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Qualitative design and quantitative analysis of sustainable business models using value triangular business model canvas and system dynamics

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A B S T R A C T

To date, the use of three key aspects together has received little attention in studies on sustainable business models (SBMs). These aspects are a) the qualitative design of SBMs based on a valid sustainable business model canvas presented so far, b) the dynamic quantitative analysis of the designed SBMs, and c) the identification of appropriate business policies for different future scenarios, not just for one. Therefore, in this research, an attempt is made to study all three aspects by proposing a new practical framework based on one of the latest SBMs, called value triangular business model canvas (VTBMC), and system dynamics. To evaluate the proposed framework in the real world, it was implemented as a case study in Farassan Industrial and Manufacturing Company, one of the companies producing composite pipes. The results showed that the proposed framework helps business owners and managers identify the proper policies to achieve their key business objectives in the future under critical uncertainties and also create appropriate balanced values for a wide range of stakeholders, rather than just for shareholders.

1. Introduction

Sustainability and business model (BM) are two fundamental components of business management, but there is hardly any study that links them together (Ferrer et al., 2022). In general, a sustainable business model is known as a tool for the systematic integration of objectives, concepts, and principles to sustainably maximize the benefits and decrease the damages in economic, social, and environmental dimensions (Cosenz et al., 2020; Méndez-León et al., 2021; Morioka et al., 2018). Moreover, developing a sustainable business model implies adopting appropriate business policies to create economic, social, and environmental values (Baumgartner and Rauter, 2017; Bolis et al., 2021; Porter and Kramer, 2011) but it is difficult and complicated to adopt proper policies without considering the key business dynamics and critical uncertainties. Cosenz and Noto (2018a) emphasized the necessity of adopting flexible and fast approaches to reformulate business models according to business dynamics. This helps to make proper strategic decisions and policies, take advantage of opportunities and evaluate the achievement of business objectives. In this regard, various researchers have emphasized the use of simulation techniques in the analysis of conventional and sustainable business models (Chesbrough, 2010; Evans et al., 2017).
The application of simulation techniques makes it possible to evaluate business models, adopt appropriate policies (Chesbrough, 2010) and achieve a good business model accordingly. The lack of an appropriate approach to assess the goodness of a business model has been identified as "one of the biggest research gaps" (Wirtz et al., 2016). In this regard, some researchers have pointed out the importance of using behavioral models, such as systems dynamics, in the analysis of conventional business models (CBMs) (Cosenz, 2017; Cosenz and Bivona, 2021; Cosenz and Noto, 2018a, 2018b; Gomez Segura et al., 2020; Jin et al., 2021) and sustainable business models (SBMs) (Evans et al., 2017; Feng et al., 2021;

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Melkonyan et al., 2017; Liu et al., 2022; Cui et al., 2022; Schlüter et al., 2023). It has also been emphasized to use simulation-based methods to test business models without spending money or taking risks (Evans et al., 2017). The dearth of knowledge of simulation approaches in conventional business models, especially in sustainable business models, has been referred to as "a gap in knowledge" (Evans et al., 2017). On the other hand, although the positive capabilities of SBMs have been widely discussed and increasingly used as the sources of competitive advantages (Nidumolu et al., 2009), the practical results of these models can rarely be seen clearly (Hart and Milstein, 2003; Joyce and Paquin, 2016). So, further research is necessary to combine practical and theoretical aspects innovatively to develop more effective sustainable business models (Silvestre et al., 2022). That is why the research interest in SBMs has increased nowadays (Lozano, 2018; Méndez-León et al., 2021; Nosratabadi et al., 2019), and many researchers seek to develop practical tools to support businesses in an integrated process of sustainability (Bocken et al., 2019; Morioka et al., 2018). Therefore, the present study aims to propose a practical simulated-based framework to help business owners and managers design their SBMs and analyze their dynamics quantitatively to make appropriate policies for different future scenarios. This framework focuses on creating proper values not only for business shareholders but also for other key business stakeholders. After this framework and its steps are designed, it is implemented as a case study in Farassan Industrial and Manufacturing Company, one of the companies producing composite pipes. The innovations of this research are twofold as follows:

1. Using three key aspects in one study including a) Designing an SBM canvas qualitatively based on one of the newest, valid, and comprehensive SBMs called the value triangle business model (VTBM) (Biloslavo et al., 2018; Biloslavo et al., 2019), b) The dynamic analysis of the designed VTBM quantitatively and c) Policy making for more than one future scenario. According to this research, no study has ever addressed these three aspects simultaneously.
2. Proposing a practical framework that combines VTBM Canvas, system dynamics approach, and scenario matrix. Based on a review of the literature, no other study has applied these three approaches and tools together.

The structure of this study is organized in several sections as follows: Section 2 reviews the research literature and identifies the research gaps. Section 3 presents the research methodology and the proposed framework. Section 4 indicates how to implement the framework through a case study. Section 5 provides the research results. Section 6 discusses the main results and Finally, Section 7 presents the conclusion, clarifies the theoretical and practical implications of the study, the limitations, and makes certain recommendations for future research.

2. Literature review

A literature review was conducted in the web of science for the time span of 1995 to 2022 by focusing on the keywords: business AND model* (in the title) and "system dynamic*" (in the topic). It is noteworthy that among the studies found, those that had not used the system dynamics approach, either conceptually or quantitatively, were excluded from the review. Then, the remaining studies were classified into four categories and reviewed in detail as reported in the following subsections.

2.1. Design

This category includes the studies that focused on the design of conventional business model canvas (CBMC) (e.g., Ammirato et al., 2021) and the design of sustainable business model canvas (SBMC) (e.g., Maresova et al., 2022; Cosenz et al., 2020).

2.2. Dynamic analysis

Some studies dynamically analyzed the conventional business models (CBMs) (e.g., Moellers et al., 2019; Ganzarain et al., 2019) and the others dynamically analyzed the sustainable business models (SBMs) (e.g., Liu et al., 2022; Luksta et al., 2021; Franco, 2019; Minato and Morimoto, 2017).

2.3. Design and dynamic analysis

Few studies focused on both the design of CBMC and their dynamic analysis (e.g., Cosenz and Bivona., 2021; Jin et al., 2021; Feng et al., 2021; Zapata Riveros et al., 2021) and just one study (Melkonyan et al., 2017) focused on designing an SBMC as well as analyzing it dynamically.

2.4. Design, dynamic analysis, and policy making for different futures

Based on the literature reviewed, no study has been conducted to consider the three aforementioned aspects together. Therefore, the present study aims to cover this gap by considering them all. The four categories discussed above are presented in Table 1.

Table 1
CBM and SBM studies through the system dynamics approach (1995- 2022)

Author(s)	**Year**	**Conventional view**	**Sustainable view**	**CBMC design**	**SBMC design**	**Dynamic analysis**	**Different futures**	**Additional explanations**
Liu et al.	2022	…	*	…	…	*	…	…
Maresova et al.	2022	…	*	…	*	…	…	…
Katsamakas & Pavlov	2022	…	*	…	…	…	…	A causal loop diagram (CLD) is designed but not analyzed quantitatively.
Qin	2022	…	*	…	…	…	…	…
Jiamahasap & Ramingwong	2022	*	…	…	…	*	…	…
Cui et al.	2022	…	*	*	…	*	*	Although this is a study on SBM, it has used the building blocks of the CBMC to design SBM.
Cosenz & Bivona	2021	*	…	*	…	*	…	…
Ammirato et al.	2021	*	…	*	…	…	…	A causal loop diagram (CLD) is designed but not analyzed quantitatively.
Jin et al.	2021	*	…	*	…	*	…	…
Feng et al.	2021	…	*	*	…	*	…	Although this is a study on SBM, it has used the building blocks of the CBMC to design SBM.
Zapata Riveros et al.	2021	…	*	*	…	*	…	…
Luksta et al.	2021	…	*	…	…	*	…	…
Gomez Segura et al.	2020	*	…	*	…	*	…	…
Barforoush et al.	2020	…	*	…	…	*	…	…
Cosenz et al.	2020	…	*	…	*	…	…	A stock & flow diagram has been designed, but the dynamics have not been analyzed quantitatively.
Ganzarain et al.	2019	*	…	…	…	*	…	…
Yun et al.	2019	*	…	…	…	*	…	…
Dehbasteh et al.	2019	*	…	…	…	*	...	…
Moellers et al.	2019	*	…	…	…	*	…	…
Franco	2019	…	*	…	…	*	…	…
Cosenz & Noto (a)	2018	*	…	*	…	*	...	…
Cosenz & Noto (b)	2018	*	…	*	…	*	…	…
Täuscher & Abdelkafi	2018	…	*	…	…	*	*	...
Cosenz	2017	*	…	*	…	*	...	…
Yun et al.	2017	*	…	…	…	*	…	…
Melkonyan et al.	2017	…	*	…	*	*	…	…
Minato & Morimoto	2017	…	*	…	…	*	…	…
Abdelkafi & Täuscher	2016	…	*	…	…	…	…	A stock & flow diagram has been designed, but the dynamics have not been analyzed quantitatively.
Wei et al.	2013	…	*	…	*	…	…	A CLD has been created, but it has not been analyzed quantitatively.
Duran-Encalada & Paucar-Caceres	2012	…	*	…	…	*	…	…
Martı´nez-Olvera	2009	*	…	…	…	*	…	…
Chiou-Guey	2007	*	…	…	…	…	…	A CLD has been created, but it has not been analyzed quantitatively.
MacDonald et al.	2003	*	…	…	…	*	…	…
Akkermans	1995	*	…	…	…	…	…	A CLD has been created, but it has not been analyzed quantitatively.
Current study	2023	…	*	…	*	*	*	This study aims to cover the research gap by considering all three aspects: 1. The qualitative design of an SBMC, 2. The quantitative dynamic analyses of

Table 1
CBM and SBM studies through the system dynamics approach (1995- 2022)

Author(s)	**Year**	**Conventional view**	**Sustainable view**	**CBMC design**	**SBMC design**	**Dynamic analysis**	**Different futures**	**Additional explanations**
								the SBMC, and 3. Policy making for different futures, not just for one.

