Presenting The System Dynamic Model To Evaluate The Performance Of The Technology Supply Chain Based On The Balanced Scorecard

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Abstract
The balance scorecard represents the tool management strategy as a set of processable requirements. Of course, the use of supply chain management based on the balanced scorecard requires the acceptance of weaknesses of the balanced scorecard, such as the lack of a mechanism for inefficient detection, the absence of a scoring system, the lack of recognition of the delay between operations and its effect on performance. In order to overcome the weaknesses mentioned in this research of dynamic modeling, which is a tool to investigate and analyze the behavior of a system in the course of taking into account causal and apparent relationships and existing dynamics. In this research, based on the combination of balanced scorecard and dynamic modeling, an executive methodology is presented to provide the model and scenarios are implemented on a model of supply chain management.
Keywords: Supply chain management, balanced scorecard, system dynamic.

1. Introduction

In general, supply chain management emphasizes on increasing the adaptability and flexibility of companies and has the ability to react and respond quickly and effectively to market changes. The intensification of the global competition scene in an environment that is constantly changing doubles the necessity of appropriate reactions of organizations and manufacturing-industrial companies and emphasizes their flexibility with the uncertain external environment, and today's organizations in the national and global arena in order to gain A suitable position and maintaining it require the use of a suitable model such as supply chain management in order to realize competitive advantage and customer expectations. In today's organizations, customers are accompanied and synchronized with the members of the organization in the production of goods and service, the procedures for doing things and processes, the development of knowledge and competitive ability (zhang,2018). The lack of necessary coordination and flexibility in the competitive markets of the age of technology provides the grounds for backwardness and possibly bankruptcy of organizations. The analysis of existing conditions by organizational policy makers in order to obtain the required information plays a very important role in increasing awareness to achieve It fulfills the goals, therefore, organizations have felt the importance of stable and non-contradictory performance evaluation based on strategic goals and have used various evaluation systems over the years. (xia et al,2020).

Due to the globalization of business, it is necessary to review and monitor the performance of the organization's processes, the performance of their supply chain, and then adjust the strategic goals of the organization. On the other hand, research has shown that only 5% of the organization's workforce knows about strategies, 25% of managers are motivated to communicate with the organization's strategy, and 85% of executive teams spend less than an hour discussing the organization's strategies.

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Also, the relationship between the budget and the strategy of organizations is 60% (Burgess, 2019).

The balanced scorecard is a comprehensive framework that transforms the vision and strategy of a company into a coherent set of performance metrics and can direct all elements of the organization towards the vision of the organization and improve the performance of the organization by focusing on strategic management. examine in the present and future and solve the need for an efficient model in performance evaluation. By simulating the dynamic system, the limitations of the balanced score card model such as the lack of credit qualification, the lack of recognition of the delay between operations and their effects can be overcome. The performance resolved the inadequacy of strategic planning and quorum determination for each of the strategic goals. Because dynamic simulation provides a suitable platform for evaluating performance criteria and appropriate decision rules with these criteria, which enables the managers of the organization to test and test different scenarios. In this way, relying on dynamic modeling, the immediate behavior of the organization can be simulated with different scenarios of different strategic goals and select a better strategy for implementation. (Hosseinzadeh Lotfi et al,2014).

The difference between a dynamic system and a static approach is the possibility of studying complex systems by using feedback loops and using flow and resource variables. It effectively addresses the balanced realization of the goals and sustainable success of the organization, empirical evidence shows that the performance evaluation system and performance management play an important key role in the development of the strategic plan, strategic evaluation and achieving the goals of the organization.

The problem is how to connect the feedback system and the cause and effect loop and the flow and resources of dynamic modeling to the supply chain management strategy and create a dynamic model based on a balanced scorecard and then based on the dynamic model to simulate the organization's behavior Payment and based on the quantitative information obtained from the model, he achieved more efficient strategic decision-making and analysis. Due to the shortcomings of the balanced scorecard, such as the lack of time dimension and the cause-and-effect relationship between the indicators, the balanced scorecard has quickly become an effective system management and performance evaluation tool among organizations today (Burgess, 2019)

To overcome this lack, the idea of using the dynamic system technique is proposed to better understand the behavior of complex systems over time. The dynamic system model considers the internal feedback loops, the delay in different times that may affect the entire behavior of the system (Safdel et al., 2019).

