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A System Dynamics Approach to Sustainable Business Model Transformation: A Manufacturing Case

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ABSTRACT

Corporates and industries must make their businesses work more sustainably to benefit from a sustainable economy. Hence, corporate leaders are in a challenge of decision-making about transforming their business logic through innovative sustainable business models. The involvement of business models and environmental issues requires dealing with complexities that arise from a large number of interrelated actors as well as the dynamic nature of environmental issues. Early in its literature review, this paper summarizes the innovations and strategies for sustainable business model transformation. Most importantly, this paper proposes using System Dynamics (SD) modeling as a decision support tool that could support business cases with sustainability concerns. Later in this paper, a plastics manufacturer trying to utilize recycling and reuse in its production process exemplifies our discussion. The implications are then generalized to support managerial decisions raised by companies and corporations willing to integrate sustainability into their business models. In the case mentioned in this article, System Dynamics modeling and simulation helped managers deal with the uncertainties regarding their decisions, demonstrating how a sustainable business model could be adapted to a working production system. The simulation results show that a 32 percent raise in the recycling and reuse capacity in the manufacturing company could significantly improve the company's green image, and the quality could be controlled above 85 percent. Besides, savings from recycling and reuse will compensate for the investment in the transformation plan in 55 months.

Keywords

Business Model Innovation, Sustainability, System Dynamics, Decision Support

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1. Introduction

Business leaders have always struggled to maintain their businesses sustainably at the individual, organizational, and social levels (Schaltegger et al., 2016a). To improve sustainability performance, business leaders must make fundamental changes in their business logic (Abdelkafi and Täuscher, 2016). In other words, to shift the concerns in businesses towards environmental and social issues, the underlying business models have to be transformed and become sustainability-oriented (Schaltegger et al., 2016b). Hence, business leaders face complex decisions that must be supported by proper decision support tools (Schaltegger et al., 2012).

In recent years, there have been great concerns about sustainability among industries. Sustainable development is defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987). In other words, sustainable development maximizes economic advancements while taking care of long-term environmental values without making tradeoffs between environmental sustainability and economic development (Emas, 2015). Admittedly, the role of industrial and corporate sustainability is inevitable in the sustainability of the national and global economic systems (Tonelli et al., 2013). In other words, global sustainable development is impossible without the sustainable development of corporations (Schaltegger et al., 2012). Yet, businesses are under growing regulatory pressure to move towards environment-friendly products and services (Moultrie et al., 2015). By the same token, governmental incentives depict more promising outlooks for sustainable businesses from an economic, social, and environmental point of view (Melkonyan et al., 2017); to such a degree that the idea of sustainability is being regarded as a competitive advantage. A partial solution to such a problem is the concept of Circular Economy, that is, in this paper's case, trying to close the resource loops through reuse, remanufacturing, and recycling (Geissdoerfer et al., 2018). This strategy could be applied to manufacturing companies and results in a circular flow of resources (Bocken et al., 2016)

In recent years, business models have attracted great notice from researchers and practitioners in the field of sustainability management (Geissdoerfer et al., 2018). Perhaps that is because to attain sustainability in business; the business models should be subject to change and evolution to maintain or increase economic gains while positively affecting the environment and society (Schaltegger et al., 2016a). The business model has been a prevalent concept in management science in recent two decades (Zott et al., 2011). A business model is the design and structure of an organization's value creation, capture, and delivery mechanisms (Teece, 2010). Business models with sustainability concerns are called terms like sustainable business models (SBM), sustainability business models, or business models for sustainability (BMfS) (Abdelkafi and Täuscher, 2016). The first contributions to sustainable business models were mainly focused on organizational structure and culture (Stubbs and Cocklin, 2008), while a growing number of academic works focused on innovations and strategies for sustainable business models (Schaltegger et al., 2016b). Business model innovation (SBMI) is exploring, revising, adjusting, developing, and innovating a business model with sustainability considerations (Geissdoerfer et al., 2018). Sustainable business model strategies (SBMS) or archetypes are groupings of solutions that could be used to build a sustainable business model (Bocken et al., 2014).

Regarding decision-making, managers choose the business model according to corporate visions and strategies (Schaltegger et al., 2012); business strategists usually modify their business models with economic prospects, but their decisions have broader consequences because of the inevitable interactions between business and the environment. Regarding the number and the changing nature of the forces affecting such problems, we can say the problems with sustainability concerns are complex. Business leaders need to employ certain tools for formulating and solving complex problems because the human capacity for dealing with such problems is very small (Simon, 1957). Decision-making for complex problems is quite challenging, and one of the most suitable decision tools for dealing with complex problems is Systems Dynamics (SD) (Sterman, 2000).

The case represented here is a plastic manufacturing company that is on its way to shifting its business model toward a cleaner and more sustainable one. The changes in the business model entail modifications in product design, manufacturing process, and material lifecycle to facilitate recycling and material reuse. The customized plastic recycling and reuse process is being integrated into the production process to enable the factory to recycle material and reuse parts besides its production under one roof. The dynamic problem here is to find out whether or not and how a mid-term or long-term approach to financing a sustainable business model will reach a breakeven point, after which the business could enjoy the economic returns (the dynamic behavior of total revenues and costs of the company are of high importance in this regard). In the mentioned case, SD modeling enables the company's managers and strategists to view the consequences of their decisions regarding sustainable business model transformation. The dynamic modeling of the case and simulation of the alternative futures

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could have implications (as a decision support tool) for corporate decision-makers and assist them in developing innovative business models. Moreover, the impact of governmental support of sustainability transformation programs is studied by including factors like governmental incentives in the forms of loans and Ecotax in the dynamic model.

This paper is organized as follows. The following section reviews previous research works about sustainable business models, innovations, strategies for business model transformations, and the relevant decision models. This section summarizes the sustainable business model transformation innovations and strategies in a useful and preferable way. After that, the research methodology is explained, and a brief review of the system dynamics methodology is reported. The third section represents the conceptual model using causal loop diagrams. This section and the next one propose a decision support framework for sustainable business model transformation for a plastic manufacturing company. In the next section of the paper, the relationships among the variables are explained in mathematical terms in the form of a stock-flow diagram. The last section entails a discussion and implications that could be derived from this study and used in practice and research.

