

Article

A System Dynamics Model for Analyzing Customer Satisfaction Drivers in a Manufacturing Context

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Abstract

Customer satisfaction offers economic benefits and competitive advantage to manufacturing enterprises. However, a gap exists in understanding how to achieve customer satisfaction due to the complexities involved in coordinating various subsystems of an enterprise in an efficient manner. In this paper, we identified four internal and external-to-the-firm customer satisfaction drivers which include: government policies, supply chain reliability, knowledge management, and manufacturing performance criteria such as on-time delivery, quality and cost. We then developed a conceptual framework to define the non-linear mathematical relationships between drivers using system dynamics modeling. We conducted “what-if” scenario analyses for a base case, optimistic case and pessimistic case using three intervention policies: “investing resources in knowledge management”, “inclusion of a safety stock”, and “decreasing cost of inventory” to study the impact of these policies on customer satisfaction. This work contributes to customer satisfaction research by presenting a decision-support tool that will enable the leadership of manufacturing enterprises to create a simplistic mental model of the complex interactions of an enterprise using easy-to-use mathematical relationships to capture system dynamics over time.

Keywords: customer satisfaction; supply chain reliability; product development; knowledge management; system dynamics modeling

1. Introduction

Customer satisfaction has long been recognized as a fundamental factor in achieving organizational competitiveness [1], playing a key role in ensuring long-term profitability [2] and in the survival of organizations [3]. The existing literature identifies several primary factors that significantly influence customer satisfaction. Key factors are product quality [4], product price [5], and on-time delivery [6], which contribute to meeting customer needs. However, in today’s complex and dynamic market environment, these factors alone may not be sufficient [7]. In this study, we expand on this view by identifying other critical factors and categorizing them into internal and external dimensions. Internal factors refer to those within a firm’s control, whereas external factors are beyond a firm’s control.

One key internal factor explored in this study is knowledge management (KM) [8,9]. KM enables firms to effectively generate, customize, and apply appropriate knowledge to improve products, services, and internal processes [10], and it can be further divided into two components: knowledge transfer (KT) and knowledge development (KD). While KT is a measure of the information flow across various functional units of the firm, KD refers to the extent to which a firm is committed to problem-solving activities such as



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testing, simulation, and prototyping, aimed at improving product quality [9]. Regarding the external factors, two focus areas are considered: supply chain reliability (SCR) and government regulations. From a manufacturing enterprise standpoint, SCR has major impacts on product price, quality, and delivery performance [11] while government regulations, such as tariffs and import control mechanisms, have significant influence on onshoring and offshoring decisions within the firm's supply chain framework [12].

Previous studies on the analysis of customer satisfaction factors have often focused on a narrow set of variables, with many of them either analyzing single factors or examining one or two broad factors in isolation. Some such studies include the works of [13,14]. Ref. [13] utilized system dynamics (SD) modeling to build a cause-and-effect simulation model that captures the feedback relationships across customer satisfaction, delivery time, and profitability. Ref. [14] implemented structural equation modeling to analyze the impact of factors that influence customer satisfaction with focus on perceived quality and perceived value, based on information from the Chinese Customer Satisfaction Index (CCSI). While the insights from past works make an important contribution to the customer satisfaction literature, they are limited in the extent to which they adequately capture the realities of customer satisfaction in today's market. For instance, the impact of upstream knowledge management decisions on a firm's long-term brand and image is one intrinsic aspect of the customer satisfaction problem that has not been fully explored. Furthermore, the complexities of the interactions between internal and external factors, such as the impact of government tariffs on downstream supply chain coordination for early product delivery, among others, also need to be addressed. The nature of the issue at hand points to the need for an approach to investigate customer satisfaction factors holistically, since each of the factors identified has some complex underlying interactions with one another. The factors considered in this study were selected because they have been consistently identified in the literature as key determinants of customer satisfaction. However, existing studies typically examine these factors individually or in limited combinations rather than as an integrated system. Therefore, this study brings these established factors together within a unified system dynamics framework to capture their interactions and feedback relationships. In this research, we contribute to the customer satisfaction literature by developing a framework for understanding and analyzing the complexities associated with the factors that influence customer satisfaction from an internal and external standpoint, and we seek to answer the following research questions:

1. What internal and external factors of a manufacturing enterprise have the greatest impact on customer satisfaction?
2. Under optimistic and pessimistic external conditions, which internal variables most positively influence customer satisfaction?
3. How can intervention strategies involving internal variables of a manufacturing enterprise be used to improve customer satisfaction?

