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DIGITAL TRANSFORMATION IN THE BRAZILIAN AUTOMOTIVE INDUSTRY: IMPACTS AND CRITICAL SUCCESS FACTORS

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Tese apresentada ao Programa de Pós-Graduação em Ciência da Computação da Universidade Federal de Pernambuco, como requisito parcial para obtenção do título de Doutor em Ciência da Computação. Área de Concentração: Engenharia de Software e Linguagens de Programação.

Orientador: Silvio Romero de Lemos Meira

Coorientador: Sergio Castelo Branco Soares

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To my wife, Vania Maria da Silva Costa Daxbacher, and my son, Gabriel Costa Daxbacher. Everything I have achieved, I owe to them.

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RESUMO

Contexto: A indústria automobilística sofreu uma verdadeira revolução econômica e tecnológica nos últimos anos, adaptando-se continuamente a um mundo cada vez mais digitalizado. A Transformação Digital desempenha um papel proeminente ao representar uma mudança abrangente que vai além da mera incorporação de tecnologias digitais em produtos automotivos. As empresas automotivas têm se esforçado para redefinir suas estratégias competitivas a fim de se adaptarem às peculiaridades desta Era Digital.

Objetivo: Esta tese tem como objetivo identificar os impactos da transformação digital no setor automotivo brasileiro e esclarecer os fatores críticos de sucesso na implementação de projetos de transformação digital, frente aos desafios e mudanças impostos pela economia digital.

Método: Foi realizado um estudo qualitativo por meio de entrevistas semiestruturadas com 14 executivos *C-Level* de cinco grandes fabricantes de veículos do Brasil (o que representa mais de 2/3 desse setor), e o software MAXQDA apoiou a análise dos dados qualitativos.

Relevância: Esta tese aborda uma lacuna na pesquisa acadêmica focada em impactos e fatores críticos de sucesso para projetos de transformação digital, particularmente no contexto da Indústria Automotiva Brasileira (IAB), para fornecer *insights* significativos para pesquisas futuras e contribuir para a base de conhecimento científico sobre transformação digital.

Resultados: Os principais resultados desta pesquisa são identificar e qualificar os impactos e fatores críticos comuns de sucesso na implementação de projetos de transformação digital na IAB e propor um modelo que possibilite sua implementação em projetos futuros para aumentar suas chances de sucesso no mercado competitivo atual.

Contribuições: Esta tese contribui para a literatura especializada ao integrar teoria e prática sobre transformação digital, destacando a importância de fatores como liderança, estratégia e inovação organizacional, e fornecendo um modelo prático baseado nos resultados obtidos para aplicação em iniciativas futuras.

Palavras-chave: Transformação Digital; Fatores Críticos de Sucesso; Indústria Automotiva Brasileira.

ABSTRACT

***Context**: The automotive industry has undergone a genuine economic and technological revolution in recent years, continually adapting to an increasingly digitalized world. Digital Transformation plays a prominent role in representing a comprehensive change beyond merely incorporating digital technologies into automotive products. Automotive companies have been striving to redefine their competitive strategies to adapt to the peculiarities of this Digital Era.*

***Objective**: This thesis aims to identify the impacts of digital transformation on the Brazilian automotive sector and to clarify the critical success factors in implementing digital transformation projects, given the challenges and changes imposed by the digital economy.*

***Method**: A qualitative study was conducted using semi-structured interviews of 14 C-Level executives from five major vehicle manufacturers in Brazil (which represents more than 2/3 of this sector), and MAXQDA software supported the qualitative data analysis.*

***Relevance**: This thesis addresses a gap in academic research focused on impacts and critical success factors for digital transformation projects, particularly in the context of the Brazilian Automotive Industry (BAI), to provide significant insights for future research and contribute to the scientific knowledge base on digital transformation.*

***Results**: The main results of this research are to identify and qualify the impacts and common critical success factors in implementing digital transformation projects in the BAI and to propose a model enabling its implementation in future projects to increase their chances of success in the current competitive market.*

***Contributions**: This thesis contributes to the specialized literature by integrating theory and practice on digital transformation, highlighting the importance of factors such as leadership, strategy, and organizational innovation, and providing a practical model based on the results obtained for application to future initiatives.*

***Keywords:** Digital Transformation; Critical Success Factor; Brazilian Automotive Industry.*

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LIST OF ABBREVIATIONS AND ACRONYMS

ANFAVEA	Associação Nacional dos Fabricantes de Veículos Automotores
BAI	Brazilian Automotive Industry
CSF	Critical Success Factors
DT	Digital Transformation
IT	Information Technology
PPT	People, Process, Technology
R&D	Research and Development
ROI	Return on Investment

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1. INTRODUCTION

In the past years, the automotive industry has been undergoing a true economic and technological revolution as it continuously adapts to an increasingly digitalized world, which requires ever-higher efforts that impact the entire production chain. Digital transformation (DT), which is frequently termed as “Industry 4.0” in the context of manufacturing, plays a prominent role in the representation of a widespread change beyond the mere incorporation of digital technologies into automotive products. DT encompasses all the industrial business processes, that is, from acquisition to manufacturing processes, passing through research and development (R&D), and extending to marketing and involving all sales and after-sales aspects (PICCININI *et al*., 2015; HESS *et al*., 2016).

Studies point out that DT is incrementing profitability, productivity and competitiveness of the automobile assemblers, resulting in improvement of the consumers’ satisfaction by means of enhanced services (LLOPIS-ALBERT; RUBIO; VALERO, 2020). In addition, the expansion of autonomous, electric and connected cars exemplifies a change in the consumer expectations and demands due to these new products and digital services (VEREVKA; GUTMAN; SHMATKO, 2019).

Nevertheless, the journey towards DT in the automotive industry does not occur without challenges. Companies face the hard task of keeping up with the rapid technological advances, which demands continuous adaptation to remain relevant and competitive (SIMONAZZI; SANGINÉS; RUSSO, 2020). Managing and analysing efficiently the vast volumes of data generated by several digital sources, including real-time prediction of quality and construction of data pipeline, are another significant challenge (UGUROGLU, 2021). Moreover, DT requires a substantial organisational re-structuration through the incorporation of new business processes and structures as well as adaptation to digital approaches, all differing significantly from the traditional automotive business models (DREMEL *et al*., 2017).

The development of a workforce with digital competencies and the promotion of transformation in the mind-set of the employees to adapt to new digital tools and approaches still remain significant challenges for the industry. This often requires the implementation of comprehensive training and development programs (MAZURCHENKO; ZELENKA, 2021). Issues related to cyber-security and data protection emerge as major obstacles given that automotive companies are

increasingly dependent on digital technologies. This requires the adoption of already-established security measures for protection of data and digital systems against possible threats (BRANDTNER; MAYRBOECK; ZIMMERMANN, 2022).

Therefore, adapting to changes in the customers' behaviour and expectations in the digital era is an inevitable requirement. In order to fulfil this challenge, the automotive companies have been striving to redefine their strategies so that they can align with the digital communication channels and data sources of the clients (TANASE, 2018).

Such efforts reflect the industry's response, particularly the automotive sector, in adapting to the peculiarities of the digital era. According to Tapscott (1996 *apud* BOWMAN, 1996), the transition to this new era is gradually pressing the society to re-think the traditional concepts regarding economy, creation of wealth and corporate organisations, among other institutional structures. This change in economic and social relationships brings chances and risks. As a result of this wave of transformations, a new challenge emerges for the companies: the digital imperative.

This imperative was introduced by a study conducted by the Centre for Digital Business (Massachusetts Institute of Technology - MIT) and Capgemini Consulting in 2013, in which the authors stated that companies have only two options in view of such reality: either adopting new technologies or facing obsolescence (FITZGERALD *et al*., 2013). In this way, several companies are achieving an understanding that the use of digital solutions can contribute to reducing the costs and consequently increasing the profits. Moreover, DT has been shown to be effective in aiding the companies to decrease costs and times in comparison to those not implementing digitalisation to their businesses (LERNER, 2015).

Nevertheless, DT has unchained the creation of innovative business models more than widening the supply of products and services under digital platforms, which are causing a revolution in the society and boosted a significant agitation in already-established industrial sectors (ESKELL; HÄRENSTAM, 2017). According to data from IDC – International Data Corporation, a global market intelligence data provider for the information technology, telecommunications, and consumer technology markets, almost U$4 billion will be invested in initiatives of DT by organisations worldwide up to 2027 (IDC, 2024) and Latin America, together with China, is the fastest growing region. (IDC, 2024).

1.1. Problematic Statement

In view of this global scenario, it raises the issue of whether investments in DT initiatives in the industry sector are having impacts on the companies, as well as whether the Brazilian companies, especially the automotive ones, are structuring their operations to adjust to this new reality. In Brazil, we have some examples of DT mainly concentrated on the retail and banking sectors, such as Magazine Luiza and Nubank, respectively, but what we can say about the industry sector. Despite of these examples, it's important to emphasize that in this work we're analysing and discuss about incumbents, specifically those from Automotive sector.

Before continuing, it is relevant to evaluate some data illustrating the situation of Brazil in the digital scenario. According to the *Digital Report* 2024 from the *site* We Are Social[1], Brazil has 187.9 million users connected to the Internet, representing a penetration of 86.6 percent of the population. Moreover, more than 144 million people have accounts in social networks and the country has 210 million cell phones subscriptions. These data offer a broad perspective of potential for Brazil to capitalise the DT. This might extend beyond the retail and banking companies, also reaching the industrial sector.

Despite such potential, most of the Brazilian companies, particularly those of the industrial sector, are still far from fully exploiting this market. A survey performed by the CNI - Confederação Nacional da Indústria in 2022 listed the expected benefits from adopting DT until 2025, such as productivity, improvement in the quality of products and services, reduction of operational costs and improvement of the decision-making process (CNI, 2022).

Although 69 percent of the industries participating in the survey had already implemented at least one of the 18 applications of DT indicated in the survey, only seven percent use ten or more. Therefore, the whole potential is not exploited. The survey also revealed that the Brazilian Automotive Industry (BAI) leads the adoption of digital technologies in the industrial sector of the country. As 88 percent of the companies of the sector use at least one of the applications, and of these eight percent use 16 applications, it is the segment using DT more intensively.

In line with their headquarters overseas, the Brazilian automotive companies have been seeking to follow this trend by massively investing in DT, thus maintaining

[1] https:// datareportal.com/reports/digital-2024-brazil

their traditional history of technological leadership. In fact, BAI has followed the global trend of automation, digitalisation and innovation of the sector (RIASANOW *et al*., 2017; LLOPIS-ALBERT; RUBIO; VALERO, 2020) and heavily invested in DT projects to keep competitiveness (ALVES, 2019).

Nevertheless, especially in the past 12 years, BAI has been facing great challenges. The successive economic crises in Brazil have caused the registration of motor vehicles no more resumed the 2012 level, when 3,627,715 cars had been licensed in the country (AUTOO, 2023). In addition, the change in the customer profile has made the selling process in the sector increasingly more digital (MERCADO & CONSUMO, 2023).

These are only two examples evidencing how this so relevant industry for the country, accounting for 2.5 percent of the national gross domestic product and for 20 percent of the Brazilian industrial GDP has been challenged by an even more difficult dynamic (ANFAVEA, 2024). These figures provoke considerations about the efficacy of these investments in achieving the expected return, not only in financial terms, but also in terms of improvement of processes, new business models, satisfaction of clients and employees, spinoffs, etc.

Based on the contextualisation and problematic issues on the impacts of DT on the Brazilian industry, particularly BAI, the following research question is proposed for the present doctoral thesis**: Which are the impacts of digital transformation on the Brazilian automotive industry?** In this way, the present study aims to elucidate this question by presenting the findings of a qualitative survey about the impact of DT on BAI and the Critical Success Factors (CSF) supporting projects of DT in BAI.

1.2. Objectives

General and specific objectives are presented in this section.

1.2.1. General Objective

To analyse the impacts of digital transformation initiatives on the Brazilian automotive industry (BAI).

1.2.2. Specific Objectives

(i) To identify and qualify the impacts of Digital Transformation initiatives on the Brazilian Automotive Industry (BAI);

(ii) To identify the Critical Success Factors (CSF) in the Digital Transformation project management in the Brazilian Automotive Industry (BAI);

(iii) To present a model of Critical Success Factors (CSF) in the Digital Transformation project management in the Brazilian Automotive Industry (BAI).

1.3. Justification

In 1987, Roberto Solow, when writing a book review on productivity for the New York Times, coined the following phrase:

> "*You can see the computer age everywhere but in the productivity statistics*".
> (SOLOW, 1987)

Although this statement has already been challenged by several authors, such as Crafts (2002), Brynjolfsson *et al*. (2019) and Remes *et al*. (2018), the ever-increasing investments in technology for digitalisation of the companies raise, by analogy, the question on whether a new Solow paradox would not be emerging due to an increase in productivity as a result of DT. In a broader and more relevant context, it is necessary to evaluate whether these investments are providing the expected return for the companies. Moreover, this return translates not only into productivity, but also into new business models (spinoffs or not), increase in market participation, satisfaction of customers and employees, among others.

In a very Darwinian sense, Karimi & Walter (2015) state that companies in transformation, which includes DT, have better conditions in the competitive arena than those not experiencing this process. And such organisational transformations can be initiated by external factors (e.g. technological or market) or internal motivations (e.g. re-structuration), with digitalisation currently being the most relevant external factor.

But, why DT? According to Fagerberg (2018), countries specialised in high-technology activities benefit from increasing rates of productivity growth compared to other countries. On the other hand, countries with low-technology specialisation generally have a relatively lower rate of productivity growth. However, investment in

technology alone is not guarantee of growth and prosperity if such a technology is not translated into a capacity to provide value to the customer and capture value for the company. As stated by Goldfarb & Tucker (2019), DT in our economy is supposed to increase productivity by providing innovation and cost reduction in a variety of business processes.

Nevertheless, it is necessary to distinguish between massive investment in information technology (IT), dissociated from a new business model, and DT in companies. According to Lee *et al*. (2015), the use of digital technology in the industrial sector would make them reduce delivery time, produce higher quality goods and reduce costs. Also, according to the authors, digitalisation can open new markets, promote innovations and yield productivity gains in developing economies.

The focus of the present study, however, is to understand how the several manifestations of DT impact the BAI in different perspectives, such as industry, commerce, production and finance, among others. BAI was chosen due to its importance for the Brazilian economy, which accounts for 2.5 percent of GDP and 20 percent of industrial GDP. The sector comprises 26 companies, also known as original equipment manufacturers (OEMs) or assemblers, with 52 manufacturing units and installed capacity of four and half million vehicles *per* year, making it the eighth largest producer and the sixth largest market in the world. Its relevance also relies on the protagonism in the adoption and launching of new technologies and trends, including its impact on the production chain comprising 491 auto-part manufacturers and 4,122 vehicle dealerships (ANFAVEA, 2024). In addition, the Informatics Centre of the Federal University of Pernambuco (UFPE) was designated as an EMBRAPII unit of Technology and Automotive Systems and the 11-year experience of the researcher regarding the automotive sector also contributed to this choice.

However, DT is not a determined fact. As discussed by Kane *et al*. (2017), DT is a process with varied levels of maturity aimed to measure the company's ability in facing the new challenges originating from the adoption of digital technologies in the society. This model stipulates three key characteristics, namely: (i) It is gradual and progressive; (ii) Future state vision is to be developed as it progresses through the process (i.e. similar to a journey); and (iii) It is not a spontaneous or automatic process, thus requiring constant learning and adaptation.

This process must involve Individuals, business partners, management models, clients, organisational structure, leadership and corporate strategy much more than

just the application of technology, which is mirrored by the words of David Rogers (2017):

> "*Digital transformation is not about technology – it is about strategy and new ways of thinking*" (ROGERS, 2017).

In this context, the present study also sought to understand whether there is a set of CSF which would be common in this process, particularly in BAI, and could aid companies in the journey of DT. For doing so, both business and academic perspectives will be followed. From the business perspective, the justification is the sense of urgency due to the wave of digitalisation in the society, which causes the companies to face a Shakespearean dilemma: "to be digital or to die". This sense can be observed in a 2017 article by Silvio Meira, who explains that the true role of DT goes beyond that.

> ""*In the long term, it is not to improve margins or launch a new product or service here and there, but to make sure the company survives."*
> (MEIRA, 2017).

Digitalisation has been transforming our society like only the industrial revolution did before in the recent history (VOR DEM ESCHE; HENNING-THURAU, 2014), and the question is not to know whether the companies will be or will not be digital during this transformation, but to know how and when they will become digital. There is no sign that such transformation is slowing down, quite on the contrary (BONNET, 2023). This phenomenon has been more relevant and deeply transformative, thus impacting companies, consumption habits, politics and even how the society sees, manifests and thinks itself. The Brazilian industry will have to be prepared for this new "competitive game", in which digitalisation becomes a new paradigm for competitiveness.

From the academic perspective, it is perceptible that the theme of DT has been more commonly addressed by the industry through consultancy reports rather than through academia. In fact, there are countless reports published by different types of consultancy, namely: research consultancy, such as Gartner (PLUMMER *et al*., 2014); strategy consultancy, such as McKinsey (DÖRNER; EDELMAN, 2022), BCG (Evan; FORTH, 2022) and Bain (RIGBY; TAGER, 2022); audit and consultancy, such as Deloitte (KANE *et al*., 2015), Fujitisu (2018) and Capgemini; with the latter in association with the MIT Centre for Digital Business (FITZGERALD *et al*., 2013). As these reports are based on empirical evidence of the real life, their insights can help

better understand the phenomenon, but the theme lacks theoretical and scientific substrate. Finally, there are a few academic studies on the process of DT in Brazil, and even fewer ones on how this phenomenon affects the BAI. Therefore, the academic contribution of the present study to future works on the theme is potentially significant for the scientific knowledge.

Still, from the academic perspective, the reason by which DT is a relevant theme for the computing science research relies on the significant impact of this theme on the development of new technologies, architecture of systems and innovation. By integrating advanced technologies, such as Artificial Intelligence and Internet of Things, the researchers can develop solutions to improve productivity and reduce costs in the companies. The interdisciplinary nature of DT stimulates the collaboration between the fields, thus promoting innovative approaches for complex challenges. In addition, computing science researchers play a crucial role in the education of future generations regarding key digital competencies to ensure that they are prepared for a fast-evolving scenario. Overall, this not only propels the computing sciences, but also benefits all the fields, thus boosting the progress and maintaining the society's confidence in digital systems.

In view of the above-exposed, the present doctoral study aims to qualify the impacts of DT on the BAI regarding productivity, process improvement, agility in the decision-making process, data availability, satisfaction of clients and employees, increase of efficacy in the supply chain, among others, In addition, one sought to identify CSF supporting the execution of DT projects in the BAI and the range of these impacts, thus contributing to the automotive segment by increasing the chances of success from these initiatives.

In fact, there are examples of successful applications of DT in the automotive sector worldwide. BMW has implemented a predictive maintenance system based on AI – Artificial Intelligence, one of the enabling technologies of Industry 4.0, at its plant in Regensburg combining data-driven decision with sensors and machine learning algorithms to detect in advance equipment anomalies, thus reducing unplanned inactivity time by 500 minutes per year (BMW, 2023).

General Motors is another example, as the company used data analysis techniques to optimise the vehicle technical assistance. With remote communication and connected cars, they can save $800 dollars per car. The company identified opportunities of improvement by analysing data from car sensors and process

parameters, applying algorithms of machine learning in the over-the-air software updating. In addition, they became their vehicles much more secure and reliable (DATAFLOQ, 2014).

Regarding management practices, the implementation of DT in automotive industry can be considered a strategic response to the demands of a dynamic market and an intensified competition, as occurs in the BAI. It is fundamental to identify CSF, such as harmonisation between people, processes and technology, for these projects to succeed. Such integration plays a crucial role in overcoming the challenges associated with the rapid technological evolution in this segment. Moreover, adaptation to changes in the expectations of the clients by aligning the customer experience strategies with new digital realities is one more factor of success promoted in these projects. Therefore, alignment of DT projects with these factors is not only a matter of strategic planning, but a necessity to ensure relevance, competitiveness and success in the automotive sector in the long term.

Finally, this study addresses a gap in the literature on the impacts of DT, particularly in the context of BAI, by providing significant insights for further studies and contributing to the body of scientific knowledge on DT.

1.4. Thesis Structure

The present thesis is organised as follows: after this chapter of introduction, the second chapter presents the theoretical basis focused on DT, Industry 4.0, automotive industry value chain and critical success factors, in addition to defining relevant concepts for supporting and carrying out this study. The third chapter presents the study design and method, in which a rapid review is used as a bibliographic reference tool, interview protocol is elaborated, interviewees are selected and data treated, including threats to validity and limitations of the method. The fourth chapter presents studies on BAI and automotive industry worldwide. Next, in the fifth chapter, the results obtained from the collection of data on interviews are presented, in which the MaxQDA software was used for treating qualitative data. The sixth chapter is dedicated to the analysis and discussion of the results found. This study is completed with the seventh chapter, which presents conclusions and contributions to the research.

2. THEORETICAL REFERENCE

This chapter presents the theoretical support of the main constructs enabling the conduction of the present study. The several definitions of DT, which is the central theme of this thesis, and its impacts; Industry 4.0, which for some authors confounds with DT, and its enabling technologies; automotive industry value chain; concepts of value, return of investments and productivity for identification of the digital impacts on BAI; and critical success factors (CSF) in projects for implementation of initiatives of DT.

2.1. Digital Transformation

DT has become an extremely used term in the past years, which has two distinct effects: the first is the solidification of the importance of the theme and the second is the vulgarisation of or even a confusion about the concept (MORAKANYANE *et al*., 2017). Table 1 shows the profusion of definitions for DT.

Table 1 - Digital Transformation definitions

Authors	Definitions
Liu *et al.* (2011)	Integration of digital technologies into the business processes.
Bharadwaj *et al.* (2013)	Organisational strategy formulated and conducted by boosting digital resources to create differential values for the customers.
Fitzgerald *et al.* (2013)	Association with the use of digital technology to allow business improvement
Lucas *et.al* (2013)	Possible fundamental changes in the traditional ways of making business through redefinition of capacities, processes and relationships of businesses.
Mithas *et al.* (2013)	It can be understood as the extent to which an organisation engages in any activity related to Information Technology.
Westerman *et al.* (2014)	Extension in which a company becomes involved in any activity related to information technology.
Piccinini *et al.* (2015)	Use of technology to improve radically the performance or increase the range of the company.
Schuchmann & Seufert (2015)	Characterisation of the digital transformation by using new digital technologies to allow significant business improvements.
Chanias & Hess (2016)	Digital transformation allows for re-alignment of technology and new business models in order to involve more efficiently digital customers in all contact points of their experience lifecycle.
Hess *et al.* (2016)	Reflection on the influence of changes induced by digital technologies throughout the company.
Henriette *et al.* (2015)	Changes the digital technologies can bring to the company's business model, resulting in changes in products, organisational structure or process automation.

Source*:* Elaborated by the author based on Morakanyane *et al*. (2017).

Regarding its definition, some authors relate DT to the adoption of new digital technologies on the part of the companies (HANNA, 2016), whereas others relate DT to new business models and corporate strategies (HESS *et al.*, 2016) as well as to an organisational transformation process, which needs to be very well planned and implemented (BERMAN; MARSHALL, 2014). The term “DT” is also often related to IT strategies, which would bring such transformation to other areas of the company (MITHAS *et al*., 2013). In a more instrumentalist view, DT would be aimed to improve the performance of organisational processes by means of new digital technologies (LUCAS, 2013; SCHUCHMANN; SEUFERT, 2015).

In another view, some authors such as Piccinini (2015), Henriette *et al*. (2015) and Chanias & Hess (2016) support that DT is aimed to create new business models by redefining products, services, production lines, processes, relationships with suppliers as well as to promote involvement of customers and employees. The fact is that the definitions for DT are so varied as the authors and researchers on the theme, as highlighted by Morakanyane *et al*. in 2017.

In view of such a scenario, the present thesis used the concept of DT in accordance with Kane *et al*. (2017), who described the term as being the adoption of digital technologies that transform processes and business models, thus allowing organisations to compete efficiently in the digital scenario. This definition is complemented by the idea that DT encompasses the integration of digital technology regarding all aspects of an organisation, resulting in improved performance and increased value for customers (LLOPIS-ALBERT; RUBIO; VALERO, 2020) (GEBAYEW *et al*., 2018). Even though DT and digitalisation can be perceived as distinct concepts, it is important to point out that the present thesis addresses both similarly (OSMUNDSEN *et al*., 2018).

In addition, it is necessary to differentiate the digital native companies, whose development of the whole process occurs in a digital environment not seen in the traditional ones, also called incumbent. These companies are still undergoing the process of adaptation or are at the beginning of their journey towards DT, as they were established before the digital era (VEREVKA; GUTMAN; SHMATKO, 2019). For these incumbent companies, DT represents a significant change of paradigm as it opens ways for new business opportunities through the adoption of digital technologies (SIMONAZZI; SANGINÉS; RUSSO, 2020; SEBASTIAN *et al.,* 2020).

The adoption of digitalisation transcends the mere implementation of technologies as it has organisational capacity to capitalise on new waves of change (DREMEL *et al*., 2017; PLUMMER *et al*., 2014). Moreover, the significant range of the benefits resulting from such transformation is intrinsically related to the successful implementation of digitalisation projects (ABYLOVA; SALYKOVA, 2019).

Finally, it is important to emphasize that DT in the BAI is related to the industry 4.0 principles, which determine an evolution integrating advanced digital technologies to optimise production, innovate products and services and quickly meet the demands of a constantly-transforming market. Therefore, this thesis highlights the importance of DT for advancement and innovation of the automotive industry in Brazil, showing how companies adapt to this new reality.

2.2. Industry 4.0

The term “Industry 4.0” was first introduced in 2011 in Germany, more precisely at the Hannover Fair, which was sponsored by the German government and represented a combined effort of university and industry aimed at increasing the competitiveness of the German industry through digitalisation of production. The proposal was to develop a national initiative to explore all the benefits by using digital technologies for automation, communication and IT in the construction of cyber-physical production systems, thus increasing the industrial performance. As one of the outcomes, this initiative provided an unprecedented moment in the history: instead of recording a socio-economic phenomenon a posteriori, the players (i.e. companies, universities, research centres, government) were capable of designing and defining future paths for the society (HERMANN; PENTEK; OTTO, 2016).

Industry 4.0, also known as the fourth industrial revolution, refers to the integration of advanced digital technologies in the manufacturing processes, resulting in more intelligent, agile and effective production systems. This process of integration is characterised by the convergence of physical and digital technologies, such as Internet of Things (IoT), Big Data Analytics, Artificial Intelligence (AI), robotics and cyber-physical systems (LASI *et al*., 2014). The adoption of key enabling technologies had and has significant impacts on the industry far beyond the manufacturing, thus transforming the traditional business models and creating opportunities for growth (SCHWAB, 2016).

The application of enabling technologies made it possible to create innovative products, services and business models not feasible before, as highlighted by Hermann, Pentek & Otto (2016). In this context, Industry 4.0 comprises six guiding principles, namely: inter-operability, service-oriented architecture, modularity, vistualisation, decentralisation and real-time operation capacity (TORTORELLA; FETTERMANN, 2018). Inter-operability refers to the capacity of systems to exchange information between them more clearly; service-oriented architecture is aimed at increasing the product-added services; modulatory represents the industry's flexibility in adapting its production modes to a variety of configurations imposed by the demands of customers; virtualisation is the computing simulation of elements of business processes by means of copies of physical systems; decentralisation, as suggested by the term itself, is the capacity of making decisions locally, rapidly and autonomously where a problem occurs; and real-time operation time is the prompt response in view of all data collected and to be made available immediately (TORTORELLA; FETTERMANN, 2018).

Within this context, Rüßmann *et al.* (2015) presented nine enabling technologies, also described as the "Nine Pillars of Industry 4.0", namely: Digital Twin, Cloud Computing, Internet of Things, Autonomous Robots, Cyber Security, System Integration (vertical and horizontal), Big Data Analytics, Additive Manufacturing and Augmented Reality.

Digital twin refers to the reproduction on a computer of a physical system, whether industrial or not. It is possible to perform simulations to aid in the improvement of processes, maintenance of these systems and conception of new lines.

Cloud computing is a set of digital services, such as storage, processing, applications and infra-structure provided by shared servers interlinked by Internet. The need for local structuring is almost eliminated as the whole operation is run on Internet. This enabling technology is one of the main pillars of DT, allowing for portability of processes (industrial or not) in large scale.

Internet of things is one of the most significant technologies of the industrial digitalisation, as it allows the integration of sensors to any type of physical device and subsequent connection to Internet, data collection, automatic command and control, and local data treatment. With this technology, it is possible to connect everything to the network, enabling connectivity, information exchange and prompt treatment of key data on corporate activity.

Autonomous robots are devices aimed to perform activities on an independent basis by interacting with the environment and without human supervision. Sensors and local processing capacity are used so that robots can perform tasks assigned to them.

Cyber security is a set of measures, procedures, processes, software and etc. aimed to increase the level of security in the digital systems, whether industrial or not, operating in a company. Perhaps one of the most under-rated enabling technologies, it can show whether a company will survive or not.

System integration, both vertical and horizontal, is the main element for business digitalisation as it allows immediate access to information from the plant floor to the top of the management chain and throughout the value chain, even reaching customers and suppliers. In this way, information is made fully available depending on the segregation of profiles.

Big Data Analytics consists of large sets of data collected from several sources, structured or not, which will be processed and analysed for decision-making. This analysis process uses statistical, mathematical and processing elements to understand the behaviour from data and draw conclusions in the form of projections and predictions. Big Data Analytics involves a concept termed five Vs of the IT industry, namely: volume of data, variety, velocity, veracity and value.

Additive manufacturing refers to a process which allows for the production of a physical product from a digital model, thus disregarding the need of physical models. Such production occurs by means of 3D printers and uses several media as raw material.

Augmented reality is the integration of virtual elements with the real physical environment by means of devices, which may be a pair of glasses aimed to this goal, tablets or even smartphones. Another application is the use of virtual reality, in which the individual is completely inserted in a virtual world. Lastly, there are applications termed “mixed reality”, in which characteristics of both augmented and virtual realities are used.

Although these nine pillars are broadly accepted in the industry, the academic world does not necessarily follow these concepts. Sturgeon (2021), for example, states that there are two market domains, namely: industrial applications (i.e. Industry 4.0) and customer applications, which are related to four basic technological areas boosting the digital economy, namely: Internet of things, Cloud computing, Big data analytics and Artificial intelligence.

Frank *et al*. (2019) stated that Industry 4.0 is based on two different levels of enabling technologies, that is, front-end and core technologies. The so-called front-end technologies comprise smart supply chain, smart work, smart manufacturing and smart products, whereas core technologies are those listed by Sturgeon (2021).

DT propelled by Industry 4.0 is essential for companies to remain competitive in an ever-increasing and challenging dynamic global scenario. Digitalisation of business processes, particularly the productive ones, allows for collecting, analysing and using large volume of data on a real-time basis. This enables decisions to be made more assertively and operations to be continuously optimised. In addition, Industry 4.0 enables the creation of new business models on the basis of digital services, such as servitisation and mass customisation, thus opening new revenue sources and strengthening the relationship with customers (FRANK *et al.*, 2019).

The adoption of technology in the industry 4.0 has significant impacts on the industrial sector, transforming the way products are projected, manufactured and delivered to the customers. Some of the main impacts include (i) increase of efficiency and productivity, in which digitalisation and automation of production processes allow for reduction of wastage, minimisation of errors and optimisation of the use of resources, thus resulting in significant gains in efficiency and productivity (DALENOGARE *et al.,* 2018); (ii) flexibility and customisation in which modularisation and re-configuration of the production processes allow for manufacturing of smaller batches and mass customisation to meet the increasingly more diversified demands of the customers (KOREN *et al*., 2018); and (iii) improvement of quality and reduction of costs, in which data collection and analysis in real-time enable the early identification of problems in quality and implementation of corrective actions to reduce costs with re-work and recalls (FOIDL; FELDERER, 2016).

As mentioned earlier, digitalisation of the value chains is one of the main characteristics of Industry 4.0. Digitalisation allows for collection, analysis and use of large volumes of data in real-time, thus facilitating the decision-making process and optimisation of production processes as well as enabling collaboration and information exchange between different companies throughout the value chain, that is, from suppliers to end customers (KAGERMANN *et al*., 2013 *apud* ARNOLD *et al.* 2018).

In the Industry 4.0, data analysis plays a central role in the optimisation of processes and in the decision-making. Digital technologies allows for collection of large volumes of data from several sources, such as sensors, machines and corporate

management systems. Analysis of such data, by means of advanced techniques of exploratory visualisation and unsupervised machine learning, which enables identification of patterns, trends and insights to be used for improvement of operational effectiveness, reduction of costs and increase in the quality of products and services (XU; DUAN, 2019).

Case studies in the automotive industry demonstrate the data analysis potential for optimisation of processes and decision-making. For example, the implementation of predictive maintenance systems in the vehicle production lines has been resulting in significant reductions in maintenance costs, increased equipment availability and improved quality of products. In addition, analysis of data on sensors in connected vehicles allows for identifying opportunities to improve product design and develop new services, such as remote maintenance and over-the-air software updates (LI *et al*., 2018).

Another important characteristic of Industry 4.0, as mentioned earlier, is related to the modularisation and decentralisation of production systems. Modularisation allows the creation of agile and re-configurable systems capable to quickly adapt to changes in the market demands and customers' needs. Decentralisation, in turn, refers to the capacity of cyber-physical systems to make decisions autonomously and self-organise according to real-time information and machine learning algorithm (BRETTEL *et al*., 2014).

There are countless benefits from the adoption of Industry 4.0 technologies. Kiel *et al*. (2017), for example, group these benefits into three dimensions, namely: economic, ecological and social. Economic benefits involve increased cost transparency, increased efficacy, customisation and quality, increased productivity, shorter delivery deadline, new business models, massive investments, uncertain profits and uncertain demand of customers. Ecological benefits involve transparency in the emission of global warming gases, increased energy efficiency, reduction of residues, increased circular economy and use of resources, reduction of product damages and wrong delivery. Social benefits involve adequate salaries, learning opportunities and increased motivation (but also uncertain professional future), decreased human involvement in repetitive tasks, increased human involvement in creative tasks, increased organisational transformations and adoption of Industry 4.0 technologies in all levels of the society in the large scale.

Nevertheless, implementation of Industry 4.0 also brings significant challenges for the companies. The adoption of advances digital technologies requires substantial investments in infra-structure, training and development of competencies. In addition, DT demands changes in the organisational culture by giving greater emphasis in innovations, collaboration and flexibility. Companies also need to deal with issues on cyber-security and data privacy, thus ensuring the protection of sensible information and compliance with more rigorous regulations (LAST *et al*. 2014).

In this way, Industry 4.0 represents a change in the paradigms of production and management, which is marked by digitalisation and integration of technologies. The transition towards Industry 4.0 brings challenges, including necessity of investments in technology and development of abilities, in addition to changes in organisational culture. Overcoming these obstacles requires not only the implementation of technologies, but also the leadership in strategic and organisational changes. Industry 4.0 not only is a technological advance but is also a new paradigm which redefines the industrial production by boosting innovation and modifying the scenario of work.

With regard to the automotive industry, the transition towards Industry 4.0 can have a direct impact on the value chain as operations are redefined from conception to production and distribution of vehicles. In the automotive industry, the adoption of Industry 4.0 technologies can facilitate mass customisation, agile production and predictive maintenance, thus meeting the specific demands of customers more accurately and quickly. In addition, an increased collaboration between suppliers and manufacturers by means of digital platforms can improve innovation and quality of the services provided. Therefore, integrating the industry 4.0 into the automotive value chain not only can transform the production and management of projects, but also can strengthen the company's competitiveness and capacity of response to changes in the market.

2.3. Automotive Value Chain

Based on the Porter's model (1997), the value chain of the automotive industry is divided into three main processes: product development, production and commercialisation.

Product development, in turn, still comprises four processes, namely: (i) concept of product, in which the customer's needs and trends should meet the technical and economic feasibility to develop a product according to the demand; (ii) product planning is the moment when all resources (i.e. financial, technological, human and material) are detailed and allocated in real-time, as well as style, lay-out and specification of the product, and (iii) The product engineering process, consisting of deployment of project engineering and elaboration of mathematic components in digital applications, such as CAD (computer-assisted design) and CAE (computer-aided engineering).

In this sense, it is worth emphasising that prototypes (virtual and physical) are constructed and tested in the product engineering process. (iv) Process engineering refers to the integration of product engineering (source of project) with real production, which actually constructs the product. Then, the project is transformed into tools, prototypes and etc. before conducting pilot tests, in which real details of production are analysed in real-time (KIEL *et al*. 2017).

The production process, also known as industrial or manufacturing, follows the Federal Decree number 7819 of October 3, 2012, regarding the Program of Incentive to Technological Innovation and growth of productive chain of automotive vehicles (INOVAR-AUTO, 2012), which regulates the manufacturing standards of any motor vehicle assembler in Brazil:

1. Stamping
2. Welding
3. Anti-corrosive treatment and painting
4. Plastic injection
5. Manufacturing of engine
6. Manufacturing of gearbox and transmission
7. Assembly of steering system and suspension
8. Assembly of electric system
9. Assembly of braking system and axles
10. Production of monoblock or assembly of chassis
11. Assembly, final revision and compatible tests
12. Laboratory infra-structure for development and testing of products.

Even with different terminologies for the above-listed terms, these phases of manufacturing have been accepted by the industry, thus being currently the standard for description of processes.

Finally, vehicle commercialisation is performed by independent agents, also known as dealerships, which account for the sales to the end customer. Regulation of the sector enforces that automotive assemblers should not be allowed to have equity participation in this sales activity. The supply of vehicles is based on the push model, in which the assemblers submit a monthly delivery planning according to the agenda of their own commercial interests, such as promotion of a new model or sales invoice already closed.

It is important emphasise that the Brazilian automotive industry is part of the global strategy dictated by the headquarters in countries such the USA, Europe and Asia. There is a trend to narrow and specialise the platforms in each country and site. Brazil has been specially known for specialising in compact and popular vehicles. On the other hand, sport utility vehicles (SUV) prevailed in the USA. One of the greatest challenges faced by this industry, as part of the present study, is to know what will be the impact of DT on such global chains (STURGEON; WHITTAKER, 2019).

Analysis of automotive value chain, according to the Porter's model and complementary studies, shows the complexity and dynamics of the sector. The interaction between product development, production and commercialisation, along with regulation challenges and technological innovation, highlights the need for adaptive strategies. In Brazil, the automotive industry is aligned with global trends of specialisation while facing digital transformation.

In fact, DT can alter design, production and vehicle selling process, in addition to becoming integrated in global chains. With regard to the automotive value chain, integrating development, production and commercialisation can become an essential factor in value generation in the sector, which has been facing challenges such as regulation and technological innovation. In Brazil, adaptation to global trends and DT can be CSF in maintaining the generation of value.

2.4. Value Generation

One of the elements to be verified in the present thesis is whether the impacts of DT include value generation. Here, the challenge is to determine the definition of

value and under which context. This section addresses the concept of value according to three perspectives regarding strategy, customer's position and business evaluation.

In the Porter's classic view of strategy (1997), value is "when clients are willing to pay for something that business offers them". On the other hand, value offer would be associated with how business makes something (i.e. product, service or solution) available for customers who want it because they identify themselves with it and would benefit from it. In the business context, value capture would be the accumulated value in cash these consumers would be willing to pay. In this way, business value generation would result from the delta of these both movements, that is, offer and capture (CALDEIRA, 2018).

On the other hand, Kaplan & Norton (1997) stated that value would be a construct resulting from the sum of characteristics of the product (i.e. service or solution), which comprises quality, price, functionality and delivery deadline, thus adding a business image to customer relationship. In view of this, value would be a set of internal elements of the business and its relationship with costumers, whose efficient management of these elements would underlie the competitive advantage.