2. Literature review

Numerous academic efforts have been toward building business cases that try to support decisions related to sustainability under different terminology and conceptualizations. The concept of Sustainability Accounting, for example, was raised by Bebbington and Gray ((Bebbington and Gray, 2001; Bebbington et al., 2001; Gray and Bebbington, 2000), and developed in the works of Schaltegger, Wagner, Bennett, and Burritt (Schaltegger et al., 2006; Schaltegger and Burritt, 2010; Schaltegger and Wagner, 2006). Following the emergence of a considerable body of literature that concentrated on creating economic value while increasing corporate environmental and social performance (e.g., Dyllick and Hockerts, 2002; Epstein and Roy, 2003; Schaltegger and Wagner, 2006), Schaltegger et al. (2012) proposed a framework for business model innovation. Some works proposed decision support frameworks using Multi-Criteria Decision Making (MCDM) (Azapagic and Perdan, 2010, 2005; Gommes et al., 2012) regarding the three dimensions of sustainability (namely, financial, social, and economic). There have also been practical approaches; for instance, the development of decision-support systems to ease the adoption of the best sustainable energy practices (Parraguez Ruiz and Maier, 2018) or multi-criteria decision support for sustainability assessment of manufacturing system reuse (Ziout et al., 2013).

Most importantly, several academic works utilized SD modeling to deal with business model innovations associated with sustainability. Abdelkafi and Täuscher (2015) investigated the characteristics of robust business models from an SD perspective. Then, Abdelkafi and Täuscher (2016) employed the graphical notations of SD to model the dynamics of the various players in a Business Model for Sustainability (BMfS). Asif et al. (2016) used a simulation tool based on SD and Agent-Based modeling to define and analyze the performance of circular product systems. In a similar work, Rodrigues et al. (2017a) used an SD approach to propose a simulation-based business case for Ecodesign implementation - a sustainability-oriented business model innovation. Later, Täuscher and Abdelkafi (2018) built a simulation model that connects different dimensions of the Business Model for Sustainability. The focal point of this paper is the application of system dynamics modeling in building decision support for sustainability-related decisions.

Regarding a review by Geissdoerfer et al. (2018), different approaches taken by the researchers around the issue of sustainable business models are mapped with several types of research from the literature. Table 1 illustrates a typology for sustainable business models (SBM) by separating their Sustainable Business Model (SBM) Types, Sustainable Business Model Innovation (SBMI) types, and Sustainable Business Model Strategies (SBMS). This categorization could help develop new paths or configurations for sustainable business model innovation (Bocken et al., 2014).

Using Table 1, we have sorted the other research works around sustainable business models. Nearly all research works presented here have used System Dynamics modeling as a decision support tool.

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Table 1. A Typology of Sustainable Business Models based on Geissdoerfer et al.(2018)

Categorization	Example	Abbr.	Description
Sustainable Business Model Innovation Type (SBMI)	Sustainable Start-Ups	SSU	Creating a new organization with a sustainable business model
	Sustainable Business Model Transformation	SBMT	Transforming the current business model into a sustainable one
	Sustainable Business Model Diversification	SBMD	Adding a sustainable business model to the organization without making major changes to the original business model
	Sustainable Business Model Acquisition	SBMA	Identifying, acquiring, and integrating a sustainable business model into the organization
Sustainable Business Model Type (SBM)	Circular Business Model	CBM	BMs that are closing, slowing, or narrowing the resource loops
	Social Enterprises	SE	BMs that generate profits from economic activity or reinvest them totally so that making a social impact
	Bottom of the Pyramid Solutions	BPS	BMs that target the customers at the bottom of the income pyramid
	Product-Service Systems	PSS	BMs that integrate products and services and offer them to customers
Sustainable Business Model Strategies (SBMS)	Maximize Material & Energy Efficiency	EFF	Material-efficient
	Closing Resource Loops	CRL	Closing the resource loops through reuse, remanufacturing, and recycling
	Substitute with Renewables & Natural Resources	REN	Replacing non-renewable resources with renewable ones, and artificial processes with natural ones
	Deliver Functionality rather than Ownership	FUNC	Offering the user the required functionality without giving them ownership of the product that provides the service
	Adopt a Stewardship Role	STEW	Protecting natural systems by introducing a gatekeeper that controls or motivates certain behaviors
	Encourage Sufficiency	SUFF	Informing and motivating less consumption
	Repurpose for the Society or the Environment	REP	Utilizing organizational resources to create societal or environmental benefits
	Inclusive Value Creation	IVC	Delivering value to formerly unattended stakeholders by including them in the value creation process
	Develop Sustainable Scale-Up Solutions	SUS	Scaling sustainable solutions and technologies

Table 2 lists research works that revolve around sustainable business models, and it also addresses the type of sustainable business model (SBM), sustainable business model innovation (SBMI), and the enable business model innovation (SBMI) for each research. As shown in Table 2, no other research has yet worked on sustainable business models in the plastic industry.

Table 2. Research Works on the topic of Sustainable Business Models

Research Study	SBM	SBMI	SBMS	Case Study	Modeling
Abdelkafi and Täuscher (2015)	CBM	SSU	EFF	Online Retailing	SD
Abdelkafi and Täuscher (2016)	SE	SSU	SUS	Crowd Funding	SD
Asif et al., (2016)	CBM	SBMT	CRL	Misc.	AB* - SD
Rodrigues et al. (2017b)	-	-	Misc.	Misc.	SD
Hutchinson and Walker (2012)	CBM	SBMA	EFF	Fast Food	None
Duran-Encalada and Paucar-Caceres (2012)	CBM	SBMD	EFF CRL REN	Oil Production	SD
Moellers et al., (2019)	PSS	SBMD SBMA	FUNC	Automotive	SD
Gomez-Segura et al., (2019)	CBM	SBMA	EFF	Print Packaging Manufacturing	SD
Chen et al., (2018)	SE	SSU	SUS	Crowd Funding	SD
Mansilha et al., (2019)	CBM	SBMA	EFF REN	Broiler Production	SD
Geissdoerfer and Weerdmeester, (2019)	CBM	SBMD	CRL FUNC	Process and Manufacturing	None

*AB= Agent-Based

3. Research methodology

The paradigm that governs this research is that of shifting the economic view in our businesses to a more sustainable one. That means we should make innovations to turn our business models sustainable. Consequently, we face complex decisions while dealing with different scenarios that might happen as a result of the decisions we make about the business model. Supporting such decisions requires dealing with complexities associated with sustainability issues and the company's business model (Schaltegger et al., 2012). Thus, a dynamic approach must be employed to define and understand the evolution of business models (Demil and Lecocq, 2010). There are some limits on human faculty to handle complex decisions (Simon, 1957); therefore, to tackle dynamic complexity and multiplicity of influential inter-related actors in the process of decision making, we need decision support tools based on systems thinking and system dynamics (Sterman, 2000). In some cases, the dynamic nature of planning leads managers to employ dynamic decision support tools to such an extent that using static approaches could mislead managers in selecting their strategies (Hosseini et al., 2019). System Dynamics (SD) is known as an ideal methodology for modeling complex dynamic problems (Sterman, 2000), especially for strategic decision-making in the manufacturing sector (Rafiei et al., 2014). In this paper, we used SD modeling to support the decisions surrounding a practical approach to a sustainable business model (SBM) in a manufacturing company.

