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INGRID SAIALA CAVALCANTE DE SOUZA FEITOSA

Soft Systems Thinking and Aspect-Based Sentiment Analysis to support performance management and better-informed decision-making

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To my parents and my brother, who make
their love and support always present
wherever I am.

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“Only faith can guarantee the blessings that we hope for,

or prove the existence of realities that are unseen.”

(Hebrews 11, 1)

ABSTRACT

FEITOSA, I.S.C.S. **Soft Systems Thinking and Aspect-Based Sentiment Analysis to support performance management and better-informed decision-making.** 2023. Thesis - São Carlos School of Engineering, University of São Paulo, São Carlos, 2023.

In order to effectively manage an organization, it is essential to incorporate stakeholders' perspectives and multiple, sometimes conflicting, objectives into decision-making processes, while handling environments that commonly include unstructured and ill-defined situations. This complex scenario hampers the identification of problem sources and the determination of necessary improvements. This doctoral research provides a structured approach for analysis in these complex scenarios to identify improvement opportunities and provide valuable insights for decision-making. This is achieved through a proposed framework that integrates Soft Systems Methodology (SSM) and customers' perceptions obtained through the implementation of Aspect-Based Sentiment Analysis (ABSA). Specialists attended a workshop to design a conceptual model using SSM, after which customer-generated data was extracted from social media for the ABSA implementation. Then, the implementation was presented in an illustrative case focused on organisations whose business models implement circular economy practices towards sustainability. The results demonstrated the framework potential of being applied in this innovative context, effectively organising relevant information for performance management and identifying improvement opportunities. Besides, this multimethodological approach broadens the scope of SSM usage by supporting recurrent management activities. Also, given the generic design of the framework, it may be applied in different contexts. The conceptual model might be employed for similar analysis within organisations that identify their process, objectives, and value proposition as similar to the ones modelled. Further developments should incorporate these structures in studies involving data from other organisations to further analyse their benefits as well as identify how they can be improved.

Keywords: Soft Systems Methodology. Problem Structuring Methods. Performance management. Aspect-Based Sentiment Analysis. Circular Economy.

RESUMO

FEITOSA, I.S.C.S. **Soft Systems Thinking e Aspect-Based Sentiment Analysis para apoiar a gestão de desempenho e a tomada de decisões.** 2023. Thesis - São Carlos School of Engineering, University of São Paulo, São Carlos, 2023.

Para gerir eficazmente uma organização, é essencial incorporar nos processos de tomada de decisão as perspectivas de seus *stakeholders* e múltiplos objetivos, por vezes conflitantes, ao mesmo tempo que se lida com ambientes que normalmente incluem situações não estruturadas e mal definidas. Este cenário complexo dificulta a identificação da origem de problemas e a determinação das melhorias necessárias. Essa pesquisa de doutorado fornece uma abordagem estruturada para análise desses cenários complexos para identificar oportunidades de melhoria e fornecer *insights* valiosos para a tomada de decisões. Isso é feito através da proposição de um *framework* que integra a *Soft Systems Methodology* (SSM) e percepções dos clientes obtidas através da implementação de *Aspect-Based Sentiment Analysis* (ABSA). Especialistas participaram de um *workshop* para construir um modelo conceitual usando SSM, após o que dados gerados pelos clientes foram extraídos de mídias sociais para a implementação do ABSA. Em seguida, essa abordagem foi apresentada em um caso ilustrativo focado em organizações cujos modelos de negócios implementam práticas de economia circular em direção à sustentabilidade. Os resultados demonstraram o potencial desse *framework* em aplicações nesse contexto inovador, organizando efetivamente informações relevantes para a gestão de desempenho e identificando oportunidades de melhoria. Além disso, esta abordagem multimetodológica amplia o domínio de utilização da SSM como o apoio a atividades de gestão recorrentes. Além disso, dada a concepção genérica do *framework*, este pode ser aplicado em diferentes contextos. O modelo conceitual pode ser empregado para análises semelhantes em organizações que identificam seus processos, objetivos e propostas de valor como semelhantes aos modelados. Futuros desenvolvimentos podem incorporar estas estruturas em estudos que envolvam dados de outras organizações para analisar melhor os seus benefícios, bem como identificar como podem ser melhoradas.

Palavras-chave: Soft Systems Methodology. Métodos de estruturação de problemas. Gestão de desempenho. Aspect-Based Sentiment Analysis. Economia Circular.

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1 INTRODUCTION

Organisations are complex entities continually faced with problematic situations whose analysis and later action-taken for improvement require a comprehensive view of related activities, processes, and stakeholders' perspectives. The management of these situations may be challenging as they are commonly ill-defined or unstructured. In addition, the success of any business model depends on how well it is capable of satisfying customers' requirements. Therefore, an organisation may benefit from methods and approaches that help to incorporate these stakeholder's perspectives and support comprehensive views of its environment for analysis of problematic situations and decision-making.

Problem Structuring Methods (PSM) is a category of methods that may provide valuable support for analysing and understanding those complex management contexts and for structuring better-informed decision-making processes. The main objective of a PSM is to provide analytical assistance to real-world situations that may be characterized as complex ones for the presence of different perspectives, multiple actors, conflicting interests to some extent, intangible aspects, and uncertainty (ROSENHEAD, 2006). There are different PSMs in literature, such as the Soft System Methodology (SSM), the Strategic Choice Approach (SCA), the Strategic Options Development and Analysis (SODA), and the Value Focused Thinking (VFT) (DE ALMEIDA, 2013; ROSENHEAD, 2006). Among those, this research focused on the Soft Systems Methodology (SSM).

The SSM proposes an organized way of thinking about complex or problematic situations and bringing about improvement (CHECKLAND; POULTER, 2020). It enables a systemic representation of a situation under analysis, and an enquiry or questioning activity that supports the identification of improvement opportunities. Hence, SSM is a valuable resource to analyse complex situations within organisations and provide a holistic view that may guide better-informed decision-making. In addition, according to the literature review by Gomes Júnior and Schramm (2021), the SSM is the most referenced PSM in studies from the last decade. At last, the set of principles of this methodology can be adopted, and adapted, to the nature of any situation that may require a comprehensive analysis to decide on improvement actions (CHECKLAND; POULTER, 2007).

Given these points, this research proposes the use of SSM to enable a systemic view of business processes to support performance management and decision-making. This systemic view may be used as a 'map' to guide the identification of improvement opportunities with the incorporation of customers' perceptions (i.e., what, and where, are the perceived issues an organisation needs to act on to provide a greater customer experience?). To achieve that, this research proposed a framework that integrates the SSM stages with knowledge obtained from implementing a text analytics task, the Aspect Based Sentiment Analysis (ABSA), on textual data produced by customers on social media.

The ABSA enables extracting specific aspects of entities (e.g., a product, a service, a brand) discussed in a text and classifying expressed sentiments (e.g., positive, negative) concerning those aspects (MEDHAT; HASSAN; KORASHY, 2014). The data to conduct these analyses may be extracted, for instance, from customers' reviews on specialised webpages, e-commerce or marketplaces, and social media. Thus, the ABSA task was implemented in a textual dataset collected from social media to extract aspects related to performance attributes of a product and the customers' perceptions (i.e., opinions or sentiments) of them.

This research focused on organisations whose business models implement circularity principles toward sustainability goals. These organisations may either already have circular business models (CBM) or are transitioning to circular economy (CE). The systemic approach proposed by CE is restorative and regenerative by design, aims to decouple economic growth from the consume of finite resources, and reduce negative impacts of the traditional linear economic model (i.e., materials extraction, production, consumption, and disposal), while provides environmental and societal benefits (ELLEN MACARTHUR FOUNDATION - EMF, 2020).

Business models in the CE context are more complex structures than linear business since achieving objectives such as keeping materials value by replacing the 'end-of-life' system and reducing the consumption of finite resources require a systemic shift in the way they generate value (EMF, 2020). In comparison with traditional business, they need to tackle challenges such as lack of knowledge about CE and CBM, product design requirements to enable repair and remanufacturing, different levels of customer interaction, and complex relationships and collaboration with partners in the value chain (GULDMANN AND HUULGAARD, 2020; OGHAZI; MOSTAGHEL, 2018). Additionally, given the innovativeness of CBM, monitoring and incorporating stakeholders' perceptions is even more relevant, for they may indicate acceptance or satisfaction or encourage actions to improvement (GUPTA et al., 2019). A strong and sustainable relationship with customers may help companies to be more effective in their value proposition and value capture (URBINATI et al., 2020). Therefore, providing means of incorporating these stakeholders' perspectives to performance management processes is certainly beneficial to those business model outcomes.

1.1 Research problem and opportunities

Circularity principles may bring positive impacts on businesses, the environment, and society; however, managerial studies on organisations that endeavour to implement those are still in development. According to Sassanelli et al., (2019), researchers have concentrated mostly on the material element of circular economy practices, i.e., the resources used in production and operations. Most of the studies have focused mainly on analysing or developing CE indicators for assessing the environmental perspective of sustainability and do not encompass CE in a systemic approach (ROSSI et al., 2020).

The assessment of CE practices implementation or circularity levels according to environmental aspects are extremely relevant to CE development. However, other aspects of business models (e.g., product durability, customer acceptance, after-sales services) that support the implementation of circularity principles should also be taken into consideration to improve their performance and ensure market competitiveness. Also, the literature highlights the importance for management of circular business models of incorporating knowledge obtained from stakeholders' viewpoints about performance of their processes (GUPTA et al., 2019; JABBOUR et al., 2019). For instance, information obtained from customers throughout a product lifecycle may provide means of implementing maintenance schemes, products monitoring, and keeping track of consumer trends and preferences (GENOVESE et al., 2017; DE SOUSA JABBOUR et al., 2019). Therefore, the incorporation of information from stakeholders' perspectives into their performance management may provide guidance on 'where to look at' to identify which business processes need improvement.

Finally, it is valuable for greater performance of organisations that implement circularity principles to be able to systemically visualise and assess processes and their interrelations. According to the BSI:2017, systems thinking is a CE principle that should guide organizational decision-making (BRITISH STANDARDS INSTITUTION – BSI, 2017). The CBM require more integration in relationships with stakeholders, such as suppliers and customers, and their value proposition shall include contributions to decrease environmental impacts and to increase social and economic impacts (OGHAZI; MOSTAGHEL, 2018).

Based on this discussion, and given the SSM guidance to implement systems thinking to analysis of complex situations, the following research question (RQ) was proposed to direct this study development:

RQ: How can soft systems thinking methodology be integrated with information extracted from a text analytics task to structure systemic views that may support performance management and decision-making?

Thus, the focus of this proposition was an approach based on systems thinking enabled by the SSM to support the identification of improvement opportunities by incorporating customers' perceptions. As previously discussed, research shows that one of the main difficulties of businesses implementing circular economy principles towards sustainability is gathering adequate information about stakeholders' requirements. Therefore, improvement opportunities might not be clearly identified or well-structured, which increases the complexity of management and decision-making tasks.

To address these challenges, this doctoral research proposed a conceptual model focused on those businesses' context. This model may be seen as a 'map' for a systemic view of a business processes and activities and was structured following SSM stages for modelling relevant system for analysis of a given problematic situation. In its turn, customers' perceptions were extracted from textual data through an ABSA approach and incorporated as a guide to identify improvement opportunities (i.e., where an organisation should act to achieve better performance).

1.2 Objectives

The objective of this research was to propose a soft systems thinking approach that incorporates customers' perceptions obtained through text analytics to guide the identification of improvement opportunities and support performance management.

The following specific objectives were defined for achieving this proposition:

I. Review the literature on the use of soft systems methodology (SSM) to support performance management and management decision-making processes.
II. Identify a text analytics approach to extract information on performance attributes from textual data produced by customers on social media.
III. Model through SSM a relevant system of activities that represent the purpose of an organisation that implements circularity practices towards sustainability.
IV. Implement text analytics task to recognise attributes (aspects) related to the performance of a business under analysis and customers' perceptions (i.e., sentiments, opinions) related to those aspects.

V. Conduct an application of the SSM conceptual model and text analytics task proposed using real-world data to illustrate this integration potential to support performance management and decision-making.

1.3 Research development

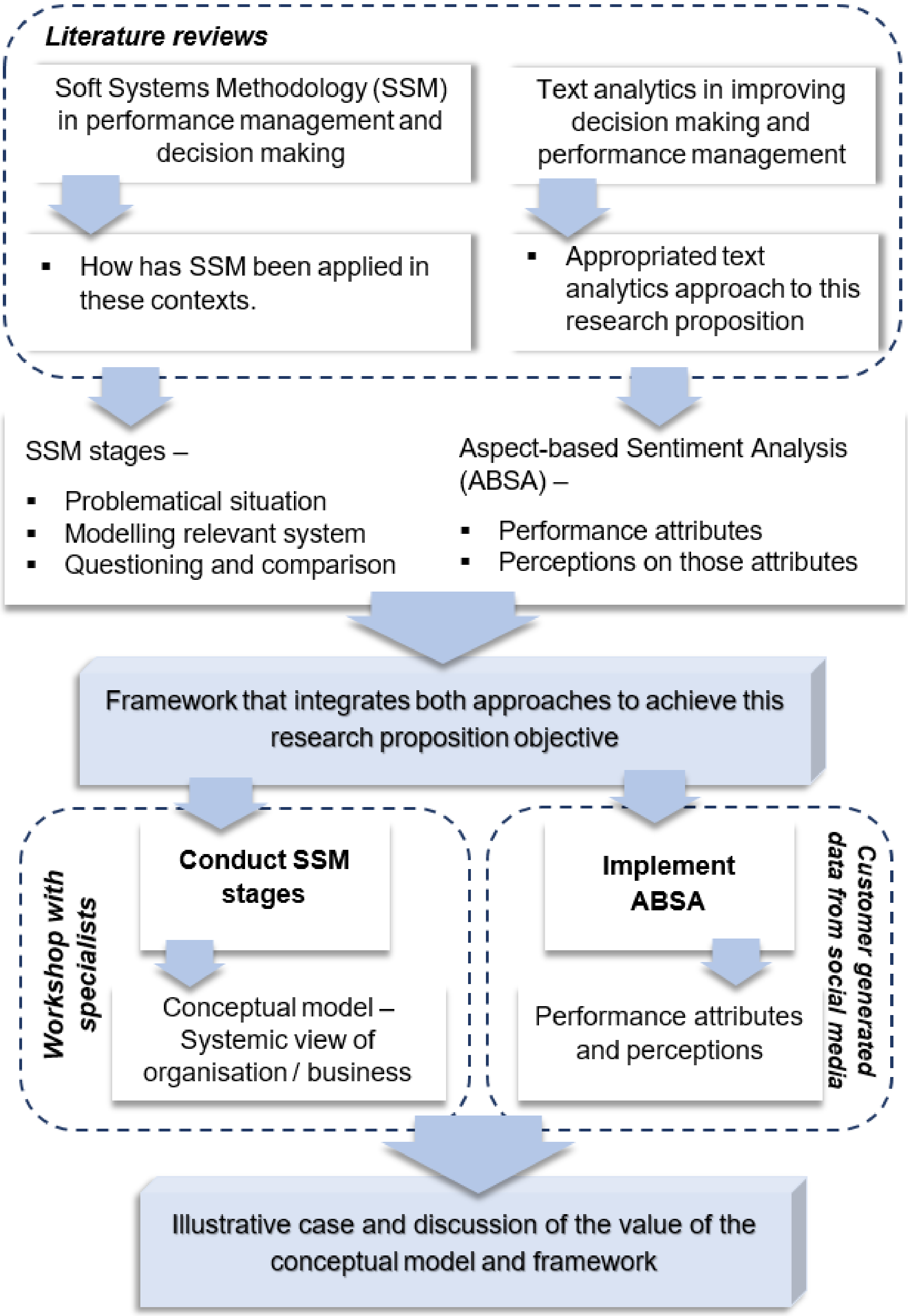
This research combines qualitative and quantitative approaches. The qualitative research characteristics are recognised as it encompasses subjective realities, and aims to describe and understand contexts, experiences, and phenomena of a reality (BERNARDES; MUNIZ JUNIOR; NAKANO, 2019). In its turn, a quantitative approach is adopted to capture customers perceptions through data analysis. Hence, a multimethodology, which may be described as the combined use of two or more methodologies within a single intervention, was designed to achieve the proposed objectives (FRANCO; LORD, 2011).

Interventions in real-world problems need to incorporate many aspects, especially in a systems thinking implementation, that are commonly addressed in several stages, which may not be supported by only one method or technique. Thus, combining methods to handle these characteristics should be more effective and enhance an intervention outcome (MIDGLEY, 2015; MINGERS 2000). Given that, this research proposed using SSM concepts to guide the analysis of a complex situation, with incorporation of stakeholders' perspectives, which was enabled by workshops with specialists and a text analytics implementation.

A theoretical background, and investigations in the literature enabled structuring a conceptual basis for a framework development, as well as identifying the most adequate text analytics task to achieve the proposed objectives. Then, a conceptual model focused on business models implementing circularity principles was designed, through SSM implementation. At last, the framework and conceptual model use and potential benefits were discussed in an illustrative case.

The steps followed to achieve the proposed objectives of this research are presented in Figure 1.

Figure 1 – Research development stages.



Source: Own authorship.

The first phase of this research comprised of an investigation of the scientific literature with two main objectives. First, to identify how SSM concepts have been used to support performance management and decision-making within organisations. This provided insights into how other authors applied SSM in several contexts, their goals, and the stages of the methodology that were implemented. In its turn, a second literature review focused on the implementation of text analytics approaches to support performance management and decision making within organisations. The results obtained were important to analyse the feasibility and relevance of the use of these techniques in this current research and to assist the selection of the most suitable text analytics approach. The findings of both literature reviews are discussed in next chapters (Chapters 3 and 4).

Once this literature analysis was concluded and a text analytics approach was defined, the subsequent step was to structure the research proposition in a framework. This framework summarizes the integration of the SSM stages and an ABSA implementation, which was the text analytics approach identified as adequate to this research proposition. The proposed framework is presented in detail in Chapter 5.

The subsequent stages of this research were to structure, by following the SSM, a conceptual model of organisations whose business models implement circular economy principles towards sustainability, and to implement the ABSA to obtain customers' perceptions. The modelling stage was conducted mainly by the researcher, as an analyst and facilitator, and required the participation of a group of specialists on the context being modelled to assess logical dependencies and consistency of the resultant conceptual model. Meanwhile, the ABSA task was implemented to conduct an illustrative application of the conceptual model and proposed framework. To do so, textual data was collected from social media and used as input to the text analytics implementation, which extracted aspects that may be seen as relevant performance attributes and customers' perceptions of them. The results of this application were then discussed regarding the conceptual model and framework potential for supporting performance management decision and decision-making.

1.4 Thesis organisation

This thesis is divided into eight chapters that present the theoretical basis required for the research development, discuss the results of two systematic literature reviews, propose a framework, and describe the modelling of the SSM conceptual model and its use in an illustrative case. This first chapter has presented a brief contextualization for this study and discussed the research problem, objectives, and the steps proposed to achieve them. The second chapter brings the main concepts concerning SSM, Text Analytics, Circular Economy and its business models, and a brief discussion on performance in this business models context. The results from the two literature reviews are discussed in Chapters 3 and 4. Subsequently, chapter 5 covers the framework proposition, and Chapter 6 details the modelling process to obtain the SSM conceptual model. Finally, an illustrative case is presented in Chapter 7, and a summary of this research's contributions, findings, and limitations is discussed in Chapter 8.

2 THEORETICAL BACKGROUND

This chapter presents the theoretical basis of this research. To begin, it introduces the application of Problem Structuring Methods (PSM) in analysing and structuring decision-making within complex situations, with a particular emphasis on systems thinking and Soft Systems Methodology (SSM). Additionally, this chapter explores the usage of text analytics and describes the aspect-based sentiment analysis task. Finally, in section 2.3, a conceptualization of CE and CBM, along with a discussion on the challenges associated with its implementation, is presented.

2.1 Problem Structuring Methods (PSM) and Soft System Methodology (SSM)

Problem Structuring Methods (PSM) is a group of modelling approaches that aim to facilitate analysis of complex, problematic situations that are of common interest for a group to reach a shared understanding and even agreements on solutions (MINGERS; WHITE, 2010). The use of PSMs promotes engagement and structured conversations that encourage people involved in a problematic situation to analyse it from different perspectives (MARTTUNEN; LIENERT; BELTON, 2017). In addition, the PSMs may use diagrammatic tools that are structured following dialogue and deliberation to capture and bring together viewpoints of the several stakeholders of a situation under analysis (KOGETSIDIS, 2023). For instance, SODA is a PSM that uses cognitive maps to represent a problem and express values and attitudes of its stakeholders and enable interpretations and discussions (CUNHA; MORAIS, 2019). These diagrams are useful to obtain a better understanding of a problematic situation and to identify areas in which stakeholders agree and where there are disagreements (KOGETSIDIS, 2023).

The PSM that is focus of this research proposition is the SSM. The SSM is an approach of systems thinking that was developed as a response to the traditional systems engineering (SE) methods that failed to incorporate complexities of management problems (MINGERS; WHITE, 2010). The SE does not incorporate the impact of people associated with a relevant situation in its analysis and assumes that defining a problem is not problematic and can be done with precision (WILSON; VAN HAPEREN, 2015). These assumptions may be inadequate to tackle complex and ill-defined problems within organisations, which may involve multiples stakeholders and conflicting interests. Hence, the SSM was developed as a means of enabling systems thinking to handle diversity of views and interests to analyse complex situations and define problems. This approach is necessary and valuable because poorly defined objectives or a lack of agreement may lead to a loss of confidence or dissatisfaction with the results of traditional SE modelling (MINGERS; WHITE, 2010).

Thus, given a complex or problematic situation that requires analysis, the SSM establishes a learning cycle using systemic models to investigate, explore, and reflect on its aspects (WILSON; VAN HAPEREN, 2015). The SSM may be defined as an action-oriented process of investigation into problematic situations in which users walk through an organised learning process by finding out about a situation, exploring it with intellectual devices (i.e., conceptual models or systems of relevant activities), and defining and taking action to improve it (CHECKLAND; POULTER, 2007). The elements that constitute the SSM's learning cycle are presented next in the topic 2.1.1.

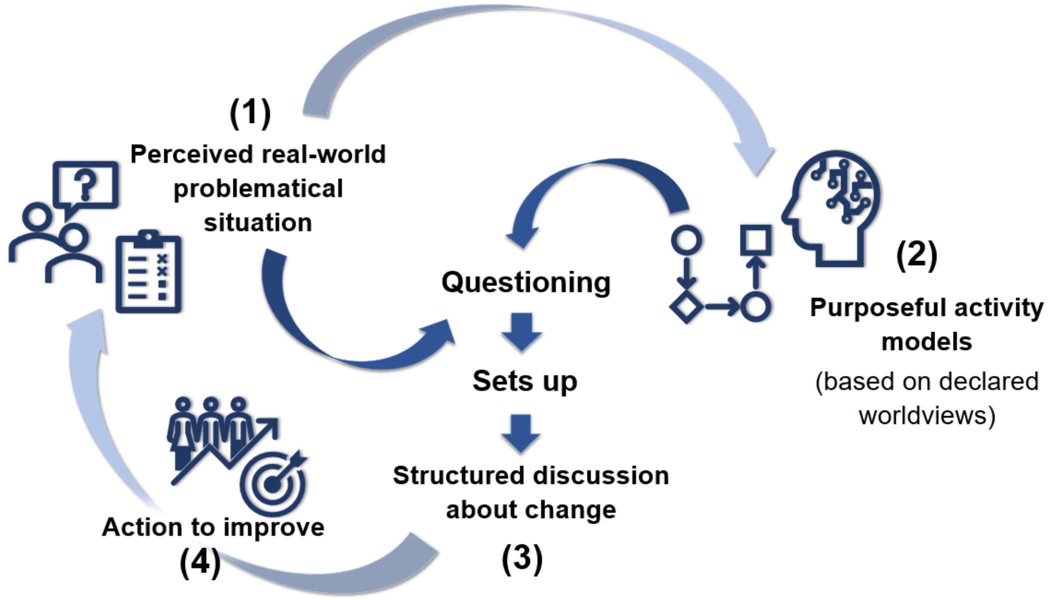
Furthermore, the use of the SSM requires an essential distinction between real-world and 'thinking about the real-world'. The modelled systems are a set of concepts (i.e., a representation of a way of thinking about a reality) used to reason about a reality under analysis, thus, they are not description of this reality (do not represent the real-world 'as it is') (WILSON; VAN HAPEREN, 2015). This distinction enables the identification of improvement opportunities in the problematic situation by a questioning and comparison exercise of reality against its systemic representation, which would not be possible if the model were a reproduction of the situation under analysis. At last, since the SSM is a methodology, implementing its essential principles and elements is not prescriptive and should be tailored to each specific situation to help to understand real-life complexity (CHECKLAND; POULTER, 2007; WILSON, 2001). Details on how to conduct an implementation of the SSM are given subsequently.