In the marketing context, the view of value addresses this concept under multiple perspectives (e.g. economic, psychological and sociological) and is divided into two levels: customer and business (ZEITHAML, 1988). Therefore, it is observed whether the value of physical and intrinsic (i.e. related to feelings and perceptions provoked by the product) attributes perceived by the customer depending on expenses and time restrictions to obtain these benefits (OLIVEIRA; IKEDA, 2005).

According to Holbrook (1999), value is associated with interactivity, in which it is obtained through the exchange between subject and object. For the author, this is a relative phenomenon as several evaluations and perceptions of the customers are different based on their preferences, that is, value is subject to judgements and experiences of those who consume.

Lastly, Woodruff (1997) presents a broad definition of value from the consumer's view:

> "*Customer's preference and evaluation of the product's attributes, performance of these attributes and consequences from its use to facilitate (or hamper) the task of meeting the goals, according to the customer's circumstances, and which is proposed in situations of product use*." (WOODRUFF, 1997).

In the business context, value is defined from the concept of fair value in the market, that is, the potential of doing business on a balanced basis. The value of a business emerges from the integration of the buyer's desires and resources with the seller's desires and expectations. This indicates the subjective characteristics of the concept of value.

Therefore, the value of a company depends on the net benefits created in the present and future. The methods of determining a business value are varied, both in terms of finance and accounting. In the evaluator's perspective, one can reflect on the results of the application of several methods to achieve the best possible estimation. It is important to emphasise that such methods are beyond the scope of this research (MARTINEZ, 1999).

2.5. Return on Investment

Despite the definition of value, there is a financing measure for assessing the benefits from an investment, including investments in DT, which is the investment return or the so-called return on investment (RoI). RoI measures the overall efficacy of investment cash-flow management, which is broadly used as a decision-making tool (GITMAN, 2010).

RoI consists of a percentage rate of gains obtained from a given investment in relation to the value invested (costs), as shown in the following formula: RoI = [(gains – costs)] / costs] x 100.

Nevertheless, despite being a widely used tool in the decision-making process regarding corporate investments, demonstration of RoI and evaluation of any project, RoI is minimally used for evaluation of projects of any nature. According to Jeffery & Leliveld (2004), a little more than half of the organisations used RoI as criterion and justification for prioritising projects. This is surprising if one considers the relevance of such a tool for choosing investments adequately. The worst thing is that only 25 percent of the companies use RoI after performing their projects.

In addition, due to cultural, structural and political obstacles of an incorrectly implemented strategy for support of DT, there may be a risk associated with a frustration of achieving expected RoIs in the same way the companies consider RoIs for uncertain projects (LLOPIS-ALBERT; RUBIO; VALERO, 2021).

2.6. Productivity

There are several definitions for the concept of productivity. According to Messa (2013):

> *"Productivity measures the degree of efficiency with which a given economy uses its resources to produce goods and services for consumption*".

However, in addition to disagreeing with such a definition, the different schools of economic thought have definitions which, beyond the semantics, maintain different calculation methods.

Consequently, work productivity is the product generated *per* hour of work (or by some other contribution of work). The formula is the following: Prd Wrk = products or services produced / resources used.

The total productivity of factors is the quantity of production obtained by a unit covering all factors of production. According to the following formula:

TPF = [P / (a*C + b*W)], where: P = Product, K = Capital and W = Work, with a and b being assigned coefficients.

Nevertheless, diametrically opposed to the work productivity, the apparent simplicity of interpreting the TPF dynamics brings the great difficulty to determine an indicator, regardless of the calculation means. In the end of 2012, many economists already pointed out that the indicators of productivity had shown a decrease in its expansion velocity and that a resumption of economic growth would increasingly depend on the evolution of this variable (MESSA, 2013).

Conceptually, the indicators of productivity should measure the efficiency with which an economy, or economic agents, transforms inputs into products or services. Empirically, this is achieved through the ratio between measurements of production and inputs.

In the practice, most of the studies on the theme use total productivity of factors (TPF) and work productivity for measurements. However, work productivity is the most simple and direct measure by which one could have an indicator on the efficiency of an economy, including its sectors or economic agents. It consists of the use of some product measure in relation to a measure of work used in the production. The first and most clear limitation of this indicator is that it is a partial measure of productivity, as it takes into account only one of the factors used in the production (i.e. the work) and

disregard both intensity and quality of capital invested in the production, as well as quality of work (or human capital).

Therefore, most of the differences observed in the work productivity between sectors, companies or even production times occur due to different intensities in the use of capital. In this sense, sectors such as large-scale mining (which is very intensive in capital) will always present much higher indicators of work productivity than those observed in intensive labour-force sectors.

In addition, there exists a series of difficulties related to the measurement of production and amount of work, with the former being measured by means of indicators of physical production or financial indicators and added value. Indicators of physical production face the difficulty of matching multiple products and multiple inputs. Therefore, only the final product was considered without deducting the inputs used, that is, these indicators do not reflect the added value, but only the amount of final product.

It is possible, for a company or for a country, to increase the intermediate consumption (i.e. inputs, pieces and components) used in the production of the same amount of final product. In this case, physical production would remain constant and added value would be lower. In a constant context, the productivity measured by physical production would remain the same and that measured by added value would decrease.

In this sense, financial indicators of added value are more precise for measuring efficiency. However, they are subject to variations in price, which do not express effectiveness. Cheaper inputs, for example, would affect positively the indicators of productivity without altering the production efficiency in a more strict sense.

In order to measure the amount of work used, one can resort to the measurement of hours worked, which are the most accurate, but not always available, or to the number of workers. In the national context, one could consider the number of occupations (or number of jobs). Finally, TPF seeks to measure the productivity by taking into consideration factors competing in the production. Of course, this is a more complete measurement compared to the work productivity. Calculation of TPF is based on the estimation of production functions, either macro-economically or organisationally (CAVALCANTE; DE NEGRI, 2014).

2.7. Relationship with Digital Transformation Projects

As seen in earlier sections, the impacts of DT have a direct relationship with value generation, RoI and productivity. Such a relationship can aid in processes for allocation of resources and adoption of technologies, thus ensuring that each step of the projects is aligned with the company's objectives, which increases benefits and reduces risks. Understanding and applying this dynamic is an important factor for conducting transformations aimed at meeting the demands and preparing for growth (LEÃO; DA SILVA, 2021).

In the BAI, this scenario is related to competitiveness. Projects of DT are considered in the modernisation of processes and adoption of new technologies, meaning that relationships of value generation, RoI and productivity with CSF play an essential role in this segment.

Therefore, it is paramount to understand and implement CSF for a successful digital transformation, which influences a company's capacity to generate value, achieve a significant RoI and improve productivity. In this way, integration of these concepts with CSF can provide a strategic vision for conducting transformations in a digital and competitive business environment, such as the Brazilian automotive industry (FLECHSIG; ANSLINGER; LASCH, 2022).

2.8. Critical Success Factors

The benefits resulting from DT will not come by simply implementing new technologies, but through the company's capacity to benefit from these new waves of changes related to the theme. This scenario occurs by successfully implementing digitalisation of processes and business models (EKSELL; HÄRENSTAN, 2017).

DT is boosted by a series of CSF and is subject to emerging trends shaping its course. This process can be complex and, in certain moments, multifaceted, which may require deep understanding and strategic approach. These factors, if well managed, are understood as characteristics, conditions or variables capable to influence significantly the project's success (MILOSEVIC; PATANAKUL, 2005). These elements are considered important management tools for the project managers as they contribute to both control and communication of the project's progress (MAZURCHENKO; ZELENKA, 2021), thus being used to increase the odds of success (BHATIA; KUMAR, 2020).

CSF for projects of DT differ between projects and sectors, which reflects a diversity of operational contexts of a company (PINTO; SLEVIN, 1989). Such a variation highlights the importance of carefully evaluating these factors, as each project and each sector have unique characteristics influencing the success of a DT implementation (TANASE, 2018).

In the DT journey, the application of technology is only one of the several necessary components. The transformation also covers the participation and development of people, construction of strategic partnerships, adoption of innovative management models, involvement of customers, organisational re-structuring and corporate strategic review BRANDTNER; MAYRBOECK; ZIMMERMANN, 2022). Therefore, organisations should adopt a holistic approach in which these aspects are considered for an effective digital transition (HOLOTIUK; BEIMBORN, 2017).

In this sense, a committed leadership emerges as a fundamental pillar in this process. Westerman, Bonnet & McAfee (2014) highlight that the combination of business skills with a deep technological understanding becomes essential for mobilising the organisation towards new digital objectives. Such leadership not only defines the strategic orientation, but also cultivate an environment where innovation can happen.

In parallel, a more adaptive organisational culture plays a critical role in this relationship. Kotter & Heskett (1992) define that when organisations promote adaptability, continued learning and innovation, they are more likely to achieve a sustained success in ever-evolving environments, thus becoming a pillar for an effect digitalisation. Therefore, such a transformation is not only desirable, but also necessary to sail on the turbulent waters of digital change.

In addition, the development of competencies and qualification become essential. The capacity to learn and rapidly adapt is a key competitive differential, not only in emerging technologies, but also in transversal competencies such as change management and innovative leadership (TIDD; BESSANT, 2018). In this way, investment in human capital becomes fundamental for a successful DT.

Regarding technologies present in DT, some can provide certain competitive advantages. In this context, Bughin *et al.* (2018) state that the adoption of technologies such as AI, blockchain and IoT, when aligned with the company's strategic objectives, can completely redefine the organisational environment and become critical factors for a successful DT. In addition, Lemon & Verhoef (2016) also highlight that organisations

need to keep focus on the customer and on the user's experience as a success, which are factors of success in a digital environment. The authors define that the use of data analysis to better understand the customer's needs and customise the user's experience is a competitive differential, as customers are more efficiently and effectively engaged.

In this way, DT becomes a complex process requiring not only the adoption of new technologies, but also a re-evaluation of business strategies, operations and, mainly, organisational culture. Factors such as leadership, culture, competencies, technology and customer focus are all elements interlacing in this process, each one contributing to the success of such projects.

In this sense, the present thesis investigates the possible CSF in initiatives of DT in the organisations, specifically those belonging to BAI. CSF have characteristics, conditions or variables which can exert a significant impact on a project's success when adequately administered, thus becoming (to a certain extent) fundamental for their management (MILOSEVIC; PATANAKUL, 2005). These factors serve as important instruments for those who play a project management role and need to both monitor and communicate about the progress of the projects (MAZURCHENKO; ZELENKA, 2021), in addition to being used to increase the odds of their success (ABYLOVA; SALYKOVA, 2019; BHATIA; KUMAR, 2020).

CSF used in projects of DT can vary significantly between different projects and sectors, reflecting the heterogeneity of operational contexts of the company (PINTO; SLEVIN, 1989). Such diversity shows the need for a more careful analysis of CSF by taking into account the particularities of each project and sector of the organization, which to a certain extent, can influence the success of the projects (TANASE, 2018).

In the process of DT, the adoption of technology is only part of the requirements necessary for the organisations. Transformation can also encompass involvement and development of human capital, formation of strategic alliances, implementation of innovative management models, interaction with customers, structural re-organisation and revision of corporate strategies (BRANDTNER *et al.,* 2022; Rogers, 2016). Therefore, organisations should adopt a broad perspective by considering all these factors as possible CSF to ensure a successful digital transition (HOLOTIUK; BEIMBORN, 2017).

In the context of DT, Holotiuk & Beimborn (2017) identified 40 CSF distributed into eight dimensions for development of digital business models, namely: culture,

leadership, human competencies, strategic vision, data management, infra-structure, operations and partnerships. These dimensions offer a framework for formulation of digital strategies. Moreover, analysis of traditional organisations (e.g. BAI) identifies commitment of customers and adoption of digital solutions, such as basic elements of DT. The process of DT requires defining digital strategies, investment in operations, development of digital platforms and promotion of a service-oriented culture (SEBASTIAN *et al*., 2020).

In this scenario, the traditional organisations face unique challenges in the implementation of DT practices, such as adoption of new technologies and training of people for project management To have an idea of this context, the 2018 Global Digital Transformation Survey Report revealed that corporate leaders from several sectors identified a series of CSF for DT, including leadership, flexibility, business integration, robust ecosystem and data valorisation, all forming the backbone of digitalisation strategies in mature companies (FUJITSU FUTURE INSIGHTS, 2018).

The importance of digitalisation, specifically regarding the BAI, for maintenance of competitive advantages and exploitation of new business models and innovations is emphasised, thus indicating a significant strategic weight of these projects (CHANIAS; HESS, 2016). In DT initiatives, several interconnected factors can lead to corporate success, including data governance, legal compliance and robust IT intra-structure, all constituting the technological basis for digital transition (BHATIA; KUMAR, 2020). Moreover, collaboration and organisational culture are acknowledged by playing a fundamental role in catalysing changes and sustaining continuous innovation, whereas definition of a clear strategic vision guides the companies during the transformation process (RIBAS; TEIXEIRA, 2021).

Connectivity, user commitment, process adaptation and team competency emerge as crucial elements which, along with strategic alignment, are indispensable for carrying out structural changes in response to the demands of an ever-evolving market (RIBAS; TEIXEIRA, 2021). These components not only facilitate the adoption of digital technologies, but also promote the company’s evolution towards a more flexible and adaptive business model.

These analyses converge in the perception that DT requires an integrated and strategically focused approach in which technology is only one of the several elements of a complex system comprising people, processes and organisational culture. All these factors become CSF in the process of DT in the Brazilian automotive industry to

support the companies to perform such transformation on an efficient and sustained basis.

2.9. Implementation Models

The academic literature provides a series of models aimed to guide organisations during their digitalization journey with focus on CSF. These models highlight the main components of executive leadership and which remain fundamental in the digital economy, such as vision of future, adaptive culture, specialised knowledge, human talent, technological innovations and clear strategic alignment (GURBAXANI; DUNKLE, 2019) (SEBASTIAN *et al.,* 2020).

One can observe a congruence between success factors identified by a survey from Fujitsu Future Insights (2018) and those highlighted in several other studies (HOLOTIUK; BEIMBORN, 2017; BARTHEL; HESS, 2019; BHATIA; KUMAR, 2020; RIBAS; TEIXEIRA, 2021). This concordance suggests a path towards the identification of critical elements which, if validated in the Brazilian context, could make up the basis of a model facilitating digitalization in the country.

Although the current literature does not offer a specific model of CSF for projects of DT in the Brazilian automotive industry, related studies provide valuable insights. For example, Felser & Wiynn (2020) developed a model to evaluate the impact of digitalization on the IT delivery strategies in the German automotive industry. De Carli *et al.* (2010) analyzed the implementation of digital manufacturers and found that factors, such as top management support and people's receptivity to changes, are essential for a successful adoption of advanced digital technologies (e.g. Digital Twin) (SIMONAZZI; SANGINÉS; RUSSO, 2020; UGUROGLU, 2021).

Furthermore, the four-dimension transformation model (MATT *et al.,* 2015), as shown in Figure 1, and Leavitt's diamond model (1965 apud GRANT; MERGEN, 1996) that integrate Tasks, Structure, People and Technology, can be adapted to meet the specific needs of the IAB.

These approaches emphasise the importance of a synergy between the various organisational components, suggesting that the inclusion of multiple operational and structural facets is necessary for a successful DT (BRANDTNER; MAYRBOECK; ZIMMERMANN, 2022; TANASE, 2018).

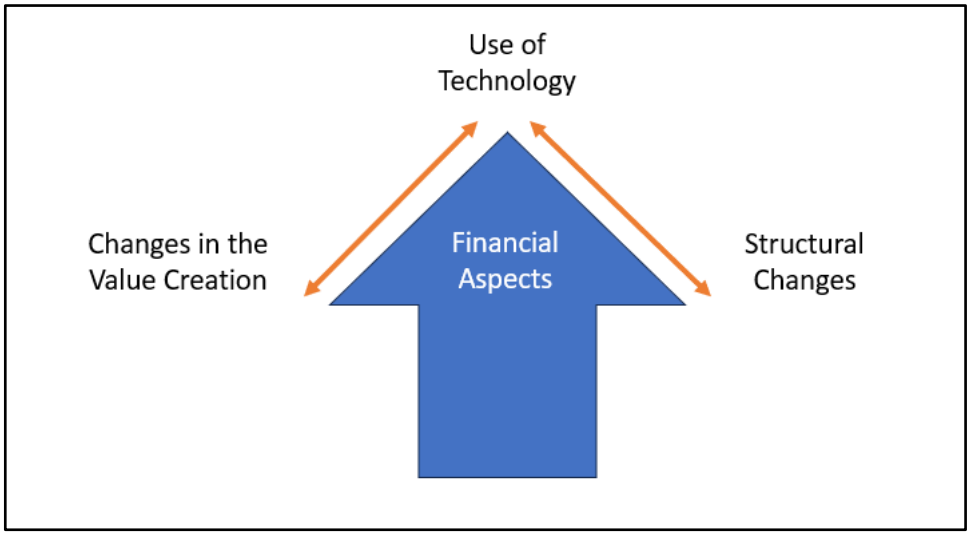

Figure 1 – Four-Dimension Transformation Model.
Source: adapted from Matt *et al.* (2015).

In the search for a model enabling CSF in projects of DT in the Brazilian automotive industry, the PPT - *People, Process & Technology* (PRODAN; PRODAN; PURCAREA, 2015), shown in Figure 2 emerges as a visually clearer and didactic approach which condenses several CSF encompassing three key elements, namely: people, process and technology.

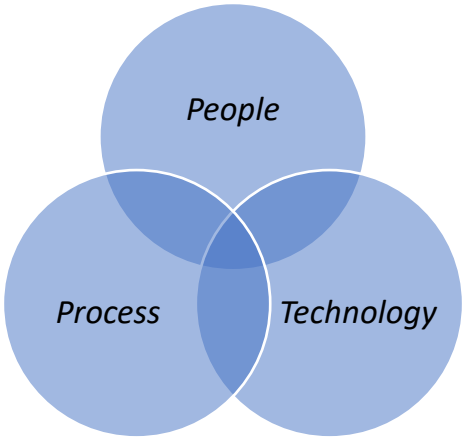

Figure 2 – PPT Model (*People, Process & Technology*).
Source: adapted from Prodan, Prodan e Purcarea (2015).

This choice is supported by previous studies (SPRUIT; JAGESAR, 2016; VERINA; TITKO, 2019; NAGLI, 2019) and has been also used in the German automotive industry, where the integration of changes in the processes, training of people and existing structure are the basis of an operational model for identification of CSF in projects of IT back-sourcing (FELSER; WYNN, 2020), thus indicating the

possibility of using this model as a guiding tool to boost DT in the BAI. These studies highlight how the use of PPT model can facilitate the understanding and implementation of CSF in specific contexts (e.g. BAI) by being a viable option for conducting these projects successfully.

The PPT model plays a fundamental role in the successful management of projects, especially those of DT, as it provides a holistic approach acknowledging the intrinsic interconnection between the three components, that is, people, processes and technology. In the context of people, the emphasis is on the importance of a team skilled, engaged and aligned with the company's strategic objectives as well as on a leadership capable of guiding and motivating people, optimising processes and boosting technological integration efficiently to ensure successful projects (VERINA; TITKO, 2019).

In the process context, the model highlights the importance of well-defined and effective structures to ensure that operations are performed with the aim to achieve excellence. The constant review and optimisation of processes allow a continuous improvement, thus favouring operational efficacy and adaptation to changes in the organisational environment as a result of from the implementation of new technologies by the companies (PRODAN; PRODAN; PURCAREA, 2015).

Lastly, in the context of technology, the strategic choice of tools and platforms plays a crucial role in facilitating operations and support for meeting the company's strategic goals. The adoption of technologies enabling DT contributes to flexibility and capacity of response to the market demands, which ensures relevance and competitiveness in the long term (NAGLI, 2019). Together, these three elements form a comprehensive model for boosting the success of digitalisation initiatives in the organisations by means of synergy between human, process and technological dimensions (PETERSEN, 2018). This contributes to a higher chance of successful management of projects, specifically those of DT, which is in accordance with the objective of the present research.

In conclusion, analysis of the existing models and identification of CSF for DT in the context of BAI show the importance of an approach encompassing people, processes and technology. Therefore, adaptation and application of PPT model emerge as strategies for guiding organisations in their journey towards digitalisation.

This model encapsulates elements identified in the literature as determinants for a digital success, in addition to providing a pathway for implementation of these

factors in the companies of the Brazilian automotive sector. According to the PPT model, the synergy between human, process and technological components is fundamental to overcome the challenges present in the projects of DT.

3. METHOD

Next, the research method used to carry out the present research is described as well as the activities in each step are detailed. These steps consisted in the following: (i) definition of qualitative research as a methodological approach; (ii) bibliographical review, as described in earlier section; (iii) rapid review as a method for identification of correlated studies; (iv) participation of the author in an earlier work which served as a pilot work for this doctoral thesis; (v) elaboration of interview protocol; (vi) choice of companies for research; (vii) data collection, treatment and analysis; (viii) construction of CSF model; and (ix) elaboration of the present thesis.

3.1. Methodological Approach

The present research is qualitative and descriptive as one sought to understand and determine relationships between DT and its impact, as well as to identify a set of CSF common to cases seen in the environment of the Brazilian automotive industry (CRESWELL, 2017). Descriptive studies are usually those seeking to understand phenomena, including their variables, relationships and applications in the practice. Moreover, they seek to specify properties, characteristics and profiles of groups, communities or any other phenomenon being analysed. This type of study is fundamental for understanding the relationships between variables and their applications (GIL, 2002).

According to Brinkmann & Kvale (2008), the qualitative study is adequate for addressing social phenomena observed in real work environments, in which the individuals' experiences related to professional practices are analysed. The methodology allows describing the way by which research events occur (DE SOUZA MINAYO; DESLANDES; GOMES, 2011), in addition to defining patterns and construction of concepts by means of data analysis (THEÓPHILO; MARTINS, 2009). Bulmer (1986) points out that this type of study is adequate to explain phenomena emerging from the synergy between theory and investigative practice, also serving as an important instrument for research.

Quantitative methodology is seen as ideal in contexts whose research is focused on abstract issues or situations to which quantification does not apply or when the study group is considered of small scale (ALVES-MAZZOTTI; GEWANDSZNAJDER, 2000). Lastly, Bartunek & Seo (2002) argue that qualitative

study is essential for identification and understanding of concepts related to the phenomena studied, which facilitates the development of new perceptions on the complexity of social phenomena.

The instrument chosen for data collection in the present research was a semi-structured interview with the objective of capturing perceptions of the topr management staff of the Brazilian automotive companies on the phenomena of DT and their impacts, as well as of identifying the existence or not of a common set of CSF based on the answers given.

For Rubin & Rubin (2011), the information obtained by means of semi-structured interviews help identify a process as a factor in the scenario where the study was carried out. The objective of using semi-structure interviews is to investigate knowledge based on the interviewees' answers for each construct, thus achieving a greater proximity with the phenomenon studied (CRESWELL, 2017). Therefore, one can presume that the learning acquired in a typical industrial company can be referential for others in the same sector. Semi-structured interviews, in turn, have an agile, accessible and intelligible format allowing the interviewees to express their perceptions spontaneously, which facilitates the understanding of how they see their activities and work environment (QU; DUMAY, 2011).

Silva, Russo & De Oliveira (2018) highlight that semi-structured interviews are conducted by using a pre-determined script of questions. Such an approach allows having a richer interaction between interviewer and interviewee, in addition to offering flexibility in introducing additional questions during the interview to exploit the theme under discussion more deeply.

Content analysis was the method of qualitative research chosen for processing and assessment of data, which allowed interpreting and examining systematically textual data from semi-structured interviews. Therefore, this approach enabled the identification of patterns, themes and meanings of the data so that the perspectives and experiences of the participants could be deeply understood, thus facilitating the extraction of insights. In the context of semi-structured interviews, content analysis allows flexibility in exploiting the participants' answers while maintaining concomitantly a structure approach for interpretation of data. This iterative process increases the validity and reliability of the study as it allows finding a differentiated understanding of social phenomena and complex human interactions (CAMPOS; DURATO, 2009; BENGTSSON, 2016).

3.2. Research Design

The present research began to be carried out with a review of the main constructs related to the theme, as outlined in the section Theoretical Reference, and with an initial construction of the semi-structured interview protocol. The interviews on the project called Foot-in-the-Door were conducted, from which two were also conducted in the automotive assemblers so that the interview protocol and bibliographical review could be feedbacked. Next, a rapid review was conducted for identification of studies on the impacts of DT in the Brazilian automotive industry as well as studies on CSF. The interview protocol was completed with interviews with the chief executives of the automotive companies selected for research. The resulting data were collected, processed, coded and analysed by using the MAXQDA software for qualitative data analysis. Subsequently, a model of CSF in projects of DT in the Brazilian automotive industry was elaborated, including the thesis itself. The steps followed in the present research are described in Figure 3.

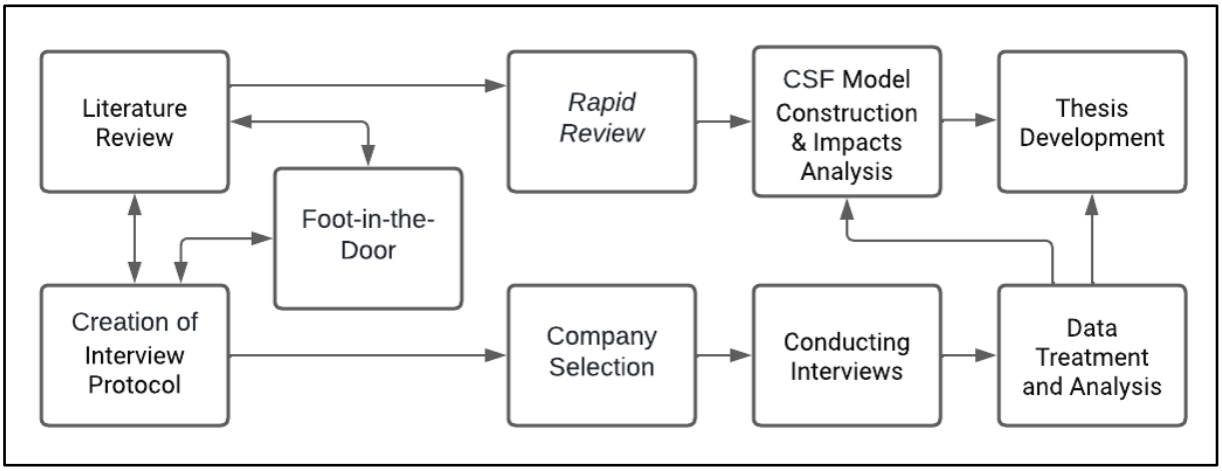

Figure 3 – Research' Steps.
Source: elaborated by the author (2024).

The steps for performing the Foot-in-the-Floor and other steps are presented in the next sections of this chapter.

3.3. *Foot-in-the-Door*

In December 2020, the Industrial Performance Centre of the Massachusetts Institute of Technology (IPC-MIT), in partnership with the Centro de Informática da

Universidade Federal of Pernambuco (Cin-UFPE), presented a proposal of project entitled “Understanding the Broader Impacts of Innovation Projects on Digital Transformation in Brazil” to the Divisão Nacional do Serviço Nacional de Aprendizagem Nacional (SENAI-DN). The objective of this study was to identify the impacts of DT projects developed in the Brazilian industrial companies in partnership with the SENAI institutes of Innovation (ISIs).

For an academic opportunity, the researcher of the present thesis took part in the project team and collaborated in the elaboration of the interview protocol and conduction of the interviews with chief executives of the companies selected for study. Based on the 2,071 projects listed by 23 SENAI institutes of Innovation, duplicated projects were eliminated and only those related to technologies enabling DT (e.g. Internet of Things, Cloud Computing, Big Data Analytics and Artificial Intelligence) were selected, as proposed by Sturgeon (2021), which resulted in a final sample of 38 companies. Of these, eight companies operating in different industrial segments accepted to participate in the interviews.

Two of the companies interviewed for the project belong to the automotive sector, in which one of them is the subject of the present research. Therefore, the results of the interviews provide some important insights on the theme, such as: choice of semi-structured interview as a data collection tool, relevance of the theme and confirmation of the target industrial sector for the present research. Moreover, conducting interviews with managers and directors of large corporate groups was an excellent opportunity of training and adapting to the type of challenge this researcher had to face when conducting the interviews with these companies. In this way, the work served as a kind of pilot study and for this reason it will be called onwards as Foot-in-the-Door project

3.4. *Rapid Review*

Rapid review was the method of bibliographic review chosen for identification of previous studies on the impacts of DT on the Brazilian automotive industry. Rapid review can be defined as a quick method synthesising the existing knowledge from simplified elements of systematic literature review (TRICCO *et al*., 2015).

According to Cartaxo *et al*. (2016), this technique provides strategies not only to minimise efforts in certain steps of the traditional systematic reviews, but also offers

more attractive means for transference of knowledge. Grath & Booth (2009) highlight that rapid review defines a more strict scope by concentrating on a well-defined research question. This allows a deeper analysis of the relevant studies, resulting in more direct findings regarding the objectives in question (KHANGURA *et al*., 2012).

A description of the steps to guide the rapid review is shown below:

1st Step - To define the research question: “What are the impacts of digital transformation initiatives on the Brazilian automotive industry?”

2nd Step - To construct a string: (“Digital Transformation” OR “Digitalization”) AND (“Automotive” OR “Automobile”) AND (“Impacts” OR “Benefits” OR “Outcomes” OR “Results”) AND (“Brazilian” OR “Brazil”).

3rd Step - To apply the string to Google Scholar: Identification of 13,200 results, with many without any relation to the theme (e.g. different segments).

Figure 4 – Third Step of the Rapid Review.
Source: image from Google Scholar (2024).

4th Step - To perform the search by using the Publish or Perish software: The same words of the string formation were used as keywords (under Google Scholar database) and yielded 13,200 results, but the use of the tool allowed the results to be saved regardless of new insertions during the update process of the rapid review.

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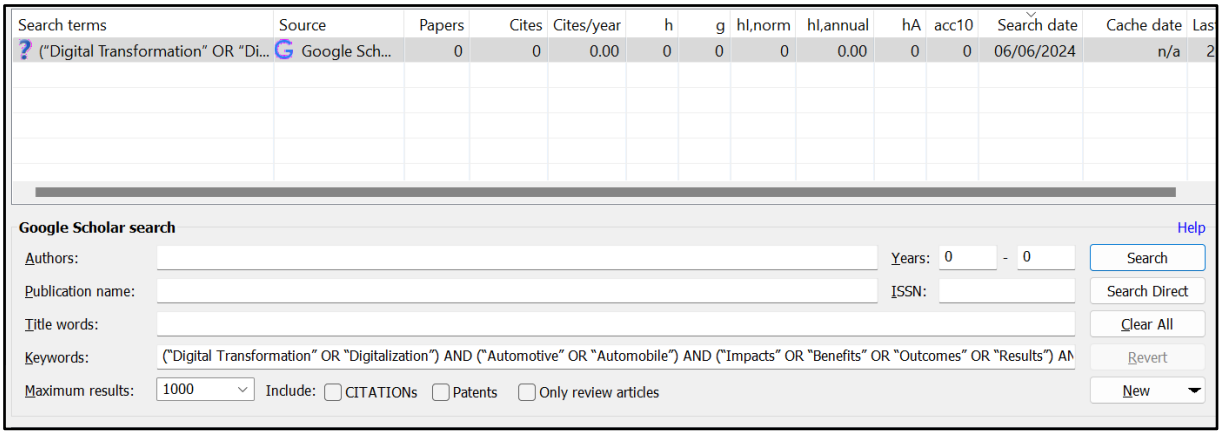

Figure 5 – Fourth Step of the Rapid Review.
Source: image from Publish or Perish (2024).

5th Step - To optimise the search: the words "Brazil" or "Brazilian" were used as title words because the objective of this step is to find studies in Brazil as there is a very high possibility that these words are in the title.

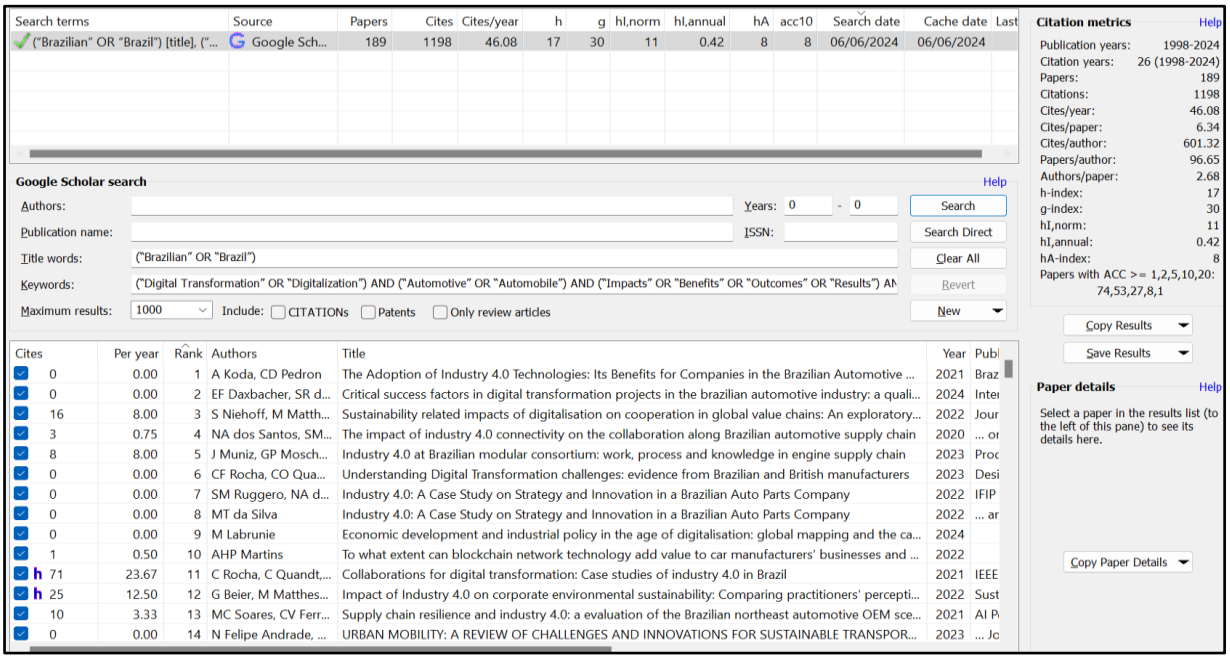

Figure 6 – Fifth Step of the Rapid Review.
Source: image from Publish or Perish (2024).

The result was 189 articles, as shown in Figure 6. It is possible that some studies do not have these words in their title, but the loss was considered to be acceptable.

This 5th step was repeated by adjusting the string to (*"Digital Transformation" OR "Digitalization") AND ("Automotive" OR "Automobile") AND ("Critical Success*

Factors") AND ("Brazilian" OR "Brazil", resulting in 18 articles. Of these, 17 had already been identified in the previous search, remaining one article to be read.

Furthermore, from the 2th to the 5th Step were repeated replacing the word "Digitalization" for "Digitalisation" to avoid missing any articles written in British English. Despite this precaution no new articles were found that had not already been identified in the previous search.

6th Step – Reading of abstracts: To identify articles not related to the research question. This resulted in 177 articles with no relation with the theme in question (e.g. Power, Smart Cities, Cinema) or, in some cases, repeated, resulting in 13 articles relevant for the present research.

7th Step – Reading of 12 articles: The article listed in the 6th step was disregarded because was produced by the researcher and addressed the theme of the present doctoral study.

This same procedure was applied to the Web of Science database according to the following steps: (i) The same string used in the 2nd step, but without the words "Brazil" or "Brazilian", was submitted, yielding 117 results (articles, proceeding papers, early access, review article, book review); (ii) The string with the words "Brazil" or "Brazilian" was submitted and limited to the search of articles only, yielding 68 results, as shown in Figure 7, *per* area of concentration (some articles are classified in more than one area).

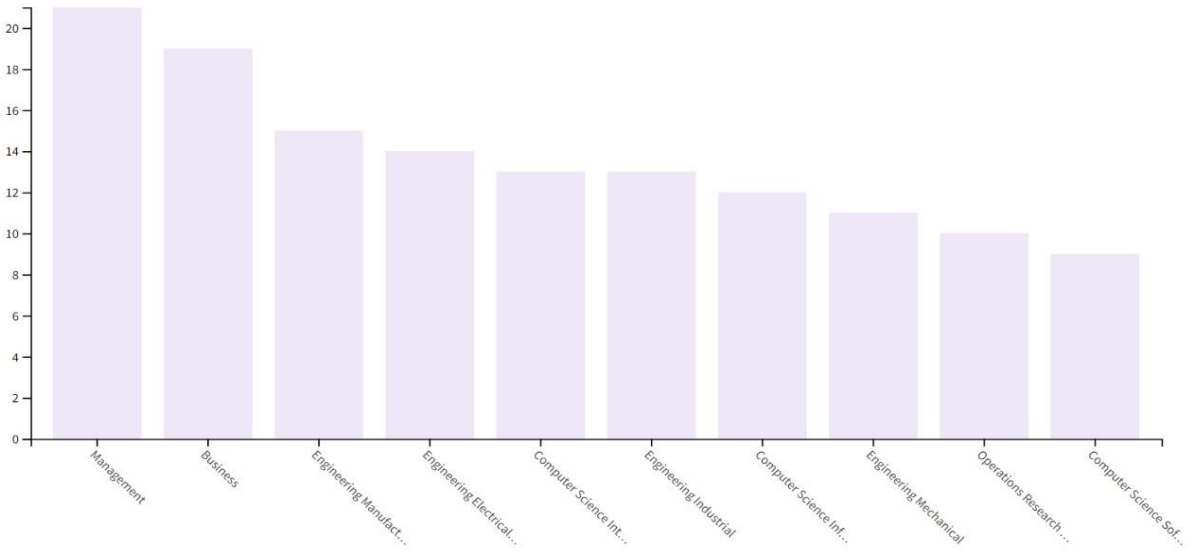

Figure 7 – Results of the search on Web of Science Database.
Source: image from *Web of Science* (2024).

By applying the string with the words “Brazil” or “Brazilian”, the amount of articles was reduced to two ones, showing the small number of studies on the theme developed in Brazil. Also, these two articles had already been identified in the earlier procedure searching on Google Scholar.

Finally, rapid review was used in the search on a third database (i.e. Scopus) with the same string, as shown in Figure 8, resulting in the identification of 11 articles. After reading the abstracts, it was found that only eight articles were related to the theme, and of these, six had already been identified in the earlier procedure. Therefore, only two articles remained for reading.

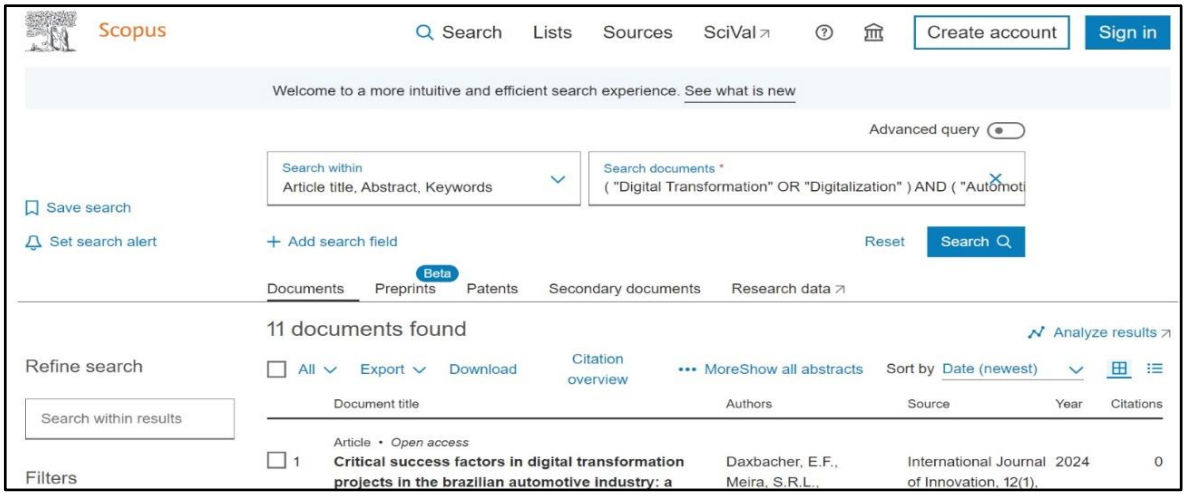

Figure 8 – Results of the search on Scopus Database.
Source: image from *Scopus* (2024).