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The presented model is based on the production system in a case study. In addition, the structure of the model in decision-making parts is based on the interviews with the experts and decision-makers in the company about the processes under study. Moreover, the data used in the simulation is gathered from the company's official reports and ERP system or inferred from them.

The model developed in this paper tries to offer business owners and strategic decision-makers insight into the probable consequences of their sustainability-oriented decisions. Moreover, the results from this research contribute to the analysis of different possible sustainable business model options suitable for use in the plastic industry, especially those with a tendency to employ a circular economy approach.

Figure 1 represents the main steps of this study based on the system dynamics methodology. In the first step, the previous works are reviewed to determine an appropriate set of variables dealing with the sustainable business model transformation proposed for the case study. Next, the problem is analyzed to select the variables we focus on throughout the study. In the third step, we have formulated a conceptual framework in which the main balancing and reinforcing loops that reflect the dynamics of the variables are clarified through causal loop diagrams (CLD). In the next step, gathering historical data of the system's variables, a mathematical model is developed to simulate the consequences of different business model design options in the case under study. Before system simulation, the validation of the model is tested in step five. In step 6, the system is simulated with 3 different sustainable business model design options. Finally, the results from the previous step are analyzed, and the system's behavior is probed under different scenarios.

It is to be mentioned that the models with the data used in simulations are developed concerning the manufacturing process of a real plastic manufacturing company. In this article, the authors have simplified the model intending to increase its objectivity and applicability to similar situations and, most importantly, propose a framework for supporting decisions in sustainable business model transformation.

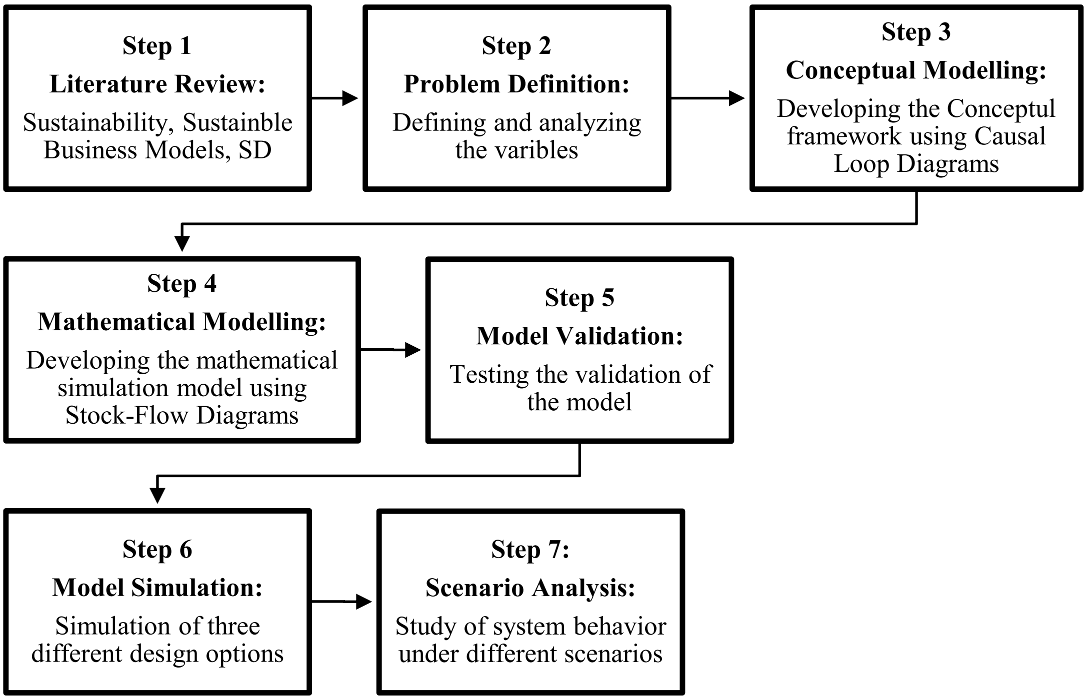

Figure 1. Research Process

4. The proposed model

This section depicts the model under discussion using causal loop diagrams (CLD). Causal loop diagrams are used to show the causal relations between system components and the feedback structure within the system (Sterman, 2000).

It is to be mentioned that the recycling process normally takes place outside the manufacturing plant. More specifically, recyclable plastic parts are normally gathered, refined, cleaned, and turned into second-hand granules in plastic recycling plants or anywhere outside the manufacturing plants. However, in the case study, a different approach is employed in which material recycling occurs at the manufacturing company. This aberrance is based on at least two reasons. Firstly and most importantly, the factory under study is located in Iran, a developing country that lacks an effective recycling system capable of collecting, refining, and reliably reproducing high-quality plastic granules. In Iran, the plastic recycling system is not integrated, and the output material is of inferior quality. The second reason for implementing this approach is that the availability of recyclable material and reusable parts create some opportunities for plastic manufacturers like this one, and by using these opportunities, they could benefit from a cheaper and more reliable supply of reusable parts and recyclable materials that could be used to build a customized reuse and recycling process at the same location in an integrated manufacturing process.

The system under study comprises manufacturing, supply chain, storage, and management subsystems. The model's boundary is limited to the functions and segments within these subsystems that have a material or data connection to the recycling and reuse components and their business sides.

The factory understudy manufactures Attached Lid Containers (ALC) and heavy-duty plastic pallets using High-Density Polyethylene (HDPE) and Polypropylene (PP). These products are used in different industries and are discarded after a period because of over-usage or misusage. This continuous flow of overused or discarded products stacked in the users' place creates an opportunity for the manufacturer to access reusable and recyclable material. Using the manufacturer's products as input to their recycling and reuse process has many advantages, including access to a defined and controllable used material and parts in terms of quality and design. Moreover, acquiring materials and parts from a customer as a supplier to the recycling and reuse process can create other win-win opportunities for both parties.