We propose an SD modeling approach to this problem as it has the capabilities to handle complex interactions and to predict complex systems with dynamic interactions over time. SD modeling offers a simplified yet powerful way to represent the complex cause-and-effect relationships within an enterprise through intuitive mathematical equations that simulate how variables evolve over time. In this study, SD was selected because the objective was not to analyze individual factors in isolation, but to examine customer satisfaction as a dynamic system. The proposed framework integrates four interrelated dimensions (government policy, supply chain reliability, knowledge management, and manufacturing firm performance) and captures how changes in one dimension influence the other dimensions through feedback relationships before ultimately affecting customer satisfaction. Unlike traditional methods such as static regression or survey-based analyses

that capture only linear or momentary relationships, SD modeling can account for feedback loops, time delays, and non-linear interactions, providing a deeper understanding of how various system drivers change dynamically within the system.

2. Literature Review

2.1. Customer Satisfaction: Concept and Evolution

Customer satisfaction has long been recognized as one of the most important indicators of organizational performance and an important factor for competitive advantage. Initial research by [15] showed that customer expectations influence satisfaction, laying the foundation for subsequent investigations. This work was further developed through the expectation–disconfirmation paradigm [16,17], which explains satisfaction as the outcome of the comparison between expected and perceived performance. Later studies expanded this perspective by incorporating multiple determinants, including product performance, service quality, equity, and customer expectations [18–21]. By the 1990s, customer satisfaction had evolved into a strategic performance construct, exemplified by the American Customer Satisfaction Index (ACSI), which enabled organizations to systematically evaluate customer satisfaction across industries [22]. Customer satisfaction is shaped not only by operational performance and service quality, but also by users' perception of trust, fairness, and procedural justice in technology-driven systems [23,24].

2.2. Factors Influencing Customer Satisfaction

Customer satisfaction is influenced by a wide range of internal and external factors. Recent studies have examined these factors from different perspectives. The following sections summarize the main factors reported in the literature.

2.2.1. Product- and Customer-Related Factors

According to [5], the price of a product and consumer buying habits are two factors that have impact on customer satisfaction, especially in competitive sectors like telecom. However, ref. [7] emphasized that demographic factors such as age and income, along with loyalty program participation, also predict satisfaction levels. From an e-commerce perspective, ref. [25] revealed that return policy leniency affects both satisfaction and return behavior. Perceived price, customer service, and sustainable brand image are three other factors that are shown in [26] work as central to building trust through satisfaction. Perceived quality is another crucial factor that enhances perceived value and satisfaction [14], especially in the context of fresh-product retail. Some factors, such as privacy worries, data security risks, and reduced human interaction can lower satisfaction while positive outcomes like reduced waiting and smooth transactions strengthen satisfaction [27].

2.2.2. Supply Chain Factors

A different view proposes vertical integration where a firm controls multiple stages of its supply chain, thereby connecting finance, marketing, and customer experience to achieve greater customer satisfaction [28]. Supply chain process [11] has a significant impact on new product development which consequently affects the quality, delivery time, and price of end products. With regard to supply chain processes, ref. [11] emphasized that customer satisfaction is not only shaped by the product but also by supply chain performances. Ref. [29] focused on Internet of Things and its impact on supply chain, thereby indicating that supply chain reliability can be affected by multiple factors. Ref. [11] showed that various dimensions of SCR positively impact satisfaction, although certain configurations yield trade-offs between financial performance and customer satisfaction.