2.1.1 SSM and steps for its implementation

The implementation of the SSM learning cycle is based on the following essential elements: (1) a problematic real-world situation where it may exist potential improvement opportunities; (2) models of a system of activities relevant to this situation, but not describing it 'as it is'; (3) use of these models as devices to explore the problematic situation; and (4) a structured debate about desirable and feasible change (CHECKLAND; POULTER, 2020).

Figure 2 illustrates these essential elements in the learning cycle proposed by this methodology (CHECKLAND, 1989; CHECKLAND; POULTER, 2020).

Figure 2 – Basic structure of the SSM learning cycle.



Source: Adapted from Checkland (1989) and Checkland, Poulter (2020)

The SSM learning cycle begins with the perception of an initial situation in the real-world that is seen as problematic (1), and which may require action-taking to improve it. The next step is to think about the problematic situation through the lenses provided by the SSM, which are a root definition and a conceptual model (2). Initially, the analyst needs to formulate the root definition. The root definition (RD) which is a formulaic description of the purpose of a system relevant to exploring the problematic situation. It is a statement that captures the essence of a system being described and may be structured as follows (WILSON, VAN HAPEREN 2015):

A system to do X … by means of Y … in order to achieve Z.

The formulation of a well-structured RD should include constituent elements that can be summarized by the mnemonic CATWOE (CHECKLAND, 1989; CHECKLAND, POULTER 2007; WILSON, VAN HAPEREN 2015). These elements are presented next on Table 1. Among the CATWOE elements, the Transformation, and the Worldview (or *Weltanschauung*) are mandatory for a statement to be a RD. The other elements, despite supporting a more comprehensive description, may be included or not, based on the analysts' judgment (WILSON, VAN HAPEREN 2015). Once the analysts have a RD, it is possible to begin the modelling of a relevant system, the SSM conceptual model.

Table 1 – CATWOE elements for root definition.

Elements of root definition	
C - Customer	Who would be the victims/beneficiaries of the transformation (T)?
A - Actors	Who would do the activities which make up T in a real organisation?
T – Transformation process	A purposeful activity expressed as a transformation process T (an *input* -> *output* relation) based on worldview W.
W – Worldview (*Weltanschauung*)	View of the world that provides the meaning of the transformation process.
O – Owner	Decision-maker who has a concern for the overall performance of the system / could stop the process T.
E – Environmental constraints	Features of the environment which the system needs to consider when doing T and over which it has no control.

Source: Adapted from Checkland (1989), Checkland, Poulter (2020), and Wilson, Van Haperen (2015).

The stage of modelling of a conceptual model consists of assembling and structuring the minimum set of activities required to realise the purpose defined as the RD, and their logical interdependencies (i.e., ‘given the words in the RD, what activities must be done together with their logical dependencies to completely represent these words?’) (WILSON, VAN HAPEREN 2015). Thus, the conceptual model (CM), or model of purposeful activity, defines what should be done to achieve the purpose expressed by the RD. These models are not descriptions of an organisation or problematic situation under analysis, but devices that express a way of looking at and thinking about a situation (CHECKLAND, POULTER 2007). A CM is a device that can be used to make questions and comparisons against a real-world situation of concern (WILSON, 2001; WILSON, VAN HAPEREN 2015). A generic conceptual model that illustrates the format proposed by the SSM is presented next in Figure 3.

The modelling is done using the imperative form of verbs of the English language (or of whichever language the analysts and stakeholders may be fluent in) to, guided by logic, define ‘*what*’ activities should be in place to achieve the purpose stated by the RD, transforming the inputs into outputs (WILSON; VAN HAPEREN, 2015). Apart from the verbs in the imperative form, the core of each activity, other words shall be added to specify and better describe the activity, as may be seen in the examples in Figure 3.

Figure 3 – A generic conceptual model.

Source: Adapted from Wilson; Van Haperen (2015).

In addition, each modelled system, or subsystems that it may encompass, should contain a pair of 'Monitor and Control' activities whose function is to monitor activities that are undertaken, measure their performance, and to take appropriate remedial action if required. The literature proposes three criteria that may be used for this purpose: efficacy, efficiency, and effectiveness. The latter measures how well the subsystem activity is contributing to achieving the objective of the wider system (i.e., the whole CM); in its turn, efficiency measures if an activity outcome is obtained with minimum use of resources, and efficacy assess if an activity achieves its expected outcomes. The monitor activity may collect information derived from these measures of performance so analysts or decision-makers within the control activity will know whether it is necessary or not to take control actions (indicated in a CM by a crocked arrow leaving a control activity) and to which activity(ies) to direct these actions.

The final crucial feature of a CM is the dependency relationships among activities, which are illustrated by full arrows in the diagram. Each full arrow represents a logical dependency where the activity on the head of an arrow is dependent upon the activity on the tail (WILSON; VAN HAPEREN, 2015). Besides the arrows indicating logical dependency relations and the 'control action' arrow, other two kinds of arrows may be seen in a CM. These elements are presented and have their meaning explained in Table 2.

Table 2 – Elements of a conceptual model

Element	Meaning
Oval/pill shapes (or freely hand-drawing shape)	Contain activities that shall be implemented in a subsystem so it can achieve its purpose.
Full arrows	Represent logical dependency among activities (activities on the head of an arrow depend on activities on the tail).
"Monitor – Control" pair of activities	Represents the monitoring activity of a subsystem's activities performance and the implementation of control measures to ensure they achieve their intended purpose.
Control Action (C.A. )	Output from a Monitor-Control activity; represents that an action may be taken to improve the performance of an activity being monitored.
Broad black arrow 	Represents restrictions on one activity, or on several or all activities of a subsystem; its label indicates what those restrictions are.
Broad white arrow 	Represents inputs that an activity(ies) receives from other activities and subsystems; its label indicates the type of input.

Source: Adapted from Wilson (2001) and Wilson; Van Haperen (2015).

Finally, it is worth commenting that instead of validation, literature on SSM proposes the assessment of a CM defensibility (WILSON, 2001). This concept's implementation assesses the logical consistency of the model components derived from the RD and the logical connections among them. Every activity in a model shall be logically derivable from the words in the RD, otherwise, they should not be included, and if there are words or phrases from the RD not represented in CM activities, then the model is incomplete (WILSON, 2001).

Once the modelling phase is concluded, the CM may be used as a device to conduct a structured discussion based on questioning and comparison (number 3 in Figure 2). This stage is an inquisitive exercise that compares the situation in the real world against its systemic representation as CM (i.e., what does the model tell us about the problematic situation?). The purpose of this activity is to discuss possible changes that could bring about improvement in the situation under consideration. It enables the identification of aspects of concern and determines logically desirable and culturally feasible changes or improvement opportunities (WILSON; VAN HAPEREN, 2015). The performance metrics previously defined are used in this stage as judgement criteria of how well the activities are done, i.e., to assess whether and how the activities in the real world achieve their purpose in comparison to what activities defined in the systemic view should achieve, or if they should be improved.

The answers from this questioning and comparison stage shall provide guidance to define feasible actions to improve performance and to decision-making processes regarding their implementation. The implementation of these actions concludes the stages illustrated in Figure 2. It is important to remind that SSM is a learning system, which means that it does not seek for optimized solutions, but an accommodation among interests and views that will enable actions to undertake feasible improvements (CHECKLAND, 1989). Moreover, it is possible to choose to continue the learning cycle after actions implementation for there may be other identified situations to act on, or it may be necessary to analyse the responses to these improvement actions (CHECKLAND, 1989; CHECKLAND; POULTER, 2020).

2.2 Text analytics and Aspect-based Sentiment Analysis (ABSA)

Nowadays, customers use to rely on reviews of products and opinionated text publicly available on the web to guide their decision on purchasing a product or service. This behaviour probably originated from the fact that seeking different opinions to support decision-making is typical in human behaviour given that opinions are a fundamental influence on almost all human actions (SOONG et al., 2019). Business may also benefit from analysis of this this sort of data available on the web to get information about quality of their products or their services performance (RAVI; RAVI, 2015). However, the analysis of the large volume of textual data published on the web, as in social media such as Twitter and review sections of e-commerce pages, could not be done by humans alone due to constraints such as subjective biases and mental limitations. The use of text analytics techniques may help to overcome these restrictions.

The text analytics or text mining (these terms may be used interchangeably) is the category of data mining developments that encompasses methodology and processes that enable obtaining high quality and useful information or even insights from textual data (AGGARWAL, 2018). Data mining consists of the application of specific algorithms to extract valid, novel, potentially useful, and understandable patterns from data (FAYYAD; PIATETSKY-SHAPIRO; SMYTH, 1996). Techniques analogous to the traditional data mining and knowledge discovery methods are implemented in the textual data domain and include Natural Language Processing (NLP), information retrieval, and machine learning (ALLAHYARI et al., 2017). These approaches may be applied to address many tasks and applications such as dimensionality reduction and matrix factorization, information extraction, text summarization, transfer learning, text mining in social media, opinion mining and sentiment analysis, unsupervised and supervised learning, and sequential language modelling and embeddings (AGGARWAL, 2018; AGGARWAL; ZHAI, 2012).

Since this is a broad field, this section focuses only on the text analytics tasks and methods strictly related to this research proposition. According to the results of a literature review that are discussed on Chapter 4, sentiment analysis (or opinion mining) is the text analytics task that has been used to support extraction of customers' perceptions from textual data so it can be incorporated into performance-related analysis. The sentiment analysis or opinion mining may be defined as "the computational study of people's opinions, evaluations, and emotions toward entities, events, and their attributes" (LIU, 2010). The information obtained from its implementation may provide means of assisting customers' and business providers' decisions (AGGARWAL; ZHAI, 2012). Sentiment analysis or opinion mining tasks are usually implemented by supervised machine learning methods, or unsupervised and semi-supervised learning approaches, and by using lexicon-based methods; thus, these topics will be further discussed next.

The supervised learning main characteristic is the requirement of labelled training data to build models. It is necessary to provide a training dataset that will be used to learn a classifier or regression function, which can then be utilised to make predictions on new data (AGGARWAL; ZHAI 2012). This problem may be defined as a partition of data into *k* pre-defined groups that are identified by their labels (e.g., "spam" and "not spam" to classify e-mails) (AGGARWAL, 2018). There are several techniques that may be used to tackle this task in text analytics applications such as Support Vector Machine (SVM), Naïve Bayes; K-Nearest Neighbour (KNN); Neural Networks (NN); Decision Tree; and Random Forest (AGGARWAL, 2018; SOONG et al., 2019).

In its turn, the unsupervised learning does not require a labelled training dataset, and therefore can be applied with less manual effort than a supervised method (AGGARWAL; ZHAI, 2012). Clustering and topic modelling are two relevant unsupervised learning tasks used in text analytics. Unsupervised learning is often implemented when it is difficult to obtain a labelled training dataset (SOONG et al., 2019). In addition, semi-supervised or hybrid process may be used to incorporate both supervised and unsupervised methods (MEDHAT; HASSAN; KORASHY, 2014).

At last, the sentiment analysis task also benefits from lexicon-based approaches, which utilize collections of opinion words to identify, for instance, text sentiment polarity (e.g., positive, negative, neutral). These collections are called opinion lexicons and contain words, opinion sentences, and idioms used to express sentiments about an entity and its attributes (ARORA; LI; NEVILLE, 2015). They can be built manually or by dictionary-based or corpus-based approaches. The dictionary-based approach is initialized by opinion seeds words (a small set usually build manually) and then it searches corpora such as WordNet or a thesaurus for their synonyms and antonyms (LIU; ZHANG, 2012). In its turn, the corpus-based approach uses syntactic or co-occurrence patterns and a seed list of opinion words to find other opinion words in a large corpus. This approach finds opinion words using a set of linguistic constraints or conventions to identify additional adjective opinion words and their context specific orientations, which helps to solve the dictionary-based disadvantage of not being able to find words with domain and context specific orientations (LIU; ZHANG, 2012).

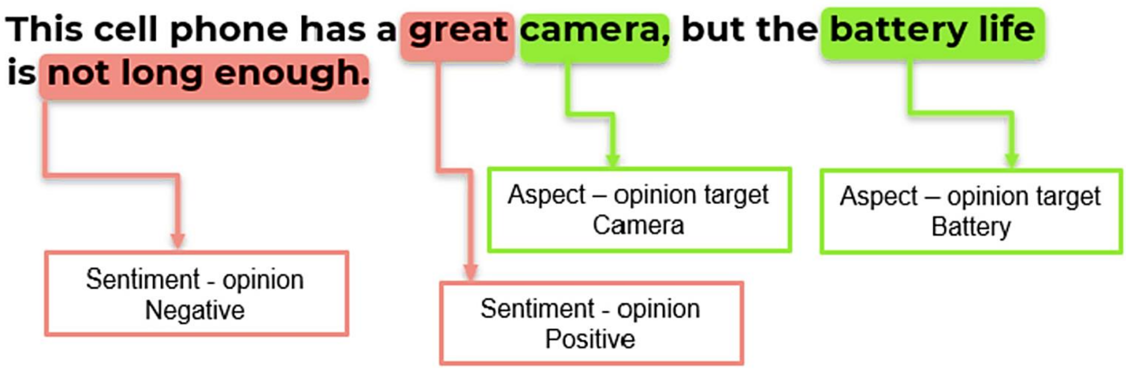
Next, as this brief discussion introduced the text analytics task of sentiment analysis and existing methods for its implementation, the section 2.2.1 discusses the ABSA, which was the sentiment analysis task identified as adequate to this research proposition. This sentiment analysis task was also selected according to results from a systematic literature review (See Chapter 4).

2.2.1 Aspect Based Sentiment Analysis (ABSA)

The sentiment analysis task may be implemented in three main classification levels, i.e., document, sentence, and aspect level. The classification at document and sentence level provides a general sentiment, e.g., negative or positive, on a given text or sentence. This approach assumes that only one topic is discussed and, thus, may disregard relevant information about aspects of entities being discussed in the same text. For instance, a review of a hotel (entity) may bring different opinions on room service and breakfast (two different aspects of a hotel service), thus, knowledge on aspects could be lost if the whole review sentiment is classified as negative. The analysis at the aspect level, the so-called ABSA, tries to overcome this limitation by predicting the aspects mentioned in a sentence and the sentiments (or polarity of opinions) associated with each of them.

Instead of treating opinion mining simply as a classification of sentiments, ABSA separates this task in the *aspect extraction* and *aspect sentiment classification* subtasks and introduces a set of problems that requires deeper natural language processing capabilities, but that can also produce a richer set of results (LIU; ZHANG, 2012; WANG; LIU, 2015). The *aspect extraction* is the first task to be implemented and aims to obtain aspects, which are the opinion targets to be evaluated. The aspects extracted are always associated to an entity that must be known by the analyst (LIU; ZHANG, 2012). Subsequently, the *aspect sentiment classification*, which may also be called sentiment polarity, is implemented with the objective of determining whether the expressed opinion on an aspect is positive, negative, or neutral (DO et al., 2019; LIU; ZHANG, 2012). An illustration of how ABSA works on a sentence is shown in Figure 4. In this example, a cell phone is the entity being discussed, and the identified aspects are its battery and camera, which are targets of a positive and a negative opinion, respectively.

Figure 4 – Illustration of ABSA in a sentence.



Source: Own Authorship.

According to Do *et al*. (2019), the first approaches developed to carry out ABSA subtasks were based on frequency of nouns and phrases in a given text (HU; LIU, 2004), which is supported by the assumption that aspect words are more likely to be repeated. Another approach is the investigation of opinion and targets relations focused on rule-based linguistic patterns. This proposition would first identify a sentiment word by using a set of opinion rules and then use grammatical relations to build the syntactic structure of sentences and detect the aspects (DO et al., 2019). More recently, Do *et al*. (2019) identified the predominance of supervised learning methods and topic modelling, mostly the Latent Dirichlet Allocation (LDA) model, as widely applied to perform to perform ABSA subtasks. This is in line with the techniques most identified in the literature review conducted in this research (see Chapter 4). Also, Do *et al*. (2019) remark deep neural networks, a supervised learning approach, among the most recent advancements in natural language processing. The method implemented to conduct ABSA in this research proposition belongs to this category of supervised learning and explores neural language models.

As previously discussed in this section, the main characteristic of supervised learning is the requirement of a labelled dataset to train an algorithm to learn a classifier function and then be used to assess new data. This requirement is a limitation for it may be difficult to obtain in many applications a labelled training and testing dataset since manually labelling a large volume of data can be very time consuming (LIU; ZHANG, 2012). The approach selected to be implemented in this research tries to overcome this challenge by proposing an aspect extractor trained in a multi-domain transfer learning scenario, the Multi-Domain Aspect Extraction using Bidirectional Encoder Representations for Transformers (MDAE-BERT) (SANTOS; MARCACINI; REZENDE, 2021).

The MDAE-BERT was built using BERT (Bidirectional Encoder Representations for Transformers), a pre-trained language model that consists of word embeddings and that can be refined (i.e., fine-tuned) for specific tasks (SANTOS; MARCACINI; REZENDE, 2021). A word embedding is a technique for language modelling and feature learning that transforms words in a *n*-dimensional vector of continuous real numbers (e.g., the word ‘book’ could have a representation such as (…, 0.15, …, 0.23, …, 0.41, …)) (ZHANG; WANG; LIU, 2018). The BERT may be seen as a vocabulary of word embeddings. In the MDAE-BERT, this pre-trained language model was fine-tuned with labelled data from multiple domains, 14 in total (e.g., Electronics, Canon, iPod, Laptop, Nikon, Nokia) (SANTOS; MARCACINI; REZENDE, 2021). Once the model is trained in the existing labelled dataset, it may be used to extract aspects on a new unlabelled dataset of a target domain. Following, it is provided a brief description of the MDAE-BERT procedures (for further details the reader may refer to Santos, Marcacini, Rezende, 2021):

a) The MDAE-BERT is trained to implement a token classification task using the *BIO* representation described below (simply put, a token may be a word, number, punctuation, or symbol - each part of a sentence that is split to be processed):

   B – indicates that the token is the beginning of an aspect.

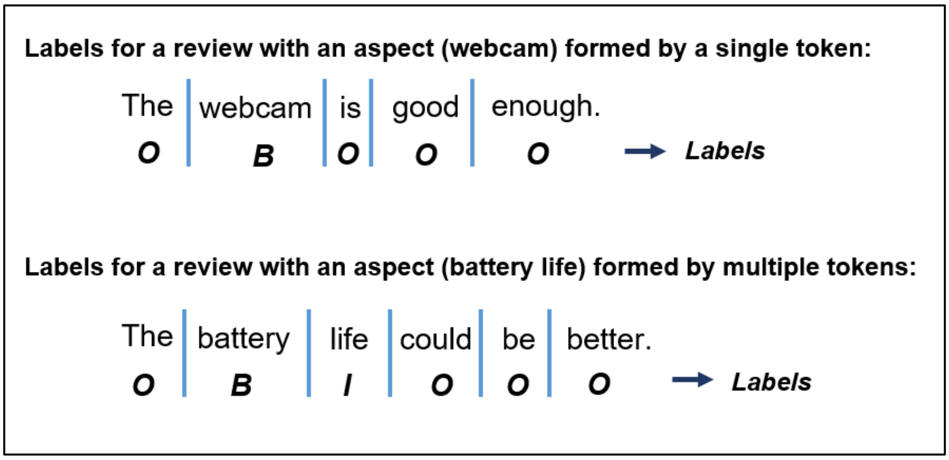
   I – indicates the token is inside an aspect.

   O – indicates the token is outside an aspect.

b) Hence, the aspect extraction task was formulated as a token-level sequence labelling problem, where for a sentence x from a target domain X^t (a domain not used in the training process) the task aims to find a label $y \in \{B, I, O\}$ for each token $x_i \in x$.

Based on the learning from the training dataset (see example of labelled sentence in Figure 4), the classes' labels (*B*, *I*, or *O*) are assigned according to the likelihood of a token x_i be part of an aspect, i.e., *B*, *I*, and *O* values are calculated probabilities. Thus, the higher the values of *B* and *I*, the stronger the probability of that token being an aspect. The MDAE-BERT approach does not require a labelled dataset from a target domain to be trained and obtained competitive results in comparison with other neural network approaches, such as Long Short-Term Memory (LSTM) algorithms (SANTOS; MARCACINI; REZENDE, 2021).

Figure 5 – Example of BIO labels in reviews.



Source: Adapted from (Santos, Marcacini, Rezende 2021).

Once the aspects were extracted, the second subtask of the ABSA is to identify sentiments associated to those aspects. This sentiment analysis task may also be implemented using a supervised learning approach, which is the case in this research proposition for a binary classification task, i.e., positive and negative opinions. The pre-trained sentiment analysis model SiEBERT (Sentiment in English) was used for this task. It was built with a BERT language model and trained for sentiment analysis with various publicly available sentiment datasets so that it can be used in an off-the-shelf manner or fine-tuned (HARTMANN et al., 2023). The language model is available in open-source scripts[1]. Further details on both the sentiment analysis and aspect extraction implemented are given on Chapter 5.

[1]Available in <https://huggingface.co/siebert/sentiment-roberta-large-english>

Next, the last section of this Chapter introduces Circular Economy principles and its business models to contextualize the conceptual model produced in this research proposition and the illustrative case, presented in Chapters 6 and 7, respectively.

2.3 Circular Economy (CE) and circular business models performance

Researchers and practitioners have not yet reached a consensus on a definition for CE. The two most largely accepted definitions are proposed by institutions that stand out by their efforts in implementing CE practices, the British Standard Institution (BSI) and the Ellen MacArthur Foundation (EMF). The EMF (2015, p.15) definition characterizes CE as:

> "A systemic approach to economic development designed to benefit businesses, society, and the environment. It is restorative and regenerative by design, in contrast to the "take-make-waste" linear mode, and aims to keep products, components, and materials at their highest utility and value at all times, and to gradually decouple growth from the consumption of finite resources."

In its turn, the BSI 8001:2017 – 'Framework for implementing the principles of the circular economy in organizations' (BSI, 2017, p.3) defines that:

> "The circular economy refers to a systemic approach to the design of processes, products/services and business models, enabling sustainable economic growth by managing resources more effectively as a result of making the flow of materials more circular and reducing and ultimately eliminating waste."

An analysis of these definitions shows the significance of re-thinking and re-designing processes and business models in the transition to more circular organisations and to enable sustainability. Achieving objectives such as keeping materials value by replacing the 'end-of-life' system and, ultimately, reducing the consumption of finite resources, requires a systemic shift in the way that business generate value (EMF, 2020). This need has led to the emergence of innovative business models that aim to support the transitioning and implementation of circular economy.

These novel business models (BM) shall leave behind the 'take-make-use-dispose' perspective and propose innovative ways of thinking and doing business. A BM focused on implementing circular practices needs to enable economically viable ways to keep reusing products and materials and using renewable resources where possible (BOCKEN et al., 2016).

These new BM shall be based on using minimum resources and extracting the maximum value in their processes (GEISSDOERFER et al., 2020). Thus, a Circular Business Model (CBM) may be defined as the rationale of how an organization creates, delivers, and captures value by slowing, closing, or narrowing flows of the resource loops (OGHAZI; MOSTAGHEL, 2018). The CBM may be classified in groups, according to The British Standard 8001:2017 (BSI, 2017). These groups are described in Table 3.

Table 3 – CBM defined by the British Standard 8001:2017

CBM groups from The British Standard 8001:2017	
CBM	**Description**
On demand (made to order)	Producing a product or providing a service only when customer demands it.
Dematerialization / Digitization	Replacing physical infrastructure and assets with digital/virtual services, without reducing the customer perceived value.
Product life cycle extension / reuse	Products are designed to be durable for a lifetime and improvements may be added to facilitate repair. Facilitated reuse and product modular design (to replace parts to update/upgrade a product, but without replace the whole item).
Recovery of secondary raw materials / by-products	Value optimization by creating products from secondary raw materials/by-products and recycling, whether open or closes loop; incentives to return used/unwanted items back to the producer, and extended producer responsibility
Product as a service/product-service system (PSS)	Leasing access and not selling ownership of a product or service (lease agreement); Performance based agreements (pay for success – company delivers product performance or defined results rather than the product or service itself).
Sharing economy / platforms and collaborative consumption	C2C, B2C (sharing economy) or P2P (collaborative consumption) where some transactional arrangement, which could be financial or not, is provided.