As in Figure 2, a rise in production rate increases the sales rate – providing that the market demand is high enough. Consequently, the number of products in use by the end-users goes up. At this point, if the collecting capacity of the used product comprised of the machinery, human resource, and the running process is in place, it can result in a rise in used product collection rates, naturally after a delay that corresponds to the time that the product is under use by the user. Collected parts will then go through the verification process.

$$Pr = Min\left(\frac{Raw\ Material}{Parts\ Inventory} \times \frac{Raw\ Material}{Parts\ Consumption\ Ratio}, Compay's\ Market\ Share\ \times Total\ Product\ Demand\right) \quad (1)$$

$$FPInUse = Sales + \ Competitors'Sales - Product\ Disposal \quad (2)$$

Pr: Production rate

FPInUse: Final Product in Use

Verification is a collective name given to the process of preparing the collected material for recycling and reuse. The verification process includes refining, cleaning, and verifying the collected used products and parts. We decided to summarize all these processes in just one process in our model because the materials and parts that are gathered and brought to the recycling site are of high quality. There is more verification than refining, sorting, and cleaning. Then, depending on the company's capacity for verifying the reusable parts, bigger numbers of collected parts increase the volume of the verified reusable and recyclable materials and parts that adds to the inventory of materials and parts. This inventory is then used in the production process. Of course, if the inventory level of materials and parts falls below the desired inventory, purchasing first-hand materials fix the shortage.

$$RRr = Min(Recycling\ Capacity \times 20000, Recycling\ Yield \times VUP) \quad (3)$$

$$VUP = Approval\ rate - RRr - Unusable\ Material \quad (4)$$

RRr: Recycling/Reuse rate

VUP: Verified Used Products for Recycling/Reuse

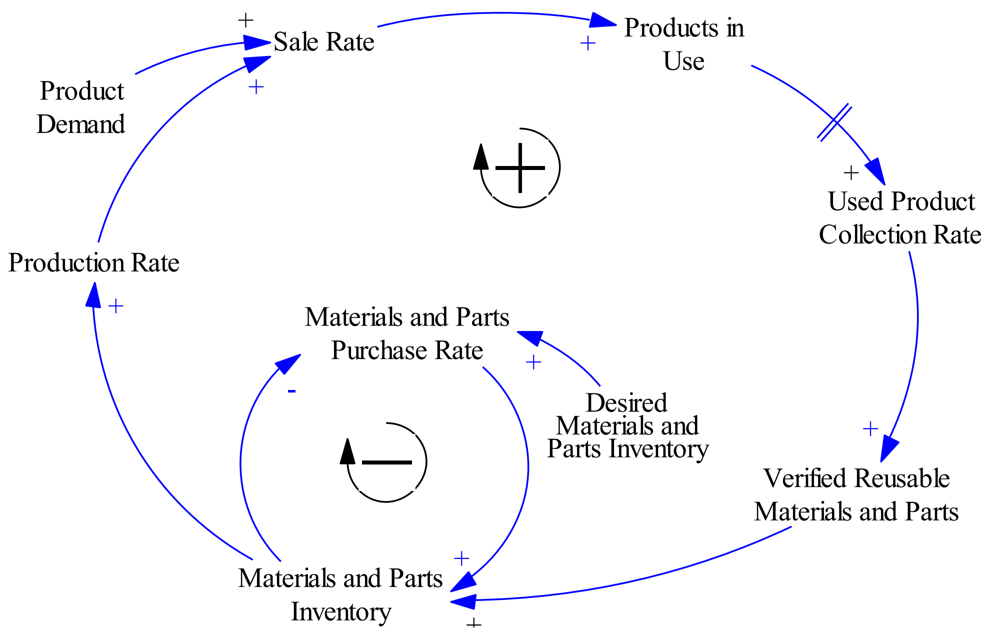

Figure 2. Recycling and Reuse Process

Figure 3 illustrates that as the percentage of recycled materials and reused parts rises, the quality of the products goes down and, in this way, controls the demand for the product. On the other hand, a high percentage of recycled materials and reused parts raise the green image of the company and incites higher demands. It should be noticed that the use of recycling and reuse cannot go further than accepted thresholds, which are generally deducted from experience, quality limits, and technology considerations.

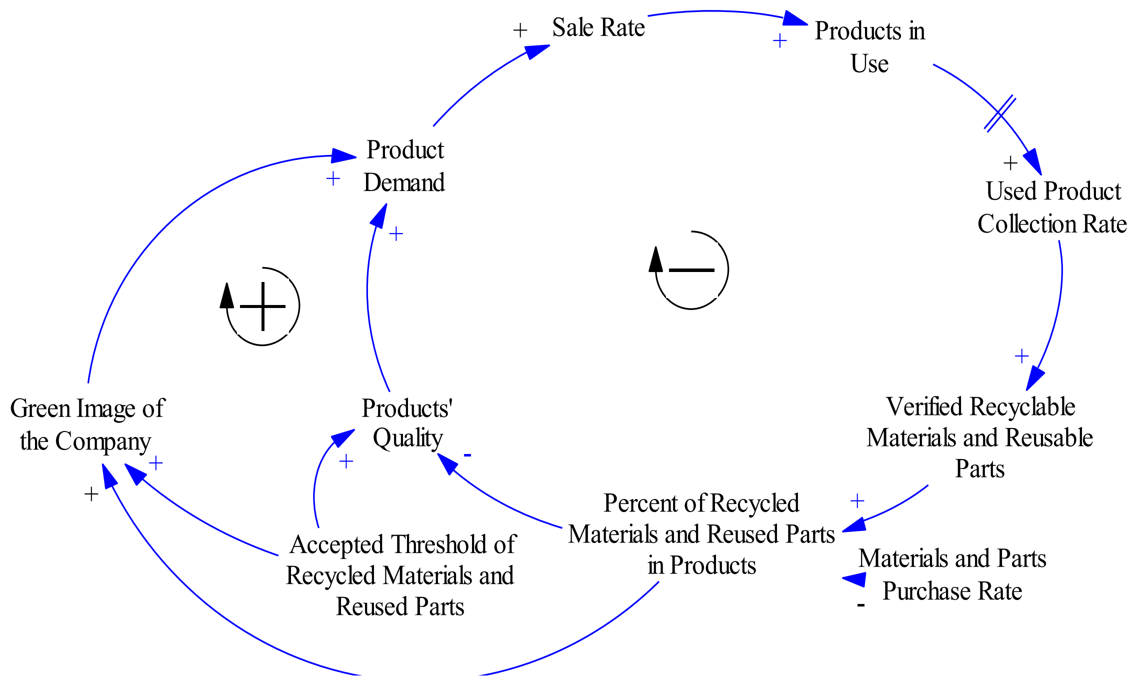

Figure 3. CLD of Production and Green Image

Figure 4 depicts some governmental and managerial issues concerning recycling and reuse. As recycling and reuse increase in the company, more governmental incentives would be available. On the other hand, purchasing first-hand (non-recycled) material might impose some pollution tax (Ecotax) on the company. These two factors may provoke the management's concerns about sustainability-related issues. As such concerns grow, the company's decision-makers might consider shifting to a more sustainable business model, and as a result, recycling and reuse capacity could expand. Besides that, there might be a higher market demand because of increased branding activities and the promotion of the green image of the company and its products.

$$SusBudg = a \times (1 + MCS) \times Financial\ Resources \quad (5)$$

$$Received\ Financial\ Recources = RRr \times Unit\ Financial\ Incentive \quad (6)$$