2.2.3. Government and Environmental Factors

Government regulations [12,30] have significant impacts on new product development, which consequently affects quality, delivery time, and price of end products. With regard to government regulations, ref. [31] focused on various regulations and among those considered, product price subsidies were the most effective way to encourage higher green degrees in products, thus indicating that a balance of regulatory support and consumer-driven demand is key to improving manufacturers' competitiveness, profitability, and customer satisfaction. Ref. [32] noted that effective regulations can steer firms toward greener innovation, but policy makers must carefully balance environmental goals with firm profitability incentives. Ref. [33] examined how government regulations influence supply chain strategies and demonstrated that policies such as taxes and subsidies can effectively shape market behavior by encouraging manufacturers. During the COVID-19 pandemic, ref. [34] investigated how service quality affects satisfaction with government policy and they concluded that during the crisis, government policies play a vital role in shaping consumer satisfaction by enhancing or undermining service delivery elements.

2.2.4. Knowledge Management Factors

Knowledge management (KM) also plays a critical role in shaping customer satisfaction by guiding how information is generated, shared, and applied throughout the organizational processes. Previous studies have demonstrated that effective KM practices improve service quality, customer relationships, and ultimately customer satisfaction. For example, ref. [35] showed that integrating KM practices into service encounters enhances customers' satisfaction evaluations, while [36] found that KM positively influences customer satisfaction through customer relationship management and organizational capabilities. To begin, in the context of new product development (NPD), recent bibliometric analysis of over 28,000 KM publications by [37] emphasized the significant role of KM practices in shaping outcomes of project, especially in NPD initiatives. Ref. [38] also found that KM is a core enabler for executing efficient and innovative strategies and that the integration of KM within product lifecycle management allows firms to address complex decision-making. Ref. [35] emphasized that tacit knowledge rather than explicit knowledge plays a better role in enhancing satisfaction during service encounters, and their findings highlight the importance of integrating KM practices with customer relationship strategies to improve perceived fairness, control, and overall service evaluations. Although knowledge management encompasses several dimensions, this study adopts knowledge development (KD) and knowledge transfer (KT) as its operational representation of KM based on [9]. They believed that by investing in KM, the level of product development and product process performance increased. Ref. [10] worked on the importance of combining internal and external knowledge through collaborative networks to achieve competitive advantage in dynamic environments.

2.3. System Dynamics Modeling in Customer Satisfaction

SD is an approach for simulating complex models over time and within the context of customer satisfaction in manufacturing settings. It can serve as a powerful lens for analyzing the interconnected components of product design, use, and end-of-life management as demonstrated by [39]. In addition, ref. [13] used SD models in an omnichannel retailing model to show optimum time, profitability, and customer satisfaction. Ref. [40] also highlighted how SD modeling supports more robust planning in high-uncertainty environments by developing an SD model to simulate and evaluate launch strategies based on evolving market feedback. Ref. [41] also utilized SD modeling to analyze customer satisfaction trends, using cost and time as the main drivers of customer satisfaction.

SD modeling is capable of providing a valuable framework for modeling complex interactions between components of a system, delays, feedback, and nonlinear relationships. These capabilities make SD modeling a very useful methodology in analyzing the dynamics associated with customer satisfaction.

2.4. Research Gap/Need for This Research

Our review of the literature suggests that customer satisfaction is essential for product launch success, and it is dependent on various factors which dynamically shape the customers' satisfaction [1]. Many researchers have investigated customer satisfaction from different perspectives, and numerous drivers of customer satisfaction have been identified in manufacturing enterprises. Existing studies have examined both internal factors that are within a firm's control and external factors such as market conditions, government regulations, and supply chain performance. However, most previous studies focus on specific groups of factors or examine their effects independently [13]. Although these studies provide valuable insights into customer satisfaction, they often do not capture the dynamic interactions among internal and external factors over time. In addition, only a limited number of studies have applied dynamic modeling approaches to evaluate different strategies under changing business conditions.