Source: Own Authorship.

The CBM defined in Table 2 show that the rationale by which they create value needs to be in accordance with circular practices, which requires novel ways of doing business. The business models in this context are more complex structures than linear business for their logic, for value creation is based on the retaining value in products at the end of their useful life (GALVÃO et al. 2020). Oghazi and Mostaguel (2018) remark that the value proposition in a CBM shall focus on products and/or services that promote decreasing environmental impacts while increasing social and economic impacts. Hence, a business model that aims to implement CE practices needs to find viable ways to continue to add, recreate, and maintain its value over time while keeping products, components, materials, and energy in circulation (BOCKEN et al., 2016; DE SOUSA JABBOUR et al., 2019).

The fulfilment of these CE implementation objectives may be challenging to management as it also requires accomplishing desired performance levels and maintaining market competitiveness. In this scenario, the case study of Oghazi and Mostaghel (2018) identified four primary challenges of CBM within a manufacturing perspective. These challenges are: (1) the value capture, for unexpected costs and risks make it difficult to design a revenue model; (2) the value creation, due to difficulties in relationships with partners and collaboration; (3) the value proposition, due to challenges on the development of new sustainable offerings; and (4) customer relationship, for it requires different interactions in comparison with traditional business models.

To help to overcome the identified challenges, and to positively influence performance, literature suggests rethinking customer engagement, reconfiguring external linkages and the revenue model, and optimizing cost structure (OGHAZI; MOSTAGHEL, 2018). Assmann, Rosati, and Morioka (2023) identified that enhancing interaction and collaboration with customers is one of the vital determinants for successful adoption of CBM. The authors also point out the importance of collaboration with suppliers and partners, and of a strategic focus on CE, sustainability, and value creation.

CBM effective performance and success requires access to reliable information and efforts to integrate multiple stakeholders' requirements (e.g., suppliers, customers, and producers) (JABBOUR et al., 2019). The main reason is the influence of stakeholders' perceptions, which may indicate acceptance or satisfaction with innovative products design and business processes; or even encourage actions to improve their performance. Despite that, literature highlights that one of the main difficulties of implementing circularity is the lack of adequate information about key stakeholders (GUPTA et al., 2019). For instance, in a product-service system, the value for customers is no longer in product ownership but rather in performance during the utilization phase; thus, it is of utmost importance to incorporate customer perceptions and use them to improve this business offer (WILBERG; HOLLAUER; OMER, 2015).

This complex and potentially problematic context was selected as the focus of the SSM implementation proposed by this research. The proposed approach provides a systemic view that incorporates stakeholders' perspectives, such as customers' perceptions, and may support addressing challenges linked to collaboration and the necessary levels of interaction with customers and partners (OGHAZI; MOSTAGHEL 2018). Also, enabling systems thinking, one of the CE principles that shall guide organisational decision-making and behaviour, is determinant to a successful transition to circularity and/or implementation of a CBM (BSI, 2017).

Thus, a framework was designed to guide the implementation of systems thinking through SSM and with the incorporation of customers' perceptions using text analytics techniques. The main objective is to support the identification of improvement opportunities and performance management decisions. This proposition resulted in a conceptual model that may be used as a 'map' to guide analysis and decision-making in problematical situations. This integrated use of SSM may support not only dealing with wicked problems, as in the most common uses of SSM, but also with recurrent management activities related to problem analysis and decisions on improvement actions. The proposed framework is presented and detailed in Chapter 5. Subsequently, Chapters 3 and 4 discuss the results of two literature reviews that provided an overview of current developments of relevant literature for this research proposition.

3 SOFT SYSTEMS METHODOLOGY (SSM) TO SUPPORT PERFORMANCE MANAGEMENT AND DECISION-MAKING WITHIN OPERATIONS MANAGEMENT

The SSM is seen as a PSM for its guidance in systems thinking implementation may help to address ill-defined and complex situations and to identify improvement opportunities. This methodology provides a structured way to investigate problematic situations and bring about improvement by incorporating the perspectives and interests of affected people, e.g., stakeholders of an organisation (WILSON; VAN HAPEREN, 2015). Literature has shown SSM usage in the most diverse fields, from the planning of infrastructure to facilitate social connectedness of communities in new housing areas to supporting the development of product and process innovations (PEPPER; SENSE; SPEARE, 2016; PRESLEY; SARKIS; LILES, 2000), which illustrates the adaptability of this methodology and its potential for further developments.

Given the SSM characteristics and its adaptability in diverse contexts, including management, and this research objective, an initial step was to understand what has been published in the literature so far and whether there are findings that may guide this research proposition. This motivated a literature review whose objective was to obtain a comprehensive view of SSM utilisation in operations management to support performance management and decision-making processes. Hence, the following research question was defined to guide this investigation:

> **RQ:** How has soft systems methodology been used to support performance management and decision-making within operations management?

The first step for answering this research question was defining a set of keywords and search strings for extracting relevant publications from scientific databases. Web of Science and Scopus were the databases accessed in this SLR for they encompass renowned scientific publications on the researched topics. The search strings defined for each database are presented next in Table 4.

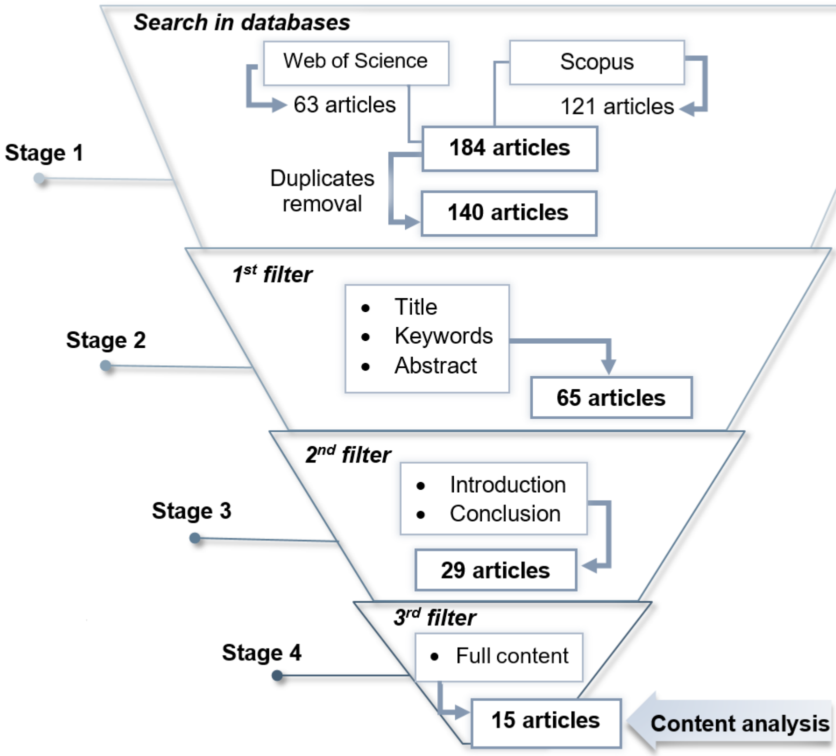
Table 4 – Search strings of SLR on SSM to support performance management and decision-making within operations management.

Database	Search strings
Web of Science	TS = ("soft systems methodology" AND ("performance management" OR ("decision-making" OR "decision making")))
Scopus	TITLE-ABS-KEY ("soft systems methodology" AND ("performance management" OR ("decision-making" OR "decision making")))

Source: Own Authorship.

The obtained results were initially filtered according to language and source type. Thus, only articles written in English and published in journals or conferences were selected for subsequent SLR phases. There was no restriction regarding the year of publication, given that the extracted dataset contained only 184 articles. Then, after a step of removal of duplicates, a filtering process was conducted in the remaining articles, which were a set of 140 publications. The filtering steps are illustrated next in Figure 6.

Figure 6 – Stages followed in SLR to support performance management and decision-making within operations management.



Source: Own Authorship.

As presented in Figure 6, 140 articles were selected to go through the filtering process. The first filter consisted of reading title, keywords, and abstract of each article. Secondly, the remaining articles were filtered by reading their Introduction and Conclusion sections. Finally, the articles on the resultant set were read in full to extract those that would be part of a content analysis. These consecutive stages selected articles that proposed applied studies of the SSM in operations management. Therefore, given the scope of this SLR, literature reviews or publications that brought only theoretical contributions were excluded. The next section presents and discusses the results of a content analysis that was conducted on the remaining 15 articles.

3.1 Main results and discussion

Following the criteria described by the end of the last section, 15 articles were selected to be read in full (third and last filter). These were focus of a content analysis that aimed to extract: (1) the objective of each study and how the SSM supported that; (2) which tools of the SSM were used in these articles; (3) whether or not the SSM was combined with other methods, and (4) the research field of these developments. The subsequent paragraphs discuss the main findings of this content analysis which are thoroughly described in the table that may be seen in Appendix A.

Overall, the analysed articles showed that researchers have recognised the benefits of using the SSM to support performance-related analysis. The SSM fundamental idea of identifying and understanding key interests of stakeholders in a situation before taking action is a valuable approach for performance management (ZHENG et al., 2019). This methodology provides rigorous and logical procedures that may guide the development of required activities to achieve improvement and innovation (LIU et al., 2012). Accordingly, from the 15 articles in the final set, 8 brought the use of the SSM in the design or implementation of a performance management system (PMS) or to identify improvement opportunities in different operation aspects (CONLON; MOLLOY; ZOLZERBRYCE, 2020; DA PIEDADE FRANCISCO; AZEVEDO, 2009; JACOBS, 2009; LIU et al., 2012; NORDIAWAN; PRASODJO; HARDJOSOEKARTO, 2017; SGOUROU et al., 2012; SIDDIQUI; TRIPATHI, 2011; YU, 2021; ZHENG et al., 2019).

Liu et al. (2012) designed and implemented a PMS based on the SSM phases through structuring required organizational activities to achieve strategic goals and breaking down these into key performance indicators (KPIs). More recently Yu (2021) also used the SSM to support the design and implementation of a performance management system; however, the author focused on understanding strategic change in organisations and associated the methodology with Viable System Model (VSM). The author highlights the SSM value to understand the problematic nature of strategic decisions and its emphasis in participation, learning, and self-reflexivity. In its turn, Zheng et al. (2019) proposed a stakeholder-oriented performance management framework focused on performance management in the public sector. Among the main tasks that the SSM assisted in this framework, there were also the decomposition of the organization's strategic goals into required activities to achieve them, besides identifying stakeholders and balancing their interests (ZHENG et al. 2019).

In addition, Nordiawan, Prasodjo, and Hardjosoekarto (2017) implemented the SSM components to define building blocks of Performance-Driven Culture that can be applied to improve the effectiveness of performance management. In its turn, Jacobs (2009) used SSM concepts to design a performance management focused on strategic partnerships for a local government in the UK, and Da Piedade Francisco and Azevedo (2009) used the methodology to identify requirements for the definition of a performance management framework for collaborative networks. At last, considering performance with a focus on resources usage, Gibbons et al. (2012) used SSM to implement a value improvement model (a-VIM) that focused on asset management effectiveness, and Siddiqui and Tripathi (2011) used the methodology to incorporate viewpoints, perceptions, expectations, and requirements related to design, improve, and manage Servicescape for organizations delivering high contact services.

Moreover, regarding its usage in the decision-making process in the context of operations, the SSM was part of the structuring of decision models and simulation models by supporting the identification of stakeholders, objectives, and defining of criteria (BERNARDO; GASPAR; ANTUNES, 2018; CADENAS-ANAYA; GUAITA; RODRIGUEZ-MONROY, 2022). For instance, Cadenas-Anaya, Guaita, and Rodriguez-Monroy (2022) associated SSM tools with Systems Dynamics for decision-making on selecting projects aligned with organisational strategy. Also, Conlon and Molloy (2022) built a discrete event simulation (DES) and service improvement scenarios to propose a framework to capture the staff experience and metrics to evidence workload in healthcare.

Finally, it is worth remarking that most of the analysed SSM implementations did not used all tools or components proposed by the methodology. The most cited component was the Root Definition, associated with the mnemonic CATWOE, identified in 12 articles (see table in Appendix A). Comparatively, only 7 articles built a conceptual model, either following only the SSM guidance or incorporating other techniques in the process, like the VSM (YU, 2021). The association of the methodology with other methods was identified also in 7 articles, for instance, to enable scenario analysis after the problematic situation was structured by the SSM (CONLON; MOLLOY, 2022), or to multi-criteria decision-making as in Siddiqui andTripathi (2011) use with the Analytical Hierarchy Process (AHP).

The decision of implementing only few components of the methodology or its association with other methods to supplement steps such as the structuring of a conceptual model is not unusual but may be seen as a feature provided by the SSM flexibility. According to Checkland and Poulter (2007), the usage of SSM should be tailored to a situation under analysis, combining the set of principles that may help to make sense of its complexity. Therefore, it is valid and beneficial to conduct studies that incorporate tools into the SSM original format or decide to implement only its methods or tools that are more adequate to a focus situation.

Summarizing, the content analysis of the final set of selected articles provides answer to the proposed research question as well as give support to the use of this methodology on the development of the research proposition discussed in Chapter 1. The debated results showed that the SSM has been used in the design and implementation of PMS and to support performance-related analysis. Its role in these studies encompassed identification of stakeholders, their objectives, and attributes or criteria that should be taken into consideration in a performance management activity. The methodology tools, i.e., rich picture, root definition (with the mnemonic CATWOE), conceptual model, were also used to clarify concepts and break down strategies into activities that would bring improvement to a process.

Given these points, there is clear value in using this methodology in a performance management context where many requirements from several stakeholders shall be incorporated. Therefore, the SSM integration with a technique that enables assessing customers' perception of an organisation's performance, as the ABSA implemented by this research, is a promising approach to support better-informed management decisions. In addition, it is worth mentioning that there was not among the analysed studies any use of SSM in the context of performance management or decision-making in businesses that implement circular economy practices. Thus, the approach proposed by this research may provide useful insights into this sort of analysis, given the characteristics of these innovative business models, as discussed in section 2.3.

4 TEXT ANALYTICS USES FOCUSED ON IMPROVING DECISION MAKING AND PERFORMANCE MANAGEMENT

Text analytics techniques have been extensively used in recent years, as shown by several studies available on scientific literature. A good example is their usage to capture information from social media data and its use in a variety of contexts such as performance assessment of online retailing services, or performance of smartphone brands and their operational systems, and even sentiment analysis concerning presidential candidates in U.S. elections (ARORA; LI; NEVILLE, 2015; IBRAHIM; WANG, 2019; WANG et al., 2012). Therefore, it was essential to investigate scientific literature and recognize ways in which text analytics techniques could be used to support performance management and improve decision-making within organisations to understand the feasibility of this research proposition and the possible value of its results.

This requirement has motivated the development of a Systematic Literature Review (SLR). An SLR is a process that, by following methodological rigour, supports obtainment of insights through theoretical synthesis into fields and subfields, and aids the development of a reliable knowledge base from a range of studies for further developments (TRANFIELD; DENYER; SMART, 2003). The objective of this SLR was to identify and analyse the uses of text analytics techniques focused on extracting valuable information to improve decision-making and performance management within organisations. The following research question has guided the fulfilment of this proposition:

> **RQ:** How are text analytics techniques being used to obtain useful information to improve decision making and performance management within organisations?

To answer this research question, three renowned databases were consulted: Web of Science, Scopus, and IEEE Xplore Digital Library. Each of these databases has its own search mechanism, thus a set of keywords was defined and then used to build adequate search strings. These are presented on Table 5.

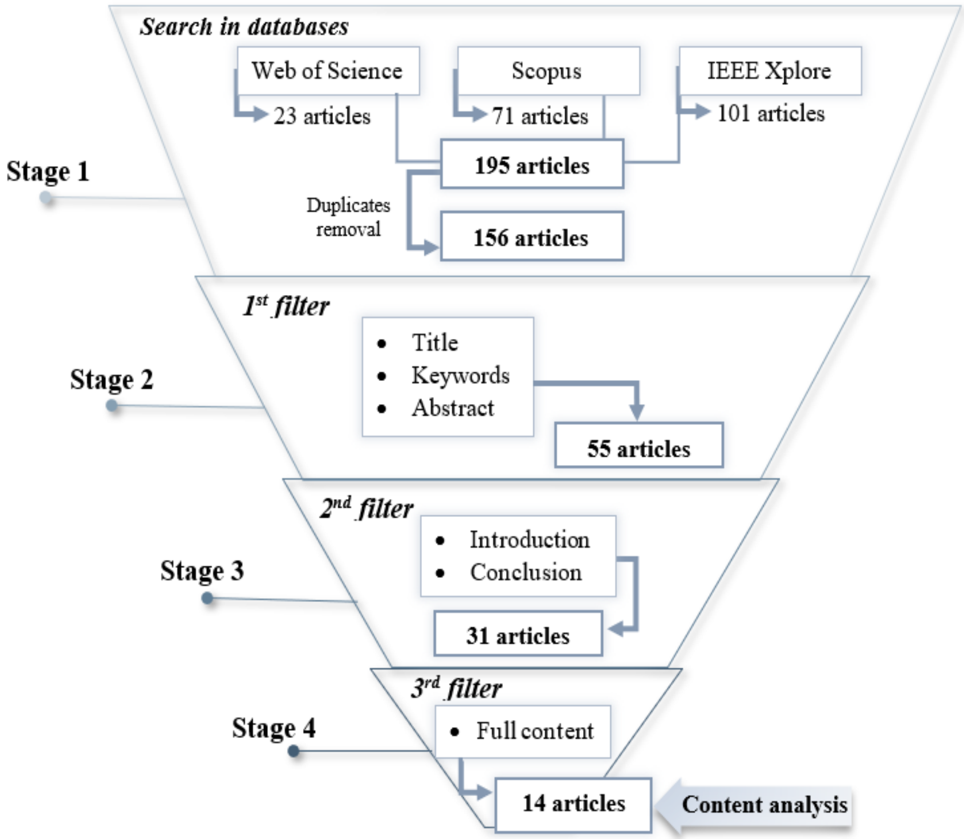
Table 5 – Search strings of SLR on text analytics to improve decisions and performance management.

Database	Search strings
IEEE Xplore	((“Text analytics” OR “Text mining” OR “Opinion mining” OR “Sentiment analysis”) AND (“decision making” OR “decision-making) AND (“Performance management” OR “business performance management” OR “business performance” OR “organizational performance”)) (("text analytics" OR "text mining" OR "sentiment analysis" OR "opinion mining") AND ("business performance" OR "performance management" OR "process improvement" OR "business performance improvement"))
Web of Science	TS = (("Text analytics" OR "Text mining" OR "Opinion mining" OR "Sentiment analysis") AND ("decision making" OR "decision-making") AND ("Performance management" OR "business performance management" OR "business performance" OR "organizational performance")) TS = (("text analytics" OR "text mining" OR "sentiment analysis" OR "opinion mining") AND ("business performance" OR "performance management" OR "process improvement" OR "business performance improvement"))
Scopus	TITLE-ABS-KEY (("Text analytics" OR "Text mining" OR "Opinion mining" OR "Sentiment analysis") AND ("decision making" OR "decision making") AND ("Performance management" OR "business performance management" OR "business performance" OR "organizational performance")) TITLE-ABS-KEY (("text analytics" OR "text mining" OR "sentiment analysis" OR "opinion mining") AND ("business performance" OR "performance management" OR "organizational performance" OR "process improvement" OR "business performance improvement"))

Source: Own Authorship.

Language, year of publication and type of source were the criteria used to filter the set of studies obtained from applying these search strings on each database. Only articles written in English and published in journals or conferences from the years from 2000 to 2021 were selected to the subsequent phases of the SLR. The initial resulting dataset consisted of 195 articles. After removal of duplicates, 156 articles remained to be filtered on the next steps. This SLR stages are summarized on Figure 7. It illustrates each review phase, filters applied and resulting set of articles.

Figure 7 – Stages followed in the SLR focused on text analytics to improve decisions and performance management.



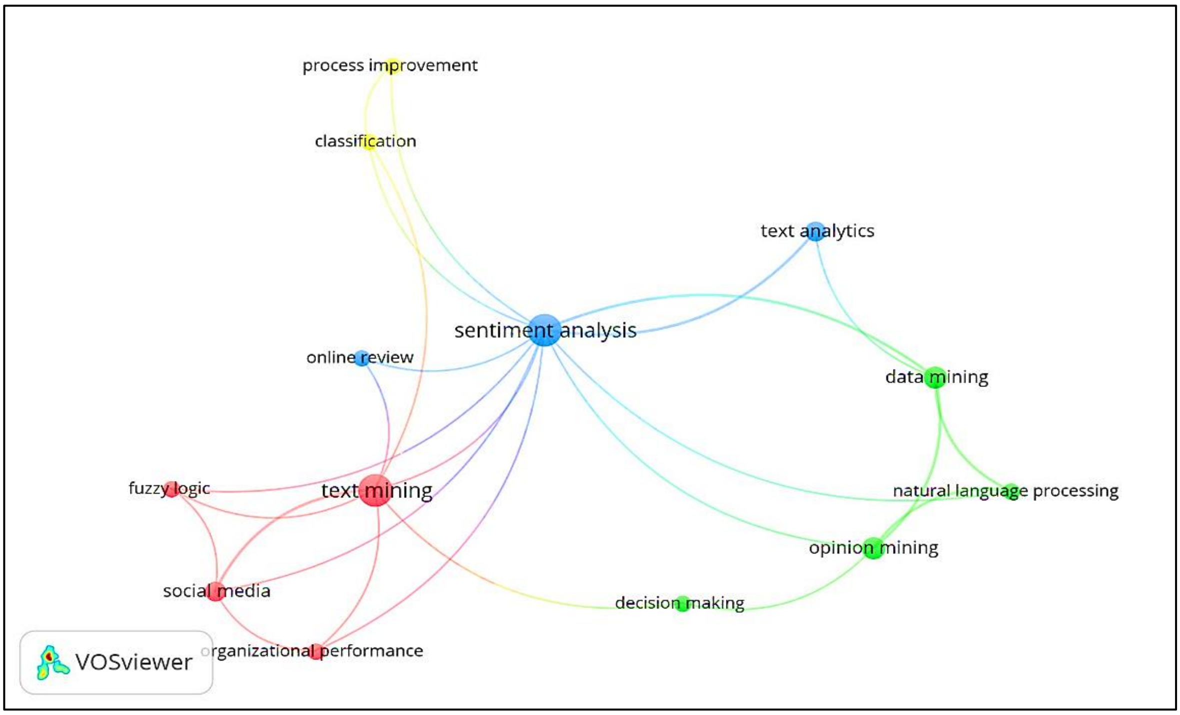
Source: Own Authorship.

As presented in Figure 7 three filters were applied to delimit the final set of studies that would be submitted to content analysis. These filters were: (1) Reading of articles title, abstract and keywords; (2) Reading of Introduction and Conclusion sections; and (3) Reading of articles full content. These consecutive stages excluded articles that do not develop uses of information obtained from text analytics techniques to improve decisions or performance in organisations. Thus, articles were excluded if they presented the use of these techniques to collect and extract information from textual data, such as online reviews or organisational reports, but did not demonstrate the practical use of the obtained information. This choice was made because to fulfil this research objective it is important to comprehend how this asset is being implemented to enhance those organisational processes. Furthermore, literature reviews and articles that focus on proposition of new techniques developments to analyse textual data were also excluded.

4.1 Main results and discussion

Given the described criteria, 31 articles were selected to be read in full (third and last filter). A network analysis of co-occurrence of keywords from these results was made in the VOSViewer software. The aim was to visualize how their content was aligned with the literature review focus and identify possible relations among topics in these preliminary results. This visual representation may be seen in Figure 8.

Figure 8 – Keywords network of articles selected to be read in full.



Source: Own Authorship.