MCS: Management's Concerns for Sustainability

SusBudg: Budget for Sustainability

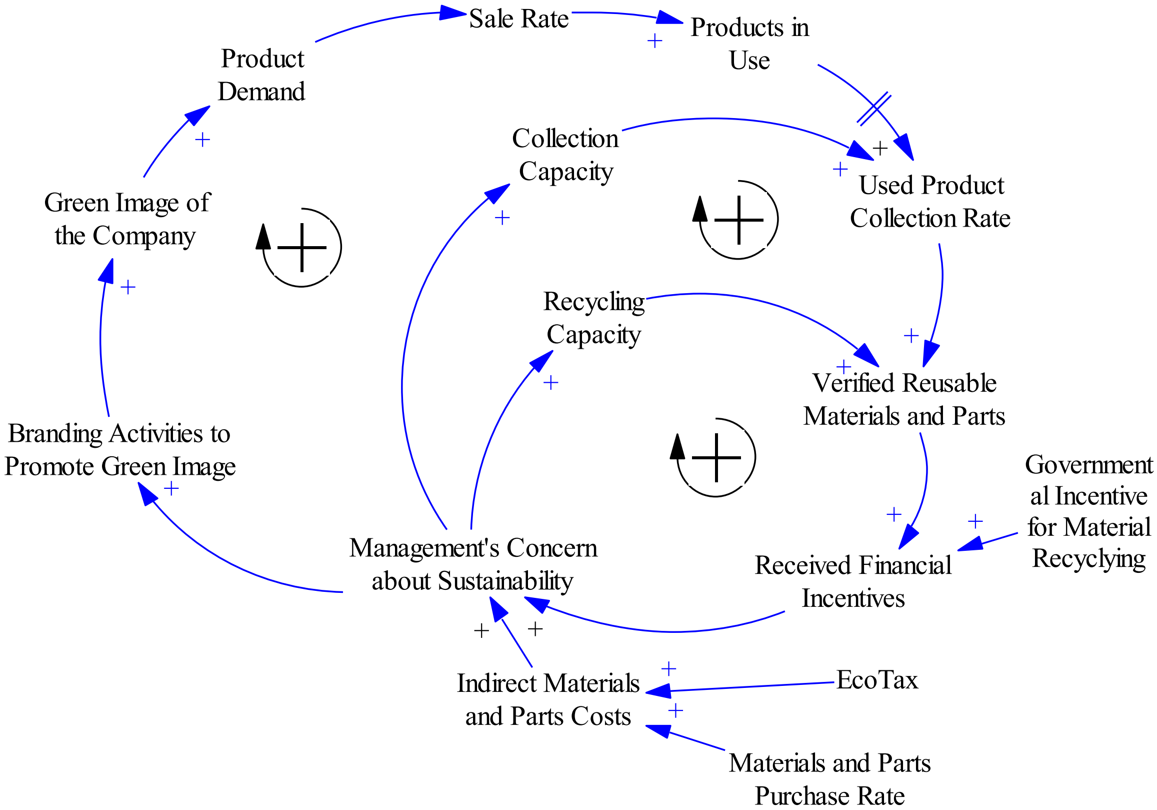

Figure 4. Economic Considerations of Recycling

Figure 5 illustrates the main financial considerations of recycling and reuse in the case. As the sale of products increases, the total revenues - including sales revenue and governmental incentives- grow higher. The total costs entail the cost of direct and indirect material and parts- the production cost and recycling and reuse costs. Costs and revenues affect a company's profit, and increasing profit increases the budget for developing recycling and reuse infrastructure and branding and advertising.

$$Financial\ Resources\ = Received\ Financial\ Incentives\ + Revenues\ from\ Sales - Total\ Costs$$
$$Total\ Costs = Production\ Cost + Collection\ Cost + Raw\ Material\ Supply\ Cost + Recycling\ Cost + Sustainable\ Business\ Model\ Development\ Cost \quad (7)$$

In System Dynamics terms, there is a reinforcing loop on the revenue side, which could be balanced by the balancing loop on the costs side. Also, in the previous CLDs, there is a reinforcing loop on the recycling and reuse infrastructure, which could be limited by the company's thresholds.

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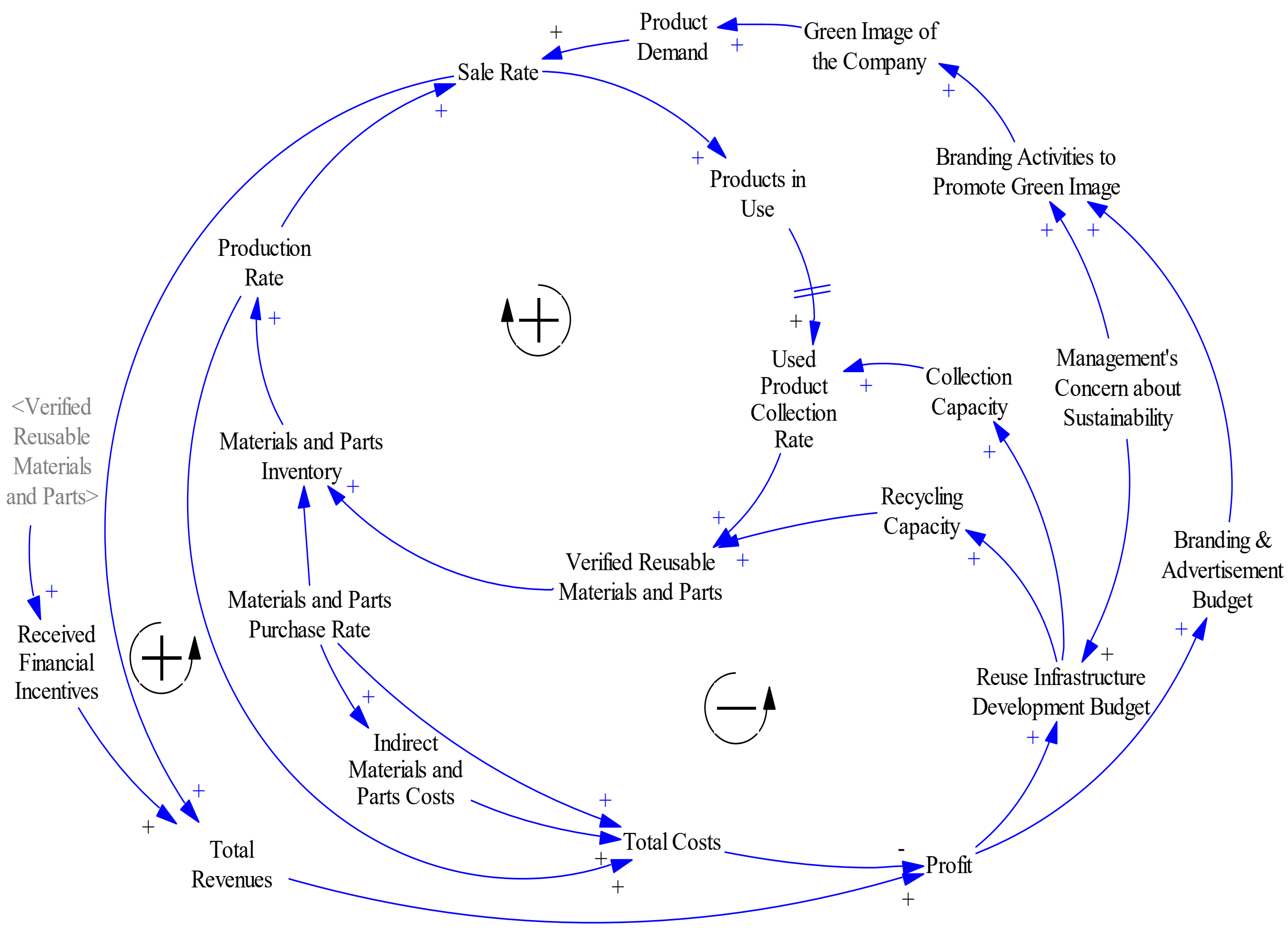

