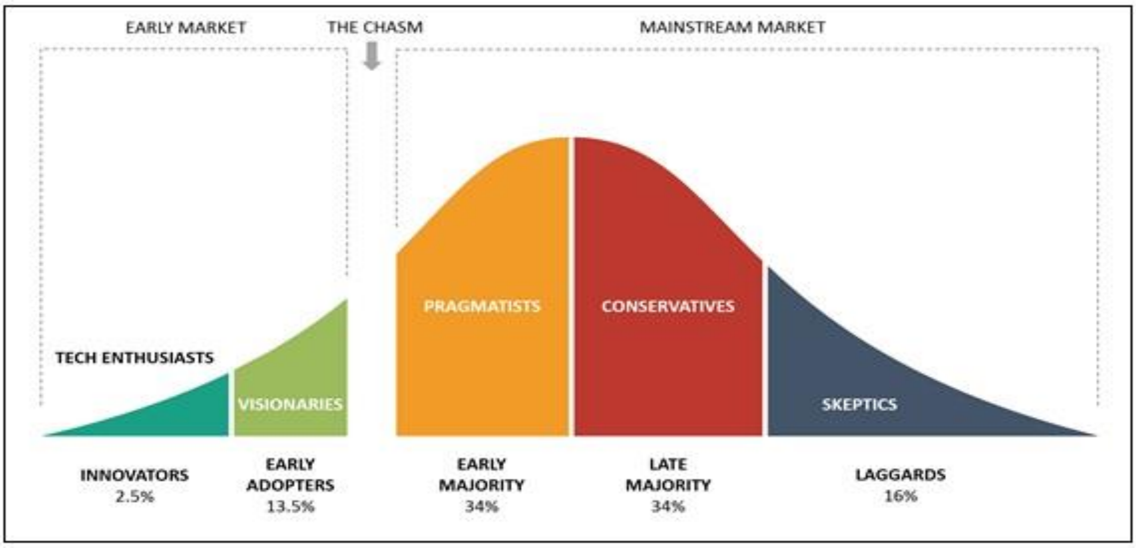


Figure 0.5: Adoption Rate of New Technological Innovations sourced from Meyer, (2011)

The first movers are the innovators as seen in the graph and make up the smallest segment. Innovation is an iterative process and not all businesses get it right, thus only a few become, first movers. After the introduction of an innovative solution, adoption begins with the early adopters. Though the early adopters are not as visionary as the innovators, they are able, however, to spontaneously identify opportunities aligned with the innovative solution and take that quantum leap. With time, the early majority joins in at an upward trajectory resulting in a saturation point being reached before the late adopters also come on board. With the late majority, the particular innovative solution would be at its mature stage and a decline in the uptake is then evident. The laggards are seen as that group that is the last to embrace innovation, after having observed its pros and cons over time and sometimes are forced to adapt due to the desuetude of previous options.

2.5.4 Lean innovation

The concept of lean thinking was introduced in the 1950s by the Japanese company, Toyota, from whence it spread, allowing manufacturing entities across the globe to adopt this concept for streamlining production processes (Balocco et al., 2019). It emerged from a change in the environment brought about by customer's needs and expectations becoming more heterogeneous. Companies that conform to lean thinking have been shown to maintain a competitive advantage over time due to a stronger focus and alignment towards customer needs. Lean manufacturing is a production process that focuses on minimising waste by aligning production with expectations from the customers, basically on-demand production. For the lean manufacturing process to be effective, production speed is a necessity so as to maintain a competitive advantage.

In referencing the works of Ries (2011), Silvi et al. (2012) mention that the contributing factor to the success of start-ups is the build-measure-learn cycle that allows start-ups to adopt a fast-learning process and a fast-to-market product introduction. The inference is thus drawn that this iterative learning cycle is what drives lean innovation in start-ups. This concept is useful in this new venture proposal as the viability of the business is dependent in part on the efficiency and cost of customisation.

2.5.5 Entrepreneurship theory

Entrepreneurship theory segments entrepreneurs into two groups, those that focus on expanding existing markets and those that focus on creating new markets through an innovative offering. The former group is responsible for increasing market competition whilst the latter is responsible for introducing ideas that are novel to society (Shahrubudin et al., 2019). Entrepreneurial activity is fuelled by changes in the environment. Where dynamic market conditions exist, innovation is required to effectively respond to those changes to maintain a competitive edge as opposed to stable environments (Matt, Hess, & Benlian, 2015). Scholars (Westerman & Bonnet, 2015) suggest that hostile environments, forged competitive rivalry as well as limited resources are a driver for increased levels of entrepreneurial activity. It is under such environments that product, service and technological innovation thrive, thus pushing entrepreneurs to act proactively. In line with entrepreneurial fulfilment, opportunity exploitation is required where entrepreneurs gain an understanding of the value by exploiting existing resources through innovation (Westerman & Bonnet, 2015).

2.6 Variables applicable to the study

The variables selected for this study are age; gender; customisation; connectedness; purchasing intent and are discussed in the following sections.

2.6.1 Age variable

In the marketing context, age plays an important role in how, together with attitude towards the past, it emanates to shape personal preferences which are then incorporated by marketing researchers into the development of a marketing strategy (Holbrook & Schindler, 1996). The age of a consumer is an important contributor to buyer behaviour based on how individuals experience changes in needs, tastes and preferences throughout the life cycle and their buying patterns corresponding to such changes (Ramya & Ali, 2016). Although this variable should be treated as a categorical variable, it is however treated as a construct to be measured to gain insight into which age group is more receptive to customised interior components of automobiles.

2.6.2 Gender variable

Gender is ordinarily classified as a categorical variable and is used to obtain demographic information. In this study, this variable is used as a construct to ascertain information that informs the marketing strategy and business case. Consumer behaviour, which involves decision making, is said to vary across the different genders from need recognition right through to the evaluation of alternatives and post-purchase behaviour and as such shows females having more satisfaction and pleasure in shopping in comparison to their male counterparts (Bakshi, 2012). For this study, this variable assists in indicating which gender has a higher appreciation of vehicle interior customisation.

2.6.3 Customisation variable

Customisation is a concept that offers consumers the ability to have input into a product or service before concluding a purchase. The works of Du et. al., (2006) define product customisation as a more personal approach to addressing the individual needs of a customer, thereby driving connectedness. It is a concept that stems from the variability of consumer preferences and needs and has been historically considered to be costly therefore catering to a niche market.

Unlike traditional manufacturing where the consumer is omitted from the design process pre-manufacturing, customisation allows for the co-creation of the end product between the consumer and the designer based on consumer preferences (Zaborek & Mazur, 2019). It must be noted though, that customisation requires a balance between consumer satisfaction and cost as the cost can be a deterrent in the advancement of customisation in the manufacturing sector in general. With 4IR digital solutions, this perception is fast changing, and mass personalisation is now possible (Aheleroff et.

al., 2019). This variable assists the study in ascertaining the appetite for a customised vehicle interior from the end of the ordinary driver.

2.6.4 Connectedness variable

Connectedness is a form of emotional attachment, as it describes how attached a person is to a product or tangible object emotionally to the point of driving brand loyalty (Ghorbanzadeh & Rahehagh, 2021). Furthermore, it is the display of feelings that are invoked concerning an exciting product (Moons & De Pelsmacker, 2012). The importance of this variable in the study is to attempt to gain insight into how connected or impartial automobile owner and drivers are towards their vehicles and if the proposed business case can change their attitudes.

2.6.5 Purchasing intent variable

Purchasing intent can be defined as the understanding of the product attributes that consumers consider when faced with the decision to make a purchase and these are attributes such as performance, size, colour, shape, style and product price (Lehdonvirta, 2009). How this variable is of significance to this study is that it is the one variable that can give an indication to the financial viability of the business venture as the end goal is opportunity exploitation and monetisation of the proposed business solution.

2.7 The Conceptual Framework

A conceptual framework is a graphical or narrative frame of assumptions, theories and beliefs that supports and informs the research through the usage of key variables and their assumed interlinks (Maxwell, 2008). As such, it assists in shaping the study by providing a story through the thread of the stated assumptions. A well-formulated conceptual framework not only indicates assumptions of connected variables but goes beyond to provide insight and a broader understanding of the variables under study

(Maxwell, 2008). The variables for the study together with their assumed relationships are depicted in the conceptual framework in Figure 2.6 below.

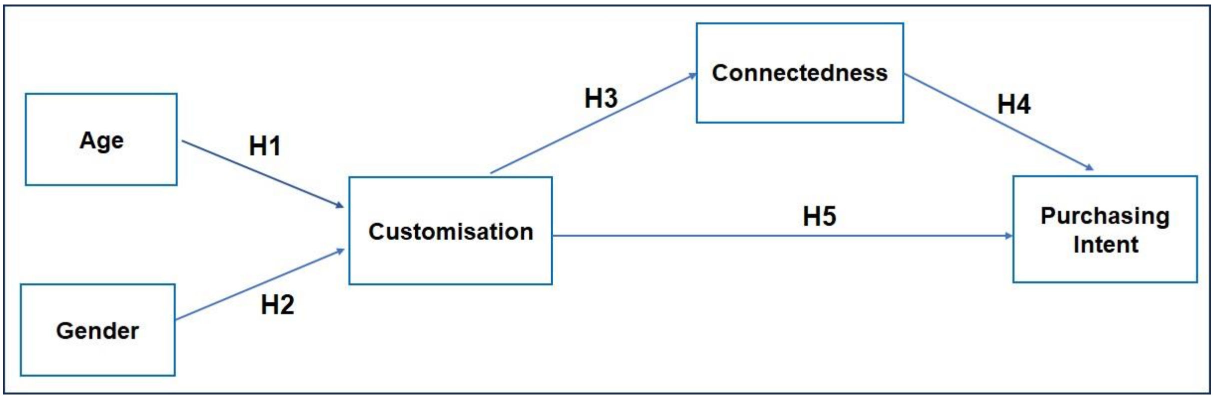


Figure 0.6: Conceptual framework

2.7.1 Age and customisation (H1)

For a business to target the different customer segments, it must strive towards having a marketing strategy aligned to the customer segments as age plays a key role in consumer behaviour (Williams & Page, 2011). In a study conducted by Vrkljan & Anaby (2011), where factors considered by consumers before the purchasing a vehicle were laid out, the various age groups showed differing interests. Customisation is a concept that is being widely used in highly competitive industries to achieve differentiation (Arora et al., 2008) and delivers the potential advantage of improved customer satisfaction. Customisation is a phenomenon that spans the various age groups as seen through segmentation by enterprises in their marketing strategies for value creation (Pech & Vrchota, 2022). Therefore, customisation is a concept that spans across the different age groups as a differentiation tool. Based on the assumed association between these two variables, I hypothesise that age has an impact on customisation.

Hypothesis 1 (H1) – Age has an impact on customisation.

2.7.2 Gender and customisation (H2)

In a study by Davis et al., (2014), wherein arguments around the motivations for shopping were presented, the findings were that consumers of both genders were motivated by a hedonistic behaviour which speaks to instant gratification. On the relationship of gender and customisation, a study by Walcher et al., (2016) showed that not only were women the largest consumer group worldwide but were more inclined to purchasing customised goods than their male counterparts. Such insight assists businesses to better target their marketing of customised goods.

Gender is said to be an essential construct which aligns with all aspects of human behaviour and is widely used as a segmentation tactic in marketing based on attributes such as easy measurability, high accessibility and identification (Seo & Lang, 2019). Furthermore, gender relates to individual differences in attitudes, cognition, affection as well as behaviours around purchasing decisions. These gender differences in attitudes and behaviours are thus likely to affect preferences for customised products. I therefore hypothesise that a relationship exists between gender and customisation.

Hypothesis 2 (H2): Gender has an impact on customisation.

2.7.3 Customisation and connectedness (H3)

An interesting concept is the Citarasa concept which looks beyond functionality and introduces an affective element in the vehicle purchasing process wherein consumers display certain emotions and a connectedness relating to the product they are purchasing (Helander et al., 2013). Customers are said to display an emotional intent when faced with the decision to purchase and this may be attributable to how they are connecting with a product before sealing the deal. The more exclusive or personal a product is, the more likely it is for the customer to choose it over other products offering the same functionality. The relationship between customization and connectedness is explored in the works of Rose et al., (2012) where customisation and connectedness are said to influence feelings of control in how the customer is empowered, and as such, indicate increased confidence levels in customers. This infers the potential existence of a direct relationship between connectedness and customisation. I therefore hypothesise that customisation affects connectedness.

Hypothesis 3 (H3): Customisation has an impact on connectedness.

2.7.4 Connectedness and purchasing intent (H4)

From a psychological perspective, connectedness in vehicles is achieved when product design serves to invoke positive emotions during the customer experience which in turn forms a powerful emotional attachment between driver and the vehicle (Gomez et al., 2004). Interior styling, trendy and the way the vehicle makes drivers feel are all aspects that form part of the ten most important purchasing criteria for automobiles (Abbot et al., 2006). A study by Moons & De Pelsmacker (2012) mentioned that purchasing intent is driven more by affective behaviour or emotional connection as opposed to cognitive behaviour based on the feelings that become invoked concerning new technology and innovations.

The concept of connectedness is factored in from the car design stage to create an emotional experience during vehicle usage as well as leave a memory of interaction after vehicle usage (Gomez et al., 2004). This implies that the emotional experience or connectedness that is felt by the customer may have an influence on vehicle purchasing. I therefore hypothesize that connectedness has an impact on purchasing intent.

Hypothesis 4 (H4): Connectedness has an impact on purchasing intent.

2.7.5 Customisation and Purchasing Intent (H5)

Customisation emerges from the consumer end and feeds into the manufacturers' business strategy as an external environmental factor (Aheleroff et al., 2019). This drives a push for automobile manufacturers to constantly scan the environment to identify external forces that may pose a threat to their existing strategies. Environmental scanning is a required strategic effort to be undertaken by businesses or organisations to identify external forces within a particular industry that may influence the current strategy employed by the said business or organisation (G. C. Kane et al., 2015).

According to a study by Lopes-Albert, Rubio & Valero, (2021), customisation was not popular 20 years ago in the automotive industry and the introduction of 4IR technologies has contributed to the flexibility of customisation. It is this transformation that has allowed automobile manufacturers to adopt diversification strategies and capture new markets (World Economic Forum, 2021). This translates to a diversification of the consumer profile and the understanding of the changing consumer behavioural attributes as well as the diversification of the product offering which summons the need for the re-visitation of the product life-cycle models. I thus hypothesize that customisation has an impact on purchasing behaviour.

Hypothesis 5 (H5): Customisation has an impact on purchasing intent.

2.8 Conclusion

This section offers insight into the context of the study, which is the evolution of the manufacturing sector to modern times of 4IR where technologies such as 3D printing are rising to compete with traditional manufacturing. The historical use of 3D printing and the extent of its usage and agility within the automotive industry is discussed. Challenges surrounding the adoption of 3D printing for components are noted which subsequently explains why traditional manufacturing is still more widely used to produce automobile parts albeit.

The theories of digital transformation, entrepreneurship and innovation gave insight into opportunity exploitation which is the motivation for a solid business case. The key variables of the study are introduced as well as the conceptual framework wherein the associated hypotheses are stated (H1-H5).