2- literature review

Shen et al (2021) investigated the performance of Chinese companies in the field of tobacco. The tool they used was the dynamic system, and the results of their research showed that the performance of the supply chain in the existing scenarios depends on the variables of sustainable development in the industry. Zhang et al (2020) investigated the reliability of the supply chain performance and considering the agility of the supply chain, they examined the performance components of the supply chain based on modeling. The results of their research showed that partnership with suppliers and suppliers and the integration of the chain lead to Performance is improved. Kumar and Barua (2021) examined the performance of the supply chain in the oil and petrochemical industry in India. Using multi-criteria decision-making methods, they identified and ranked the factors of the supply chain. The results of their research showed that the petrochemical industry, due to its close relationship with the environment Biology and environmental pollution can focus on industry 4 parameters to improve the performance of the supply chain and improve the performance of the supply chain with technological transformation. Sahu and Datta (2017) Using fuzzy logic, they presented a model to evaluate supply chain performance. They presented a structure based on uncertainty in the underlying factors. The results of their research showed that inconsistencies created due to interference in information can affect performance.

Methodology:

The scope of study in the current research includes a sugarcane cultivation and industry company as a part of the supply chain in which the balanced scorecard is implemented and the information related to the strategic plan and prospects of the balanced scorecard of that company is used as a model. Due to the fact that statistical analysis was not used in this research, sampling is not done. To evaluate the dynamic model, common validation methods of dynamic models are used. In order to collect information, first by reviewing the existing literature in this field, which has been reviewed in scientific books and articles, as well as similar theses, study gaps are identified and Various measures will be provided for them. After that, real or randomly generated data should be used to check the performance of the model built in the research. The research method is practical in terms of purpose and descriptive in terms of method. In this research, the goal of the dynamic modeling of the balanced scorecard is therefore the information of the balanced scorecard of a parts manufacturing company has been used as a basis for dynamic modeling.

3- Data Analysis:

In this section, balanced scorecard modeling processes are carried out. In this model, a small part of the details of the company is shown, so we have created the model based on assumptions, with these assumptions the very complex reality is simplified, the significant assumptions are given below:

- The company offers one type of product
- Production and distribution of the product to the customer happens over a period of time

- All employees are equally trained.
- The time horizon is 5 years.

4- Dynamic assumptions

Paying attention to the strategic map obtained from the balanced scorecard and its essence creates a dynamic hypothesis. This hypothesis can be expressed as follows:
This company intends to convert potential customers into actual customers by advertising and marketing, which on the other hand increases the productivity of employees and reduces the delivery time, which leads to an increase in customers and then leads to the loyalty of current customers and It becomes a potential customer and the company's income increases with the increase in the number of customers. This company tries to increase the productivity of the organization with strategies such as training employees, firing ineffective employees. Also, increase your income by investing in research and development.
Customer variable: A resource variable, the level of this resource expresses the number of customers at any moment of time.

Variable potential customers: is a covariate indicating the number of potential customers. Acquired customer's variable (new customer):is a flow variable that shows the number of customers acquired per unit of time, the flow variable of acquired customers increases the level of the customer resource. The variable of lost customers: A flow variable specifies the number of customers lost per unit of time, the flow reduces the level of customer source, the customer loyalty covariate affects the flow variable of lost customers. Customer variable resulting from the offer: is an auxiliary variable, which shows the number of new customers acquired through customer recommendations per unit of time. The increase of this auxiliary variable will increase the flow of acquired customers.

Current customer offers variable:is a covariate, indicating that each actual customer recommends the product to several potential customers, the increase of this covariate will increase the covariate of acquiring new customers through customer recommendations. Variable of customer loyalty: It is an auxiliary variable that shows the persistence of current customers, a decrease in this variable will increase the flow of lost customers and an increase in this variable will increase the auxiliary variable of customer recommendation.

Acceptance percentage variable: It is a covariate that shows the number of new customers who recommend current customers per time unit. increasing this variable will increase the auxiliary variable of acquiring new customers through customer recommendations. Total market customers: is a covariate indicating the total number of current customers in the market.

Acquiring customers from advertising:is a covariate that shows the number of customers attracted through marketing per unit of time. The increase of this variable will increase the flow of customers obtained. Advertising budget:is a covariate that shows the amount of budget allocated to advertising per unit of time. Advertising effect percentage: is a covariate that expresses the percentage of potential customers who respond positively to advertisements per unit of time.

Relationships and dynamic equations between elements

In this part, we determine the relationship between the source and flow and auxiliary variables.
Variable dynamics of organizational knowledge source

$$\frac{dskills(t)}{dt} = skills\ learned(t) - skills\ Lost(t) \quad (1)$$

$$skills = skill\ Learned - Skill\ Lost \quad (2)$$

The initial value for organizational knowledge is considered to be 10000. The variable of organizational skill flow is modeled by covariates of training efficiency with the variable of employee resource and the covariate of the number of training per time unit.

$$Skill\ Learned = Training\ Efficiency * Staff * Number\ Of\ Training \quad (3)$$

Training efficiency is modeled by R&D activities

$$Training\ Efficiency = 10\% * (R\&D\ Activity) \quad (4)$$

The skill loss flow variable is modeled by the loss rate covariate (percentage of skill loss per month) and the skill resource variable.