As depicted in Fig. 1, since 2017, growing attention has been paid to conventional and sustainable business models and most SBM studies have been conducted in 2022. According to the graph in Figure 1, in recent years, the studies conducted on conventional or sustainable business models through the system dynamics approach have grown in number and attracted increasing attention.

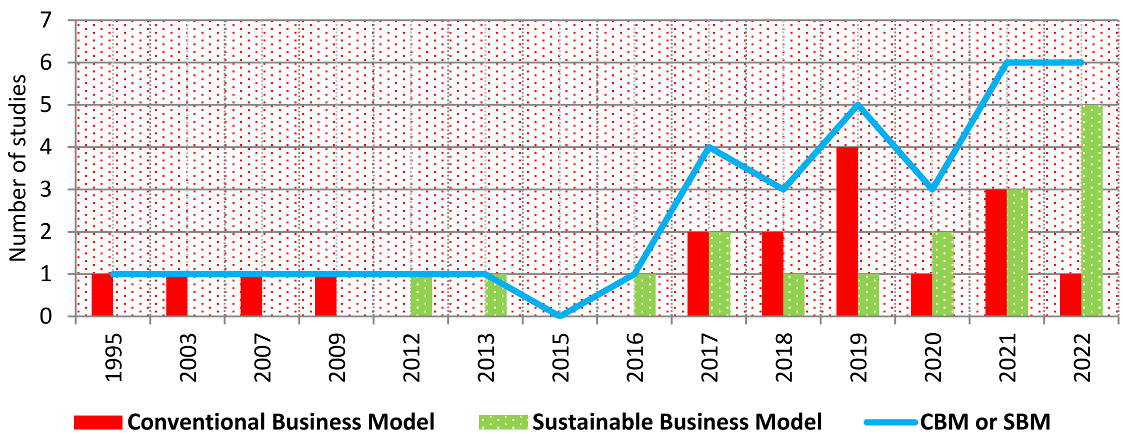

Fig. 1. The trend of studies on CBM and SBM and those on either CBM or SBM through the system dynamics approach (1995-2022)

3. Materials and methods

This research is of a hybrid type because it utilizes both qualitative and quantitative approaches and methods as follows:

3.1. System dynamics

System dynamics (SD) is a simulation-based approach derived from the nonlinear dynamics and the feedback control theory developed in mathematics, physics and engineering. System dynamics utilizes rate and stock variables as the main components which allow simulation. The changes in the rate variables per unit of time determine the value of the stock variables. In fact, the integration of the input rate minus the output rate is the value stored in the stock variable (Sterman, 2000). From the business perspective, the SD methodology entails a feedback view of a business model which embraces all the key business variables (Forrester, 1961; Morecroft, 2007; Sterman, 2000) and clarifies the dynamics of business systems accordingly (Cosenz and Noto, 2018a).

Although the SD approach has been widely used in business models (Cosenz and Bivona, 2021; Jin et al., 2021) and sustainable business models (Melkonyan et al., 2017; Täuscher and Abdelkafi, 2018), there has not been found a comprehensive methodology to design SBMs and analyze the dynamics of the designed models so as to identify the policies for possible future scenarios.

3.2. Value Triangle Business Model Canvas (VTBMC)

One of the valid and comprehensive sustainable business models presented in 2018 is VTBMC (Biloslavo et al., 2018; Biloslavo et al., 2019). It is shown as an SBM canvas in Fig. 2.

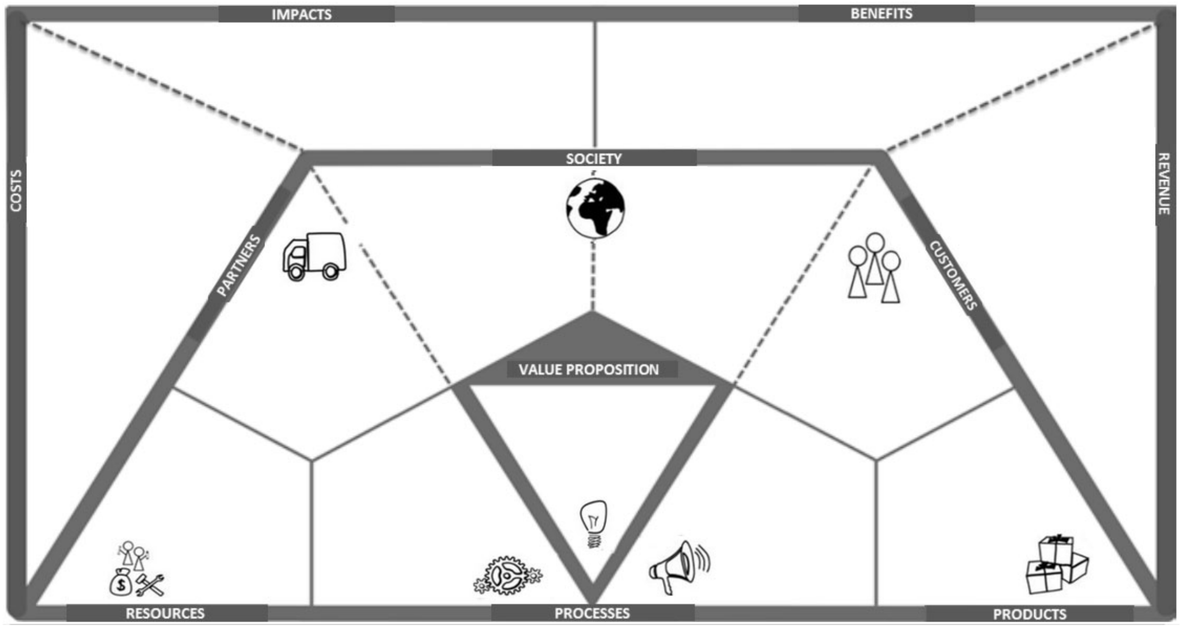

Fig. 2. Value Triangle Business Model (VTBM) canvas. Source: adopted from Biloslavo et al. (2019)

Biloslavo et al. (2018) performed an analysis on 20 business models and then, based on the results, presented an SBM called 'Value Triangle' (VT). This model assumes that companies co-create values within an eco-system that contains the society and the natural environment (see Stubbs and Cocklin., 2008). The VT illustrates how a company co-creates and co-delivers values with its stakeholders within a circular value system and how it captures values from the system. In addition, Biloslavo et al. (2018) proposed the VT to close the sustainability gaps in business models. Accordingly, there are some key characteristics that differentiate the value triangle from most other business model frameworks. They include a) an obvious focus on co-creating values for the society at large and for not only customers but also partners and finally for the business itself, b) close and wide attention to the benefits and costs created through business activities, c) adequate attention to capital which contains anything that has the potential to create many benefits including the natural environment, d) the triangularity approach which makes the BM components repeat themselves to visually create a sustainable systemic relationship among many stakeholders in a business ecosystem and e) The VTBM canvas includes a circular notion of co-creating and co-delivering values for business actors (Biloslavo et al., 2018). Moreover, it has several key building blocks as follows:

1. Society: It refers to the different stakeholders of the firm including the natural environment, 2. Value proposition: It is a statement to show how the firm co-creates and co-delivers values for its stakeholders, 3. Customers: They are the various groups of people or organizations that the firm targets to attract and serve, 4. Products: It refers to the set of goods and services which create values for different customers, 5. Key operational activities: These are the various business activities that include inbound and outbound logistics, 6. Resources: They are the different capital resources used by the firm such as manufactured, human, intellectual, financial, natural, and social capital, 7. Partners: They are the various suppliers and partners that help the business model work, 8. Benefits: it includes both the benefits which the business delivers to the society and environment and the revenue resources from which the business can capture economic values and, 9. Costs: They refer to both the negative impacts of the business outputs on the society and environment and the financially adverse impacts on the business performance.

3.3. Scenario matrix

A tool that helps to make a complex scenario structure is the scenario matrix (Melkonyan et al., 2019). Future scenarios can be formulated based on the effects of critical uncertainties on business variables (Ghazinoory et al., 2018). In fact, a scenario matrix displays four different possible futures based on the combination of the effects of two critical uncertainties (Benedict, 2017). This matrix includes two dimensions (critical uncertainties), four building blocks (future business scenarios), and two axes (vertical and horizontal axes from low to high to show the intensity of the effects of each critical uncertainty) (Benedict, 2017; Moqaddamerad et al., 2017). A scenario matrix and its components are depicted in Fig. 3.

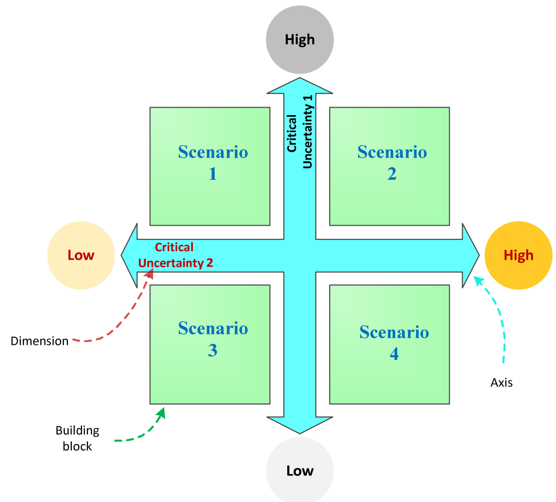

Fig. 3. A scenario matrix and its components

3.4. Proposed framework

The framework, its steps, and the approaches, methods or tools used in each step are presented in Fig. 4. In the first step, the key business objectives are identified so as to determine what economic, social and environmental variables need to be considered in designing the SBM. In the second step, an SBM canvas is designed qualitatively to introduce the variables that would help to achieve the key business objectives and clarify the logic of value creation for stakeholders. In the third step, the designed qualitative SBM canvas is simulated quantitatively. In the fourth step, the simulated SBM is evaluated to be approved. In the fifth step, some future scenarios are designed on the basis of critical uncertainties. Finally, in the sixth step, proper policies are adopted according to the dynamic analysis of the designed SBM canvas.