Figure 5. Financial Considerations

5. The simulation model

In this section, the mathematical model is illustrated and explained (Figure 6). Causal loop diagrams illustrate the feedback structure of systems, while stock and flow diagrams emphasize the underlying mathematical relationships in a system (Sterman, 2000).

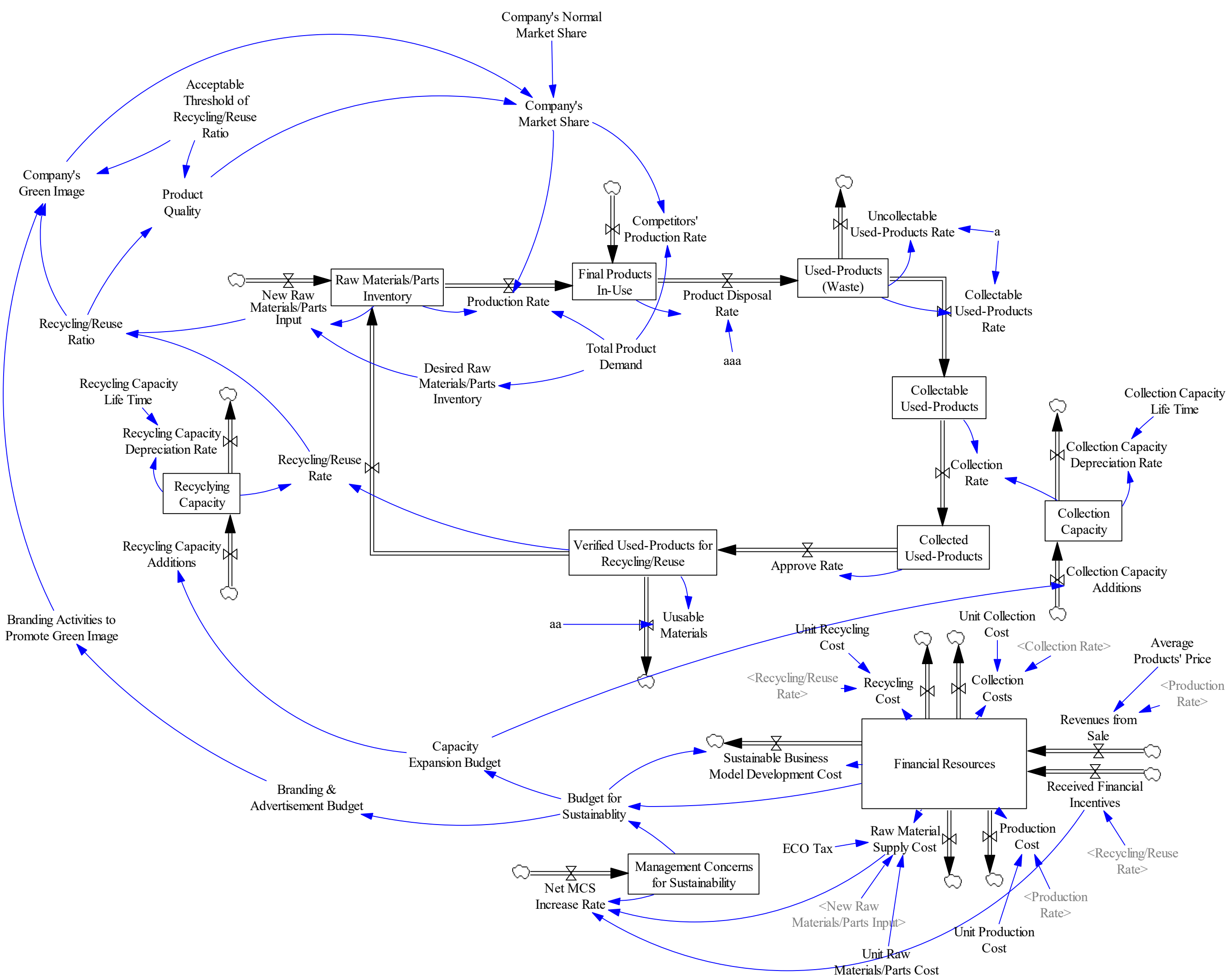

Figure 6. Stock and flow diagram

The innovations have caused many changes in the company's business model; therefore, the Stock-flow diagram looks different in several ways. First, the management concerns about sustainability create a budget line for maintaining a recycling and reuse capacity and branding activities that promote the company's green image. Second, recycling and reusing close the material flow and allow the waste to be used in the production process. Third, the company's financial resources are affected in many ways, the most important of which is the income mostly from savings of new material, the costs of collecting and processing used products, and the government incentives that help to make such a change economically feasible.

In this case, the management's concerns about sustainability triggered the change. The transformation into a more sustainable business model yields changes in different factory parts. In addition, different parts of the company must work in harmony. In the case under study, it all started with defining a budget line by which plastic collection, storage, and processing became possible. Making this change requires the investments to create, modify and coordinate supply chains and production lines; hence, it needs initial investments. In addition, to take advantage of the improved green image of the company in the future, some branding activities may start immediately that also need investment. From a financial point of view, transforming to a sustainable business model is a long-term investment. In other words, there is a delay between investing money in a sustainable business model and receiving its financial benefits in terms of lower material costs or an improved green image of the brand.