$$Skill\ \ Lost = Skills * Lost\ Rate \quad (5)$$

A loss rate of .03% is assumed.
The dynamics of changing the state of employees

$$\frac{\mathrm{dStaff(t)}}{\mathrm{dt}} = \mathrm{Recruits(t)\text{-}Resignation(t)} \quad (6)$$

$$Staff = Recruits - Resignation \quad (7)$$

The employment flow variable is modeled by the auxiliary variable of employment rate (percentage of employees per month) and the number of employees.

$$\mathrm{Recruits = Staff * Rate\ Of\ Recruits} \quad (8)$$

The withdrawal flow variable is modeled by the co-variable withdrawal rate (the percentage of employee withdrawals per month) and the number of employees.

$$\mathrm{Resignation = Staff * Rate\ Of\ Resignation} \quad (9)$$

Variable dynamics of the work-in-progress resource

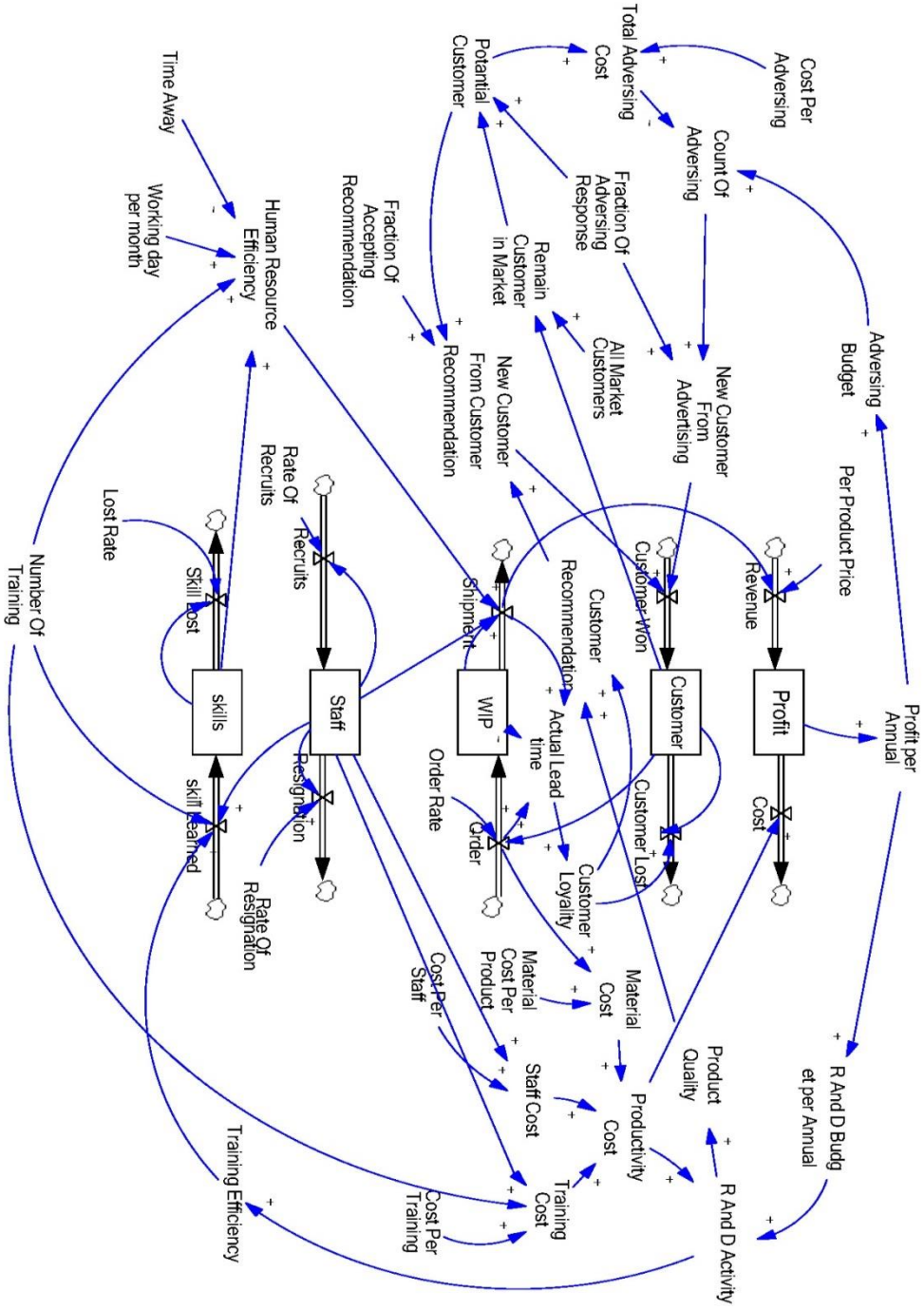

Figure 1: The overall dynamic balanced scorecard model

$$\frac{dWIP}{dt} = Order(t) - Shipment(t) \qquad (10)$$

$$WIP = Order - Shipment \qquad (11)$$

The initial value for the task variable in the build flow is set to 1000.