CHAPTER 3 - RESEARCH METHODOLOGY

3.1 Introduction

This section covers the methodology adopted for this research. It unpacks the research strategy and research design used and the reasons for choosing these. It further identifies the target population and drills down to how the sample was selected from the population. The section also covers the research instrument, the measurement scales used as well as the procedure used for the collection of data. The data analysis section covers how reliability and validity were assessed using appropriate testing models. The analysis section further explains which statistical tests were undertaken to achieve results pertinent to answering the research questions. All ethical considerations concerning the study were stated as a means to protect all respondents who partook in the study. Lastly, the methodological limitations of the study were noted.

3.2 Research Strategy

This study adopts the quantitative strategy which allows for the appropriate testing of theory around the stated hypotheses. A quantitative methodology makes use of statistical or numerical data as a research tool (Watson, 2014). With this methodology, measurement is a key aspect and assumes that the subjects of the study can be measured. The quantitative methodology makes use of the links between variables, is deductive in nature, focuses on specific variables and hypotheses and the testing of theory whilst the qualitative methodology focuses on narrative inquiry where the emphasis is normally on words as opposed to the quantification in data collection and analysis (Bahari, 2010).

3.3 Research Design

This is a descriptive study. Concerning research design, the four types that research follows are descriptive, correlational, experimental and quasi-experimental (Munck & Verkuilen, 2005). A descriptive research design is one that assists with uncovering new facts around the studied phenomenon (Schindler, 2019). In this study, the results were analysed to uncover new facts and obtain a deeper understanding into vehicle interior customisation using the variables of age, gender, customisation, connectedness and purchasing intent. Descriptive research is concerned with conditions, structures, variances or relationships that exist and it seeks to gather and analyse data in the attempt to develop knowledge (Mohajan, 2020).

Though the testing of hypotheses in this quantitative research uses correlations, the analysis went beyond the testing of relationships and delved into uncovering more facts about the variables explaining vehicle interior customisation. A descriptive research design differs from a correlational research design in that the former uses collected data to present a picture of a certain situation whilst the latter seeks only to identify and measure a possible relationship between two or more variables (Babbie, 2020).

3.4 Population of Interest

The population of interest for this study is all the current automobile drivers and owners as well as all the potential automobile drivers and owners within South Africa. The population encompasses respondents of all ages, genders, vehicle ownership and driver status.

The population refers to the entire target population for which the study is intended. When identifying the population of interest, important categories to consider are age, gender, race, marital status, socio-economic status and level of education amongst others (Majid, 2018). In the population, certain eligibility criteria determine whether a group of individuals are eligible to partake in the study or ought to be excluded however this criteria ought not to be discriminatory (Majid, 2018).

3.5 Sample

Probability sampling was used for this study. The main types of sampling are: probability sampling where each sample has the same probability of being selected; purposive sampling which is subjective due to specific respondents being selected and finally, the no-rule sampling where no sampling criteria exists (Barreiro & Albandoz, 2001).

The required representative sample size for the study was 380 respondents through the probabilistic sampling technique. This number was obtained using a simulation calculation with a 5% margin of error and a confidence level of 95 % (Raosoft, 2021). A key purpose of a sampling strategy is to achieve optimal recruitment and retention (Majid, 2018) therefore regarding this study, the sample was the maximum number of automobile drivers, owners, potential drivers and owners that were willing to partake in the research. The sample was obtained from the student community of Wits University. Sampling from the student community allowed for ease of reach to a wider group through an updated and accurate email base therefore increasing the possibility of achieving a high response rate (Saleh & Bista, 2017). The ease of reaching out to the student community assisted with shortening the data collection duration as well as in keeping the research costs low (Acharya et al., 2013).

The final number of respondents was 1437, a value that exceeds the requirement of 380. Of this total, only 996 respondents completed the survey however this number was further reduced by the removal of respondents who had missing information. After the removal of those respondents, the valid sample size was 821. Therefore, the sample was confidently accepted as being representative of the population to make the relevant inferences in the study.

3.6 Research instrument

Using existing measurement scales contained in *Annexure B*, a survey questionnaire was developed and used to randomly survey respondents. The scale used for the survey was a forced response, five-point Likert-type scale, with poles from strongly disagree (1) to strongly agree (5) using the online survey tool *Qualtrics* (questionnaire included under *Annexure C*).

The survey included graphics (contained under *Annexure D*) depicting the business concept to assist respondents with obtaining a graphic presentation of the proposed customised interior designs. The inclusion of the concept design was a deliberate approach for validating the responses from respondents and to eliminate false assumptions and perceptions of what vehicle interior customisation encompasses.

3.7 Procedure for data collection

Transparency and articulation are important aspects in the collection of data. Research (Zaza et al., 2000) shows that many studies are not reproducible due to data collection procedures that are not clearly articulated. This means that other researchers would not be able to draw the same conclusions to those drawn by the original scholars as a result of these flaws.

The survey questionnaire was developed using the *Qualtrics* survey tool comprising of 27 questions relating to the hypotheses being tested. Respondents were sampled randomly through the distribution of emails within the Wits University student community and were required to consent to partaking in the study. The use of online surveys is a tactful means of eliciting participation from respondents in research given the ease of access, the quick times to complete them and the low costs associated (Saleh & Bista, 2017). The survey included exit points in the earlier questions which prohibited a respondent from proceeding with the survey if the response was not in the affirmative. This was done to ensure that more meaningful data was collected.

The demographic information that was sourced as part of the survey was that of age and gender groupings, vehicle ownership and driver status. The survey was disseminated on 7 Feb 2024 and data was collected until 11 February 2024, after which no further respondents could participate in the survey as it had been locked.

3.8 Data analysis method

Once the data had been collected and cleaned to remove missing information, the demographic information was extracted first. Subsequent to that, custom tables were created to achieve the mean and standard deviation values. Reliability testing was then carried out using the Confirmatory Factor Analysis (CFA) as a means of establishing validity and reliability of the factor constructs. The IBM Analysis of Moment Structure (AMOS) version 29 was used to perform the CFA. A correlation analysis was carried out to determine correlation strength and direction. The data was then further analysed using Structural Equation Modelling (PLS–SEM) where both the assessment model and structural model were used to assess the interrelationships amongst the set of constructs as a means of hypothesis testing. Structural equation modelling was carried out using Smart PLS 4.0.

3.9 Ethical considerations

An ethics approval was obtained for this research with Protocol Number WBS/BA2410165/594. It was only after the ethics approval was granted that the process for data collection commenced. The survey included a consent section in which respondents s had to consent to being part of the study. The survey was created to be anonymous so as to allow respondents to express themselves freely. The legal driving age in South Africa is eighteen years old therefore the survey required that only respondents of this age and above partake in the study and a declaration had to be made prior to participating. The data collected was used solely for the purposes of this research.

3.10 Data validity and reliability

The study used existing measurement scales for data collection to strengthen the reliability and validity of the data collected. The confirmatory factor analysis (CFA) was used to determine model fit.

Reliability of the model was determined through the absolute and relative fit indices from the CFA. The Chi-square analysis for determining absolute fit indices resulted in p-values > 0.05 which suggested model fit and reliability of constructs. The relative fit indices were determined and were all found to be within the threshold values, with the Tucker Lewis Index values being > 0.90, the Root Mean Square Error of Approximation values falling between 0 – 0.1 and the Comparative Fit Index values being > 0.95. The internal consistency of the constructs was obtained through the Cronbach Alpha coefficient values, and all were greater than 0.7 which proves internal consistency reliability.

To prove construct validity, the demonstration for both convergent validity and discriminant validity was done. Convergent validity assists in validating research findings by showing how closely related different variables measuring the same concept are or how well a particular measure relates with other measures of the same construct. This was assessed using the average variance extracted where the obtained values for all the constructs were confirmed to be above the minimum acceptable threshold of 0.5 (50%) thus suggesting convergent validity.

Discriminant validity on the other hand, tests whether measurements that are not meant to be related are indeed unrelated. In testing for discriminant validity, the correlation between the constructs was compared with the square root of the average variance extracted and the confirmed values square root of the average variance were all greater than the correlation values therefore confirming discriminant validity.

3.11 Methodological limitations to the study

The study focuses on a business venture that aims to penetrate the automobile value chain as a direct supplier, and as such, it would have been more appropriate to support it with qualitative data collected from the OEMs of automobile manufacturers. There was a challenge, however, in obtaining participants from the OEMs who were willing to speak on behalf of their companies for reasons relating to confidentiality thus the study was limited to the quantitative research strategy.

Another limitation to the study was that of the target population. The population was limited to the student community of Wits university which tends to have a generally younger population therefore not as many responses were received from the older age categories, particularly age 30 and above.

3.12 Conclusion

The research strategy adopted for the study was the quantitative strategy. The research instrument used for the collection of data was a survey questionnaire developed through existing measurement scales and was distributed to random respondents to attract vehicle owners, drivers and potential vehicle owners. Data was then retrieved, cleaned, and analysed. Reliability assessment was carried out using the confirmatory factor analysis. The structural equation model was used to test the hypotheses. Only responses from respondents who had consented to be part of the study and declared to be above the consenting age of eighteen were used in the study in line with ethical considerations. The methodological limitation concerned the research strategy used for this study.

CHAPTER 4 - RESULTS OF THE STUDY

4.1 Introduction

This section presents the results of the data analysis. The results focus firstly on the profiling of the respondents then on assessing the respondents' perceptions and finally on understanding the relationships that exist between the constructs of the study. The analyses carried out were frequencies, custom tables, means, standard deviations, confirmatory factor analysis, reliability analysis, correlation analysis as well as structural equation modeling.

4.2 Response rate

The response rate is an indication of the participation level obtained from the target population, which translates to the sample. The survey was distributed to 31,623 respondents and of those, only 1,437 partook in the survey. After cleaning the data to remove the respondents with missing information, a total of 821 respondents remained. This translated to a valid response rate of 2.6% of the population. Though this low figure is low compared to the total invited respondents, it is still double the minimum sample size requirement of 388 respondents therefore the sample is a representative sample. From the total of 1,437 respondents, the responses from 616 respondents were discarded due to missing information and could not be used further in the study.

4.3 Descriptive statistics

Descriptive statistics are used to estimate the characteristics of a sample (Nick, 2007) or in simplified terms, obtain a profile of the respondents. For this study, the descriptive statistics deployed were: frequency counts; and means and standard deviations obtained though custom tables.

4.3.1 Demographic details

The frequency counts were generated and used to assess the demographic characteristics of the sample. This demographic assessment included gender, age, vehicle driver status, and vehicle ownership status. In the composite Table 4.1 below, is the summary of the demographic details of the sample.

Table 4.3.1: Demographic details

Characteristic	Category	n	Percentage
Gender	Male	513	62.5%
	Female	300	32.5%
	Other	8	1.0%
Age	18 – 29 years	723	88.1%
	30 – 39 years	66	8.0%
	40 – 49 years	27	3.3%
	50 – 59 years	5	0.6%
Vehicle ownership and driver status	Do not own a vehicle but intend to own one in the near future	444	54.1%
	Drive a vehicle but do not own one	162	19.7%
	Own a vehicle	215	26.2%

The demographic details reflect that 62.5% of the respondents were female whilst the male respondents were approximately half the number of the female counterparts at 32.5%. The rest of the respondents ascribed to other genders, and they comprised of 1.0%.

For the age categories, the largest respondent group was that between the ages of 18-29 years at 88.1% followed by the category of 30-39 years at 8.0%. The last age categories were 40-49 and 50-59 and the participation from these was 3.3% and 0.6%, respectively. This translated into the bulk of the study respondents (>80%) being in the lowest age category.

Of the respondents that undertook the study, more than 50% stated that though they do not own a vehicle currently, they do intend to own one in the near future. This group can be classified as "potential car owners" for marketing purposes. The next highest group was those who own a vehicle at 26.2% and the lowest stat represented the group that drives a vehicle yet does not own one. This group may not be the most influential as they would use whichever vehicle is assigned to them yet have no contribution to the purchasing decisions required during the vehicle acquisition stage.

4.3.2 Custom tables, means and standard deviations

In order to generate usable data for ease of analysis, custom tables were created for the three constructs namely, customization, connectedness and purchasing intent. The custom tables were created with the inclusion of the means and standard deviations and were then used to assess the perception of participation on the three constructs. The constructs of the study were initially measured on a 5-point Likert scale however for ease of interpretation of the results, the two lower scales (Strongly disagree and Disagree) were merged together to obtain a combined disagreement statement and similarly for the two upper scales (Strongly agree and Agree), merging was done also to obtain a combined statement of agreement (Morgan et al., 2002). This resulted in the re-creation of a 3-point scale for ease of analysis.

Table 4.3.2: Customisation

Customisation Items	Strongly Disagree/ Disagree	Neither Disagree nor Agree	Strongly Agree/ Agree	Mean ($\bar{x}$)	Standard Deviation (σ)
The look and feel of the car interior is important when buying a car	21	30	770	4.44	0.754
	2,6%	3,7%	93,7%		
I like it when I am able to customize the interior of a vehicle to my own liking	31	109	681	4.22	0.857
	3,8%	13,3%	82,9%		
A customised interior of a vehicle should feel like it is talking to me personally as a driver	43	147	631	4.08	0.890
	5,2%	17,9%	76,9%		
The customised vehicle to my preference makes me feel recognized as a customer	75	159	587	3.94	0.995
	9,1%	19,4%	71,5%		
The aesthetics of a customised vehicle interior promote a perception of quality	49	107	665	4.11	0.903
	6%	13%	81%		
I like it when I am able to customize certain vehicle parts to my own liking	92	344	385	3.46	0.932
	11,2%	41,9%	46,9%		
Customised cars using 3D printing will contribute to environmental sustainability	58	126	637	4.00	0.895
	7,1%	15,3%	77,6%		

For the customization construct, the St Dev (σ) is <1 which indicates a low variance in terms of the data spread (Curran-Everett, 2008). All the scales reflected mean values ($\bar{x}$) above 3 with the highest being 4.44 coming from respondents' perceptions on the importance of the look and feel of the car interior when purchasing. The above average means value translates to more respondents in agreement with the statements around customization and therefore an overall appreciation for customization. From the responses, six out of the seven statements yielded agreement rates of 70% and above to the statements made around vehicle interior customization.