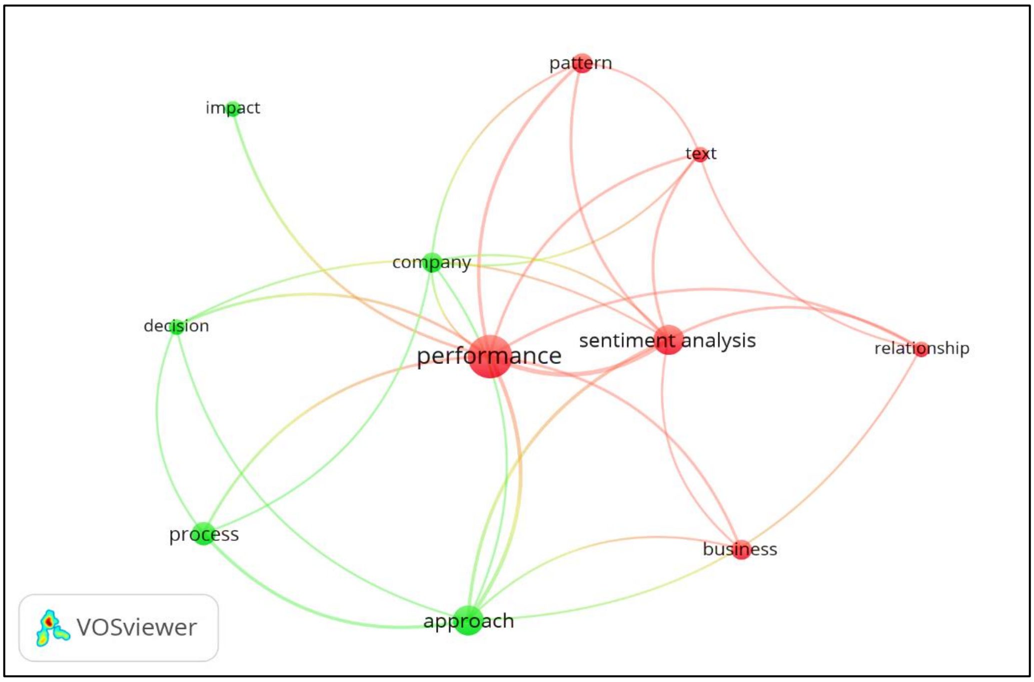
Each colour in Figure 8 represents a cluster of keywords, and the keywords in the same cluster are closely related to each other in the studies analysed. The intensity of the relationship among clusters is represented by the size and length of the lines connecting them, and the size of the circles of each keyword indicates their frequency of occurrence in the set of keywords analysed. As can be seen on the network illustrated, ‘sentiment analysis’ and ‘text mining’ were the most frequent words. This is not surprising, as these terms were used on all the search strings applied, but the relationships among them and other identified keywords are worthy of comment.

Initially, it is important to remark that sentiment analysis is one of the possible approaches enabled by text mining (or text analytics) techniques. The analysis of the keyword’s representation indicates that this was the main approach identified in the captured studies. Also, the blue and red clusters shows that the use of text mining and sentiment analysis techniques on these studies is associate to textual data from ‘*social media*’ and ‘*online reviews*’. Another important observation is the presence of the term ‘*organizational performance*’ associated to '*social media*' and '*text mining*', and the term '*process improvement*' also linked to sentiment analysis, although this last one appears in a distant cluster.

These results observation indicates a connection among uses of text analytics and organisational performance analysis and improvement, which was the focus of this SLR proposition. However, the co-occurrence of these terms, illustrated by their links and circles in the network, suggests that this relation is not being widely explored yet. In addition, the green cluster brings '*decision making*' also related to '*opinion mining*' (a synonym to sentiment analysis) and '*text mining*', even though the co-occurrence of this terms is smaller on the SLR results. Finally, the network also brings terms related to techniques used in the studies, i.e., '*natural language processing*' and '*fuzzy logic*', and analytics approaches, i.e., '*classification*'.

After this preliminary results investigation, the articles were read in full to identify the ones that would be on the content analysis phase. As shown on Figure 7, only 14 studies were selected for this last stage. These articles were published in diverse journals or conferences from the years of 2015 to 2021, and there were no co-occurrence authorship relations identified. At last, a network analysis of terms co-occurrence was made for this set of 14 articles. However, as it was a small collection and the keywords clusters obtained illustrated only each article individually, the textual data from the articles title and abstract was chosen to be used in this analysis. This network is shown in Figure 9.

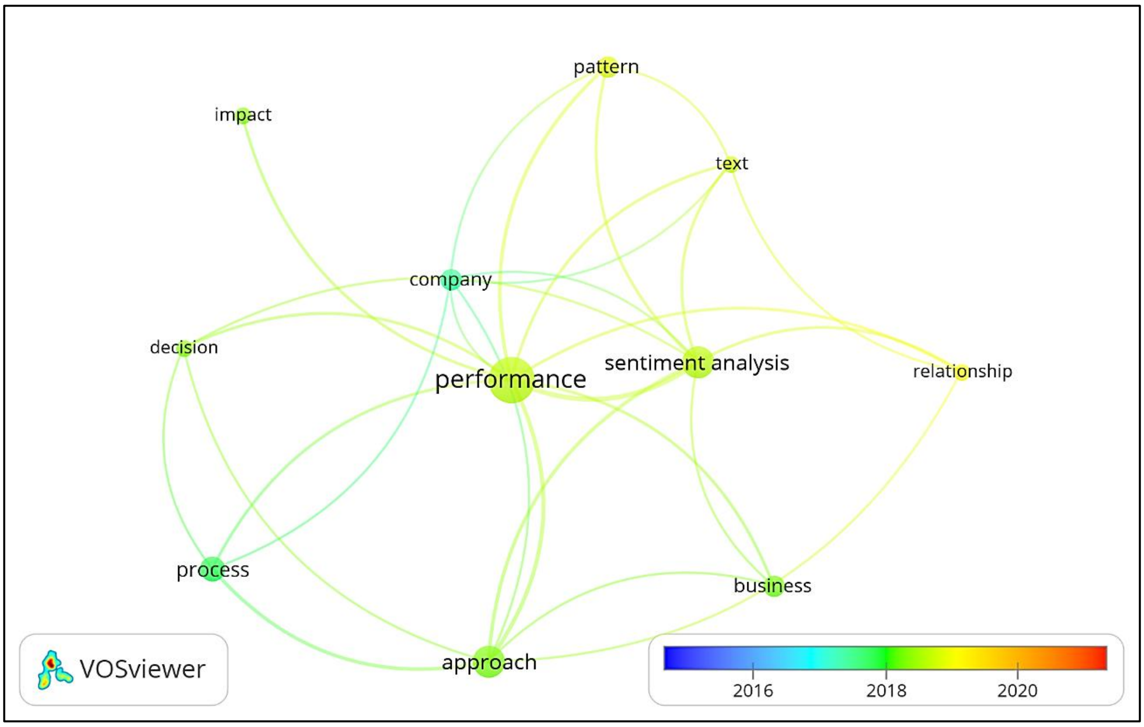
Figure 9 – Network of most frequent terms from titles and abstracts.



Source: Own Authorship.

The analysis of Figure 9 indicates a strong co-occurrence of the term '*performance*' and its allocation on the cluster that includes '*sentiment analysis'* and '*business*' (red cluster). This representation of the final set of 14 articles corroborates the analysis of the first network with the identification of a close relationship between performance-related analysis and text analytics techniques, specifically sentiment analysis, in the examined studies. The small length of the line linking the two terms remarks that as well. In addition, the term '*performance*' is also linked to each component of the green cluster, illustrating that they occurred jointly in at least part of the studies. At last, these relationships are also illustrated in Figure 10; however, the information represented by colours is the studies years of publication. The time interval when the articles analysed where published, from 2015 to 2021, is represented on the right corner of the figure.

Figure 10 – Most frequent terms from titles and abstracts by year of publication.



Source: Own Authorship.

The co-occurrence of the relevant terms of this SLR (performance, sentiment analysis, decision) is identified in publications from the years of 2018 to 2020. Few of the identified terms are seen on articles published before 2018. As some of the main topics were recognised in the most recent interval, it may point out a recent development of research on the topics, and novelty of text analytics techniques in this sort of applications. Finally, a comprehensive analysis of the 14 articles content was conducted. The information extracted on the content analysis phase is discussed in the next paragraphs and the articles details were organized on the tables that may be found on Appendix B.

The findings have shown use of text analytics techniques in different contexts as a means of supporting performance analysis and/or improving decision processes in organisations. The analysis of the selected articles provided answer to the research question proposed as well as gave support to the use of these techniques on the implementation of this research proposition. Examples of applications of text analytics techniques are analysis of customer reviews to monitoring restaurant performance; analysis of tweets to identify disruptions in a telecommunication company processes and to evaluate organisational performance in railway services; and decision automation on acceptance of students transfer requests in a university (AYOUB; ELGAMMAL, 2018; CHING; DE DIOS BULOS, 2019; DLAMINI; MAREBANE; MAKHUBELA, 2020; FERNANDES et al., 2021; YANG; ANWAR, 2016). The selected articles have mainly used data from customers' reviews and social media. However, organisational reports were also a source of data in applications such as corporate operating performance assessment (CHANG et al., 2017), credit risk evaluation in a decision-making process for loans (ZHANG et al., 2015), and analysis to build forecast models of a firm performance (SAI; GUPTA; FERNANDES, 2019).

Regarding text analytics techniques, sentiment analysis and topic modelling stand out in the examined studies. They are present in 12 of the 14 articles and are also seen associated with the text analytics task Aspect-Based Sentiment Analysis (ABSA). This evidences that these are largely used text analytics approaches in performance-related analysis. This supports the choice of this class of methods to achieve the objectives of the proposed study.

The sentiment analysis applications identified are mostly lexicon-based, using the lexicon SentiWordNet or the SentimentR package from the statistical software R (FERNANDES et al., 2021; IBRAHIM; WANG, 2019; SAI; GUPTA; FERNANDES, 2019; SINGH; JENAMANI; THAKKAR, 2020). The Support Vector Machine (SVM) algorithm is also used to classify sentiments, as well as few specialized software (CHING; DE DIOS BULOS, 2019; PENGNATE; LEHMBERG; TANGPONG, 2020; YANG; ANWAR, 2016). The algorithm used to the topic modelling task in the majority of works is the Latent Dirichlet Allocation (LDA) (AYOUB; ELGAMMAL, 2018; CHANG et al., 2017; DLAMINI; MAREBANE; MAKHUBELA, 2020; IBRAHIM; WANG, 2019; SINGH; JENAMANI; THAKKAR, 2020).

At last, among the analysed articles, three stand out for their comprehensive approaches that integrate information obtained from sentiment analysis into process monitoring and improvement and incorporate this information into already well-established performance management techniques. The first example of these studies is the application of Ashton; Evangelopoulos, and Prybutok (2015), which integrates semantic analysis and statistical process control. They propose to extract factors related to service quality categories from customers comments and used their frequency of occurrence to build control charts. A *p*-chart was defined for each factor selected as a means of monitoring the occurrence of non-conformities and the effects of improvement actions implemented on the processes.

The approach proposed by Ayoub and Elgammal (2018) identified disruptions in the process of a telecommunication company by analysing negative tweets which would contain complaints from customers. The tweets dataset was then used to train a prediction model that, given a customer tweet, automatically classifies its sentiment and disruption class it belongs. This enables quicker decisions and implementation of corrective actions. At last, the third study, proposed by Singh, Jenamani and Thakkar (2019), combines text analytics, quality management, and multicriteria decision-making techniques to evaluate and compare performance of car manufacturers. Firstly, attributes that may be related to clients' requirements are extracted from customer reviews, and a sentiment index is calculated with a lexicon-based approach. Then, Pareto graphs were made with the frequency of the negative opinions identified. These graphs were used to identify the most relevant attributes that would be used to assess and rank car manufactures performance using TOPSIS, a multicriteria decision-making technique. Finally, the worst-performance manufacturer was analysed using its Pareto graph, root cause analysis and fishbone diagram.

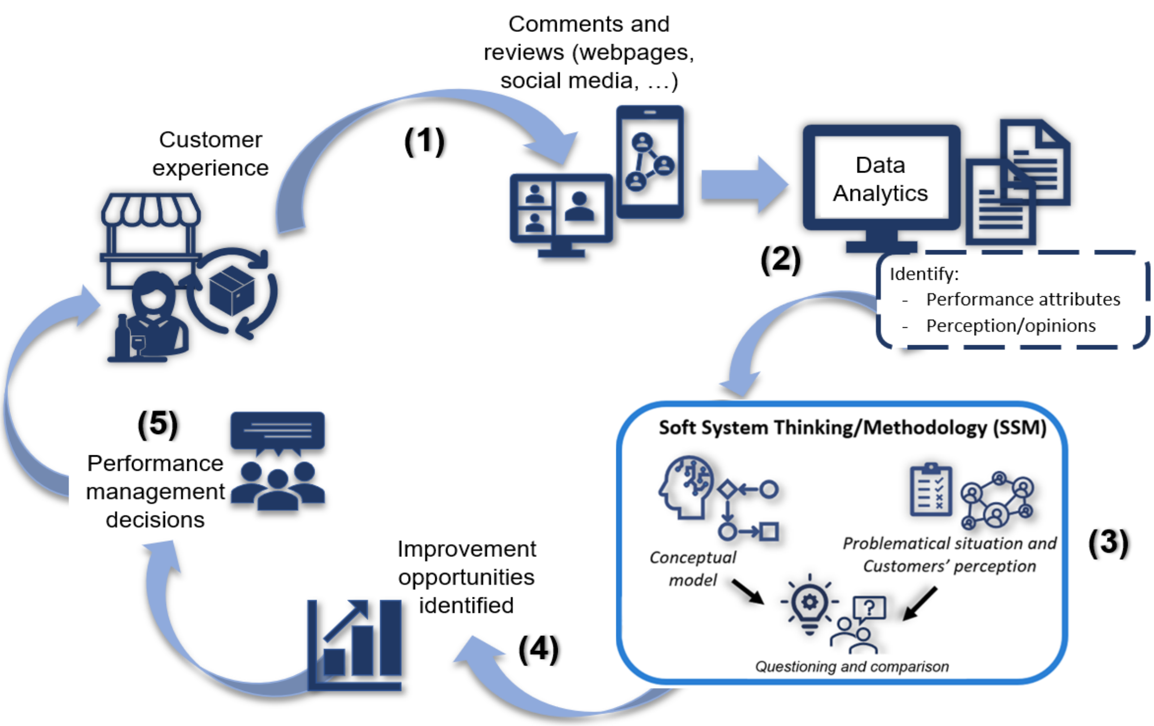
To summarize, regarding text analytics approaches, sentiment analysis or ABSA were identified associated to performance improvement and decision-making as means of obtaining and monitoring customers' perceptions. The methods applied in these approaches included lexicon-based sentiment identification, topic modelling algorithms, mainly LDA, and algorithms to build classifiers, such as SVM and Naïve Bayes. Although the analysed articles validate sentiment analysis uses in several organisational contexts to acquire useful information to monitor process performance, and support more informed decision-making or its automation, there is still a small number of studies that integrates these techniques into organisational process. This fact, associated with an increasing volume of data generated by customers in online reviews and social media, and the great analytical potential of these techniques, points out to a promising growth of this research field and motivate future developments.

In addition, the surveyed literature has shown that the use of sentiment analysis associated with performance management was not developed yet in CE contexts nor used to assess perceptions of customers of businesses that implement circularity practices, which are focused on this research proposition. Given the adaptability of those techniques and the value of their outcomes, this study may add valuable contributions to the processes and performance of organisations from this context. To achieve this objective, this research proposes a framework to guide the incorporation of customers' perceptions obtained through ABSA to identify improvement opportunities. This framework is introduced in the next chapter.

5 FRAMEWORK – INTEGRATION OF SSM AND ABSA TO SUPPORT IDENTIFICATION OF IMPROVEMENT OPPORTUNITIES

The aim of this research proposition was to structure a systemic approach to guide the identification of improvement opportunities and support performance management decisions by incorporating customers' perceptions through ABSA. An overview of this proposition is presented in Figure 11.

Figure 11 – Overview of research proposition.



Source: Own Authorship.

The numbered sections illustrated in Figure 11 should be read as follows: (1) Customers produce textual data on specialized webpages and social medial where they freely comment on their experiences and perceptions about a product and/or service; (2) This customer generated textual data is a valuable input for performance analysis and may be used to extract useful information through data analytics techniques, in this case, an ABSA implementation that enables extraction of aspects, which are then associated to performance attributes, and sentiments about them; (3) SSM implementation enables structuring a systemic view that, with customers' perceptions, may guide the identification of improvement opportunities; (4) Potential improvement opportunities may now be available to support decision-making; and (5)

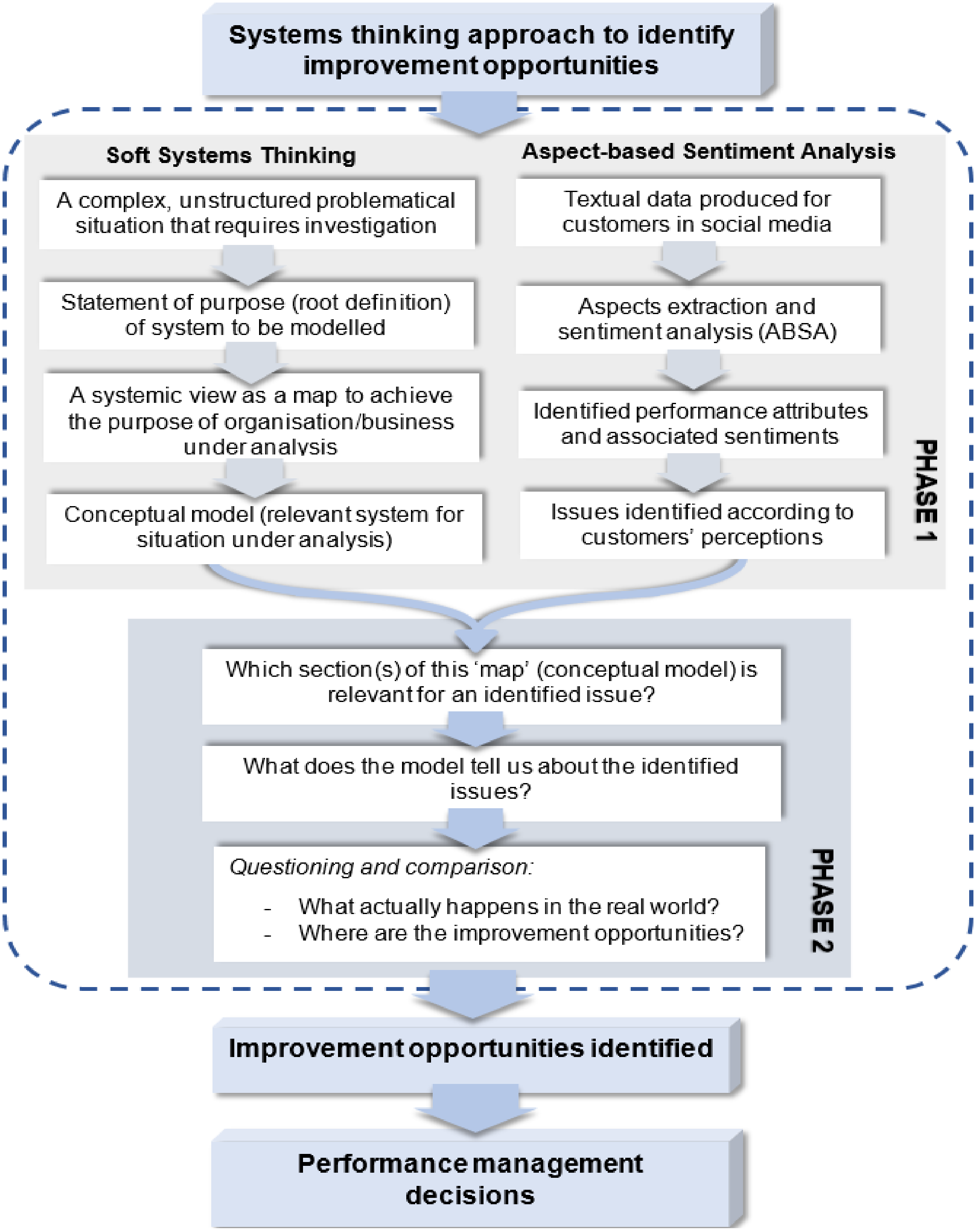
Performance management decisions may incorporate these information to become more assertive and improve customer experience.

The main outcomes of the development of these stages are a conceptual model and a framework. The conceptual model may be seen as a ‘map’ of a systemic view of a business or organisation's purpose being modelled. This conceptual model was built following the SSM stages to model a relevant system for a given problematic situation. In turn, customers’ perceptions were extracted through an ABSA implementation. This proposed approach that integrates these two methods was summarized in a framework that presents the steps to be followed and enables the replication of this proposition in different contexts. This framework is illustrated in Figure 12.

The conceptual model mentioned previously was obtained in phase 1 (see Figure 12), through systems thinking enabled by the SSM. The SSM learning cycle comprises essentially the stages: (1) Perceived real-world problematic situation; (2) Purposeful activity models; (3) Questioning and structured discussion about change; and (4) Action to improve (CHECKLAND, 1989; CHECKLAND; POULTER, 2020). As illustrated in the framework on Figure 12, this proposition encompasses elements (1) and (2) into Phase 1 and uses its output to enable a comparison against what happens in the real world (3), which was the core of Phase 2 of this framework.

Still on Phase 1, the framework describes the ABSA implementation. Subsequently, its outputs join the conceptual model in Phase 2 so the ‘Questioning and discussion about change’ activity of SSM may be conducted. This stage is where the identification of improvement opportunities may happen. At last, the findings of this questioning activity shall be provided as inputs to performance management decision-making. Moreover, as this research proposition focus on providing information to performance management, it does not include the stage number (4) of the SSM learning cycle: implementation of actions to improvement.

Figure 12 – Framework that describes and guides SSM and ABSA integration to identify improvement opportunities to support performance management.



Source: Own Authorship.

Given these points, the following section 5.1 provides an overview of the stages for modelling the systemic representation, the so-called conceptual model, conducted according to the SSM elements (left side of Phase 1 of the framework in Figure 12). Then, section 5.2 discusses the ABSA implementation of this research proposition (right side of Phase 1 of the framework in Figure 12). Subsequently, Chapter 6 describes the modelling process of the conceptual model proposed in this research, and Chapter 7 presents an illustrative case of its use with results from an ABSA implementation.

5.1 Soft Systems Thinking to model systemic view of a situation under analysis

The initial activity of a systemic analysis according to SSM is to recognise a problematic situation that requires investigation. This activity encompasses identifying stakeholders, clarifying worldviews that involve a context being analysed, and defining which purpose a system to be modelled should represent. For instance, in the application proposed by this research, the modelled system represents the purpose of organisations whose business models implement circularity practices towards sustainability.

The purpose of a system to be modelled shall be specified in a statement, the root definition (RD), that will include the elements defined by the mnemonic CATWOE (see Table 1, Chapter 2). Among these elements, *Worldview* (W) and *transformation* (T) must always be present and clearly distinguishable in a RD to well-describe the purpose and beliefs that lead to its definition. Once the RD is stated, it may be used to guide the structuring of the conceptual model (CM).

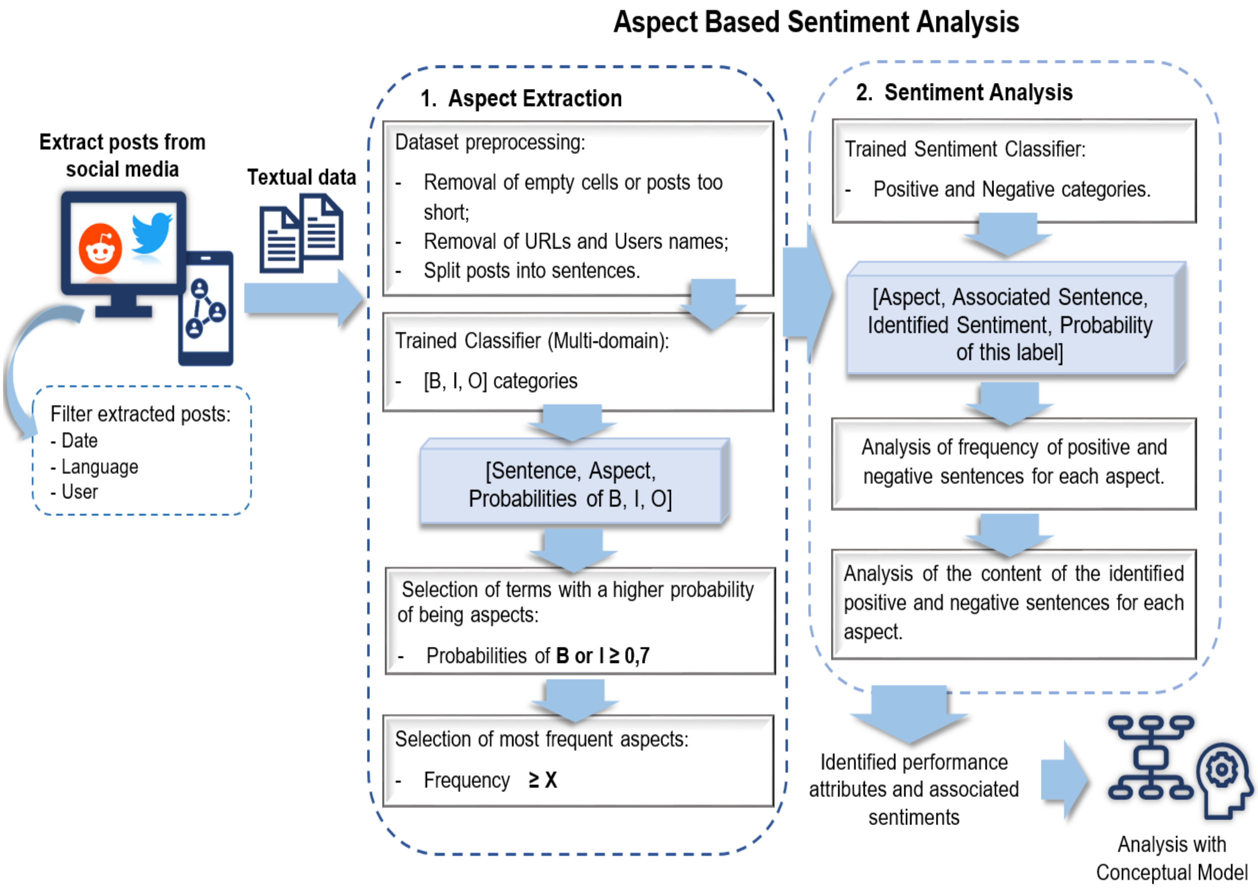
The CM is a generic model that represents a systemic view of how a previously defined purpose, the RD, could be achieved. Therefore, it does not describe an organisation or business model that already exists, but comprises activities that should be found in its reality if its purpose is as the one stated by the RD. This differentiation between reality and systemic representation is what enables the ‘Questioning and comparison’ stage of the SSM and, therefore, Phase 2 of the proposed framework. The analysts shall look at this systemic view that maps what should be done to achieve a given purpose and compare it against activities that are undertaken in reality to question what could be improved (i.e., what need to be adjusted in order to better achieve the stated purpose).