The order flow variable is modeled by the covariate number of orders per customer and the source variable of customers.

$$Orders = Order\ Rate * Customer \qquad (12)$$

The transmission flow variable is modeled by the minimum function between the work resource variable in progress and the displacement capacity resulting from the auxiliary variable of real productivity and the employee resource

variable.

Shipment

$$= \text{Min}\left(\begin{matrix}\text{WIP},\\ \text{Human Resource Efficiency} * \text{Staff}\end{matrix}\right) \quad (13)$$

The productivity of human resources is modeled by the time lost per unit of time, the number of trainings and the number of working days

$$\text{Human Resource Efficiency} = \left(1 - \left(\text{Time Away} * \frac{\text{Number Of Training}}{\text{Workingday per month}}\right)\right) * \text{skills} \quad (14)$$

In this research, the figures are considered as follows:

Time away=.5

Number Training=1

Working day per month=24

Variable dynamics of customer resource

$$\frac{\text{dCustomer(t)}}{\text{dt}} = \text{Customer Won(t)-Customer Lost(t)} \quad (15)$$

$$\text{Customer} = \text{Customer Won-Customer Lost} \quad (16)$$

The initial value for this resource variable is assumed to be 2000.Variable flow of new customers acquired

$$\text{Customer Won} = \text{New Customer From Customer Recommendation} + \text{New Customer From Advertising} \quad (17)$$

The variable of customers acquired by the recommendation of customers is modeled with the source variable of current customers and the covariate of the percentage of new customers who have accepted the recommendation of previous customers.

$$\begin{aligned}&\textit{New Customer From}\\ &\textit{Customer Recommendation}\\ &= \textit{IF THEN ELSE}(\textit{Customer Recommendation}\\ &> 0, \textit{Fraction Of Accepting Recommendation}\\ &* \textit{Potantial Customer}, 0) \end{aligned} \quad (18)$$

$$\text{Customer Recommendation} = \text{Customer Loyality} + \text{Product Quality} \quad (19)$$

The customer loyalty variable is modeled by half the lead time

$$\text{Customer Loyality} = -\frac{\text{Actual Lead time}}{2} \quad (20)$$

The supply time variable is modeled by the sum of the orders and the card in progress plus the shipment amount

$$\text{Actual Lead Time} = \frac{\text{Order+WIP}}{\text{Shipment+1}} \quad (21)$$

$$\text{new Customer From Advise} = \text{Count Of Adversing} * \text{Fraction Of Adversing Response} \quad (22)$$

The potential customer variable is modeled by the product of advertising response to the remaining customers in the market.

$$\text{Potantial Customer} = \left(\text{Fraction Of Adversing Response} * \text{Remain Customer in Market}\right) \quad (23)$$

$$\textit{Total Adversing Cost} = \textit{Adversing Cost Per Potantial} * \textit{Total Customer} \quad (24)$$

Lost customer is modeled as a zero and one variable based on customer loyalty

$$\begin{aligned}&\textit{Costomer Lost}\\ &= \textit{IF THEN ELSE}\ (\textit{Customer Loyality}\\ &< 0, -0.1 * \textit{Customer}\\ &* \textit{Customer Loyality}, 0) \end{aligned} \quad (25)$$

Profit variable dynamics

$$\frac{dProfit(t)}{dt} = Revenue(t) - Cost(t) \quad (26)$$

$$Profit = Revenue - Cost \quad (27)$$

Income flow covariate

The income variable is obtained by multiplying the amount of the product sent by the product price

$$evenue = Shipment * price\ Per\ Product \quad (28)$$

$$Cost = Productivity\ Cost \quad (29)$$

Production cost covariate

$$\textit{Productivity Cost} = \textit{Material Cost} + \textit{Staff Cost} + \textit{Training Cost} \quad (30)$$

raw material cost covariate

$$Material\ Cost = Material\ Cost\ Per\ Product * Order \quad (31)$$

Auxiliary variable of personnel costs

$$taff\ Cost = Cost\ Per\ Staff * Staff \quad (32)$$

Education cost auxiliary variable

$$\text{Training Cost} = \text{Cost Per Training} * \text{number Of training Per Month} * \text{Staff} \quad (33)$$

Auxiliary variable of research and development activities

This variable is modeled by the square root of annual R&D budget over production cost

$$R\&D\ Activity = SQRT\left(\frac{R\ And\ D\ Budget\ perAnnual}{Productivity\ Cost}\right) \quad (34)$$

auxiliary variable of research and development activity budget

The value of this variable always fluctuates between zero and 60% of the annual profit

$$R\&D\ Budget\ per\ Annual = max(0, Profit\ per\ Annual * 0.6) \quad (35)$$

Annual profit based on source of profit

The value of this variable is modeled based on the profit earned in the 12th month of each period

$$Profit\ per\ Annual = SMOOTHi(Profit, 12, 6e+008) \quad (36)$$

Run the model created with Vensim software

According to the equations and relationships mentioned in the previous part, with the help of Vensim software, we implemented and simulated the behavior of the system based on the developed dynamic balanced scorecard (financial, customer, research and development activities, internal processes, personnel, etc.), and in a 5-year horizon (60 months) based on the current state of the company as shown in Figure (2).