Table 4.3.2: Connectedness

Connectedness Items	Strongly Disagree/ Disagree	Neither Disagree nor Agree	Strongly Agree/ Agree	Mean ($\bar{X}$)	Standard Deviation (σ)
A customised vehicle interior increases my feelings of connectedness	74 9%	112 13,6%	635 77,4%	4	0.945
Connectedness to a vehicle exhumes positive feelings	61 7,4%	160 19,5%	600 73,1%	3.88	0.899
It is important to me that the interior of a vehicle feels like my personal area when inside the car	35 4,3%	92 11,2%	694 84,5%	4.22	0.828
I have felt connected to the interior aesthetics of the car I drive or own	123 14,9%	288 35,1%	410 50%	3.49	0.991
The feeling of self-fulfilment I get from a personalised car interior is significant	109 13,3%	209 25,5%	503 61,2%	3.66	1.008
I feel a sense of personal satisfaction when inside a car with a personalised interior	70 8,5%	167 20,3%	584 71,2%	3.86	0.917
I was attracted to this interior design at first sight	140 17%	259 31,5%	422 51,5%	3.46	0.997
I would be happier if I could afford buying a car with a customised interior	98 11,9%	101 12,3%	622 75,8%	4.04	1.056

For the connectedness construct, the St Dev (σ) for two of the scales was >1 whilst for the rest of the scales, it was <1. In the instances where the St Dev was found to be >1, the variance was not significant (Curran-Everett, 2008) therefore the data points were treated as being close to the mean and indicating an acceptably low variance in terms of the data spread given that a larger variance means greater dispersion. Although the mean values ($\bar{x}$) are above the mid-point of 3, there are notably more respondents who are either neutral or in disagreement to the statements around connectedness in comparison with the customization construct. As a result, this pulled the obtained values closer to the mean value with only three of the scales reflecting values of 4 and above. The scale that had the highest mean at 4.22 was that which assessed the importance of the vehicle interior feeling like a personal space when the respondent was in it.

Table 4.3.2: Purchasing intent

Purchasing Intent Items	Strongly Disagree/ Disagree	Neither Disagree nor Agree	Strongly Agree/ Agree	Mean ($\bar{X}$)	Standard Deviation (σ)
The look and feel of the car interior is important when buying a car	68	81	672	4.09	0.917
	8,3%	9,9%	81,8%		
I like it when I am able to customize the interior of a vehicle to my own liking	89	128	604	3.95	1.015
	10,8%	15,6%	73,6%		
A customised interior of a vehicle should feel like it is talking to me personally as a driver	18	60	743	4.43	0.768
	2,2%	7,3%	90,5%		
The customised vehicle to my preference makes me feel recognized as a customer	138	365	318	3.32	1.042
	16,8%	44,5%	38,7%		
The aesthetics of a customised vehicle interior promote a perception of quality	214	323	284	3.15	1.046
	26,1%	39,3%	34,6%		
I like it when I am able to customize certain vehicle parts to my own liking	134	331	356	3.36	0.971
	16,3%	40,3%	43,4%		
Customised cars using 3D printing will contribute to environmental sustainability	197	308	316	3.2	1.047
	24%	37,5%	38,5%		
The prices of customised vehicles are too high	22	156	643	4.17	0.865
	2,7%	19%	78,3%		

For the purchasing intent construct, the St Dev (σ) for half of the scales was >1 whilst for the other half, it was <1. In the instances where the St Dev was >1, the variance was not significant (Curran-Everett, 2008) therefore the data points were treated as being close to the mean and indicating an acceptably low variance in terms of the data spread given that a larger standard deviation indicates greater dispersion. For this construct, the respondents were more neutral and there was also an increased number leaning towards the disagreements with the statements in comparison to the customization and connectedness constructs. This pull therefore brought the mean values of the respective scales to just over the mid-point of 3. The scale with the highest mean at 4.43 was that where respondents noted how the interior ought to speak to them personally as the driver. It is worth noting that about 78% of the respondents held a perception that vehicle prices for customized cars were high.

4.4 Confirmatory factor analysis

The confirmatory factor analysis (CFA) was performed in this study to validate the factor structure of the study constructs namely, customization, connectedness and purchasing intent. The IBM Analysis of Moment Structure (AMOS) version 29 was used to perform the CFA. The absolute and relative fit indices were used to confirm the factor structure of the study constructs and they are discussed in Table 4.5 below.

Table 4.4: Confirmatory Factor Analysis results

Absolute and Relative Fit indices	Recommended Values	References	Customisation	Connectedness	Purchasing Intent
Chi-square p-value	p-value > 0.05	Barrett (2007)	0.415	0.438	0.157
Root Mean Square Error of Approximation (RMSEA)	0 – 0.1	Browne & Cudeck (1993) p.144	0.000	0.000	0.024
Root Measure Square Residual (RMR)	0 – 0.08	Hu & Bentler (1999)	0.010	0.007	0.014
Goodness-of-Fit statistic (GFI)	0 – 1	Bentler (1990)	0.998	0.999	0.995
Tucker-Lewis Index (TLI)	≥ 0.9	Marsh et. al. (1986)	1.000	1.002	0.996
Comparative Fit Index (CFI)	≥- 0.95	Carlson & Mulaik (1993)	1.000	1.000	0.998
Normed-Fit Index (NFI)	0 – 1	Ding et. al. (1995)	0.995	0.998	0.993
Relative Fit Index (RFI)	0 - 1	Widaman & Thompson (2003)	0.987	0.991	0.988
Incremental Fit Index (IFI)	0 - 1	Brosseau-Liard & Savalei (2014)	1.000	1.000	0.998
Cronbach Alpha Coefficient			0,761	0,830	0,778

The absolute fit index was determined through the chi square analysis where the obtained p-values were greater than 0.05 suggesting that the model fit the data very well. The relative fit indices used in Table 4.5 are said to be the most traditionally used in statistics and they assist the study by assessing the quality of the model and how far from perfect it is (Bentler, 1990). For this study, all the relative fit indices for the three constructs namely customization, connectedness and purchasing intent were found to be within the specified threshold values as shown in Table 4.5 thereby indicating that there is model fit and that the factor structure is valid.

4.5 Structural equation model

Structural equation modelling (SEM) was performed in this study to determine the associations between the driving factors behind the concept of 3D Printing for vehicle interior customisation. Based on Partial least squares structural equation modelling (PLS–SEM), the measurement model was assessed first, then followed by the structural model using Smart PLS 4.0.

4.5.1 Assessment of the measurement model

To assess the measurement model, the reliability analysis, convergent validity, and discriminant validity were determined.

The reliability analysis was examined using both the Cronbach Alpha coefficient values and the composite reliability values. As indicated in Table 4.5 (Confirmatory Factor Analysis Results), all the constructs deemed to be reliable given that the Cronbach Alpha Coefficient Values were all above the minimum threshold value of 0.7. According to (Afthanorhan, 2013), the composite reliability values ought to be > 0.6. In this study, the composite reliability values were calculated as follows: customisation (0.748), connectedness (0.819) and purchasing intent (0.860). It is evident that all the obtained values are above the minimum threshold value of 0.6 and this infers that the measurement model is deemed to be reliable.

In determining the convergent validity, the average variance extracted was utilised. The acceptable value for the average variance extracted is said to be > 0.5 (50%)

(Afthanorhan, 2013). The average variance extracted values for customisation, connectedness and purchasing intent were determined as 0.664, 0.643 and 0.625, respectively. Given that the obtained values are all above the minimum acceptable value of 0.5 for average variance extracted, this translates to the measurement model being convergently valid.

The discriminant validity is an indicator of how distinct a construct or a continuous variable is and is demonstrated when the average variance extracted exceeds the shared variance between the constructs (Hair Jr et al., 2020). For assessing the discriminant validity, the correlation between the constructs was compared with the square root of the average variance extracted. In Table 4.6, the values of the square root of the average variance extracted are indicated as customisation (0.81), connectedness (0.80) and purchasing intent (0.79). In the same table, it is evident that the correlation values (0.617, 0.545, 0.580) are less than the discriminant validity values which translates to the assessment model being discriminantly valid.

Table 4.5.1: Discriminant validity results

Continuous Variable	Average Variance Extracted	Square Root of Average Variance Extracted
Customisation	0.664	0.81
Connectedness	0.643	0.80
Purchasing Intent	0.625	0.79

4.5.2 Correlation analysis

Correlation Analysis was utilized in this study to measure the relationships between customization, connectedness and purchasing intent. The Pearson Correlation coefficient was used as it measures both the strength of the correlation between the constructs and the direction of the correlation. The desired range is from (-)1 to (+)1 where (-)1 indicates a total negative linear correlation whilst (+)1 indicates a total positive linear correlation. For the correlation coefficients, values ≤ 0.39 indicate a low correlation, whilst a range between 0.4 – 0. 69 is deemed to be a moderate correlation and lastly, values ≥ 0.7 indicate a strong correlation (Schober et al., 2018). At very low ranges i.e. < 0.1, the correlation is deemed negligible (Schober et al., 2018). For the correlation analysis, only the continuous variables (customisation, connectedness, purchasing intent) were used as depicted in Table 4.7. For the categorical variables (age, gender), correlation is determined through the chi square test of independence.

Table 4.5.2: Correlation of constructs

		Customisation	Connectedness	Purchasing Intent
Customisation	Pearson Correlation	1		
	Sig. (2-tailed)			
	N	821		
Connectedness	Pearson Correlation	,617**	1	
	Sig. (2-tailed)	<,001		
	N	821	821	
Purchasing Intent	Pearson Correlation	,545**	,580**	1
	Sig. (2-tailed)	<,001	<,001	
	N	821	821	821

**. Correlation is significant at the 0.01 level (2-tailed).

As shown in Table 4.7, there is a statistically significant (p-value < 0.05) moderate positive correlation ($r = 0.545$) between customisation and purchasing intent. Also, there is a statistically significant (p-value < 0.05) moderate positive correlation ($r = 0.580$) between connectedness and purchasing intent.

4.5.3 Assessment of the Structural Model

The structural model was assessed by using the path coefficients, the t-values, the p-values, and the coefficient of determination as presented in Figure 4.1 and Table 4.7 below. In this study, age and gender variables, which are ordinarily classified as categorical variables were used as constructs. In order to use these as constructs for the structural model, reference groups had to be identified and these are excluded from the model, leaving the groups above them to be used in the model. For age, the reference group was 18-29 years and for gender, the reference group was females.

When running categorical variables as constructs, each category was converted to dummy variables where values of 0 and 1 were used to code these dummy variables. When the category for age 50-59 was coded, the 0 values exceeded 99% of the sample given that there were only 5 out of 821 respondents from this category. This then brought about an extremely low/negligible percentage (0.6%) which could not be used in the model (0.6% tends to 0). Since this value restricted the equation from running, it was then excluded in the model. It was only after excluding this category from the equation that the SEM model was able to run smoothly.

Furthermore, when plotting categorical variables as constructs, the first group needs to be labelled as the reference group and for this study, the category 18-29 was made the reference group. This reference group is excluded in the equation and only the categories above it are plotted, save where the categories are negligible (close to 0). In this study, the categories that were used in the equation were therefore the age categories 30-39 and 40-49 which are indicated in the Figure 4.1 (SEM Model).

For the gender construct, a similar approach was followed wherein all categories which tend to 0 were removed and in this study, that was the gender category labelled as “other” as the respondents accounted for only 1% (8 out of 821). The next step was to identify the reference or base group, which in this instance was the gender category for females. This reference group was then excluded from the equation leaving only the gender category for males being plotted in the equation.

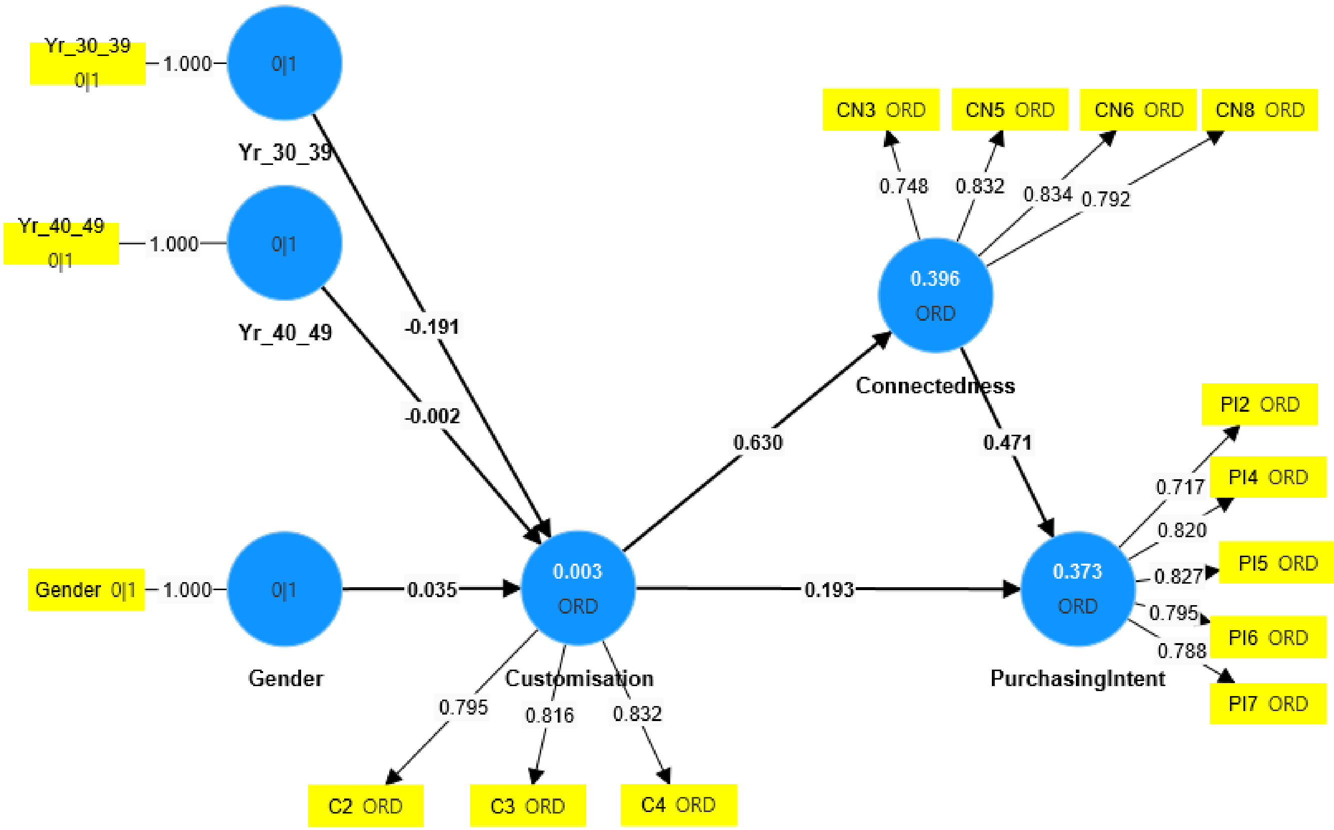


Figure 4.5.31: Structural Equation Model

The coefficient of determination, also known as multiple correlation coefficient, is the percentage of variance in one variable that is explained by another variable (Ozer, 1985). It is a useful measure of successfully predicting the dependent variable from the independent variables (Nagelkerke, 1991) and is presented as a percentage. The coefficient of determination ranges from 0 – 1 (0 – 100%) and values closer to 1 indicate a very strong correlation amongst the variables, whilst those closest to 0 indicate no correlation amongst the variables (Chicco et al., 2021).

From the model above, the obtained coefficient of determination for customisation is 0.003 suggesting that the amount of variance explaining customisation by gender and age is 0.3% which is extremely low and close to zero. This translates to both gender and age not having an impact on customisation in this study.

For connectedness, the coefficient of determination is 0.396 which suggests that the amount of variance explaining connectedness by customisation is 39.6% and is deemed a moderate effect. Therefore, it can be said that there is a moderate correlation between customisation and connectedness.

Lastly, the coefficient of determination for purchasing intent was calculated to be 0.373 which suggests that the amount of variance explaining purchasing intent by both customisation and connectedness is 37.3% and is deemed a moderate effect. Therefore, it can be said that both customisation and connectedness have a moderate effect on purchasing intent.