To do so, customers’ perceptions of an organization's current performance were used as guidance to ‘where to look for’ improvement opportunities in this ‘map’ or systemic view. These customers’ perceptions of an organisation's product or service were obtained through an ABSA (right side of Phase 1 of the framework in Figure 8) implementation on customer-generated data from social media. The steps of this implementation are the subject discussed in the next section.

5.2 ABSA implementation on datasets extracted from social media (Reddit and Twitter)

As previously discussed, the objective of this study comprised an implementation of ABSA to obtain useful information on customers' perceptions of current performance of a product and/or service of an organisation under analysis. The information extracted will help, by looking at the 'map' modelled using SSM, to guide the questioning stage of this methodology for identification of improvement opportunities (i.e., 'where to act', 'what needs change'). Thus, the objective of this section is to describe the steps followed to extract useful information through an ABSA technique. These steps are illustrated in Figure 13.

Figure 13 – Steps of the ABSA implementation.



Source: Own authorship.

The initial activity of the ABSA implementation was collecting a dataset. The source of textual data in this application is social media, more specifically Reddit® and Twitter® (currently rebranded as X) posts. This textual data was collected using the Python Reddit API Wrapper (PRAW) and the Snscrape Python library for Twitter. The initial accessed interval for Reddit and Twitter was from 2021 to 2022, later updated to include the first semester of 2023. The length of posts in Reddit are longer than tweets and they may bring more details on a product or service performance; however, Twitter provided a larger volume of posts. In addition, only posts in English were selected since the text analytics tools usually have a better performance in this language. Further details on the datasets are given in Chapter 7.

Following, the collected textual data went through the aspect extraction steps, which are presented in the box named 1. *Aspect Extraction* in Figure 13. After the pre-processing steps (i.e., removal of empty cells, removal of URLs, splitting text), the aspect extraction was conducted by using a classifier trained in a multiple-domain approach, the MDAE-BERT (SANTOS; MARCACINI; REZENDE, 2021), which was described in section 2.2.1. This classifier extracts the terms that are likely to be aspects according to probabilities of a term to belong to classes B, I, or O (short for *Beginning*, *Inside*, and *Outside,* related to position of a term as a likely aspect). According to the model, the higher the value associated to B and I, the greater the likelihood of that term being a relevant aspect. Therefore, after some tests to assess the quality of the extracted aspects, a threshold of $B \text{ or } I \geq 0.7$ was defined to select only those possible aspects that would be more relevant to this study. Finally, as the number of aspects was still high for further analysis, the study focused only on those most frequent in the analysed texts.

After that, the identified aspects were used to gather the sentences that would go through sentiment analysis, which were the respective sentences where these aspects occurred. The steps of this phase are presented in the box named *2. Sentiment Analysis* in Figure 13. The trained classifier[1] (HARTMANN et al., 2023) used in this study categorizes the sentences in *positive* or *negative* and provides a probability of this classification. In addition to this approach, a lexicon and rule-based sentiment analysis tool, the VADER[2] (Valence Aware Dictionary and sEntiment Reasoner) (HUTTO; GILBERT, 2014) was used as a means of comparison to assess the quality of the results obtained. VADER is a tool that was specifically adjusted to analysis of sentiments expressed in social media. The results obtained by the application of this tool were very similar to the ones from the trained classifier. Therefore, the researchers considered it as validation of the sentiment analysis results firstly obtained. As the positive and negative classification obtained through the trained classifier satisfied the research objectives, the subsequent analysis was done considering these results.

At last, an analysis of the frequency of the positive and negative comments regarding each aspect was conducted to identify which of them should be prioritised, i.e., those whose number of negative comments was higher. Finally, the content of the sentences categorized as positive and negatives for each of these aspects was analysed manually by the analyst for an

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[2] Available in <https://github.com/cjhutto/vaderSentiment>

overall idea of what was being said about them. This information was illustrated in diagrams that will be used in the ‘Questioning and Comparison’ stage of the SSM with the conceptual model, as illustrated in the final part of the framework in Figure 12. The results obtained in each of the described steps are presented and discussed in Chapter 7.

[2] Available in <https://github.com/cjhutto/vaderSentiment>

6 CONCEPTUAL MODEL – MODELLING OF A RELEVANT SYSTEM

This section is focused on describing the implementation of the SSM steps required to obtain the CM that may be used as a 'map' to guide the identification of improvement opportunities, as described in the framework previously discussed. A CM is a relevant system of required activities to achieve the purpose stated by the RD and the logical dependencies among these activities. One way of understanding the process of modelling a CM is as an exercise of providing answers to the question: 'What activities must be done together with their logical dependencies to completely represent the words in the root definition?'.

As proposed by the SSM, the initial activity is to obtain perceptions or understandings of the problematic situation that will be focus of the implementation. The chosen focus to implement the proposed framework, as introduced in previous chapters (see Chapter 1 and section 2.3), is organisations whose business models implement circularity practices towards sustainability. That said, this first activity was conducted through consulting publications (e.g., scientific articles and organisational reports) to extract information regarding their context, features, and challenges to be addressed.

As previously discussed, to succeed in the market, these organisations need to manage challenges associated with the innovativeness of their sustainable offers, the higher level of interaction with customers, and collaboration with partners from the value chain. These businesses shall incorporate stakeholders' requirements about environmental, social, and economic aspects of their activities while ensuring a competitive customer experience. Based on that, the following assumptions were defined:

a) Organisations want to be capable of managing the environmental, social, and economic aspects of their business, providing value for their stakeholders, and remaining competitive in their market.
b) Stakeholders want the organisation to perform as well as possible and generate value by fulfilling their requirements and expectations.

These assumptions established the basis of the system to be modelled, for they helped to define which *worldview* (W) could determine the purpose of organisations in this context. Thus, based on consulted literature and assumptions (a) and (b), the following worldview was defined:

Worldview: *It is possible to provide products and services that satisfy customers' expectations and market demands through implementing and promoting circularity practices towards developing sustainable business.*

As a result, from this worldview, the transformation (T) could also be described (i.e., W and T from the mnemonic CATWOE). The Transformation is presented next on Figure 14.

Figure 14 – Transformation (T) incorporated into the root definition.

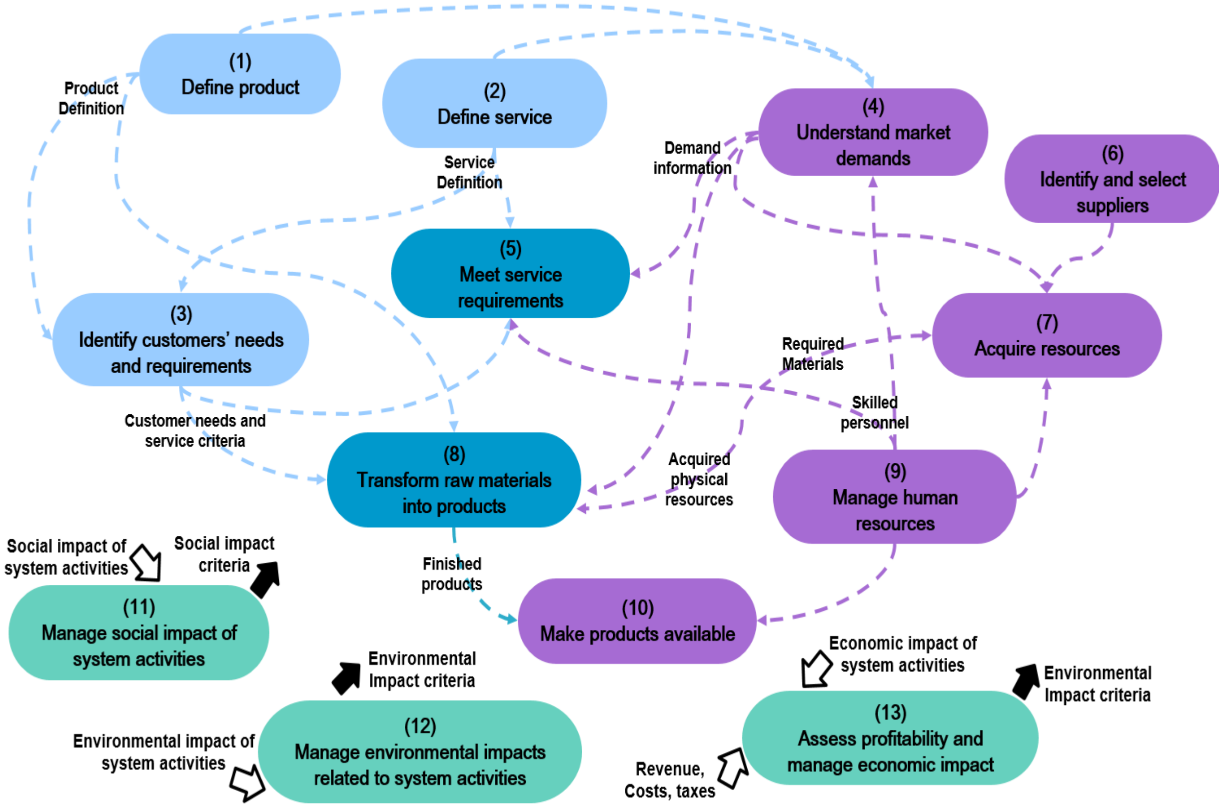
Source: Own Authorship.

After these two elements were defined, the analyst could propose an initial RD for the system to be modelled. The RD is a statement that describes the purpose of a system and guides the structuring of the CM. The *Worldview* (W) and *transformation* (T) are the two elements from the mnemonic CATWOE that must always be present and clearly distinguishable in a RD. Thus, the initial RD was proposed as follow:

Root definition – Initial: *A company-owned system operated by its skilled personnel according to organisational policies to provide products and services that satisfy customers' requirements and expectations, and continually match market demands by transforming raw materials into products, and meeting services requirements, through production processes that effectively manage environmental, economic, and social impacts, while ensuring profitability of the system.*

The subsequent activity of this implementation was modelling the CM. Given the complexity of this RD and of the context it encompasses, the modelling began with the design of which was called a *high-level conceptual model* (HL-CM). Differently from a detailed conceptual model, instead of assembling activities and their interrelationships, this high-level model first introduces a set of subsystems (and their interrelations) that would be required to achieve the purpose stated by the RD. The HL-CM is presented in Figure 15. Later on, each of these subsystems were broken down into activities required to achieve the purpose of the whole system, constituting a detailed conceptual model.

Figure 15 – Initial version of the high-level conceptual model.



Source: Own Authorship.

The oval or pill shapes on the HL-CM represent the subsystems required to achieve the purpose stated by the RD. Their interrelations are indicated by the dashed arrows in which subsystems in the head of an arrow depend on inputs from a subsystem in the tale of the arrow. There are labels on these arrows to indicate which inputs are provided. The subsystems on the bottom of the picture receive inputs from all other subsystems, which is represented for simplicity by the broad white arrows. In addition, these subsystems also provide inputs for all other subsystems and this relation is illustrated by the broad black arrows. These other two types of arrows are labelled with the kind of input the related subsystem is providing to or receiving from the entire system.

For instance, activities in the subsystem ‘Transform raw materials into products’ require inputs from the subsystems “Identify customers’ needs and requirements” and ‘Understand market demands’ (dashed arrows coming into the subsystem), and also needs to meet ‘Environmental Impact criteria’ provided by the subsystem ‘Manage environmental impacts related to systems activities. In its turn, ‘Transform raw materials into products’ provides inputs to activities in the subsystem ‘Make products available’.

Finally, as mentioned previously, the subsystems from the HL-CM were broken down into activities and their interrelations to constitute a comprehensive CM. The initial stages described so far were conducted by the analyst responsible for this SSM implementation. Once the CM was obtained, a group of specialists on the modelled context was gathered in two workshops where they acted as stakeholders of an organisation under analysis. Thus, they could incorporate their experience from working within companies, regulatory bodies, and conducting research in related areas, while the analyst acted only as a facilitator. The facilitator in this sort of problem structuring should initially encourage divergent thinking so the participants may explore their different perspectives, and then support convergent thinking to form a consolidated perspective of the context under analysis, i.e., the HL-CM and detailed subsystems in the CM (FRANCO; MONTIBELLER, 2010). The workshop participants also helped to assess the model defensibility, i.e., the logical dependencies, and consistency of the HL-CM and the resultant CM regarding the purpose being represented.

A profile of the specialists is presented next in Table 6, where they were anonymised to preserve their identity and details of the organisations they are from. These specialists were selected and invited considering their expertise on sustainability and/or transition to CE, and their experience within companies, either as analysts, consultants, or in management positions. Ideally, the selected specialists should bring a broad range of perspectives to the modelling process, as they acted from the point of view of stakeholders modelling the systemic representation. Thus, an effort was made to include a variety of experts on the context of this implementation. As table 6 presents, the group of participants included ranges from industrial and environmental engineers to a professor with experience in environmental regulatory bodies.

Table 6 – Profile of participants on workshops to assess conceptual model.

Specialist	Experience
Participant #1	Environmental engineer with fifteen years of experience as manager of Sustainability and analyst of environmental management in manufacturers and retailers. The expertise encompasses topics such as ESG (Environment, Social, Governance) analysis, circular economy, and lifecycle analysis.
Participant #2	Post-doctoral researcher in Denmark, conduct studies focused on consumer behaviour in the context of textile industry transition to the circular economy. Also has experience as a project manager in a circular economy consultancy company.
Participant #3	Environmental engineer, currently member of an Environmental Engineering association and a consultancy group focused on companies transitioning to circular economy in Brazil. Also conducts doctoral research on CE-related topics.
Participant #4	Industrial engineer currently working as a business analyst in a retailer and marketplace. Also has experience as a business analyst in innovation projects and conducts doctoral research on Innovation and Sustainability.
Participant #5	Ph.D. in Environmental Engineering, professor in a Civil and Environmental Engineering department in Brazil with 20 years of experience in an Environmental regulatory body, also in Brazil. Coordinates a research group focused on Sustainability, solid waste management, the 17 United Nations Sustainable Development Goals, and Lifecycle Analysis.

Source: Own Authorship.

The workshops were conducted in an online environment (Google Meet®) for approximately two hours each. Initially, the participants observed a brief presentation that introduced the modelling objective as well as the defined assumptions, which are the ones previously presented in this section. After that, they learned about the statement of purpose of the system to be modelled, i.e., the RD, and were presented to the HL-CM. Subsequently, the participants were separated in on-line rooms to assess pre-defined sections of the HL-CM and comprehensive CM, which were designed using the software Miro®. One example of the material provided for the specialists' assessment is available in Appendix C for illustrative purposes.

During the workshops, every specialist had a board in the software Miro® in the same format as the one presented in the Appendix C, Figure C1. The colours used to differentiate the subsystems in the HL-CM (see Figure 15) are the same as seen in the comprehensive CM and used in its sections in the Miro® boards for the workshop. The specialists were asked to make notes, preferably in different colours, and add or adjust activities and relationships among them according to what they thought would bring more consistency for the model or better represent the purpose stated in the RD. Appendix C, Figure C2, presents a board obtained after one of the workshops, where a participant's contributions may be seen highlighted in yellow and orange. Then, for the last phase of the workshop, the participants were brought back together in the same room so their contributions could be presented and debated for incorporation into the modelling process.

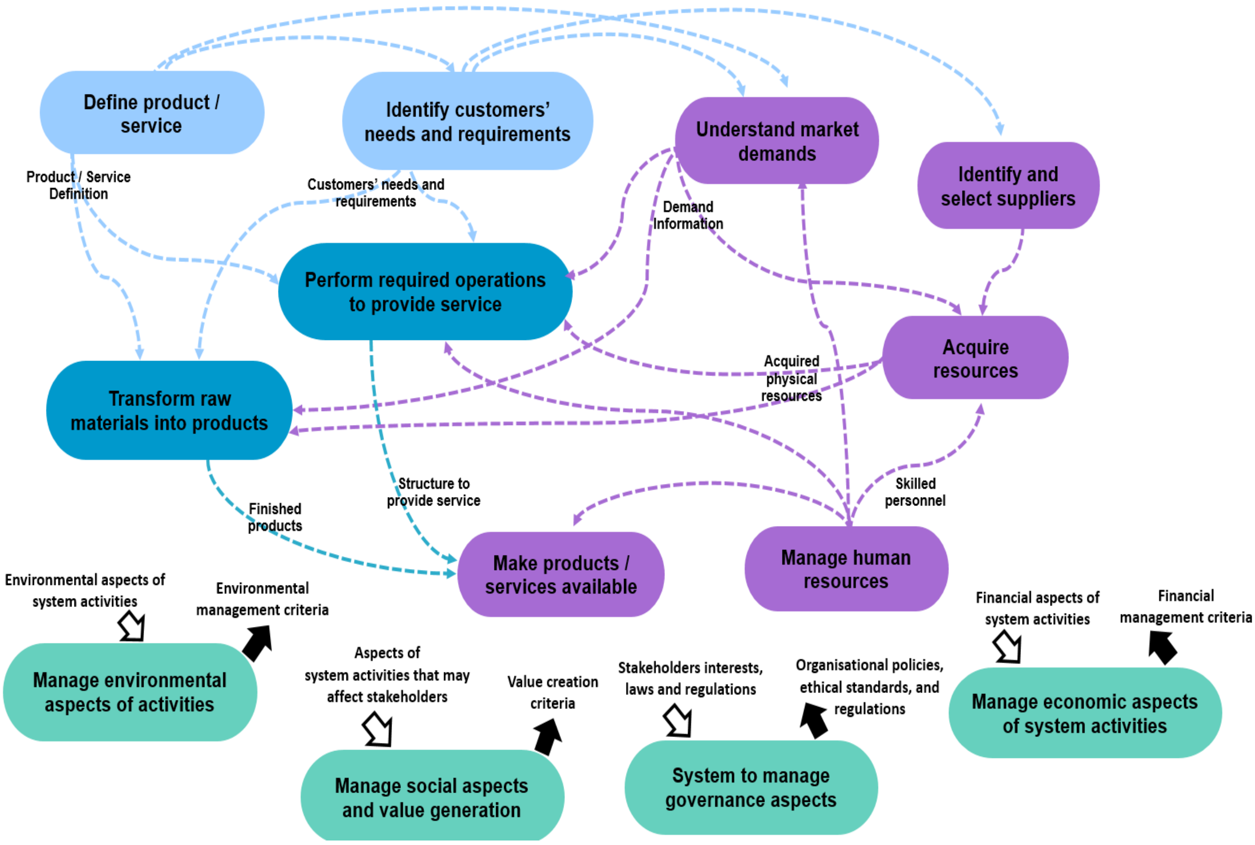
This described approach was designed to optimize the efficiency of the activity, given the substantial size and complexity of the CM. Also, this experience has shown that three to five specialists per workshop is an adequate number of participants. This range ensures that the online events do not extend excessively and allows participants to maintain focus during the discussions. A suggestion for larger groups is to make these events in person, incorporating brief breaks strategically throughout the activity. This could be done, for instance, after each specialist addresses their section of the CM before they return to present and debate their perceptions with the whole group. This approach may enhance the overall consistency and engagement in the workshop.

Concluding this activity, the contributions from the workshops were compiled and incorporated into the HL-CM and comprehensive CM. Firstly, a new RD was proposed to better describe the purpose to be represented by the conceptual model. The main topics discussed by the specialists that should be explicit in the RD and conceptual models were related to value generation to stakeholders and its association to social aspects, management of environmental aspects throughout the production chain, and governance aspects (e.g., management of stakeholders, decision-making, regulations). Therefore, the initial RD was updated as follow:

> ***Root definition – Updated:*** *A company-owned system operated by its skilled personnel according to organisational policies to provide products and services that satisfy customers' needs and requirements and continually match market demands, by transforming raw materials into products and gathering required resources to provide services through a production chain that effectively manages its associated environmental aspects, while generates economic and social value for its stakeholders.*

Hence, the elements of this RD guided the modelling of an updated HL-CM, an improved version of the one presented previously in Figure 15. The updated HL-CM that incorporated workshop contributions may be seen in Figure 16.

Figure 16 – Updated High-Level Conceptual Model (HL-CM).



Source: Own Authorship.

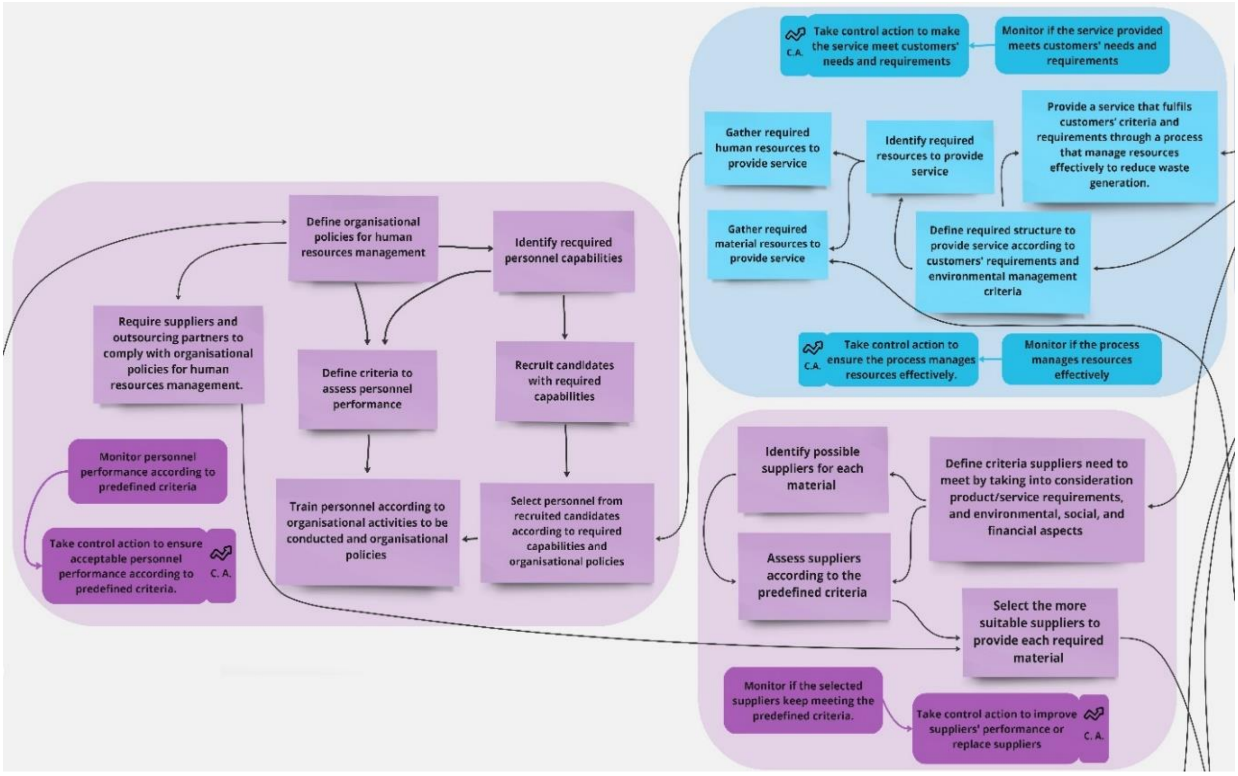
The main adjustments incorporated into the new HL-CM based on the specialists' contributions are detailed next:

- Junction into only one subsystem of the previous subsystems 'Define product' and 'Define service'. According to specialists' perceptions, there would be an overlap of activities in those subsystems, even more, if organisations' business model is a product service system (PSS). Thus, it makes sense they constitute only one subsystem.
- Definition of a clearer term for the subsystem "Meet service requirements". Participants of the workshops did not find the previous denomination a good description of what the subsystem comprises. After some consideration, now it is called 'Perform required operations to provide service'.
- Removal of the numbering of subsystems, for they seemed to represent an idea of ordering or workflow. However, the map shall not be seen as a flow chart, and analysis using the proposed map would not necessarily follow precedence through subsystems nor cover all of them.