Our review also shows that factors such as price, quality, and delivery time remain central to improving customer satisfaction across many industries. However, today's business environment is becoming increasingly complex, requiring a more comprehensive approach that considers the interactions among multiple factors affecting customer satisfaction [7]. Therefore, there is a need for a dynamic decision-support framework that integrates key internal and external factors influencing customer satisfaction in manufacturing enterprises. To address this need, this study incorporates knowledge management into the proposed system dynamics model and evaluates customer satisfaction under optimistic and pessimistic external conditions.

3. Proposed Methodology

3.1. Problem Definition and Conceptual Framework

In this section, our goal is to define the conceptual and analytical basis for studying the internal and external factors of a manufacturing enterprise that shape customer satisfaction for a firm's product offerings. We consider four dimensions that simultaneously interact with one another to influence the customer satisfaction system. Government policy and supply chain reliability (SCR) are considered external factors, while knowledge management (KM) and manufacturing firm performance criteria are internal factors. This distinction is important because external factors represent environmental conditions that firms cannot directly control, whereas internal factors correspond to managerial decisions that can be adjusted in response to changing business conditions. Emissions, tariffs, and subsidies are government regulations that directly and indirectly impact a firm's supply chain framework, which has significant bearing on delivery time, quality of raw materials, prices, and cost. Rather than attempting to control these external factors, the proposed framework supports managerial decision-making by evaluating how different internal strategies perform under alternative external conditions. In our proposed model, firms can invest in KM and improve the quality of product through increased testing and simulation and product customization by transferring knowledge from customers to the firm. In addition, firms can adjust internal operational decisions, such as inventory levels, product pricing, and investments in knowledge management, to mitigate the negative effects of external conditions and improve customer satisfaction. Finally, these variables can have an impact on product price, quality, delivery time, and customization of product which are core variables

for customer satisfaction. Therefore, the proposed framework serves as a decision-support tool by helping managers evaluate alternative internal strategies under different external scenarios rather than attempting to control external factors. The relationship between these factors is as shown in Figure 1. This Figure illustrates the interrelationships among the four dimensions. Government policy influences supply chain reliability, which affects manufacturing performance, while knowledge management improves manufacturing capabilities and product quality. Together, these interactions determine customer satisfaction through changes in price, quality, delivery performance, and product customization.