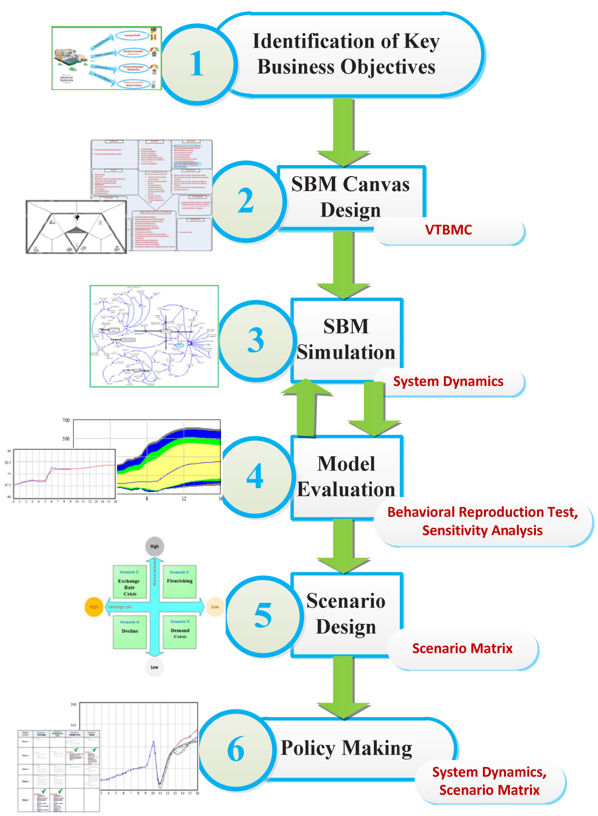

Fig. 4. The proposed framework for the designing and dynamic analysis of SBMs quantitatively

3.5. Case and data

The proposed framework was practically implemented as a case study in Farassan Manufacturing and Industrial Company producing glass-reinforced plastic pipes (GRP) in Fars Province, Iran. In this case study, the required data were gathered through a purposive method of interviewing the business owners, key managers, and experts of the company. To this end, focus groups, questionnaire surveys, and document reviews were performed.

4. Case study

To use and assess the proposed framework in the real world, it was implemented in Farassan Company. The steps are presented in detail below.

4.1. Step 1: Identification of key business objectives

At this step, Farassan key objectives were identified through interviews with its four business owners and senior managers as well as the review of the company documents. This was an attempt to consider the key economic, social, and environmental dimensions simultaneously to create balanced values for a wider range of stakeholders, not just for the shareholders. Indeed, the company intended to have achieved four objectives as depicted in Fig. 5 by 2026. In this regard, the company owners were willing to know the answer to the question 'what would the proper policies be to help achieve these objectives in the future under critical uncertainties?'

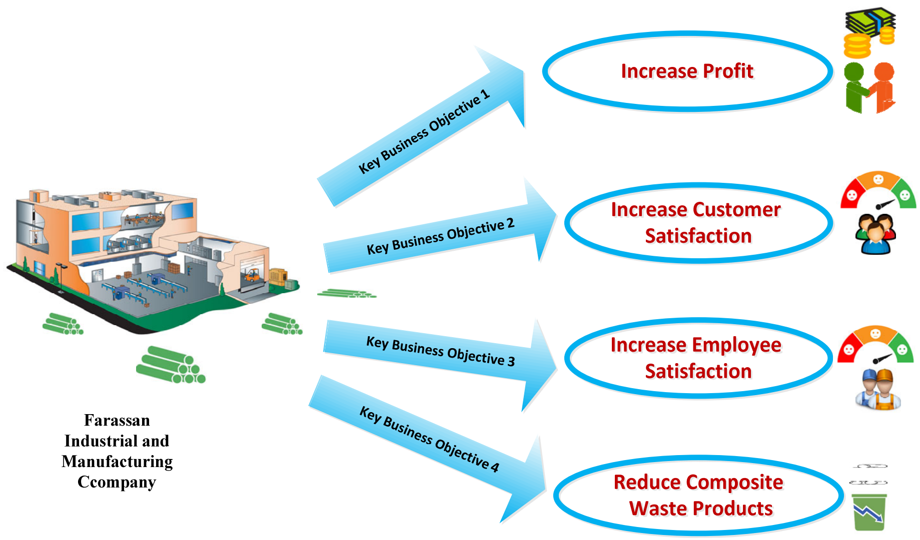

Fig. 5. Farassan key business objectives

4.2. Step 2: SBM canvas design

At this step, the economic, social, and environmental variables that play key roles to achieve the Farassan objectives were identified based on each VTBMC building block presented by Biloslavo et al. (2018) and placed on the canvas as shown in Fig. 6. The designed SBM not only demonstrated the logic of creating value for Farassan shareholders but also clarified this logic for the other stakeholders.

Considering that a main purpose of this study was to identify critical uncertainties and help to design different future scenarios, first, interviews were conducted with fifteen key individuals working in the composite and GRP industry, including Farassan business owners, managers, experienced experts, and consultants. The uncertainties involved in that business were thus identified, and the frequency of each was calculated. Then, a questionnaire was designed and sent to the same individuals to measure the uncertainty level and impact (Benedict, 2017) of each identified uncertainty quantitatively with scores from 1 to 5. In the next step, the average score was calculated for each uncertainty. Through this scoring, finally, the market demand and exchange rate were identified as the critical uncertainties (Fig. 7).

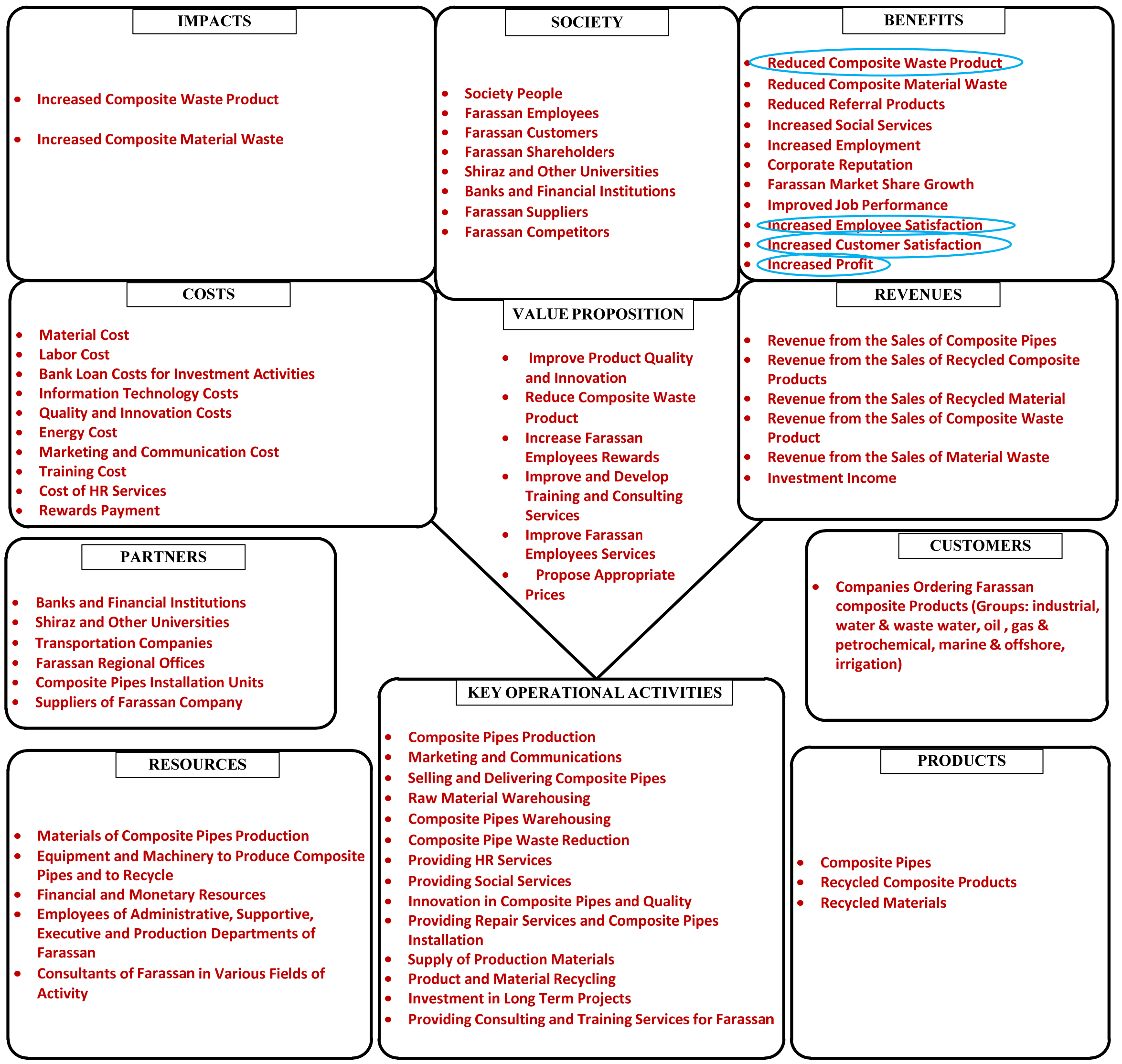

Fig. 6. Farassan SBM canvas (Farassan SBMC) based on the VTBM canvas adopted from Biloslavo et al. (2018); Biloslavo et al. (2019)

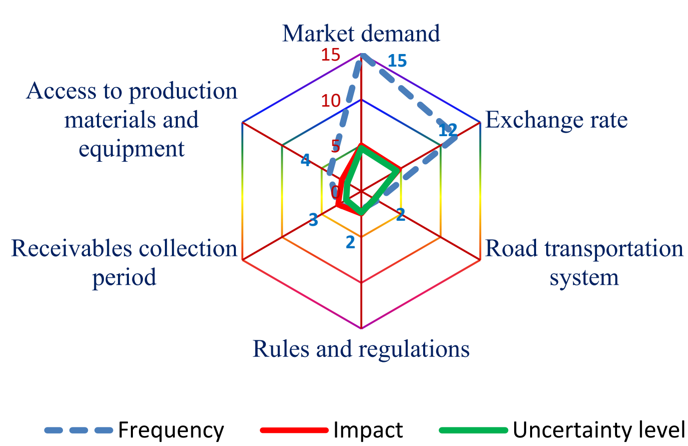

Fig. 7. Uncertainties identified for Farassan

4.3. Step 3: SBM simulation

At this step, the designed Farassan SBM canvas was simulated by the system dynamics approach, and the qualitative SBMC was converted to a quantitative model in the form of stock and flow diagrams. In order to better understand these diagrams, the main variables of Farassan SBM canvas and their interactions are shown as a conceptual model presented in Fig. 8. As it can be seen, each variable consists of two parts, upper and lower. The upper part represents the title of the variables in Farassan SBMC, and the lower part represents the related titles of the same variables in the stock and flow diagrams demonstrated in Figures 9, 10, and 11. Furthermore, the thick circles drawn in this conceptual model represent the variables related to the business objectives, as identified in the first step. In fact, this conceptual model shows how Farassan SBMC variables interact together to attain the objectives presented in Fig. 5.