- Addition of a subsystem focused on governance aspects, given the relevance of those to the overall performance of an organisation and the growing importance of Environmental, Social, and Governance indexes for a company value.

Once the HL-CM was updated, contributions regarding activities on the comprehensive CM and their interrelationships were also incorporated. Also from Figure 16, it is important to remark that the CM comprises thirteen subsystems. Given its broad and rich structure, the CM has not been presented in this chapter, but it may be seen in Appendix D. However, as a means of illustrating how the CM is structured, a section of this model with some subsystems is shown in Figure 17.

Figure 17 – Section of CM illustrating three subsystems.



Source: Own Authorship.

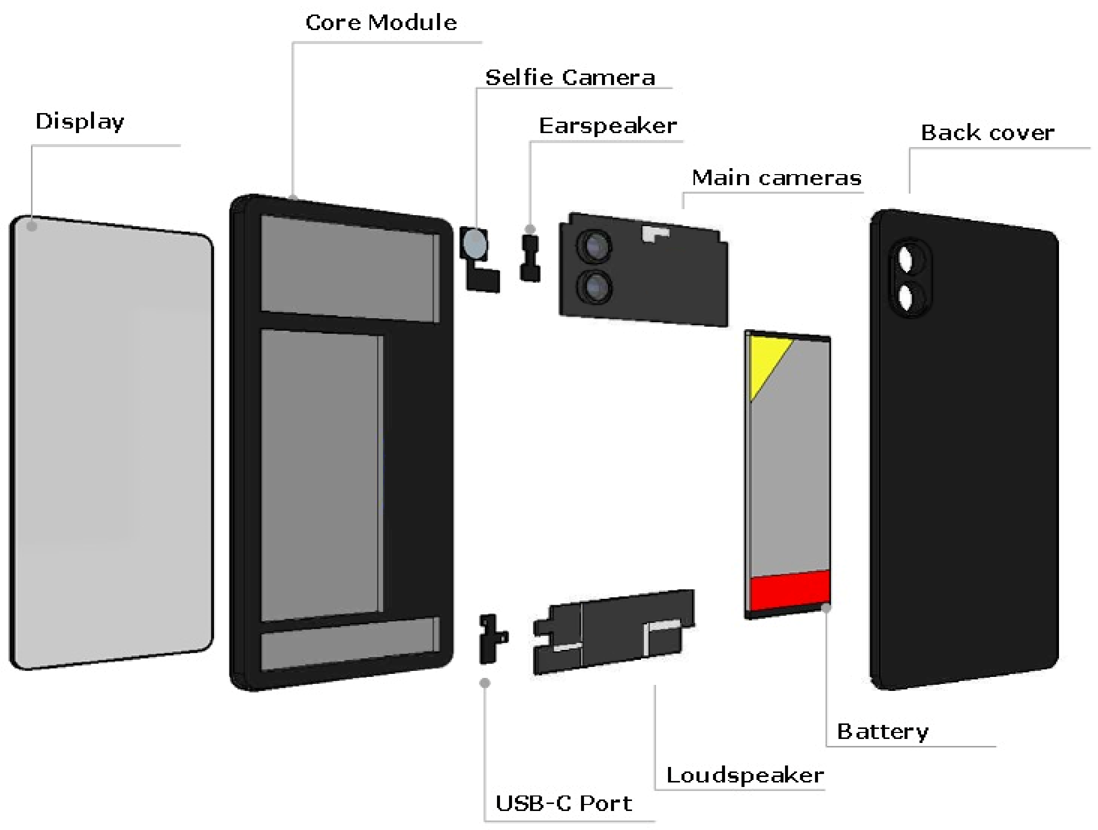
This section of the CM shown in Figure 17 encompasses the subsystems defined as ‘Perform required operations to provide service’ (in blue), ‘Manage resources’ and ‘Identify and select suppliers’ (both in light purple). These subsystems and their interconnections with other subsystems may also be seen in the HL-CM in Figure 16. Following, Chapter 7 brings the implementation of the obtained CM in an illustrative case to support the identification of improvement opportunities.

7 ILLUSTRATIVE CASE – ETHICAL ELECTRONICS: MODULAR SMARTPHONE

7.1 Focus organisation

The illustrative case discussed here is focused on a company whose business model is centred on ethical electronics. It is essential to remark that neither the brand nor the product name was included in this manuscript to protect company data. The focus company main product is a modular smartphone. The concept of modular smartphone means that their product was designed to be repairable, thus, it is possible to easily replace components such as camera, speakers, battery, and even the display without sending the device to specialised support. To achieve that, the company business model provides spare parts at an affordable price so the customers may easily replace by themselves whatever is faulty. The illustration in Figure 18 exemplifies a modular smartphone and its components that may be replaced.

Figure 18 – Modular Smartphone.



Source: Own Authorship.

By promoting its innovative business model, the company wants to pave the way in the market for long-lasting electronic products in opposition to the current culture of rapid obsolescence in the electronics industry. The company's practices aim to maintain the value of products for as long as possible, reduce demand for raw materials and new products, include recycled components in their products whenever it is possible, and promote recycling when it is not possible to reuse a device anymore. Moreover, this company also makes efforts to acquire raw materials from sources where environmental and social aspects of production are respected, i.e., buying responsibly mined materials and ensuring that suppliers pay adequate wages and provide satisfactory work conditions. Hence, their practices make clear their values are focused on sustainability and walk towards circular economy.

Given these points, the described company was identified as an adequate case to illustrate the usage of the model proposed by this research. In addition, its product belongs to a category of goods (electronics in general, such as smartphones, laptops, and cameras) that customers commonly write reviews about on specialised web pages and social media. Customers also use these sources to obtain other people's opinions when deciding on acquiring a new product. Therefore, there is potentially valuable customer-generated data available on social media regarding these goods. This data may be explored by organisations to assess current performance and identify improvement opportunities.

Based on this assumption, the researcher collected data from social media and implemented a text analytics approach to extract information regarding the products of the focus organisation, i.e., the modular smartphone. The search query used to gather textual data was this organisation's brand. By doing that, the search instruments would return any post or comments where the company, or its main product, which has the same name, was mentioned during the interval taken into consideration. The next section describes the procedures followed in the text analytics implementation and discusses its main findings. To protect the company information, whenever the brand or the name of one of its modular smartphones appears in this thesis on texts extracted from social media, they are replaced by the following symbols: *{...}*.

7.2 Aspect-Based Sentiment Analysis results

The textual data used to implement the ABSA was constituted of posts collected from the social networks Reddit® and Twitter® (currently rebranded as X®). These were accessed firstly in the second semester of 2022, and data from the years of 2021 to 2022 was gathered. Then, this dataset was updated in the first semester of 2023 to include more recent publications. However, because of changes in Twitter's policy for academic research and new fees to access its data, it was unfeasible to collect new data from this source; therefore, only the Reddit API was accessed again. Hence, this text analytics implementation was conducted in a dataset of 25826 posts from Twitter and Reddit, where 24148 posts came from the former and 1678 from the latter.

Subsequently, the trained model MDAE-BERT (SANTOS; MARCACINI; REZENDE, 2021) was implemented to extract aspects that could potentially be associated with performance attributes. Before that, pre-processing steps were applied on the dataset, to clean and organise it, e.g., remove empty cells and URLs. Examples of the obtained results from the MDAE-BERT implementation are shown next in Table 7.

Table 7 – Sample of results of aspect extraction through MDAE-BERT.

Sentence	Aspect	B	I	O
Don't forget to mention, replaceable battery and camera.	battery	***0,7027***	0,002107	0,29522
Even with a small battery it still has an impressive battery life of 1.5 days of usage.	battery	***0,96055***	0,000955	0,03849
It took 5 weeks to get through to you and now you tell me my 3 month old {...} is out of warranty!	warranty	***0,9671***	0,001956	0,03096
Five year warranty, easily repairable, very good performance.	warranty	0,1741	***0,8101***	0,01578
Love that I have a 5yr warranty on it & support.	warranty	***0,9476***	0,02214	0,03027
I'd definitely love one of these though, the design of the components is such a good idea	design	***0,9986***	0,000466	0,000923
This is a game breakingly stupid design especially when combined with the fact you removed the audio jack for cheap wired headphones with a mic for a workaround...	design	***0,94443***	0,000873	0,05469

Source: Own Authorship.

Following, the extracted aspects, as exemplified in Table 7, were filtered by a threshold of B or $I \geq 0{,}7$ to select those that more likely would be relevant to the case focused on this application. As described previously (see section 2.2.1), the label B indicates that the term is the beginning of an aspect, and I indicates it is inside an aspect. This procedure was followed for the extracted terms from both datasets. At last, a total of 14456 terms from the Twitter dataset and 2476 from the Reddit dataset were selected as potentially relevant aspects. This amount included many repetitions of the same term or terms that occurred only once and, therefore, would not be relevant to this illustrative case. Then, a further filter to list terms without counting repetitions reduced this set to 2478 aspects from Twitter and 731 from Reddit.

After the filtering procedure, the most frequent aspects of both datasets were compared manually to constitute a unified set. This procedure eliminated a few terms that could not be related to aspects of the product or performance attributes or were likely related to features outside of the focus organisation scope, e.g., ‘wintech’, ‘winit’, ‘google’. Finally, a unified list was built with the fifty aspects identified with the highest frequency from both Twitter and Reddit posts to make the next steps of analysis more efficient (a complete list of these aspects may be seen in Appendix D). This decision was made for there was still a high number of identified aspects that could potentially be associated with performance of the product. Table 8 presents an extract of this final group of aspects that may represent performance attributes of the organisation's product under analysis.

Table 8 – Sample of aspects identified with the highest frequency.

	Aspect	**Frequency**
1	Support – customer support	693
2	Battery	368
3	Software	300
4	Screen	270
5	Design – modular design	243
6	Repairability – Repair	208
7	Hardware	202
8	Warranty	186
9	Case	166
10	Audio jack – Jack	141
11	Price	137
12	System	137
13	Headphone	133
14	Charging	90
15	Security	89
16	Materials	85
17	Sustainability	85
18	Performance	85
19	Camera	77
20	Supply	75

Source: Own Authorship.

Once these main aspects that may be associated with performance attributes were identified, the original sentences of these terms were retrieved so the sentiment analysis step could be implemented on them. This step result is a probability of an opinion or sentiment expressed in a sentence being negative or positive. As commented in section 5.2, besides using a trained sentiment classifier, the lexicon and rule-based sentiment analysis tool VADER (Valence Aware Dictionary and sEntiment Reasoner) was used to compare and assess the resultant sentiment classification. An extract of these results may be seen in Table 9.

Table 9 – Sample of results obtained from sentiment analysis with trained classifier and VADER.

Sentence	Aspect	Label – score (Classifier)	VADER results
The big PROs of the {…} (besides the certified fair production and repairability): overall build quality, aluminium frame, battery capacity, open to alternative OSs, fingerprint sensor, speed more than enough for everything (except high end gaming).	Battery	'label': 'POSITIVE', 'score': 0.9987	'neg': 0.0, 'neu': 0.94, 'pos': 0.06, 'compound': 0.3182
The battery completely died after no more than 3 weeks.	Battery	'label': 'NEGATIVE', 'score': 0.99950	'neg': 0.443, 'neu': 0.557, 'pos': 0.0, 'compound': -0.7474
It took 5 weeks to get through to you and now you tell me my 3 month old {…} is out of warranty!	Warranty	'label': 'NEGATIVE', 'score': 0.99949	'neg': 0.0, 'neu': 1.0, 'pos': 0.0, 'compound': 0.0
The {…} has upgradeable components, scores a perfect 10/10 from and comes with a 5-year warranty.	Warranty	'label': 'POSITIVE', 'score': 0.99887	'neg': 0.0, 'neu': 0.802, 'pos': 0.198, 'compound': 0.5719
Not very happy with the slippery design that enforces you to buy a rubber-based case.	Design	'label': 'NEGATIVE', 'score': 0.9995	'neg': 0.187, 'neu': 0.813, 'pos': 0.0, 'compound': -0.4964
A sustainable modular design means you can swap out and replace its components super-easily, so it'll last you longer.	Design	'label': 'POSITIVE', 'score': 0.9987	'neg': 0.0, 'neu': 1.0, 'pos': 0.0, 'compound': 0.0

Source: Own Authorship.

Regarding the results obtained from VADER, the main value to be observed from the column 'VADER Results' in Table 9 is the 'compound' one, which may be seen as a normalized, weighted composite score of the general sentiment of a sentence (HUTTO; GILBERT, 2014). Thus, if compound ≥ 0.5, the sentence is marked as positive, and if compound ≤ -0.5 the general sentiment of the sentence is negative. Values in between this interval indicate the sentence is neutral. As may be exemplified from Table 9, VADER results either agreed with the sentiment previously classified or defined a sentence as neutral, but it never indicated an opposite outcome.

Finally, from the final set of extracted aspects from both Reddit and Twitter datasets (see Table 8), it was observed which ones had a higher frequency of negative comments to prioritise the aspects that should be focused first in an analysis with the conceptual model in Phase 2 of the proposed framework (see Figure 12, Chapter 5). The selected aspects accordingly to this criterion were '*battery*', '*software*', '*screen*', '*hardware*', '*audio jack – jack*', '*price*', and '*headphone*'.

Additionally, despite a reduced frequency of negative comments about it, another aspect was included: '*design – modular design*'. This decision aimed to discuss customers' perceptions of this feature that evidently portrays the organisation value proposition focused on sustainability and CE principles.

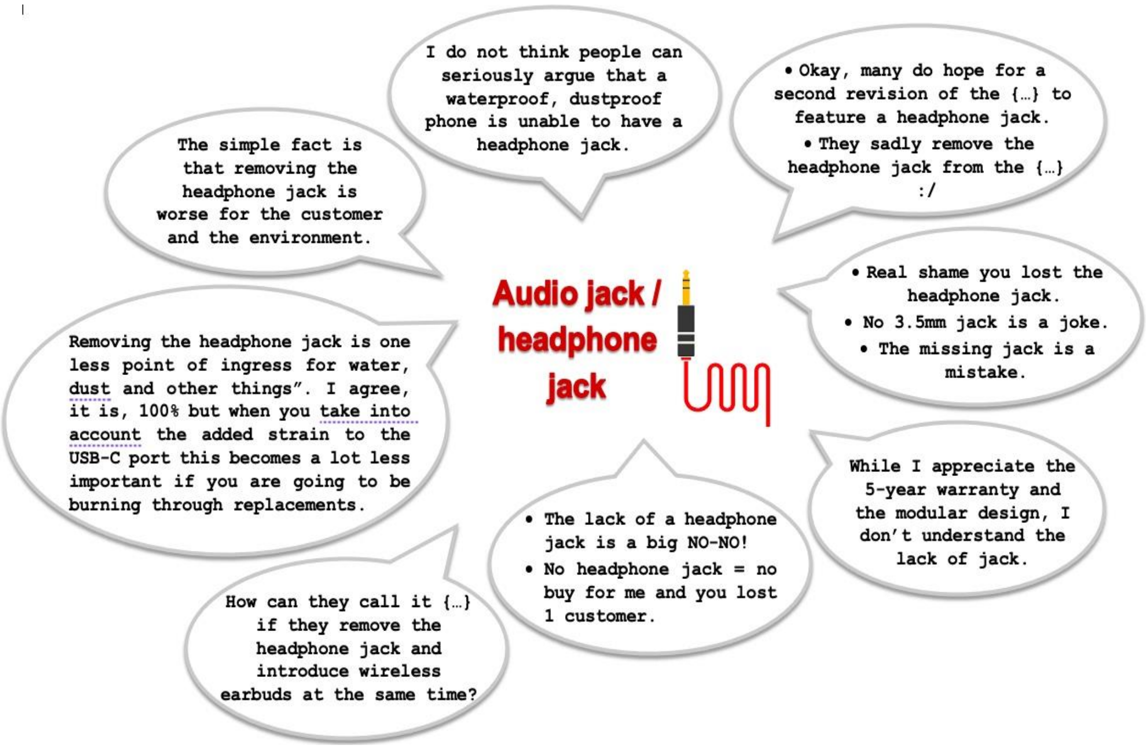
Subsequently, the original sentences that contained the selected terms were retrieved and grouped for content analysis. The researcher conducted this activity manually after some experiments with keyword extraction algorithms and topic modelling showed these could not provide a comprehensive enough view of the sentences' content. The manual content analysis helped to exclude from the list of aspects those whose original sentences could not contribute to performance analysis of the focus company product, i.e., terms like '*hardware*' and '*software*', and '*price*', whose associated sentences were too generic or mentioned products of other companies (e.g., "*In general I do not care too much about the hardware, since I hardly play demanding games.*"; "*I am tired of having to change phones only because of a worn-out USB port...";* "*I do not need the latest hardware, as long as it is able to run current software with up-to-date security patches."*).

At last, some of the most relevant sentences, according to richness of information on performance attributes identified during the content analysis, were represented on diagrams. These should be used to start the SSM 'Questioning and Comparison' stage with the conceptual model (Phase 2 of proposed framework). The diagrams built for the main selected aspects are presented in the next section with the carrying out of the mentioned SSM stage.

7. 3 Conceptual model and customers' perceptions to conduct SSM's 'Questioning and Comparison' stage

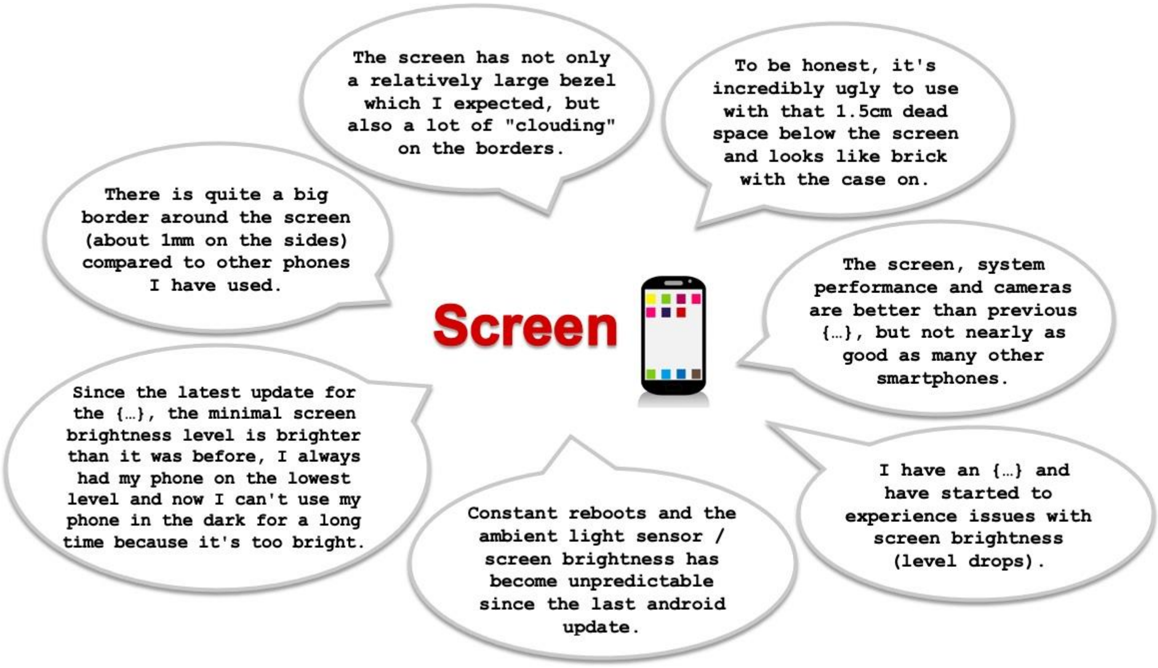
As introduced in the previous section, during content analysis the aspects '*software*', '*hardware*', and '*price*' were excluded from subsequent steps. This happened for even though they may be related to the smartphone, their group of sentences did not provide enough information on issues specifically related to the company's product and their content regarding customers' preferences was mostly generic. After this content analysis, diagrams were built for the remaining aspects to illustrate some of the most relevant obtained results on negative perceptions and support the 'Questioning and Comparison' stage with the conceptual model. These diagrams are illustrated next in Figures 19 to 21 for the aspects '*audio jack – headphone jack'*, '*screen*', and *battery*'. In its turn, Figure 22 brings both positive and negative comments on '*design – modular design*' for there were few bad comments and this is a highly relevant aspect for the company value creation.

Figure 19 – Customers' perceptions on audio jack or headphone jack.



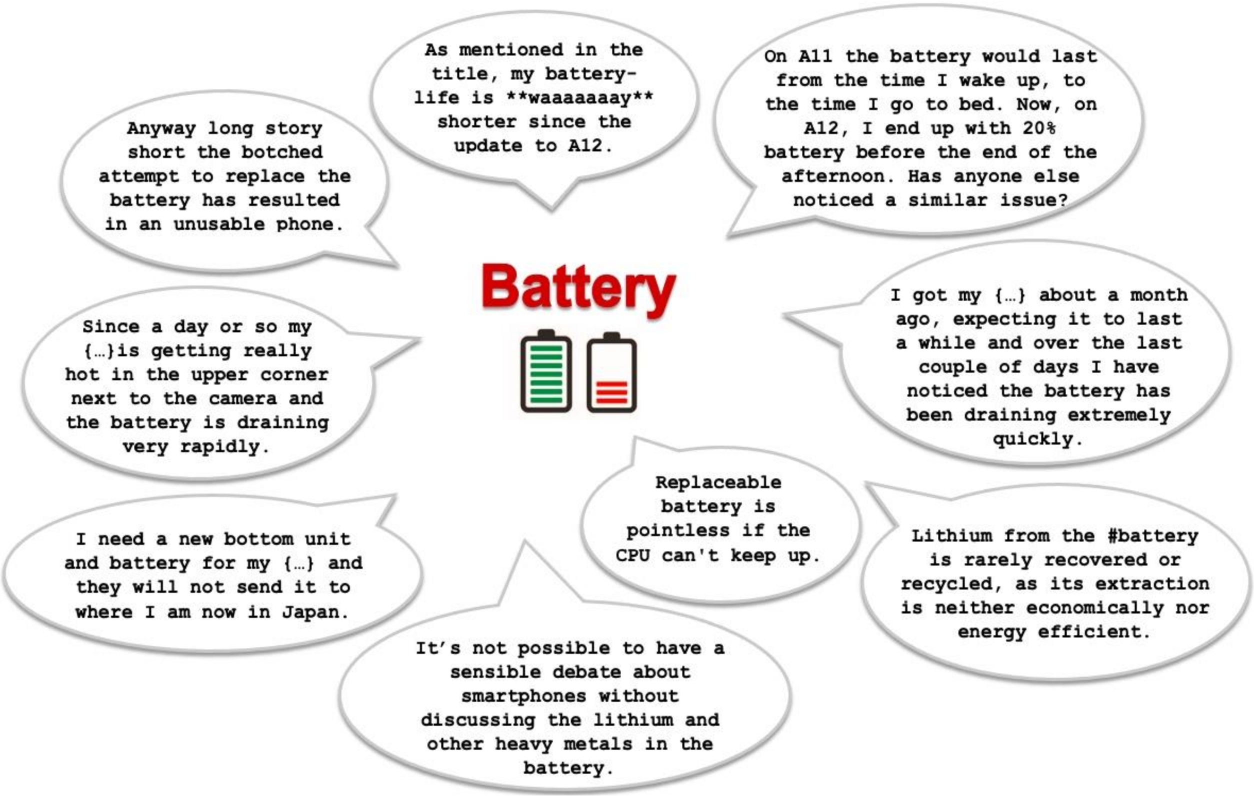
Source: Own Authorship.