In the end, after application of rapid review to the three databases with the two strings, that is, (“Impacts” OR “Benefits” OR “Outcomes” OR “Results”) and (“Critical Success Factors”), 14 related articles were found.

Due to the global character of the automotive industry, in which almost all the companies operating in Brazil are subsidiaries of foreign multinational organisations, one decided to perform the rapid review on the theme as well, but without considering the operational limitation of the Brazilian industry. The objective of this procedure was to identify related articles elsewhere in the world, which could contribute to the understanding of the impacts of DT on the Brazilian automotive industry and potential CSF.

By using the Publish or Perish software, but this time with the string without the words “Brazil” or “Brazilian”, 122 results among articles, textbook chapters and theses

were found, almost all related to the theme. H-index was used for further selection before reading the abstracts of the filtered studies, which resulted in nine articles, as shown in Figure 9.

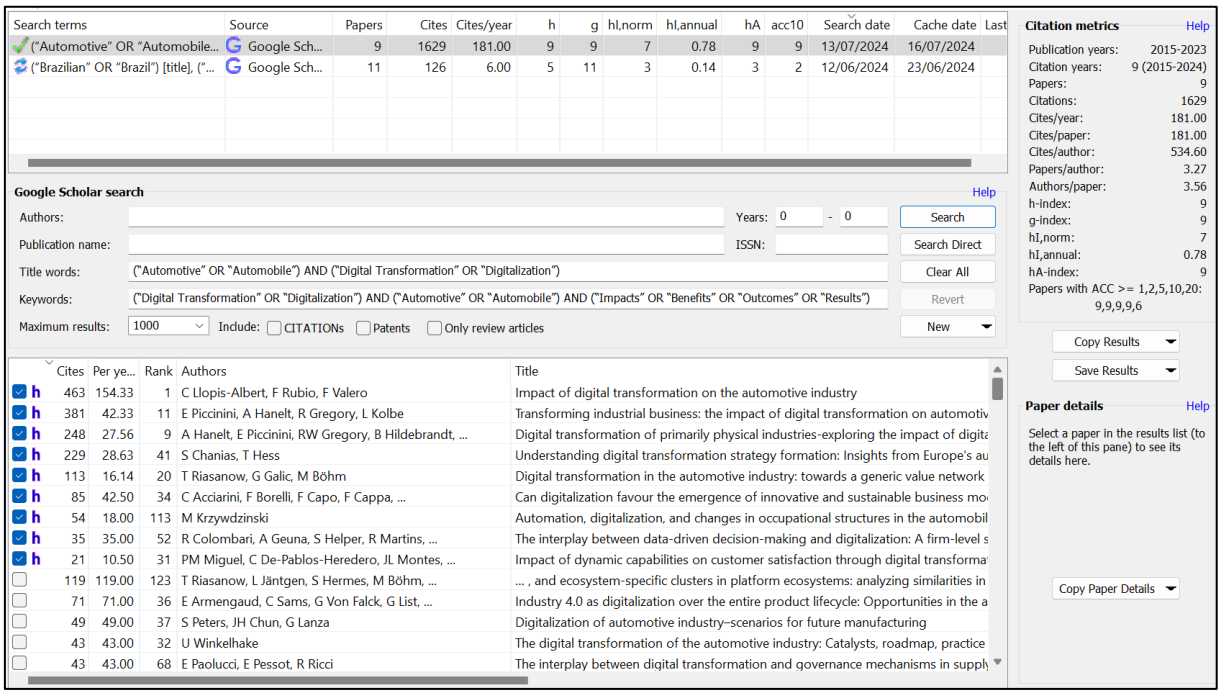

Figure 9 – Results of the global search with H-Index.
Source: image from Publish or Perish (2024).

H-filter was chosen as a data filter because it is one of the most accepted indexes for acknowledging of scientific production as well as due to its calculation simplicity (BORNMANN; DANIEL, 2007). In addition to these nine articles, another two ones were included after being found in the searches for publications on CSF on the global automotive industry.

Next, the steps of interviews and data processing are described in details.

3.5. Creation of Interview Protocol

Semi-structured interview was chosen as a tool for data collection in the present research. This choice is due to the fact that this instrument is flexible and aids in guiding questions, capturing impressions, perceptions and thoughts of the interviewees on a given theme while providing them with an opportunity to express their ideas on related issues not necessarily addressed in the interview guide.

According to Gil (1999), a semi-structured interview allows the interviewees to freely express their opinions on the theme being studied by the interviewer, who can return to the focus if there is deviation from original theme. Moreover, Thiollent (2009) defines that semi-structured interviews are aimed to let interviewees entirely free to express their thoughts, thus allowing a further deepening on the theme.

The interview protocol was elaborated with 30 questions covering aspects on the characteristics of DT projects in these companies, how the approval and implementation processes were, whether there was sponsorship, strategic alignment, main difficulties and learned lessons, as well as the most relevant impacts, negative points and CSF in the projects (Table 2). In order to encourage a discussion, open questions were elaborated based on the literature and objectives of the interview.

Table 2 – Questions of the interview protocol and bibliographic references

Objective: Description of the projects	
Question	**Reference**
1. What were the digital transformation initiatives (needs to qualify) implemented in the company in the past 10 years? In which areas? With which enabling technologies?	Chanias & Hess, 2016; Barthel & Hess, 2019; Gurbaxani & Dunkle, 2019; Bathia & Kumar, 2020
2. Was the scope of these projects internal or did it involve the company's ecosystem?	
3. What digital transformation projects (needs to qualify) do you are currently implementing in the company? In which areas? With which enabling technologies?	
4. Is the scope of these projects internal or does it involve the company's ecosystem?	
Objective: Qualification of the projects	
Question	**Reference**
5. What were the most difficulties in the approval of digital transformation projects?	Abylova, V., & Salykova, L. (2019); Holotiuk e Beimborn, Gurbaxani e Dunkle (2019), Barthel e Hess (2019); Bathia e Kumar (2020), Ribas e Teixeira (2021); Cordeiro, G. A. (2022).
6. What were the most difficulties in the implementation of these projects?	
7. What were the critical success factors of these projects?	
8. Were these projects developed locally or rolled out?	
9. How much are/were these projects aligned with the company's strategic objectives?	
10. Were these projects included in the budget plan or were extra-budget?	
11. Is there a roadmap/governance/project office/portfolio specific for digital transformation projects?	
12. Was there participation of external entities (consulting agencies, ICTs, start-ups, partners, suppliers) or was it developed internally?	
13. Has the executive board sponsored the project? How specifically?	
14. What were the lessons learned with the already-implemented projects? Are they being considered in the new projects?	
Objective: Impact of the projects	
Question	**Reference**
15. Following the implementation of the projects, how was the day-after?	

16. What were the benefits provided by the projects for the customer area?	Lucas, Jr., H. C., *et al*.. (2013); Piccinini *et al.* (2015); Riasanow, T., Galic, G., & Böhm, M. (2017); Alves, M. S. (2019); Llopis-Albert, C., Rubio, F., & Valero, F. (2020); Simonazzi, A., Sanginés, J., & Russo, M. (2020). Rocha, C., *et al*.. (2021).
17. Were the results of these projects perceived in the areas?	
18. What were the changes the areas had to make to adapt to the projects?	
19. Were there increases in the productivity, market share and customer's satisfaction? Were there reductions in the costs, delivery time of inputs, pieces and parts, and finished products? Were there improvements in the company's image or products, internal processes and relationship with dealerships?	
20. Which are the metrics used to measure the results of the digital transformation Project?	
21. Was there creation of new products, new processes or reduction of overhead costs?	
22. Was there financial return with the projects? In which average percentage (i.e. project)? And in which proportion (i.e. number of projects with positive financial return)?	
23. Which were the "champions" (i.e. references)?	
24. Was there creation of spin-offs or start-ups from these projects?	
25. Was there spillover as a result of these projects?	
26. What were the negative impacts of these projects?	
Objective: Qualification of the projects	
Question	**Reference**
27. What was the perception of the customer areas about the results of the digital transformation projects?	Ribas, A. I., & Teixeira, L.; Verevka, T., Gutman, S., & Shmatko, A. (2019).
28. What might be done differently in the portfolio management of these projects?	
29. What is the evaluation of the executive board about these projects?	
30. Is there any further comment?	

Source*:* elaborated by the author (2024).

After completing the step of elaborating the interview protocol, the step of selecting companies for the research was initiated.

3.6. Company Selection

The methodology used in the present research follows a qualitative approach focused on the analysis of the companies selected by convenience, as the author has more than 10 years of experience in the automotive sector. This methodological choice allows a deeper investigation of the phenomena studied, thus facilitating the understanding of the internal dynamics and specific strategies of these organisations.

A sample of convenience, which may limit the generalisation of the results, is broadly recognised in the literature as a valid strategy in contexts in which access to data is restricted when one seeks to deeply exploit particular aspects of specific cases (PATTON, 2002; BRYMAN, 2012).

The companies were selected by convenience on the basis of the accessibility and relevance of these organisations to meet the established research objectives. This approach is particularly useful for exploratory studies, whose focus is to generate insights and understand the trends in a specific context (SAUNDERS; LEWIS, THORNHILL, 2019). According to Yin (2014), cases selected by convenience can be relevant for a qualitative study, especially when the selected cases can provide data on complex issues which are difficult to find out by means of quantitative methods.

In order to ensure a robust analysis, the selection of the companies was guided by criteria which included the willingness of the companies to participate in the research, representativeness within the sector of interest and possibility of access to detailed information on their operations and strategies. The present thesis is not aimed to determine a statistical generalisation from the cases studied, but rather exploit particularities and nuances of the phenomena observed, thus contributing to a detailed understanding of the theme in question (EISENHARDT, 1989; STAKE, 1995).

This doctoral study was carried out with five automotive assemblers, all subsidiaries of large multinational companies, which together account for almost 60 percent of the participation in the automotive market. These companies were selected due to their predominance in the Brazilian automotive marked. Moreover, these industries have in their portfolios relevant projects in the area of DT, all implemented by roll-outs developed in the headquarters or by local independent initiatives. Interestingly, some Brazil-originated projects are being implemented in other countries where one of the companies operates, thus adding greater value to the present study.

For reasons of confidentiality, these companies will not have their names revealed or any evidence that might identify them. The list of generic characteristics of the participating companies is shown in Table 3.

Table 3 – List of companies participating in the research

Company	Description	Relationship with Digital Transformation
I-01	Subsidiary of a large multinational	The focus of its investments is mainly on the commercial area.
I-02	Subsidiary of a large multinational	The focus of its investments is mainly on the industrial area.
I-03	Subsidiary of a large multinational	The focus of its investments is mainly on the industrial and commercial areas.
I-04	Subsidiary of a large multinational	The focus of its investments is mainly on the industrial and commercial areas.
I-05	Subsidiary of a large multinational	The focus of its investments is mainly on the industrial and commercial areas

Source: elaborated by the author (2024).

After completing the step of selecting the companies for research, the interviews were conducted.

3.7. Conduction of the Interviews

Data collection was performed by means of semi-structured interviews with managers and key employees of the top management of the companies selected, which included direct observation whenever possible. This combination of methods for data collection is recommended by Creswell (2013), who argues it is an efficient way of obtaining a holistic understanding of the cases studied. Data analysis was performed based on the principles of thematic analysis, thus allowing the identification of patterns and relevant issues regarding the objectives of the research (BRAUN; CLARKE, 2006).

The interviews were conducted according to four guidelines of the systematic process proposed by Brinkmann & Kvale (2008), namely: (i) formulation of objective and theme; ii) planning; iii) conduction of the interviews; (iv) transcription. In this sense, the theme refers to projects of DT in the Brazilian automotive assemblers and their impacts and characteristics.

With regard to the interviewees, three profiles were selected for each company: chief information officer (CIO), director of the area with the greatest concentration of DT projects and chief financial officer (CFO). This composition was designed to allow for different perspectives on the same theme, thus ensuring the capture of different points of view on the research object. In some cases, for reasons of availability or higher knowledge on the projects, the interviewee was a senior executive officer involved in the initiatives of digitalisation in the company. The reason for choosing the strategic level of organisation for the interviewees derives from their broader knowledge and long-term vision.

The sequence of interviews, as shown in Figure 10, was used according to the idea that CIO is the individual who most knows about the projects of DT in the company, addition to being more qualified to indicate which area was more impacted by these initiatives. Consequently, the director of the area was interviewed and the series of interviews was completed with the CFO, who has greater financial knowledge and knows about the return of these projects.

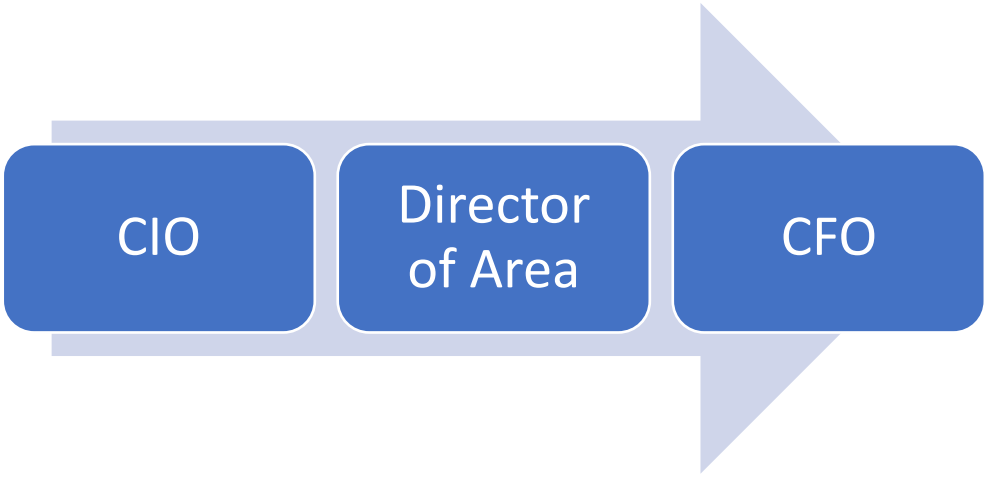

Figure 10 – Sequence of the interviews.
Source: elaborated by the author (2024).

The profile of the interviews was defined, as shown in Table 4. For reasons of confidentiality their names are not revealed, nor any other evidence that might identify them. In one of the companies, it was not possible to interview one executive officer of the financial area because of the company's policy that professionals of this area are prohibited to be interviewed or participate in any type of survey.

Table 4 – Profile of the interviewers

Interviewee	Company	Position	Time in the Company	Time in the industry sector	Time in executive position
E-01	**I-01**	CIO	> 25 yrs	> 25 yrs	> 15 yrs
E-02	**I-01**	Director	> 20 yrs	> 20 yrs	> 15 yrs
E-03	**I-01**	CFO	> 10 yrs	> 15 yrs	> 10 yrs
E-04	**I-02**	IT manager	> 15 yrs	> 15 yrs	> 5 yrs
E-05	**I-02**	Director	> 25 yrs	> 25 yrs	> 15 yrs
E-06	**I-02**	Controller	> 15 yrs	> 15 yrs	> 10 yrs
E-07	**I-03**	IT manager	> 15 yrs	> 15 yrs	> 10 yrs
E-08	**I-03**	Sr. manager	> 25 yrs	> 25 yrs	> 15 yrs
E-09	**I-04**	IT manager	> 10 yrs	> 10 yrs	> 5 yrs
E-10	**I-04**	Vice-president	> 5 yrs	> 25 yrs	> 5 yrs
E-11	**I-04**	Controller	> 20 yrs	> 20 yrs	> 10 yrs
E-12	**I-05**	CIO	> 20 yrs	> 20 yrs	> 15 yrs
E-13	**I-05**	Vice-president	> 25 yrs	> 25 yrs	> 15 yrs
E-14	**I-05**	Controller	> 25 yrs	> 25 yrs	> 5 yrs

Source: elaborated by the author (2024).

All the interviewees were invited through e-mail and informed on the objective of the research, including duration and themes of the interviews. The interviews were conducted by using the Microsoft Teams software after being previously agreed on between researcher and interviewees and scheduled according to their availability and preference. Each interview lasted 1 hour, totalising 14 hours. The participants asked not to have their interviews audio-recorded, which were transcribed by the researcher word-by-word during the interview by using verbatim method. This allowed the dialogue to be detailed, including non-verbal and para-verbal elements (OLIVER, SEROVICH & MASON, 2005). Altogether, 51 pages with single spacing and 11,671 transcribed words in size 11 were produced.

After completing the step of conducting the interviews, the step of data treatment and analysis was initiated.

3.8. Data Treatment and Analysis

Data analysis was performed in three phases: (i) pre-analysis, in which the transcribed material was read; ii) exploitation of the collected material, which was cut out and grouped by theme; and iii) treatment of coded data, inference and interpretation. In this latter phase, manifest and latent content of the collected material is categorised and interpreted based on the theoretical reference (STRAUSS; CORBIN, 2008).

After pre-analysis and exploitation of the collected material, an open coding process was performed, as shown in Table 5. Coding schemes based on content analysis allow ensuring that conclusions remain grounded on real data. By coding the transcripts of the interviews, it is possible to categorised answers, highlight recurring ideas and establish connections between different concepts (BERGTSSON, 2016). Such a strategy allowed a more detailed analysis to be performed, thus resulting in a more comprehensive understanding of the interviewees' opinions.

Table 5 – List of codes

Sponsorship	Strategic alignment	Critical success factors	
Positive impact	**Negative impact**	**Operational impacts**	**Obstacles**

Source: Elaborated by the author (2024).

In a qualitative study, coding is shown to be a visual guide to aid in browsing the collected data, thus revealing insights and correlations. By means of this process, it is possible to attribute labels or codes to relevant data excerpts to unveil themes, patterns and meanings which were then hidden. This approach helps organise, interpret and analyse data as well as allows communicating conclusions in a more assertive way.

Once data collection from the interviews is completed, the resulting data were qualitatively treated by using the MAXQDA software. This software has an intuitive interface allowing the interview transcripts to be efficiently imported and organised, which provides a more systematic and complete analysis of the collected data. With this software it is also possible to code and categorise the data for identification of patterns, which allows comparison of data between the interviewees of the same company and then between the companies before construction of associations based on concepts raised in the step of theoretical references.

According to Miles & Huberman (1994), after the coding process it is possible to analyse the correlations between information emerging from the answers and CSF highlighted in the literature. This method allowed creating significant inferences based on the data obtained.

3.9. Construction of the Critical Success Factor Model

Based on the perceptions collected by means of interviews with executive officers of Brazilian automotive companies for confirmation or not of the existence of CSF in their projects of DT, it was possible to construct a model of CSF. This model was grounded on the theoretical reference shown in the present thesis, especially on models proposed in the Implementation Models section.

During the coding process and data analysis, it was possible to identify patterns in the interviewees' answers revealing the existence of CSF in the management of DT projects in the Brazilian automotive companies selected for research. Therefore, by mapping CSF cited during the interviews, observing their presence in several answers and determining their inter-relationships with a conceptual model, which is very similar to that proposed by Leavitt (1964), an enabling model of DT projects emerged and will be addressed in the Discussion and Results section.

3.10. Elaboration of the Thesis

The present thesis followed the steps necessary for elaboration of a text, based on academic rigour, reflecting the development of the research. The text started from a contextualisation, in which context, relevance of the theme, objectives of the research were evidenced, including introduction of the thesis. Next, theoretical reference was elaborated by addressing the main constructs, highlighting the themes of DT, Industry 4.0 and CSF, before choosing the method with its respective instruments. The results were then presented and discussed for the impacts of DT in the Brazilian automotive industry, in which CSF common to the companies being studied were found. Lastly, the final considerations were elaborated and the relevance of the model of CSF, proposed as an enabling project of DT, in contributing to both industry and academy was demonstrated.

3.11. Threats to Validity

As with any other study, the present work has aspects threatening the validity of the expected results and which were faced to mitigate their influence, since every researcher seeks to use measurement instruments accordingly to meet expectations (KITCHENHAM *et al*., 2015). In this way, and based on Kitchenham *et al*. (2015), Shull *et al*. (2008) and McGrath (1994), there were four types of threats to validity identified and duly mitigated, namely: content validity, internal validity, external validity and construct validity.

Content validity is a subjective evaluation of how adequate the instrument (i.e. questionnaires, scales, interviews, etc.) is for a group of reviewers (SHULL *et al*., 2008). It can occur when the concept being measured by the instrument is not clearly defined, the items do not represent the concept to be measured adequately and the instrument has biases influencing the participants' answers or flaws in its elaboration (e.g. poorly formulated items, ambiguous instructions or lack of clarity in the organisation of the questions). The development of items in the interview protocol based on a clear definition of the concept, which is fundamental for elaboration of constructs, and on a robust literature aimed to validate the interview protocol. In addition, the interview protocol used in the foo-in-the-door study, as well as the

feedback from the interviewees at the end of the interviews, corroborated the validity of the instrument.

With regard to internal validity, it refers to the degree of security a study has when inferring causal relationships (MCGRATH, 1994). Selection bias is a threat to internal validity when the sample is not representative of a population, which was mitigated in the present research by choosing companies accounting for almost two-thirds of the Brazilian automotive market. Also, measurement bias is another threat when instruments are not precise. The use of previously-applied questionnaire and the access to results obtained helped mitigate such a threat.

With regard to external validity, it refers to the replicability of the results so that generalisations can be made. Although this is qualitative research on companies from the same sector, it might have been used even in a study of multiple cases. However, due to the impossibility of access to internal documents, participant observation or even confirmation of data and records from each company interviewed, triangulation was not possible despite being an element necessary to characterise a case study, whether single or multiple (YIN, 2009), which hampered the application of this method. Notwithstanding, in view of the similarity between the companies, same competitive arena in which they are inserted and convergence of answers, it is safe to suppose that such threat was mitigated. In addition, another threat to external validity is the Hawthorne effect, that is, when study subjects change their behaviour because they know they are being interviewed. The fact that the interviews would not be recorded and that both secrecy and anonymity of the participants would be preserved resulted in the mitigation of this threat.

Finally, contrast validity can be seen as on how much the theoretical model is well defined and clear regarding the study and relationships to be exploited (KITCHENHAM *et al*., 2015). With regard to such threat, a judicious explanation of theoretical concepts in clear biding constructs the questions of interview protocol sought to minimise such effect.

3.12. Limitations of the Method

Every scientific method has advantages and limitations. They are the result of the choice of the method to be applied to the development of a given study. Each

method offers potential opportunities not available in others, despite the limitations inherent to them (MCGRATH, 1994).

The qualitative study, with its wealth of data and deep immersion in social phenomena, has increasingly become more important to produce knowledge in several areas. However, as any other scientific method, the qualitative study also has limitations which should be considered and mitigated to ensure the validity and reliability of the results.

As for the bibliographic study, the major limitations involve difficulty in establishing a wide and systematic synthesis of the studies, the access to primary sources not always is ensured, which brings misunderstanding or use out of the context due to the use of secondary sources. Moreover, as addressed earlier, the literature on the theme of DT is scarce worldwide, even worse in Brazil.

The following procedures were used to overcome this limitation, namely: (i) clear definition of the review focus, delimiting the theme, and elaboration of research questions; (ii) use of MAXQDA, qualitative analysis software for organisation, treatment, coding and analysis of data; (iii) recognition and minimisation of potential biases.

In addition, all qualitative studies have limitations regarding veracity and precision of information as well as the researcher's bias during the conduction of interviews. The limitations of qualitative studies are well known and examined in the academia, with one of the main limitations being the attempt of generalisations to a universe of conclusions on the deepening into one unit only (KITCHENHAM *et al*., 2015).

In general, the qualitative study is based on a relatively small number of cases, which can limit the generalisation of the results to other populations or contexts. Such limitation results from the peculiar nature of the qualitative data, which capture the richness and complexity of specific cases, but which are not always representative of a broader population. To enhance the generalisation of the results, the companies were carefully selected in the present research based on their representativeness, richness of information and diversity in the Brazilian automotive sector.

The reliabilityof a qualitative study can be challenged by the difficulty in standardising the methods of collecting and analysing data. In order to increase such reliability, all the steps of the present research were described in details, that is, from the data collection (which was rigorously replicated in all interviews) to analysis and

interpretation of the results by using codification and qualitative analysis software. In this way, it was possible to allow other researchers to understand the process of study and evaluate its replicability.

The present research is limited by its scope as it is only aimed at automotive assemblers within the Brazilian automotive industry, thus not involving the auto-parts industry and automotive dealerships, which are the three pillars of the automotive industry. Similarly, as the study focused on top managers rather than the factory floor personnel and middle managers, some perceptions may be limited.

4. RELATED STUDIES

A summary of related studies published until the date of conclusion of the present research is presented here. They were identified by searching Google Scholar platform (with aid of Publish or Perish software) as well as Web of Sciences and Scopus databases. The search for specific studies on impacts of DT on the Brazilian automotive industry identified only 14 articles.

For this reason and due to the global character of the automotive industry, one sought to identify studies on the theme not only in Brazil, but also across the world. The result of this step yielded 11 articles.

This chapter is aimed at situating the present research within a broader context by showing how it relates to other already-developed studies on the theme. By doing so, one seeks to demonstrate the relevance and originality of the present thesis. In addition, this serves to avoid the repetition of earlier studies and identify tools and techniques which had already been successfully used in similar works.

4.1. Related Studies in the Brazilian Automotive Industry

This section addresses the rapid review results obtained from the following question “What are the impacts of digital transformation initiatives on the Brazilian Automotive Industry?”, which is shown in Chapter 3 of the present research and where the methodology and quantitative results are presented.

One of the studies found was that by Ruggero *et al*. (2002), who addresses models of maturity in DT in the Brazilian automotive industry by raising the research question “what is the maturity level of companies in the automotive segment Brazil to make the transition to industry 4.0?”. The authors conducted a survey with supervisors, managers and directors of Brazilian automotive companies and found that the gains obtained from DT, such as effective horizontal integration, improved real-time communication between machines and people, optimised production processes and better use of equipment would be directly related to the level of maturity of each company in the process of adopting DT.

The same authors performed a study, also in 2020, on the importance of data connectivity in the value chain processes in the automotive industry. The present research also conducted a survey with several players in the Brazilian automotive industry based on Piloni (2018), who states that Industry 4.0 proposes a new

manufacturing model by using new technologies for improving the value creation processes. Therefore, by considering connectivity as an enabling technology of Industry 4.0, the authors sought to understand the role of connectivity in automotive industry and reported that there was a very low level of connectivity and collaboration between company, suppliers and customers despite the high level of importance attributed to the theme by the participants of the study. They also found that the main bottlenecks in the adoption of digital technologies are related to the following: low level of connectivity between the players, low financial resources available for this type of investment and low level of knowledge on this type of technology on the part of the collaborators. It is worth emphasising that with regard to the financial resources, their study obtained information that the RoI of the projects has been over-estimated and financial return expectations have been frustrated.

In 2021, these same authors performed a study on the difficulties on the part of automotive assemblers and auto-parts suppliers in the adoption of industry 4.0 technologies for integration of supply chain. Their study was developed, once again, from a survey with managers of the companies. The results indicated that data connectivity and collaboration between the supply chain players are the main bottlenecks in the adoption of such technologies, which, according to the authors, impedes the achievement of benefits from DT by the automotive chain due to the inter-dependence between the players. Also, their results showed that there is a gap in the adoption of enabling technologies of DT, as 88 percent of the auto-parts suppliers do not use Artificial Intelligence, process simulation or autonomous communication between machines through radio frequency identification (RFID) (RUGGERO *et al*., 2021).

How much the blockchain technology can add value to the businesses and stakeholders of an automotive assembler was theme of master's dissertation by Martins (2022). In their study, the author investigates by means of semi-structured interviews with management staff of an automotive assembler the impacts on businesses and stakeholders after adopting blockchain technology. One of the obstacles in adopting the blockchain technology, according to the respondents' perception, was the lack of technological infra-structure in both company and Brazil. However, the greatest challenge reported by the respondents was the technology itself, considered by many very poor for managing potential results.

On the other hand, Soares & Ferreira (2021) address on the capacity of Industry 4.0 technologies to ensure supply chain activities during the COVID-19 pandemic as well as in the process*s of economic recovery and definition of future actions. Supply chain, as understood in this study, is a network between company and its suppliers for production and distribution of a specific product until end customer delivery, in which Industry 4.0 (e.g. technological development and digitalization of processes) increasing significantly the productivity. The study emphasises the restrictions imposed by the COVID-19 pandemic, particularly circulation, agglomeration, confinement in closed spaces, and how this affected the industry across the world and companies with many factory floor workers, as was the case of the automotive sector. The authors cite Belhadi *et al*. (2021), who propose the use of digital technologies as one of the ways to mitigate the effects of the COVID-19 pandemic on the supply chain activities in the automotive industry by making real-time information available. A survey was applied to manufacturing engineers of two automotive companies in the north-east region of Brazil and it was concluded that the most used technologies used by them were IoT, Cloud, Adaptive Robotics and VR/AR, with a future trend of increased use of cyber-security and AI. Therefore, the use of these technologies has helped in the approach of supply chain resilience.

Rocha, Quandt & Deschamps (2021), in turn, used as research question from the foot-in-the-door study conducted by the present researcher in collaboration with IPC-MIT and (SENAI-DN) in which they question “How R&D collaborations with scientific and business partners contribute to the digital transformation of three multinational organizations in Brazil that have initiated the process of manufacturing digitalization?”.

The concept of DT used by the authors refers to the creation of projects and consequent change in the business processes as well as in the new models of biasness as a result of the use of digital technologies, thus providing faster and more accurate decision-making, increase of productivity, reduction of operational costs, decrease in the number of failures and increased automation of the production lines. It was also highlighted that DT is not only about adopting new technological architecture, but also development of digital strategy, leadership, collaborative culture and new digital competencies to support the organisational structure. The focus of their study was to investigate strategic, social and managerial aspects of the digitalisation process. For doing so, the authors developed three case studies and compared them

to a conceptual framework to elaborate a questionnaire and an interview script. These three case studies investigated a German auto-plants supplier, a Japanese company operating several activities in the metal-mechanic sector, including automotive; and a Sweden company leader in manufacturing of domestic and professional devices. All these three companies have plants operating in Brazil. It is important to highlight that they are inserted in industrial sectors adopting very advanced digital technologies, according to CNI report on Industry 4.0.

In an industry very similar to the Brazilian automotive industry, Muniz, Moschetto and Wintersberger (2023) conducted a study on a joint venture for diesel engine production involving MWM and Cummins and managed by VWCO (*Volkswagen Caminhões and Onibus*) to identify impacts of Industry 4.0 on the assembly line regarding human resources, physical production resources and sharing of knowledge. By means of a case study, the authors conducted semi-structured interviews with production line managers by asking eight questions in two dimensions, namely: organisation and employment. The results were categorised into work, process and knowledge, all indicating that human factor would be a nuclear element for implementation of DT technologies in a diesel engine assembly line due to the human-machine interaction of the Industry 4.0. On the other hand, they identified that managers are preoccupied with the lack of qualified professionals to deal with this new environment, which manifests itself more critically and worrying on the workers.

Zilber, Vasconcelos & Stelmach (2003) investigated the way how traditional automotive companies react to innovations coming from the sol-called e-business by applying the multiple-case analysis method to three companies in the sector, with Ford Brasil being more deeply studied. The authors point out a contradiction due to the fact that the large traditional companies have the assets necessary to be successful in e-business, but they have been failing because of lack of digital organisational structures. Their study was based on the model set by Mutiriba & Vasconcelos (2001), who propose four levels of integration between e-business and organisational structures as follows: level 1 – separated virtual and physical businesses; level 2 – e-business as a business unit or even a separate company; level 3 – business unit of e-business integrated to the company by sharing resources; and level 4 – e-business inserted in the organisation covering all areas of the company.

The case of Ford Brasil could be deeply studied and described in details. A questionnaire was used in the interview with five managers of the company to obtain answers to two major answers, namely: the degree of integration of digital businesses in the company and how much these businesses are coordinated according to the organisational structure. The results obtained indicated that the company went through a 22-year journey following the model set by Muritiba & Vasconcelos (2001), thus achieving the level 4 as all the operations were integrated to a decentralised management of e-business and inserted in the decision-making context, which allowed e-business activities to be adapted to the specific needs of each area.

Still regarding the case studies, Pereira *et al*. (2020) investigated an automotive assembler to identify barriers, challenges and practices of DT in the company. For doing so, the authors conducted semi-structured interviews, documental analysis and visits to the plant. The results of their case study found several barriers against the adoption of DT on the part of the automotive companies, such as: lack of qualified personnel, absence of digital competencies and high-cost acquisition of enabling technologies. With regard to practices for implementation of digitalisation in their business processes, one can highlight the creation of innovation laboratories, digital governance policies, focus on decision-making based on data, including collaboration with research institutes and universities.

In another case study, Santos, Ruggero & Silva (2022) analysed the impact of Industry 4.0 on an auto-parts supplier company. Based on the premise that the impacts of DT are different between large, middle and small-sized companies (Müller, Buliga & Voigt, 2021), their study sought to answer the question “How small and middle-sized auto-parts companies in Brazil are adapting their strategies to the transition towards Industry 4.0?”. The authors analysed the case of a middle-sized company by using a differentiated strategy of Industry 4.0 technologies in their industrial processes. The results obtained from a semi-structured interview with chief executive officers of the company, including documental analysis and visit to the plant, demonstrated an organisational culture aimed to create business models through digitalisation, contrary to the majority of the companies seeking, in a fist moment, to improve at least their operational efficiency. The benefits for the company, as shown in the case study, were the following: stimulation for creativity by establishing corporate intelligence groups, autonomous capture of operational data by means of sensorisation of the industrial

plant, establishment of real-time human-machine communication patterns, process optimisation and raw material consumption.

Other case study is that of Random Corp, an automotive supplier park, conducted by Valdivia *et al*. (2024) with the aim to analyse the impact of DT on the automotive supply chain. The authors identified five dimensions impacting the digitalisation of the supply chain, namely: governance, intelligent networks, qualification, automation and workforce. Based on Benitez, Ayala & Frank (2020), they state that supply chains shifted from a transaction-based model to an approach of value-co-creation between supplier and their customers. Their case study involved participant observation, semi-structured interviews, with IT executive officers, survey with IT employees of all participants of the conglomerate and documental analysis of the company. The authors propose a representative model of DT to be applied to supply chains, as shown in Figure 11.

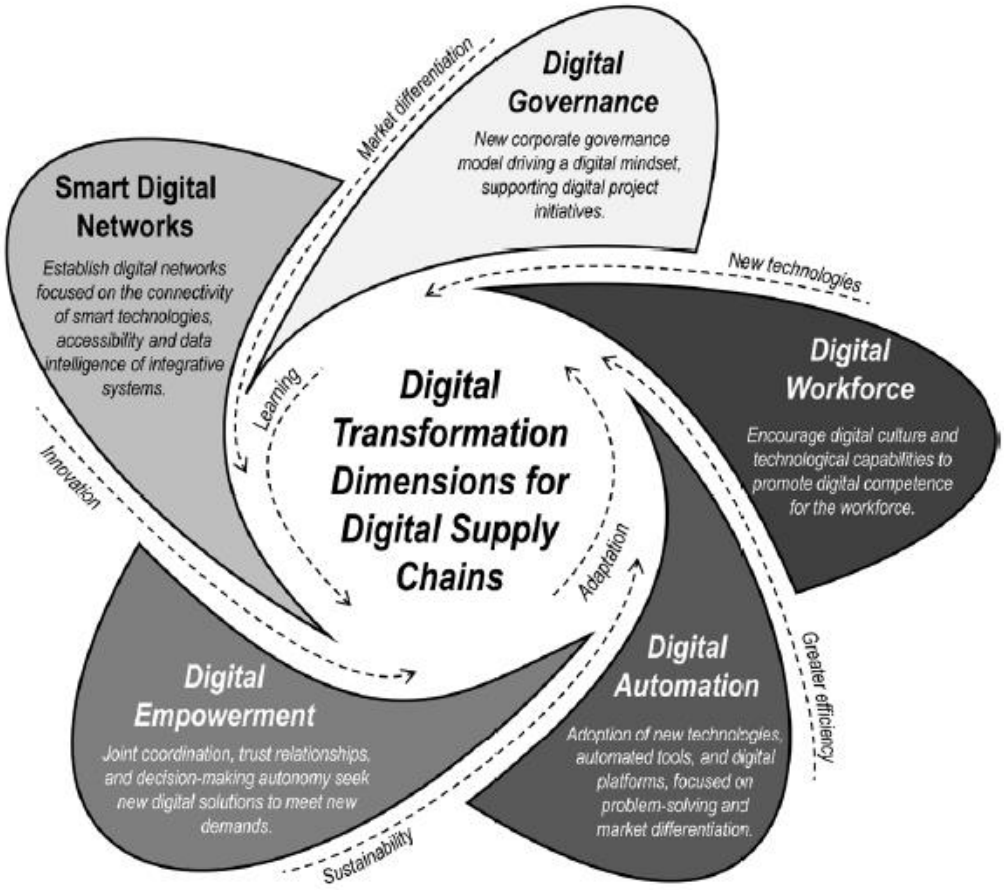

Figure 11 – **Multidimensional model for digital supply chains.**
Source: Valdivia *et al* (2024).

The model shows that the process of DT for supply chains does not follow a linear and predictable trajectory, but rather a dynamic, highly mutable and unpredictable pathway, which is influenced by external demands. The search for greater efficiency, adoption of new technologies, market differentiation, innovation and sustainability boost the transformation. Internally, the pressure within the supply chain requires learning and adaptation to absorb these demands. The central challenge of this process resides on the ability to deal with the system's dynamic nature (VALDIVIA *et al*., 2024).

Beier *et al*. (2022) conducted a survey by applying an on-line questionnaire to 314 professionals from several sectors in Brazil, China and Germany to determine the impacts of Industry 4.0 on the corporate environmental sustainability with focus on de-carbonisation and de-materialisation of the operations. In Brazil, the participation of the automotive sector was the most significant, corresponding to 29 percent. They sought to understand how optimisation of the resource consumption (i.e. de-materialisation) and energy conservation (de-carbonisation) are being impacted by digital technologies. The results provided the opportunity to compare the different perceptions of the professionals of these countries regarding the level of benefits from the adoption of such technologies. The most interesting observation is that in the three countries the impacts of Industry 4.0 on these two factors was weak, and in some cases, energy conservation even decreased with the use of digital technologies. On the other hand, a better stock management, supply chain and industrial production has contributed to de-materialisation and consequently to a greater corporate environmental sustainability.

In 2017, Shinohara *et al*. performed a study in which they proposed a set of CSF, based on the literature and consultancy reports, for implementation of DT in the manufacturing context. In order to triangulate these references, 12 interviews were conducted with professionals from several areas of an automotive assembler. These interviews were elaborated with focus on a single question: "Today, what are the main difficulties in the implementation of digital manufacturing in the company regarding both technical and organisational aspects, including financial ones and innovation?". In the authors' view, this set of CSF would aid the companies in successfully implementing the digitalisation of their manufacturing operations. The result was the construction of a list of CSF, based on the Risk Breakdown Structure proposed by PMI

(KÜHN, 2008), which were grouped into four categories: technical, organisational, project management and external.

Finally, Koda & Pedron (2021) developed a multiple-case study on an automotive assembler (Toyota) and an auto-parts supplier (Robert Bosch) to determine which actions these companies in the Brazilian automotive industry could take to obtain the benefits promised in the literature on DT. The author used the techniques of benefits management and benefit dependency network to identify the main benefits expected by the managers of these companies, namely: more productive efficiency, cost reduction and generation of customer value. All these benefits can be achieved provided that the organisational culture and mind-set of managers and employees are changed. Semi-interviews were conducted with 19 executive officers, among directors, managers and section chiefs, and documental analysis of reports on the implementation of digital technologies was performed, including visits to the plants of both companies. By comparing the answers of the companies' executive officers, the authors could determine that their guidelines were competitiveness, whereas the most expected benefits were productive efficacy and generation of value to the end customer, in addition to those related to innovation, such as business model.