Table 4.5.3: Structural Equation Model results

Hypothesis	Relationship	Path-coefficient	t-value	p-value	Decision
H1a	Age (30-39) → Customisation	-0.191	1.192	0.233	Not supported
H1b	Age (40-49) → Customisation	-0.002	0.010	0.992	Not supported
H2	Gender → Customisation	0.035	0.469	0.639	Not supported
H3	Customisation → Connectedness	0.630	24.326	0.000	Supported
H4	Connectedness → Purchasing Intent	0.471	11.150	0.000	Supported
H5	Customisation → Purchasing Intent	0.193	4.682	0.000	Supported

For the hypothesis to be supported or the relationship between the constructs to be significant, the t-value ought to be > 1.96 (Kotrlik & Higgins, 2001) (Kim, 2015) and the p-value<0.05 significance level.

Having removed the reference groups from the equation, the results in Figure 4.1 are for the categorical variables which were used as constructs in the study. The results revealed that the Hypothesis H1a, which represents age category 18-29 years and the

Hypothesis H1b which represents age category 40-49 years, were not supported. H1a presented a t-value of -1.192 and p-value = 0.233 and H1b presented a t-value of 0.010 and p-value 0.992 and all values are outside of the recommended threshold values thereby implying that age has no direct impact on customisation. Since the results of the categories above the reference group hold true for the reference group, this translates to the age category 18-29 being deemed statistically insignificant.

From the results, the Hypothesis H2 is also not supported as indicated by the t-value of 0.469 (less than 1.96) and a p-value = 0639 thereby inferring that gender has no direct impact on customisation. The same treatment of the age categories in relation to the reference group applies for the gender categories where the statistical non-significance of the male gender group holds true for the female gender group.

With respect to Hypothesis H3 however, the results revealed that customisation does have an impact on connectedness and the hypothesis is supported given the t-value of 24.326 and a $p\text{-value}<0.05$. Concerning Hypothesis H4, a similar finding was acquired where the hypothesis was supported with an obtained t-value of 1.150 and a $p\text{-value}<0.05$ thereby suggesting that connectedness does have an impact on purchasing intent. Lastly, Hypothesis H5 revealed that customisation also has a direct impact on purchasing intent as the hypothesis is supported with a t-value of 4.682 and a $p\text{-value} < 0.05$.

4.6 Conclusion

The chapter focuses on the analysis of the data, using the confirmatory factor analysis as well as the structural equation modelling. The results reveal an understanding of the respondents' perceptions on the concept of vehicle interior customisation as well as the relationships that exist between the constructs of the study. The assessment of both the measurement model for reliability analysis and the structural model for hypothesis testing was done. The categorical variables of age and gender were treated as constructs in carrying out the analysis in this study.

CHAPTER 5 - DISCUSSION OF FINDINGS

5.1 Introduction

In this chapter, the findings are discussed in relation to the five hypotheses which underpin this study. Inferences is made with reference to existing theory selected for this study in order to support and/or oppose the findings.

5.2 Is there an effect of customer age on their view of 3D printing for customization?

The findings reveal that there is no direct association between the various age categories and customisation and the hypothesis that age has an impact on customisation was not supported (t-value < 1.96, p-value > 0.05). There was an expectation that the findings of this study would align to those of Vrkljan & Anaby, (2011) where the different age groups displayed heterogeneous characteristics pertaining to factors considered before the purchasing of a vehicle. Another contrary finding was presented by Potoglou & Kanaroglou, (2007) in a similar study where segmentation according to age was proven to be significant and revealed differences in preferences where vehicle customisation was concerned.

In lieu of such opposing findings, the position taken is that of continuing to address the research gap through a different market segmentation strategy of segmenting by needs/preference and not by age as was the approach of the study (Kara & Kaynak, 1997). This translates to the concept of 3D printing for customisation remaining a concept that should be targeted at all customers with a preference for such without necessarily segmenting according to age.

5.3 Is there an effect of customer gender on their view of 3D printing for customization?

The findings reveal that there is no association between age and customisation, as is the case with gender and therefore the hypothesis that gender has an impact on customisation does not hold true in this study. Evidence emanates from the obtained t-value of 0.469 and p-value > 0.05. Theory reviewed from Walcher et al., (2016) suggests that women are more inclined to purchasing customised goods compared to their male counterparts and the findings of this study do not make such a distinction. Further inconsistencies to the findings of this study were extracted from the work of Tuck et al., (2008), where gender consideration is used to customise certain components of the cockpit using the rapid manufacturing process.

Albeit the findings do not adequately address one of the research gaps of this study which concerns inclusivity in vehicle interior design where gender differences have been largely discounted (Walcher et al., 2016). There is still a work-around in addressing this gap through a different market segmentation strategy. The position that is held in lieu of the findings is that segmentation by gender, for the concept of 3D printing for vehicle interior customisation, may not be the best approach and that segmentation ought to be rather done by preference or customer need (Kara & Kaynak, 1997). This approach will cluster the homogeneous group of customers who will respond to a marketing strategy in a similar way (Kara & Kaynak, 1997).

5.4 What relationship exists between vehicle interior customisation and connectedness?

The hypothesis that customisation has an impact on connectedness holds true. In line with previous studies (Rose et al., 2012), such a finding is expected given that customisation and connectedness are said to invoke customer empowerment through feelings of control. Such a connection is supported by the works of Du et al., (2006) where product customisation is said to have a more personal approach to addressing the individual needs of a customer**,** thereby driving connectedness. An opposing view is brought up by Kressmann et al., (2006) where joint car ownership of a customised car may lead to disproportionate emotional attachment where one party has a strong connection to the vehicle whilst the other feels indifferent or feels no connection to the vehicle altogether.

The position taken in this study is that not only does customisation impact on connectedness, but the confirmed association is strong (t-value = 24.326, p-value = 0.000) therefore it can be deduced that vehicle interior customisation through 3D printing has the ability to increase a higher emotional connection to the vehicle owners, drivers and potential vehicle owners.

5.5 What impact does connectedness have on purchasing intent?

The hypothesis that customisation influences purchasing intent holds true. From the findings, connectedness had a moderate impact on purchasing intent and this association will be used to inform the marketing strategy. This finding is synonymous the McKinsey study mentioned in the works of Abbot et al., (2006) where connectedness or how the product makes the vehicle consumer feel was listed amongst the top ten criteria for vehicle purchasing. Previous studies (Moons & De Pelsmacker, 2012) are in support of this relationship wherein they mention feelings being the superior driver of vehicle purchases to rationale or cognitive behaviour.

The demographics of the study reveal that the age group 18-30 years accounts for 88% of the respondents, therefore inference can be made that the confirmed association between connectedness to purchasing intent is attributable to this group. A different view is held by scholars (Lee & Govindan, 2014) however, where they state that for this particular age group, fuel economy and price are the most important vehicle attributes considered when purchasing a vehicle.

The concept of customisation proves to create an emotional connection for vehicle drivers, owners and potential owners and it is this connection that will be the inherent psychological justification for the business venture (Ariely, 2008).

5.6 Does customisation influence purchasing intent?

From the findings, customisation was found to have an impact on purchasing intent therefore proving the alternative hypothesis true. This finding is supported by the works of a similar study (Pauwels et al., 2004) where the firm revenues were found to have emanated from strong sales as a result of new product introductions in the car industry. The concept of 3D printing for customisation is meant to introduce an innovative, lean, sustainable and cost-effective method of customisation (Jandyal et al., 2022) in the automotive industry therefore finding that there is an interest to purchase vehicles with customised interiors in the market is a key leverage point.

A notable argument is presented by (Pauwels et al., 2004) where the study mentions that although vehicle styling changes may lead to increased sales, the efforts do not however pay off financially. This is due to the high costs associated with traditional customisation. The position held by this study is that despite theory holding a view of compromised profitability due to high costs of customisation, the business venture concept of 3D printing is lean and more cost-effective (Jandyal et al., 2022) in comparison to traditional manufacturing therefore it will be able to achieve styling or customisation whilst remaining price competitive.

5.7 Conclusion

The categorical variables, age and gender prove to not have any significant impact on customization in this study. This means that the business case ought to be targeted at all age and gender categories, and segmentation be based on customer need or preference rather than age or gender. The findings reveal that both customisation and connectedness influence purchasing intent which is the bottom line and the ultimate business objective (sales). The findings reveal that customization has an impact on connectedness which translates to the positive feelings invoked through a customised vehicle interior. The invoked feelings emanating from a personalised interior is what the business venture aims to focus on in marketing the concept of customisation.

CHAPTER 6 - BUSINESS PLAN OF MAGEZA 3D PRINTING

6.1 Executive summary

Mageza 3D Printing is a start-up business in the automotive industry of South Africa and was established to offer customized solutions, though innovation, to drivers and vehicle owners using 3D printing. The mission of the business as well as the strategic objectives align with addressing the scourge of unemployment in South Africa as well as allowing previously marginalized groups to enter the manufacturing sector using 4IR technologies.

The market penetration strategy details the level at which Mageza 3D Printing will be penetrate the market as a business to business (B2B) supplier. The market analysis and trends of the global automotive industry was presented to give insight into the market opportunities within this industry. The macro and micro environmental analyses were carried out to identify challenges affecting components manufacturers as well as the opportunities to be leveraged. With respect to competitive positioning, the competitor analysis revealed that the Mageza 3D Printing is entering the sector with a competitive advantage of both cost leader and innovation leader.

The business will reach full scale by Year 4. The staggered rollout strategy of setting up operations in a different region in each year showed profitability from Year 1 through a net profit ratio of 20% and increasing to 30% by Year 5. The Operations Plan detailed the operational resources for Mageza 3D Printing and given the limited resource capabilities in the first few years of operation, the non-core functions will be outsourced whilst strategically building the capabilities in-house. Through the marketing plan, proper customer segmentation was done. The product offering for Mageza 3D Printing was shown and as part of the promotional strategy, the marketing budget will be used to customize a few a few units for each of the OEMs as a means of strengthening product visibility.

6.2 Strategic overview

6.2.1 Business strategy

A product differentiation strategy will be adopted by Mageza 3D Printing to set the business apart from other components manufacturers supplying directly to OEMs. Differentiation will be achieved through the product offering of customised vehicle interior components providing an aesthetic appeal. Value creation will be driven by operational efficiencies achieved through operational flexibility and low costs associated with 3D printing.

6.2.2 Market penetration

As a components manufacturer, Mageza 3D Printing will penetrate the market as a Tier 1 and Tier 2 supplier. In the automotive industry, Tier 1 businesses supply complete systems or units directly to the OEMs, whilst Tier 2 businesses supply components to Tier 1 businesses (Vazquez et al., 2016). Under Tier 1, Mageza 3D Printing of interior aesthetic components will focus on the co-creation of customized vehicle interiors with the OEMs. At the Tier 2 level, supply opportunities to other components manufacturers will be exploited. At this Tier 2 level, it will be possible to service the after-market clientele keen on customizing independently.

The rollout of the operations facilities will be staggered over four years where each year, new facilities will be set up in a specific region. This staggered approach will assist with the evaluation of concept buy-in within the first year as well as the identification of improvement points to apply in the other regions. With each new OEM that is onboarded, the business assumes a starting market share of 5% in the first year and a 2% year on year growth for the respective OEMs. This market share growth will follow the similar staggered approach as the operations rollout strategy.

6.2.3 Vision

To create value-add in the automotive industry by embracing digital transformation and innovation for providing environmentally sustainable customer-centric solutions.

6.2.4 Mission

To address the scourge of unemployment in the South African market through innovation and technology.

6.2.5 Strategic objectives

Mageza 3D Printing has measurable objectives aligned with the business strategy as follows: to create sustainable jobs by providing skills aligned to 4IR leading up to 2035; to be the trusted and preferred supplier of interior customized parts to all South African OEMs by 2035 and to have a global footprint within the first 5 years of operation through exports of customized vehicles.

6.3 Market analysis

Globally, the automotive industry plays an important role in the broader manufacturing sector through development with its capital-intensive structure and the employment opportunities created via its value chain. In 2019, the size of the automotive industry in the global economy was reported at approximately USD 4.5 trillion which accounts for approximately 5% of the world economy (*Statista 2020*, 2020)

In South Africa, the automotive industry supports the improvement of the country's biggest socio-economic challenge which is unemployment. The current unemployment figure in South Africa is reported to be 31.9% (*Tradingeconomics.Com South Africa*, 2024) and this is one of the industries that continues to make a vital contribution to the social upliftment of the communities in the regions of operations.

In 2022, the components manufacturing portion of the automotive industry in South Africa recorded a contribution of 2.4% to GDP. This resulted in combined value addition of 17,3% to the domestic manufacturing sector stemming from vehicle and component manufacturers (*Naamsa | Industry Overview Latest*, 2023). According to the Department of Trade, Industry and Competition (DTIC), the South African automotive sector is said to achieve 1% of global output by the year 2035 from the current 0.6% output (*Masterplan-Automotive_Industry*, 2018.)

According to a report on the Automotive Masterplan (Barnes et al., 2018), global vehicles sales are forecasted to grow from 107 million units in 2019 to 129 million units in 2035 on a 1% year-on-year growth trajectory or 149 million units on a 2% year-on-year growth trajectory. The report further mentions that the future growth of the automotive industry is likely to be strongly driven by emerging as well as middle-income markets. A case in point is China's consumption of 47% of the global output and this points to a shift in ownership densities towards developing countries. In developed economies such as the United States, for example, the person-to-vehicle ratio is 1.3 whereas, in emerging economies such as China and India, the ratios are approximately 17:1 and 58:1 respectively (Barnes et al., 2018.) Below is a graph, Figure 6.1, depicting the vehicle sales forecast leading to 2035.

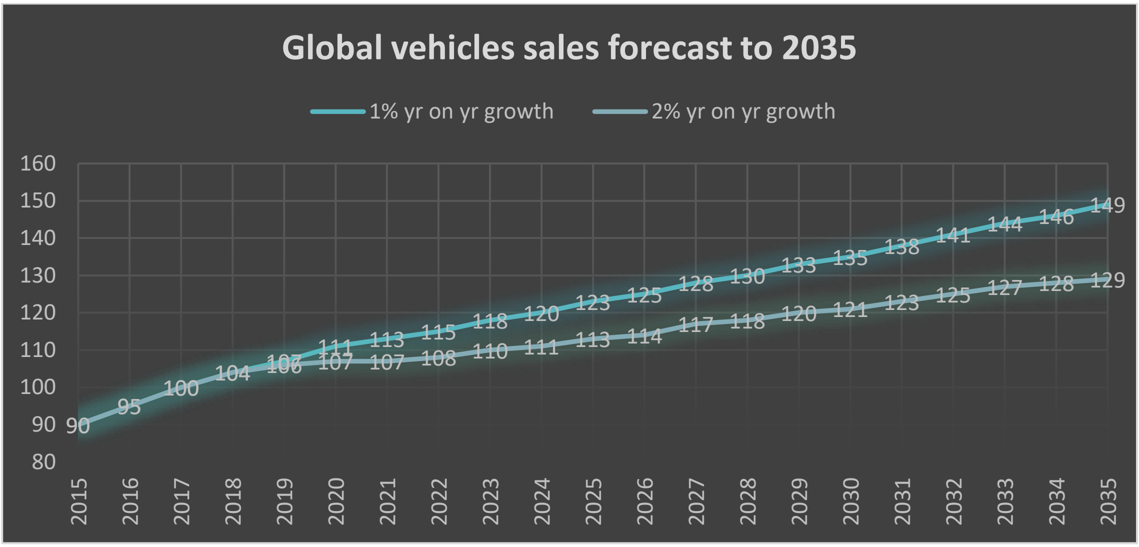


Figure 6.31: Forecast of global vehicles sales in millions leading to 2035

Though the automotive industry was impacted immensely by the recent Covid-19 pandemic and lockdown restrictions which impacted most sectors of production, the industry projects a bullish growth for the coming years, and this is a promising opportunity for exploitation. The automotive industry is reported as one that has notably received direct foreign investments to the tune of R9,2 billion in 2020 with the components manufacturing leg attracting R2,4 billion in foreign investments. For business entities within the automotive value chain, such investments will aid in the promotion of local value-addition and improvements in technological solutions.