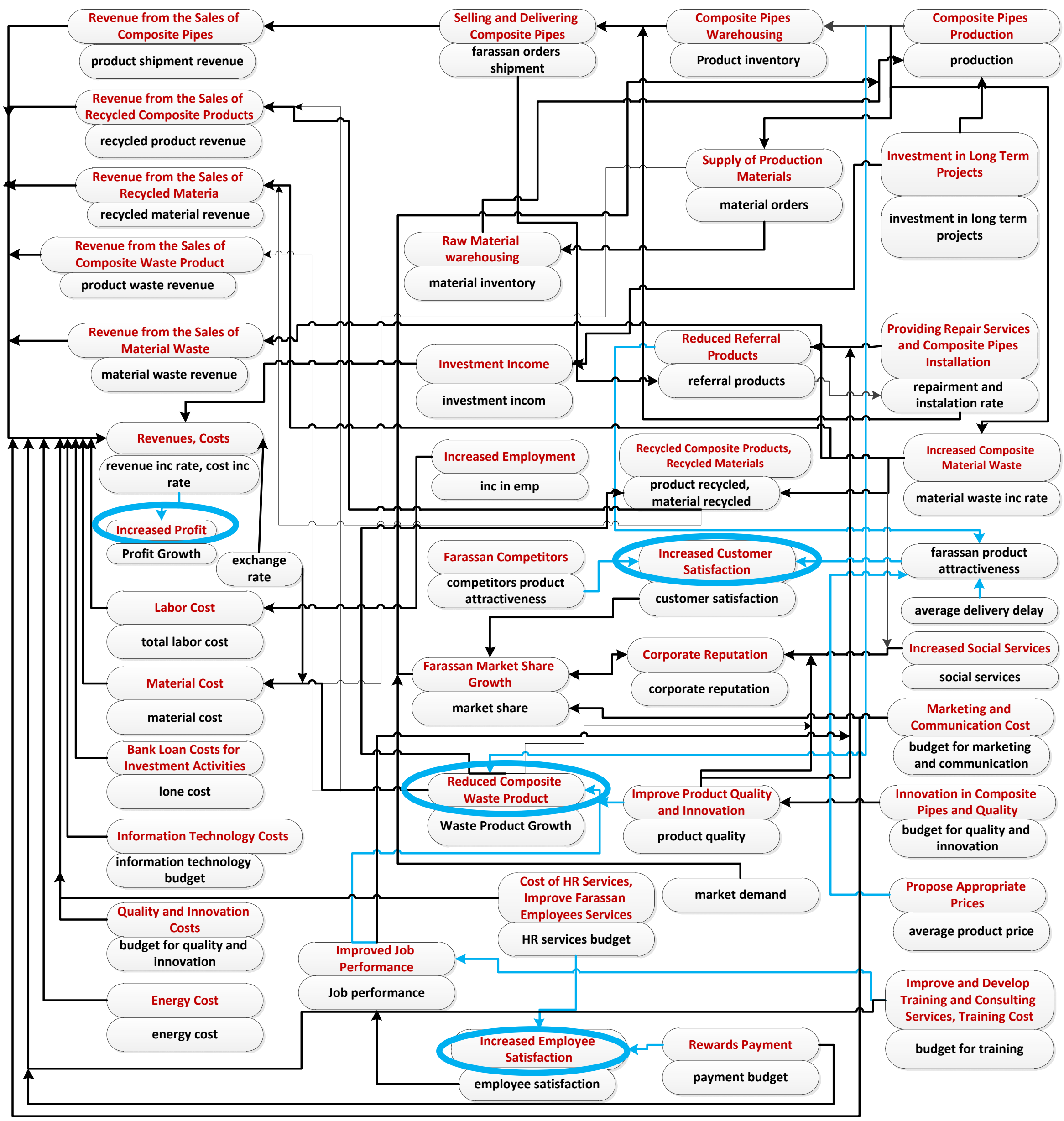

Fig. 8. Farassan conceptual model.

As shown in Fig. 8, one of the Farassan key objectives was to increase the business profit. In this regard, increasing the revenues from the sales of various products such as composite pipes, recycled composite products, and recycled materials would increase the profit of the company. In addition, decreasing the costs of such items as the product materials, quality and innovation, information technology, energy, marketing and communication, reward payment and HR services could increase the profit. Another Farassan objective was to increase the customer satisfaction. A main factor to achieve this objective was appropriate prices to offer to the customers. Another main factor that could help to increase the customer satisfaction was the reduction of referral products from the customers. Moreover, reducing the product delivery delay would lead to an increase in the product attractiveness and ultimately improve the level of customer satisfaction. Another objective of the company was to increase the employee satisfaction. Two main factors could affect it directly. One was rewards to pay to the employees (rewards payment) and the other was human resource services provided for them (employees services). The last business objective was to reduce the composite waste products. Farassan would achieve this objective by improving the product quality and innovations. It could also be achieved by increasing the level of the employee job performance. In addition, the reduction of the production in the long term could directly decrease the waste products. These dynamic interactions can be seen in more detail in the stock and flow diagrams given in Figures 9 to 11. In these diagrams, the variables related to Farassan key business objectives are shown clearly with thick circles that indicate the key business objectives in the SBM canvas of Farassan (Fig. 6) and conceptual model (Fig. 8).

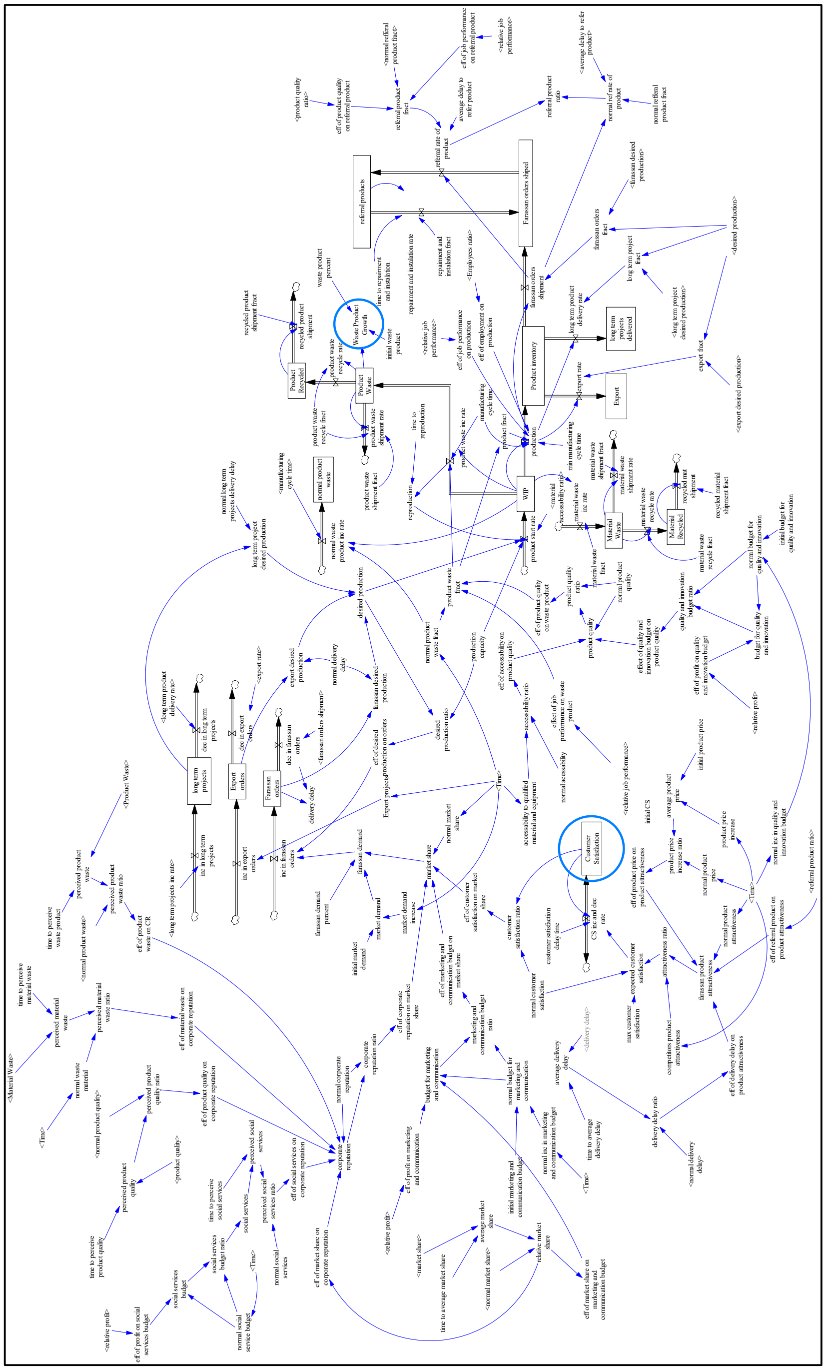

Fig. 9. Farassan SBMC in the form of a stock and flow diagram to achieve the objectives of increasing customer satisfaction and reducing composite waste products