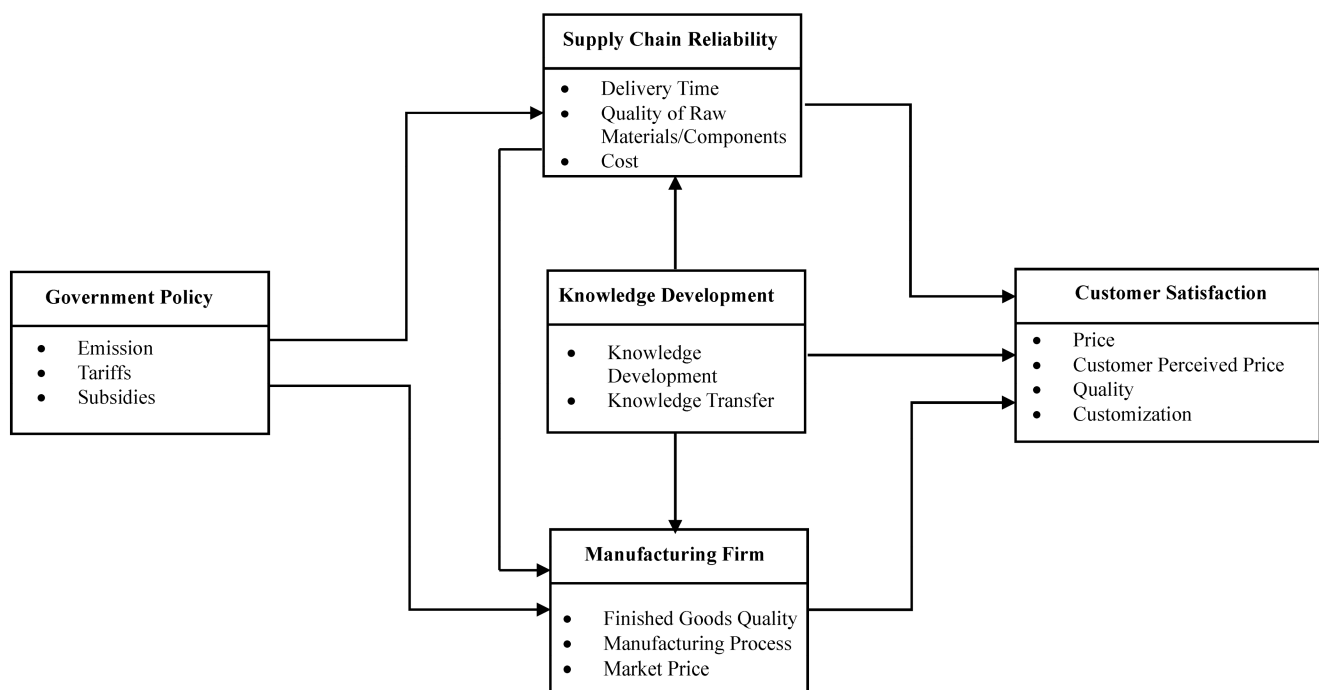


Figure 1. Conceptual framework.

3.2. List of Variables and Parameters

To aid the development of the SD model, each subsystem in Figure 1 was divided into various components to identify its associated variables and parameters. The variables were selected based on the literature on customer satisfaction factors and represent the key internal and external factors that have been widely recognized in previous studies. They were then classified according to the subsystem to which they belong within the proposed framework, allowing the interactions among the four dimensions to be represented within a unified SD model. The factors identified for each subsystem are presented in Table 1.

Table 1. List of variables and parameters used in SD model.

#	Variable	Unit	Type	Description	References
1	Production Volume (PV)	Units	Stock	Represents the accumulated production capacity of the manufacturer over time.	[42]
2	Inventory (INV)	Units	Stock	The stock of finished products available to meet customer demand.	[43]
3	Learning Curve (LC)	Percentage	Stock	Represents accumulated experience and knowledge over time, which improves efficiency, lowers costs, and enhances product quality through learning-by-doing effects.	[44]
4	Market Price (MP)	Dollar/Units	Stock	Price of the product in the market after considering costs, demand, and competition.	[40]
5	Customer Satisfaction (CS)	Percentage	Stock	Overall satisfaction level of customers.	[45]
6	Production Output (PO)	Units	Flow	Rate at which finished products are produced and added to inventory.	[40]
7	Order (O)	Units	Flow	Rate at which customer orders are placed, representing incoming demand for the product over time.	[46]
8	Order Received (OR)	Percentage	Flow	Rate at which customer orders are successfully received and processed by the system, influenced by order and demand.	
9	No. of Sales	Units	Flow	Representing the actual number of products sold to customers over time.	
10	Knowledge Development (KD)	Percentage	Flow	Rate at which knowledge and expertise are generated internally.	[9]
11	Production Cost (PC)	Dollar/Units	Flow	Total unit cost of producing the product includes labor, overhead, and materials.	[47]
12	Quality of End Product (QEP)	Percentage	Flow	Degree of improvement in product quality as production and testing occur.	[3]
13	Customization of End Product (CEP)	Percentage	Flow	Rate of tailoring the product to meet customer-specific needs.	[8]
14	Perceived Price Fairness (PPF)	Percentage	Flow	Customer perception of whether the price of the product is fair relative to value.	[5]
15	On-time Delivery Rate (ODR)	Percentage	Flow	Rate of delivery of products to customers within the promised timeframe.	[48]
16	Government Reg. for Emissions (Env. Impact) (GRE)	Dollar/Units	Input	Additional costs imposed by government regulations on emissions per unit produced.	[30]

Table 1. Cont.