Validation of the model

In this part, the validation of the presented model is discussed. Limit policy test: To implement the limit policy test, the order rate is increased to 9 units of the product for each customer, it can be seen that the change in the model works in a completely logical way and affects all the influential items such as: annual profit, next year's advertising budget and Work in the process of construction.

Explore different strategies

According to the verification of the model in the previous part, various strategies are investigated to increase the number of customers and consequently increase the company's profit: The first strategy: increasing the price of the product to to 800,000 monetary units: At first glance, it may seem that this will lead to fewer customers, but considering that 60% of the profit code is directed to product improvement programs, it can be said that the customer is willing to pay an additional price for better product quality. will be, figure 5 price increase strategy and its effect on income and figure 6 price increase strategy and its effect on customer increase and figure 7 price increase strategy and its effect on R&D budget increase are given. The second strategy: increasing the price of the product to 500,000 and reducing the costs of raw materials.

Finally, by choosing the second strategy, you can be sure that the goal of a balanced scorecard, which is to attract more customers and increase revenue, will be provided. An example of this strategy can be seen in the smart phone market at the time of compiling this research. It is obvious that each of the indicators key performance indicators are a subset of one of the strategic goals of the balanced scorecard strategy map. Therefore, by selecting or excluding any group of indicators based on the environmental and surrounding conditions, the organization moves towards appropriate strategies.

5- Research results

As seen, the impact of each of the indicators, strategic goals and views on the organization's supply chain management performance can be analyzed and measured by Dynamic Model diagrams. After presenting the balanced scorecard by Kaplan and Norton in 1992, a lot of researches were done to develop and use it. The balanced scorecard model with a comprehensive and all-round look towards the supply chain management strategies of the organization tries to balance them, even though the balanced scorecard has many weaknesses, in this research it has been tried to use simulation based on dynamic relationships should in this research it has been tried to use simulation based on Dynamic relationships should cover part of its weaknesses. Simulation based on balanced scorecard can be used by managers as an effective tool to evaluate various supply chain management strategies of the organization and compensate for its weaknesses. If the modeling is carried out carefully and the validity of the model is verified, this approach can be used to determine the quorum of the target indicators in a certain period of time and also as a tool to investigate and identify ineffective supply chain management strategies.

Among the problems of using this method is the correct and complete selection of the model relationships due to the existing complexity of the relationships between the variables caused by the complexity of the real world. To ensure the strategic goals of the company's supply chain,