After customers have used the final products, they are collected by the factory's supply chain, which has gone through some modifications as part of the business model transformation. Our model calculates the collection rate based on the collectible used products and the collection capacity.

$$Collection\ Rate = \min(Collectable\ Used\ Products, Collection\ Capacity * 50000) \tag{8}$$

Final products of the factory that are in use by the end-users transform into used products with a product disposal rate. The product disposal rate is calculated based on the product lifetime.

$$Product\ Disposal\ Rate = \frac{Final\ Products\ In - Use}{Product\ Lifetime} \tag{9}$$

Only a part of the used-products stock is collectible, so the used products are stocked into collectible used products with a collectability rate. After that, only collectible used products are stocked in collected used products, following the collection rate. A portion of collected used products is verified with a verification rate maintained according to the company's quality considerations. After the parts are collected, they go through several preparation steps summarized in our model under the name of verification. The verified used products then go through the recycling/reuse process, the output of which is the raw materials/parts stocked in the inventory. Finally, the prepared used parts and materials are fed into the production line, closing the production loop. Another input to this inventory is, of course, first-hand materials/parts. Only after the recycled material or parts are used in the production process do the financial benefits emerge in the model. For some time, the benefits compensate for the initial investment of business model transformation; after that, the company could benefit financially from making its business model sustainable. There are some other forms of financial benefits in the model, for instance, government incentives and the benefits from the company's green image. These side benefits could come in different forms and, if managed correctly, could add to the financial rewards of the sustainable business model.

6. Simulation results

In this part, we discuss the differences between the original business model (base run) and the transformed sustainable business model (SBM Scenario). It is obvious in Figure 7 that the ratio of recycling and reuse grows to around 32 percent in the SBM scenario.

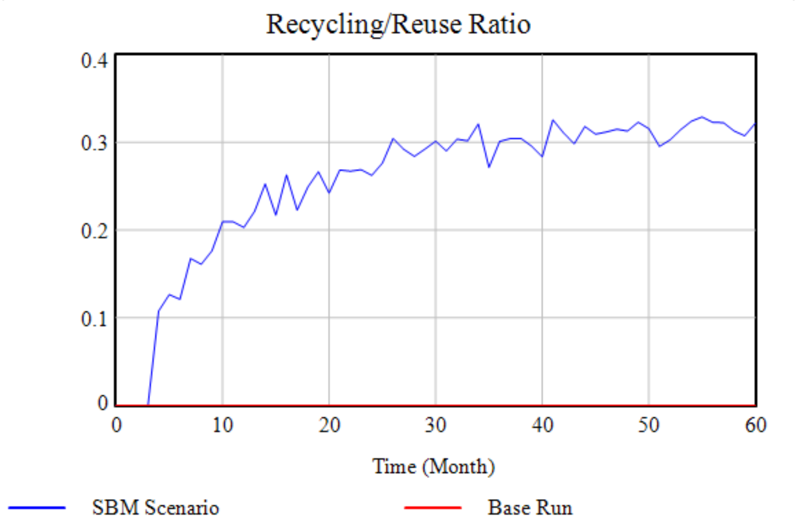

Figure 7. Recycling/Reuse ratio

In figure 8, although there has been a slight decline in the quality of products in the SBM scenario, the quality level of the products is maintained and controlled at a steady rate above 85 percent.

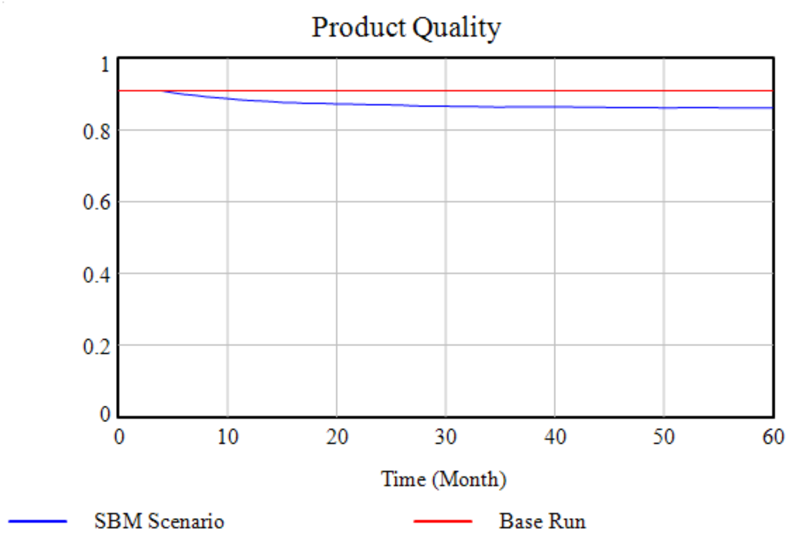

Figure 8. Product quality

In figure 9, it is obvious that the company's green image has increased as a result of business model transformation and branding activities and remains for a couple of years at a high level, giving the company enough time to improve the brand.

Figure 9. Company's green image

As in figure 10, the production rate increases after establishing the sustainable business model because, in the SBM scenario, the company enjoys an extended production capacity that can respond to the higher market demands caused by an improved brand in the light of the company's green image.

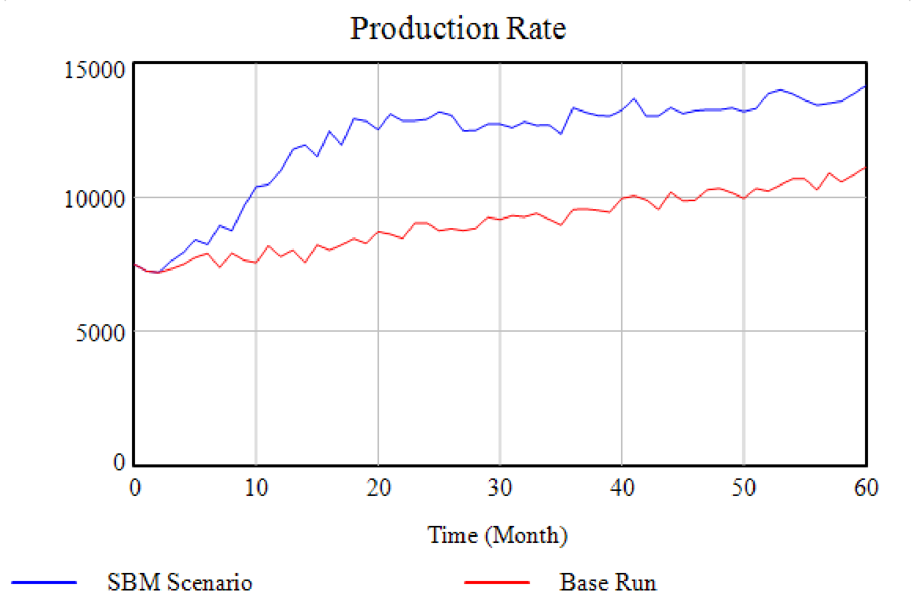

Figure 10. Production rate

The long-term nature of the investment in the transformation to a sustainable business model is evident in Figure 11. The financial resources decline in the process of creating collection capacity and establishing the recycling and reuse capacity in the production line. The money that is saved by using recycled material and used parts and the money earned by the higher demands caused by improved brand compensates for this decline, and eventually, there is a breakeven point at the 55th month; after that, the company financially benefits from transforming to a sustainable business model.