Figure 20 – Customers' perceptions on screen.



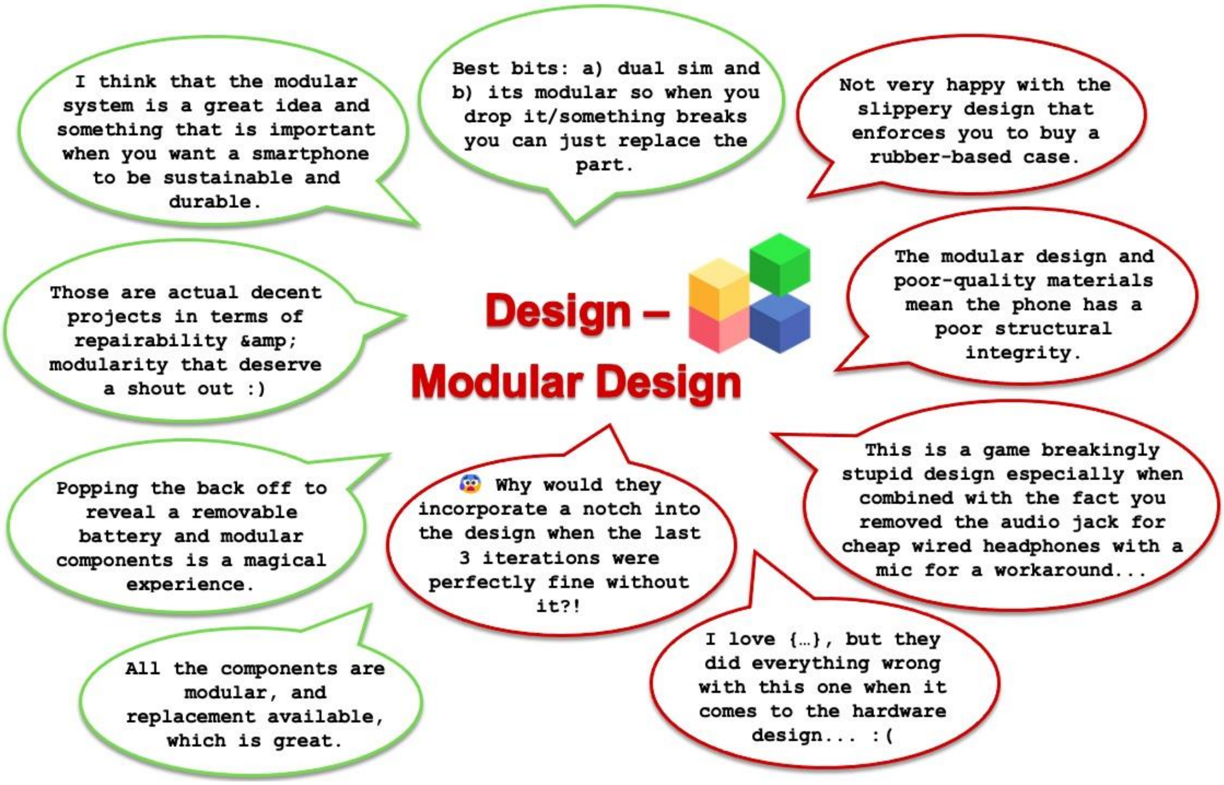
Source: Own Authorship

Figure 21 – Customers' perceptions on battery.



Source: Own Authorship.

Figure 22 – Customers' perceptions on modular design.

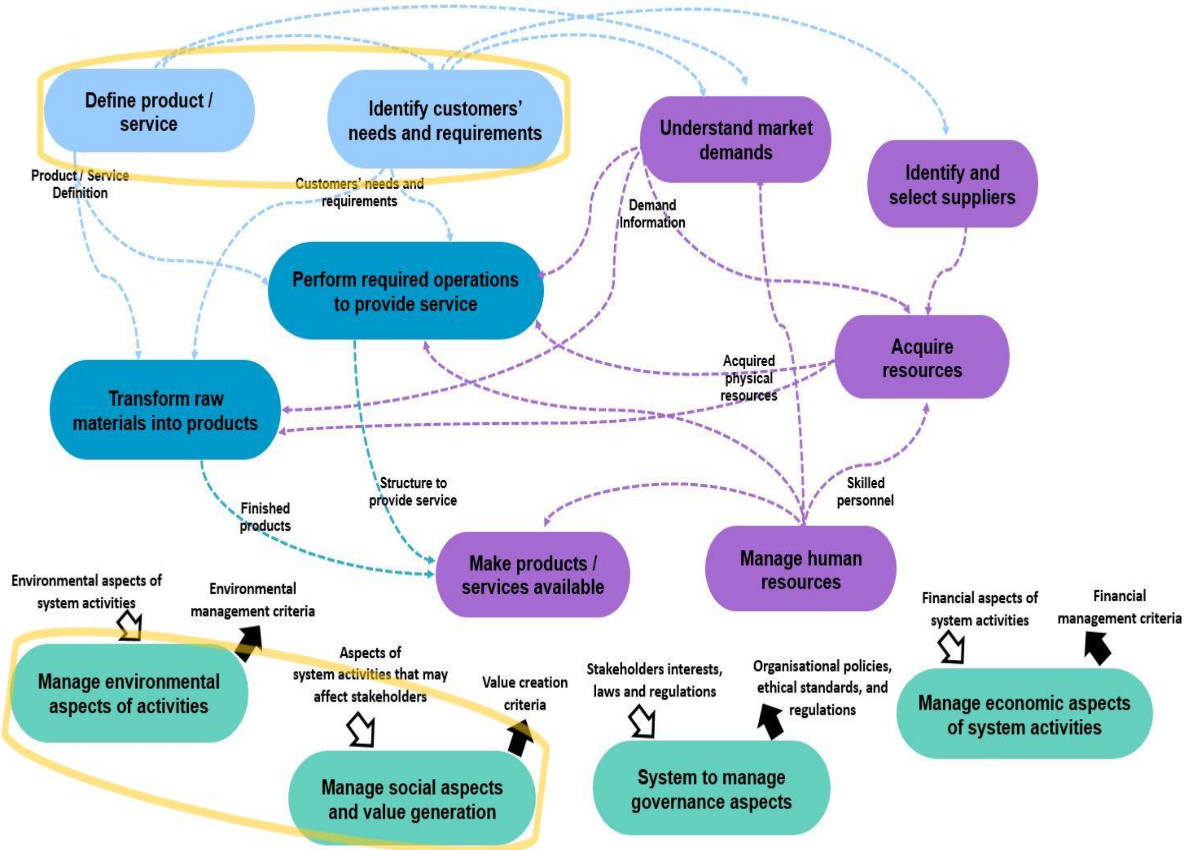


Source: Own Authorship.

The diagrams represented in Figures 19 to 21 were built to be an overview of potential identified issues that would guide analysts on '*where to look at'* in the 'map' or systemic view proposed in this research to identify improvement opportunities. Following, the use of these diagrams and the SSM Questioning and Comparison stage (Phase 2 of framework from Chapter 5 – Figure 8) are illustrated for the aspects *'audio jack – headphone jack'*. These two aspects were unified in only one diagram for they concern the same product feature. Afterward, taking by example the main issue highlighted from the '*Audio jack/headphone jack'* diagram, which was "*the removal of the audio jack from the new version of the modular smartphone*", the analysis begins by asking: "To which subsystems would the issue be associated?".

To answer that question, an analysis of the HL-CM indicates that the following subsystems would be connected for addressing this customers' complaint: (1) Identify customers' needs and requirements, (2) Define product / service, (3) Manage social aspects and value generation, and (4) Manage environmental aspects of activities. These subsystems are highlighted in yellow in the HL-CM represented in Figure 23.

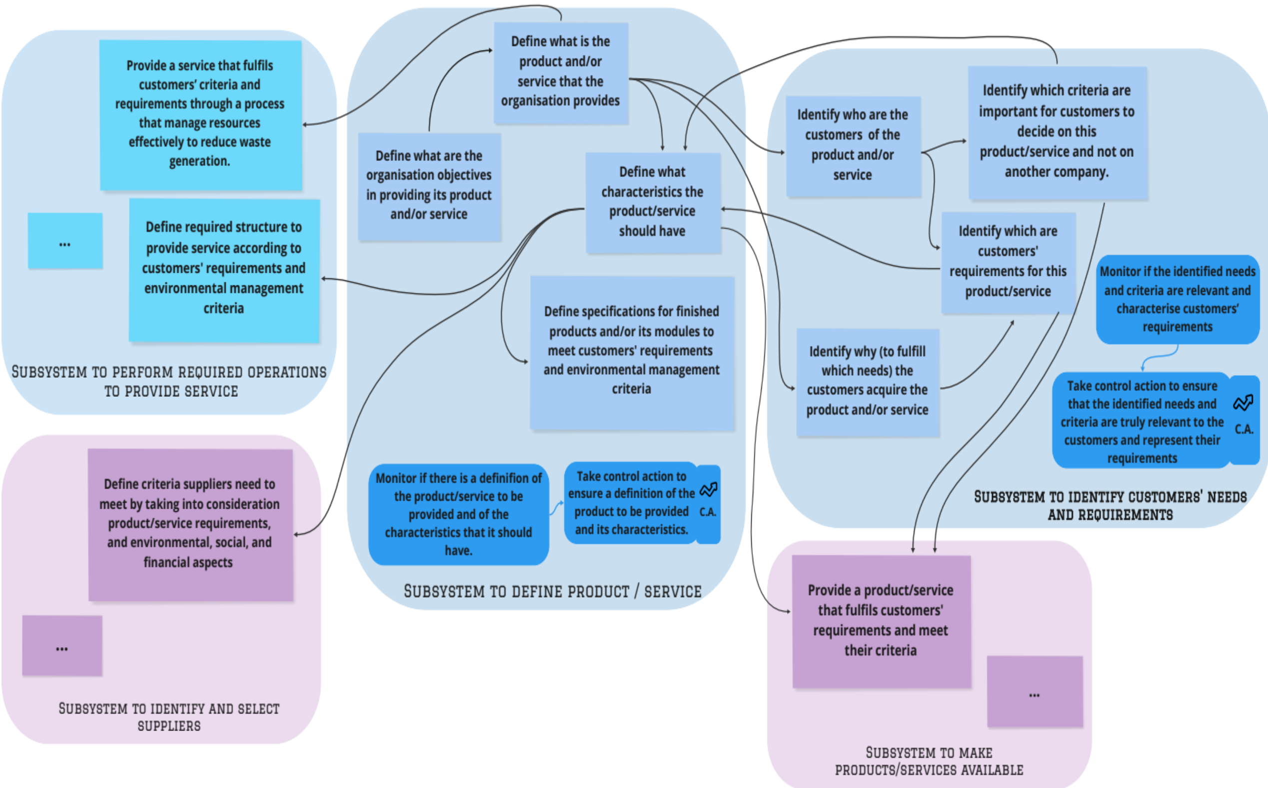
Figure 23 – Highlight of subsystems from HL-CM that are associated with the issue 'removal of audio jack – headphone jack'.



Source: Own Authorship.

The customers' perceptions identified from the ABSA in social media posts show that removing the audio jack has brought dissatisfaction to the company's consumers. Therefore, there may be failures in activities associated with obtaining customers' requirements and defining a product to be provided. Additionally, the content of the comments from Figure 19, demonstrate that the removal of this component also raised questions regarding environmental aspects and value provided to customers (e.g., "*removing the headphone jack is worse for the customer and the environment*", "*How can they call it {…} if they remove the headphone jack and introduce wireless earbuds at the same time*", "*No headphone jack = no buy for me and you lost 1 customer.*"). Thus, performance of activities from the subsystems that manage environmental aspects and value generation may also need further analysis. This comprehensive analysis may be done by looking to the activities within the referred subsystems of the map, which are presented in Figures 24 and 25 for the identified subsystems of the CM.

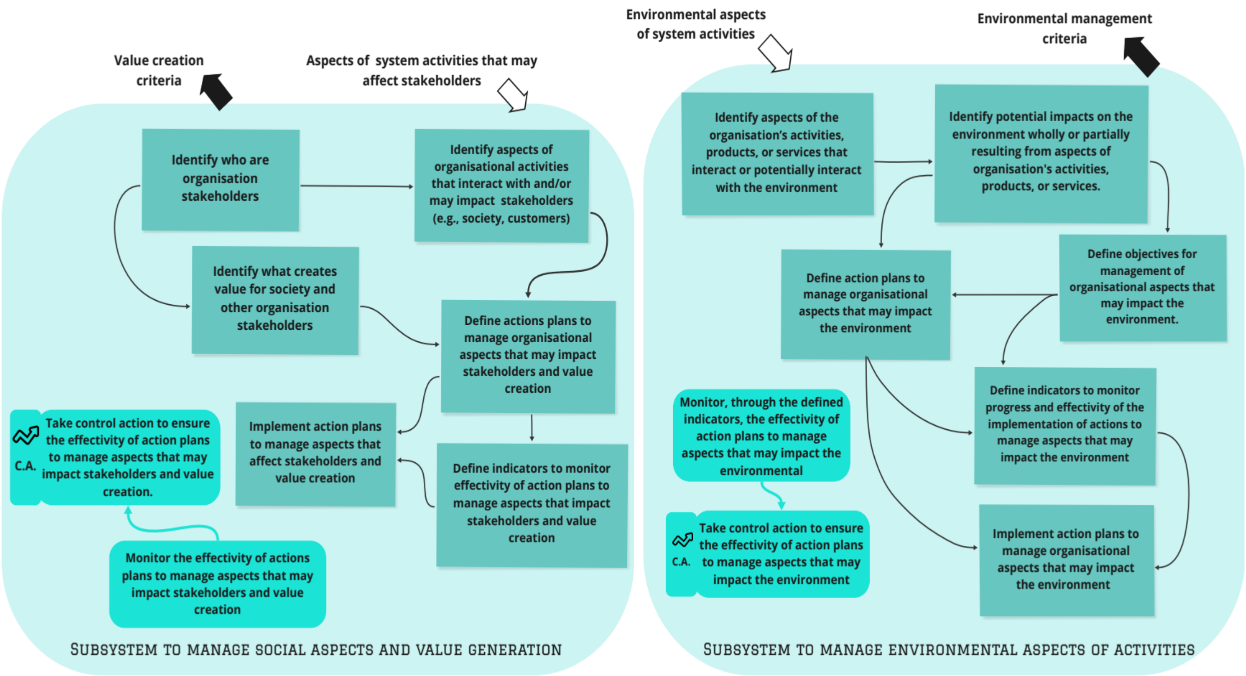
Figure 24 – Relevant subsystems for issue 'removal of audio jack – headphone jack' – part 2.



Source: Own Authorship.

It is important to note from Figure 24 that the subsystems analysed are the ones represented in the darker blue (i.e., Identify customers' needs and requirements and Define product / service). The other three were added only to help to keep the systemic view in mind and to remind which activities are receiving inputs from the subsystems analysed. Additionally, it is essential to highlight that subsystems and its activities were modelled in a generic manner so different organisations whose purpose is fulfilled by the previously stated RD could recognise themselves on the CM and use it as a 'map' to support the identification of improvement opportunities. Finally, due to space restrictions, the other two subsystems (i.e., Manage social aspects and value generation and manage environmental aspects of activities) involved in this analysis of the identified issue are represented in Figure 25.

Figure 25 – Relevant subsystems for issue 'removal of audio jack – headphone jack' – part 2.



Source: Own Authorship.

Afterward, the focus organisation may compare the required activities of each relevant subsystem against what happens in its reality to question how well the existing activities are being undertaken and identify whether there are opportunities for improvement. To support that, generic performance measures (i.e., efficacy, efficiency, effectivity) were proposed as judgment criteria to enable a more precise analysis of these model activities. These enabled to conduct the SSM's Questioning and Comparison stage of this illustrative case. This stage is presented in Tables 10 to 13, which contains the questioning activity and the performance measures that should be in place for each subsystem taken into consideration.

Table 10 – Table to conduct questioning and comparison stage of SSM for the subsystem 'Identify customers' needs and requirements'.

Subsystem: Identify customers' needs and requirements						
Activity	**Questions that may be raised:**			**Measured by:**		
	Does it exist?	**How is it done?**	**Who is responsible for this?**	**Efficacy**	**Efficiency**	**Effectivity**
Identify who are the customers of the product and/or service.	Yes/No/ Partially	[Real-world activity]	[Department/ Personnel]	Evidence that customers are identified.	Minimum use of resources (human, financial, …) to identify customers and their requirements / expectations.	The subsystem provides information on who are the customers of this organisation, which needs they want to fulfil when acquiring the product and/or service, and which criteria make them choose a product and/or service from this organisation.
Identify which criteria are important for customers to decide on this product/service and not on another company.	Yes/No/ Partially	[Real-world activity]	[Department/ Personnel]	Evidence that criteria that make customers choose this product are identified.		
Identify why (to fulfil which needs) the customers acquire the product/service.	Yes/No/ Partially	[Real-world activity]	[Department/ Personnel]	Evidence that customers' needs are identified.		
Identify which are customers' requirements for this product/service.	Yes/No/ Partially	[Real-world activity]	[Department/ Personnel]	Evidence that customers' requirements are identified.		

Source: Own Authorship.

Table 11 – Table to conduct questioning and comparison stage of SSM for the subsystem 'Define product/service'.

Subsystem: Define product/service						
Activity	**Questions that may be raised:**			**Measured by:**		
	Does it exist?	**How is it done?**	**Who is responsible for this?**	**Efficacy**	**Efficiency**	**Effectivity**
Define what is the product and/or service that the organisation provides.	Yes/No/ Partially	[Real-world activity]	[Department/ Personnel]	Evidence that there is a definition of what is the product or service that the organisation provides.	Minimum use of resources (human, financial, …) to define product/service, its characteristics and specifications	The subsystem provide clear definition of what is the product and/or service provided by the organisation, characteristics it should have, and its specifications.
Define what are the organisation objectives in providing its product and/or service.	Yes/No/ Partially	[Real-world activity]	[Department/ Personnel]	Evidence that organisational objectives in providing a product or service are well-defined.		
Define what characteristics the product/service should have.	Yes/No/ Partially	[Real-world activity]	[Department/ Personnel]	Evidence that characteristics that a product or service should have are well-defined.		
Define specifications for finished products and or its modules to meet customers' requirements and environmental management criteria.	Yes/No/ Partially	[Real-world activity]	[Department/ Personnel]	Evidence that specifications to meet customers' requirements and environmental management criteria are well-defined.		

Source: Own Authorship.

Table 12 – Table to conduct questioning and comparison stage of SSM for the subsystem 'Manage environmental aspects of activities'.

Subsystem: Manage environmental aspects of activities.						
Activity	**Questions that may be raised:**			**Measured by:**		
	Does it exist?	**How is it done?**	**Who is responsible for this?**	**Efficacy**	**Efficiency**	**Effectivity**
Identify aspects of the organisation's activities, products, or services that interact or potentially interact with the environment.	Yes/No/ Partially	[Real-world activity]	[Department/ Personnel]	Evidence that all aspects that interact with the environment are identified.	Minimum use of resources (human, financial, …) to define environmental criteria and action plans to manage aspects that may impact the environment.	The subsystem identifies potential impacts of system activities, and defines action plans to manage these impacts and indicators to monitor this management.
Identify potential impacts on the environment wholly or partially resulting from aspects of organisation's activities, products, or services.	Yes/No/ Partially	[Real-world activity]	[Department/ Personnel]	Evidence that all potential impacts that may result from identified aspects are identified.		
Define objectives for management of organisational aspects that may impact the environment.	Yes/No/ Partially	[Real-world activity]	[Department/ Personnel]	Evidence that objectives of the management of environmental aspects are defined.		
Define action plans to manage organisational aspects that may impact the environment.	Yes/No/ Partially	[Real-world activity]	[Department/ Personnel]	Evidence that action plans to manage organisational aspects that may impact the environment are defined.		
Define indicators to monitor progress and effectivity of the implementation of actions to manage aspects that may impact the environment.	Yes/No/ Partially	[Real-world activity]	[Department/ Personnel]	Evidence that indicators to monitor progress and effectivity of the implementation of action plans are defined.		
Implement action plans to manage organisational aspects that may impact the environment.	Yes/No/ Partially	[Real-world activity]	[Department/ Personnel]	Evidence that action plans are implemented and effective, according to predefined indicators.		

Source: Own Authorship.

Table 13 – Table to conduct questioning and comparison stage of SSM for the subsystem 'Manage social aspects and value generation'.

Subsystem: Manage social aspects and value generation.						
Activity	**Questions that may be raised:**			**Measured by:**		
	Does it exist?	**How is it done?**	**Who is responsible for this?**	**Efficacy**	**Efficiency**	**Effectivity**
Identify who are the organisation's stakeholders	Yes/No/ Partially	[Real-world activity]	[Department/ Personnel]	Evidence that all organisation's stakeholders are identified.	Minimum use of resources (human, financial, …) to identify and manage stakeholders and value creation.	The system identifies and manage stakeholders and aspects of the system activities that may affect stakeholders and value creation.
Identify aspects of organisational activities that interact with and/or may impact stakeholders (e.g., society, customers)	Yes/No/ Partially	[Real-world activity]	[Department/ Personnel]	Evidence that aspects of organisational activities that interact with and/or may impact stakeholders are identified.		
Identify what creates value for society and other organisation stakeholders.	Yes/No/ Partially	[Real-world activity]	[Department/ Personnel]	Evidence that what creates value for society and other organisation's stakeholders is identified.		
Define action plans to manage organisational aspects that may impact stakeholders and value creation.	Yes/No/ Partially	[Real-world activity]	[Department/ Personnel]	Evidence that action plans to manage organisational aspects that may impact stakeholders and value creation.		
Define indicators to monitor effectivity of action plans to manage aspects that impact stakeholders and value creation.	Yes/No/ Partially	[Real-world activity]	[Department/ Personnel]	Evidence indicators to monitor effectivity of action plans are defined.		
Implement action plans to manage aspects that affect stakeholders and value creation.	Yes/No/ Partially	[Real-world activity]	[Department/ Personnel]	Evidence that action plans are implemented and effective, according to predefined indicators.		

Source: Own Authorship.

Following the analysis in these tables, it is possible to answer the final question of Phase 2 of the proposed framework (Figure 8, Chapter 5): "Where are the improvement opportunities?". Given the issue that has been discussed so far, "*removal of audio jack – headphone jack*", based on customers' perceptions and the Questioning step, the main activities that would likely be a focus of improvement were listed in Table 14. Now, the company may analyse the process by which these activities are currently conducted, how well they are performed (see measures proposed in the discussed tables), and prioritise where to act to improve the product and ensure customer satisfaction.

Table 14 – Main activities that should be a focus of improvement actions.

Activity	Source Subsystem
Identify which criteria are important for customers to decide on this product/service and not on another company	Identify customers' needs and requirements
Identify which are customers' requirements for this product/service	
Define what characteristics the product/service should have	Define product/service
Define specifications for finished products and or its modules to meet customers' requirements and environmental management criteria	
Identify aspects of the organisation's activities, products, or services that interact or potentially interact with the environment	Manage environmental aspects of activities
Identify potential impacts on the environment wholly or partially resulting from aspects of organisation's activities, products, or services environment	
Identify what creates value for society and other organisation stakeholders	Manage social aspects and value generation

Source: Own Authorship.

Action-taking to improve how these activities are currently undertaken could either avoid similar issues or help to adequate next versions of the modular smartphone to customers' requirements. Also, the comparison of "what is done" against "what should be done" and the performance assessment based on the proposed measures may indicate a need of change in the ways to conduct an activity. For instance, given the activity *Identify which criteria are important for customers to decide on this product/service and not on another company* recognised as potentially in need of improvement, the focus company could benefit of a clearer definition of which are relevant criteria for customers when deciding on a purchase. Thus, an analysis of order-winners and qualifiers criteria may be valuable since textual data indicated that lack of a feature may make their customers decide on another product (e.g., *The lack of a headphone jack is a big NO-NO! No headphone jack = no buy for me and you lost 1 customer*.). Additionally, the Quality Function Deployment (QFD) (CHAN; WU, 2002), a Total Quality Management resource that help to develop customer needs and requirements and study the interrelation among them, may also support the improvement of the activities listed on Table 14. This tool would support the incorporation of requirements including the ones related to environmental aspects of the addressed issue, which were also discussed by customers (e.g., *The simple fact is that removing the headphone jack is worse for the customer and the environment*.)