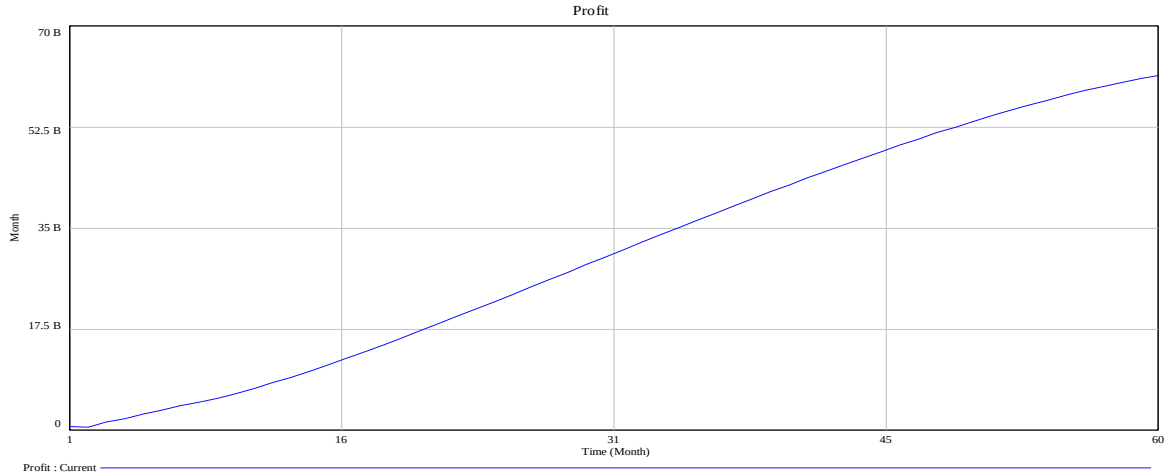

Figure 2: profit flow

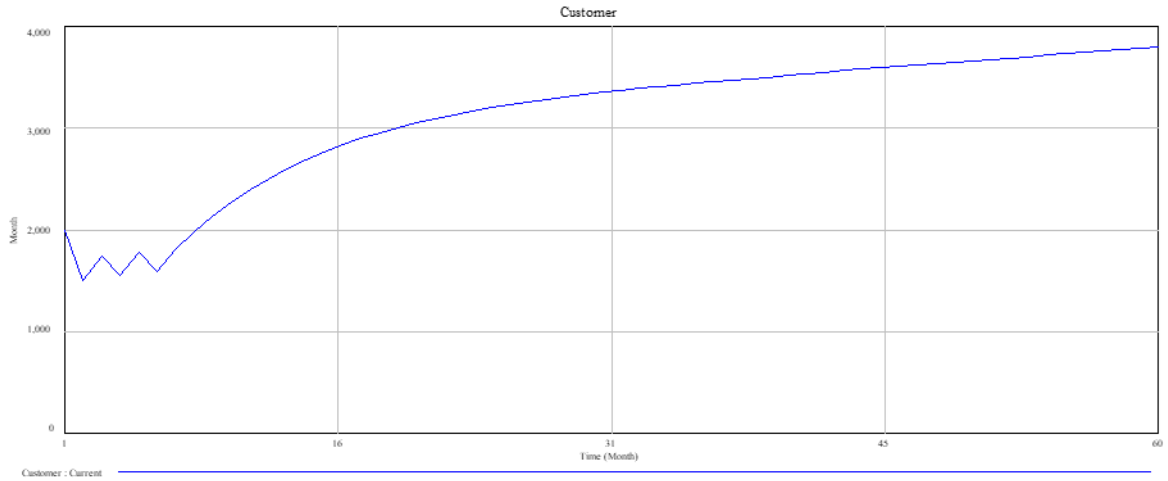

Figure 3: Customer Flow

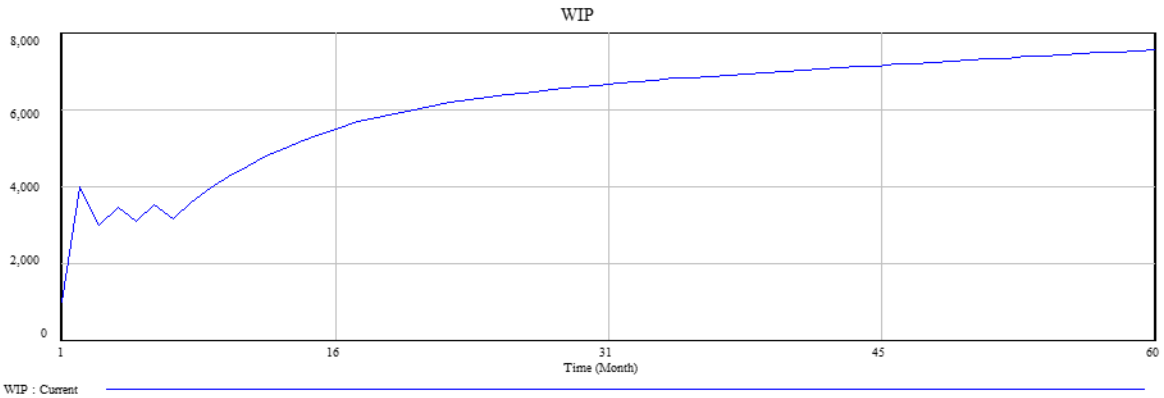

Figure 4: Work in Process Flow

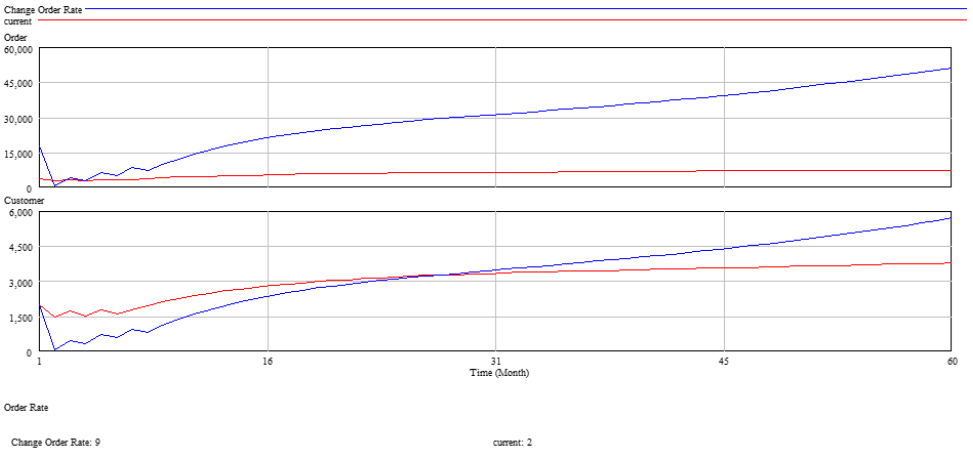

Figure 5: The effect of changing the order rate on the customer and the order

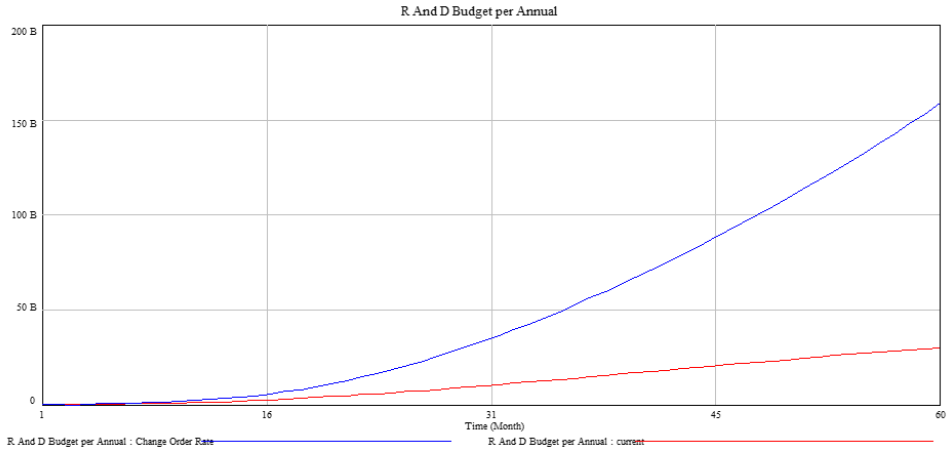