In 1995, through strategic governance policies, the Motor Industry Development Programme (MIDP) was formed and subsequently contributed to the acceleration of the automotive industry in becoming the leader in the manufacturing sector of the economy. The existence of free trade policies and preferential trade policies in place has allowed the South African automotive industry to form an integral part of the international supply chains and be fully integrated into the global automotive environment. As much as this is a positive for the industry, there is an associated threat of the industry being impacted by the economic climate in international markets thereby affecting exports.

Vehicle exports from the South African market between the period 1995 to 2022 were reported to total 5,641,644 units of which 3,848,480 units were light motor vehicles. The corresponding value of these exported units totalled R 1,548 trillion whilst the automotive components export value amounted to R892,6 billion. Apart from direct foreign investment, the growth in this industry has been attributed to other factors such as skills development, improved affordability measures, technological advancements as well as digital transformation for business streamlining.

Though the market trends in the automotive industry are electrification of vehicles (electric vehicles) and autonomous or self-driving vehicles, there is a need for innovation pertaining to other aspects of an automobile. This business venture serves to tap into that market of innovation within the automotive industry.

6.3.1 Macro-environmental analysis of the automotive industry

The situational analysis for the business venture focuses on the macro-environment, the industry forces as well as existing competition. It gives a holistic view of the various forces, threats, and competitive rivalry that the Mageza 3D Printing will be subjected to as well as the opportunities which to be exploited. Comprised in this section is the PESTEL model, Porter’s 5 forces model as well as a Competitor Analysis for benchmarking.

Table 6.3.1: PESTEL analysis of the environmental factors in the automotive Industry

Identified Issue	Impact on 3D Printing Business
Political ➢ Political instability and high corruption levels	• Low investor confidence affects sectors reliant on direct foreign investment such as manufacturing
➢ Weak trade control - Statistics indicate that machinery and transportation equipment account for one-third of the country's imports.	• The South African business market imports significant volumes of goods meaning that the existing tariffs may not be as sufficient to protect locally produced goods from international competition.
➢ Bureaucracy created through multi-layers of control systems	• Red tape, which is usually created to put systems in place and create a controlled environment, leads to tedious paperwork and causes confusion in terms of setting up and running a new business
Economic ➢ Greylisting of South Africa	• The grey-list status impacts negatively upon direct foreign investment. This negative impact will have a negative on the manufacturing sector which is strongly boosted by foreign investment.
➢ Contraction in the South African Economy	• This decline in economic growth results in high inflation and reduced circulation of money in the economy. This makes it a bit harder for the consumer to afford high-value products such as vehicles.
Social ➢ Lifestyle	• With the growing usage of taxi services such as Uber and Bolt, customers may show less interest in purchasing vehicles
➢ Buying habits	• During times of economic hardship, inferior goods are preferred by consumers and this may see a rise in the purchase of second-hand vehicles where the appetite to customise may be low

Technological ➢ Shortage of skills in the technology sector ➢ Exorbitant import tariffs on imported printing machinery and filaments ➢ Lag in the adoption of 4IR technologies	• South Africa has a high shortage of skills concerning technology and the learning curve will be quite high to achieve the relevant skill set to sustain the operations. • 3D printers are sourced internationally and are subjected to local import taxes. If these taxes are exorbitant, this will drive up the selling price in an attempt to obtain a return on the investment. Ultimately, this will affect the business's competitive position. • South Africa lags in comparison to most countries concerning the adoption and usage of modern technologies
Environmental ➢ Unreliable Power supply ➢ Unemployment rate ➢ Labour unrests	• Impact on manufacturing operations across the industry. Interruptions in productivity translate to businesses not being able to fulfil orders timeously thus seeing an impact on the entire value chain. • With a high proportion of the working class unemployed (32.9% unemployment), this means a challenge in affording vehicle finance. • Prolonged strike actions imposed by unions and workers have a direct impact on production levels in the automotive value chain
Legal ➢ Changes in legislation and disagreements in policy amendments	• With strong opposing political groups, the policy amendment and adoption processes tend to prolong leaving stakeholders charting ambiguous terrain.

6.3.2 Porter's Five Forces of the Automotive Components Industry

Given that Mageza 3D Printing will be operating within the automotive industry, this compels an understanding of the said industry for positioning purposes. The Porter's Five forces model was used to ascertain competitive rivalry and attractiveness for starting up a 3D printing business for customisation of vehicle interior aesthetics This model considered buyer and supplier power, the potential of new entrants into the market as well as threats brought about by substitute products. In Figure 6.2, the competitive rivalry was found to be moderate through the composition of a strong supplier power, moderate threats of new entrants and substitutes and a weak buyer power.

To address the threat of competition, one aspect to consider is that of improving buyer power. This can be done through a marketing strategy that serves to exhume feelings of connectedness or emotional attachment. From the data analysis, it was evident that connectedness has an influence on purchasing intent therefore increasing awareness of the concept of vehicle interior customisation will expectantly increase drive up buyer power.

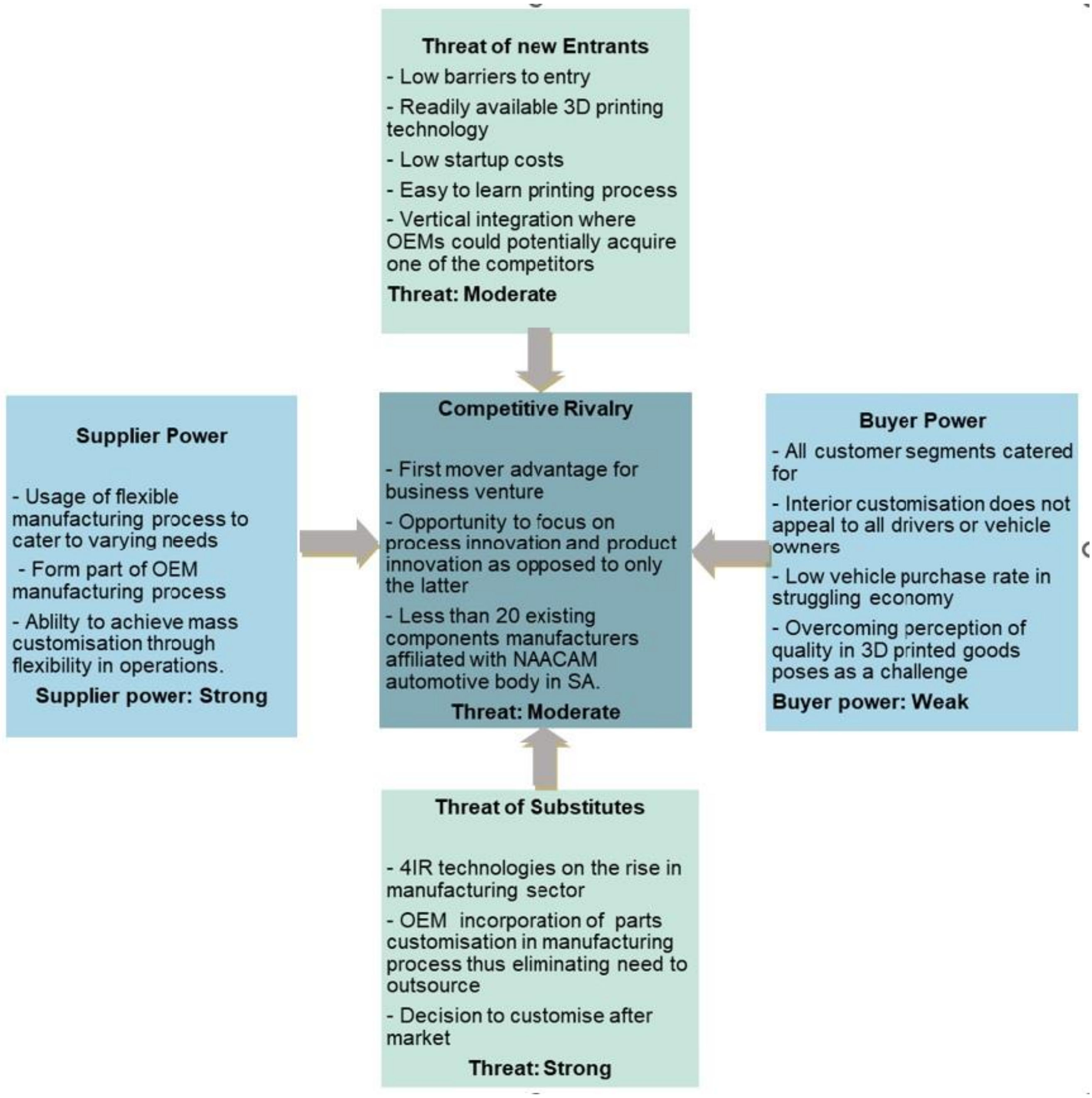


Figure 6.3.2: Porter's Five Forces

6.3.3 Competitor Analysis

Mageza 3D Printing will not be immune to existing competition within the niche group of interior components suppliers within the South African automotive industry. Affiliated to NAACAM are 137 of the estimated 180 component manufacturers and just over 20 of those supply parts for vehicle interiors. A few of these component manufacturers are using additive manufacturing as part of their manufacturing processes, but not for the customisation of interior parts. In joining the South African automotive value chain as a components manufacturer, Mageza 3D Printing ought to employ a differentiation strategy that will set it apart from the existing competition and appeal to the existing OEMs as an innovative value add.

From the list of competitors, the following three companies were selected as depicted in Figure 6.1, and their respective capabilities, strengths and weaknesses were dissected. Gaining insight into their operations is key given that such insight is needed to gauge the strength of the value proposition for this business. A notable observation is the different value propositions for the respective companies, where Ebor is driven by strong technical capabilities, Weidplas by innovation and Feltex by economies of scale (price). Entering this industry as 3D printers for customisation positions our business comfortably amongst its competitors as the value proposition is a combination of both innovation and price.

Table 6.3.3: Competitor Analysis

Competitor Analysis				
		Companies producing vehicle interior components		
		EBOR	**Weidplas**	**Feltex**
Company Profile	Company Information	An independent supplier of components to the South African motor industry, with several products exported globally by its original equipment manufacturing (OEM) customers.	Producer of highly engineered and technically complex plastic components and decorative solutions based on advanced plastic manufacturing technology.	A company with six business units that supply products directly and indirectly to the South African OEMs
Key Competitive advantage	Company Information	***Advanced Technical Capabilities*** Invested in a MOTAN hardware system which is the first of its kind to be installed on the African continent supporting their innovative strategy. This investment has increased the business' technical capabilities.	***Leaders in innovation*** The company has highly sophisticated combinations of product technologies, manufacturing processes and plastics integrated with other materials such as aluminium and steel	***Competitive Price*** Through a prominent supply position by each of the business units in their product sectors, the business has been able to achieve competitive prices through economy-of-scale benefits.
Target Market	Market Information	South African OEMs Other Components Manufacturers in South Africa	South African OEMs Global footprint	South African OEMs
Market share	Market Information	A portion of the R133bn market in passenger vehicle exports and a portion of the 555,889 units produced in 2022.	A portion of the 555,889 units produced in 2022 and a portion of the global production based on the company's global footprint.	A portion of the R133bn market in passenger vehicle exports and a portion of the 555,889 units produced in 2022.
Products and Services	Product Information	Interior trim parts for vehicles	Interior decorative products of plastic/metal composites to create a high-grade look and feel	Door handles, head rests, trunk trims, tufted floor carpets, seat rear trims
Pricing	Product Information	Competitive pricing as the company also operates as a Tier-2 company wherein it supplies its Tier-1 competitors	Competitive pricing as a result of in-house capabilities and refined business processes over 80yrs Purchasing strategy in place allows effective sourcing of raw materials and price-reducing alternatives	Competitive pricing as a result of economies of scale production

Strengths		The company falls within Tiers 1 & 2 wherein it supplies directly to the OEMs as well as to competitors (other Tier 1 suppliers)	Pioneers in plastics. The company has over 80yrs experience in injection-moulding. Complete in-house engineering capabilities. Flexible supply chain management and all partners are fully integrated via EDI which allows just-in-time sequence shipments	Has a specific business unit that deals solely with servicing the automotive industry.
Weaknesses		Logistics costs (port and rail). Skills deficiency. The company has only been in existence for less than 10 years and does not have capabilities as strong as its competitors.	Logistics costs (port and rail). Skills deficiency.	Logistics costs (port and rail). Skills deficiency.
Opportunities	SWOT Analysis	The company conforms to black empowerment which is one of the 7 key development objectives listed in the 2035 Masterplan by the Department of Trade and Industry. This will allow the company to benefit from growth funding aimed at driving transformation in the industry.	As a company with a global footprint, it can take advantage of the projected export volumes for manufactured vehicles leading up to 2035 through economies of scale.	Potential for the long-term development of the South African automotive industry.
Threats		If the Tier 2 supply strategy is stronger than the Tier 1 supply strategy, the business may suffer at times when the OEM source from its competitors. As a start-up entity, cost pressures may be felt more strongly. Unstable electricity supply.	Growing low-cost competition (in domestic, regional, and broader international markets) A weak Rand/dollar exchange rate may affect its global operations. Unstable electricity supply. Increasing environmental regulations.	Increasingly expensive industrial infrastructure. Growing low-cost competition. Rise in production costs.

6.4 SWOT Analysis of Mageza 3D Printing

To understand the competitive position of Mageza 3D Printing within the components' environment, an assessment of the internal capabilities and shortcomings is required at a micro-level. The SWOT analysis not only provides those insights.