Even though this discussion has focused on only one identified issue and its associated improvement opportunities, the described analysis may be replicated for other issues (e.g., customers' complaints about battery performance) and their related subsystems. Ideally, management shall incorporate these findings on potential improvement opportunities to support better-informed decision-making processes, e.g., prioritise improvement opportunities that will be addressed and select action plans to face them. In addition, the relations illustrated in the systemic view show that many systems' activities provide inputs to other systems (e.g., value generation and environmental criteria shall be incorporated into the 'define product/service' subsystem). Therefore, actions to improve a given activity will likely create opportunity to enhance performance in other subsystems (e.g., QFD may support activities of the subsystems that manage social aspects and value generation, and environmental aspects).

Concluding, it is worth discussing customers' perception of the '*design – modular design*' aspect (see Figure 22) given its importance for the focus company. The core of the company's value generation is providing a modular smartphone that enables repairability and promotes more ethical practices in the electronics industry towards a circular economy and sustainability. Thus, customers must perceive and experience this value proposition and the organisational practices that enable them. If not, it is critical to deploy improvement actions regarding these attributes. That said, there were few negative opinions from customers regarding *design* or *modular design*, as illustrated in the diagram in Figure 22 in parallel with positive perceptions.

The analysis of the referred illustration reinforces that, even though this dimension is performing well (e.g., *I think that the modular system is a great idea and something that is important when you want a smartphone to be sustainable and durable*; *Popping the back off to reveal a removable battery and modular components is a magical experience.*), it is important to keep track of customers' perceptions, especially when adding modifications in a product (e.g., *Why would they incorporate a notch into the design when the last 3 iterations were perfectly fine without it?!*, *The modular design and poor-quality materials mean the phone has a poor structural integrity*).

Summarizing, the integration of the SSM and information obtained using ABSA provided a means of identifying areas that require attention in the focus organisation, i.e., improvement opportunities to enable a greater customer experience. This illustrates the potential of the framework proposed by this research to support performance management and decision making. Its implementation provides findings that may help to decide where to act first (i.e., which issues should be our priority?) as well as to design action plans and select the one that matches the organisation objectives. In addition, the designed CM is a generic systemic view that may be used as a 'map' to identify improvement opportunities in different organisations as long as their purpose is identified as the one from the RD that guided the modelling process. This might be a valuable asset for organisations that implement CE practices and that lack a systemic analysis of their process and incorporation of stakeholders' perspectives.

8 CONCLUSIONS

The SSM is a PSM that enables systems thinking with the objective of identifying improvement opportunities in complex, unstructured, or problematic situation. This methodology helps to incorporate different perspectives, i.e., stakeholders' points of view and requirements, to structure a comprehensive view of a given context. In addition, it is adaptable and may be tailored to a variety of contexts and analysis, as literature has shown. These characteristics pointed out to the SSM potential to support management and decision-making in organisations and inspired this research proposition. The following sections summarise the main contributions of this research, discuss its limitations, and propose further developments.

8.1 Main contributions

This research proposed using SSM concepts to model a systemic view that incorporates customers' perceptions to guide the identification of improvement opportunities. Differently from most common applications of SSM that support a single analysis or project development, such as deciding on social programs activities, planning infrastructure, or even developing a performance management system, this research proposed using SSM tools in recurrent management activities, aiming to facilitate decision-making regarding performance. This approach brings novelty and insights on the use of systems thinking to structure a way for organisations to reason when tackling problems and deciding on improvement actions.

Firstly, this proposal presented a generic framework describing the steps to integrate SSM and the ABSA task, enabling its replication in a variety of contexts. It is worth to highlight that the consulted scientific literature does not offer any previous uses of the SSM associated with ABSA. Secondly, the CM obtained through the SSM implementation may be used to guide analysis in organisations whose business models implement CE principles towards sustainability. In this regard, using the obtained CM may help organisations that are transitioning to CE to succeed. This transition process and implementation of CE practices is challenging, given the innovativeness of business models and the variety of requirements that shall be present, such as incorporation of systems thinking to guide decision-making. Additionally, the illustrative case provided insights on the complexity of defining customers' requirements in innovative business models that implement circularity principles. For instance, the proposed approach enabled the identification of issues such as the removal of the audio jack, that impacted customers' perceptions of the company's compromise with sustainability.

In summary, this research proposed an approach that may support better-informed decision-making by identifying issues of concern, i.e., where management should focus its attention. The designed CM provided a systemic view that works as a 'map' of subsystems and their activities and enables a comparison against organisational reality to identify improvement opportunities. This comparison is guided by customers' perceptions, i.e., what are, and where are, the perceived issues that the organisation should act on to provide a greater customer experience, improve value creation to stakeholders and enhance relationships.

8.2 Research limitations and further developments.

The applicability of the proposed framework was assessed in an illustrative case structured with data from organisational reports and the company web pages. Ideally, the findings obtained from the CM analysis with the customers' perceptions should be compared with organisational processes. However, the company personnel were not available to conduct this last stage of this research implementation. Although their participation would enrich this analysis and discussion of results, the lack of it does not diminish the contributions of the framework and the CM.

The identification of improvement opportunities has been illustrated and discussed, proposing tables that guide this analysis and performance assessment (see section 7.3). The illustrative case also provided suggestions of tools that could be incorporated to tackle identified issues. Moreover, the modelling process incorporated multiple perspectives of specialists on the focus context, which contributed to enrich the systemic view modelled according to the SSM concepts and to the obtained CM defensibility. The logical consistence of the model was also assessed by specialists in the workshops previously described and the incorporation of their perspectives corroborate to the value of the CM.

In conclusion, the defined research question was answered by showing that the implementation of the SSM enabled a systemic view that may support performance management and decision making. The research also proved the value of incorporating customers' perceptions in this kind of analysis. Furthermore, the multimethodological approach of the framework may be used to conduct similar analysis in a variety of contexts. Therefore, its implementation is recommended in other cases to highlight its benefits and identify possible drawbacks. Besides, the CM should be used to guide the identification of improvement opportunities using customer-generated data from other companies. This will enable to verify the CM value in different contexts, as well as to go a step further and conduct decision-making processes using information extracted from these implementations (e.g., prioritizing issues or action plans using multi-criterion decision-making).

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APPENDIX A – Table summarising content analysis of literature review on SSM to support performance management and decision-making within operations management (Chapter 3) – Part 01

Author (s)	Research objective supported by SSM usage	Research domain	Implemented SSM stages	Combined methods (if there are any)
Cadenas-Anaya, Guaita, & Rodriguez-Monroy (2022)	Use of SSM and System Dynamics (SD) to build a model to support decision-making when selecting projects aligned with organisational strategy	Project portfolio management	Root Definition (with CATWOE)	System Dynamics
Conlon & Molloy (2022)	SSM tools are used to identify components for a discrete event simulation (DES) and service improvement scenarios to propose a framework to capture the staff experience and metrics to evidence workload in healthcare.	Healthcare service	Root Definition (with CATWOE); Rich picture	Discrete Event Simulation (DES)
Yu (2021)	Use of SSM for tackling problems which occurred during the process of designing and implementing a PMS (Performance Management System).	Human Resource management and performance management system	Root Definition (with CATWOE); Conceptual model built according to VSM (Viable System Model) concepts	VSM (Viable System Model)
Conlon, Molloy, & ZolzerBryce (2020)	Use of SSM tools to identify opportunities for improvement of a CT (Computed Tomography) service.	Healthcare service	Root Definition (with CATWOE); Rich Picture	____
Zheng, Yi et al. (2019)	SSM was used to identify and understand key interests of stakeholders to design a generic performance management model (referred to as the BSM - Balanced Stakeholder Model).	Public sector - hospital in China	Root Definition (with CATWOE)	____
Bernardo, Gaspar, & Henggeler Antunes, C. (2018)	SSM was used to identify objectives that reflect attributes to be incorporated in a decision model to evaluate energy efficiency of buildings.	Energy performance management in schools	Rich picture; Root Definition (CATWOE); Conceptual Model; Comparison of models with reality.	VFT (Value Focused Thinking)
Nordiawan, Prasodjo, & Hardjosoekarto (2017)	Use of SSM tools to define building blocks of Performance-Driven Culture that can applied to improve effectiveness of Performance Management.	Public sector - local government	Rich picture; Root Definition (CATWOE); Conceptual Model	____

APPENDIX A – Table summarising content analysis of literature review on SSM to support performance management and decision-making within operations management (Chapter 3) – Part 02

Author (s)	Research objective supported by SSM usage	Research domain	Implemented SSM stages	Combined methods (if there are any)
Liu et al. (2012)	Use of the ‘‘3E’s’’ (Efficiency, Efficacy, Effectiveness) of SSM to support decomposition process of strategic goals into key performance indicators (KPI) to design and implement a PMS.	High-tech enterprise (China)	Strategy decomposition based on Conceptual Model; The 3E’s metrics	____
Sgourou et al. (2012)	Use of SSM tools for a systemic evaluation of occupational safety and health (OSH) performance and support decision making for safety improvement programs.	Occupational safety and health (OSH) performance assessment	Rich picture; Root Definition (with CATWOE); Conceptual Model; Comparison of models with reality; The 3E’s metrics	____
Gibbons et al. (2012)	A value improvement model (a-VIM) approach was built and the SSM was used to develop an implementation model that focused on asset management effectiveness.	Airport operations management	CATWOE; Conceptual Model	Responsible, accountable, consulted and informed (RACI) tool
Ekionea et al. (2012)	Uses an adaptation of the original 7 SSM steps to obtain a consensus on Knowledge Management capabilities and design a maturity model.	Healthcare service	Root Definition; Seven steps structure proposed by Checkland (1981)	____
Siddiqui, & Tripathi (2011).	SSM was used to understand and define a Servicescape model incorporating most of the diverse viewpoints, perceptions, expectations, requirements related to design, improve and manage Servicescape for organizations delivering high contact services.	Servicescape - Service environment	Rich picture; Root Definition (with CATWOE); Conceptual Model; Comparison of models with reality.	Strategic Choice Approach (SCA) and Analytical Hierarchy Process (AHP)
da Piedade Francisco & Azevedo (2009)	Use of SSM to develop an adequate methodology to identify necessary requirements for the definition of a performance management framework.	Performance management for collaborative networks	None - only the methodology concepts of comparison and monitor and control.	____
Jacobs (2009)	SSM was used to develop a high-level conceptual model of a performance management process.	Public sector - local government	Root Definition (CATWOE); High-level conceptual model	____
Olson et al. (2006)	Use of SSM to support the process of developing a simulation tool to structure decision-making by aiding the description of the complexities involved in it (capacity planning, production, pricing, promotion, and quality).	Winery	Root Definition (with CATWOE)	Monte Carlo Simulation

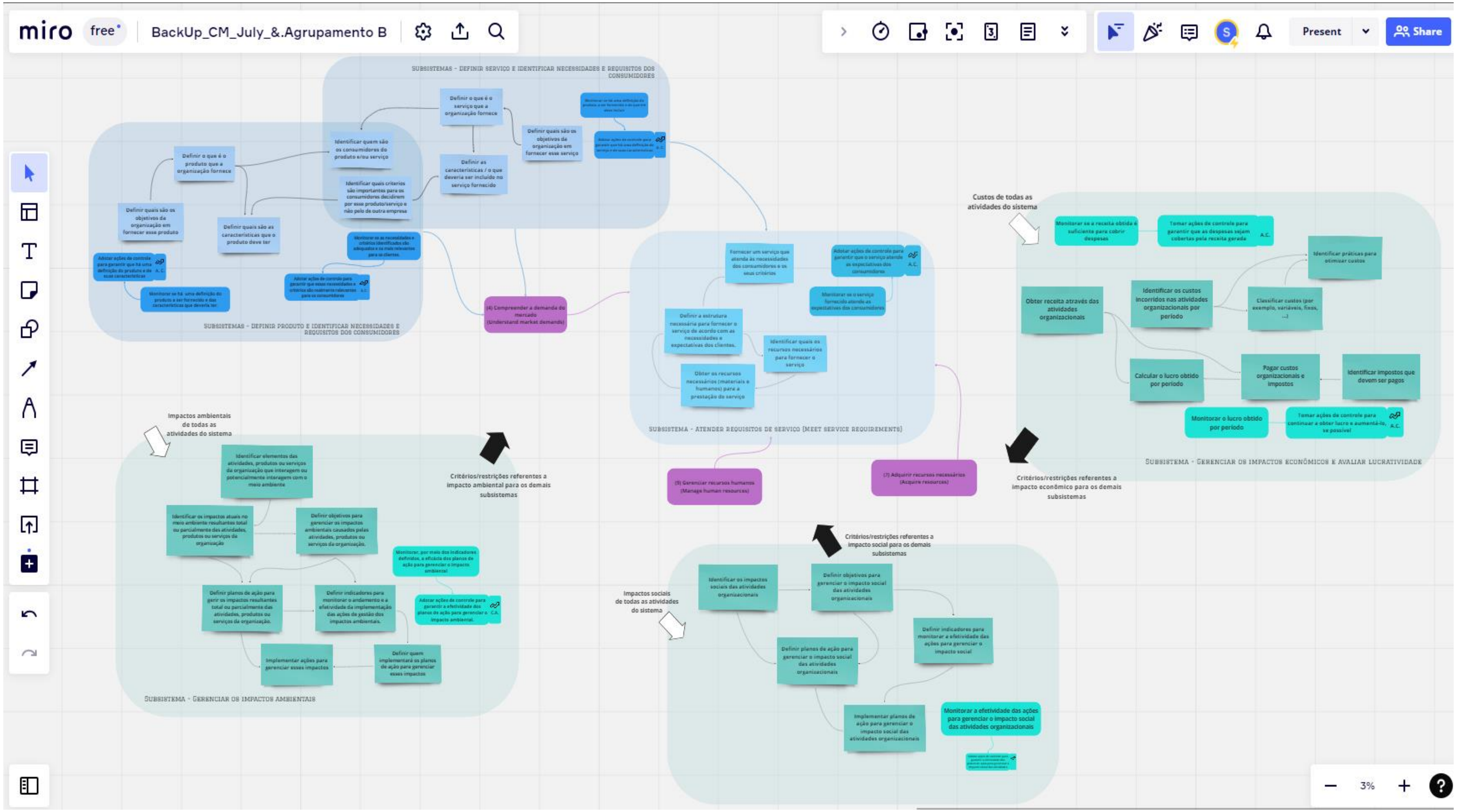
APPENDIX B – Table summarising content analysis of the selected articles from the SLR on Text Analytics uses focused on improving decision making and performance management (Chapter 4) – Part 01

Author(s)	Research description	Domain and data sources	Text Analytics techniques and/or tools used
Fernandes et al., (2021)	Descriptive analysis of customer satisfaction or dissatisfaction factors based on text mining techniques and use of these factors to build a performance indicator. A sales forecast model is also proposed.	TripAdvisor comments on restaurants from Portugal and revenue management information system.	Text mining preprocessing and factors extraction using the *tm*, NPL and *udpipe* packages from R statistical toll, and Sentiment Analysis with R package SentimentR.
Dlamini; Marebane; Makhubela (2020)	Propose use of text analytics and machine learning algorithms to improve and automate the process of analysing students transfer requests (deciding on accepting or rejecting them)	University's faculty management process of analysing motivation letters (text-data written in English language) submitted when students request campus transfer.	Latent Dirichlet Allocation (LDA) for topic modelling and Multinomial Naïve Bayes classifier build to categories prediction.
Pengnate; Lehmberg; Tangpong (2020)	Analyse if sentiments expressed in managerial letters to stakeholders may reflect in the subsequent firm's performance.	Letters to shareholders and financial reports of industries from US and Japan (from heavy machinery to food)	Sentiment analysis on Watson Natural Language Understanding (NLU), software developed by IBM.
Sai; Gupta; Fernandes (2019)	Use of text analytics to investigate textual component of annual reports and obtain useful information about company's performance. The information is used to make a forecast of the firms' performance and a comparison of actual performance of the company with the forecast.	Annual reports collected from company's websites of TI multinational firms and Start-Ups operating on Indian Market.	A custom build software and sentiment lexicons for sentiment analysis used on R statistical tool.
Ching; De Dios Bulos (2019)	Analyse restaurants' customers reviews to recommend business strategies in sustain and/or improve customers' satisfaction.	Customers' reviews posted on Yelp about five restaurants: Burger King, KFC, McDonald's, Popeye's, and Subway.	Aspect-Based Sentiment Analysis (ABSA) using the AYLIEN Text Analysis Application Program Interfaces (API) available in RapidMiner data science tool.
Singh; Jenamani; Thakkar (2020)	Propose a framework to draw relevant information from automobile consumer reviews by integrating Sentiment Analysis, HoQ, TOPSIS, Pareto chart and fishbone diagram.	Review data set received from Carwale.com, a well-known car portal in India.	Aspect Based Sentiment Analysis with Latent Dirichlet allocation (LDA) topic modelling; and lexicon-based (SentiWordNet) sentiment analysis.

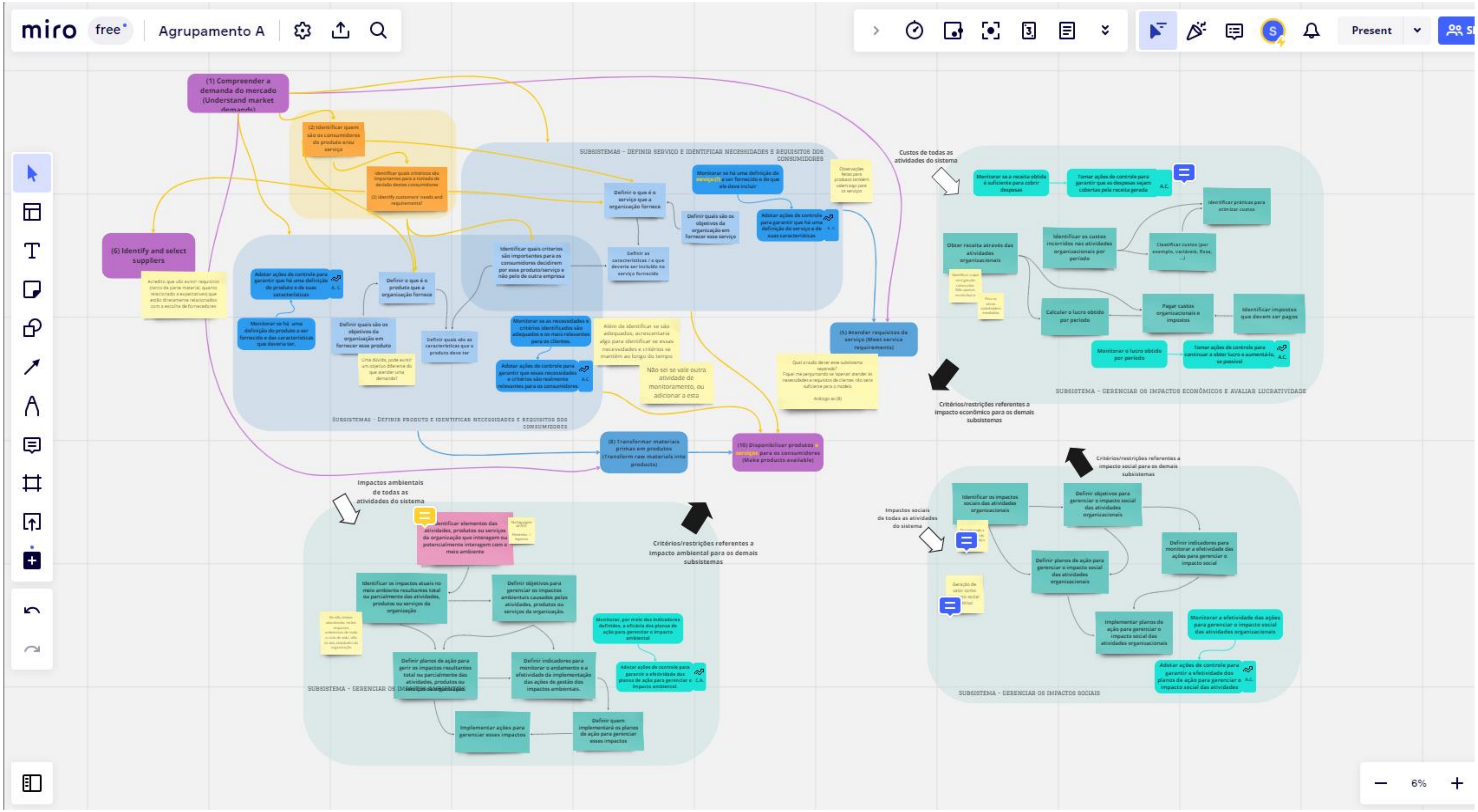
APPENDIX B – Table summarising content analysis of the selected articles from the SLR on Text Analytics uses focused on improving decision making and performance management (Chapter 4) – Part 02

Author(s)	Research description	Domain and data sources	Text Analytics techniques and/or tools used
Speer et al., (2019)	Identify job performance information, such as descriptions of competencies and goals achievement, in appraisals narratives and build a custom dictionary based on a framework of job performance.	Performance appraisals of managers from US companies.	Text mining preprocessing steps in R packages and use of the Linguistic Inquiry and Word Count (LIWC) software to score text into a pre-existing performance taxonomy.
Ibrahim; Wang (2019)	Analyse Twitter content to discover emerging topics associated with online retailing to better understand customers' needs and improve online retail service.	Twitter data from five leading UK online retailers, Amazon, Argos, Asda, John Lewis and Tesco.	Aspect Based Sentiment Analysis with latent Dirichlet allocation (LDA) topic modelling and lexicon-based sentiment analysis.
Ayoub; Elgammal (2018)	Propose a framework that integrates the social and business domains and utilizes social textual data to identify and offer resolutions of business process disruptions.	Tweets about mobile communication services of a telecommunication company.	Twitter Latent Dirichlet Allocation (LDA) and classification algorithms (Random Forest, Naïve Bayes, Naïve Bayes Multinomial, Sequential Minimal optimization (SMO), evaluated using Weka).
Chang et al. (2017)	Build a model for corporate operating performance assessment that incorporates numerical and textual information.	Financial media news reports collected from websites of electronic industries from Taiwan.	Latent Dirichlet allocation (LDA) topic modelling; hybrid mechanism combining incremental filter-wrapper feature subset selection technique (IFWFSS) and extreme learning machine (ELM).
Yang; Anwar (2016)	Propose a big data analytical framework to facilitate social-data mining for evaluating organisational performance in railway services.	Twitter data on the railway service in New South Wales, Australia.	Support Vector Machine (SVM) classifiers for Topic modelling and Sentiment Analysis. Hadoop framework and Spark module were used to support the approach.
Ashton; Evangelopoulos; Prybutok (2015)	Develop an approach that uses unstructured textual feedback to extract quality related factors and establishes a mechanism for transitioning these into data to Statistical Process Control (SPC).	Comments provided by customers that had decided to cancel their subscription service of a U.S retailer that offers online service.	Latent Semantic Analysis (LSA) topic modelling.
Zhang et al. (2015)	Propose a novel credit risk evaluation approach to mimic the decision-making process of the leadership.	Loan applicant dataset from a commercial bank in China.	Sentiment analysis; Generalized Multiple Kernel Learning (GMKL).

APPENDIX C – Figure C1 – Example of Miro® board that specialists received during workshops.



APPENDIX C – Figure C2 – Miro® board with annotations made by specialists during workshops.



APPENDIX D – Table of the fifty aspects identified with the highest frequency from Twitter® and Reddit®.

	Aspect	Frequency
1	Support - Customer Support	693
2	Battery	368
3	Software	300
4	Screen	270
5	Design - modular design	243
6	Repairability - Repair	208
7	Hardware	204
8	Warranty	186
9	Case	166
10	Audio jack - jack	141
11	Price	137
12	System	137
13	Headphone	133
15	Updates	114
16	Apps	105
14	Charging	90
17	Security	89
18	Materials	85
19	Sustainability	85
20	Performance	85
21	Life	83
22	Tech	82
23	Camera	77
24	Supply	75
25	Longevity	74
35	Components	74
26	Display	72
27	Screwdriver	69
28	Shipping	68
34	Service	66
29	Audio	64
33	Linux	60
30	Pixel	58
32	Specs	53
31	Video	45
36	Recovery	23
42	Sim (sim card)	23
37	Bootloader	21
38	USB port	21
39	Bluetooth	16
40	Protector	14
41	Brightness	13
43	Size	12
44	Cover	11
46	Launcher	11
45	Fingerprint	10
47	Power	10
48	Speakers	9
49	Volume	9
50	Speed	9

APPENDIX E – Conceptual Model

(Root Definition: A company-owned system operated by its skilled personnel according to organisational policies to provide products and services that satisfy customers' needs and requirements and continually match market demands, by transforming raw materials into products and gathering required resources to provide services through a production chain that effectively manages its associated environmental aspects, while generates economic and social value for its stakeholders.)