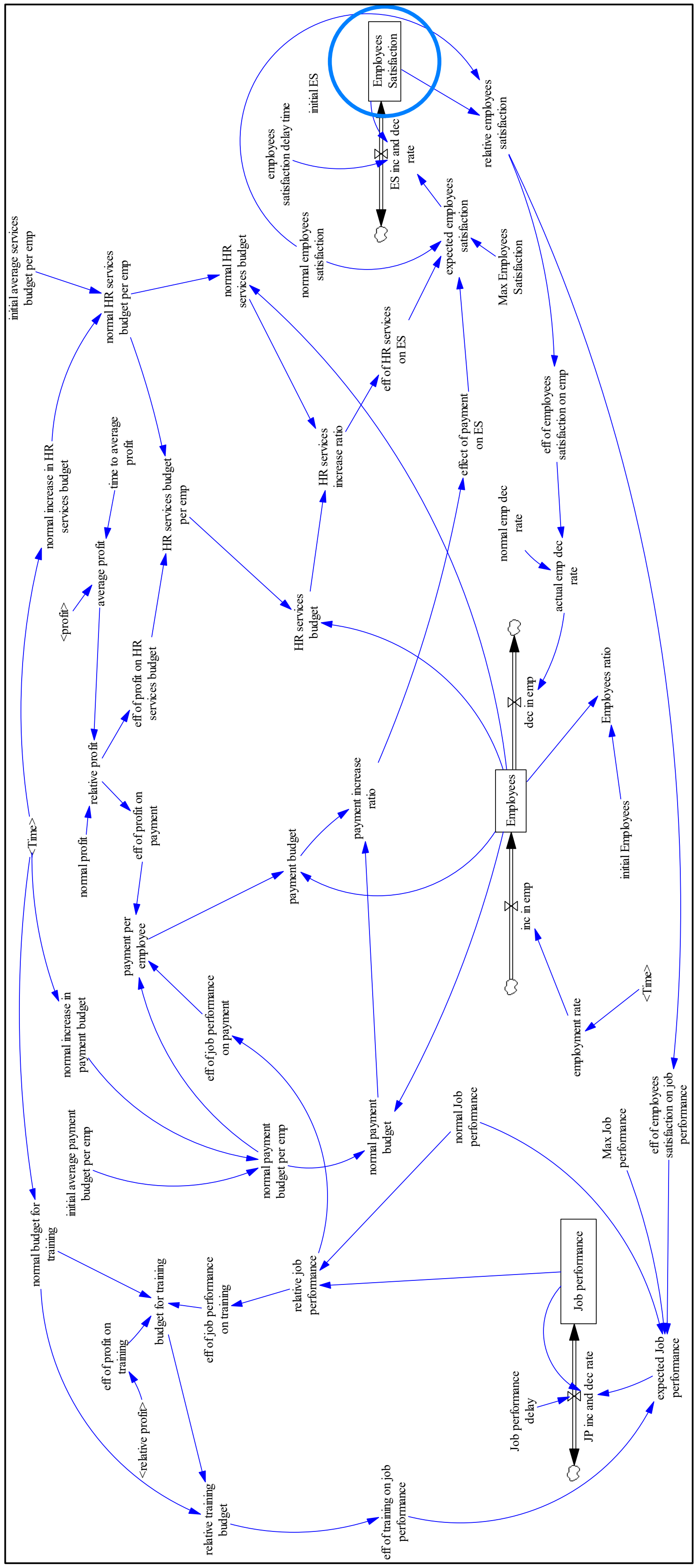

Fig. 10. Farassan SBMC in the form of a stock and flow diagram to achieve the objective of increasing employee satisfaction

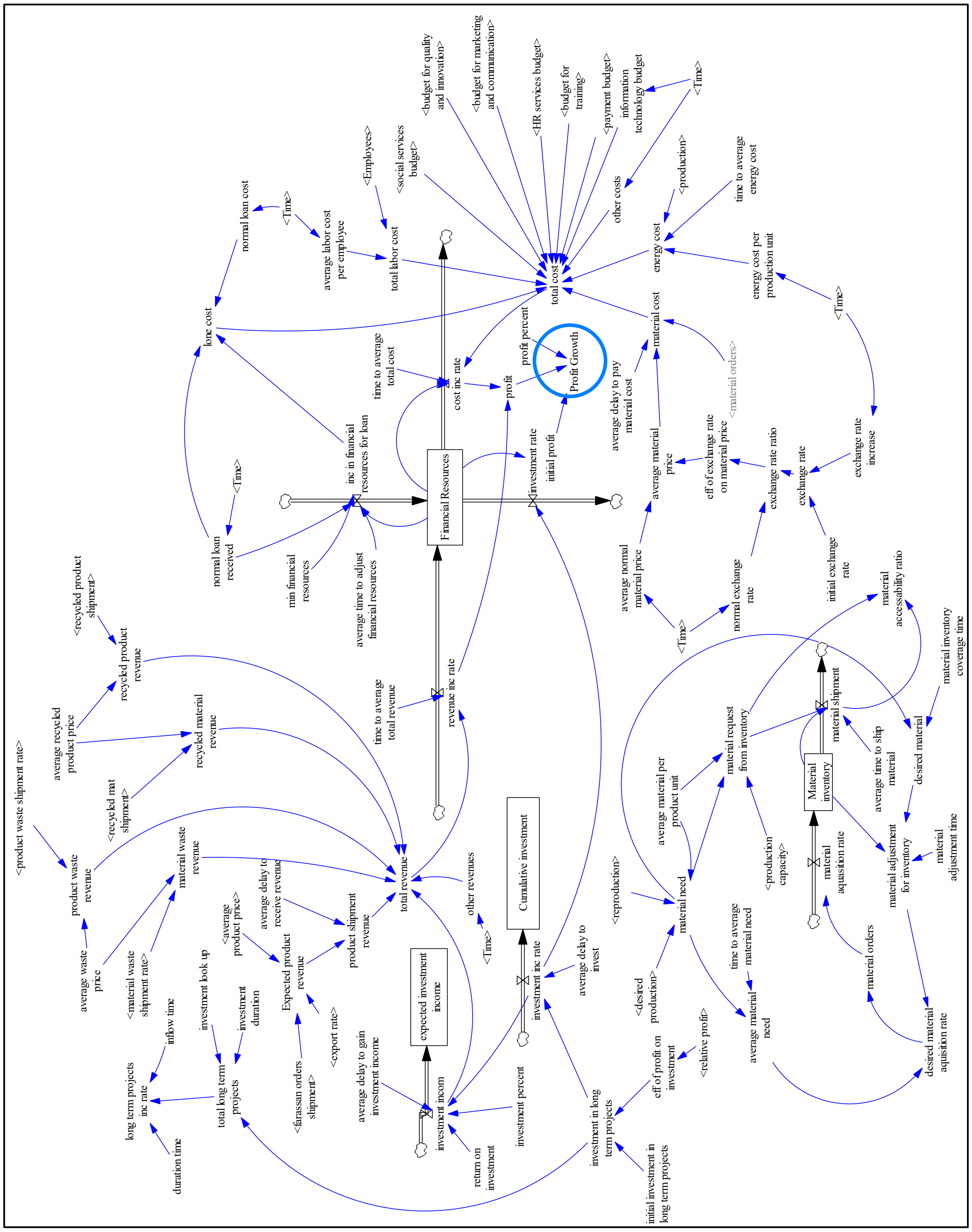

Fig. 11. Farassan SBMC in the form of a stock and flow diagram to achieve the objective of increasing the profit

Table 2 presents the abbreviations used in the stock and flow diagrams and their explanations.

Table 2
Abbreviations and explanations in the stock and flow diagrams

Row	Abbreviation	Explanation
1	eff	Effect
2	inc	Increase
3	dec	Decrease
4	CS	Customer satisfaction
5	ES	Employees satisfaction
6	HR	Human resource
7	emp	Employees
8	fract	Fraction
9	mat	Material

4.4. Step 4: Model evaluation

4.4.1. Behavioral reproduction test

This section of the study evaluates whether the SBMC simulated in the company could reproduce the past behavior (referenceMode) of the key business objectives. To this end, the historical data from 2010 (the zeroth period) to 2019 (the ninth period) were used to simulate the variables of the business objectives from 2020 (the tenth period) to 2026 (the sixteenth period). Based on this, a behavioral reproduction test was carried out for each objective as follows:

4.4.1.1. Objectives: a) increase of profit and b) increase of customer satisfaction

The model simulated in Farassan could reproduce the past behavior of the profit growth (referenceMode1) from the zeroth to the ninth period as shown in Fig. 12. In addition, the simulated model could reproduce the past customer satisfaction behavior (referenceMode 2) during the historical period (Fig. 13).

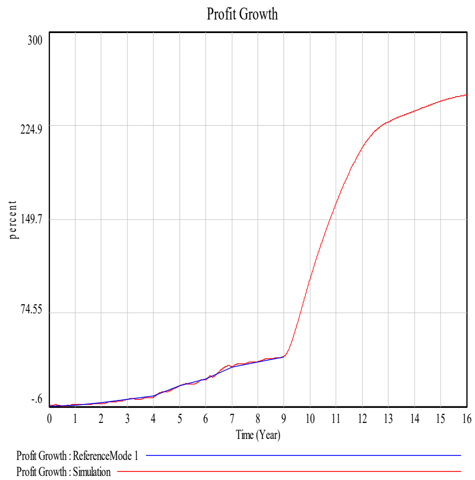

Fig. 12. Behavioral reproduction test for the objective of increasing the profit

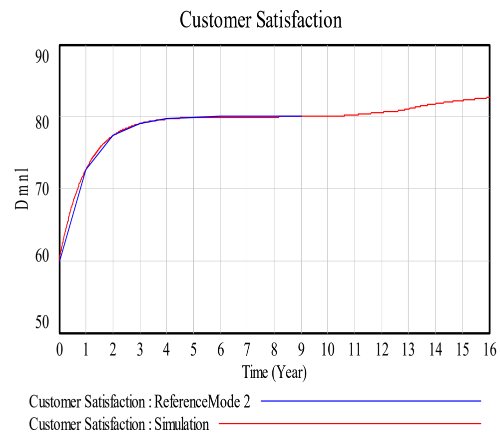

Fig. 13. Behavioral reproduction test for the objective of increasing the customer satisfaction

4.4.1.2. Objectives: c) increase of employee satisfaction and d) reduction of composite waste products

The simulated model could reproduce the past behavior of the employee satisfaction (referenceMode 3) from the zeroth to the ninth period (Fig. 14). The model could also reproduce the past behavior of the waste products (referenceMode 4) as displayed in Fig. 15.