Figure 6: Effect of order rate on research and development budget

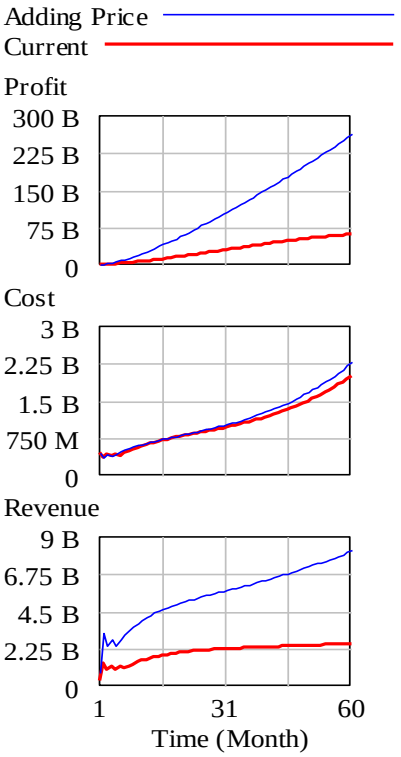

Figure 7: Price increase strategy and its effect on income

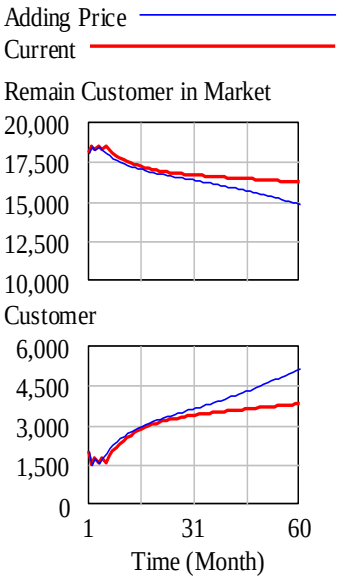

Figure 8: Price increase strategy and its effect on customer increase

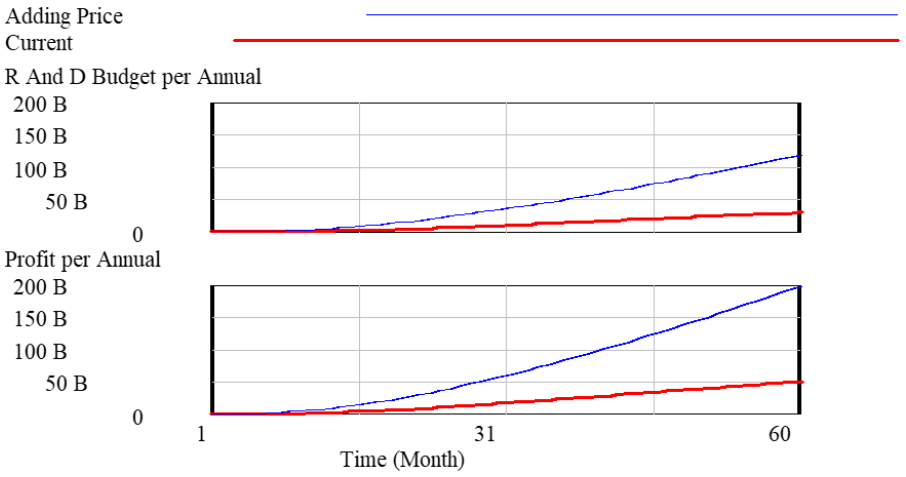

Figure 9: The price increase strategy and its effect on increasing the research and development budget