4.1.1. Comparative Table

Below, Table 6 shows the comparison between authors and their respective areas of concentration from the studies on impacts of DT and corresponding CSF on the Brazilian automotive industry. In the third column are listed the areas of concentration in each of the studies analysed, whereas in the last column are shown the points of convergence with the present study, thus allowing an overall view of the academic and practical contributions on the theme.

Table 6 – Related studies on the Brazilian automotive industry

Authors	Publication year	Areas of concentration	Convergence
VALDIVIA, C.A.; MAMÉDIO, D.; LOURES, E.; TORTATO, U.	2024	Analysis of the impacts of DT – Case study of an automotive supplier park	Impacts of DT on BAI
MUNIZ JR., J.; MOSCHETTO, G.P.; WINTERSBERGER, D.	2023	Impacts of Industry 4.0 – Case study of two Brazilian diesel engine manufacturers	Impacts of DT on BAI

SANTOS, N.; RUGGERO, S.M.; SILVA, M.	2022	Impacts of Industry 4.0 – Case study of an auto-parts supplier	Benefits of DT on BAI
MARTINS, A.H.P.	2022	Added value of blockchain technology in an assembler in BAI	Impacts of DT technologies on BAI
BEIER *et al.*	2022	Relationship between DT and corporate sustainability	Impacts of DT on BAI
KODA, A.; PEDRON, C.D.	2021	Benefits of DT – Case study of an assembler and an auto-parts supplier	Benefits of DT on BAI
ROCHA, C.; QUANDT, C.; DESCHAMPS, F.	2021	Collaboration in DT – Three case studies on the Brazilian automotive industry (two auto-parts companies)	Collaboration between R&D centres and BAI (*foot-in-the-door research*)
SOARES, M.C.; FERREIRA, C.V.	2021	Analysis of the digitalisation of supply chain in an OEM during COVID-19 pandemic	Benefits from the application of DT technologies to BAI
SANTOS, N.; RUGGERO, S.M.; SACOMANO, J.B.; ESTENDER, A.C.; SILVA, M.	2021	Difficulties in adopting Industry 4.0 technologies for implementation of supply chain – A survey on auto-parts assemblers	Barriers against the adoption of digital technologies in BAI
	2020	Analysis of the role of data connectivity in value chain processes in BAI	Main barriers against the adoption of data connectivity in BAI
	2020	Models of DT maturity in BAI	Benefits of DT on BAI
PEREIRA, D.I.; LIMA, E.P.; MACHADO, C.G.; COSTA, S.G.	2020	Analysis of the challenges, barriers and best practices – Case study of an automotive OEM	Barriers and best practices in BAI
SHINOHARA, A.C.; SILVA, E.H.; DESCHAMPS, E.P; COSTA, S.E.	2017	Identification of CSF in the implementation of digital manufacturing	CSF of DT in BAI
ZILBER, S.N.; VASCONCELOS, E.; STELMACH, J.	2003	Analysis of organisational structures of e-business in BAI – Case study on Ford Brasil	CSF in the e-business of an assembler

Source: elaborated by the author (2024).

By observing Table 6, it is possible to note that the present study identified several case studies on the impact of DT under different aspects, such as: Valdivia *et al*. (2024) studied such impacts on an automotive supplier park; Muniz, Moschetto & Wintersberger (2023) studied a diesel engine production plant; Santos, Ruggero & Silva (2022) analyzed the benefits of an auto-parts supplier; Koda & Pedron (2021) analysed the benefits of DT in the Toyota and Robert Bosch companies; Rocha, Quandt & Deschamps (2021), examined the collaboration with research & development centres; Pereira *et al*. (2020) analysed the barriers and practices in adopting digital technologies on an automotive assembler; and Shinohara *et al*. (2017) identified a list of critical success factors on an automotive assemblers. In turn, Santos

et al. conducted three relevant works for the present study: a survey on the difficulties in adopting digital technologies in the Brazilian automotive industry (2021); a case study on the role of data connectivity in the value chain process in the Brazilian automotive industry; and another study on digital maturity in the automotive industry by identifying gains in efficiency and optimisation related to the level of digital maturity in Brazilian automotive companies (2020). Other studies, such as that by Martins (2022), investigated the impact of blockchain technology, whereas Soares & Ferreira (2021) analysed the resilience of automotive supply chain during the COVID-19 pandemic. The survey by Beier *et al*. (2022) addressed the environmental sustainability in the Industry 4.0 and Zilber, Vasconcelos & Stelmach (2003) examined in another case study the critical success factors in the adoption of e-business in Ford Brasil.

4.2. Related Studies in the Global Automotive Industry

The related studies were supplemented with 11 articles on the impacts of DT on the automotive industry worldwide and corresponding critical success factors in the implementation of such transformation and not only on companies operating in Brazil. The reason for such complement is due to the global aspect of this industry, which operates across the whole world with branches in several countries. In this way, this sub-section aimed to supplement the present study with aspects and insights from studies on automotive industry developed elsewhere and not only in Brazil.

Llopis-Albert, Rubio & Valero (2020) analysed the impact of DT on the automotive industry under the perspective of different players of this sector: automotive assemblers, supplier, service providers, IT companies, government, consumers, etc. Their study used a comparative qualitative analysis called fsQCA (i.e. fuzzy-set qualitative comparative analysis), which is focused on the Spanish automotive market. The method of fsQCA consists of a qualitative analysis based on Boolean algebra for determine causal relations between results and a set of conditions. It is to be applied to situations of multiple cases in which the players are heterogeneous with different interests.

The objective of their study was to identify how digitalisation is transforming the entire automotive value chain in Spain, with the authors concluding that there is a significant change boosted by DT. New business models are emerging, such as car-

sharing platforms and autonomous vehicles. This requires adaptation on the part of incumbent automotive assemblers, which should explore new markets to remain competitive. In addition, the growth of connected cars, which generate real-time data, opens doors for innovative services and a more personalised experience for the customer. The production itself is undergoing a revolution with Industry 4.0 technologies. Robotics, automation and 3D printing are making the manufacturing of motor vehicles more efficient, agile and potentially more customisable (LLOPIS-ALBERT; RUBIO; VALERO, 2020).

Nevertheless, DT is not exempt of challenges. Preoccupations with cyber-security of connected vehicles emerge as a significant obstacle. In addition, the automotive industry increasingly needs a qualified workforce to deal with new digital technologies. The authors also highlight the rupture of the traditional business models as another challenge to be faced.

The study concluded that DT is an opportunity for automotive assemblers to remain competitive and meet the customers' increasing demands. Companies successfully integrating these technologies to their processes and developing innovative business models will be better positioned in the competitive arena of the automotive market.

In the study by Hanelt *et al*. (2015), the authors investigated the impact of digital technologies on business models of predominantly physical industries, such as the automotive assemblers. In this way, they sought to understand how digitalisation is remodelling the automotive industry and its impact on the traditional business models of the automotive assemblers. The authors used a content analysis approach by examining journals of the sector and relevant publications to identify the main digitalisation trends and their influence on the sector.

The results show that digitalisation is a superposition rather than a replacement of business processes in the companies of the sector. The study highlights that digital trends are creating a "digital layer" on the existing physical infra-structure rather than replacing physical products (i.e. automobiles). This layer includes resources of connected vehicles, on-line services and data-based decision-making. Notwithstanding, digital technologies reinforce the focus on the client's journey. Automotive assemblers are using digital tools to customise the experience of purchasing vehicles and to provide remote diagnosis, resources of connected vehicles and on-line support. Finally, the changes in business models resulting from mobile

applications, big data and cloud computing are creating new flows of revenues beyond the sales of automobiles, such as data-based services, models of subscriptions for car functionalities or car-sharing platforms.

Understanding how European automotive companies elaborate their strategies of DT was the aim of a study by Chanias & Hess (2016), who sought to understand the process by which these companies develop strategies to deal with challenges and opportunities resulting from digital technologies. By using the multiple-case approach and concentrating on several European automotive manufacturers, the authors assessed data collected by means of interviews, corporate documents and reports of the sector to understand the internal processes of elaboration of such strategies.

Their study suggested that strategies of DT are not boosted by the top management only. There is a bottom-up process in which several sub-units within the organisation exploit and implement digital technologies on an independent basis, showing that these efforts influence the company's overall strategy. Although this bottom-up strategy plays a significant role, the top management still has a fundamental role in aligning the digital initiatives with the company's vision of future, thus promoting a more comprehensive strategy. In this way, the authors challenge the traditional views of strategy formation. They suggest that, in the context DT, a more ascending and collaborative approach can eventually prevail through an alignment with the topr management for a unified vision.

On the other hand, Piccinini *et al*. (2015) in their study exploited the managerial challenges associated with the impacts of DT on the automotive industry. The authors conducted a Delphi exploratory study in collaboration with 19 specialists in the sector. Delphi studies involve iterative rounds of contributions from specialists to achieve a consensus on a given topic (PICCININI *et al,* 2015). The main findings were the following: (i) DT goes beyond the intra-organisational challenges as it transforms radically the way companies operate by impacting processes, structures and strategies; (ii) Automotive industry is undergoing significant changes due to digital innovation and emergence of new technologies, data-based insights and new business models. (iii) As the physical and digital worlds merge (i.e. a phygital world), new paradoxes emerge and organisations should balance efficiently both domains; (iv) Dealing with these two domains requires the organisational ambidexterity, that is, management of the current operations while exploiting new opportunities resulting from digital technologies.

Piccinini *et al*. (2015) argue that DT brings challenges and opportunities for automotive organisations. By promoting organisational flexibility, embracing digital innovation and managing the interaction between physical and digital worlds ambidextrously, the automotive assemblers can browse through this transformation and ensure the longevity of their businesses.

The study by Miguel *et al*. (2022) investigated the relation between DT, dynamic capacities and customer satisfaction in the automotive industry. Dynamic capacities are understood here as the patterns learned and followed by the organisation in the execution of its tasks for efficiency (MIGUEL *et al*. 2022). These capacities were grouped into three types, namely: (i) detection, which is the ability to understand the environment and meet the consumer's needs before the competitors do; (ii) optimisation, which are the ability to find solutions to threats and identify opportunities in the earlier type; and (iii) innovation, which is the capacity to transform assets in view of the environmental changes and needs for consumers.

Their study quantified the effect of these dynamic capacities on the customer satisfaction, considering the role of DT in this relationship. The authors collected data by means of questionnaires distributed to 42 collaborators of several automotive companies during the period prior to COVID-19 pandemic (i.e. 2019-2020).

A positive correlation between dynamic capacities of a company and satisfaction of the customer in the automotive sector was confirmed in their study. Therefore, companies highlighted for detecting the customer needs, improving the opportunities and promoting innovation are more likely to satisfy their customers (MIGUEL *et al*., 2022). Their study also highlighted the role of DT in facilitating the dynamic capacities. Digital tools and technologies can help the companies gather information on clients (i.e. detection), identify new market opportunities (optimisation) and develop innovative products and services (innovation). Lastly, the authors suggest that the development of s=dynamic capacities is a requirement for automotive companies to achieve a high satisfaction level of their customers. By taking advantage of DT to improve these capacities, the companies can better understand their customers, adapt to the new market demands and, ultimately, provide a more satisfactory experience to the customer.

Riasanow, Galic & Böhm (2017) investigated how digital innovation is transforming the automotive industry with the generation of new business models, thus permeating the whole industry value chain. They mapped the evolution of automotive

ecosystem regarding the digitalisation by identifying the main actors in this network and the value flows connecting them. For doing so, the authors used a three-step research approach to analyse the company's database, identifying different factors operating in the sector (e.g. assemblers, auto-parts suppliers, dealerships) and value flows connecting them (e.g. supply chain, sales channels, post-sales services). They used the *e³-value* method, a framework to analyse value chains in the context of electronic business and applied it to the collected data in order to create a visual representation of the automotive value network in the digital era.

In this way, the authors managed to identify new players in the automotive value chain as a result of digitalisation, including companies specialised in areas such as autonomous vehicle technology, car-sharing platforms and data analysis, and detected that the way value is created and delivered in the automotive industry is changing as digital technologies are allowing new value flows (e.g. data-based services and connected vehicle functionalities). Their study presented a generic model of automotive value chain in the digital era, which can serve as a basis for understanding the complex interactions between the different players and value flow within the industry sector.

In a qualitative study, Acciariri *et al*. (2022) sought to understand how digital technologies are influencing the creation of new business models aimed to be innovative and to promote the sustainability in the automotive industry. The method used was a case study of an European automotive assembler. The authors gathered data by means of semi-structured interviews with key personnel and analysis of corporate documents to understand its approach on digitalisation and development of new business models.

Their study suggests that digitalisation and sustainability are interlinked rather than separate forces. Digital technologies can be used to create innovative business models which are ecological as well, such as car-sharing platforms aiming to reduce the ownership rates of automobiles by introducing the concept of mobility-as-a-service (MaaS). In addition, the authors emphasised that automotive companies should give priority to innovation and sustainability in their business models. Digital tools can be used to optimise production processes, reduce resource consumption and develop electric or hybrid vehicles. Finally, the findings indicate that although companies and consumers are aware of the digitalisation potential for a sustainable innovation, there still uncertainty about the actual adoption of new technologies in the history sector.

Colombari *et al*. (2023), in turn, investigated how automotive assemblers and auto-parts suppliers take advantage of data and digital technologies for making decisions and exploiting possible competitive advantages. The authors conducted a survey by means of questionnaires, elaborated and distributed to representatives of automotive companies in Italy and the United States, to address the use of data analysis, digitalisation strategies and decision-making processes by the companies. They analysed the correlation of data captured from two dimensions, as follows: decision-making process and range of new digital technologies. The results revealed that the companies of both countries have a variety of organisational structures, in which some follow a more traditional approach (i.e. Taylorism), whereas others follow a more flexible approach based on data. Despite the structural differences, both Italian and North American companies give priority to the use of data and digital tools to improve the quality of the products and ensure security on the manufacturing floor. Nevertheless, their study found a potential gap between data collection and its effective usage. Although the companies actively gather data by means of automation and sensors, they are not fully exploiting their potential for data-based decision-making.

The common perception that the automation resulting from DT rapidly eliminates jobs in the automotive industry was challenged by Krzywdzinski (2020), who performed a study on companies in Germany, Japan and the United States regarding the period from 1990 to 2018. The author evaluated the impact of automation and digitalisation on job structures in the automotive industry in these three countries by reviewing related press articles to understand how automation and digitalisation were perceived and discussed by examining data on robot stocks (i.e. number of industrial robots) along with sources of official statistics in each country.

The author still found that the sector was focused on an agile automation as automation involves robots and other technologies which can be easily adapted to different tasks, thus potentially supplementing the human work instead of fully replacing it. Also, analysis of data on employment suggested that automation and digitalisation did not lead to significant losses of jobs in the automotive production in these three countries. However, the study recognises that automation can create the need for new technologies in the workforce, imposing the employees to adapt to working with robots and digital technologies. Krzywdzinski (2020) argues that the narrative that automation leads to mass unemployment in the automotive industry is

an exaggeration. Although automation and digitalization are present, the focus on flexible automation and data on employment suggest a less dramatized image than the common sense, but which indicates that workers need to qualify themselves in new digital competencies to keep their jobs.

In a study performed by Ribas & Teixeira (2021), the authors investigated the role of information systems in DT. They identified critical success factors in the implementation of such systems by means of a practical case study on a manufacturing unit of an auto-parts supplier with several plants across the world. Their study aimed to analyse how information systems are used to facilitate digitalisation of an automotive company and identify the main factors contributing to a successful implementation of information systems in a project of DT.

Their study emphasised the basilar role of information systems in enabling DT in the automotive industry. These systems facilitate the collection, analysis and communication of data, which are fundamental to improve processes, innovation and adaptation to new market demands. Also, the authors identified five key factors contributing to a successful implementation of these systems in the company's digitalisation project, as shown in Table 7.

Table 7 – Critical Success Factors in Information Systems implementation

Critical success factor	Short description
Connectivity	To have a reliable, robust infra-structure of information technology to support new solutions and communication between machine and systems with robust, reliable data.
User's environment	To actively involve users in the development of new systems to ensure that their needs are fulfilled and the system effectively used, in addition to developing a comprehensive strategy to manage the changes during possible resistance to them and ensure a quiet transition to new system-oriented processes.
Analysis of process and adaptable solutions	To analyse processes before changes so that new technical solutions or alterations in the existing ones can be integrated in the existing systems and processes.
Partners and Support team	To have reliable technological partners and a committed team and to promote effective communication.
Strategy plan and roadmaps	To ensure that initiative of Information systems are aligned with the general strategy of DT in the company and that it is clear and publicised within the organisation.

Source: adapted from Ribas & Teixeira (2022) and translated by the author.

Finally, Bhatia & Kumar (2020) examined factors which are not critical for a successful implementation of Industry 4.0 technologies in the Indian automotive industry. They sought to identify the main factor influencing indicators of performance associated with the adoption of Industry 4.0, which were categorised as follows: operational, product, economic and responsiveness. The authors used data from the literature on CSF and indicators of performance regarding the Industry 4.0 which were then addressed by specialists in the sector. Based on this information, a questionnaire was elaborated and sent to 156 collaborators of the sector. The resulting data were submitted to confirmatory tests and factorial analysis for validation of the properties of factors and indicators before having their relationships submitted to regression analysis. The CSF listed by the authors from a literature review were the following: (i) organisational leadership, (ii) IT infra-structure, (iii) financial aspects, (iv) external support, (v) data governance, (vi) collaboration and teamwork, (vii) involvement of collaborators, (viii) strategic integration, and (ix) legal aspects.

Their study suggested that data governance is the most critical success factor for achieving positive performance results with the implementation of Industry 4.0. Data governance refers to policies and practices ensuring that an organisation’s data are safely, reliably and efficiently managed. This CSF is essential because it allows taking advantage of the great amount of data generated by Industry 4.0 technologies to improve operations, product development and general business performance. It is also highlighted that legal aspects, which encompass data privacy and intellectual property rights, can affect not only the operational efficacy, but also the development of products and economic performance. Teamwork, especially between different departments of the company, can significantly improve responsiveness. Effective collaboration promotes better communication and sharing of information, thus allowing companies to adapt more quickly to the new market demands as well as to the customers’ needs (BHATIA; KUMAR, 2020).

4.2.1. Comparative Table

Table 8 lists the authors and their areas of studies regarding the impacts of DT on the world automotive industry and CSF in the implementation of digitalisation initiatives. In the third column are shown the areas of concentration and in the fourth

column one can see the points of convergence of each article with the present doctoral work.

Table 8 – Related studies on global automotive industry

Authors	Publication year	Areas of Concentration	Convergence
LLOPIS-ALBERT, C; RUBIO, F.; VALERO F.;	2021	Analysis of the impacts of DT on the Spanish automotive industry – Qualitative using fuzzy logic (fsQCA)	Impacts of DT on automotive industry
HANET, A.; PICCININI, E.; GREGORY, R.W.; HILDEBRANDT, B.; KOLBE, L.M.	2015	Analysis of the impacts of DT on automotive industry – Analysis of content from secondary sources.	Impacts of DT on automotive industry
CHANIAS, S.; HESS, T.	2016	Study on the elaboration of DT strategies – Multiple-case study of European assemblers	CSF of DT in automotive industry
PICCININI, E.; HANET, A.; GREGORY, R.W.; KOLBE, L.M.	2015	Analysis of managerial challenges of DT in the automotive industry – Delphi exploratory study	Impacts of DT on automotive industry
MIGUEL, P.M.; DE-PABLOS-HEREDERO, C.; MONTES, J.L; GÁRCIA, A.	2022	Relationship between DT, dynamics capacities and consumer satisfaction – Quantitative e analysis.	Impacts of DT on automotive industry
RIASANOW, T.; GALIC, G. BÖHM, M.	2017	Creation of a generic value chain model in the automotive industry – Data analysis & semi-structured interviews	Impacts of DT on automotive industry
ACCIARINI, C; BORELLI, F.; CAPO, F.; CAPPA, F.; SARROCCO, C.	2022	Analysis of the relationship between DT and sustainability – Case study of European assembler.	Impacts of DT on automotive industry
COLOMBARI, R.; GEUNA, A.; HELPER, S.; MARTINS, R.	2023	Analysis of the relationship between DT and decision-making process – Survey on Italian and North American auto-parts assemblers	Impacts of DT on automotive industry
KRZYWDZINSKI, M.	2020	Impact f automation and digitalisation on job structure in German, North American and Japanese automotive industries.	Impacts of DT on automotive industry
RIBAS, A.I.; TEIXEIRA, L.	2021	CSF in the implementation of information systems in the context of DT – Case study on auto-parts supplier	CSF of DT in automotive industry
BATHIA, M.S.; KUMAR, S.	2020	Correlation between CSF and performance indicators – Quantitative analysis of Indian automotive industry	CSF of DT in automotive industry

Source: elaborated by the author (2024).

As shown in Table 8, one can observe that eight out of the 11 selected articles directly addressed the theme of impacts of DT on the automotive industry. And emphasising the global character of this section, all these studies were carried out in several countries (i.e. Germany, USA, Spain, Italy and India), and in some cases, they addressed European automotive assemblers.

The method of qualitative research were present in several studies, such as that by Llopis-Albert, Rubio & Valero (2022), who used comparative analysis with fuzzy logic to assess the impacts of DT on the whole automotive chain in Spain; Hanet *et al*. (2015) conducted a content analysis of secondary sources aiming to measure the impact of DT on the traditional business models of automotive assemblers; Piccinini *et al*. (2015) used a Delphi exploratory study to identify managerial impacts of the digitalisation; Riasanow, Galic & Böhm (2017) used data analysis and semi-structured interviews in order to create a generic value chain model for automotive industry; lastly, Acciarini *et al*. (2022) developed a case study of an European assembler to analyse the relationship between DT and sustainability.

Miguel *et al*. (2022) conducted a quantitative study by surveying collaborators of several automotive companies to determine the relationship between DT, dynamic capacities and consumer satisfaction. Similarly, Colombari *et al*. (2023) also surveyed Italian and North American auto-parts assemblers to determine a relationship between decision-making and DT. Lastly, Krzywdzinski (2020) developed a study on automotive companies in Germany, USA and Japan by using qualitative and quantitative methods to challenge the common perception that the automation resulting from DT rapidly eliminates jobs in this sector.

Moreover, three studies concentrating on CSF were selected, namely: Chanias & Hess (2016), who carried out a multi-case study on European automotive assemblers to determine the key success factors in the elaboration of strategies of DT; Bathias & Kumar (2020), who used a quantitative study on Indian automotive industry to correlate CSF and performance indicators related to Industry 4.0; and finally, Ribas & Teixeira (2021), who performed a case study to determine which would be the most important success factors for implementation of information systems in the context of DT.

However, after analysis of the related studies, one can point out some gaps in the identification of the impacts of DT on the Brazilian automotive industry. Particularly,

there are a very few studies addressing the effects of this transformation on automotive assemblers on a comprehensive basis rather than focusing on a specific company only. Although there are studies (e.g. Valdivia *et al*.; 2024) concentrating on auto-parts suppliers, there is a gap in the application of these models to automotive assemblers in the Brazilian automotive industry. Similarly, the study by Ribas & Teixeira (2021) addressed these factors in the implementation of information systems, showing that there is a need to expand this analysis by including all enabling technologies of DT.

These gaps indicate that further studies focusing on the identification of impacts of DT on the Brazilian automotive industry should be carried out on a broader basis. This includes not only technical and organisational aspects, but also cultural and strategic ones. Moreover, it is essential to exploit business models facilitating the implementation of DT in the Brazilian automotive industry in order to allow a more integrated and broader view on the challenges and opportunities associated with such a transformation.

Therefore, future studies should focus on investigating the impacts of DT on all automotive assemblers in the sector as a whole and on developing models to consolidate CSF, thus expanding the analysis so that all the enabling technologies can be addressed. Such studies become essential to meet the gaps identified and to advance the knowledge on DT in the Brazilian automotive industry, which will provide insights for scholars and professional of the sector.

5. RESULTS

The results from interviews and data treatment by means of MAXQDA software are presented in this section. They are shown in a consolidated manner, with answers from all participating companies being grouped by seven codes as follows: positive impacts, negative impacts, operational impacts (internal), barriers, sponsorship, strategic alignment and CSF, resulting in 220 segments of interviews coded and distributed as shown in Figure 12.

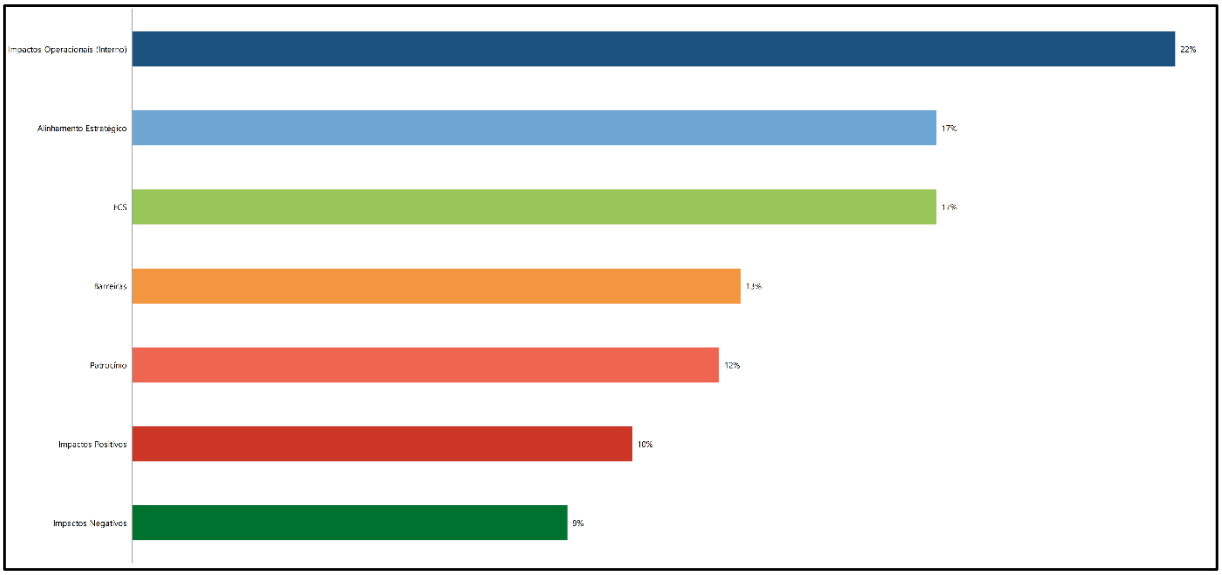

Figure 12 – Percentage distribution of the codes selected.
Source: MaxQDA software for treatment of qualitative data.

It is important to emphasise that some of the answers had to be erased or edited in order to maintain information secrecy, mainly regarding the respondents identity or their company's name, but one sought to keep the meaning of their answers by avoiding changing the meaning of the phrase, even when replacement of a given word was necessary.

The projects of DT implemented in the past ten years regarding several value chain areas of the participating companies were listed during the step of interviews. One can highlight the commercial, industrial and production development areas.

In the commercial areas, there are initiatives of paperless technologies covering from scheduling to payment of technical assistance services, all completely digital. For instance, vehicles sensorised with alerts to the driver; cloud data allowing remote monitoring by the dealership technical assistance, which anticipates diagnosis so that

interventions can be planned accordingly and consequently the vehicle spends shorter time in the mechanical workshop, thus increasing the productivity of the dealership. One can also cite digital sales channels for vehicle, parts & accessories and services; centralisation of all digital marketing channels regarding websites, apps, call centres and dealerships by using chatbots; on-line services in the dealership such as digital sales of vehicles, including financing lines; purchase reservation and customer relationship system using SalesForce and WhatsApp, which are the main channels of communication with the purchaser of a new car.

Industry 4.0-biased projects are focused on reducing manual activities and non-added value task, as well as on improving data analysis for decision-making. For instance, collaborators are connected to production lines with screens in each workplace displaying all information on the manufacturing of different vehicle models, including automated production with a set of parts controlled by tablets or smartphones. One can also cite collaborators trained with augmented reality technology; welding process inspected and painting defects detected on a real-time basis; assembly robotisation; digitalisation of processes, generating data for analysis and decision-making process; digital inventory using drones; production lines ergonomically adjusted and evidence of industrial feasibility for new vehicles developed by means of digital twins (i.e. virtual reality); automated re-supplying sensorised for predictive analysis and traceability; 100-percent automated requirement and receipt of direct material; and traceability of the newly-purchased car in the production line on the part of the customer.

The development of new vehicles is validated with fully virtual prototypes (except crash test due to regulatory reasons), that is, there is a virtualisation of the product development. One can cite other technological applications, such as car-as-a-service using vehicles connected and electrified; advanced driver-assistance services (ADAS); sensorised, connected vehicles generating great volumes of data; digital relationship with customer; remote calibration updating; and car-fleet testing with artificial intelligence for reliability, run test and root-cause failure analysis.

In addition, projects in the logistic (inbound), quality, legal and purchase areas were listed. These initiatives involved technologies such as big data, artificial intelligence, Internet of things, robotics, augmented reality, 3D printing, drones (for warehouse), as well as changes in the legacy system (some running on mainframes) for digital systems on cloud platforms.

As evidenced in the answers from the question “Were these projects developed locally or rolled out?”, most of the DT projects developed by the companies subject to this research were local, with some even being rolled out to other plants in Latin America and even one to the USA. The majority of these were in the commercial area, respecting local characteristics. Projects in the industrial and R&D areas showed a predominant trend of being rollouts from the headquarters. In all cases, due to the strategic relevance of these initiatives, all had some level of approval or monitoring from the headquarters.

These initiatives generated both negative and positive impacts, as well as operational impacts which will be presented below. As for the identification of positive impacts perceived by the respondents, there are 23 segments coded from the interview protocol answers to question #16 “What were the benefits provided to the customer area with the delivery of the projects?” and question #17 “What was the perception of the areas about the results of these projects?”. Answers on positive impacts are described in Table 9 below:

Table 9 – Answers on positive impacts

Positive Impacts
Flexibility in providing services to the end customer in order to reduce the time the car is in the dealership. Convenience for the end customer, with possibility of scheduling whenever and wherever needed. Generation, availability and control of data for decision-making (Big data). Reinforcement and modernisation of the transnational trademark. Increase in NPS. Quick check-in of the vehicle, thus reducing attrition with the end customers.
Mastery of the tool for using the proposed functionalities. Synchronisation of the inventory with the end customer’s schedule. Real-time data on the vehicles available for the customers .
Shorter time for intervention in the customer’s vehicle and simplification of processes, thus making the customer’s life easier.
Yes, with the increased adoption of solutions and perception of value to the end customer. There was a perception of productivity gain.
Efficiency by speeding up the conduction of tasks with less personnel; greater availability of access to data for decision-making; increase of NPS by the end customer in the dealerships; simplification of the direct sales processes and gathering of customer orders.
Operational area (dealership floor) recognising the added value with the implemented projects.
Quicker response time in operation and problems; increased quality due to more efficient prevention of breakdowns; reduction of down time, thus increasing productivity; possibility of global monitoring (by telemetry) by means of maintenance centres; greater availability of information for decision-making; automated training through augmented reality; paperless.
Time gain in the execution of processes by increasing productivity of the production line (vehicles per minute); increased availability and quality of data for decision-making.

Perception that processes have become more efficient and productivity (vehicles produced *per* line and cost *per* vehicle produced) and quality (defects per vehicle) increased.
Reduction in costs *per* vehicle produced; reduction in overhead costs; reduction in down-time (non-added value); increase in sustainability (elimination of papers, ink cartridges and printers in the production lines); increased quality of the product.
Positive management area, as its personnel began to use data for making decisions. Increase in productivity as result of the reduced time *per* vehicle produced and reduced unit cost; increased quality of the products.
Yes. There was empowerment of the business areas. “Shining eyes” after the initial barrier. There was an initial preoccupation with reduction of personnel, which did not happen. Surplus employees were relocated after production solutions were implemented.
Improvement in processes in the medium term. Improvement of the image (innovative). Three-time increase in the use of new technologies by the dealerships.
Yes, good customer perception and high grades in the app stores. Greater visibility of data. Increased sales. Fully digital sales. Increased perception of convenience by the customer.
Flexibility, such as a reduction over 90% in the process time. Greater perception of modernity by the customers. Dramatic reduction in the use of paper (ESG). Reduction in more than 92% in work leaves due to ergonomic problems.
Yes, in part due to the broad disclosure of the results, including internationally. Reflection of a consistent management of cultural changes.
Increase in the level of NPS. Greater availability of time and data for decision-making. Anticipation of failures. Improved perception by the customer. Reduction in costs. Increase in leads generation.
Integration. More agile processes. Quicker and more effective analysis and decision-making process. Increase in productivity (more activities with less personnel), Flexibility in processes due to RPA. Greater availability of data for decision-making.
Reduction in costs and time (development of products, supply, delivery of vehicles, etc.) Increase in productivity.
Yes, increased operational efficiency with greater productivity and less personnel in operative activities. Paperless. Increased integration between the areas, greater availability of data for decision-making and increase in competitiveness.

Source: elaborate by the author (2024).

It is remarkable that the theme of productivity was mentioned in the majority of the answers on positive impact resulting from the projects of DT. This issue is present in the identification of an increased operational efficiency, reduction in cost and time (i.e. execution of tasks and down-time), reduction in wastage and use of paper for operational tasks, and reduction in personnel. These elements are consecrated in the literature as being directly related to the increase of productivity (MESSA, 2013; BRYNJOLFSSON, ROCK e SYVERSON, 2017). In addition, changes in the profile of the collaborators’ activities (e.g. analysing data for decision-making instead of

performing manual tasks) emphasise the importance of data in the respondents' view due to either greater access to data or improvement of decision-making process, as cited in the answer below:

"[…] Data, data and data." (Respondent E-13)

In the interview protocol, more specifically question #19 "Was there increase in productivity, reduction of costs, increase in customer satisfaction, increase of market share, improvement of the company's or product's image, improvement of internal processes, reduction in development time, reduction in delivery time of inputs, parts & pieces and finished products, and improvement in the relationship with dealerships?", the respondents were asked about their perceptions on the impacts the initiatives of DT had on the company's performance indicators. Figure 13 shows a compilation of the answers represented as percentages of positive perceptions on the impacts of DT on each indicator raised in question #19.

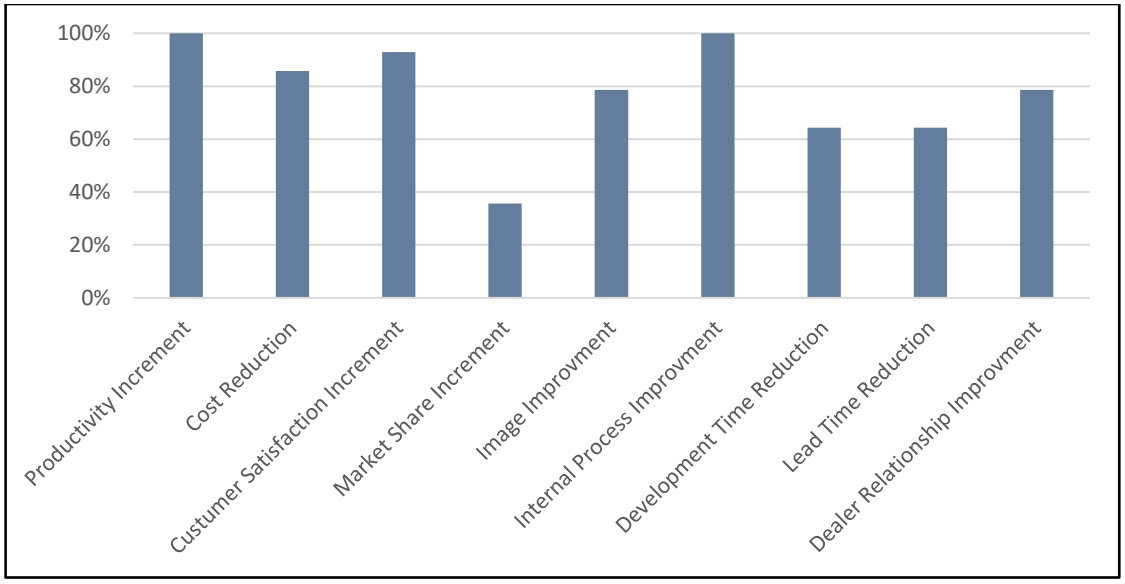

Figure 13 – Percentage of answers about performance indicators.
Source: elaborate by the author (2024).

All respondents of the companies investigated in the present research were unanimous in affirming that those projects of DT increased productivity and improved internal processes. On the other hand, a few respondents managed to identify a relationship between projects of digitalisation and increase of market share. Lastly, one

can also emphasise that more than 80 percent of the respondents indicated that reduction in costs was one of the impacts resulting from DT.

Table 10, in turn, shows the respondents' perceptions on the negative impacts, in which 20 segments were coded from the answers to the question #26 "What were the negative impacts of these projects?", and some answers to question #17 "What was the perception of the areas on the results of these projects?"

Table 10 – Answers on negative impacts

Negative Impacts
Loss of qualified personnel after final implementation of the project.
Difficulty in demonstrating the benefits with necessary explanations. Low degree of adoption of solutions by the end customers.
Some processes became more complicated for the dealership's personnel.
Low number of projects to scale the processes of digital transformation in the company.
Pain, on the part of the dealership's personnel, in the adaptation to the new digital solutions.
Complicated, with high impact on people (due to lack of preparation and qualification), affecting the return time as promised by digital solutions (up to two years of pay back beyond the planned one)
Initial losses, with stopped production and down-time resulting from the learning curve.
Frustration with projects which were interrupted, thus increasing the resistance of part of the organisation; lack of transversality (industrial focus) generating distrust in other areas.
Deception with the lack of topicalization of solutions. Frustration with financial return of the initiatives.
Digitalisation hampered (in the collaborators' view) the process.
Loss of qualified personnel for competitors and IT companies.
Conflicts with headquarter regarding financial aspects.
Disappointment with low adherence by end customers.
Increase in the complexity of the systems. Disorderly digital growth needing unification.
Relation with trade union and consequent negative image of digital transformation as a threat to employment.
Difficulty of the company in visualising the benefits more rapidly. Culture impact.
Increase in the complexity of the activities. Cultural shock. Budget of the IT area increased dramatically.

Source: elaborate by the author (2024).

Impacts regarding adaptation difficulties as a result of the increased complexity, absence of training or low engagement of customers and collaborators emerge objectively and manifest itself in the answer highlighted below:

"Today, people cannot work if digital tools are removed" (Respondent E-14)

In the Figure 14 it's possible to see the percentage distribution of the negative impacts answered by the BAI executives interviewed.