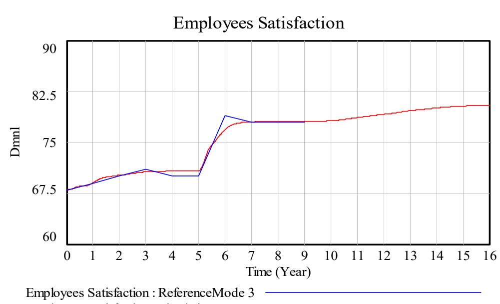

Fig. 14. Behavioral reproduction test for the objective of increasing the employee satisfaction

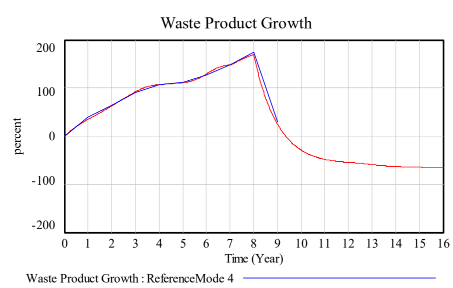

Fig. 15. Behavioral reproduction test for the objective of reducing the composite waste products

4.4.2. Sensitivity analysis

Considering that the critical uncertainties identified for Farassan were exchange rate and market demand, the sensitivities of the key objectives were examined in two different parts.

4.4.2.1. The first part: The effect of the exchange rate on the key business objectives

In this part, the exchange rate amount was increased and decreased up to 70% according to the past trend and the industry experts' opinions to study its effect on the objectives. As shown in Fig. 16, the exchange rate variation could severely affect the profitability of the company in medium and long terms. Moreover, a severe decline in profitability would reduce the budget allocation to quality improvement and innovations, which could considerably decrease the customer satisfaction (Fig. 17).

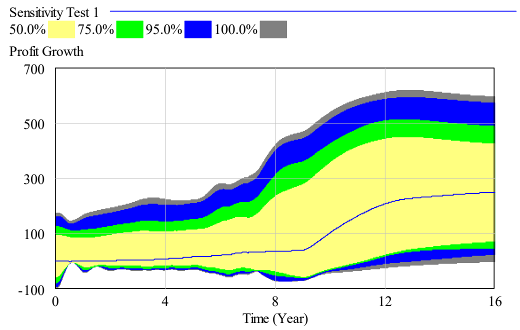

Fig. 16. Sensitivity test 1: The effect of exchange rate on profit

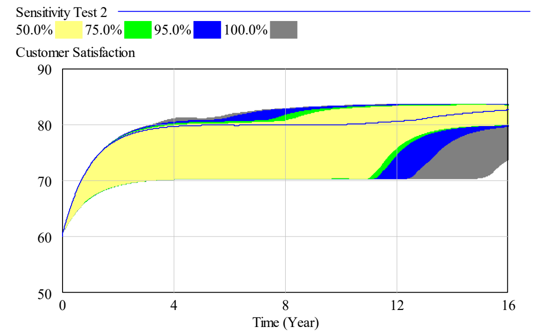

Fig. 17. Sensitivity test 2: The effect of exchange rate on customer satisfaction

This decline could also reduce the budget allocation to employee services and reward payment, which, in turn, would seriously reduce the level of employee satisfaction in medium and long terms (Fig. 18). Furthermore, as shown in Fig. 19, the exchange rate variation would have less effect on the waste products in the long run because the company has controlled and reduced the growing trend of the waste products by launching a waste recycling system in the eighth period.

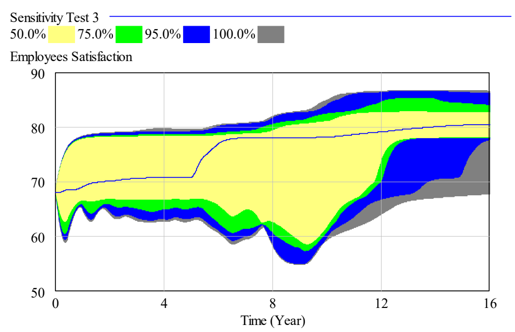

Fig. 18. Sensitivity test 3: The effect of exchange rate on employee satisfaction

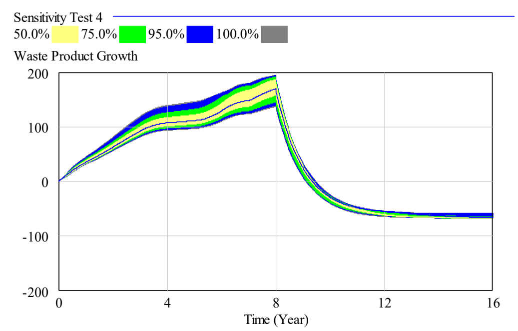

Fig. 19. Sensitivity test 4: The effect of exchange rate on waste products

4.4.2.2. The second part: The effect of market demand on the key business objectives

In this part, the market demand was increased and decreased up to 40% based on the past experiences. As displayed in Fig. 20, the change in the market demand could greatly affect Farassan profitability in medium and long terms. A great decrease in profitability would reduce the budget allocation to quality improvement and innovations. As displayed in Fig. 21, this could noticeably reduce the customer satisfaction in the future.

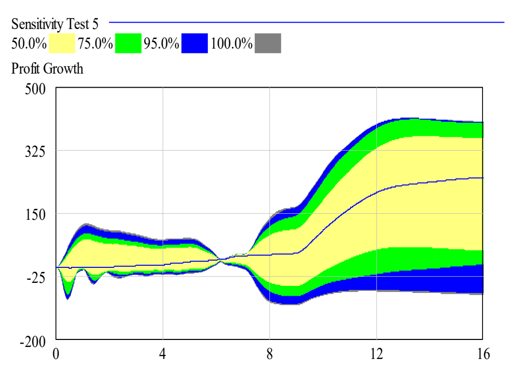

Fig. 20. Sensitivity test 5: The effect of market demand on profit

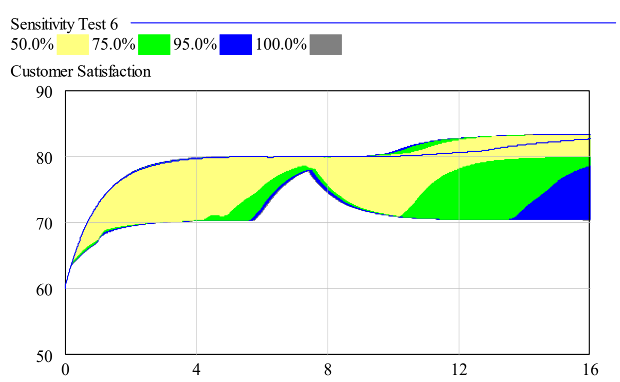

Fig. 21. Sensitivity test 6: The effect of market demand on customer satisfaction

A big reduction in the business profit could also remarkably decrease the allocation of proper budgets to employees, leading to a sharp reduction of the employee satisfaction (Fig. 22). Additionally, the variation in market demand would have less effect on waste products in the long run because the company has launched a waste recycling system in the eighth period (Fig. 23).

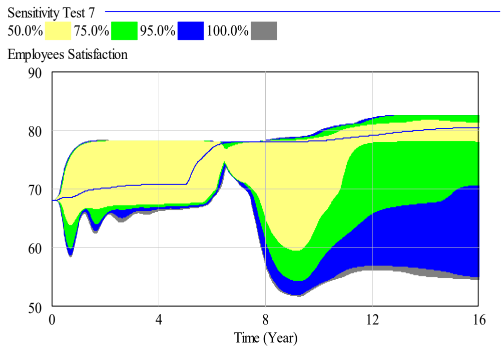

Fig. 22. Sensitivity test 7: The effect of market demand on employee satisfaction

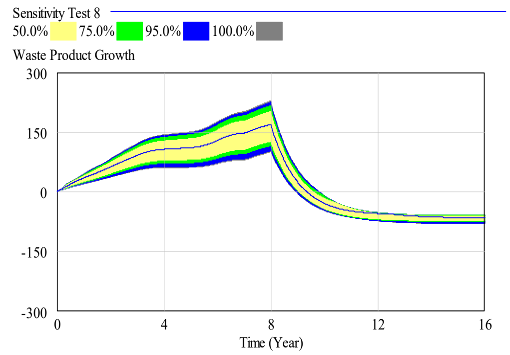

Fig. 23. Sensitivity test 8: The effect of market demand on waste products

4.5. Step 5: Scenario design

According to the critical uncertainties identified in the first step, four future scenarios were proposed for Farassan Company, as depicted in Fig. 24.