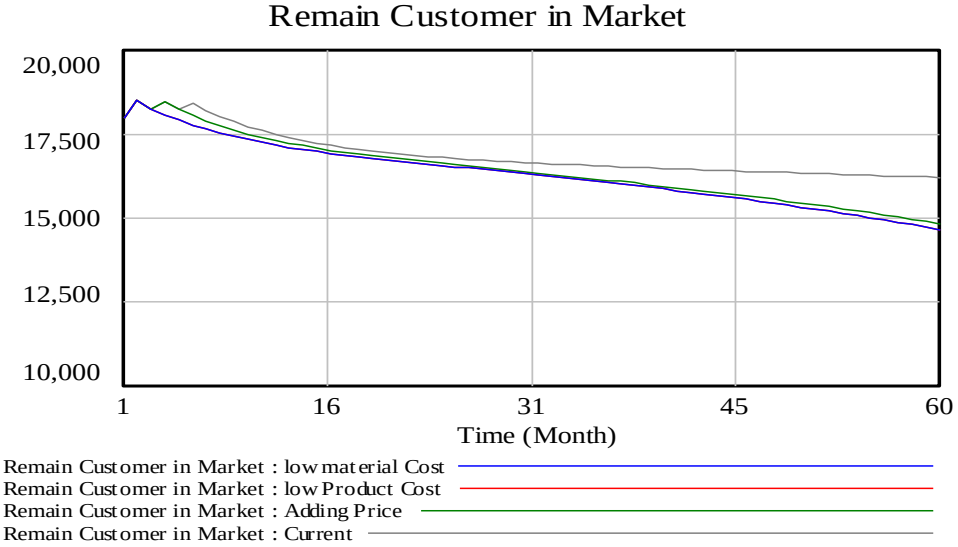

Figure 10: The strategy of increasing the price and reducing the cost of materials and its effect on attracting new customers

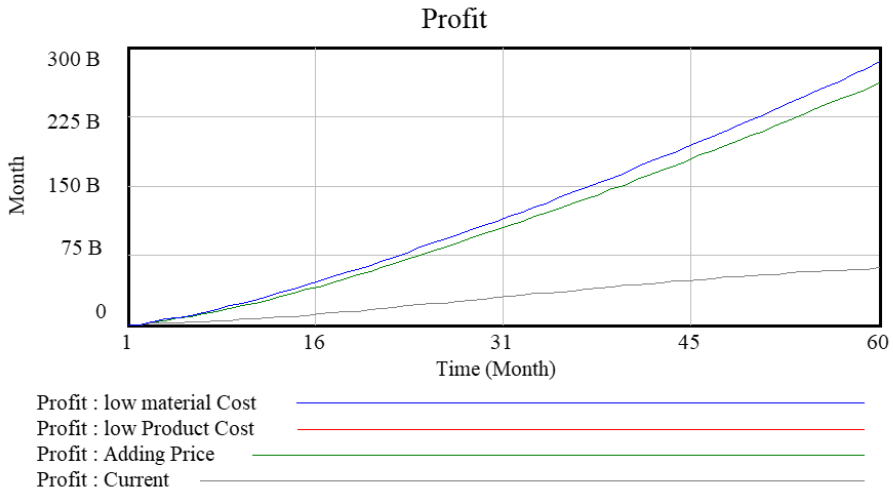

Figure 9: The strategy of increasing the price and reducing the cost of materials and its effect on the company's profit

cover part of its weaknesses. Simulation based on balanced scorecard can be used by managers as an effective tool to evaluate various supply chain management strategies of the organization and compensate for its weaknesses. If the modeling is carried out carefully and the validity of the model is verified, this approach can be used to determine the quorum of the target indicators in a certain period of time and also as a tool to investigate and identify ineffective supply chain management strategies. Among the problems of using this method is the correct and complete selection of the model relationships due to the existing complexity of the relationships between the variables caused by the complexity of the real world. To ensure the strategic goals of the company's supply chain, which is attracting more customers and increasing revenue, is necessary to the increase in price to reduce the cost of raw materials, to increase the quality of the product based on research and development activities in such a way that with higher product technology and higher quality. The price of the product can be justified for the customer. An example of this strategy is in the time of compiling this research that can be seen in the smart phone market. It is obvious that each key performance indicator is a subset of one of the strategic goals of the balanced scorecard strategy map resulting from the supply chain management. So, by selecting or excluding each category of indicators based on the environmental conditions, the organization moves towards appropriate strategies.

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