Table 6.4: SWOT Analysis for Mageza 3D Printing

Strengths	**Weaknesses**
• Continuous innovation to stay ahead of the competition. • Research and development to not only penetrate the industry but to also remain sustainable in the fast-paced automotive industry. • Unique customer offering and value proposition. • Personalised solutions catering to vehicle users of all ages and genders for a unique experience. • Strong distribution channels established through the strategic locations of the operations. • Affordability of 3D Printers available in the market	• From the data analysed, it can be concluded the current product offerings may not appeal to a wider market i.e. mass appeal. To address this, the business is actively exploring new product offerings that cater to a wider customer base. Continuous research is underway. • The business has not yet established a formidable reputation in the industry and there is an appreciation of the fact that building a formidable reputation takes time. However, the business will focus on actively establishing partnerships and collaborations with industry leaders to enhance credibility, gain recognition and strengthen capabilities.
Opportunities	**Threats**
• The automotive industry is constantly evolving thus presenting with it numerous opportunities for innovation to meet the changing needs of the industry. By staying updated with the latest trends and technologies such as 3D Printing for manufacturing, the business can capitalise on these opportunities and gain a competitive advantage. • Notable demand for personalised automotive solutions as seen by customers seeking unique and personalised solutions for their vehicles. This presents a growing market for the business to exploit and capitalise on. • In the start-up phase, opportunities exist for collaboration with other components manufacturers in the industry whose distribution channels are well established. Through such partnerships, the business can leverage off their expertise and resources to enhance the product offerings and reach a wider customer base. • Expansion into international markets. Whilst our current focus is on the South African market, there is potential for the business to expand its offering into other countries through vehicle exports. This would allow the business to tap into new customer segments and increase its market share.	• There is fierce competition in the automotive industry with numerous players vying for market share. However, there is confidence in the business around the ability to differentiate itself through innovative solutions and providing a personalised offering. • Low barriers to entry in the 3D Printing space. This threat is mitigated through the stringent manufacturing standards set by the respective OEMs, where approvals would need to be done for suppliers seeking to enter the value chain.

6.5 VRIO Analysis for Competitive Positioning

To establish the uniqueness of the concept of 3D printing for customisation, a VRIO analysis was conducted. As a tool, this framework seeks to identify the competitive advantage of the business through the assessment of the valuable resources and capabilities aimed at supporting the idea of 3D printing for customisation. Through the VRIO analysis, the business will identify those unique assets relating to vehicle interior customisation that can be leveraged on. This analysis considers how valuable the resources are, how rare they are, how costly it is to imitate them and how organised the business is to capture value from these. The difference between a Porter's five forces model and the VRIO framework is that the former considers mostly external environmental factors in the automotive industry whilst the latter focuses on internal resources and capabilities of the business. Table 6.4 below displays the internal resources and the competitive position in relation to the components manufacturers space.

Table 6.5: VRIO Analysis of Mageza 3D Printing

Resources/Capabilities	Valuable	Rare	Inimitable	Organised	Competitive Implications
Research & Development	✓			✓	Competitive Parity
Digital transformation	✓	✓		✓	Temporary competitive advantage
Distribution Model	✓			✓	Competitive Parity
Marketing & Sales	✓	✓	✓	✓	Sustained competitive advantage
3D Printing for industrial applications	✓	✓		✓	Temporary competitive advantage

6.6 Management and organisation

The business start-up will have a Managing Director (MD) who will be responsible for all the management decisions of the company for the first five years. Reporting to the MD will be four regional managers responsible for overseeing the daily operations of the business in the respective regions. The Marketing and Finance functions will be centralized. In the initial years, non-core activities will be outsourced until the relevant capabilities have been built in-house. The organogram below in Figure 6.3 represents the structure of the business once setting up has been fully achieved in all the regions.

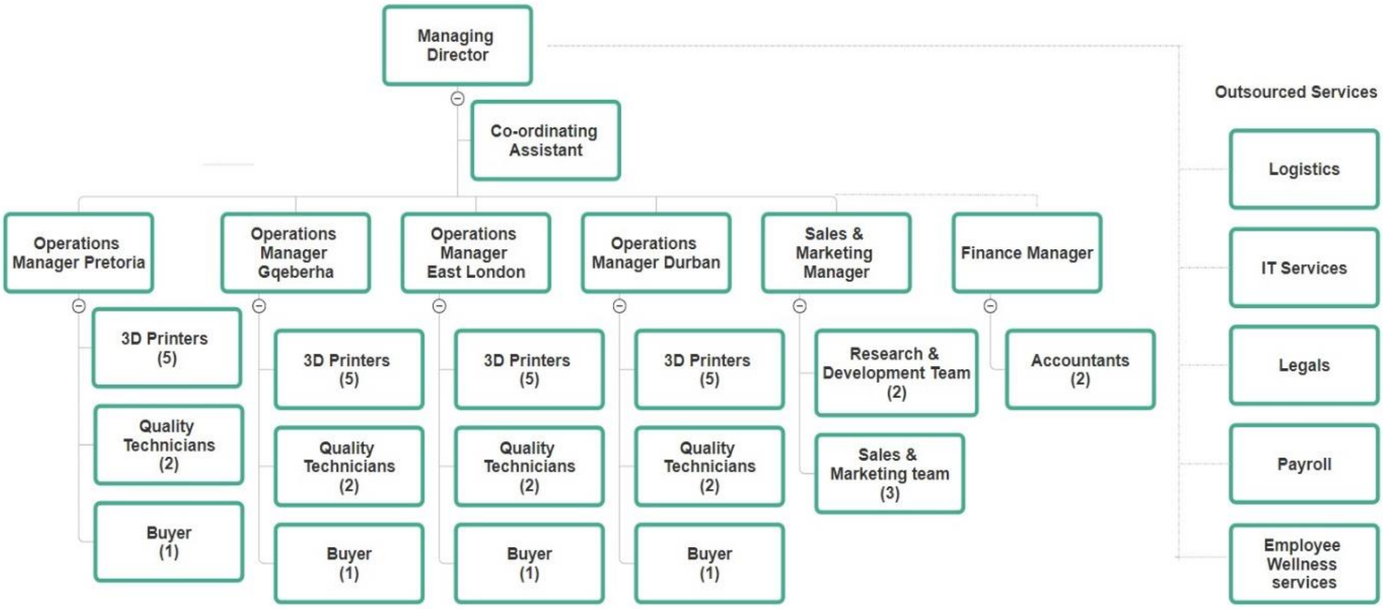


Figure 6.6: Organogram of Mageza 3D Printing

6.7 Operations plan

The Operations Plan details the setting up of operations for Mageza 3D Printing, as well as the operational resources required for achieving customisation success.

6.7.1 Location of operations

The strategic regions for setting up the 3D printing facilities are those where the OEMs have based their operations for ease of logistics and are the following: Pretoria for access to BMW; Port Elizabeth for access to Volkswagen; East London for access to Mercedes Benz and Durban for access to Toyota.

The advantage of setting up operations in these locations is that both the OEMs as well as the component manufacturers have based their operations in these in these regions. Setting up operations facilities here will therefore result in the reduction of logistics costs and minimised product handling risks post production.

6.7.2 Operational resources

The main operational resources for Mageza 3D Printing are equipment resources, human resources, and utilities. The equipment resources include industrial 3D printers (Stereolithography or SLA 3D printers), resin for the printing of interior components, industrial computers, and 3D design software. In the first years of operation, the production facilities and office space will be rented.

Mageza 3D Printing will source industrial 3D printers that have the capability of printing complex parts as well as printing at high speeds to meet the service level agreements in place with the respective customers. These will be sourced from international suppliers given the limited availability of the industrial 3D printers locally. The raw material to be used is resin which will be procured in bulk. Though 3D printing is an energy-efficient manufacturing process, there lies the need to ensure uninterrupted power supply during the printing process considering that any interruptions may result in possible quality issues. To mitigate against the risks of load-shedding and power outages, the premises will be set up with back-up generators at the various operations sites.

6.7.3 Human resources

Human capital is a critical component for the success of Mageza 3D Printing. The recruited personnel will be involved in the setting up of operations in the various regions, the rigorous marketing and sales that is required, the monitoring of operations and quality control. As a start-up, Mageza 3D Printing has a limitation concerning certain capabilities in-house and to address this limitation, some of the human resources functions will be outsourced.

The functions to be outsourced are: Engineering (Consultants); Logistics; IT services; Legal services; Audit services; Payroll services and Employee wellness services. Another limitation is that of availability of sufficient cash flows to sustain extensive overheads during the start-up phase. The strategy is to outsource the Engineering and Design work in the initial years of operation whilst working on progressively building those capabilities in-house.

6.8 Marketing plan

6.8.1 Marketing strategy

It must be noted that customer centricity is key in driving an effective marketing strategy. As a start-up, Mageza 3D Printing needs to ensure high product visibility and for this to be achieved, the marketing budget needs to be significant. As a rule of thumb, the marketing budget ought to be approximately 7% of the revenue, therefore a similar approach will be followed for this business. To accelerate buy-in of the concept of customisation, alliances will be formed with OEMs whereby in the first year of onboarding, a few units will be customised at no cost. This will serve as a means of promoting interior aesthetic appeal to the customer base and essentially garnering buy-in. Whilst this differentiation strategy will allow the OEMs to improve on their competitive advantage, it will in turn grow the visibility of Mageza 3D Printing within the automotive industry.

6.8.2 Target market

The target market is advised largely by the findings of the study. The findings revealed that segmentation according to age and gender is not the best fit for customisation and as a result, the suitable segmentation strategy is that of segmenting by customer preferences and needs. It is evident that customers embodying a deepened sense of connectedness towards vehicles are more likely to purchase cars with customized interiors therefore the target market is comprised of buyers that exhume emotional attachment. Therefore, the concept of 3D printing for customization will be targeted at all drivers and owners who prefer exclusivity and want a more personalized solution.

6.8.3 Products

The products to be produced are 3D printed components of the vehicle interior that create an aesthetic appeal. These products are: the dashboard; the centre console; the door paneling; the sun visors; the gear knob and air vents. These are all components that do not tamper with the safety aspects or performance of the vehicle.

6.8.4 Customer value proposition

Product positioning is one of the key factors in developing a sustainable competitive advantage in business. For sustainability, a competitive advantage should not be based on price alone but ought to offer something of value to the customer. The value creation in 3D printing for customisation will be achieved through the environmentally sustainable mode of production given the minimal waste associated with the manufacturing process as well as the low cost of production for achieving this customisation. Additionally, the manufacturing agility offered by 3D printing will offers speedy delivery of printed parts to customers.

6.8.5 Marketing mix

i. Product

The product offering of customised interior components will be in line with the product differentiation strategy adopted by the company. The innovative and environmentally sustainable 3D printing production process will deliver a competitive product offering. The printed interior aesthetic components will contribute towards environmental sustainability within the automotive industry given the minimal waste associated with 3D printing. This will be achieved through recyclable raw materials (filament) to be used in the printing process as well as the reduced energy as a result of the simplified multi-step manufacturing process.

ii. Price

The process of 3D printing simplifies the multi-step processes used in conventional manufacturing. Moreso, the 3D printing process eliminates waste as it is designed to use up almost the entire filament. These added advantages will assist with competitive pricing as Mageza 3D Printing penetrates a market that competitors have successfully positioned themselves in.

iii. Place

Given that this is a B2B business concept, setting up within close proximity to the OEMs is aimed at simplifying the logistics process from the order placement for components to the delivery of 3D printed products. Setting up operations in the strategic regions will hasten brand positioning through operational visibility. These strategic locations will allow ease in terms of the visitation of premises which in turn allows for business validation from the end of the OEMs and Tier 1 suppliers. Another advantage to setting up in these regions is the logistical flexibility of just-in-time supply as well as the timeous attendance to any quality concerns raised.

iv. Promotion

The product will be promoted through the OEMs. Design concepts will be pitched to the various OEMs with the associated pricing. As a promotional strategy through the marketing budget, a few units will be customised for free for the respective OEMs in an effort of creating product visibility Once buy-in has been obtained from the OEMs, the design concept will be extended to the end-users or potential customers by means of rigorous marketing. The customised interior components will be promoted as affordable personalisation that aligns to environmental sustainability.

6.9 Funding Model

i. Piloting stage

At the piloting stage, funding will be obtained through bootstrapping and the involvement of family, friends and impulsive investors for the procurement of a commercial 3D printer and ABA filament for creating prototypes.

ii. Market-entry stage

At this stage, funding will be obtained from grant funding reserved for: small businesses; tech businesses; black-owned businesses and female owned businesses. There are transformation-targeted funds set aside by the Department of Trade Industry and Competition (DTIC) and the Automotive Industry Transformation Fund in South Africa to assist new entrants into the automotive industry and these are the pools to be considered for funding operations start-up. In the masterplan issued by the DTIC (*Masterplan-Automotive_Industry.Pdf*, 2018.), there is an undertaking to support black-owned components manufacturers in line with broad based black economic empowerment (BBBEE) objectives for transformation within the automotive industry.

iii. Full-scale operations stage

At this stage, the 3D printing business will have stabilised and proven itself to be profitable. It will then be possible to fund the operations through debt (loans) as well as the re-investment of profits.

iv. Scale-up stage

The plan is to retain control of the business for as long as is practical to do so and rope in investors at a much later stage. At the scale-up phase, the business is assumed to have matured enough to attract investors through the release of equity. The funding obtained will be focused towards driving mass customisation through 3D printing and ultimately achieving economies of scale in terms of production.

Below is the funding model depiction as contained in *Figure* 6.4.

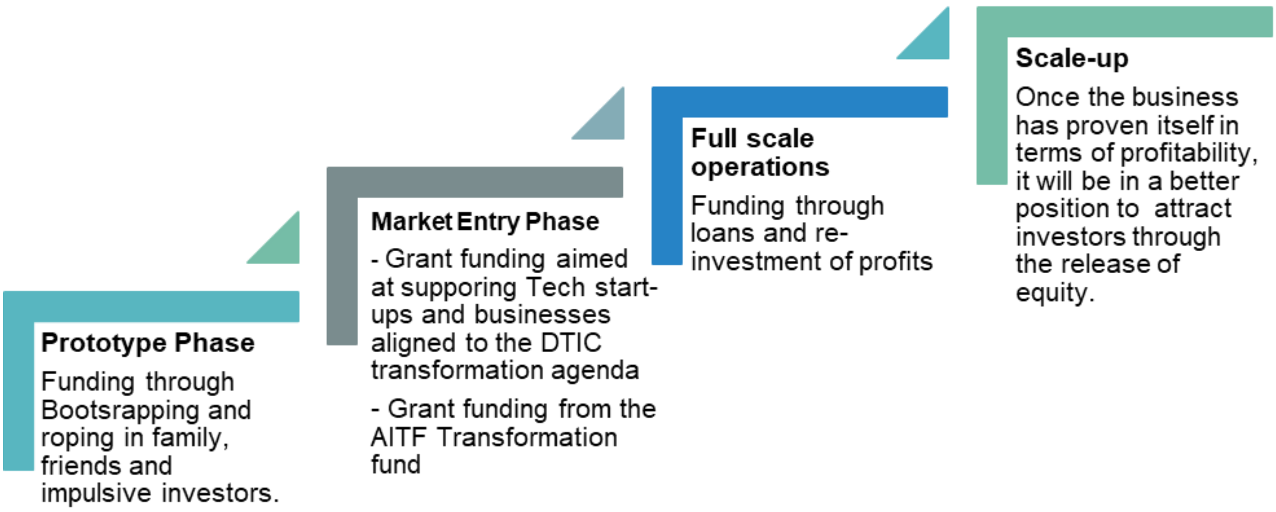


Figure 6.9: Funding model of Mageza 3D Printing

6.10 Financials of Mageza 3D Printing

Given the rollout strategy for setting up operations in a different region each year, the financials are aligned to this approach. In the first year of operation, sales, cost of sales and operational expenses are calculated from the income generated from operating in one region and servicing VW. In the second year, the cashflows are aligned with the operations being carried out in two regions where VW and BMW are being serviced. In the third year, Toyota is onboarded, and Mercedes Benz is only onboarded in the fourth year.