#	Variable	Unit	Type	Description	References
17	Government Reg. for Tariffs (GRT)	Dollar/Units	Input	Tariff costs applied to imported raw materials or components.	[49]
18	Government Reg. for Subsidies (GRS)	Dollar/Units	Input	Financial support from the government per unit that reduces production costs.	[30]
19	Max. Fairness Price ($PF_{\max}$)	Dollar/Units	Input	Benchmark price that customers perceive as the maximum fair price.	
20	Avg. order size (AOS)	Units	Input	Average number of units requested per order by customers.	[50]
21	Knowledge Management (KM)	Dollars	Input	Level of organizational capability to create, store, share, and apply knowledge, enabling continuous learning and improvement in system performance.	[9]
22	Knowledge Transfer (KT)	Percentage	Auxiliary	Rate of transferring knowledge to processes, employees, or systems.	[9]
23	Customer Return Rate (CRR)	Percentage	Auxiliary	Rate at which sold products are returned by customers, reflecting dissatisfaction or issues with product quality here.	[13]
24	Sale (S)	Units	Auxiliary	Cumulative sales volume represents the total products sold to customers.	
25	Inventory Cost (InvC)	Dollar/Units	Auxiliary	Cost associated with holding and managing inventory per unit.	[13]
26	Offshoring (OFFS)	Percentage	Auxiliary	Proportion of production carried out in foreign countries.	[12]
27	Onshoring (ONS)	Percentage	Auxiliary	Proportion of production carried out domestically.	[12]
28	Knowledge Gap (KG)	Percentage	Auxiliary	Difference between the current level of knowledge and the desired or required level of knowledge within the organization.	
29	Demand (D)	Units	Auxiliary	Rate at which customers request products in the market.	[48]
30	Cost of Raw Materials (CRM)	Dollar/Units	Auxiliary	Unit cost of raw materials sourced from suppliers.	[47]
31	Supply Chain Reliability (SCR)	Percentage	Auxiliary	Degree to which the supply chain consistently delivers on time and with quality.	[11]
32	Supplier Quality of Raw Materials (SQR)	Percentage	Auxiliary	Proportion of raw materials that meet the required quality standards.	[51]
33	Order Rate (OR)	Percentage	Auxiliary	Frequency and volume of orders placed by customers over time.	[46]
34	Potential Customers (PC)	Units	Auxiliary	Number of customers in the target market who may purchase the product.	[40]
35	Supplier Delivery Rate (SDR)	Percentage	Auxiliary	Degree to which supply chain delivers raw material on time.	

3.3. Causal-Loop Diagram, Stock-And-Flow Diagram and Mathematical Modeling

The parameters identified in Table 1 are used to develop a causal-loop diagram, which describes the causal relationship between the parameters. This model demonstrates how government regulations, particularly those related to tariffs and emissions, directly influence corporate decisions regarding offshoring and onshoring. These decisions, in turn, affect overall supply chain performance. A shift toward onshoring typically enhances SCR, while offshoring may introduce vulnerabilities. A reliable supply chain contributes positively to product quality, delivery performance, and cost of raw materials.

In parallel, internal investments in KM can significantly enhance both knowledge transfer (KT) and knowledge development (KD). As KD progresses, the accumulation of experience and expertise leads to improved efficiency and product quality, while reinforcing learning capabilities over time. As the quality of the end product improves, the absence of new knowledge generation may create a knowledge gap (KG) within the organization.

Another critical factor influencing customer satisfaction is product pricing [5]. In the reference model, variables that contribute to market price formation are also included. For example, increased demand drives higher sales, which in turn raises market prices [40]. While sales growth is generally positive, sustained price increases can eventually reduce customer satisfaction. Therefore, the model emphasizes the importance of balancing demand-driven pricing strategies with customer expectations. Moreover, this model includes the on-time delivery rate as an indicator of how effectively demand is converted into actual orders. It reflects the percentage of market demand that the company can fulfill. In this model, we have five loops: two reinforcing loops and three balancing loops, which are shown separately in Figures 2 and 3.