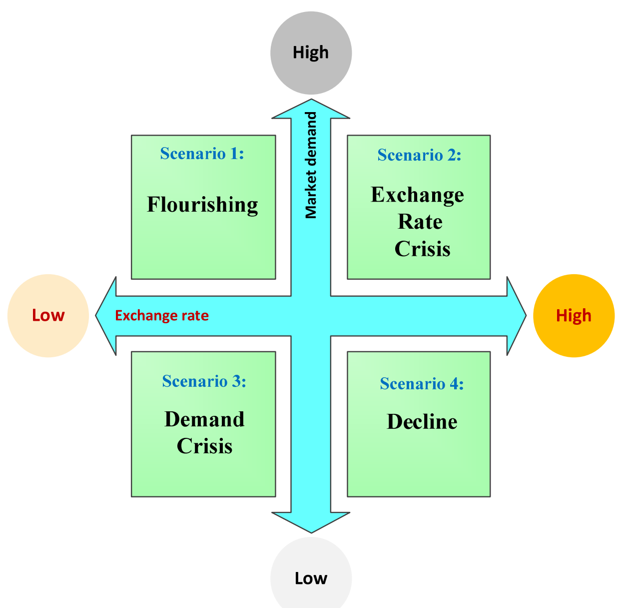

Fig. 24. Four possible future scenarios for Farassan Company

1. Scenario 1: Flourishing (The market demand is high, but the exchange rate is low.)
2. Scenario 2: Exchange rate crisis (Both the market demand and the exchange rate are high.)
3. Scenario 3: Demand crisis (Both the market demand and the exchange rate are low.)
4. Scenario 4: Decline (The market demand is low, but the exchange rate is high.)

4.6. Step 6: Policy making

After the identification of four future scenarios for Farassan Company, two key tasks were done. First, as presented in Table 3, all the factors (possible policies) were identified separately for each scenario through a focus group of six experts. The group consisted of four business owners with more than 20 years of experience and two key managers.

Table 3
Possible policies (factors) identified for each future scenario

Factors (Possible policies)	**Scenario 1: Flourishing**	**Scenario 2: Exchange rate crisis**	**Scenario 3: Demand crisis**	**Scenario 4: decline**
Factor 1	**Increase in:** • Production capacity (45%)	**Increase in:** • Production capacity (45%)	**Increase in:** • Budget for quality and innovation (30%) **Decrease in:** • Average product price (10%)	**Decrease in:** • Average product price (10%)
Factor 2	**Increase in:** • Production capacity (45%) • Budget for quality and innovation (35%)	**Increase in:** • Production capacity (45%) • Budget for quality and innovation (20%)	**Increase in:** • Budget for quality and innovation (30%) • Budget for marketing and communication (35%)	**Increase in:** • Budget for quality and innovation (35%) • Budget for marketing and communication (40%)
Factor 3	**Increase in:** • Production capacity (45%) • Budget for quality and innovation (35%) • Payment budget (50%)	**Increase in:** • Production capacity (45%) • Budget for quality and innovation (20%) • Payment budget (30%)	**Increase in:** • Budget for marketing and communication (35%)	**Increase in:** • Budget for quality and innovation (35%) **Decrease in:** • Average product price (10%)
Factor 4	**Increase in:** • Production capacity (45%) • Budget for quality and innovation (35%) • Payment budget (50%) • HR services budget (30%)	**Increase in:** • Production capacity (45%) • Budget for quality and innovation (20%) • Payment budget (30%) HR services budget (20%)		**Increase in:** • Budget for quality and innovation (35%) • Budget for marketing and communication (40%) **Decrease in:** Average product price (10%)
Factor 5	**Increase in:** • Production capacity (45%) • Budget for quality and innovation (35%) • Payment budget (50%) • HR services budget (30%) • Budget for training (20%)	**Increase in:** • Production capacity (45%) • Budget for quality and innovation (20%) • Payment budget (30%) • HR services budget (20%) • Budget for training (10%)		

In the next step, the final policies were adopted through a quantitative dynamic analysis for each factor.

5. Results

In this section, the proper policies are adopted for each future scenario by the dynamic analysis of the factors (possible policies). The implementation of these policies increases the likelihood of achieving the key objectives of Farassan Company more than the other policies.

5.1. Scenario 1: Flourishing

In the Flourishing scenario, the market demand and the exchange rate are both optimistic. Not only is the amount of sale largely due to the high market demand, but also the costs are at a desirable level due to the low exchange rate. In this scenario, the fifth policy can not only create more profit for Farassan shareholders than the other policies as depicted in Fig. 25, but also increase the customer satisfaction (Fig. 26) and employee satisfaction further (Fig. 27) and reduce waste products more in the long term (Fig. 28). This policy can help the company owners and senior managers achieve their business objectives and create balanced values for a broader range of stakeholders in the long run, not just for the company shareholders.

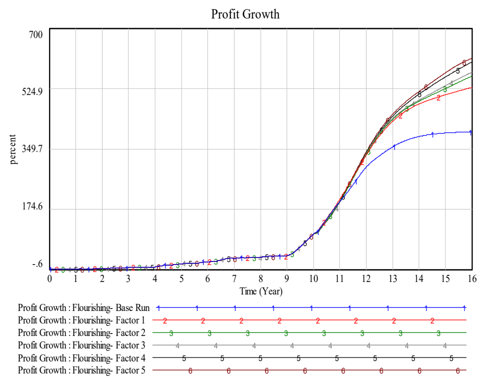

Fig. 25. Scenario 1: Flourishing and policies to increase the profit

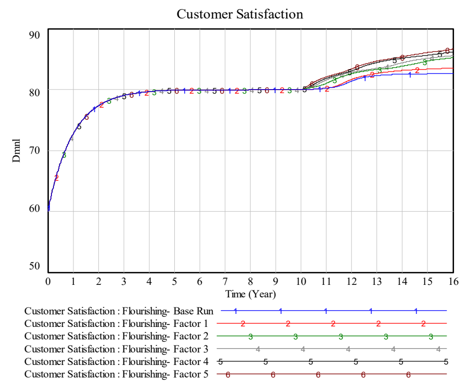

Fig. 26. Scenario 1: Flourishing and policies to increase customer satisfaction

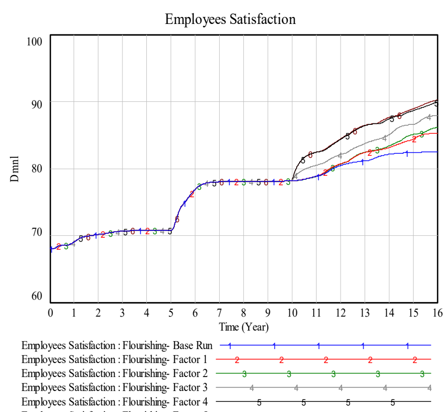

Fig. 27. Scenario 1: Flourishing and policies to increase employee satisfaction

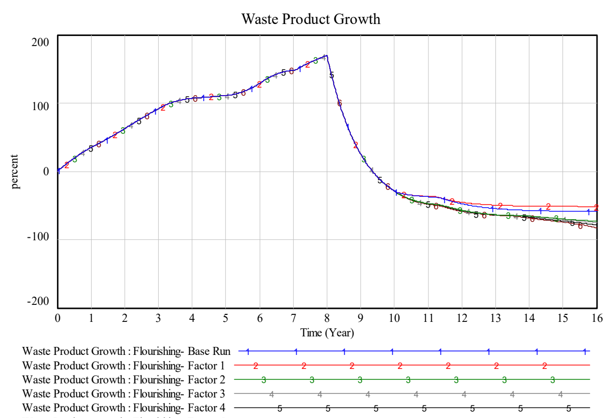

Fig. 28. Scenario 1: Flourishing and policies to reduce the waste products

5.2. Scenario 2: Exchange rate crisis

In this scenario, both the market demand and the exchange rate are very high. In the exchange rate crisis, although it is possible to increase the revenue due to the large orders received from the customers, the sharp increase in the exchange rate leads to a drastic rise in the price of the raw materials and costs. This reduces the profit of the company quickly and drastically (the 11th period) as depicted in Fig. 29. Then, as the production and sale of the ordered pipes increase gradually, the revenues of the company and, consequently, its profitability grow over time and compensate for the sharp decline of the profit experienced in the 11th period. In this scenario, in comparison with the other policies, the fifth policy can not only generate more profit for Farassan shareholders as shown in Fig. 29 but also improve the customer satisfaction (Fig. 30) and employee satisfaction further (Fig. 31). Moreover, this policy can reduce waste products and keep them under the current trend (Base run) in the future (Fig. 32).

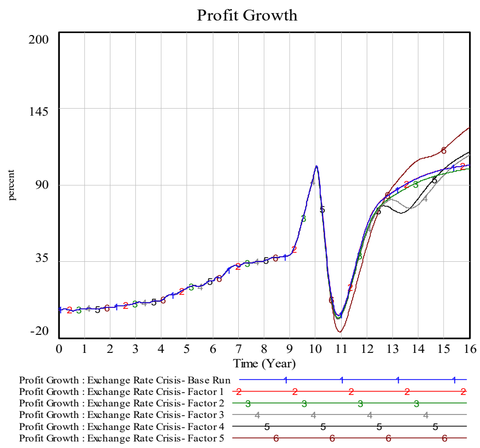

Fig. 29. Scenario 2: Exchange rate crisis and policies to increase the profit

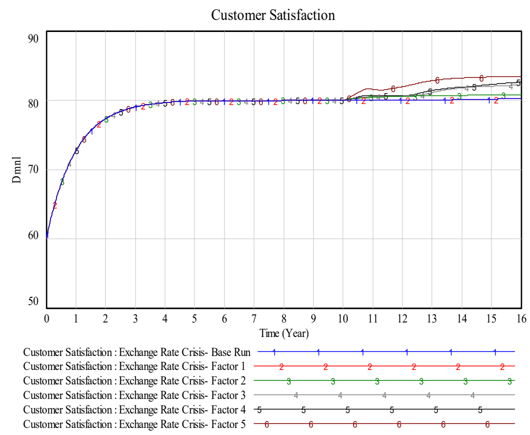

Fig. 30. Scenario 2: Exchange rate crisis and policies to increase customer satisfaction

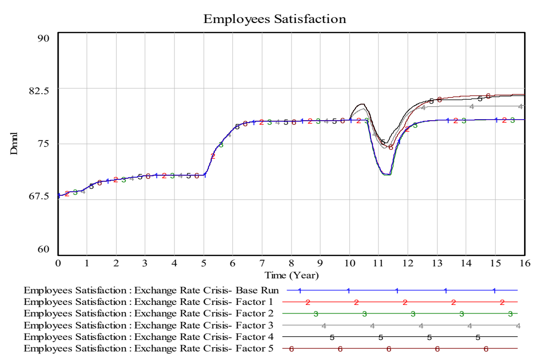

Fig. 31. Scenario 2: Exchange rate crisis and policies to increase employee satisfaction

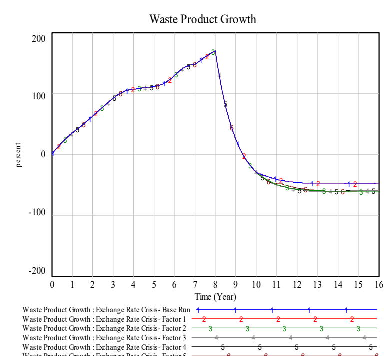

Fig. 32. Scenario 2: Exchange rate crisis and policies to reduce the waste products

5.3. Scenario 3: Demand crisis

In this scenario, although the exchange rate is desirable, the market demand is very low and undesirable. In the demand crisis, among the policies adopted, the second one can make more profit (Fig. 33), create better employee satisfaction (Fig. 35), and decrease waste products in the long run (Fig. 36). Due to no reduction of the product price in this policy, it cannot increase the customer satisfaction level more than the first policy can, but it keeps it higher than both the base run and the third policy (Fig. 34). In fact, the customer satisfaction increases much more by the first policy which reduces the average product price by 10% (Table 3).