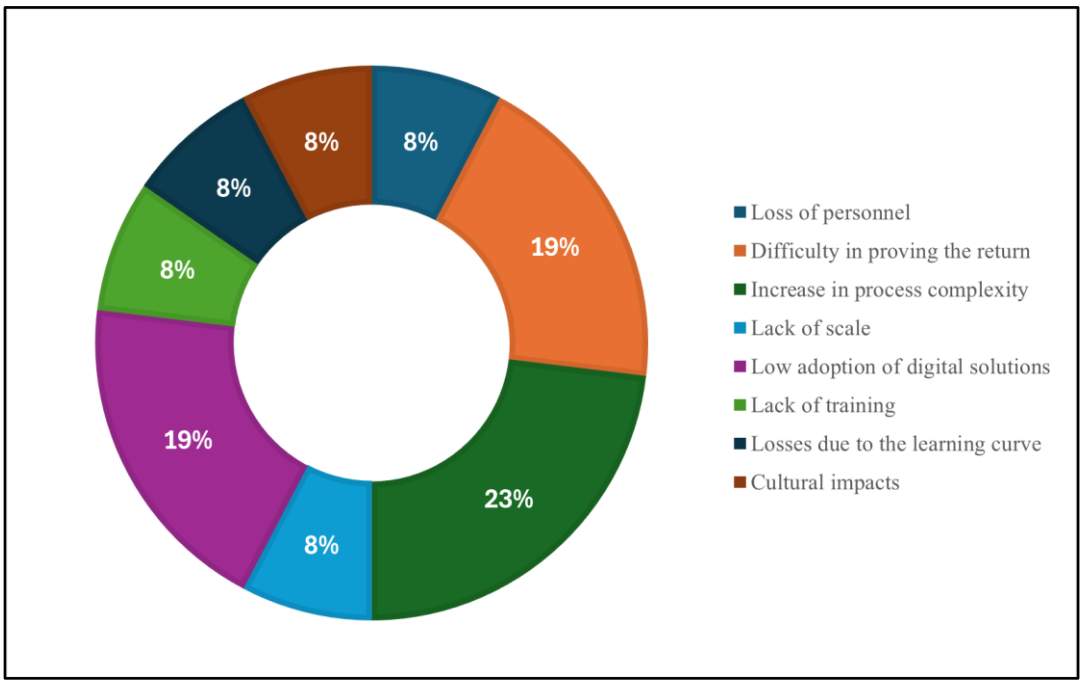

Figure 14 – Percentage distribution of negative impacts
Source: elaborate by the author (2024).

The adaptations the organizations had to make due to the implementation of projects of DT were captured by coding the operational impacts (internal), as shown in Table 11. There are 48 coded segments from answers to question #18 "What were the changes the areas had to make to adapt to the projects?", including some other answers to question #21 "Was there creation of new products, new process or reduction of overhead costs?", question #15 "How was the day-after following the implementation of the projects?", question #24 "Was there creation of spin-offs or start-ups from these projects?" and question #25 "Were there spillovers as result of these projects?"

The word “processes” is recurrently used when one analyses the respondents’ answers on the operational impacts resulting from the digitalization in the companies under study. Adjustments, uniformity and alignment of processes were some examples mentioned in the answers on this theme. There was the creation of new processes in most of the cases, with some respondents reporting reduction in overhead costs, whereas others citing changes in the profile of activities without the necessity to reduce personnel.

Table 11 – Answers on operational impacts (Internal)

Negative Impacts
Difficult in several dealerships, with overlapping of manual and digital tasks at different intensities.
Allocate field time to the project; adjustment of the auto-parts sales project to the tool.
Yes. As for new processes as well as reduction of overhead costs.
Necessity of changing operational processes and activities.
Scheduling of new intervention services and process for end customers.
No crisis, with operations proceeding normally and partially recognised by the area of business value solution.
Uniformity of processes in different countries (Latam); change (with “pain”) in the customer service process.
There was creation of some processes with digital scheduling and ordering and reduction of warehouse overhead cost.
Digital training (qualification); mind-set change; change in manual processes.
There was creation of services for Industry 4.0 solution implementation provided to ecosystem companies as well as new processes (continuously with digital twins).
Yes. A start-up of autonomous industrial vehicles.
Yes. Changes in the undergraduate engineering curriculum (two engineering graduate degrees)
Part of the collaborators resistant to changes and another part of them committed as they see value and future in the operations.
Adaptation to daily routines with support of continuous training. Greater dedication in terms of hours during the first moments as routines are normalised and the experience curve is increased with digital solutions.
Creation of new processes and analyses due to availability of data not available earlier.
Uniformity of industrial processes, including supply chain and digital mind-set model (paperless)
Reduction of personnel and creation of new industrial processes.
Yes. Training in information technology in poor districts and near the plant.

With obstacles. None of the initiatives of digital transformation began operating without resistance (mind-set model), demanding change of course in the areas. Such resistance was decreasing as the process improved continuously.
Learning of new technologies (gain of knowledge) and organisational preparation.
There was creation of new processes and reduction of overhead costs in the area, but which was relocated.
Yes. A company to digitally perform vehicle inventory in the dealerships and a start-up aimed at detecting defects in painting. Incubation of innovation projects through technology park gathering start-ups, science and technology institutes (STIs) and higher education institutes (HEIs)
Production systems with misaligned processes. Need of manual activities to fill the gap in the processes. Parts of the new systems under development. Adequacy of inventories. Update of legacy systems. Review of processes and procedures.
Yes, new processes.
Awareness of the competitive differential, but with poor disclosure. Increase in training, adjustment in processes and procedures, and demanding more from the sales team by means of goals.
There was creation of new products and processes, but no reduction in overhead costs.
The day was calm if the project was operating accordingly. However, if the project was not operating well, then it was a chaos.
Yes. *Fintech* for technological financing services.
A shift from euphoria to preoccupation due to the need to escalate a solution for new procedures, training of collaborators and dealerships, instruction of customers and cultural change aiming at a digital perception.
Yes. There was creation of new products and of a new process, and reduction in overhead costs.
Yes, there was the development of a new technology with a supplier aiming at reduction of CO2 in the atmosphere.
It's calm because of the level of involvement of the teams in the projects. "Panic" is restricted to the step of testing.
Yes, for new processes. There was no reduction in overhead costs, but there was a change in the profile of the activities of the personnel, which are less operative and more analytical.
Yes. Marketplace embedded. Start-up of car rental business.
Yes, projects of digital inclusion in needy communities near the plant.
It's never calm. Efforts for adaptation. Lack of focus. "War room". Need of changing processes and procedures. Need of having a shared, strategic, internalised view. Total transformation in the financial area. Cultural change
Yes. Digital community formation. Car connection platform.
Business and TI were together for "the good or for the bad". In the industrial area, it was a critical mission; in the commercial area, focused on quickness; in the back-office, aimed at structural efficiency.
Review of the processes and cultural adequacy.

Source: elaborated by the author (2024).

Changes in mind-set and culture were themes also greatly reported by the respondents. Resistance, including that to changes in processes and to new ones, lack of organisational preparation and need of having a shared strategic view were examples mentioned by the respondents. Absence of a culture suitable for the new reality was observed with the need for changing the mid-set model impacted by DT. These answers are echoed in the study by Koda & Pedron (2021), who reported the benefits from DT in the Brazilian automotive industry.

On the other hand, the creation of spin-offs, start-ups or even spillovers was less mentioned by the respondents. Some start-ups are aimed at financial area, car-as-a-service platforms and others providing industrial services. In the external context, there were only initiatives along with higher education institutes, in which the undergraduate engineering curriculum was changed, and others aimed at digital literacy in the communities near the industrial plants.

In the Figure 15 it's possible to see the percentage distribution of the operational impacts (internal) answered by the BAI executives interviewed.

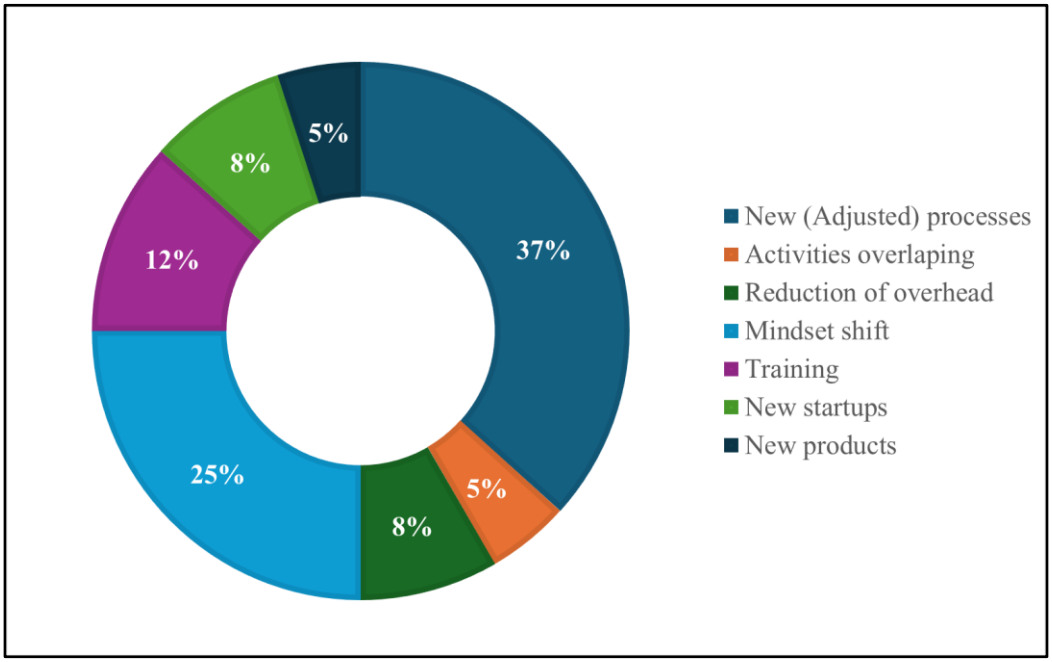

Figure 15 – Percentage distribution of operational impacts (internal).
Source: elaborate by the author (2024).

It is interesting to note and clarify an apparent ambiguity in the term "Process", which appears both as a Positive and Negative Impact, as well as Operational (Internal

Processes). In fact, it has been used in different contexts and meanings. Regarding the Positive Impacts, “Process” appears in the responses about “simplification of processes”, “improvement of processes”, and “reduction of downtimes”. On the other hand, “Process” also appears in the responses about Negative Impacts, when respondents refer to the “increased complexity of processes” arising from DT. Finally, in the Operational Impacts (Internal Processes), “Process” is mentioned by respondents when referring to “adapting to new processes”, “aligning processes across all Latin American units”, and the “need for change in existing processes”.

Another theme was the barriers found by the companies in their journey towards digitalisation. Table 12 lists 28 segments coded from answers to question #5 “What were the main difficulties in the approval of the projects of digital transformation?” and question #6 “What were the main difficulties in the implementation of these projects?”

Table 12 – Answers on barriers

Barriers
Need to demonstrate increase in the customer satisfaction and added value to the company. Focus on the customer as a facilitator in the approval process. Joint work with IT and financial areas.
Change in mind-set, training, analogical profile of the dealership personnel, end customer adaptation and resistance to changes. Difficulty in orchestrating different partners (dealerships, employees and consultants).
To make people believe in change, in novelty! To demonstrate financial return and that the project adds value to the company.
To convince the several stakeholders to adopt the new technologies. Impact on the network of dealerships. Shorter deadlines.
Resource competitiveness (financial, managerial and human) with global projects; need to “tie” the investment (NPV = 0) and emphasise the financial issue in the approval process (“speak in the idiom of CFO”). To explain the fulfilment of the business requirement.
To achieve application performance as promised by the project regarding the response time. High level of complaints due to problems in architecture and infra-structure. Attrite between dealerships and project team, which demands change management.
Priority number 1 is the financial profitability of the projects; mind-set of the decision makers depending on the difficulty in measuring indirect gains.
High cost of technology devices, decreasing the investments in infra-structure. To demonstrate gains from the adoption of Industry 4.0 technologies.
To demonstrate financial return (positive business case); to ensure global support; to have people available and qualified for the projects.
Curve of innovation adoption in the industrial area, generating distrust. Frustration with the absence of immediate return.

Financial availability (budget); high cost of technological infrastructure (imported equipment as defined by the headquarter) and not always there is financial return (positive business case).
Legacy infra-structure is poorly digitalised and outdated; company's mind-set sometimes with resistance; human resources are qualified and available.
Global approval of project roll-outs from both headquarter and local initiatives. Differentiation in the rules of global approval for strategic projects of digital transformation. Use of INOVAR-AUTO as differential for approval of local projects, although demanding more efforts and time for being approved than roll-outs.
Balance between risks involved and gains; dependence on the headquarter. Certain resistance by the organisation due to the newness of the issue, which was mitigated as the experience increased.
Technology far beyond the reality of the customers. To demonstrate negative business cases in order to be ahead of the competitors through an image of innovation. To demonstrate projects of technological update.
Technological difference in relation to the headquarter, evidencing a gap in comparison with the national technological reality. Outdated, non-defined processes. Integration with bank systems. Low adherence of end customers. Low disclosure. Cultural and time barriers.
Competitive demand for more human resources and investments. Inclusion of new technologies in the development of vehicles. Active voice of the interested areas.
Collection of data from vehicles and delays in the production entry of projects.
Tyro make people believe in the change, in novelty! To demonstrate financial return, that the project adds value to the company.
To convince the several stakeholders to adopt the new technologies. Impact on the network of dealerships. Shorter deadlines.
To associate the gains with improved image of product and company to the business case. To demonstrate financial return (NVP and RoI), mainly in post-go-live audits. To measure the value of customer data captured with the projects.
Digital adaptability on the part of the collaborators, dealerships and customers. High expectations of rapid gains of productivity in the process. Change in the processes. Trade union!
To demonstrate the level of relevance for business. Newness. Effort with integration. Change in mind-set, adoption of agile methodologies. Collaboration between the areas. Cultural change.
To present the correct solution design with the due alignment between the areas. Validation of business case numbers. Elaboration of the project's proposal.
Competitiveness between human resource projects. High volume of competing projects. Resource cannibalisation.
To make the company understand that projects of digital transformation are expensive, but they have return. To work on cultural changes at organisational and executive levels. "Business is not sustainable without digital transformation".
Cultural change and balance of expected results between short and long terms.

Source: elaborated by the author (2024).

To demonstrate the financial return of the projects of DT by using classic instruments of business case, such as net present value (NPV) and return on investment (RoI) (GITMAN, 2010) was the greatest barrier reported by the respondents in their answers. Such as pointed out by Albert, Rubio & Valero (2021, this barrier is enhanced by the second major difficulty mentioned by the same respondents, which is the change in the mind-set of decision-makers and other stakeholders of these initiatives. There is a perception that the greatest difficulties in approving these undertakings are due to the difficult demonstration of their value, that is, to associate these investments to an increased customer satisfaction and show the achievement of financial goals at the end of the projects. The combination of these both factors has worried the executive officers in charge of such initiatives, which is illustrated by the statement below:

"[…] speak in the idiom of CFO" (Respondent E-01)

Also, cultural barriers were pointed out as well as those related to difficulty of adaptability, including resistance by collaborators and customers, who create obstacles to the success of these undertakings. In addition, issues on outdated, expensive infra-structure in comparison to their headquarters and dependence on global support and sponsorship were also mentioned.

Based on the studies by Gurbaxani & Dunkle (2019) as well as by Chanias & Hess (2016), the present work sought to identify the influence of top management sponsorship and company as a whole, on the implementation of projects of digital transformation in the Brazilian automotive industry. This theme was object of question #13 "Did you have sponsorship from the executive board? Which one specifically? Was there involvement of collaborators and customer areas?", as well as of question #10 "Were these projects included in the budget plan or were extra-budget?" and question #29 "What is the executive board's evaluation on these projects?", generating 27 coded segments, as shown in Table 13.

Table 13 – Answers on sponsorship

Sponsorship
Yes, sponsorship was immediate as a result of the alignment with the strategic planning, with effective involvement of the collaborators of the areas.
Sponsors took part in the budget plan, but when there was a solid case business, the project could be required am extra-budget.

Yes, the executive board meets once a month to evaluate the projects of digital transformation.
All projects were formalised within the company's budget plan, but with own budget for initiatives of digital transformation in the industrial area.
Yes, from the CIO to the middle managers of the company.
Yes, including own budg*et al*location for initiatives of digital transformation. It's a non-return pathway.
Completely, including leadership of projects in charge of the business executives. Conviction about the journey.
All projects were formalised within the company's budget plan, except those categorised as R&D that were subsided by INOVAR-AUTO program.
Yes, mainly of the business areas, with IT playing a support role. "The project of digital transformation is the business area".
There was a complete buy-in of the business area.
The need of continuity with the initiative of digital transformation, counting on full support and approval from top management.
Yes, completely, by following up the roadmap and working on cases requiring priority.
High stakes on digital transformation. Increased investments in projects of digital transformation.
Positive. We're on the right way. Creation of a digital transformation board.
Having initiated the project earlier and with stronger sponsorship.
More encouragement for execution of projects due to their relevance.
"The penny dropped". The entire company is committed. Digitalisation is a basic necessity to survive".
Yes, with quarterly reports to the executive board on the in-progress projects and the results of the already-implemented ones.
Increasing. More in the IT board in the past, but today all the executive boards are involved and strongly engaged in sponsoring the initiatives.
The majority included in the budget plan, but sometimes extra-budget.
Unrestricted support. Desire of the executive board.
Yes, in all moments.
Extremely positive and satisfied with the results. We want more.

Source: elaborated by the author (2024).

The present research showed that sponsorship is a fundamental requirement for implementation of digitalisation projects in the company. At the same time,

leadership engagement, investments and demands increase as the results of these projects appear. An unequivocal sign is the presence of own budget for such initiatives, including release of extra-budget depending on the results promised in the business cases. Also, such a sponsorship is expressed in the interest of the top management, spreading across the organisation.

> "The penny dropped". The entire company is committed. Digitalisation is a basic necessity to survive". (Respondent E-11)

Table 14 lists the results of the respondents' perceptions on strategic alignment of the digitalization projects in the company, with 37 coded segments obtained from the answers to question #9 "How much are/were these projects aligned with the strategic objectives?", question #2 "Was the scope of these projects internal or involved the company's ecosystem?' and question #11 "Is there a roadmap, governance, project office or portfolio specific for projects of digital transformation?". There were also some answers to question #8 "Were the projects developed locally or through roll-outs?", question #17 "Was there perception of the areas about the results of these projects?" and question #29 "What is the executive board's evaluation on these projects?"

Table 14 – Answers on strategic alignment

Strategic Alignment
100-percent aligned with the strategic plan, including the assembler's commitment in becoming digital.
Much more digital initiatives will come. That the future is digital and focus should be on the consumer experience and data science as a tool.
100-percent aligned with the strategic plan, with focus on generating value to the company.
Company and dealerships .
100-percent aligned with the strategic plan, with focus on generating value to the company
100-percent aligned with the company's strategy.
Yes, with specific internal areas, including selling of services to ecosystem companies (supplier of parts and tools)
Completely aligned, both locally (Latam) and globally
It's a requirement, mainly for the industrial area to avoid obsolescence.
There's no possibility of approval of initiatives not aligned with the company's value stream.

The company's strategy is aimed at end-to-end digitalisation of the industrial processes.

Yes. There's a well-defined digital transformation roadmap with governance aligned with business area and critical success factors, from the approval process to final validation. Such initiatives follow agile methodologies with mixed teams (business and IT).

100-percent aligned with strategy, as digital transformation is part of the company's global strategy.

The company's ecosystem was included, mainly dealerships (basic work)

Completely aligned with the business objectives.

Yes. There exists and it's global, with a 5-year roadmap. Governance and resources shared globally.

Internal and with the network of dealerships in Brazil.

Fully alighted, since they are projects affecting the decision-making for sales by the customer.

Positive, recognising the digital transformation as a trademark differential.

Preoccupation with new entrants with higher level of digitalization in products and processes (Chinese)

100-percent aligned with the strategic plan, but also impacted the strategic objectives as the results were appearing.

Internal and with the network of dealerships in Brazil.

Local projects with roll-outs in Brazil to other plants overseas.

100-percent aligned because digital transformation is one of the strategic pillars of the company.

Innovation and improvement of customer services are elements of the strategic planning enabled by digitalisation.

Yes, responding directly to the top management, but migrating to the IT area as the projects reach maturity.

Since the change in the strategic plan two years ago, when digital focus was established, alignment has been total.

It has digital governance with specific roadmap, portfolio and program.

It's not possible to operate efficiently the business without being digitally.

Rejecting digitalisation is to hire a not-so-slow death.

100-percent aligned with the strategic planning.

Yes, it's specific for digital transformation with own portfolio and roadmap.

Current technology + shared strategy + engaged people. Technology is nothing without people.

The whole ecosystem.

100-percent aligned with the strategic planning. The origin of the projects of digital transformation resides on strategic plan. Initially lead by the IT area with evangelising people in the areas to promote cultural change. Today, this belongs to the business areas.

Source: elaborated by the author (2024).

As supported by Piccinini *et al*. (2015), Ribas & Teixeira (2021) and Uguroglu (2021) also state that strategic alignment is unanimity among the executives of the companies under study. In the majority of the cases, the projects of DT involved not only the company, but also dealerships and suppliers. In addition, these projects are part of a global strategy and in some cases they are locally originated in Brazil and are a base for roll-outs to other countries. The strategic plans of these companies are already digitalised or at least they aim at digitalisation. Definitely, they are no longer seen as a property of the IT area, thus being considered under the auspices of the digital imperative (FITZGERALD *et al*., 2013), as exemplified below:

> "Rejecting digitalisation is to hire a not-so-slow death" (Respondent E-10)

Finally, the last topic in this research was on critical success factors of the digitalization initiative. With 37 coded segments, this theme was raised from the interview protocol answers to question #7 "What were the critical success factors of these projects?", question #14 "What were the lessons learned with the already-implemented projects? Are they being considered in the new projects?" and question 28 "What might be differently done in the portfolio management of these projects?", as shown in Table 15 below:

Table 15 – Answers on Critical Success Factors

Strategic Alignment
Competency and mind-set model of the team involved in the initiatives. Selection of collaborators with more digital profiles (having the right team). Financial commitment (investment) on the part of dealerships. Cultural alignment. Focus on all organisational levels of the dealerships. Ambitious, shared objectives between assemblers and dealerships. 100-percent digital pilot (1 month) with 80 percent of the customers in the new process. Better planning with anticipation of problems and better selection of members for the project team by selecting those with more digital profiles. Leadership of the managers of initiatives and sponsorship from the executive board. Company's obsession with successful projects of digital transformation. Adopting no obsolete technology and seeking more autonomy. Incrementing financial results to the project.

Mind-set model based on a thought focused on a design thinking and strong culture.

The main lessons learned which are guiding the current projects of digital transformation were: well-structured work methodology, need of ensuring delivery with application performance (response time) in line with the users' expectations and prioritisation of urgencies consuming much attention and generating stress in the team.

Technical competency of the team; organizational culture opens to changes; business & IT partnership; sponsorship from executive board; global support.

Openness to opportunities emerging throughout the execution of the projects; need for pilots; preparation of people regarding competencies; "digital transformation is different from digitalisation"

Business leading the process since ideation.

"Digital transformation is a living process and has to add value to the company!"

More focus on generation and availability of information.

Commitment of the team; connection with suppliers of systems and products; strategy of implementation with adoption of pilots.

Business as protagonist; product owner has to have a knowledge profile (business and technical) and attitude (leadership) aligned with the company's culture from the beginning.

Technological devices are critical for initiatives of digital transformation due to its specificity, different technologies, employment, high cost and delivery time (lead time)

Need of including lead time in the schedules for these devices.

More focus on competitive advantage.

Support from the executive board; financial discipline.

Need for institutional partners (STIs & HEIs) to develop R&D projects (difficulty in developing this type of project internally due to difficult measurement of positive financial return). Need for more care following the days after the initial production. A more careful selection of partners. Monthly follow-up of the global projects.

Greater flexibility in financial goals and more support from the headquarter.

Qualified and focused technical team. Agile methodology.

Mor involvement of the business area. To resist to pressure for shorter implementation time. To have more quality time for go-live.

Prioritisation of projects for business necessity.

Synergy between areas, sponsorship from top management, financial availability.

Quicker implementation of projects and need to overcome the technological lag of the company.

Recognition of the relevance of the projects. Sponsorship from executive board.

Error is a key element in the learning process and prototype (MVP) is a learning instrument.

More investments in the approval phase.

Maiores investimentos já na fase de aprovação.
Time expectation for initial operation aligned with execution time
Control of anxiety of collaborators and top management. Understanding that this is a journey requiring process changes, mainly culturally. Sponsorship from top management. management in strategic projects, mainly those developed for the areas of product development and marketing. Involvement of more people in projects to add more value to the company. More attention to cultural transformation**.**
Digital transformation should be born within the areas using it; to work in squads; to adopt prototypes (MVP); well-elaborated questionnaires used as an initial filter.
Continuous improvement. Creation of adequate environments for digital transformation. Disconnection of the development teams from the daily tasks. Better workload planing. “Digital transformation goes beyond the hype” is structural.
Engagement of the areas. Need of adaptability. Willingness to change. People uncomfortable with the status quo. More engagement of people and greater flexibility.
Communication. Innovation internalised as value. Company direction willing to leave the comfort zone. Presence of IT area in the executive board.
That presentations/proposals do not deliver results. Planning is different from execution.
It’s necessary to have a unique vision. Value is what is delivered to the end customer, dealership or internally. The IT area must be an allied rather than a protagonist and speaks business idiom. Flexibility should be part of the company’s culture. Communication and management of change are pillars of digital transformation.

Source: elaborated by the author (2024).

CSF emerging from the respondents’ answers are mainly related to people: the need for a technical team with qualification, digital profile, digital mind-set, aligned with business objectives, more engaged, open to the new and sensitised to changes; as for financial aspects, the team is supposed to have digital investment, demonstrate financial objectives of the project and have budget support; as for cultural aspects, the team must have an aligned, agile, strong, digital and open culture open to changes, with an active leadership; as for strategy, the team must have focus on the long term and unique vision, besides sharing objectives and delivering value to the end customer; as for the processes, the team is supposed to have structured and agile methodologies, use of prototypes and adapt to changes in the processes; and as for technology, the team is supposed to use new market technologies aligned with the state-of-art, technological updates, etc. The results indicate a great variety of factors listed as critical for successful projects of digital transformation, which demands a view focused on its application in the industry.

This section presented the results of the impacts of DT initiatives on the Brazilian automotive industry. There were positive impacts regarding service flexibility, convenience for customers, more data control, increased productivity and cost reduction. On the other hand, negative impacts are related to the loss of qualified personnel and complexity of the systems. Lastly, sponsorship from the top management and strategic alignment were considered to be essential for the success of the projects.

Based on these results, the next chapter will present the analysis and discussion on the impacts and implications of the initiatives of DT on the Brazilian automotive industry.

6. DISCUSSION

Before we begin discussing the results of this research, it is important to highlight that, as mentioned in Chapter 2 – Theoretical Framework, the terms DT and Digitalisation are treated as similar in this study. This is because both terms are commonly used interchangeably by BAI, which is also supported by the literature. Furthermore, as this chapter demonstrates, BAI is undergoing a transformation in its operations and business models, thus characterising a true DT (OSMUNDSEN et al., 2018).

With the objective of identifying and qualifying the impacts of DT on the Brazilian automotive industry, the answers given by the executives participating of the present research were coded, analysed and grouped into three categories as follows: (i) positive impacts, (ii) negative impacts and (iii) operational impacts (internal).

In the category of positive impacts, as previously demonstrated in the chapter Results, the increase in productivity was unanimous in the respondents' perception as it was one of the positive impacts with the advent of projects of DT. However, such a statement does not find support in the relationship with vehicles produced *per* employee. As demonstrated in the graph shown in Figure 16, the productivity rate decreased from 22.4 vehicles by employee to 17.71 (ANFAVEA, 2024). Only for comparison the European rate in 2022 was 5.4 vehicles per employee which Spain with the highest rate – 15.5 vehicles per employee (ACEA, 2024).

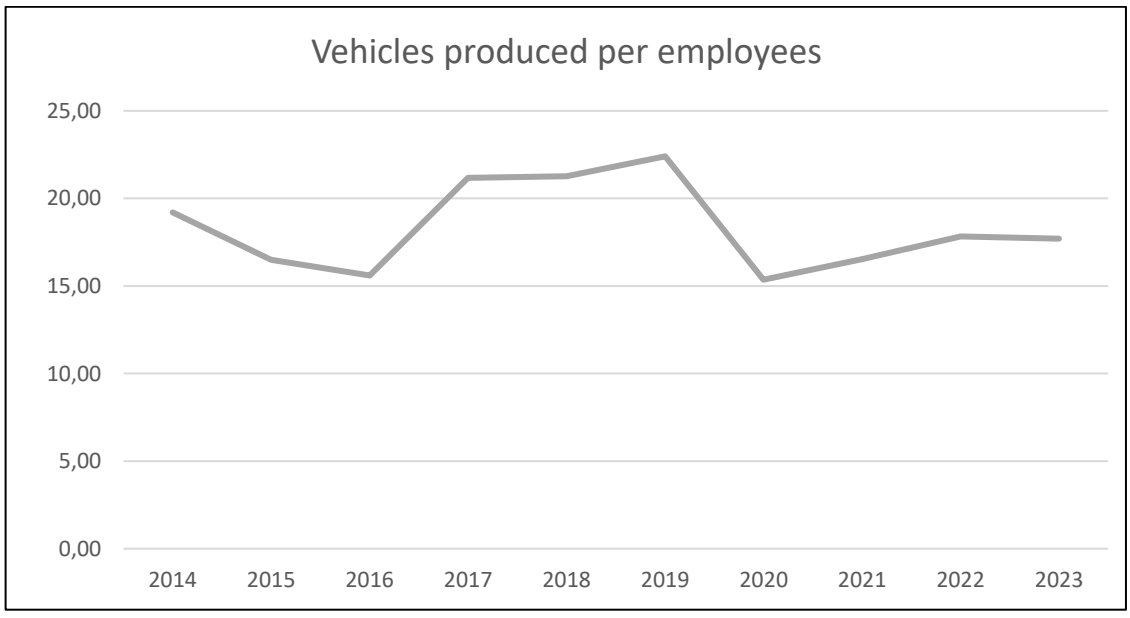

Figure 16. Relationship of vehicles produced per employees.
Source: Elaborated by the author from ANFAVEA – Dados Estatísticos para *Download*, 2024.

This ambiguity, which could be a confirmation of a new Solow paradox (1987), is challenged by Brynjolfsson *et al*. (2019), who suggest that all new technologies undergo a period of adaptation before causing impacts on the companies' productivity. This was exemplified in the present research, as the majority of DT projects are five years old or less since their implementation, and some are still in pilot phase. In addition, a recent study by Acemoglu (2024) states that productivity gains resulting from Artificial Intelligence, one of the enabling technologies of DT (STURGEON, 2021), are far from contributing significantly to increase productivity, even in low-complexity activities.

Remes *et al*. (2018), in turn, point to the lack of effectiveness in adopting new technologies due to the difficult cultural adaptation by companies and collaborators, an aspect highlighted in the respondents' answers on barriers. Lastly, Crafts (2002) argue that the traditional indicators of productivity in a sector may not capture adequately the impact of DT on the productivity, although they may be occurring in the case of the Brazilian automotive industry. In fact, this is illustrated in the statement of one of the respondents:

> *"Time gained in the execution of processes by increasing the productivity of the production line (vehicles per minute)" (Respondent E-06).*

Another aspect to be emphasised is that DT technologies may be contributing to the development of general-purpose technologies, which is characterised by permeating all aspects of the society (BRESNAHNAN; TRAJTENBERG, 1995), thus becoming a pre-requisite for participating in the competitive game rather than being a differential. In this way, the potential gains of productivity resulting from projects of DT would be diluted and difficulty to detect.

In addition to productivity, the respondents reported the following positive impacts as a result of DT, namely: (i) **improvement of internal processes**, such as increased operational efficiency, with higher speed and less people performing tasks or more tasks, more effective prevention of equipment breakdown and decrease in downtime, as well as more flexible automated lines; (ii) **improvement in the relationship with dealerships**, with simplification of orders for new vehicles, synchronisation of auto-parts stocks and fully digital sales, thus decreasing time and costs as well as increasing the number of leads; (iii) **increase in customer**

satisfaction, measured by net promoter score (NPS) based on greater availability and convenience in the scheduling of services, vehicle in the mechanical workshop for a shorter time and reduction of customer attrition; (iv) **data availability** (including vehicles owned by customers) for better decision-making; and (v) reduction of costs by decreasing overhead costs, including costs and time of vehicle production, and elimination of paper use, thus contributing to meeting the ESG agenda (environmental, social and governance).

On the other hand, the impacts characterised as negative the respondents cab be categorised as follows: (i) **complexity**, in which processes are more difficult to be performed by the collaborators, with initial losses and downtimes, loss of quality in the process according to the collaborators' view, and increase in the complexity of systems and activities; (ii) **Disappointment with the projects**, which is expressed in the low quality of the projects aimed to enhance DT in the company, including frustration with projects interrupted and low adaptation to the local reality (topicalization); (iii) **Unmet financial promises**, which are observed in the difficulties faced by the company in rapidly visualising the benefits, including conflicts with the headquarter due to financial goals, frustration with financial return from the projects and difficulty in demonstrating the benefits. These negative impacts can be seen in the study by Ruggero *et al*. (2020) on automotive assemblers and auto-parts suppliers in the Brazilian automotive industry; (iv) **Adherence,** which was low among customers and collaborators, as well as pain in the adaptation of the dealerships; and (v) **Loss of qualified personnel**, which is a negative impact corroborated by Llopis-Albert, Rubio & Valero (2020), who conducted a qualitative study on the Spanish automotive sector and identified an increasing need for qualified workforce, as well as by Muniz, Moschetto & Wintersberger (2023) who studied a joint venture for diesel engine production. Although the negative impacts are little exploited in the literature on DT in automotive industry, which is more focused on showing DT as a benefit generator, it is worth emphasising that the present research sought to assess the impacts of DT on the Brazilian automotive industry on an impartial basis by examining all the aspects involved.

DT had an impact on the operations of the companies participating in the present research, which can be demonstrated in the answers given by the executive officers of the companies operating in the Brazilian automotive sector. As for the (i) **adequacy of processes**, adjustments need for standardisation and even creation of

new processes was the constant spirit in all companies, which is echoed by several researchers on the theme of DT (PICCININI, 2015; HENRIETTE *et al.*, 2015; CHANIAS, HESS, 2016; ROCHA, QUANDT DESCHAMPS, 2021). Another adjustment even more difficult to make was (ii) **mind-set change** of the collaborators with consequent (iii) **cultural change**. There was resistance to changes resulting from the new technologies and new processes over the implementation of projects of DT in the Brazilian automotive industry, which made the companies seek adequacy to a new digital-based culture. This finding can be observed in the study by Rocha, Quandt and Deschamps (2021). Although not disclosed by the companies, (iv) **reduction of overhead costs** was observed because of DT, whereas re-allocation of personnel to other areas for less manual tasks occurred in other cases. It is important to highlight the (v) **externalities** to the projects of DT, materialised in the creation of spin-offs, start-ups and spillovers, which is also reported by Llopis-Albert, Rubio & Valero (2020). Lastly, there was a demand for (vi) **training** in new technologies, systems and processes.

Figure 17 summarises this discussion and shows a list of positive, negative and operational impacts resulting from DT. This list is in accordance with the objective of the present research, that is, to identify and qualify the impacts of DT on the BAI.

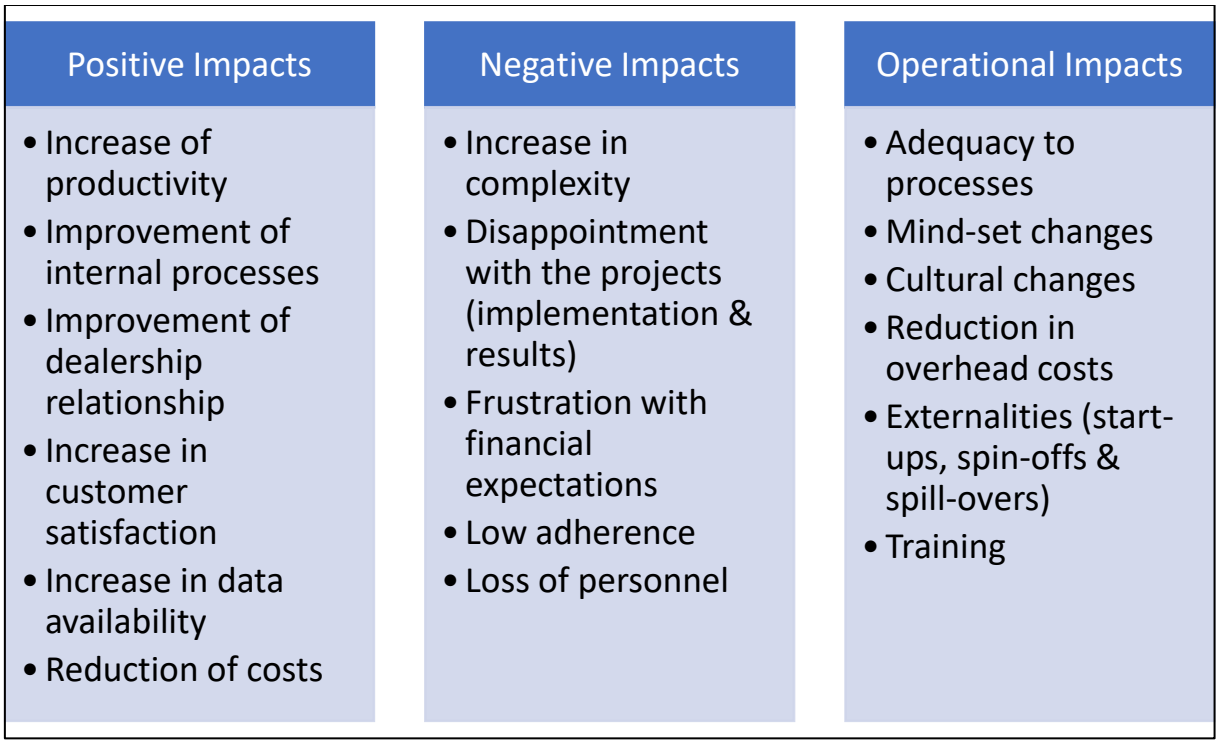

Figure 17 - List of categorised impacts.
Source: elaborated by the author, 2024.

Ruggero *et al*. (2020) highlighted low connectivity and collaboration between the companies belonging to the automotive value chain in the Brazilian automotive industry, including lack of training of the collaborators and insufficiency of financial resources for necessary investments, thus generating the same type of frustration with the financial expectations, as highlighted in the tables of negative impacts. Such frustration and the need of demonstration of financial returns, potentialized by the mind-set change of decision-makers and collaborators, were the main barriers mentioned by the executives participating in the present research. This necessity also appeared in the answers on cultural barriers, including lack of collaboration between the areas and difficulty of digital adaptability on the part of the collaborators, dealerships and customers.

Martins (2022), in turn, reported on the lack of technological infra-structure as a barrier to implementation of these projects. This finding was also observed in the answers on the high level of complaints due to **deficiencies in infra-structure**, which is poorly digitalized, outdated and full of gaps compared to the headquarters, thus compromising the performance of the applications implemented. **Insufficiency of resources** was another issue related to the high cost of technological infra-structure.

The barriers related to people are also elements highlighted in terms of loss of qualified personnel, which appears in several answers on cannibalisation of the little resources. Moreover, having people available and trained is a finding corroborated by Muniz, Moschetto & Wintersberger (2023), who emphasise the lack of specialised workforce, whereas Pereira *et al*. (2020) identified the lack of qualified personnel, absence of digital competencies and high cost in the acquisition of enabling technology as previously mentioned.

The present research confirms that the automotive industry, traditionally characterised by linear and robust processes, is undergoing a profound revolution driven by digital transformation. This revolution is not limited to isolated technologies but permeates the entire value chain: R&D, production, and commercialisation, reshaping strategies, structures, and the very culture of automotive companies.

In R&D, digitalisation enables the creation of more precise and complex virtual models, accelerating the development of new products and reducing costs. Computational simulation, artificial intelligence, and big data facilitate project optimisation, early fault detection, and the customisation of vehicles according to

consumer preferences. Connectivity between vehicles and manufacturers opens new possibilities for real-time data collection, enabling product performance analysis and the development of remote software updates.

Production, in turn, is transformed by Industry 4.0, integrating technologies such as the Internet of Things (IoT), robotics, digital twins, and data analytics to create smart factories. Flexible and personalised production becomes feasible, with assembly lines capable of quickly adapting to different models and production volumes. Predictive maintenance, based on sensor data analysis, reduces machine downtime and increases operational efficiency. The supply chain also benefits from digitalisation, with optimised routes, intelligent inventory management, and real-time collaboration with suppliers.