The sales figures are estimated at 5% of total annual unit sales for each of the OEMs when they are onboarded initially and grow by 2% year on year. A sliding scale in market shar will be applied where in Year 3, VW share will be 9%, whilst BMW will be at 7% and Toyota at 5%. This sliding scale approach is based on the notion that the new concept of customisation needs to gain acceptance in the market in the initial years. Once traction is gained through rigorous marketing and visibility in the subsequent years, the business will begin to report an upward trajectory in the market share.

In the Income Statement under Figure 6.6*,* the expected revenue for Year 1 is R117m with a net profit of R 17m, translating to a net profit ratio of 15%. This is a considerably good ratio considering the limited operations in only one region. In Year 2 and Year 3, the net profit margins increase to 20% and 24% respectively which is a positive cashflow trajectory. In Year 3, the onboarding of Toyota will increase the sales units substantially given that Toyota's records the highest number of annual sales (statista.com, 2023) whilst operational expenses remain fairly constant resulting in a high net profit margin. By Year 4, all the regions will be in operation and these figures are indicative of the full operations of the 3D printing business and set the benchmark for the subsequent cash flows into Year 5 and beyond. At Year 4, the profit margins are expected to plateau from whence steady growth kicks in. By Year 5, the expected revenue is R 605m with a net profit of R 159m therefore translating to a 26% net profit margin.

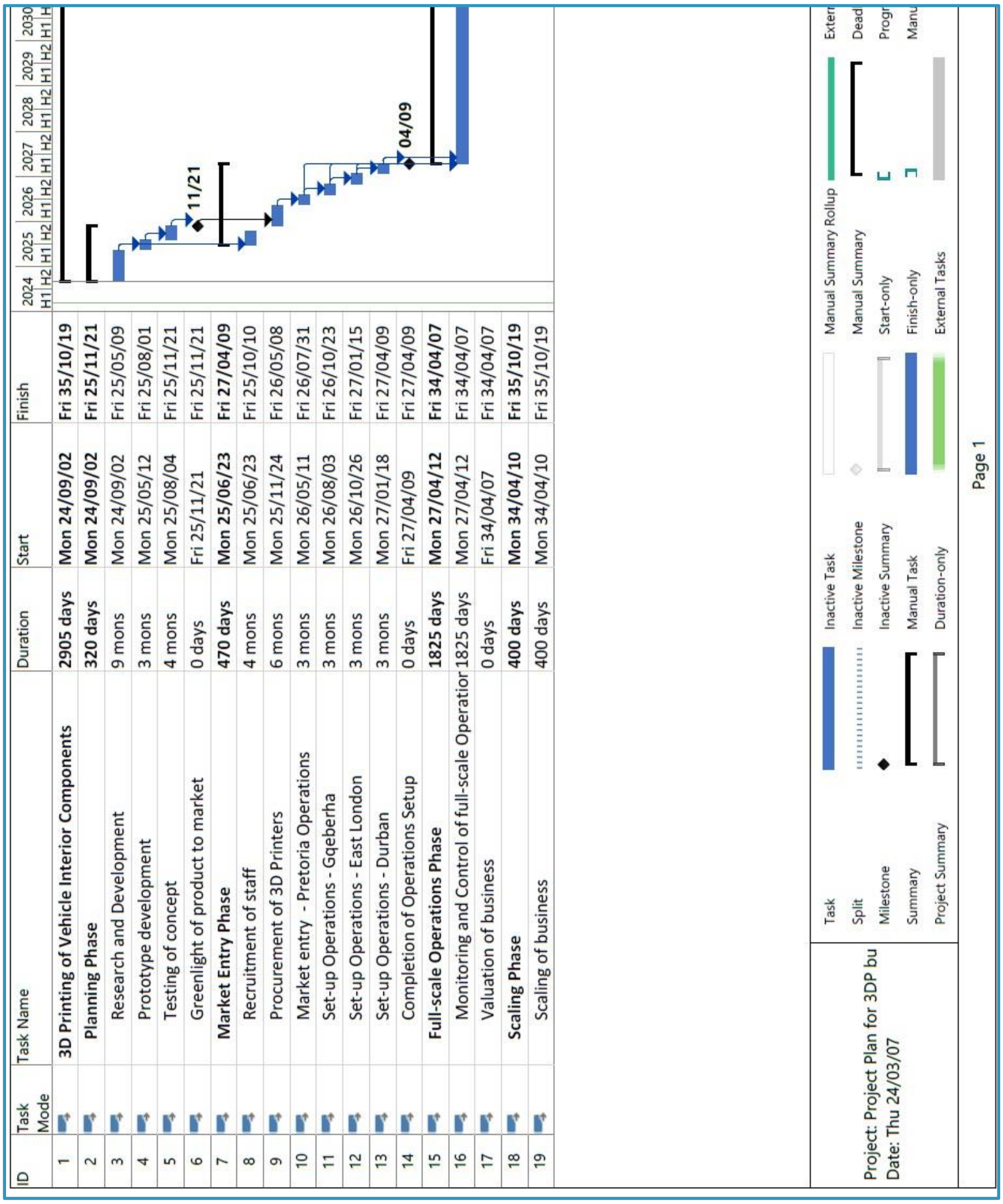
Table 6.10: Income Statement of Mageza 3D Printing

Income Statement

Mageza 3D Printing Business for Vehicle Interior Customisation					
5 Year Income Statement					
	Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**
REVENUES					
VW Sales of customised components	117 650 870,00	165 617 129,70	214 107 459,32	263 126 172,64	312 677 615,06
BMW Sales customised components	-	26 545 672,59	37 368 343,30	48 309 260,38	59 369 397,16
Toyota Sales customised components	-	-	117 654 884,31	165 622 780,64	214 114 764,78
Mercedes Sales customised components	-	-		13 855 788,55	19 504 793,54
TOTAL REVENUES	**117 650 870,00**	**192 162 802,29**	**369 130 686,93**	**490 914 002,21**	**605 666 570,54**
COST OF GOODS SOLD					
VW - 3D Printing Filament	60 349 410,00	84 953 864,46	109 827 142,35	134 976 600,00	160 380 000,00
BMW - 3D Printing Filament	-	13 616 692,16	19 168 217,55	24 789 600,00	30 452 400,00
Toyota - 3D Printing Filament	-	-	60 351 469,16	84 961 800,00	109 830 600,00
Mercedes - 3D Printing Filament	-	-		7 108 200,00	9 999 000,00
TOTAL COST OF GOODS SOLD	**60 349 410,00**	**98 570 556,61**	**189 346 829,05**	**251 836 200,00**	**310 662 000,00**
GROSS PROFIT (LOSS)	**57 301 460,00**	**93 592 245,68**	**179 783 857,88**	**239 077 802,21**	**295 004 570,54**
OPERATING EXPENSES					
Industrial 3D Printers	8 000 000,00	4 000 000,00	4 000 000,00	0	0
Industrial Computers & Laptops	304 000,00	87 000,00	90 000,00	93 000,00	45 000,00
3D CAD Software	65 000,00	140 000,00	210 000,00	270 000,00	290 000,00
Marketing and Advertising	8 235 560,90	13 451 396,16	25 839 148,09	34 363 980,15	42 396 659,94
Company Vans	400 000,00	440 000,00	480 000,00	520 000,00	0
Transportation of Goods	400 000,00	800 000,00	1 300 000,00	1 600 000,00	1 800 000,00
Engineering Consulting services	3 000 000,00	2 800 000,00	2 500 000,00	2 500 000,00	2 500 000,00
IT Services	550 000,00	800 000,00	1 000 000,00	1 200 000,00	450 000,00
Business Licenses and Permits	300 000,00	300 000,00	300 000,00	300 000,00	300 000,00
Professional Services - Legal, Accounting	700 000,00	700 000,00	700 000,00	700 000,00	700 000,00
Information Management Systems	70 000,00	100 000,00	130 000,00	130 000,00	130 000,00
Insurance	18 000,00	24 000,00	30 000,00	36 000,00	36 000,00
Training and Development	250 000,00	300 000,00	350 000,00	400 000,00	250 000,00
Rental Payments	420 000,00	840 000,00	1 260 000,00	1 680 000,00	1 920 000,00
NAAMSA Fees (Premium Package)	82 000,00	83 000,00	84 000,00	85 000,00	86 000,00
Salaries	10 056 000,00	14 709 780,00	18 709 920,00	22 710 060,00	24 186 213,90
Office Supplies	20 000,00	40 000,00	60 000,00	80 000,00	90 000,00
Payroll Processing	10 800,00	18 000,00	26 880,00	37 440,00	42 120,00
Postage and Delivery	30 000,00	60 000,00	90 000,00	120 000,00	120 000,00
Telephone	22 000,00	26 000,00	30 000,00	36 000,00	42 000,00
Travel	120 000,00	140 000,00	160 000,00	180 000,00	200 000,00
Utilities	200 000,00	350 000,00	500 000,00	650 000,00	700 000,00
Sundry Expenses	100 000,00	200 000,00	300 000,00	400 000,00	450 000,00
TOTAL OPERATING EXPENSES	33 353 360,90	40 409 176,16	58 149 948,09	68 091 480,15	76 733 993,84
PROFIT BEFORE INTEREST & TAX (PBIT)	**23 948 099,10**	**53 183 069,52**	**121 633 909,79**	**170 986 322,06**	**218 270 576,70**
Less Tax @ 27%	6 465 986,76	14 359 428,77	32 841 155,64	46 166 306,95	58 933 055,71
NET PROFIT (LOSS)	**17 482 112,34**	**38 823 640,75**	**88 792 754,15**	**124 820 015,10**	**159 337 520,99**
Net Profit Ratio	**15%**	**20%**	**24%**	**25%**	**26%**

6.11 Timelines for operations setup

The timelines of the 3D Printing business are shown in the Gantt Chart in Figure 6.5 below and are indicative of the phases from R&D till the scaling phase leading to 2035. In year 1, the planning phase commences and expected completion date is November 2025. This will be followed by the market entry phase from January 2026 for setting up operations in the various regions and the targeted completion date is April 2027. From this date, Mageza 3D Printing will be operating at full scale until the business is ready for expansion.



ID	Task Mode	Task Name	Duration	Start	Finish
1		3D Printing of Vehicle Interior Components	2905 days	Mon 24/09/02	Fri 35/10/19
2		Planning Phase	320 days	Mon 24/09/02	Fri 25/11/21
3		Research and Development	9 mons	Mon 24/09/02	Fri 25/05/09
4		Prototype development	3 mons	Mon 25/05/12	Fri 25/08/01
5		Testing of concept	4 mons	Mon 25/08/04	Fri 25/11/21
6		Greenlight of product to market	0 days	Fri 25/11/21	Fri 25/11/21
7		Market Entry Phase	470 days	Mon 25/06/23	Fri 27/04/09
8		Recruitment of staff	4 mons	Mon 25/06/23	Fri 25/10/10
9		Procurement of 3D Printers	6 mons	Mon 25/11/24	Fri 26/05/08
10		Market entry - Pretoria Operations	3 mons	Mon 26/05/11	Fri 26/07/31
11		Set-up Operations - Gqeberha	3 mons	Mon 26/08/03	Fri 26/10/23
12		Set-up Operations - East London	3 mons	Mon 26/10/26	Fri 27/01/15
13		Set-up Operations - Durban	3 mons	Mon 27/01/18	Fri 27/04/09
14		Completion of Operations Setup	0 days	Fri 27/04/09	Fri 27/04/09
15		Full-scale Operations Phase	1825 days	Mon 27/04/12	Fri 34/04/07
16		Monitoring and Control of full-scale Operatior	1825 days	Mon 27/04/12	Fri 34/04/07
17		Valuation of business	0 days	Fri 34/04/07	Fri 34/04/07
18		Scaling Phase	400 days	Mon 34/04/10	Fri 35/10/19
19		Scaling of business	400 days	Mon 34/04/10	Fri 35/10/19

Figure 6.11: Timelines for Operations Rollout

6.12 Business risks identified for Mageza 3D Printing

Mageza 3D Printing will not be immune to business risks and Table 6.6 below indicates the identified major risks as well as the mitigation responses for these risks. The risks will be monitored and periodically assessed to test the effectiveness of the mitigation responses in reducing or eliminating the associated threats and impacts.

Table 6.12: Major Risks and Mitigations for Mageza 3D Printing

Risk	Threat (High, Moderate, Low)	Impact	Mitigation Response
Failure of product to gain traction in the market given the findings of the study pointing out to the general population and not to a specific segment in the market	High	High	Increase marketing budget to increase product awareness through rigorous marketing and advertising. Promotion Strategy - Customise a few units for free for each of the OEMs as concept advertising.
Failure to meet customer (OEM) demand	High	High	Test production capacity by rolling out operations in one region at a time. If demand increases, scale up through the addition of 3D Printers and operations team.
Challenges with timeously accessing after-sales support for 3D Printers during breakdowns	Moderate	High	Procurement Decision – Purchase 3D Printers from an international supplier with support offices in South Africa in order to access timeous after sales support.
Power supply interruptions during printing resulting in compromised product quality	High	High	Alternative Power Source - Invest in sufficient generators capable of powering up the entire operations. Programme the 3D Printers to "fail-safe" mode when an interruption occurs.
Shortage of technical skills relating to 4IR technologies in South Africa	High	Moderate	Invest substantially in training and development in the initial years (Sizeable training budget).

6.13 Conclusion

The business case for Mageza 3D printing presented the strategic overview of the business with measurable strategic objectives. The market penetration strategy detailed the phased operations roll out plan as well as how the different supply tiers will benefit the business in the automotive supply chain. Insight into the market was obtained through a market analysis which indicated a projected growth of 1-2%

year on year globally, with more sales expected from the emerging markets. The macro-environmental factors affecting the business were analysed using the PESTEL model as well as Porter’s five forces model of competitive rivalry.

For the competitor analysis, three components manufacturing entities were used to assess their competitive strengths and value propositions for benchmarking purposes. The funding model was aligned to the phasing of the operations and the different funding sources were presented, especially the available transformation funds set aside for previously marginalised entrepreneurs in South Africa. The financials indicated that the business is profitable from the first year with net profit of 15%, which is to be expected given the comparatively low production costs associated with 3D printing. With year-on-year growth, the profitability margins reached 26% by the fifth year. The business case concluded with the identified business risks and the mitigation strategies.

CHAPTER 7 - RESEARCH SUMMARY, CONCLUSION, LIMITATIONS AND RECOMMENDATIONS

7.1 Research Process and Content Summary

This section summarises the conceptualisation of the research, the development of the conceptual framework, the research methodology used, the research results, the findings of the research and the business case.