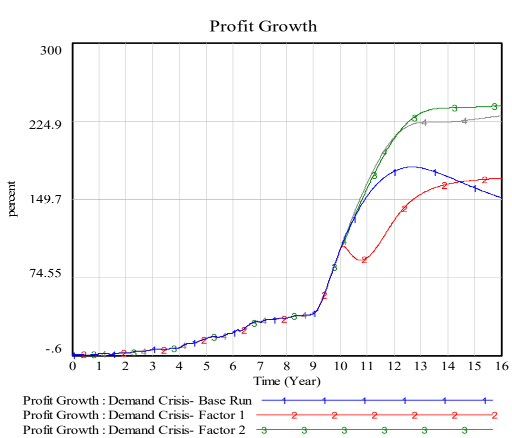

Fig. 33. Scenario 3: Demand crisis and policies to increase the profit

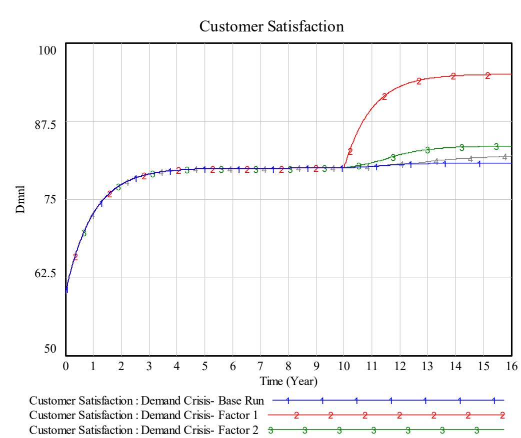

Fig. 34. Scenario 3: Demand crisis and policies to increase customer satisfaction

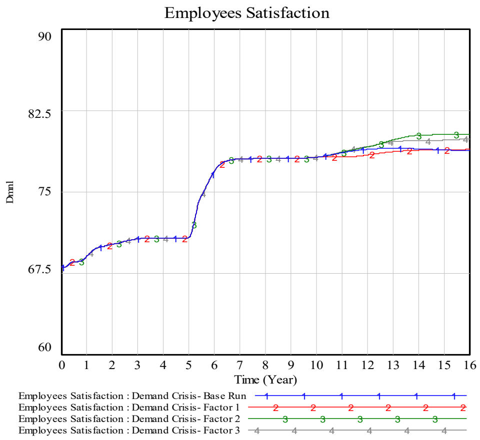

Fig. 35. Scenario 3: Demand crisis and policies to increase employee satisfaction

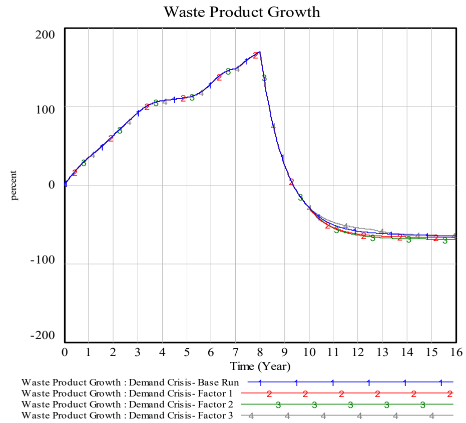

Fig. 36. Scenario 3: Demand crisis and policies to reduce the waste products

5.4. Scenario 4: Decline

In this scenario, the market demand and the exchange rate are both pessimistic and undesirable.
A very exciting and surprising result obtained from the dynamic analysis of the worst scenario (decline) is that the adoption of the second policy not only increases the company's profit to a level higher than the base run and prevents its sharp decline in the long term (the 16th period) as in Fig. 37 but also provides the possibility of achieving customer satisfaction (Fig. 38) and employee satisfaction (Fig. 39) at a level higher than the base run, simultaneously keeps the waste product at a desirable level in the future and prevents it from increasing more than the current trend (Fig. 40). Fortunately, the results showed that, even under this pessimistic scenario, there is still a solution for Farassan owners and managers to create a balanced and appropriate value not only for the company's shareholders but also for the other stakeholders in the future.

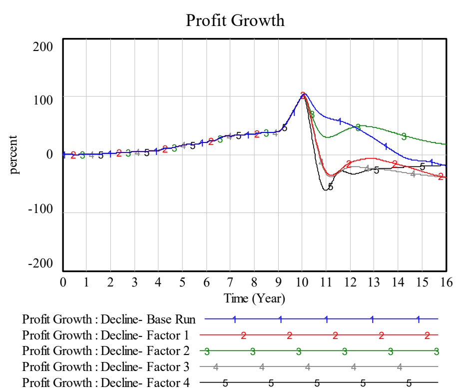

Fig. 37. Scenario 4: Decline and policies to increase the profit

Fig. 38. Scenario 4: Decline and policies to increase customer satisfaction

Fig. 39. Scenario 4: Decline and policies to increase employee satisfaction

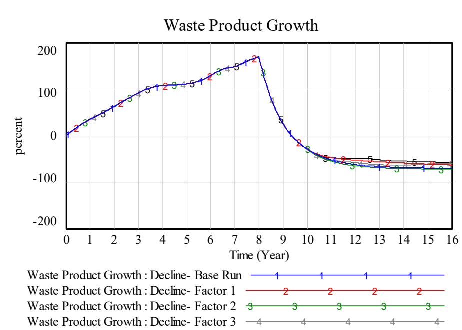

Fig. 40. Scenario 4: Decline and policies to reduce the waste products

Finally, through the steps of the framework presented in this study and the dynamic analysis performed on the SBMC (VTBMC) designed for Farassan, proper policies have been extracted to help the company owners and managers achieve their key business objectives in the long term (the 16^{th} period) and create balanced values for a wider range of stakeholders, not just for Farassan shareholders. In this regard, a good sustainable business model for Farassan in scenarios one and two is a model that includes the fifth policy, and in scenarios three and four it is a model that includes the second policy.

6. Discussion

According to the results, the use of the framework with its six steps (i.e., Identification of key business objectives, SBM canvas designing, SBM simulation, model evaluation, scenario designing, and policy making) can help managers and business owners make proper decisions and adopt appropriate policies. The main characteristics and advantages of this framework are a) identifying the key business objectives, b) designing a sustainable business model canvas based on VTBMC, as one of the newest SBMs, c) determining the critical uncertainties, d) analyzing the designed SBM canvas quantitatively and dynamically, e) designing different future scenarios, f) identifying and adopting proper policies separately for each designed scenario, not just for one. In addition, based on the literature review conducted in this research, the merits of the current study can be clarified when compared to the features of the other related studies categorized as follows:

1. SBMC design but no quantitative dynamic analyses and no variety of future scenarios (e.g., Maresova et al., 2022; Cosenz et al., 2020).

2. Quantitative dynamic analyses but no SBMC designs and no variety of future scenarios (e.g., Liu et al., 2022; Luksta et al., 2021; Barforoush et al., 2020; Franco, 2019; Minato and Morimoto, 2017; Duran-Encalada and Paucar-Caceres, 2012).

3. No SBMC design but quantitative dynamic analyses and policymaking for different future scenarios (e.g., Cui et al., 2022; Täuscher and Abdelkafi, 2018).

4. SBMC design, quantitative dynamic analysis and policymaking for different future scenarios
Based on the literature review conducted in this research, no study was found to have covered all these three aspects simultaneously.
Therefore, the present research sought to fill the identified gap by proposing a practical framework that makes it possible to consider all the above three aspects together.

7. Conclusion

In this study, an attempt was made to fill a research gap in the field of designing and analyzing sustainable business models (SBMs). The implications of the research are twofold, theoretical and practical. Theoretically, a new framework is proposed on the basis of various approaches and tools including the value triangle business model canvas (VTBMC), as one of the newest valid sustainable business models, system dynamics, and scenario matrix to develop the knowledge of how to convert a qualitative SBM to a quantitative model and how to simulate it comprehensively and dynamically. The insight provided through this knowledge can open a new window to the theoretical development of SBMs and the formation of a basis or paradigm to study sustainable business models and their dynamics beyond qualitative and static levels. The practical managerial implications of this research include: a) helping business owners and managers better understand the various important dynamics of SBMs and, accordingly, create sustainable and balanced values for a wide range of business stakeholders rather than just for shareholders, and b) enabling business owners and managers to identify proper policies for more than one future scenario so that they can achieve their business objectives under different critical uncertainties. This study also has some limitations. Firstly, it has designed and analyzed a sustainable business model only in a manufacturing and industrial context. Secondly, the current study has focused on just one sustainable business model canvas, namely VTBMC. Therefore, it is suggested that future related studies be implemented in other areas, such as the service sector, as well. In addition, it is suggested that future researchers use other valid SBM canvases to develop further theoretical and practical knowledge of the design and dynamic quantitative analysis of SBMs.

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Disclosure statement

No potential conflict of interest was reported by the author(s).

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