Finally, commercialisation is being radically transformed by digitalisation. The customer experience is increasingly personalised through digital platforms for configuring and purchasing vehicles. Direct-to-consumer sales and subscription models are gaining momentum, challenging traditional distribution channels. Data analytics allows the identification of consumer needs and preferences, enabling the creation of more effective marketing campaigns and the provision of personalised services. Interrelations between different areas of the chain are intensified, with data generated in one area being used to optimise processes in another. All of this is taking place not only in the headquarters of automotive companies but throughout the industry.

It is important to highlight that no evidence was found suggesting that digital transformation is destroying the existing value chain. Instead, there is evidence that it elevates it to a new level of efficiency and competitiveness. Organisational culture must also adapt, valuing innovation, collaboration, and agility. Companies that manage to integrate digital technologies into their processes strategically and efficiently will be better positioned to face challenges and seize opportunities in the ever-evolving automotive market.

In summary, digital transformation is redefining the automotive industry, creating new possibilities and requiring companies to adapt swiftly to an increasingly dynamic and competitive environment. The value chain, once linear and fragmented, becomes more integrated and agile, with digitalisation playing a fundamental role in all its processes.

After completing this step, it is possible to progress for what the CSF are in the management of DT projects in the Brazilian automotive industry. Analyses of the results found from the answers made in the interview revealed the constant presence of two factors among all the participants of all companies under study, namely, (i) sponsorship from top management and (ii) strategic alignment.

Sponsorship from the top management, as well as in all types of projects (BRYDE, 2008), is crucial for the success of projects of DT, especially due to the significant financial investment and impacts on the organisational processes resulting from such projects. This support is indispensable as the top management has the resources and authority necessary to overcome technological and managerial challenges inherent to these projects. An effective sponsorship facilitates the overcoming of barriers and channels the resources for implementation of these initiatives (GURBAXANI; DUNKLE, 2019) (CHANIAS; HESS, 2016) (SIMONAZZI; SANGINÉS; RUSSO, 2020).

In general, the support of top management is conceived because these projects are usually of strategic character and, consequently, determinant for the company's future (BARTHEL; HESS, 2019). The execution of these projects determines the route for achieving the objectives and goals defined in the strategic plan, which contributes to a long-term vision. Therefore, a strategic alignment of the DT initiatives facilitates proper prioritisation, allocation of critical resources and continuous attention from the top management, thus integrating and maintaining the importance of support (RIBAS, TEIXEIRA, 2021; UGUROGLU, 2021; SHINORARA *et al*., 2017).

Therefore, it is reasonable to consider these both elements as indispensable pre-requisites for projects of DT in the Brazilian automotive industry, thus forming a base for model of CSF, which could be adopted by the automotive industry as the implementation of these initiatives would be very difficult without them (BATHIA; KUMAR, 2020).

Analysis of the data collected from the Brazilian automotive companies under study showed associations between the CSF indicated, which allowed common patterns to be identified. This understanding facilitated the construction of a unified model of critical factors for a successful implementation of DT projects potentially adaptable by these companies. An analytic process also enabled grouping inter-related factors into unique categories, thus simplifying their understanding and application.

This synthesis not only minimises interpretative efforts, but also provides a base for a more efficient, lean model of CSF, which can be used as reference for future initiatives of digitalisation in the Brazilian automotive companies. The similarities found in the studies by Rogers (2016), Bathia & Kumar (2020) and Holotiuk & Beimborn (2017) evidenced the convergence of factors as “data” and “ecosystem”, reinforcing the importance of collaboration and data management as essential lessons for a successful DT. The results found, in turn, reflect a consensus in the perceptions on the challenges faced during the implementation of DT projects, as exemplified by the experience of difficulties shared in the orchestration of different partners and collaborators.

Analysis of these results, in association with conclusions from related studies and bibliographic survey, indicate the possibility of developing a model of CSF with nine factors as follows: culture, leadership, people, vision, ecosystem, data, infra-structure, operations and flexibility. For instance, *vision* emerges as an important factor (HOLOTIUK; BEIMBORN, 2017), in addition to strategic alignment and strategic view for projects of DT (GURBAXANI, DUNKLE, 2019; RIBAS, TEIXEIRA, 2021; KODA, PEDRON, 2021). These concepts also appeared in the respondents’ answerers, as shown by the emphasis on long-term actions

Other examples are the concepts of *data* and *data value*, synthesised into a unique critical factor (i.e. data), which emphasises the need of efficient use of data for DT (ROGER, 2016; BATHIA, KUMAR, 2020). Similarly, *ecosystem* and *partners* were integrated as another critical factor (i.e. ecosystem) due to its relevance in combination with the development of collaborative networks of innovation (DREMEL *et al*., 2017; MAZURCHENKO, ZELENKA, 2021; HOLOTIUK, BEIMBORN, 2017).

Table 16 shows a summary of the correlations extracted from the five companies regarding CSF with elements addressed by the above-mentioned authors. One can observe that the respondents’ answers are aligned with the nine CSF common to the projects of DT in the Brazilian automotive industry.

Table 16 - Summary of the respondents’ answers on CSF cited in prior studies

Culture	Cultural alignment. More attention to cultural transformation. Company’s mind-set, sometimes with resistance. Leader must have a profile of knowledge (business and technical) and attitudes (leadership) aligned to the company’s culture from the beginning. Change in mind-set by adopting a digital thought. Strong culture. Organisational culture opened to changes. Synergy between the areas. Understanding that it is a journey requiring

	changes in processes, but mainly culturally. Creation of environments adequate for digital transformation. Communication and change management are pillars of digital transformation.
Leadership	Better planning with anticipation of problems and better selection of team members of the project by identifying more digital profiles. Involvement of more people in projects with more added value. Attrition between dealerships and project team demanding change management. Prioritisation of urgencies requiring more attention and generating stress in the team. Openness to opportunities emerging over the execution of projects. Leader must have profile of knowledge (business and technical) and attitude (leadership) aligned to the company's culture from the beginning. Leadership of managers of initiatives and sponsorship from top management. Sponsorship from executive board. Control of anxiety among collaborates and top management. Alignment of expectations. Executive board wiling to leave the zone of comfort.
People	Training, resistance of collaborators to changes. Evaluation of time regarding competencies and mind-set of the team involved in the initiatives. Selection of collaborators with more digital profiles (having the right team). To prepare people in terms of competency. Qualified human resources available. Technical competency of the team. Commitment of the team. Disconnection of the development teams from daily routines. Engagement of the areas. Need of adaptability. Willingness to change. People uncomfortable with status quo. More engagement of people.
Vision	To increase the long-term focus to the detriment of short-term actions. High expectation of rapid gains of productivity in the process. To demonstrate gains resulting from the adoption of digital transformation. Need of pilots. Curve of innovation adoption generating distrust. Frustration with absence of immediate return. Business as protagonist. Company's obsession with the success of digital transformation projects. Global Support. Strategy of implementation with adoption of pilots. Innovation internalised as value. It is necessary to have a unique vision. Value is what is delivered to the end customer, dealerships or internally. Area of IT should be allied, but not as a protagonist and should speak in the business idiom.
Data	Collection of data and delay in the production entry of projects.
Infra-structure	High level of complaints due to problems of architecture and infra-structure. No adoption of outdated technologies. Search for more autonomy. To achieve performance in the application promised by the project in terms of response time. Need of ensuring delivery of application according to the users' expectations (response time). High cost of technological devices, resulting in decreased investments in infra-structure. Legacy infra-structure with poorly digitalised and outdated equipment. Technological devices are critical in initiatives of digital transformation due to its specificities, different technologies and uses, high cost and delivery time (lead time). Connection with suppliers of systems and products.
Operations	To increase financial results of the project. Change in processes. Need of including lead-time schedules. Well-structured work methodology. Planning of user experience aiming at future usage of the application. Partnership, business and IT. Financial discipline. Financial availability. Planning is different from execution. Better planning of workload of employees.
Flexibility	Quicker implementation of projects. To overcome the technological lag of the company. To adopt prototypes (MVP). Greater flexibility. Flexibility should be part of the company's culture. To work in squads.
Ecosystem	Difficulty in orchestrating different partners (dealerships, employees and consultants). Adaptability to digitalisation on the part of collaborators, dealerships and customers. Adaptation to customers. Focus on all organisational levels of the dealerships. Ambitious objectives to be shared between assemblers and dealerships.

Source: elaborated by the author, 2024.

The present thesis on what CSF are in the implementation of projects of DT in the Brazilian automotive industry was based on the results found and discussed in this chapter, as well as on the correlations between the factors identified in the Theoretical References and Related Studies sections. The convergence of the respondents' answers and the authors' conclusions support the formulation of a set of CSF covering nine critical factors (See Table 16). This summary also shows that sponsorship from top management and strategic alignment are essential pre-requisites for carrying out and managing such projects due to their consistent presence in all companies under research.

Nevertheless, the model supposed to be reference for the industry needs to be accessible and easy for implementation. A model with nine factors can be perceived as complex. Therefore, to make it simple, a conceptual model condensing these CSF was proposed rather than eliminating them. Thus, the model proposed for CSF in DT projects in BAI is a synthesis of several influential models, each contributing to its comprehensive nature as mentioned in the Theoretical Reference chapter as well as the data collected from the interviews with the BAI executives.

At its core, the model builds upon Matt *et. al*. (2015) 4-dimensional framework, which identifies strategy, organization, technology, and financial aspects as key drivers of DT and incorporates Leavitt's diamond model (GRANT; MERGEN, 1996), which emphasizes the interconnectedness of people, technology, structure, and task. These foundational models provide a broad perspective on the multifaceted nature of DT initiatives highlighting the importance of align these elements to achieve successful on these projects.

Moreover, the model draw inspiration from the PPT model (PRODAN; PRODAN; PURCAREA, 2015), which simplifies for three dimensions: people, process, and technology emphasizing the importance of a clear organizational culture, a robust technological infrastructure, and strong process design. By combining the strengths of these foundational models, this CSF model offers a comprehensive framework for understanding the critical success factors in DT projects. It provides a holistic view of the complex interplay between strategic, structure, and human factors, emphasizing the importance of aligning these elements to achieve sustainable DT initiatives.

Based on the PPT model (PRODAN; PRODAN; PURCAREA, 2015) presents in studies on DT (VERINA, TITKO, 2019; NAGLI, 2019), including in the automotive

industry (FELSER; WYNN, 2020), one proposes an alternative model simplifying the visualisation and facilitating the understanding, which can lead to an effective integration of the nine critical factors identified.

In this way, **strategy** gathers a shared vision (digital) of the future, a mind-set model, planning and co-ordination of actions for meeting the long-term objectives, always taking in to account the company's operational environment and generation of added value. Fusion of the factors *culture, leadership, qualification, change management* and *people* into a unique category called **culture** (organisational) is also suggested, reflecting the idea that culture is expressed through people and, notably, in the leadership. Moreover, the model still gathers the factors i*nfra-structure, data, operations*, and *material and financial resources* into a category called **structure**, which is based on the understanding that these elements are intrinsically related to organisational configuration and its efficient operationality.

Therefore, the present qualitative research on the Brazilian automotive industry allows deriving a model of CSF for projects of DT, which is structured around three major pillars, namely: strategy, structure and culture (organisational). This model is reinforced by strategic alignment and sponsorship from top management, as illustrated in Figure 18 below.

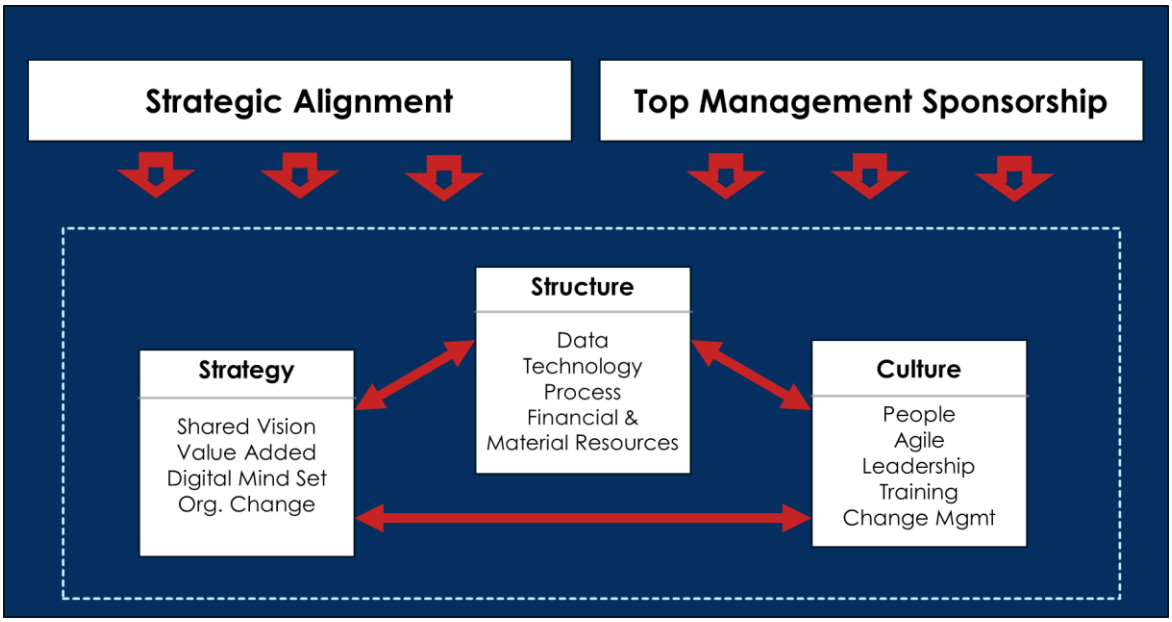

Figure 18. Model of Critical Success Factors in the implementation of Digital Transformation projects in the Brazilian Automotive Industry.
Source: elaborated by the author, 2024.

With the purpose of detailing and modelling the components and their respective interactions, a component diagram in UML – Unified Modeling Language of the proposed model was constructed as shown in Figure 19. This allows the identification of the main components, the relationships and interdependencies between them, as well as the organisation of the structure.

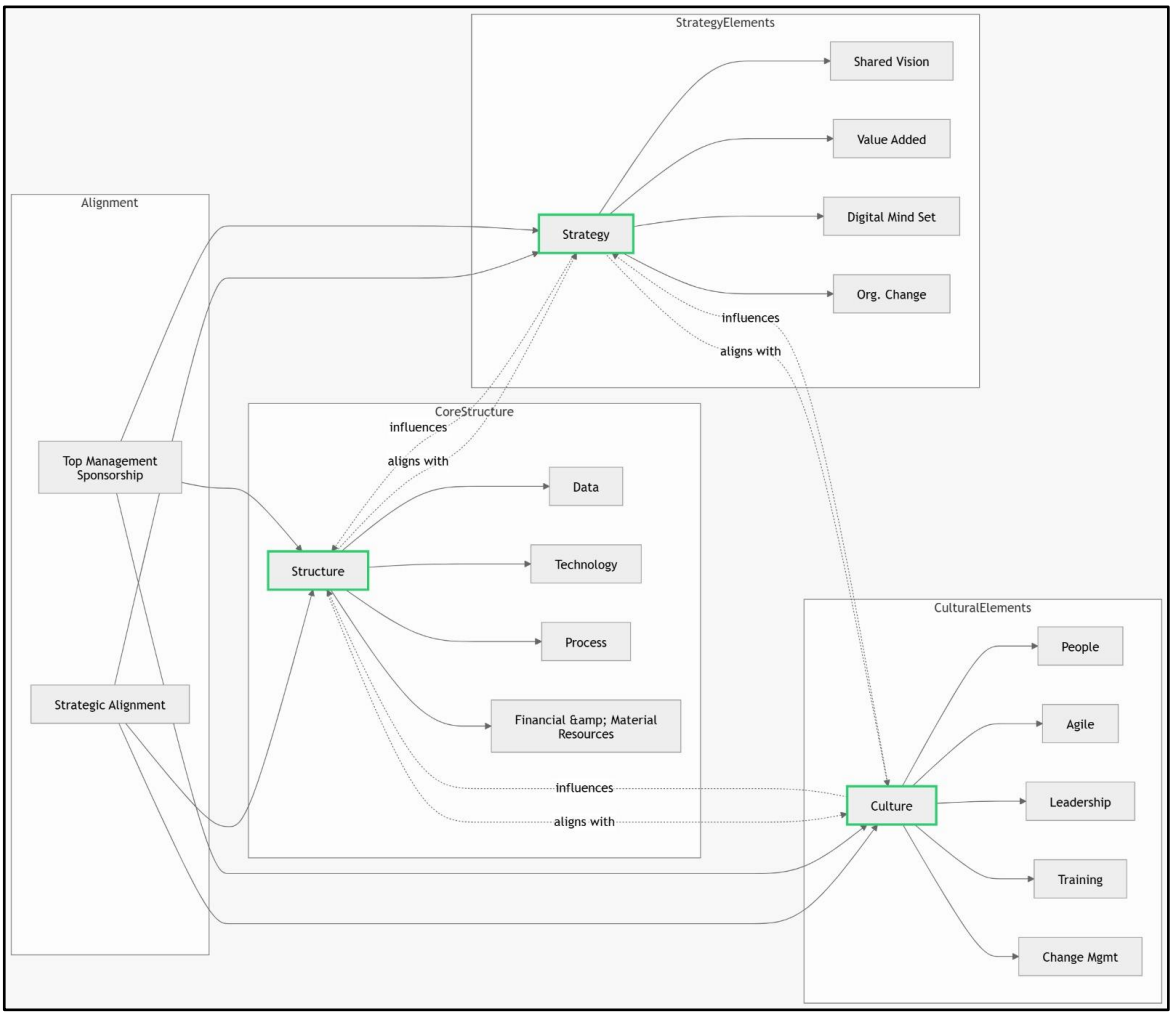

Figure 19. UML components diagram of Critical Success Factors Model in the implementation of Digital Transformation projects in the Brazilian Automotive Industry.
Source: elaborated by the author, 2024.

This Figure presents the CSF model to be adopted in DT projects in the BAI. It drives that **Strategic Alignment** and **Top Management Sponsorship** are prerequisites for the success of these projects. From then on, the elements of **Strategy, Structure and Culture** must share the same attention and focus from the managers and team. In this way, aspects such as Shared Vision, Added Value, Digital Mind Set and Organizational Change coexist and have the same priority as Data,

Technology, Processes and Financial & Material Resources, as well as People, Agility, Leadership, Training and Change Management.

The proposal of an alternative simplified model integrating strategy, structure and culture (organisational) incorporates the essence of theoretical debates on these three factors, which was originally made by Chandler (1962) in a proposition on strategy and structure. This was followed by Schein (2010), who made a reflection on the prevalence of culture over other factors, and by Neves & Meira (2020), who depicted the contemporary thoughts on the dynamics between culture and strategies (Neves & Meira, 2020). This concise approach not only facilitates the adoption of DT projects by the companies operating in the Brazilian automotive sector, but also can enable a more efficient implementation of these initiatives.

In the practice, the proposed model can serve as a guide for the companies, not as a road map but as a North Star Strategy (Rogers, 2023) highlighting factors such as strategy, structure and culture, which provides an approach aired at organizational transformation (and not only digitally). This practical aspect of model is in accordance with the needs of those companies seeking more viable and accessible strategies for digitalization by following the principles of the PPT model proposed by Prodan, Prodan & Purcarea (2015) as well as its derivations addressed by other authors (VERINA, TITKO, 2019; NAGLI, 2019; FELSER, WYNN, 2020).

A comparison with the banking and retail sectors, both mentioned in the Introduction of this document, brings some interesting reflections about the three central elements of the DT implementation process model proposed in this thesis. Digital transformation in the banking sector has driven profound changes in the organisational culture, strategy, and structure of financial institutions. According to Barroso and Laborda (2022), Fintechs have pressured traditional banks to adopt a more agile, customer-centric culture, with an increasing focus on innovation. This cultural shift reflects an adaptation to new technological demands, where companies seek to incorporate technologies such as artificial intelligence and blockchain, as well as create more flexible and efficient business models. The strategy of banks has shifted to focus not only on traditional financial services but also on the creation of digital solutions that meet the emerging needs of the market. The organisational structure of these institutions has also evolved, with more integrated IT teams working alongside operations and customer service departments, resulting in greater collaboration between areas and a quicker adaptation to technological innovations.

On the other hand, in the retail sector, digital transformation has also significantly altered these three elements (Sabbatino, 2021). The organisational culture in retail now emphasises personalisation and customer experience, requiring companies to focus on integrating digital and physical channels to provide a seamless omnichannel experience. Data-driven strategies, such as the use of big data and predictive analytics, have become essential for making quick and informed decisions, adapting more effectively to consumer expectations. Companies in this sector have adapted by promoting collaboration across different areas, such as marketing, technology, and operations. This enables a more agile response to changes in consumer behaviour and the market, consolidating digitalisation as a central element of the sector's competitiveness.

Finally, as demonstrated in this work, the introduction of advanced technologies such as the Internet of Things and connected cars requires a significant cultural shift, with companies in the BAI adopting more innovative and collaborative approaches. The strategy of automotive companies now includes technological innovation as a fundamental pillar, focusing not only on improving production and internal processes but also on meeting new consumer demands for embedded technological solutions in the final product. This transformation directly impacts the structure of companies, which need to be more agile and multidisciplinary, incorporating new roles and skills in areas such as IT, engineering, and design. The process of adapting to new technologies demands effective change management, clear communication, and strategic alignment across different areas of the company, ensuring that all organisational levels understand the importance of digitalisation and work towards achieving the goals of transformation.

As evidenced in the answers from the question “Were these projects developed locally or rolled out?”, most of the DT projects developed by the companies subject to this research were local, with some even being rolled out to other plants in Latin America and even one to the USA. The majority of these were in the commercial area, respecting local characteristics. Projects in the industrial and R&D areas showed a predominant trend of being rollouts from the headquarters. In all cases, due to the strategic relevance of these initiatives, all had some level of approval or monitoring from the headquarters.

Although mentioned by only one of the respondents, government programmes offering tax incentives for R&D, such as INOVARAUTO and Rota 2030, have

contributed to accelerating DT in the BAI. By providing tax benefits to automotive companies investing in innovation, these programmes have created a conducive environment for the development of new technologies and digital solutions. Access to "extra-budget" financial resources enabled automotive companies to invest in R&D, driving the creation of more connected, autonomous, and efficient vehicles.

In addition to encouraging investment in R&D, these programmes have also fostered collaboration among companies, universities, and research centres. This synergy allowed for the creation of innovation ecosystems where automotive companies could access the knowledge and expertise of research institutions, expediting the development of new technologies that enable DT.

INOVARAUTO, initially focusing on flex-fuel vehicles, provided an early impetus for the BAI to invest in new technologies and processes. By promoting the production of vehicles with more efficient engines, it stimulated the development of more sophisticated embedded systems and the integration of electronic components. While its primary focus was not digitalisation per se, the programme created an environment conducive to the adoption of digital technologies across various areas, such as production management, quality control, and new product development.

On the other hand, Rota 2030, with its broader scope, has proven to be a catalyst for DT in the BAI by establishing ambitious targets for the production of electric and hybrid vehicles. This programme has driven the development of high-performance batteries, electric propulsion systems, and charging infrastructure. Additionally, Rota 2030 has encouraged vehicle connectivity, the adoption of advanced driver assistance systems (ADAS), and the implementation of data platforms for fleet management.

In summary, government tax incentive programmes have supported the DT of the BAI by providing a favourable environment for innovation and collaboration, driving the development of new technologies, the creation of new products and services, and enhancing the competitiveness of Brazilian companies in the automotive industry.

Finally, a comparison was conducted between the results of related works published on the BAI and the results found in this thesis (Table 17), as well as a comparison between the results of related works in the global automotive industry and the results of this thesis, presented in Table 18.

Table 17 – Comparison between results from related works on the BAI and results from this Thesis

Authors	Publication year	Results	Comparison w/h Thesis Results
VALDIVIA, C.A.; MAMÉDIO, D.; LOURES, E.; TORTATO, U.	2024	The results demonstrated that the search for greater efficiency, adoption of new technologies, market differentiation, innovation and sustainability boost the DT.	Several were the adaptations the companies of BAI made. New (or adapting) processes, overhead reduction, changes in culture & mind-set, new startups and spin offs were mentioned in this research.
MUNIZ JR., J.; MOSCHETTO, G.P.; WINTERSBERGER, D.	2023	The results indicated that human factor would be a nuclear element for implementation of DT technologies. On the other hand, they identified that managers are preoccupied with the lack of qualified professionals to deal with this new environment.	Cultural is one of the central elements of the CSF Model proposed in this thesis, besides that the “human factor” was mentioned in change of mind set, cultural adaptation, training etc.
SANTOS, N.; RUGGERO, S.M.; SILVA, M.	2022	The results demonstrated an organisational culture aimed to create business models besides operational efficiency increment.	This work was not able to indicate that new business models are rising from the respondents’ answers. Some new startups were created but most of the results were related to the increment of efficiency.
MARTINS, A.H.P.	2022	One of the obstacles in adopting the blockchain technology, according to the respondents’ perception, was the lack of technological infra-structure in both company and Brazil.	The companies of the BAI are adopting several digital technologies, and the results have indicated there is no problem related to infrastructure. However, one of the answers complain against the device costs in Brasil.
BEIER *et al.*	2022	This work indicates that a better stock management, supply chain and industrial production originating from DT has contributed to de-materialisation and consequently to a greater corporate environmental sustainability.	Besides this study not cover aspects of sustainability but the better stock and industrial management was pointed out which might indicate a better condition for sustainability.
KODA, A.; PEDRON, C.D.	2021	The authors could determine that their guidelines were competitiveness, whereas the most expected benefits were productive efficacy and generation of value to the end customer, in addition to those related to innovation, such as business model.	In the current study the main guideline was efficiency gains. Besides that there were several benefits regards cost reduction, decision data quality increment, lead time reduction etc.

ROCHA, C.; QUANDT, C.; DESCHAMPS, F.	2021	The study realized benefits from open innovation practices, such as gaining a competitive edge. However, the success of digital transformation hinges not only on technological advancements but also on the active engagement and skill development of employees.	In the current work we could not establish a direct correlation between gain of market share and DT. Although, it was able to indicate engagement and skills development as CSF.
SOARES, M.C.; FERREIRA, C.V.	2021	it was concluded that the most used technologies used by them were IoT, Cloud, Adaptive Robotics and VR/AR, with a future trend of increased use of cyber-security and AI.	In the BAI the DT initiatives involved technologies such as: IoT, IA, Big Data, Cloud and Robotics as well.
SANTOS, N.; RUGGERO, S.M.; SACOMANO, J.B.; ESTENDER, A.C.; SILVA, M.	2021	Their results showed that there is a gap in the adoption of enabling technologies of DT.	The results of this work shown that there is large use of digital technologies by the companies of the BAI.
	2020	The main bottlenecks in the adoption of digital technologies are related to low level of connectivity between the players, low financial resources available for this type of investment and low level of knowledge on this type of technology on the part of the collaborators. Also the RoI of the projects has been over-estimated and financial return expectations have been frustrated.	This work could demonstrate the some of the Negative Impacts and Barriers are related to the financial frustrations (even ROI) and some of the Barriers are related to low level of collaborators knowledge. Regards the connectivity itself this was not part of the study.
	2020	The gains obtained from DT, would be directly related to the level of maturity of each company in the process of adopting DT.	Despite of this work is not related to analyze the level of maturity, all of companies interviewed have demonstrated high level of DT adoption and consequently the gains are showing up.
PEREIRA, D.I.; LIMA, E.P.; MACHADO, C.G.; COSTA, S.G.	2020	The results found several barriers against the adoption of DT on the part of the automotive companies, such as: lack of qualified personnel, absence of digital competencies and high-cost acquisition of enabling technologies.	The main barriers pointed out by the respondents in this research were: demonstrate the financial return, change in the mind-set of decision-makers and other stakeholders, cultural barriers related to difficulty of adaptability, including resistance by collaborators and customers.

SHINOHARA, A.C.; SILVA, E.H.; DESCHAMPS, E.P; COSTA, S.E.	2017	The result was the construction of a list of CSF, based on the Risk Breakdown Structure proposed by PMI, which were grouped into four categories: technical, organisational, project management and external.	The model proposed in this work is based in three elements: culture, structure and strategy.
ZILBER, S.N.; VASCONCELOS, E.; STELMACH, J.	2003	The authors point out a contradiction due to the fact that the large traditional companies, as Ford, have the assets necessary to be successful in e-business, but they have been failing because of lack of digital organisational structures	This research emphasizes the triple approach between Culture, Structure & Strategy as a path for those companies want to be successful in the DT journey.

Source: elaborated by the author, 2024.

Below, in table 18, it is shown the comparison between the results of related works in the global automotive industry and the results of this thesis.

Table 18 – Comparison between results from related works on the BAI and results from this Thesis

Authors	Publication year	Results	Comparison w/h Thesis Results
LLOPIS-ALBERT, C; RUBIO, F.; VALERO F.;	2021	The authors concluded that there is a significant change boosted by DT. New business models are emerging. This requires adaptation on the part of incumbent automotive assemblers, which should explore new markets to remain competitive. In addition, the growth of connected cars, which generate real-time data, opens doors for innovative services and a more personalised experience for the customer. The production itself is undergoing a revolution with Industry 4.0 technologies.	The current work indicates that the BAI is undergoing a real revolution due to the DT impacts. It has changing all the three main areas of the automotive value chain: R&D, Production & Commercial. A lot of data is helping the decision makers, new process & services are emerging as well as new startups.
HANET, A.; PICCININI, E.; GREGORY, R.W.;	2015	The study highlights that digital trends are creating a “digital layer” on the existing physical infra-structure rather than replacing physical products (i.e. automobiles). This layer includes resources of connected vehicles, on-line services and data-based decision-making. Notwithstanding, digital	This research is about Bai an incumbent company with a robust physical layer. Like in the related work this research found digital tools been used to increase the customer experience such as on line and mobile sales & service. IN

HILDEBRANDT, B.; KOLBE, L.M.		technologies reinforce the focus on the client's journey. Automotive assemblers are using digital tools to customise the experience of purchasing vehicles and to provide remote diagnosis, resources of connected vehicles and on-line support.	all of the companies interviewed data-based decision-making was one of the main objectives of DT.
CHANIAS, S.; HESS, T.	2016	Their study suggested that strategies of DT are not boosted by the top management only. There is a bottom-up process in which several sub-units within the organisation exploit and implement digital technologies on an independent basis, showing that these efforts influence the company's overall strategy. Although this bottom-up strategy plays a significant role, the top management still has a fundamental role in aligning the digital initiatives with the company's vision of future, thus promoting a more comprehensive strategy.	As could be identified in the current work top management support is a pre-requisite for a successful DT project. It is part of the CSF model proposed. Nevertheless, the company engagement in all levels is one of CSF inside the Culture elements.
PICCININI, E.; HANET, A.; GREGORY, R.W.; KOLBE, L.M.	2015	The authors argue that DT brings challenges and opportunities for automotive organisations. By promoting organisational flexibility, embracing digital innovation and managing the interaction between physical and digital worlds ambidextrously, the automotive assemblers can browse through this transformation and ensure the longevity of their businesses.	Despite ambidextrously between physical and digital worlds was not part of this study the relationship between them appears in some of the interviews such as: data for production line fulfillment or sale through app.
MIGUEL, P.M.; DE-PABLOS-HEREDERO, C.; MONTES, J.L; GÁRCIA, A.	2022	A positive correlation between dynamic capacities of a company and satisfaction of the customer in the automotive sector was confirmed in their study. Therefore, companies highlighted for detecting the customer needs, improving the opportunities and promoting innovation are more likely to satisfy their customers. Digital tools and technologies can help the companies gather information on clients, identify new market opportunities and develop innovative products and services.	In some of the cases the DT focus was the Commercial area with focus on the customer satisfaction increment. The intense use of digital technologies for post sale services & digital sales appeared in most of the cases.
		The authors managed to identify new players in the automotive value chain as a result of	

RIASANOW, T.; GALIC, G. BÖHM, M.	2017	digitalisation, including companies specialised in areas such as autonomous vehicle technology, car-sharing platforms and data analysis, and detected that the way value is created and delivered in the automotive industry is changing as digital technologies are allowing new value flows.	In some cases there was a creation of startups related to car rental or financial services however this were not the focus of DT on the BAI.
ACCIARINI, C; BORELLI, F.; CAPO, F.; CAPPA, F.; SARROCCO, C.	2022	Their study suggests that digitalisation and sustainability are interlinked rather than separate forces. Digital technologies can be used to create innovative business models which are ecological as well, such as car-sharing platforms aiming to reduce the ownership rates of automobiles by introducing the concept of mobility-as-a-service. Digital tools can be used to optimise production processes, reduce resource consumption and develop electric or hybrid vehicles.	DT on the BAI has some a lot of examples of processes efficiency improvement and costs & lead time reductions however it was not any mention to sustainability in the current study.
COLOMBARI, R.; GEUNA, A.; HELPER, S.; MARTINS, R.	2023	The results revealed the companies give priority to the use of data and digital tools to improve the quality of the products and ensure security on the manufacturing floor. Nevertheless, their study found a potential gap between data collection and its effective usage. Although the companies actively gather data by means of automation and sensors, they are not fully exploiting their potential for data-based decision-making.	The companies of the BAI are also developing solutions to automate the production lines and optimization the raw material consumption. It has been pointed by them that this is a start point instead of a final destination in terms of exploiting all potentialities from DT.
KRZYWDZINSKI, M.	2020	The author sugested that automation and digitalisation did not lead to significant losses of jobs in the automotive production. However, the study recognises that automation can create the need for new technologies in the workforce, imposing the employees to adapt to working with robots and digital technologies. He argues that the narrative that automation leads to mass unemployment in the automotive industry is an exaggeration. Although automation and digitalization are present, the focus on flexible automation and	Some of the respondents from the BAI has mention overhead reduction on the other hand most of them has no mention it or people relocation for more “brain” activities.

		data on employment suggest a less dramatized image than the common sense, but which indicates that workers need to qualify themselves in new digital competencies to keep their jobs.	
RIBAS, A.I.; TEIXEIRA, L.	2021	The authors identified five key factors contributing to a successful implementation of these systems in the company's digitalisation project: Connectivity, User's environment, Analysis of process and adaptable solutions, Partners and Support team, Strategy plan and roadmap.	This thesis has proposal a DT project management model with three elements: Culture, Structure and Strategy.
BATHIA, M.S.; KUMAR, S.	2020	Their study suggested that data governance is the most critical success factor for achieving positive performance results with the implementation of Industry 4.0. Teamwork, especially between different departments of the company, can significantly improve responsiveness. Effective collaboration promotes better communication and sharing of information, thus allowing companies to adapt more quickly to the new market demands as well as to the customers' needs	All of these aspects are inside the proposed model in this thesis within the three elements: Culture, Structure and Strategy.

7. CONCLUSION

Digital transformation represents a challenge and at the same time a significant opportunity for the Brazilian automotive sector. The present research deepened into the analysis and qualification of the impacts of Digital Transformation (DT) on the Brazilian Automotive Industry (BAI), in addition to identifying Critical Success Factors (CSF) in these projects by detecting elements to construct an enabling model for future implementations to be adopted by the industry. Although the present results provide valuable insights for automotive assemblers operating in Brazil, it is important to recognise that these factors can eventually be applied to broader contexts of the automotive industry, thus requiring further validation.

Moreover, the dynamic nature of the digital environment requires a continuous and adaptive approach so that the benefits from DT can be used accordingly (GEBAYEW *et al*., 2018). The accelerated technological evolution and the consequent changes in the business models highlight the need for longitudinal studies in order to follow up the evolution of the impacts and CSF identified over time. Adoption of this conceptual model, as proposed here, requires an experiment or a quasi-experiment demonstrate the effectivity of the model. The search for quantitative data can further enrich our understanding, which enables to validate statistically the qualitative findings and exploit the generalizations more widely (WAZLAWICK, 2009). Ultimately, DT in the automotive industry is a continuous journey and the present research offers a solid base for future research and practical initiatives aiming to boost the success in a digital era under ongoing evolution.

The present thesis contributes to the literature by qualifying the impacts of DT on the BAI. For doing so, three different groups were categorised and inter-correlated, namely: (i) positive impacts, (ii) negative impacts, and (iii) operational impacts. Additionally, the universality of two pre-requisites were confirmed: top management support and strategic alignment for successful projects of DT (GURBAXANI, DUNKLE, 2019; CHANIAS, HESS, 2016; SIMONAZZI, SANGINÉS, RUSSO, 2020; KODA, PEDRON, 2021). At the same time, the theoretical scope is widened with the identification and qualification of CSF in the specific context of the BAI by offering valuable insights for application in other industrial contexts. Lastly, the development of a conceptual model of CSF enabling projects of DT in the Brazilian automotive sector

increases the odds of success not only by simplifying the complexity inherent to DT, but also providing a theoretical picture for future research.

The practical contribution of this thesis relies on the formulation and proposition of a model enabling CSF for DT in the Brazilian automotive sector, in which a model can serve as a guide for the companies in their digitalization journeys, thus increasing the odds of success and achievement of the promised benefits. The proposed model can play a relevant role in maintaining the competitiveness in the Brazilian industry sector. This, in turn, can have a positive economic impact by boosting productivity and innovation in the sector. Additionally, by highlighting the importance of a digitally qualified workforce, the present research emphasises the need of initiatives for development of digital skills, which can influence the future educational and professional policies, thus resulting in social contributions.

This research was limited to bibliographic research, identification and reading of related articles, collection and treatment of data by means of semi-structure interviews, qualitative data analysis and respective inferences. Due to the impossibility to have access to the companies' documents and records on the impact of DT and little disclosure of numbers on this theme, it was not possible to conduct a triangulation of information, which is typical of a case study or multiple case study. Therefore, it is suggested that futures studies should approach ANFAVEA in order to obtain access to such documentation.

This thesis presents a detailed analysis of DT in the Brazilian automotive sector, and although it is concentrated on large assemblers in the specific Brazilian context, the principles and CSF identified have can potentially form similar strategies in other automotive segments, such as the auto-parts manufacturers and car dealerships. However, the application of these insights in a broader context should be addressed with caution. The relevance and effectiveness of these CSF in different operational, cultural and economic environments require supplementary validation. In this sense, it is suggested that new studies should be conducted to exploit how these findings are translated into different sub-sectors of the automotive industry, considering variables such as company size, market, internationalization and technological capacity.

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APPENDIX - INTERVIEWS

E01

Descrição dos Projetos

1. Quais foram as iniciativas de Transformação Digital (precisa qualificar) implantadas na empresa nos últimos 10 anos? Em quais áreas? Com quais tecnologias habilitadoras?
2. Quais os projetos de Transformação Digital (precisa qualificar) vocês estão implantando atualmente na empresa? Em quais áreas? Com quais tecnologias habilitadoras?
3. Listagem dos projetos com sumário do histórico seus objetivos, tecnologias, resultados, tempo de implantação, custos etc.

Mudança de modelo mental!

Payperless experience – desde o agendamento até o pagamento dos serviços, com escolha da concessionária pelo condutor (match tipo Uber), histórico de intervenções do automóvel, nome do consultor, horário e tempo da intervenção.

Automóveis sensorizados com modem gerando alertas ao condutor e dados na nuvem para monitoramento por parte da assistência técnica nas concessionárias antecipando o diagnóstico do veículo antecipado, identificando problemas, permitindo planejamento das intervenções, reduzindo tempo do veículo na oficina e aumentando a produtividade da concessionária.

4. O escopo destes projetos foi interno ou envolveu o ecossistema da empresa?

Empresa e concessionários.

Qualificação dos Projetos

5. Quais foram as maiores dificuldades na aprovação dos projetos de Transformação Digital?

Concorrência de recursos (financeiros, gerenciais e humanos) com os projetos globais; Necessidade de “empatar” o investimento (VPL = 0) e de enfatizar o financeiro no processo de aprovação (“falar a língua do CFO). Explicitar o atendimento ao requerimento do Business.

6. Quais foram as maiores dificuldades na implantação destes projetos?

Atingir a performance da aplicação prometida pelo projeto em termos de tempo de resposta. Nível alto de reclamação devido a problemas de arquitetura e infraestrutura. Atritos entre as concessionárias e a equipe do projeto demandando Change Management.