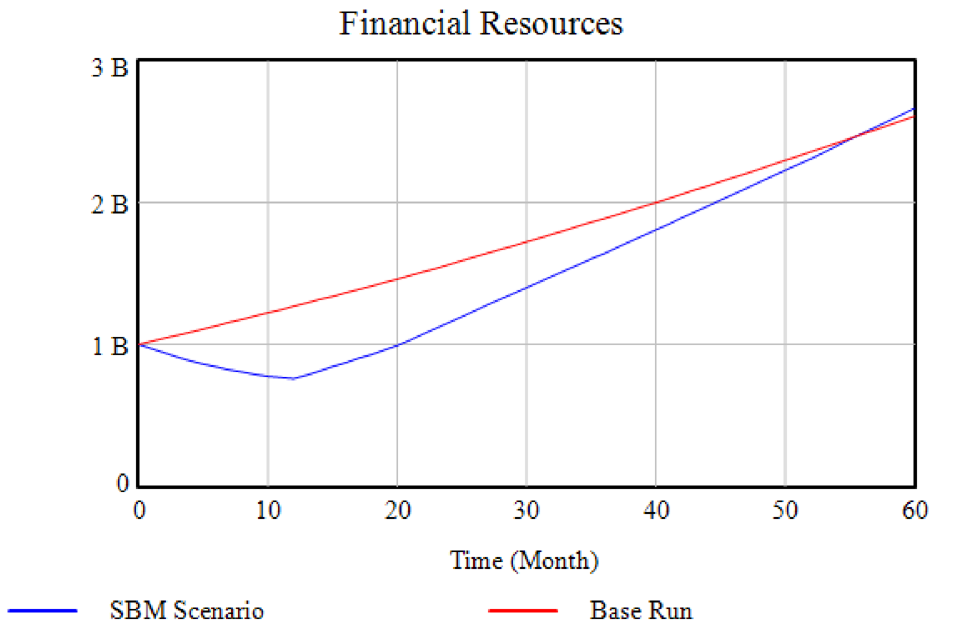

Figure 11. Financial resources

7. Discussion

This section of the article develops some discussions around the issues raised during the research and offers some policy recommendations that might be helpful at different levels.

First, as mentioned in the previous section, the decision to move towards a sustainable business model is a tough decision regarding the risks, the most important of which is the financial risk coming mostly from the initial investment needed to establish production lines and reorganize the factory. According to the simulation results based on the data from the case, the initial investment for establishing and the changes in the production line, together with other costs, are compensated in 55 months from the savings of material and parts. There are also other advantages in this plan, for instance, the improvement of the company's green image; however, the benefits of such advantages are not guaranteed and may take a long time. Most companies withdraw from ambitious plans of changing their business plan when facing the costs of

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transformation. It is very appropriate at this point for the government incentives to enter the game when companies are making their initial investments in changing their business model. By looking at the dynamic of the model in Figure 6, you will find out that everything depends on the financial resources of the plan, and if the government takes the lead in investing in the sustainable business model transformation, it could start the engine of this transformation, and then different parts of the system could run in their sequence. If the government pays for the initial investment in long-term loans, more companies might be interested in getting their shoes muddy in the transformation process.

Second, the company under study uses the parts and the used products from its customers and then maintains the whole recycling and reuse process in the manufacturing factory. The model has no supply chain between the recycling and reuse processes and the production processes. In other words, in the model, the recycling and reuse processes are integrated into the production processes. This is aberrant because gathering, preparation, and production of reusable parts and recycled raw material are generally done in separate supply chains in separate places and perhaps by separate vendors. The case under study is in Iran, where no reliable local recycling and reuse supply chain is available. Integrating recycling and reuse in the production processes in this company is a result of using the opportunity to access the customers' recyclable and reusable waste. This could be a good example for plastic manufacturers in countries where a reliable recycling supply chain is absent and for those with access to their customers' waste and used products. To persuade the customers to get involved in the plan, the manufacturer could offer incentives with a mutual benefit like renewal plans for the products. One policy recommendation that could be implied from this issue is to build an effective plastic recycling life cycle near cities and industrial areas. It is best to collect, refine, and reproduce the raw materials in separate factories because they have their supply chains, processes, and requirements. In some countries, each of these steps is handled by a separate factory that is specialized in one of these steps. In this way, the whole process would be more efficient, and the general quality of the output material would be expectedly higher.

Third, one of the key factors in our model is the quality of products. The quality of products is affected by many factors depending on the product's type and process. A simple way of expressing this issue is that by adding second-hand material to the input of the production system, the product quality declines. It is the job of the factory's quality management system to measure, control and manage the quality of the product. The quality management system also defines the product quality and finds out what factors affect the quality of the product by the product design, usage, and other factors and expectations. However, we should consider the quality issues in our model because the input material is key in maintaining the quality of the product. A concern of the quality management system is to find the correlation between the ratio of recycled material to raw material and the quality of the product.

Nevertheless, some important practical concerns here might complicate the relations between these factors. First, the quality of the input material is not the only factor that affects the product quality. There are always ways to increase the quality of the final product by maintaining those other factors without changing the input materials. These practical concerns are outside the scope of this research; however, to name a few, we should refer to maintaining the production process with the ratio of recycled material. Another inexpensive way to compensate for the quality decline is to add some chemicals to the recycled material. It is a long list that changes for each product and material type. We had to omit such concerns from our model to make it simple and universal.

Finally, the model put forward by this research is a simplified version of the real model; however, it is detailed enough to convey the complexity of business decision-making in the real world. We had to limit the level details on the proposed model to make it applicable to other cases of the same nature. Although the number of variables in the case might not be the same as in a real problem, there is at least one variable with the same characteristics as in a detailed version of any real problem of this kind.

8. Conclusion

In this paper, we used the System Dynamics Modelling approach as a decision tool for evaluating decisions regarding the changes made to a plastics manufacturing company's business model to make it more sustainable.

According to the literature study, there are several ways to transform the business model into a sustainable one. Of course, for every industry, some options work better. In the case under study, there was access to the customers' waste and used inventory; therefore, the manufacturing company integrated the recycling and reuse processes with production processes.

The modeling helps make a better understanding of the business model transformation, and with the help of simulation results, the company's decision-makers can have an outlook on the strategic factors that play a role in the decision-making process. In addition, we offered some recommendations that could help the business owners transform their business models.

We recommend that future research measure the environmental factors in the model. Factors like changes in the price of raw materials, changes in the public policies regarding the use of first-hand materials, and changes in the tax laws are not under focus in our model, and playing them could make a more accurate model.

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