7.1.1 Conceptualisation of the Research

The research was conceptualised around the need for offering vehicle interior customisation as a means of catering to the diverse preferences of vehicle owners and drivers. The concept therefore delved into the approach of customisation using one of the 4IR technologies, namely 3D printing, which has the capabilities of achieving manufacturing flexibility at high speeds and reduced costs as opposed to traditional manufacturing, thus justifying customisation. The purpose of the research was to investigate the viability of introducing an innovative solution of 3D Printing for customising vehicle interior components for an aesthetic appeal. This investigation was done by reaching out to ordinary drivers and vehicle owners to ascertain interest and acceptance levels of customisation for the justification of that concept and business case. The research gap that the study served to address was that of inclusivity in terms of customer preference and personalisation in the current vehicle interior offering in line with customer heterogeneity.

7.1.2 Conceptual framework

The five variables which were used to establish the conceptual framework were age, gender, customisation, connectedness and purchasing intent. The hypotheses were developed around this framework assuming that: age has an impact on customisation; that gender has an impact on customisation; that customisation drives connectedness; that connectedness drives purchasing intent and finally, that customisation has an impact on purchasing intent. The conceptual framework was developed to provide the linkages between the dependent and the independent variables.

7.1.3 Methodology

The research strategy adopted for the study was that of quantitative research accompanied by a descriptive research design. The target population comprised of all the vehicle drivers, owners, and potential owners, from whence the representative sample was determined. A probability sampling approach was followed where data was collected from random respondents through a Likert-scale survey. For the survey questionnaire, existing measurement scales were explored and used.

For analysing the data, the structural equation model was used whereby the measurement model was assessed followed by the structural model. In addition, the confirmatory factor analysis was carried out to validate the factor structure of the study constructs of age, gender, customisation, connectedness and purchasing intent. The data analysis served to either accept or reject the alternative hypotheses.

7.1.4 Empirical research results

The confirmatory factor analysis revealed a desirable absolute fit as well as desirable relative fit indices thus suggesting model fit and reliability. From the assessment of the measurement model in the structural equation, reliability analysis through the obtained Cronbach Alpha coefficient values revealed that all the constructs were reliable. The assessment model confirmed the data to be discriminantly valid as well as convergently valid. The coefficients of determination in the structural model revealed age and gender as not having any effect on customisation whilst customisation and connectedness had a moderate effect on purchasing intent. The structural model assisted with determining the associations between the variables of the study.

7.1.5 Discussion of the findings and the business case

These findings inferred that the concept of customisation does not appeal to certain demographics and that segmentation ought to be done by customer need and not by demographics. Using this approach, the business case was then drafted to cater to all demographics displaying a preference for customised vehicle interior components.

The business case delved into the macro and micro environmental analyses to understand the automotive industry market and trends, competition within the components manufacturing sector and the competitive position of the 3D Printing business. The Operations Plan laid out the required resources to start up the business as well as the roll-out strategy in the various regions. The Marketing Plan detailed the marketing strategy and the customer value proposition. The funding stages were aligned with the activities timeline to 2035, starting with bootstrapping in the piloting stage up till the scaling stage where shareholder investment will be sought. The business showed profitability of 15% in Year 1 which increased year on year to 26% by Year 5.

7.2 Conclusion

7.2.1 Research finding contribution to the knowledge gap

The contributions from the research findings are that the vehicle interior design which is predominantly black, grey and beige brown should not be the only offering in the automobile market. The study shows that there exists an interest for other designs which are more aesthetically pleasing. The study revealed that customers who have a deepened sense of connectedness to the interior of a vehicle are more likely to purchase the vehicle given the feelings exhumed. What can be deduced from the study is that 4IR technology such as 3D printing is a disruptor in the context of traditional manufacturing and has the potential to enhance value creation in the automotive industry value chain.

7.2.2 Comparison of findings to similar studies

Concerning age and gender as drivers for vehicle interior customisation, similar studies were not congruent with the findings of this study in that certain age groups presented higher acceptance levels to the concept and in other studies, females were more inclined to the concept. On the hypothesis of customisation having an impact on connectedness, similar studies were in support of the findings in that indeed, there is a connection between the two variables. Similar supporting views were held by previous scholars regarding the impacts of customisation and connectedness on purchasing intent whereby their studies revealed that both customisation and connectedness had an effect on purchasing intent.

7.3 Limitations

The limitations of the study emanated from the research strategy adopted for the research methodology. A qualitative research strategy needed to be explored as well through the involvement of the OEMs in the collection of data given that Mageza 3D Printing is a B2B supplier. However, given the challenges encountered in sourcing willing participants from the respective OEMs to partake in interviews, the qualitative aspect of the research was deliberately omitted.

7.4 Recommendations

7.4.1 Policy implications

This study gives insight into how 4IR technologies can be embraced for start-ups in the automotive industry and it is recommended that policymakers in this industry introduce policies that drive manufacturing localisation through technology, with the overall objective of job creation.

Of the 180 estimated first tier suppliers in the automotive industry (inclusive of the 137 affiliated to NAAMSA), 75% of these are multi-national companies (Mashilo & Moothilal, 2022). For a country that rolled out a strategic governance policy called the Motor Industry Development Programme as far back as 1995, it is expected that significant strides would have been made to accelerate the participation of more local components manufacturers within the automotive value chain, with a targeted focus on previously disadvantaged entrepreneurs. The objectives of manufacturing localisation, industry transformation and industry-required skills development are further supported by the South African Automotive Masterplan (SAAM) and the AITF however, real transformation is yet to be seen. As much as there exists free trade policies and preferential trade policies with other countries, these policies benefit the imports and exports part of the industry and not necessarily the accelerated localisation of components manufacturing.

7.4.2 Implications to practitioners

The practitioners that this study benefits are those involved in marketing as well as new entrants into the components manufacturing space. The recommendation for marketing is to sample from the older age group of vehicle owner and driver population to ascertain interest from this demographic. This study focuses more on a young age demographic. For new components manufacturers, the concept of 3D printing offers a relatively simplified manufacturing process compared to traditional manufacturing with the potential to create a wide range of opportunities within manufacturing. Furthermore, using 3D printers in the components manufacturing sector may prove more profitable as a result of the low capital investment and the simplified production process involved. A notable challenge is that there is a limited range of industrial 3D printers available locally resulting in the need to source abroad and that may impact on the product testing required prior to making the capital investment.

7.4.3 Theoretical implications

For the academic fraternity, the study makes recommendations in line with the identified research gaps. Further insight is required in understanding the barriers to entry for local components manufacturers, especially in reaching the Tier 1 stage and supplying directly to OEMs as well as the extent of 4IR technology usage in advancing the automotive industry value chain.

7.4.4 Future research

Future research is recommended for this work in order to target a more diverse group of respondents in terms of demographics and to ascertain interest directly from the OEMs through a quantitative research strategy concerning the concept of 3D Printing for customisation. The combination of the findings from the end users together the with the OEMs will give the necessary weight to a business case such as this from buy-in that would have been assessed throughout the value chain.

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Annexures to the research

Annexure A – Confirmation of ethics approval

Graduate School of Business Administration
University of the Witwatersrand, Johannesburg

Wits Business School

Wits Business School Ethics Committee
Constituted under the University Human Research Ethics Committee (Non-Medical)

Ethics Clearance Certificate

Ethics protocol number: WBS/BA2410165/594

This certificate is only valid with a legitimate ethics protocol number and signed by the Researcher (below)

Project title	Using 3D printing technology to manufacture interior aesthetic components for automobiles
Investigator / Researcher	Miss Nondumiso Mbambo
Nature of Project	MBA (Business Venture Proposal)
Decision of the Committee	Approved, provided stakeholders and participants are guaranteed confidentialty.
Issue Date of Certificate	04/02/2022
Expiry date	Date of submission of the project report
Chairperson	Ms Ayanda Magida ☎ +27 11 717 3953 ✉ ayanda.magida@wits.ac.za

Declaration by Researcher

One copy must be signed by the Researcher and returned to the Chairperson of the Wits Business School Ethics Committee.

I fully understand the conditions under which I am authorized to carry out the abovementioned research and I guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I undertake to resubmit the protocol to the Committee.

Signature   07 Feb 2022
                                                 Date:

Annexure B – Measurement scales

		Measurement Scales (Confirmatory Factor Analysis)		
Declaration		Declaration - I consent to partaking in the study	Ethical consideration	
		I am above the age of 18	Ethical consideration	
Demographic info	1	Respondent currently owns or drives a vehicle	Rose et.al, 2012	Journal of Retailing 88, Vol 2 (2012) pg 317
	2	Gender of the respondent		
	3	Age group of the respondent (18-29) (30 - 39) (40 - 49) (50 - 59) (60+)	Luo et.al.	Technological Forecasting & Social Change 194; 122752
Customisation	4	The look and feel of the car interior is important when buying a car	Rose et.al, 2012	Journal of Retailing 88, Vol 2 (2012) pg 317
	5	I like it when I am able to customize the interior of a vehicle to my own liking	Rose et.al, 2012	Journal of Retailing 88, Vol 2 (2012) pg 317
	6	A customised interior of a vehicle should feel like it is talking to me personally as a driver	Rose et.al, 2012	Journal of Retailing 88, Vol 2 (2012) pg 317
	7	The customised vehicle to my preference makes me feel recognized as a customer	Rose et.al, 2012	Journal of Retailing 88, Vol 2 (2012) pg 317
	8	The aesthetics of a customised vehicle interior promote a perception of quality	Rose et.al, 2012	Journal of Retailing 88, Vol 2 (2012) pg 317
	9	I like it when I am able to customize certain vehicle parts to my own liking	Rose et.al, 2012	Journal of Retailing 88, Vol 2 (2012) pg 317
	10	Customised cars using 3D printing will contribute to environmental sustainability	Degirmenci & Breitner, 2017	Transportation Research PartD: Transport and Environment, 51, pp.250260
	11	The aesthetics of a customised vehicle interior promote a perception of quality	Rose et.al, 2012	Journal of Retailing 88, Vol 2 (2012) pg 317
Connectedness	12	A customised vehicle interior increases my feelings of connectedness	Rose et.al, 2012	Journal of Retailing 88, Vol 2 (2012) pg 317
	13	Connectedness to a vehicle exhumes positive feelings	Lee & Robbins, 1998	Journal of Counselling Psychology
	14	It is important to me that the interior of a vehicle feels like my personal area when inside the car	Rose et.al, 2012	Journal of Retailing 88, Vol 2 (2012) pg 317
	15	I have felt connected to the interior aesthetics of the car I drive or own	Watts et.al., 2022	Psychopharmacology (2022) Issue 239 pg 3468
	16	The feeling of self-fulfilment I get from a personalised car interior is significant	O'Cass, 2000	Journal of Economic Psychology Vol 21 pg 545-576
	17	I feel a sense of personal satisfaction when inside a car with a personalised interior	O'Cass, 2000	Journal of Economic Psychology Vol 21 pg 545-576
	18	I was attracted to this interior design at first sight	Vilches-Montero et.al., 2018	Journal of Retailing and Consumer Services Volume 40 pg 82–90
	19	I would be happier if I could afford buying a car with a customised interior	Vilches-Montero et.al., 2018	Journal of Retailing and Consumer Services Volume 40 pg 82–90
Purchasing Intent	20	The internal appearance of a vehicle is an important factor that influences vehicle purchase decisions	Carly et.al. 2019	Transportation Research Part D Issue 70 pg 101
	21	Given that I had the opportunity, I predict that I would buy a vehicle with a customised interior	Degirmenci & Breitner, 2017	Transportation Research PartD: Transport and Environment, 51, pp.250260.
	22	I place great value in making the right decision when it comes to purchasing a vehicle	O'Cass, 2000	Journal of Economic Psychology Vol 21 pg 545-576
	23	I cannot wait to own a vehicle customised through 3D printing	Vilches-Montero et.al., 2018	Journal of Retailing and Consumer Services Volume 40 pg 82–90
	24	I would buy this 3D printed customised vehicle than the standard vehicles currently in the market	Vilches-Montero et.al., 2018	Journal of Retailing and Consumer Services Volume 40 pg 82–90
	25	I would be willing to purchase this place in the near future	Vilches-Montero et.al., 2018	Journal of Retailing and Consumer Services Volume 40 pg 82–90
	26	This 3D printed customised interior really matches my desire	Vilches-Montero et.al., 2018	Journal of Retailing and Consumer Services Volume 40 pg 82–90
	27	The prices of customised vehicles are too high	Carly et.al. 2019	Transportation Research Part D Issue 70 pg 100

Annexure C - Survey Questionnaire

Item	Question
	Declaration - I consent to partaking in the study
	I am above the age of 18
1	Respondent currently owns, drives a vehicle or intents to own a vehicle in the future
2	Gender of the respondent (Male) (Female) (Other)
3	Age group of the respondent (18-29) (30 - 39) (40 - 49) (50 - 59) (60+)
4	The look and feel of the car interior are important when buying a car
5	I like it when I am able to customize the interior of a vehicle to my own liking
6	A customised interior of a vehicle should feel like it is talking to me personally as a driver
7	The customised vehicle to my preference makes me feel recognized as a customer
8	The aesthetics of a customised vehicle interior promote a perception of quality
9	I like it when I am able to customize certain vehicle parts to my own liking
10	Customised cars using 3D printing will contribute to environmental sustainability
11	The aesthetics of a customised vehicle interior promote a perception of quality
12	A customised vehicle interior increases my feelings of connectedness
13	Connectedness to a vehicle exhumes positive feelings
14	It is important to me that the interior of a vehicle feels like my personal area when inside the car
15	I have felt connected to the interior aesthetics of the car I drive or own
16	The feeling of self-fulfilment I get from a personalised car interior is significant
17	I feel a sense of personal satisfaction when inside a car with a personalised interior
18	I was attracted to this interior design at first sight
19	I would be happier if I could afford buying a car with a customised interior
20	The internal appearance of a vehicle is an important factor that influences vehicle purchase decisions
21	Given that I had the opportunity, I predict that I would buy a vehicle with a customised interior
22	I place great value in making the right decision when it comes to purchasing a vehicle
23	I cannot wait to own a vehicle customised through 3D printing
24	I would buy this 3D printed customised vehicle than the standard vehicles currently in the market
25	I would be willing to purchase this place in the near future
26	This 3D printed customised interior really matches my desire
27	The prices of customised vehicles are too high

Annexure D - Graphic representation of the customised interior components

Annexure E - Summary of the theory bases

No	Theory or theoretical framework	Area of emphasis	Relevance to the study
1	Digital Transformation and Digital Maturity	i) Extend of transformation within the automotive industry in the digital era ii) Adoption of 4IR technologies in the automotive industry	The level of digital maturity in the automotive industry is directly related to the level of application of 3D printing. A higher level of maturity is favourable to the new business venture
2	Innovation adoption	Adoption of innovation and technologies by companies and industries	The new business venture is a new innovative solution that needs to be adopted by the automotive industry to be successful. Key purpose = Adoption
3	Diffusion of Innovation	The cascade of new technology or innovation to individuals, which in turn drives institutional adoption	The customisation of the interior of automobiles is aimed at individuals. Their acceptance validates the new business proposal. Key purpose = Validation
4	Lean Innovation	Emphasis on the elimination of waste and efficiency	Efficiency and cost reduction are key considerations in the viability of customisation using 3D printing
5	Entrepreneurship	Opportunity identification and exploitation	The identified opportunity in the automotive industry will be exploited through the new business proposal put forward in this study