7. Quais foram os fatores críticos de sucesso destes projetos?

Modelo mental adotando um pensamento com foco em Design Thinking. Cultura forte. Planejamento da experiência do usuário visando a usabilidade futura da aplicação.

8. Foram projetos desenvolvidos localmente ou *rollouts*?

Localmente.

9. O quão alinhados com os objetivos estratégicos estes projetos estão / estavam?

100 % alinhados ao Planejamento Estratégico com foco em gerar Valor à companhia.

10. Existe um *roadmap* / governança / escritório de projetos / *portfolio* específico para os projetos de Transformação Digital?

A gestão da carteira de projetos de transformação digital é feita de forma consolidada na gestão da carteira de projetos de TI.

11. Houve a participação de entidades externas (consultorias, ICTs, startups, parceiros, fornecedores) ou foi desenvolvimento interno?

Estas iniciativas contaram com a participação de recursos internos, consultorias de TI, startups, ICTs e diversos parceiros. Quando os projetos adotaram solução de mercado houve a contratação de consultorias especializadas de TI, quando os projetos eram soluções específicas, o desenvolvimento era feito por recursos internos da TI e da área de negócios.

12. Contou com o patrocínio da Diretoria? Alguma em específico? Houve envolvimento dos colaboradores das áreas clientes?

Sim, em decorrência do alinhamento com o Plano Estratégico o patrocínio era imediato. No caso destes projetos om foco foi na Diretoria Comercial e de Serviços, com efetivo envolvimento de colaboradores das áreas.

13. Quais foram as lições aprendidas com os projetos já implantados? Elas estão sendo consideradas nos novos projetos?

As principais lições aprendidas e que estão norteando os projetos de transformação digital atuais foram a metodologia de trabalho bem estruturada, a necessidade de garantir uma entrega com a performance (tempo de resposta) da aplicação em linha com as expectativas dos usuários e a priorização das urgências que consumiram muita atenção e geraram estresse na equipe.

Impactos dos Projetos

14. Como foi o “dia seguinte” à implantação dos projetos?

Sem crise, com a continuidade das operações de forma normal. Com reconhecimento por parte da área de negócio do valor das soluções.

15. Quais foram os benefícios propiciados para a área cliente com a entrega dos projetos?

Eficiência, com maior velocidade na realização das tarefas com menos pessoas; maior disponibilidade a acesso aos dados para a tomada de decisão; aumento do NPS pelo cliente final nas concessionárias; simplificação do processo de venda direta e de coleta de pedidos dos veículos.

16. Houve percepção das áreas dos resultados destes projetos?

Área operacional (chão de concessionária) reconhecendo o valor agregado com os projetos implantados,

17. Quais foram as mudanças que as áreas tiveram que fazer para se adaptar aos projetos?

Uniformidade dos processos em diferentes países (Latam); Mudança (com “dor”) nos processos de atendimento ao cliente final.

18. Houve aumento de produtividade, redução de custos, aumento da satisfação do cliente, incremento de *market share*, melhoria da imagem da empresa ou dos produtos, melhoria dos processos internos, redução dos tempos de desenvolvimento, redução dos tempos de entrega dos insumos, peças e partes, bem como, dos produtos acabados, melhoria no relacionamento com os concessionários etc?

Sim (redução do tempo de execução das atividades com menos pessoas), sim, sim, não, n/a, sim, n/a, sim, sim.

19. Quais métricas são utilizadas para medir os resultados dos projetos de Transformação Digital?

Performance (tempo de reposta das aplicações), simplificação dos processos e paperless.

20. Houve a criação de novos produtos, de um novo processo, redução de overhead?

Houve a criação de alguns processos com o agendamento e pedidos digital e redução de overhead no almoxarifado.

21. Houve retorno financeiro nos projetos? Em que percentual médio (projeto)? E em que proporção (quantidade de projetos com retorno financeiro positivo)?

Os projetos não são medidos ponto de vista financeiro ao final.

22. Quais foram os “campeões” (referências)?

Agendamento e serviço de assistência digitais. E a venda direta totalmente digital.

23. Houve a criação de *spin offs* ou *startups* a partir destes projetos?

Não.

24. Houve *spillovers* como consequência destes projetos?

Não.

25. Quais foram os impactos negativos?

Dor, por parte dos concessionários, na adaptação às novas soluções digitais.

Avaliação dos Projetos

26. Qual a percepção das áreas clientes sobre os resultados dos projetos de Transformação Digital?

Desconhecimento por parte da diretoria da área cliente e boa percepção das concessionárias.

27. O que poderia ser feito diferente na gestão do *portfolio* destes projetos?

Adoção de soluções de mercado mais frequentemente em detrimento de soluções desenvolvidas in-house; melhor arquitetura dos sistemas; implantação de um processo de melhoria contínua das aplicações com envolvimento dos usuários.

28. Qual a avaliação da Diretoria sobre estes projetos?

Indiferente.

E02

Descrição dos Projetos

1. Quais foram as iniciativas de Transformação Digital (precisa qualificar) implantadas na empresa nos últimos 10 anos? Em quais áreas? Com quais tecnologias habilitadoras?
2. Quais os projetos de Transformação Digital (precisa qualificar) vocês estão implantando atualmente na empresa? Em quais áreas? Com quais tecnologias habilitadoras?
3. Listagem dos projetos com sumário do histórico seus objetivos, tecnologias, resultados, tempo de implantação, custos etc.

“Entendimento que o mundo é digital!” mas que o negócio de uma montadora é físico = automóvel.

Payperless experience – desde o agendamento até o pagamento dos serviços, com escolha da concessionária pelo condutor (match tipo Uber), histórico de intervenções do automóvel, nome do consultor, horário e tempo da intervenção.

Automóveis sensorizados com modem gerando alertas ao condutor e dados na nuvem para monitoramento por parte da assistência técnica nas concessionárias antecipando o diagnóstico do veículo antecipado, identificando problemas, permitindo planejamento das intervenções, reduzindo tempo do veículo na oficina e aumentando a produtividade da concessionária.

4. O escopo destes projetos foi interno ou envolveu o ecossistema da empresa?

Empresa e concessionários.

Qualificação dos Projetos

5. Quais foram as maiores dificuldades na aprovação dos projetos de Transformação Digital?

Comprovar aumento da satisfação do cliente e valor agregado à companhia. Foco no cliente como facilitador no processo de aprovação. Trabalho conjunto com TI e Financeiro.

6. Quais foram as maiores dificuldades na implantação destes projetos?

Mudança de modelo mental, treinamento, perfil “analógico” dos colaboradores das concessionárias, adaptação dos clientes finais e resistência a mudanças. 10% dos agendamentos dos serviços de assistência técnica são feitos de forma digital (10/22) – meta 40% em 2024. Dificuldade de orquestrar diferentes parceiros (concessionários, funcionários e consultores).

7. Quais foram os fatores críticos de sucesso destes projetos?

Foco em todos os níveis organizacionais dos concessionários. Objetivos ambiciosos e compartilhados entre montadora e concessionários. Piloto (1 mês) 100% digital com 80% dos clientes no novo processo.

8. Foram projetos desenvolvidos localmente ou *rollouts*?

Localmente (LATAM).

9. O quão alinhados com os objetivos estratégicos estes projetos estão / estavam?

100 % alinhados ao Planejamento Estratégico com compromisso da montadora em se tornar digital.

10. Contou com o patrocínio da Diretoria? Alguma em específico? Houve envolvimento dos colaboradores das áreas clientes?

Sim, em decorrência do alinhamento com o Plano Estratégico o patrocínio era imediato. No caso destes projetos om foco foi na Diretoria Comercial e de Serviços, com efetivo envolvimento de colaboradores das áreas.

11. Quais foram as lições aprendidas com os projetos já implantados? Elas estão sendo consideradas nos novos projetos?

Avaliação do time em termos de competência e modelo mental da equipe envolvida nas iniciativas. Seleção dos colaboradores com perfis mais digitais (ter o time certo). Compromisso financeiro (investimento) por parte das concessionárias. Alinhamento cultural.

Impactos dos Projetos

12. Como foi o “dia seguinte” à implantação dos projetos?

Difícil, em diferentes concessionários com sobreposição de trabalhos manuais com o digital em diferentes intensidades.

13. Quais foram os benefícios propiciados para a área cliente com a entrega dos projetos?

Agilidade no atendimento aos clientes finais com redução do tempo do carro na concessionária (produtividade). Conveniência para os clientes finais com a possibilidade de agendamento onde quando quiser. Geração, disponibilidade e controle dos dados para tomada de decisão (Big Data). Reforço de marca transnacional e moderna. Aumento do NPS. Celeridade na recepção (check in) do veículo reduzindo atrito com os clientes finais.

14. Houve percepção das áreas dos resultados destes projetos?

Sim de forma 100%. Domínio da ferramenta para uso das funcionalidades propostas. Sincronização dos estoques de peças com os agendamentos dos clientes finais. Dados dos veículos real time a disposição dos consultores.

15. Quais foram as mudanças que as áreas tiveram que fazer para se adaptar aos projetos?

Alocar o time de campo no projeto; ajuste do processo de venda de peças à ferramenta.

16. Houve aumento de produtividade, redução de custos, aumento da satisfação do cliente, incremento de *market share*, melhoria da imagem da empresa ou dos produtos, melhoria dos processos internos, redução dos tempos de desenvolvimento, redução dos tempos de entrega dos insumos, peças e partes, bem como, dos produtos acabados, melhoria no relacionamento com os concessionários etc?

Sim (menos tempo dos veículos dos clientes finais na concessionária), sim, sim, não, sim (um grande benefício percebido), sim, sim, sim.

17. Quais métricas são utilizadas para medir os resultados dos projetos de Transformação Digital?

Quantidade de clientes cadastrados no App; Número de atendimentos digitais vs. Número de atendimentos tradicionais. NPS. Tempo do veículo na concessionária.

18. Houve a criação de novos produtos, de um novo processo, redução de overhead?

Sim. De novos processos, bem como, redução de overhead.

19. Houve retorno financeiro nos projetos? Em que percentual médio (projeto)? E em que proporção (quantidade de projetos com retorno financeiro positivo)?

Não, pois não era o foco dos projetos em questão.

20. Quais foram os “campeões” (referências)?

Agendamento e serviço de assistência digitais. E a venda direta totalmente digital. Paperless.

21. Houve a criação de *spin offs* ou *startups* a partir destes projetos?

Não.

22. Houve *spillovers* como consequência destes projetos?

Não.

23. Quais foram os impactos negativos?

Perda de pessoal capacitado após o final do projeto.

Avaliação dos Projetos

24. Qual a percepção das áreas clientes sobre os resultados dos projetos de Transformação Digital?

“Que é uma jornada sem volta!”

25. O que poderia ser feito diferente na gestão do *portfolio* destes projetos?

Melhor planejamento com antecipação de problemas e melhor seleção de integrantes das equipes de projeto selecionando perfis mais digitais.

26. Qual a avaliação da Diretoria sobre estes projetos?

“Que ainda falta muito!”. Que virão muito mais iniciativas digitais. Que o futuro é digital e que o foco deve ser na experiência do consumidor e na ciência de dados como ferramenta.

E03

Qualificação dos Projetos

1. Quais foram as maiores dificuldades na aprovação dos projetos de Transformação Digital?

Fazer as pessoas acreditarem na mudança, na novidade! Comprovar o retorno financeiro, que o projeto agrega valor.

2. Foram apresentados Business Cases e os mesmos apresentavam indicadores financeiros claros e positivos (RoI, VPL, TIR etc.)?

Sim, VPL, TIR, RoI e Payback.

3. Quais foram as maiores dificuldades na implantação destes projetos?

Convencer os diversos stakeholders a adotar as novas tecnologias. Impacto na rede de concessionários. Prazos muito curtos.

4. Quais foram os fatores críticos de sucesso destes projetos?

Liderança dos gerentes das iniciativas e patrocínio da alta direção. “Obsessão” da companhia com o sucesso dos projetos de transformação digital.

5. O quão alinhados com os objetivos estratégicos estes projetos estão / estavam?

100 % alinhados ao Planejamento Estratégico com foco em gerar Valor à companhia.

6. Estes projetos foram incluídos no planejamento orçamentário ou foram extra budget?

Fizeram parte do planejamento orçamentário, todavia, quando havia um Business Case sólido o mesmo poderia requerer um budget extra.

7. Existe um *roadmap* / governança / escritório de projetos / *portfolio* específico para os projetos de Transformação Digital?

A gestão da carteira de projetos de transformação digital é feita de forma consolidada na gestão da carteira de projetos de TI.

8. Houve a participação de entidades externas (consultorias, ICTs, startups, parceiros, fornecedores) ou foi desenvolvimento interno?

Há uma Governança própria para os projetos de Transformação Digital com revisão de todos os projetos periodicamente com o owner de cada iniciativa. Avaliação sob dois aspectos:

1. Inovação – Data Analytics
2. Cliente – Satisfação

9. Contou com o patrocínio da Diretoria? Alguma em específico? Houve envolvimento dos colaboradores das áreas clientes?

Sim, uma vez por mês o board executivo se reúne para avaliar os projetos de Transformação Digital.

10. Quais foram as lições aprendidas com os projetos já implantados? Elas estão sendo consideradas nos novos projetos?

Aumentar o foco no longo prazo em detrimento de ações de curto prazo. Não adotar tecnologias obsoletas e buscar maior autonomia. Incrementar os resultados financeiros do projeto.

Impactos dos Projetos

11. Como foi o “dia seguinte” à implantação dos projetos?

Dificuldade de comprovar os benefícios com as consequentes explicações necessárias. Baixo grau de adoção das soluções pelos clientes finais.

12. Quais foram os benefícios propiciados para a área cliente com a entrega dos projetos?

Redução do tempo das intervenções nos automóveis dos clientes, simplificação dos processo e consequentemente tornando a vida do cliente mais fácil.

13. Houve percepção das áreas dos resultados destes projetos?

Sim, com o crescimento do grau de adoção das soluções e a percepção do valor ao cliente final. Houve percepção de ganho de produtividade mas também de que alguns processos ficaram mais complicados para os colaboradores das concessionárias.

14. Quais foram as mudanças que as áreas tiveram que fazer para se adaptar aos projetos?

Necessidade de mudar processos e atividades operacionais.

15. Houve aumento de produtividade, redução de custos, aumento da satisfação do cliente, incremento de *market share*, melhoria da imagem da empresa ou dos produtos, melhoria dos processos internos, redução dos tempos de desenvolvimento, redução dos tempos de entrega dos insumos, peças e partes, bem como, dos produtos acabados, melhoria no relacionamento com os concessionários etc?

Sim, sim, sim, não, n/a, sim (começando), sim, sim, sim.

16. Quais métricas são utilizadas para medir os resultados dos projetos de Transformação Digital?

Rating nas lojas de celulares (Apple Store & Google Store). Grau de adoção do App pelos clientes finais. NPS. Clima interno dos colaboradores.

17. Houve a criação de novos produtos, de um novo processo, redução de overhead?

Novos serviços aos clientes finais no agendamento das intervenções nos veículos e novos processos.

18. Houve retorno financeiro nos projetos? Em que percentual médio (projeto)? E em que proporção (quantidade de projetos com retorno financeiro positivo)?

Ainda não.

19. Quais foram os “campeões” (referências)?

Projeto de digitalização da jornada do cliente final nos serviços das concessionárias.

20. Houve a criação de *spin offs* ou *startups* a partir destes projetos?

Não.

21. Houve *spillovers* como consequência destes projetos?

Não.

22. Quais foram os impactos negativos?

Baixa quantidade de projetos para dar escala ao processo de transformação digital na empresa.

Avaliação dos Projetos

23. Qual a avaliação da Diretoria sobre estes projetos?

Bom início.

E04

Descrição dos Projetos

1. Quais foram as iniciativas de Transformação Digital (precisa qualificar) implantadas na empresa nos últimos 10 anos? Em quais áreas? Com quais tecnologias habilitadoras?
2. Quais os projetos de Transformação Digital (precisa qualificar) vocês estão implantando atualmente na empresa? Em quais áreas? Com quais tecnologias habilitadoras?
3. Listagem dos projetos com sumário do histórico seus objetivos, tecnologias, resultados, tempo de implantação, custos etc.

Projetos de Transformação Digital com viés de Indústria 4.0, focados em paperless, redução de atividades, tarefas sem valor agregado (non value added) e análise de dados para tomada de decisão. Padronização dos Processos Industriais.

Colaboradores conectados à linha de produção: telas em cada posto de trabalho com todas as informações sobre a linha de produção para diferentes modelos de veículos), início de produção automatizado com seu conjunto de peças, ferramental mais urgências, controlados por tablets ou celulares. Chefe da unidade industrial com visão real time dos sistemas, da produção e dos colaboradores. Soluções de treinamento dos colaboradores com Realidade Aumentada.

Estas iniciativas envolvem tecnologias de Big Data, Inteligência Artificial, Realidade Aumentada, Impressão 3D, Drones (para almoxarifados), bem como, a mudança de sistemas legados (alguns operando em mainframes) para sistemas digitais móveis na nuvem.

4. O escopo destes projetos foi interno ou envolveu o ecossistema da empresa?

Interno.

Qualificação dos Projetos

5. Quais foram as maiores dificuldades na aprovação dos projetos de Transformação Digital?

Disponibilidade financeira (orçamento); alto custo da infraestrutura tecnológica (equipamentos importados definidos pela matriz) e nem sempre presença de retorno financeiro (Business Case positivo).

6. Quais foram as maiores dificuldades na implantação destes projetos?

Infraestrutura legada pouco digitalizada e desatualizada; modelo mental da companhia, as vezes com resistências; recursos humanos qualificados disponíveis.

7. Quais foram os fatores críticos de sucesso destes projetos?

Comprometimento da equipe; conexão com os fornecedores de sistemas e produtos; estratégia de implantação com a adoção de pilotos.

8. Foram projetos desenvolvidos localmente ou *rollouts*?

Projetos locais (principalmente os relacionados com a realidade local das operações); rollouts da matriz e a partir do Brasil para outras plantas.

9. O quão alinhados com os objetivos estratégicos estes projetos estão / estavam?

Não há a possibilidade de aprovação de iniciativas que não estejam alinhadas com o Value Stream da companhia. A estratégia da empresa busca uma digitalização end-to-end dos processos industriais.

10. Existe um *roadmap* / governança / escritório de projetos / *portfolio* específico para os projetos de Transformação Digital?

Sim. Existe um roadmap de transformação digital bem definido com Governança alinhado com a área de negócios e indicadores críticos de sucesso desde o processo de aprovação até a validação final. Tais iniciativas seguem metodologias ágeis com times mistos (negócios e TI).

11. Houve a participação de entidades externas (consultorias, ICTs, startups, parceiros, fornecedores) ou foi desenvolvimento interno?

Time interno com desenvolvedores externos (consultorias) para soluções desenvolvidas internamente e soluções de mercado homologadas pela matriz. Além disto, startups e ICTs fizeram parte nos projetos de transformação digital.

12. Contou com o patrocínio da Diretoria? Alguma em específico? Houve envolvimento dos colaboradores das áreas clientes?

Total, inclusive com a liderança dos projetos a cargo das diretorias do negócio.

13. Quais foram as lições aprendidas com os projetos já implantados? Elas estão sendo consideradas nos novos projetos?

Business como protagonista; o PO (Product Owner) tem que ter o perfil de conhecimento (negócios e técnico) e atitude (liderança) alinhado a cultura da companhia desde o início. Dispositivos tecnológicos são ponto crítico nas iniciativas de transformação digital devido a sua especificidade, distintas tecnologias e empregos, alto custo e tempo de entrega (lead time). Necessidade de incluir nos cronogramas um tempo de lead time para estes dispositivos.

Impactos dos Projetos

14. Como foi o “dia seguinte” à implantação dos projetos?

Diferentes percepções a depender do ator:

- Negócio – percepção que os processos se tornaram mais eficientes e que a produtividade (veículos produzidos por linha e custo por veículo produzido) e a qualidade (defeitos por veículo) aumentou.
- TI – decepção com a falta de tropicalização das soluções.
- Financeiro – frustação com o retorno financeiro das iniciativas.

15. Quais foram os benefícios propiciados para a área cliente com a entrega dos projetos?

Redução dos custos por veículo produzido; redução de overhead; redução dos tempos ociosos na linha (Non Value Added); incremento da sustentabilidade (eliminação do consumo de papeis, cartuchos de tinta e impressoras nas linhas de produção); Aumento da qualidade do produto.

16. Houve percepção das áreas dos resultados destes projetos?

Área gerencial positiva, pois, passaram a trabalhar sobre dados na tomada de decisão. Área operacional negativa, pois, digitalização atrapalhou (na visão dos colaboradores) o processo.

17. Quais foram as mudanças que as áreas tiveram que fazer para se adaptar aos projetos?

Uniformidade dos processos industriais, inclusive de supply chain e modelo mental digital (paperless).

18. Houve aumento de produtividade, redução de custos, aumento da satisfação do cliente, incremento de *market share*, melhoria da imagem da empresa ou dos produtos, melhoria dos processos internos, redução dos tempos de desenvolvimento, redução dos tempos de entrega dos insumos, peças e partes, bem como, dos produtos acabados, melhoria no relacionamento com os concessionários etc?

Sim (redução do tempo de produção de cada veículo com menos pessoas, redução dos tempos ociosos, redução do custo por veículo produzido), sim, sim, sim, n/a, sim, não, sim, n/a.

19. Quais métricas são utilizadas para medir os resultados dos projetos de Transformação Digital?

Financeiro (VPL e ROI); Percentual de utilização da solução; tempo de uso; Custo por veículo produzido; Tempo de produção por veículo.

20. Houve a criação de novos produtos, de um novo processo, redução de overhead?

Redução de pessoal e a criação de novos processos industriais.

21. Houve retorno financeiro nos projetos? Em que percentual médio (projeto)? E em que proporção (quantidade de projetos com retorno financeiro positivo)?

Sim. 65% dos valores de VPL esperados em média. Todos os projetos apresentram algum tipo de retorno financeiro.

22. Houve a criação de *spin offs* ou *startups* a partir destes projetos?

Não.

23. Houve *spillovers* como consequência destes projetos?

Sim. Treinamento em tecnologia da informação em bairros pobres e vizinhos a planta.

24. Quais foram os impactos negativos?

Perda de pessoas qualificadas para os competidores e para empresas provedoras de serviços de TI.

Avaliação dos Projetos

25. Qual a percepção das áreas clientes sobre os resultados dos projetos de Transformação Digital?

Processos mais rápidos, mais produtivos, mais eficientes. Mudança de modelo mental da companhia para uma inevitável Digitalização.

26. O que poderia ser feito diferente na gestão do *portfolio* destes projetos?

Maior foco na vantagem competitiva.

27. Qual a avaliação da Diretoria sobre estes projetos?

Certeza da jornada.

E05

Descrição dos Projetos

1. Quais foram as iniciativas de Transformação Digital (precisa qualificar) implantadas na empresa nos últimos 10 anos? Em quais áreas? Com quais tecnologias habilitadoras?
2. Quais os projetos de Transformação Digital (precisa qualificar) vocês estão implantando atualmente na empresa? Em quais áreas? Com quais tecnologias habilitadoras?
3. Listagem dos projetos com sumário do histórico seus objetivos, tecnologias, resultados, tempo de implantação, custos etc.

Projetos de Transformação Digital com viés de Indústria 4.0, focados em paperless, redução de atividades, tarefas sem valor agregado (non value added) e análise de dados para tomada de decisão. Padronização dos Processos Industriais.

Colaboradores conectados à linha de produção: telas em cada posto de trabalho com todas as informações sobre a linha de produção para diferentes modelos de veículos), início de produção automatizado com seu conjunto de peças, ferramental mais urgências, controlados por tablets ou celulares. Chefe da unidade industrial com visão real time dos sistemas, da produção e dos colaboradores. Soluções de treinamento dos colaboradores com Realidade Aumentada.

Estas iniciativas envolvem tecnologias de Big Data, Inteligência Artificial, Realidade Aumentada, Impressão 3D, Drones (para almoxarifados), bem como, a mudança de sistemas legados (alguns operando em mainframes) para sistemas digitais móveis na nuvem.

4. O escopo destes projetos foi interno ou envolveu o ecossistema da empresa?

Interno.

Qualificação dos Projetos

5. Quais foram as maiores dificuldades na aprovação dos projetos de Transformação Digital?

Prioridade número 1 à rentabilidade financeira dos projetos; Modelo mental dos decisores por conta da dificuldade de mensurar os ganhos indiretos.

6. Foram apresentados Business Cases e os mesmos apresentavam indicadores financeiros claros e positivos (RoI, VPL, TIR etc.)

Sim. Necessidade de Business Case (EVTE) positivo Latam e Global.

7. Quais foram as maiores dificuldades na implantação destes projetos?

Alto custo dos dispositivos de tecnologia diminuindo os investimentos planejados em infraestrutura. Demonstrar os ganhos advindos com a adoção da Indústria 4.0.

8. Quais foram os fatores críticos de sucesso destes projetos?

Competência técnica da equipe; cultura organizacional aberta às mudanças; parceria Manufatura & TI; patrocínio da alta direção; apoio global.

9. Foram projetos desenvolvidos localmente ou *rollouts*?

Projetos locais (principalmente os relacionados com a realidade local das operações); rollouts da matriz e a partir do Brasil para outras plantas.

10. O quão alinhados com os objetivos estratégicos estes projetos estão / estavam?

100% alinhados à Estratégia da empresa no eixo Indutech.

11. Estes projetos foram incluídos no planejamento orçamentário ou foram extra budget?

Todos os projetos foram formalizados dentro do planejamento orçamentário da companhia, mas como budget próprio para as iniciativas de transformação digital na área industrial.

12. Existe um *roadmap* / governança / escritório de projetos / *portfolio* específico para os projetos de Transformação Digital?

Sim, com áreas internas específicas e inclusive, com a venda de serviços para empresas do ecossistema (fornecedores de peças e ferramentais).

13. Houve a participação de entidades externas (consultorias, ICTs, startups, parceiros, fornecedores) ou foi desenvolvimento interno?

Time interno forte e capacitado; parceiros externos fornecedores de soluções e Indústria 4.0 globais; startups; ICTs; IEs.

14. Contou com o patrocínio da Diretoria? Alguma em específico? Houve envolvimento dos colaboradores das áreas clientes?

Sim, desde o CIO até as gerencias médias da empresa.

15. Quais foram as lições aprendidas com os projetos já implantados? Elas estão sendo consideradas nos novos projetos?

Abertura à oportunidades que surgem ao longo da execução dos projetos; Necessidade de pilotos; preparar as pessoas do ponto de vista das competências; “Transformação Digital é distinto de Digitalização”.

Impactos dos Projetos

16. Como foi o “dia seguinte” à implantação dos projetos?

Complicado, com alto impacto nas pessoas (por falta de preparo e capacitação) prejudicando o tempo do retorno prometido das soluções digitais (até dois anos de payback além do planejado).

17. Quais foram os benefícios propiciados para a área cliente com a entrega dos projetos?

Tempo de resposta mais rápido na operação e nas respostas aos problemas; incremento da qualidade devido a prevenção de quebras mais eficaz; redução dos dias parados aumentando a produtividade; possibilidade de monitoramento (por telemetria) global por meio de centros de manutenção; maior disponibilidade de informações para a tomada de decisões. Treinamento automatizado por meio de RA. Paperless.

18. Houve percepção das áreas dos resultados destes projetos?

Sim e bastante positiva.

19. Quais foram as mudanças que as áreas tiveram que fazer para se adaptar aos projetos?

Formação digital (capacitação); mudança de modelo mental; mudança nos processos mais manuais.

20. Houve aumento de produtividade, redução de custos, aumento da satisfação do cliente, incremento de *market share*, melhoria da imagem da empresa ou dos produtos, melhoria dos processos internos, redução dos tempos de desenvolvimento, redução dos tempos de entrega dos insumos, peças e partes, bem como, dos produtos acabados, melhoria no relacionamento com os concessionários etc?

Sim (tempo de resposta mais rápido na operação; redução da quantidade de quebras), sim, sim, não, sim (envolvendo as concessionárias), sim, sim, não (ainda), não.

21. Quais métricas são utilizadas para medir os resultados dos projetos de Transformação Digital?

Financeiro (VPL e ROI); tempo médio entre falhas (MTBF); Processo (tempos de execução).

22. Houve a criação de novos produtos, de um novo processo, redução de overhead?

Houve a criação de serviços de implantação de soluções de Indústria 4.0 ofertadas às empresas do ecossistema, bem como, a criação de novos processos (continuamente com o gêmeo digital).

23. Houve retorno financeiro nos projetos? Em que percentual médio (projeto)? E em que proporção (quantidade de projetos com retorno financeiro positivo)?

Sim. 80% dos valores de VPL esperados em média. Todos os projetos apresentaram algum tipo de retorno financeiro.

24. Houve a criação de *spin offs* ou *startups* a partir destes projetos?

Sim. Uma startup de veículos industriais autônomos.

25. Houve *spillovers* como consequência destes projetos?

Sim. Mudanças no currículo de cursos de graduação de engenharia em duas IEs.

26. Quais foram os impactos negativos?

Perdas iniciais com paradas de produção e tempos ociosos em decorrência da curva de aprendizado.

Avaliação dos Projetos

27. O que poderia ser feito diferente na gestão do *portfolio* destes projetos?

Business liderando o processo desde a ideação.

E06

Descrição dos Projetos

1. Quais foram as iniciativas de Transformação Digital (precisa qualificar) implantadas na empresa nos últimos 10 anos? Em quais áreas? Com quais tecnologias habilitadoras?
2. Quais os projetos de Transformação Digital (precisa qualificar) vocês estão implantando atualmente na empresa? Em quais áreas? Com quais tecnologias habilitadoras?
3. Listagem dos projetos com sumário do histórico seus objetivos, tecnologias, resultados, tempo de implantação, custos etc.

Projetos de Transformação Digital com viés de Indústria 4.0, focados em paperless, redução de atividades, tarefas sem valor agregado (non value added) e análise de dados para tomada de decisão. Padronização dos Processos Industriais.

Colaboradores conectados à linha de produção: telas em cada posto de trabalho com todas as informações sobre a linha de produção para diferentes modelos de veículos), início de produção automatizado com seu conjunto de peças, ferramental mais urgências, controlados por tablets ou celulares. Chefe da unidade industrial com visão real time dos sistemas, da produção e dos colaboradores. Soluções de treinamento dos colaboradores com Realidade Aumentada.

Estas iniciativas envolvem tecnologias de Big Data, Inteligência Artificial, Realidade Aumentada, Impressão 3D, Drones (para almoxarifados), bem como, a mudança de sistemas legados (alguns operando em mainframes) para sistemas digitais móveis na nuvem.

4. O escopo destes projetos foi interno ou envolveu o ecossistema da empresa?

Interno.

Qualificação dos Projetos

5. Quais foram as maiores dificuldades na aprovação dos projetos de Transformação Digital?

Comprovar o retorno financeiro (Business Case positivo); garantir apoio global; ter pessoas disponíveis e qualificadas para os projetos.

6. Foram apresentados Business Cases e os mesmos apresentavam indicadores financeiros claros e positivos (RoI, VPL, TIR etc.)

Sim, com estimativas e medição de VPL e TIR, inclusive com a metodologia de medição do retorno desdobradas nas áreas do negócio.

7. Quais foram as maiores dificuldades na implantação destes projetos?

Curva de adoção das inovações na área industrial gerando desconfianças. Frustação com a ausência de retorno imediato.

8. Foram projetos desenvolvidos localmente ou *rollouts*?

Projetos locais (principalmente os relacionados com a realidade local das operações; rollouts da matriz e a partir do Brasil para outras plantas.

9. O quão alinhados com os objetivos estratégicos estes projetos estão / estavam?

Completamente alinhados, tanto localmente (Latam) quanto globalmente.

10. Estes projetos foram incluídos no planejamento orçamentário ou foram extra budget?

Sim, inclusive contando com dotação orçamentária própria às iniciaitvas de transformação digital.

11. Quais foram as lições aprendidas com os projetos já implantados? Elas estão sendo consideradas nos novos projetos?

“Transformação Digital é um processo vivo e tem que agregar valor à companhia!”

Impactos dos Projetos

12. Como foi o “dia seguinte” à implantação dos projetos?

Uma parte dos colaboradores resistentes e a outra parte engajada por verem valor presente e futuro às operações.

13. Quais foram os benefícios propiciados para a área cliente com a entrega dos projetos?

Ganho de tempo na execução dos processos incrementando a produtividade da linha de produção (veículos por minuto); incremento da disponibilidade e da qualidade dose dados para tomada de decisão.

14. Houve percepção das áreas dos resultados destes projetos?

Sim e bastante positiva.

15. Quais foram as mudanças que as áreas tiveram que fazer para se adaptar aos projetos?

Adaptação nas rotinas diárias com apoio de treinamento contínuo. Maior dedicação em termos de horas nos primeiros momentos que foi normalizando a medida que foi incrementando a curva de experiência com as soluções digitais.

16. Houve aumento de produtividade, redução de custos, aumento da satisfação do cliente, incremento de *market share*, melhoria da imagem da empresa ou dos produtos, melhoria dos processos internos, redução dos tempos de desenvolvimento, redução dos tempos de entrega dos insumos, peças e partes, bem como, dos produtos acabados, melhoria no relacionamento com os concessionários etc?

Sim (ganho de tempo na operação) sim, sim, não, sim, sim, sim, sim, sim.

17. Quais métricas são utilizadas para medir os resultados dos projetos de Transformação Digital?

Tempo de produção por veículo; disponibilidade da informação; qualidade de vida do colaborador; retorno finaceiro.

18. Houve a criação de novos produtos, de um novo processo, redução de overhead?

Criação de novos processos e novas análises devido à disponibilidade de dados anteriormente não disponíveis.

19. Houve retorno financeiro nos projetos? Em que percentual médio (projeto)? E em que proporção (quantidade de projetos com retorno financeiro positivo)?

Sim, pelo menos os mais visíveis.

20. Quais foram os impactos negativos?

Frustação com projetos que foram interrompidos, aumentando a resistência de parte da organização; falta de transversalidade (foco na Industrial) gerando desconfianças nas outras áreas.

Avaliação dos Projetos

21. Qual a percepção das áreas clientes sobre os resultados dos projetos de Transformação Digital?

É pré-requisito, principalmente para a área Industrial, para evitar a obsolescência.

22. O que poderia ser feito diferente na gestão do *portfolio* destes projetos?

Maior foco na geração e disponibilização da informação.

23. Qual a avaliação da Diretoria sobre estes projetos?

“É um caminho sem volta.”

E07

Descrição dos Projetos

1. Quais foram as iniciativas de Transformação Digital (precisa qualificar) implantadas na empresa nos últimos 10 anos? Em quais áreas? Com quais tecnologias habilitadoras?
2. Quais os projetos de Transformação Digital (precisa qualificar) vocês estão implantando atualmente na empresa? Em quais áreas? Com quais tecnologias habilitadoras?
3. Listagem dos projetos com sumário do histórico seus objetivos, tecnologias, resultados, tempo de implantação, custos etc.

Mais de 20 projetos voltados para digitalização do processo industrial, análise de dados e paperless, com foco no aumento de competitividade industrial da filial Brasil, utilizando soluções digitais desenvolvidas internamente, complementando (roll out), projetos iniciados na matriz de incremento da competitividade dos sistemas fabris.

Inspeção do processo de soldagem real time; detecção de defeitos na pintura; robotização na montagem todos em linha com o modelo de Indústria 4.0, digitalizando os processos e gerando dados para análise e tomada de decisão.

Além disto, houveram projetos nas áreas de Logística (inbound), Marketing (pós vendas); Produto (lançamentos virtuais de veículos novos), Jurídico e Compras.

e-Commerce. Canais de venda digitais para veículos e peças & acessórios e serviços. Plataforma Digital. Veículos conectados.

Estas iniciativas envolveram tecnologias de Big Data, Inteligência Artificial, Internet das Coisas e Robótica no aumento dos níveis de automação e ressuprimento das linhas de produção.

4. O escopo destes projetos foi interno ou envolveu o ecossistema da empresa?

Incluiu o ecossistema da empresa principalmente as concessionárias (trabalho de base).

Qualificação dos Projetos

5. Quais foram as maiores dificuldades na aprovação dos projetos de Transformação Digital?

Tecnologia muito à frente da realidade do consumidor. Provar Business Cases negativos para poder estar adiante da concorrência com uma imagem de inovação. Aprovar projetos de update tecnológico.

6. Quais foram as maiores dificuldades na implantação destes projetos?

Diferença de tecnologia em relação à matriz evidenciando uma lacuna com relação à realidade tecnológica nacional. Processos desatualizados e não definidos. Integração com os sistemas bancários. Baixa adesão dos clientes finais. Baixa divulgação. Barreiras culturais do time.

7. Quais foram os fatores críticos de sucesso destes projetos?

Equipe técnica qualificada e focada. Metodologia Ágil.

8. Foram projetos desenvolvidos localmente ou *rollouts*?

Projetos locais com rollouts do Brasil para outras plantas na Latam.

9. O quão alinhados com os objetivos estratégicos estes projetos estão / estavam?

Completamente alinhados com os objetivos do negócio.

10. Existe um *roadmap* / governança / escritório de projetos / *portfolio* específico para os projetos de Transformação Digital?

Sim. Existe e é Global e Local, com um roadmap de 5 anos. Gestão conjunta – IT & Business. Governança e recursos compartilhados globalmente.

11. Houve a participação de entidades externas (consultorias, ICTs, startups, parceiros, fornecedores) ou foi desenvolvimento interno?

Consultorias contratadas pela matriz.

12. Contou com o patrocínio da Diretoria? Alguma em específico? Houve envolvimento dos colaboradores das áreas clientes?

Sim, total, acompanhando o roadmap e atuando nos casos necessários de priorização.

13. Quais foram as lições aprendidas com os projetos já implantados? Elas estão sendo consideradas nos novos projetos?

Maior envolvimento da área de negócios. Resistir as pressões por tempos de implantação menores. Ter mais tempo de qualidade para o Go Live.

Impactos dos Projetos

14. Como foi o “dia seguinte” à implantação dos projetos?

Sistemas em produção com processos desalinhados. Necessidade de atividades manuais para cobrir a lacuna dos processos. Partes dos novos sistemas em desenvolvimento.

15. Quais foram os benefícios propiciados para a área cliente com a entrega dos projetos?

Melhoria dos processos a médio prazo. Incremento da imagem inovadora.

16. Houve percepção das áreas dos resultados destes projetos?

Sim.

17. Quais foram as mudanças que as áreas tiveram que fazer para se adaptar aos projetos?

Adequação de inventários. Atualização de sistemas legados. Revisão dos processos e procedimentos.

18. Houve aumento de produtividade, redução de custos, aumento da satisfação do cliente, incremento de *market share*, melhoria da imagem da empresa ou dos produtos, melhoria dos processos internos, redução dos tempos de desenvolvimento, redução dos tempos de entrega dos insumos, peças e partes, bem como, dos produtos acabados, melhoria no relacionamento com os concessionários etc?

Sim, não, n/a, não, sim, sim, não, não, sim.

19. Quais métricas são utilizadas para medir os resultados dos projetos de Transformação Digital?

Número de leads digitais (aumento de 20% nos leads totais).

20. Houve a criação de novos produtos, de um novo processo, redução de overhead?

Sim, novos processos.

21. Houve retorno financeiro nos projetos? Em que percentual médio (projeto)? E em que proporção (quantidade de projetos com retorno financeiro positivo)?

Não. Negativos.

22. Houve a criação de *spin offs* ou *startups* a partir destes projetos?

Não.

23. Houve *spillovers* como consequência destes projetos?

Não.

24. Quais foram os impactos negativos?

Decepção com a baixa adesão dos clientes finais.

Avaliação dos Projetos

25. Qual a percepção das áreas clientes sobre os resultados dos projetos de Transformação Digital?

Aposta alta na Transformação Digital. Aumentos dos investimentos em projetos de Transformação Digital.

26. O que poderia ser feito diferente na gestão do *portfolio* destes projetos?

Priorização dos projetos pela necessidade do negócio.

27. Qual a avaliação da Diretoria sobre estes projetos?

Positiva. Estamos no caminho certo. Criação de uma diretoria de Transformação Digital.

E08

Descrição dos Projetos

1. Quais foram as iniciativas de Transformação Digital (precisa qualificar) implantadas na empresa nos últimos 10 anos? Em quais áreas? Com quais tecnologias habilitadoras?
2. Quais os projetos de Transformação Digital (precisa qualificar) vocês estão implantando atualmente na empresa? Em quais áreas? Com quais tecnologias habilitadoras?
3. Listagem dos projetos com sumário do histórico seus objetivos, tecnologias, resultados, tempo de implantação, custos etc.

Mais de 20 projetos voltados para digitalização do processo industrial, análise de dados e paperless, com foco no aumento de competitividade industrial da filial Brasil, utilizando soluções digitais desenvolvidas internamente, complementando (roll out), projetos iniciados na matriz de incremento da competitividade dos sistemas fabris.

Inspeção do processo de soldagem real time; detecção de defeitos na pintura; robotização na montagem todos em linha com o modelo de Indústria 4.0, digitalizando os processos e gerando dados para análise e tomada de decisão.

Além disto, houveram projetos nas áreas de Logística (inbound), Marketing (pós vendas); Produto (lançamentos virtuais de veículos novos), Jurídico e Compras.

e-Commerce. Canais de venda digitais para veículos e peças & acessórios e serviços. Plataforma Digital. Veículos conectados.

Estas iniciativas envolveram tecnologias de Big Data, Inteligência Artificial, Internet das Coisas e Robótica no aumento dos níveis de automação e ressuprimento das linhas de produção.

4. O escopo destes projetos foi interno ou envolveu o ecossistema da empresa?

Interno.

Qualificação dos Projetos

5. Quais foram as maiores dificuldades na aprovação dos projetos de Transformação Digital?

Aprovação global tanto nos roll outs dos projetos oriundos da matriz quanto nas iniciativas locais. Diferenciação das regras de aprovação global para os projetos estratégicos de transformação digital. Utilização do INOVAR-AUTO como diferencial para a aprovação de projetos locais, mas mesmo assim, demandaram mais esforço e tempo para aprovação do que os roll outs.

6. Foram apresentados Business Cases e os mesmos apresentavam indicadores financeiros claros e positivos (RoI, VPL, TIR etc.)

Sim. Extremamente estruturados seguindo os procedimentos de aprovação de projetos de investimento. Foco na lucratividade e no aumento de market share.

7. Quais foram as maiores dificuldades na implantação destes projetos?

Equilíbrio entre os riscos envolvidos e os ganhos; dependência da matriz. Certa resistência por parte da organização devido ao ineditismo do tema, que foi diminuindo a medida que a curva de experiencia foi avançando.

8. Quais foram os fatores críticos de sucesso destes projetos?

Apoio da alta direção; disciplina financeira.

9. Foram projetos desenvolvidos localmente ou *rollouts*?

Quase todos roll outs, todavia, alguns projetos poderam ser categorizados como de Pesquisa e Desenvolvimento dentro do arcabouço de incentivo fiscal do INOVAR-AUTO

10. O quão alinhados com os objetivos estratégicos estes projetos estão / estavam?

100% alinhados à Estratégia pois transformação digital é parte integrante da estratégia global da empresa.

11. Estes projetos foram incluídos no planejamento orçamentário ou foram extra budget?

Todos os projetos foram formalizados dentro do planejamento orçamentário da companhia, com exceção daqueles categorizados como P&D que tiveram subsídios do programa INOVAR-AUTO.

12. Existe um *roadmap* / governança / escritório de projetos / *portfolio* específico para os projetos de Transformação Digital?

Não, estas iniciativas seguem a estrutura de governança normal nas áreas de negócio e TI.

13. Houve a participação de entidades externas (consultorias, ICTs, startups, parceiros, fornecedores) ou foi desenvolvimento interno?

Sim. Além do time interno, foram envolvidos diversos ICTs e IES principalmente nos projetos de P&D, além de consultorias, desenvolvedores e provedores de solução de digitalização.

14. Contou com o patrocínio da Diretoria? Alguma em específico? Houve envolvimento dos colaboradores das áreas clientes?

Sim, principalmente das áreas de negócio, sendo que a TI, desempenha papel de suporte. “O projeto de transformação digital é da área de negócio”.

15. Quais foram as lições aprendidas com os projetos já implantados? Elas estão sendo consideradas nos novos projetos?

Necessidade de parceiros institucionais (ICT e IES) para desenvolver projetos de P&D (dificuldade de desenvolver internamente este tipo de projeto pela dificuldade de mensurar retorno financeiro positivo). Necessidade de maiores cuidados nos dias seguintes à entrada em produção. Seleção mais cuidadosa dos parceiros. Acompanhamento mensal dos projetos globais.

Impactos dos Projetos

16. Como foi o “dia seguinte” à implantação dos projetos?

Com percalços. Nenhuma das iniciativas de transformação digital entrou em operação sem resistências (modelo mental), demandaram mudança de rumo nas áreas. Essas resistência forma diminuindo em um processo de melhoria contínua.

17. Quais foram os benefícios propiciados para a área cliente com a entrega dos projetos?

Aumento da produtividade em decorrência da redução do tempo por veículo prioduzido e da redução de custo unitário; incremento da qualidade dos veículos.

18. Houve percepção das áreas dos resultados destes projetos?

Sim. Houve um empoderamento das áreas de negócio. “Brilho nos olhos”, após a barreira inicial. Havia uma preocupação inicial com redução de pessoal que não ocorreu - pessoal excedente após a entrada em produção das soluções foi realocado.

19. Quais foram as mudanças que as áreas tiveram que fazer para se adaptar aos projetos?

Aprendizado nas novas tecnologias (ganho de conhecimento) e preparo organizacional.

20. Houve aumento de produtividade, redução de custos, aumento da satisfação do cliente, incremento de *market share*, melhoria da imagem da empresa ou dos produtos, melhoria dos processos internos, redução dos tempos de desenvolvimento, redução dos tempos de entrega dos insumos, peças e partes, bem como, dos produtos acabados, melhoria no relacionamento com os concessionários etc?

Sim (diminuição do tempo de produção por veículo e redução do custo de produção unitário), sim, sim, não, sim, sim, sim, sim, sim.

21. Quais métricas são utilizadas para medir os resultados dos projetos de Transformação Digital?

Financeiro (VPL e ROI e Payback).

22. Houve a criação de novos produtos, de um novo processo, redução de overhead?

Houve a criação de noivos processos e a redução de overhead na área mas que foi realocada.

23. Houve retorno financeiro nos projetos? Em que percentual médio (projeto)? E em que proporção (quantidade de projetos com retorno financeiro positivo)?

Sim. 70% dos projetos apresentaram algum tipo de retorno financeiro.

24. Houve a criação de *spin offs* ou *startups* a partir destes projetos?

Sim. Uma empresa para realizar o inventário de veículos nas concessionárias de forma digital e uma startup voltada para a detecção de falhas na pintura.

25. Houve *spillovers* como consequência destes projetos?

Incubação de projetos de inovação, via um parque tecnológico que reúne, startups, ICTs e IES.

26. Quais foram os impactos negativos?

Conflitos com a matriz por aspectos financeiros.

Avaliação dos Projetos

27. Qual a percepção das áreas clientes sobre os resultados dos projetos de Transformação Digital?

Houve um completo buy-in das áreas de negócio.

28. O que poderia ser feito diferente na gestão do portfolio destes projetos?

Maior flexibilidade nas metas financeiras e maior apoio da matriz.

29. Qual a avaliação da Diretoria sobre estes projetos?

Da necessidade de continuidade com as iniciativas de transformação digital, contando com total suporte e aprovação da alta administração.

E09

Descrição dos Projetos

1. Quais foram as iniciativas de Transformação Digital (precisa qualificar) implantadas na empresa nos últimos 10 anos? Em quais áreas? Com quais tecnologias habilitadoras?
2. Quais os projetos de Transformação Digital (precisa qualificar) vocês estão implantando atualmente na empresa? Em quais áreas? Com quais tecnologias habilitadoras?
3. Listagem dos projetos com sumário do histórico seus objetivos, tecnologias, resultados, tempo de implantação, custos etc.

Desenvolvimento de um manual de instrução dos veículos cognitivo, por meio de aplicação desenvolvida com a tecnologia de Inteligência Artificial da IBM – Watson. Este projeto resultou na economia de 120 campos de futebol por ano em termos de uso de celulose, significando ESG em pura essência.

Inventário digital realizado por Drones substituindo os seres humanos e reduzindo o tempo de execução em mais de 90%, implantado em 4 plantas industriais.

Linha de produção com ajustes ergonômicos desenvolvidos por meio de Gêmeos Digitais (Realidade Virtual) reduzindo os afastamentos em 92%.

Centralização de todos os canais de marketing digital da empresa: websites, apps, call center, concessionárias; com o emprego de chatbots. Atendimento on-line nas concessionárias.

e-Commerce. Canais de venda digitais para veículos e peças & acessórios e serviços. Plataforma Digital

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Linha de produção com ajustes ergonômicos desenvolvidos por meio de Gêmeos Digitais (Realidade Virtual) reduzindo os afastamentos em 92%.

4. O escopo destes projetos foi interno ou envolveu o ecossistema da empresa?

Interno e com a rede de concessionárias no Brasil.

Qualificação dos Projetos

5. Quais foram as maiores dificuldades na aprovação dos projetos de Transformação Digital?

Associar ao Business Case os ganhos com a melhora da imagem do produto e da empresa. Comprovar o retorno financeiro (VPL e RoI) principalmente nas auditorias pós go live. Mensurar o valor dos dados do cliente capturados com os projetos.

6. Quais foram as maiores dificuldades na implantação destes projetos?

Adaptabilidade ao digital por parte dos colaboradores, concessionários e clientes. Alta expectativa de ganhos rápidos de produtividade no processo. Alteração nos processos. Sindicato!

7. Quais foram os fatores críticos de sucesso destes projetos?

Expectativa de tempo para a entrada em produção alinhada com o tempo de execução. Controle da ansiedade dos colaboradores e da alta administração. Entendimento que é uma jornada que exige mudança processual, mas principalmente mudança cultural. Patrocínio da alta administração.

8. Foram projetos desenvolvidos localmente ou *rollouts*?

Projetos locais com rollouts do Brasil para outras plantas (EUA, África e Europa).

9. O quão alinhados com os objetivos estratégicos estes projetos estão / estavam?

100% alinhados devido à transformação digital ser um dos pilares estratégicos da companhia. Inovação e melhoria do atendimento aos clientes são elementos do planejamento estratégico, habilitados pela digitalização.

10. Existe um *roadmap* / governança / escritório de projetos / *portfolio* específico para os projetos de Transformação Digital?

Sim, respondendo diretamente à alta administração, mas migrando para a área de TI a medida de os projetos vão conquistando maturidade.

11. Houve a participação de entidades externas (consultorias, ICTs, startups, parceiros, fornecedores) ou foi desenvolvimento interno?

Time interno com desenvolvedores externos (consultorias), grandes consultorias e provedores de tecnologia de transformação digital, além disto, startups e ICTs fizeram parte nos projetos de transformação digital, assim como, ecossistemas de inovação.

12. Contou com o patrocínio da Diretoria? Alguma em específico? Houve envolvimento dos colaboradores das áreas clientes?

Sim, com relatórios quinzenais à diretoria sobre o andamento dos projetos e os resultados dos já implantados.

13. Quais foram as lições aprendidas com os projetos já implantados? Elas estão sendo consideradas nos novos projetos?

Sigilo nos projetos estratégicos, principalmente, aqueles desenvolvidos para a área de desenvolvimento do produto e marketing. Envolvimento de mais pessoas e em projetos de maior valor agregado. Maior atenção à transformação cultural.

Impactos dos Projetos

14. Como foi o “dia seguinte” à implantação dos projetos?

Uma migração de euforia para preocupação para necessidade de escalar a solução.

15. Quais foram os benefícios propiciados para a área cliente com a entrega dos projetos?

Agilidade, como por exemplo a redução em mais de 90% nos tempos de execução dos processos. Maior percepção de modernidade por parte dos clientes. Redução dramática do consumo de papel (ESG). Redução em maios de 92% dos afastamentos por problemas relacionados a ergonomia.

16. Houve percepção das áreas dos resultados destes projetos?

Sim, em parte pela ampla divulgação dos resultados inclusive internacionalmente. Reflexo de um trabalho consistente de gestão da mudança cultural.

17. Quais foram as mudanças que as áreas tiveram que fazer para se adaptar aos projetos?

Inclusão de procedimentos novos, treinamento de colaboradores e concessionários, instrução de clientes e mudança cultural visando uma percepção digital.

18. Houve aumento de produtividade, redução de custos, aumento da satisfação do cliente, incremento de *market share*, melhoria da imagem da empresa ou dos produtos, melhoria dos processos internos, redução dos tempos de desenvolvimento, redução dos tempos de entrega dos insumos, peças e partes, bem como, dos produtos acabados, melhoria no relacionamento com os concessionários etc?

Sim, Sim, Sim, Sim, Sim, Sim, não, não, sim.

19. Quais métricas são utilizadas para medir os resultados dos projetos de Transformação Digital?

Financeiro (VPL e ROI); tempo de operação, custo da operação, otimização dos processos, satisfação do cliente.

20. Houve a criação de novos produtos, de um novo processo, redução de overhead?

Sim. Houve a criação de novos produtos, de um novo processo e redução de overhead.

21. Houve retorno financeiro nos projetos? Em que percentual médio (projeto)? E em que proporção (quantidade de projetos com retorno financeiro positivo)?

Sim. Todos os projetos apresentaram algum tipo de retorno financeiro, chegando a alcançar 1.200%.

22. Houve a criação de *spin offs* ou *startups* a partir destes projetos?

Não.

23. Houve *spillovers* como consequência destes projetos?

Sim, houve a desenvolvimento de uma nova tecnologia junto com um fornecedor voltado para a redução de CO2 na atmosfera..

24. Quais foram os impactos negativos?

Relação com o sindicato e consequentemente a imagem negativa da transformação digital como ameaça ao emprego.

Avaliação dos Projetos

25. Qual a percepção das áreas clientes sobre os resultados dos projetos de Transformação Digital?

Sem resposta.

26. O que poderia ser feito diferente na gestão do *portfolio* destes projetos?

A transformação digital deveria ter nascido dentro das áreas usuárias.

27. Qual a avaliação da Diretoria sobre estes projetos?

Positiva.

E10

Descrição dos Projetos

1. Quais foram as iniciativas de Transformação Digital (precisa qualificar) implantadas na empresa nos últimos 10 anos? Em quais áreas? Com quais tecnologias habilitadoras?
2. Quais os projetos de Transformação Digital (precisa qualificar) vocês estão implantando atualmente na empresa? Em quais áreas? Com quais tecnologias habilitadoras?
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e-Commerce. Canais de venda digitais para veículos e peças & acessórios e serviços. Plataforma Digital

Inventário digital realizado por Drones substituindo os seres humanos e reduzindo o tempo de execução em mais de 90%, implantado em 4 plantas industriais.

Linha de produção com ajustes ergonômicos desenvolvidos por meio de Gêmeos Digitais (Realidade Virtual) reduzindo os afastamentos em 92%.

Centralização de todos os canais de marketing digital da empresa: websites, apps, call center, concessionárias; com o emprego de chatbots.

4. O escopo destes projetos foi interno ou envolveu o ecossistema da empresa?

Interno e com a rede de concessionárias no Brasil.

Qualificação dos Projetos

5. Quais foram as maiores dificuldades na aprovação dos projetos de Transformação Digital?

Demanda concorrente por mais recursos humanos e por investimentos. Inclusão de novas tecnologias no desenvolvimento dos veículos. Voz ativa das áreas interessadas.

6. Quais foram as maiores dificuldades na implantação destes projetos?

Coleta dos dados dos veículos e atrasos na entrada em produção dos projetos.

7. Quais foram os fatores críticos de sucesso destes projetos?

Sinergia entre as áreas, patrocínio da alta administração, disponibilidade financeira.

8. O quão alinhados com os objetivos estratégicos estes projetos estão / estavam?

Totalmente alinhados, visto que são projetos que afetam a tomada de decisão de compra por parte do cliente.

9. Quais foram as lições aprendidas com os projetos já implantados? Elas estão sendo consideradas nos novos projetos?

Maior velocidade na implantação dos projetos e recuperação do atraso tecnológico da empresa.

Impactos dos Projetos

10. Como foi o “dia seguinte” à implantação dos projetos?

Consciência do diferencial competitivo mas com pouca divulgação.

11. Quais foram os benefícios propiciados para a área cliente com a entrega dos projetos?

Aumento (3x) da usabilidade das novas tecnologias por parte das concessionárias.

12. Houve percepção das áreas dos resultados destes projetos?

Sim, boa percepção dos clientes e nota alta nas app stores.

13. Quais foram as mudanças que as áreas tiveram que fazer para se adaptar aos projetos?

Aumento no treinamento, ajuste nos processos e procedimentos, cobrança junto ao time de vendas inclusive fazendo parte das metas e bonificação.

14. Houve aumento de produtividade, redução de custos, aumento da satisfação do cliente, incremento de *market share*, melhoria da imagem da empresa ou dos produtos, melhoria dos processos internos, redução dos tempos de desenvolvimento, redução dos tempos de entrega dos insumos, peças e partes, bem como, dos produtos acabados, melhoria no relacionamento com os concessionários etc?

Sim, Não, Sim, Não, Sim, Sim, n/a, n/a, Sim.

15. Quais métricas são utilizadas para medir os resultados dos projetos de Transformação Digital?

KPI de usabilidade. Notas nas App Stores.

16. Houve a criação de novos produtos, de um novo processo, redução de overhead?

Houve a criação de novos produtos e de novos processos, mas não houve redução de overhead.

17. Houve retorno financeiro nos projetos? Em que percentual médio (projeto)? E em que proporção (quantidade de projetos com retorno financeiro positivo)?

Sim, por meio do aumento da satisfação do cliente e da coleta de maiores volumes de dados dos clientes.

18. Houve a criação de *spin offs* ou *startups* a partir destes projetos?

Não.

19. Houve *spillovers* como consequência destes projetos?

Não.

20. Quais foram os impactos negativos?

Baixo uso da nova tecnologia nos primeiros momentos. Atraso frente a concorrência.

Avaliação dos Projetos

21. Qual a percepção das áreas clientes sobre os resultados dos projetos de Transformação Digital?

Positiva pelo avanço da digitalização, mas consciência que ainda estão no início da jornada.

22. O que poderia ser feito diferente na gestão do *portfolio* destes projetos?

Ter iniciado o processo mais cedo e com maior patrocínio.

23. Qual a avaliação da Diretoria sobre estes projetos?

Positiva, reconhecendo a transformação digital como um diferencial da marca. Maior cobrança na execução dos projetos devido a relevância dos mesmos. Preocupação com os novos entrantes com maior nível de digitalização nos produtos e processos (chineses).

E11

Qualificação dos Projetos

1. Quais foram as maiores dificuldades na aprovação dos projetos de Transformação Digital?

Fazer as pessoas acreditarem na mudança, na novidade! Comprovar o retorno financeiro, que o projeto agrega valor.

2. Foram apresentados Business Cases e os mesmos apresentavam indicadores financeiros claros e positivos (RoI, VPL, TIR etc.)?

Sim, VPL, TIR, RoI e Payback.

3. Quais foram as maiores dificuldades na implantação destes projetos?

Convencer os diversos stakeholders a adotar as novas tecnologias. Impacto na rede de concessionários. Prazos muito curtos.

4. Quais foram os fatores críticos de sucesso destes projetos?

Reconhecimento da relevância dos projetos. Patrocínio da alta direção.

5. O quão alinhados com os objetivos estratégicos estes projetos estão / estavam?

100 % alinhados ao Planejamento Estratégico mas também impactaram os objetivos estratégicos à medida que os resultados foram aparecendo.

6. Estes projetos foram incluídos no planejamento orçamentário ou foram extra budget?

Houve ambos os casos. Alguns foram incluídos no planejamento orçamentário e outros foram extra budget.

7. Existe um *roadmap* / governança / escritório de projetos / *portfolio* específico para os projetos de Transformação Digital?

A gestão é a cargo da TI.

8. Houve a participação de entidades externas (consultorias, ICTs, startups, parceiros, fornecedores) ou foi desenvolvimento interno?

Sim. Grandes consultorias trabalhando com o time interno.

9. Contou com o patrocínio da Diretoria? Alguma em específico? Houve envolvimento dos colaboradores das áreas clientes?

Sim, principalmente das Diretorias Comercial e Marketing.

10. Quais foram as lições aprendidas com os projetos já implantados? Elas estão sendo consideradas nos novos projetos?

Erro é elemento fundamental na aprendizagem e o protótipo (MVP) é instrumento de aprendizado.

Impactos dos Projetos

11. Como foi o “dia seguinte” à implantação dos projetos?

Se o projeto estivesse funcionado a contento, o dia foi calmo. Todavia, se o projeto não estivesse funcionando aí foi um caos.

12. Quais foram os benefícios propiciados para a área cliente com a entrega dos projetos?

Maior visibilidade dos dados. Aumento nas vendas. Venda completamente digital. Aumento da percepção do cliente de comodidade.

13. Houve percepção das áreas dos resultados destes projetos?

Sim.

14. Quais foram as mudanças que as áreas tiveram que fazer para se adaptar aos projetos?

Não sei.

15. Houve aumento de produtividade, redução de custos, aumento da satisfação do cliente, incremento de *market share*, melhoria da imagem da empresa ou dos produtos, melhoria dos processos internos, redução dos tempos de desenvolvimento, redução dos tempos de entrega dos insumos, peças e partes, bem como, dos produtos acabados, melhoria no relacionamento com os concessionários etc?

Sim, sim, sim, sim, sim, sim, sim, sim, não sei.

16. Quais métricas são utilizadas para medir os resultados dos projetos de Transformação Digital?

Tempo de fechamento da venda. RoI. Pesquisa qualitativa. Completude do budget

17. Houve a criação de novos produtos, de um novo processo, redução de overhead?

Sim, em piloto.

18. Houve retorno financeiro nos projetos? Em que percentual médio (projeto)? E em que proporção (quantidade de projetos com retorno financeiro positivo)?

Sim. Não sei. A maioria dos projetos.

19. Quais foram os “campeões” (referências)?

Manual Cognitivo e DDX – venda digital do carro.

20. Houve a criação de *spin offs* ou *startups* a partir destes projetos?

Sim. Fintech de serviços financeiros tecnológicos.

21. Houve *spillovers* como consequência destes projetos?

Sim, com a EMBRAPII.

22. Quais foram os impactos negativos?

Aumento da complexidade dos sistemas. Crescimento digital desordenado necessitando unificação.

Avaliação dos Projetos

23. Qual a percepção das áreas clientes sobre os resultados dos projetos de Transformação Digital?

Muito boa.

24. O que poderia ser feito diferente na gestão do portfolio destes projetos?

Maiores investimentos já na fase de aprovação.

25. Qual a avaliação da Diretoria sobre estes projetos?

“A ficha caiu”. Toda a empresa está comprometida. O Digital é “uma necessidade básica para existir”.

E12

Descrição dos Projetos

1. Quais foram as iniciativas de Transformação Digital (precisa qualificar) implantadas na empresa nos últimos 10 anos? Em quais áreas? Com quais tecnologias habilitadoras?
2. Quais os projetos de Transformação Digital (precisa qualificar) vocês estão implantando atualmente na empresa? Em quais áreas? Com quais tecnologias habilitadoras?
3. Listagem dos projetos com sumário do histórico seus objetivos, tecnologias, resultados, tempo de implantação, custos etc.

Mudança de modelo mental! Validação de desenvolvimento de novos veículos com protótipo à 100% virtual (exceto Crash Test). Virtualização do desenvolvimento do produto. Carro as a Service, conectado e eletrificado. ADAS. Carros sensorizados gerando big data. Aplicativo para relacionamento digital com o cliente e atualização de calibração, software etc. remota. Gêmeo digital na linha de produção para prova de fatibilidade de produção de novos veículos. Linha de produção e ressuprimento automatizados, sensorizadas, com análise preditiva e rastreabilidade, em linha com os conceitos de I4.0. 100% de requerimento e recebimento de material direto automatizados. Rastreabilidade pelo cliente do carro novo adquirido na linha de produção. Venda de veículos totalmente digital, inclusive financiamento. Reserva de compra de veículos em pré-lançamento via Whatsapp. CRM totalmente operado no SalesForce e Whatsapp como principal canal de comunicação com o cliente de um carro novo. Teste de frota: confiabilidade, rodagem, análise de falhas (causa-raiz).

4. O escopo destes projetos foi interno ou envolveu o ecossistema da empresa?

Todo o ecossistema.

Qualificação dos Projetos

5. Quais foram as maiores dificuldades na aprovação dos projetos de Transformação Digital?

Fazer a empresa entender que projetos de Transformação Digital são caros mas tem retorno. Trabalhar a mudança cultural da empresa e do nível executivo. “O negócio não é sustentável sem Transformação Digital”.

6. Quais foram as maiores dificuldades na implantação destes projetos?

Mudança cultural e equilíbrio dos resultados esperado entre curto e longo prazo.

7. Quais foram os fatores críticos de sucesso destes projetos?

Comunicação. Inovação internalizada como valor. Direção da empresa disposta a sair da zona de conforto. Presença da área de TI no Board.

8. Foram projetos desenvolvidos localmente ou *rollouts*?

Local 100%.

9. O quão alinhados com os objetivos estratégicos estes projetos estão / estavam?

100 % alinhados ao Planejamento Estratégico. A origem dos projetos de Transformação Digital reside no Plano Estratégico.

10. Existe um *roadmap* / governança / escritório de projetos / *portfolio* específico para os projetos de Transformação Digital?

Inicialmente liderado pela área de TI com pessoas evangelizadoras nas áreas promovendo mudança cultural. Hoje pertence as áreas de negócio.

11. Houve a participação de entidades externas (consultorias, ICTs, startups, parceiros, fornecedores) ou foi desenvolvimento interno?

O desenho e a estratégia da Transformação Digital totalmente interna. Na execução com a participação de Consultorias, time interno, ICTs, IEs e startups.

12. Contou com o patrocínio da Diretoria? Alguma em específico? Houve envolvimento dos colaboradores das áreas clientes?

Sim, em todos os momentos.

13. Quais foram as lições aprendidas com os projetos já implantados? Elas estão sendo consideradas nos novos projetos?

Que Apresentações / Propostas não entregam resultados. Planejamento é diferente da execução. É necessário ter uma visão única. Valor é o que se entrega ao cliente: final, concessionário ou interno. A área de TI deve ser uma aliada, mas não a protagonista, e deve falar o idioma do negócio. Agilidade deve fazer parte da cultura da empresa. Comunicação e Gestão da Mudança são pilares da Transformação Digital.

Impactos dos Projetos

14. Como foi o “dia seguinte” à implantação dos projetos?

O negócio e a TI estiveram juntos para “o bem ou para o mal”. Na área industrial foi missão crítica; na área comercial foco na velocidade; no back-office voltado para eficiência da estrutura.

15. Quais foram os benefícios propiciados para a área cliente com a entrega dos projetos?

Redução de custos e tempos (desenvolvimento dos produtos, de suprimento, de entrega dos veículos etc.). Aumento da produtividade.

16. Houve percepção das áreas dos resultados destes projetos?

Sim, amento da eficiência operacional com maior produtividade e menos pessoas nas atividades operativas. Paperless. Aumento da integração entre as áreas, maior disponibilidade de dados para a tomada de decisão e aumento da competitividade.

17. Quais foram as mudanças que as áreas tiveram que fazer para se adaptar aos projetos?

Revisão dos processos e adequação cultural.

18. Houve aumento de produtividade, redução de custos, aumento da satisfação do cliente, incremento de *market share*, melhoria da imagem da empresa ou dos produtos, melhoria dos processos internos, redução dos tempos de desenvolvimento, redução dos tempos de entrega dos insumos, peças e partes, bem como, dos produtos acabados, melhoria no relacionamento com os concessionários etc?

Sim, sim, sim, sim, sim, sim, sim, sim.

19. Quais métricas são utilizadas para medir os resultados dos projetos de Transformação Digital?

Time to market dos produtos. Tempo de execução das tarefas. Produtividade.

20. Houve a criação de novos produtos, de um novo processo, redução de overhead?

Sim, sim e sim.

21. Houve retorno financeiro nos projetos? Em que percentual médio (projeto)? E em que proporção (quantidade de projetos com retorno financeiro positivo)?

Sim. Não sei. A maioria.

22. Quais foram os “campeões” (referências)?

Carro conectados e linha automatizada digital.

23. Houve a criação de *spin offs* ou *startups* a partir destes projetos?

Sim. Plataforma de conexão dos carros.

24. Houve *spillovers* como consequência destes projetos?

Não.

25. Quais foram os impactos negativos?

Aumento da complexidade das atividades. Choque cultural. Budget da área de TI cresceu vertiginosamente.

Avaliação dos Projetos

26. Qual a percepção das áreas clientes sobre os resultados dos projetos de Transformação Digital?

Já respondido.

27. O que poderia ser feito diferente na gestão do *portfolio* destes projetos?

Iniciado a jornada mais cedo.

28. Qual a avaliação da Diretoria sobre estes projetos?

Extremamente positiva e satisfeita com os resultados. Querendo mais.

E13

Descrição dos Projetos

1. Quais foram as iniciativas de Transformação Digital (precisa qualificar) implantadas na empresa nos últimos 10 anos? Em quais áreas? Com quais tecnologias habilitadoras?
2. Quais os projetos de Transformação Digital (precisa qualificar) vocês estão implantando atualmente na empresa? Em quais áreas? Com quais tecnologias habilitadoras?
3. Listagem dos projetos com sumário do histórico seus objetivos, tecnologias, resultados, tempo de implantação, custos etc.

Tudo. Validação de desenvolvimento de novos veículos com protótipo à 100% virtual (exceto Crash Test). Virtualização do desenvolvimento do produto. Carro as a Service, conectado e eletrificado. ADAS. Carros sensorizados gerando big data. Aplicativo para relacionamento digital com o cliente e atualização de calibração, software etc. remota. Gêmeo digital na linha de produção para prova de fatibilidade de produção de novos veículos. Linha de produção e ressuprimento automatizados, sensorizadas, com análise preditiva e rastreabilidade, em linha com os conceitos de I4.0. 100% de requerimento e recebimento de material direto automatizados. Rastreabilidade pelo cliente do carro novo adquirido na linha de produção. Venda de veículos totalmente digital, inclusive financiamento. Reserva de compra de veículos em pré-lançamento via Whatsapp. CRM totalmente operado no SalesForce e Whatsapp como principal canal de comunicação com o cliente de um carro novo. Teste de frota: confiabilidade, rodagem, análise de falhas (causa-raiz).

4. O escopo destes projetos foi interno ou envolveu o ecossistema da empresa?

Montadora como líder “puxando” os fornecedores e concessionários.

Qualificação dos Projetos

5. Quais foram as maiores dificuldades na aprovação dos projetos de Transformação Digital?

Comprovar nível de relevância para o Business. Ineditismo. Esforço com integração.

6. Quais foram as maiores dificuldades na implantação destes projetos?

Mudança de modelo mental, adoção de metodologias ágeis. Colaboração entre as áreas. Mudança cultural.

7. Quais foram os fatores críticos de sucesso destes projetos?

Trabalhar em times (squads). Adotar protótipos (MVP). Questionamentos iniciais bem elaborados e resolvido atuando como um filtro inicial.

8. Foram projetos desenvolvidos localmente ou *rollouts*?

Maioria iniciativas locais para atender à demandas locais. Algumas iniciativas rollouts da matriz e outras rollouts reversos.

9. O quão alinhados com os objetivos estratégicos estes projetos estão / estavam?

Desde a mudança do Plano Estratégico ocorrida há dois anos, quando adquiriu um foco digital, o alinhamento foi total.

10. Existe um roadmap / governança / escritório de projetos / portfolio específico para os projetos de Transformação Digital?

Possuí uma governança digital com roadmap, portfólio e programa específicos.

11. Houve a participação de entidades externas (consultorias, ICTs, startups, parceiros, fornecedores) ou foi desenvolvimento interno?

Sim. Há de tudo. Parcerias com ICTs, incentivos financeiros governamentais, parcerias com IEs, desenvolvimentos internos e com consultorias.

12. Contou com o patrocínio da Diretoria? Alguma em específico? Houve envolvimento dos colaboradores das áreas clientes?

Crescente. No passado mais forte na diretoria de IT, mas hoje todas as diretorias estão envolvidas e engajadas patrocinando fortemente as iniciativas.

13. Quais foram as lições aprendidas com os projetos já implantados? Elas estão sendo consideradas nos novos projetos?

Melhoria contínua. Criação de ambientes apropriados para a Transformação Digital. Desconexão dos times de desenvolvimento das rotinas diárias. Melhor planejamento da carga horária das pessoas. “Transformação Digital vai além do Hype”, é estrutural.

Impactos dos Projetos

14. Como foi o “dia seguinte” à implantação dos projetos?

Tranquilo, devido ao nível de envolvimento dos times nos projetos. “Pânico” restrito a etapa de testes.

15. Quais foram os benefícios propiciados para a área cliente com a entrega dos projetos?

Incremento do nível de NPS. Maior disponibilidade de tempo e de dados para tomada de decisão. Antecipação de falhas. “Dados, dados, dados, dados”. Melhora na percepção do cliente. Redução de custos. Incremento na geração leads.

16. Houve percepção das áreas dos resultados destes projetos?

Sim. “Hoje se tirar as ferramentas digitais as pessoas não trabalham”.

17. Quais foram as mudanças que as áreas tiveram que fazer para se adaptar aos projetos?

Mudanças nos processos, procedimentos e atividades.

18. Houve aumento de produtividade, redução de custos, aumento da satisfação do cliente, incremento de *market share*, melhoria da imagem da empresa ou dos produtos, melhoria dos processos internos, redução dos tempos de desenvolvimento, redução dos tempos de entrega dos insumos, peças e partes, bem como, dos produtos acabados, melhoria no relacionamento com os concessionários etc?

Sim, sim, sim, sim, sim, sim, sim, sim.

19. Quais métricas são utilizadas para medir os resultados dos projetos de Transformação Digital?

NPS. Produtividade.

20. Houve a criação de novos produtos, de um novo processo, redução de overhead?

Sim, para novos processos. Não houve redução de overhead, mas uma mudança no perfil de atividades das pessoas, menos operativo e mais analítico.

21. Houve retorno financeiro nos projetos? Em que percentual médio (projeto)? E em que proporção (quantidade de projetos com retorno financeiro positivo)?

Sim. Não sei. Quase 100%.

22. Quais foram os “campeões” (referências)?

Atendimento ao cliente. Linha automatizada. Carros conectados.

23. Houve a criação de *spin offs* ou *startups* a partir destes projetos?

Sim. Marketplace embarcado. Startup de aluguel de carros.

24. Houve *spillovers* como consequência destes projetos?

Sim, projetos de inclusão digital em comunidades carentes vizinha à planta.

25. Quais foram os impactos negativos?

Dificuldade da empresa em visualizar os benefícios mais rapidamente.

Avaliação dos Projetos

26. Qual a percepção das áreas clientes sobre os resultados dos projetos de Transformação Digital?

Não há como operar eficientemente o negócio sem ser de forma digital.

27. O que poderia ser feito diferente na gestão do *portfolio* destes projetos?

Nada.

28. Qual a avaliação da Diretoria sobre estes projetos?

“Se recusar a embarcar o digital é contratar uma morte não muito lenta”.

E14

Qualificação dos Projetos

1. Quais foram as maiores dificuldades na aprovação dos projetos de Transformação Digital?

Apresentar o desenho correto da solução com o devido alinhamento entre às áreas. Validação dos números do Business Case. Construção da proposta do projeto.

2. Foram apresentados Business Cases e os mesmos apresentavam indicadores financeiros claros e positivos (RoI, VPL, TIR etc.)?

Sim, VPL, TIR, RoI e Payback. Exceto projetos classificados como estratégicos (ex,: autonomia energética).

3. Quais foram as maiores dificuldades na implantação destes projetos?

Concorrência entre projetos de recursos humanos. Grande volume de projetos concorrentes. Canibalização de recursos.

4. Quais foram os fatores críticos de sucesso destes projetos?

Engajamento das áreas.

5. O quão alinhados com os objetivos estratégicos estes projetos estão / estavam?

100 % alinhados ao Planejamento Estratégico.

6. Estes projetos foram incluídos no planejamento orçamentário ou foram extra budget?

Maioria incluídos no plano orçamentário, mas as vezes extra budget.

7. Existe um *roadmap* / governança / escritório de projetos / *portfolio* específico para os projetos de Transformação Digital?

Sim, específico para Transformação Digital com portfólio e roadmap próprios.

8. Houve a participação de entidades externas (consultorias, ICTs, startups, parceiros, fornecedores) ou foi desenvolvimento interno?

Sim. Consultorias, ICTs, startups, além do time interno dedicado à Transformação Digital.

9. Contou com o patrocínio da Diretoria? Alguma em específico? Houve envolvimento dos colaboradores das áreas clientes?

Apoio irrestrito. Desejo da diretoria.

10. Quais foram as lições aprendidas com os projetos já implantados? Elas estão sendo consideradas nos novos projetos?

A necessidade de adaptabilidade. Disposição à mudança. Pessoas desconfortáveis com o status quo.

Impactos dos Projetos

11. Como foi o “dia seguinte” à implantação dos projetos?

Nunca é tranquilo. Esforços de adaptação. Falta de foco. “Sala de guerra”.

12. Quais foram os benefícios propiciados para a área cliente com a entrega dos projetos?

Integração. Processos mais ágeis. Análises e tomadas de decisão mais rápidas e efetivas. Aumento da Produtividade – mais atividades com as mesmas pessoas. Agilidade nos processos devido ao RPA. Maior oferta de dados para a tomada de decisão.

13. Houve percepção das áreas dos resultados destes projetos?

Total, principalmente pelos antigos (não nativos digitais).

14. Quais foram as mudanças que as áreas tiveram que fazer para se adaptar aos projetos?

Necessidade de mudar processos e procedimentos. Ter visão estratégica compartilhada e internalizada. Total transformação na área financeira. Mudança cultural.

15. Houve aumento de produtividade, redução de custos, aumento da satisfação do cliente, incremento de *market share*, melhoria da imagem da empresa ou dos produtos, melhoria dos processos internos, redução dos tempos de desenvolvimento, redução dos tempos de entrega dos insumos, peças e partes, bem como, dos produtos acabados, melhoria no relacionamento com os concessionários etc?

Sim, sim, sim, sim, sim, sim, não, sim.

16. Quais métricas são utilizadas para medir os resultados dos projetos de Transformação Digital?

Custo de transformação. Custo de produção.

17. Houve a criação de novos produtos, de um novo processo, redução de overhead?

Sim, sim e não (exceto na linha de produção com a automação).

18. Houve retorno financeiro nos projetos? Em que percentual médio (projeto)? E em que proporção (quantidade de projetos com retorno financeiro positivo)?

Sim. Menor que 1 ano (payback). 100% dos projetos.

19. Quais foram os “campeões” (referências)?

Veículos conectados e com IA embarcada; RPA na área financeira.

20. Houve a criação de *spin offs* ou *startups* a partir destes projetos?

Sim.

21. Houve *spillovers* como consequência destes projetos?

Sim. Formação comunitária digital.

22. Quais foram os impactos negativos?

Impacto Cultural.

Avaliação dos Projetos

23. Qual a percepção das áreas clientes sobre os resultados dos projetos de Transformação Digital?

Boa, sempre após um período de adaptação.

24. O que poderia ser feito diferente na gestão do portfolio destes projetos?

Maior engajamento das pessoas e maior agilidade.

25. Qual a avaliação da Diretoria sobre estes projetos?

Apoio 100%, com avaliação super positiva.

“Tecnologia Atual + Estratégia Compartilhada + Pessoas Engajadas”

“Tecnologia não é nada sem as pessoas”.