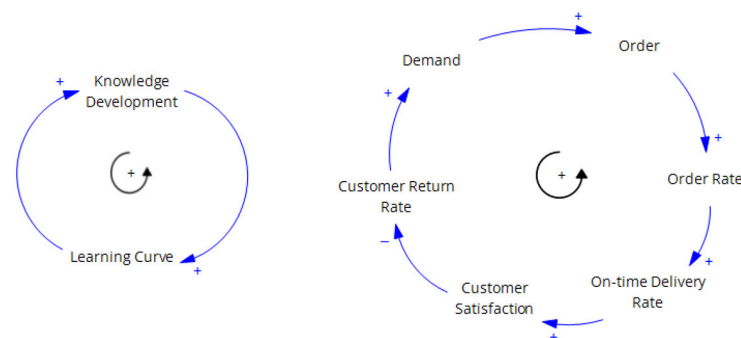


Figure 2. Reinforcement loops. A “+” indicates a positive causal relationship, arrows indicate the direction of causality.

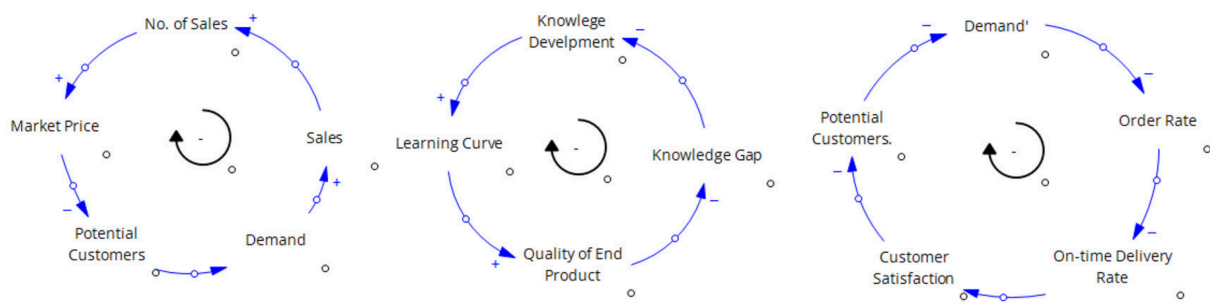


Figure 3. Balancing loops. A “−” indicates a negative causal relationship, arrows indicate the direction of causality.

Figure 2 shows the reinforcing loops. As KD increases, the learning curve also improves, which in turn further enhances KD. This captures the positive feedback between KD and the learning curve. The second positive loop represents the relationship between

demand and customer return rate. Rising demand leads to higher order and delivery rates, thereby improving on-time delivery performance and increasing customer satisfaction. The more customers are satisfied, the less return rate is possible, which causes more demand in the market.

Figure 3 shows three balancing loops. The correlation between market price and no. of sales is such that an increase in market price results in a decline in potential customers, thus leading to a decrease in demand and sales, which negatively impacts market prices, causing them to fall. The second balancing loop applies to KD and KG. An enhanced KD increases the learning curve and the quality of the end product, resulting in a reduction in KG and ultimately KD. The third balancing cycle refers to demand and potential customers. A rise in demand will result in a decline in order rates and on-time delivery rate, negatively affecting customer satisfaction and number of potential customers, ultimately leading to a fall in demand.

In SD modeling, stocks represent the accumulation of quantities that change over time. We identified five key stock variables: production volume, inventory, learning curve, market price, and customer satisfaction, as depicted in Figure 4. To enhance clarity and consistency with the overall system framework shown in Figure 1, we disaggregated these units in Figure 4. This separation helps visualize how each stock interacts with related parameters and variables across the system. The conceptual relationships shown in Figure 1 are implemented in the SD interface model shown in Figure 4, where the interactions among the variables are represented using stock–flow structures and feedback relationships.

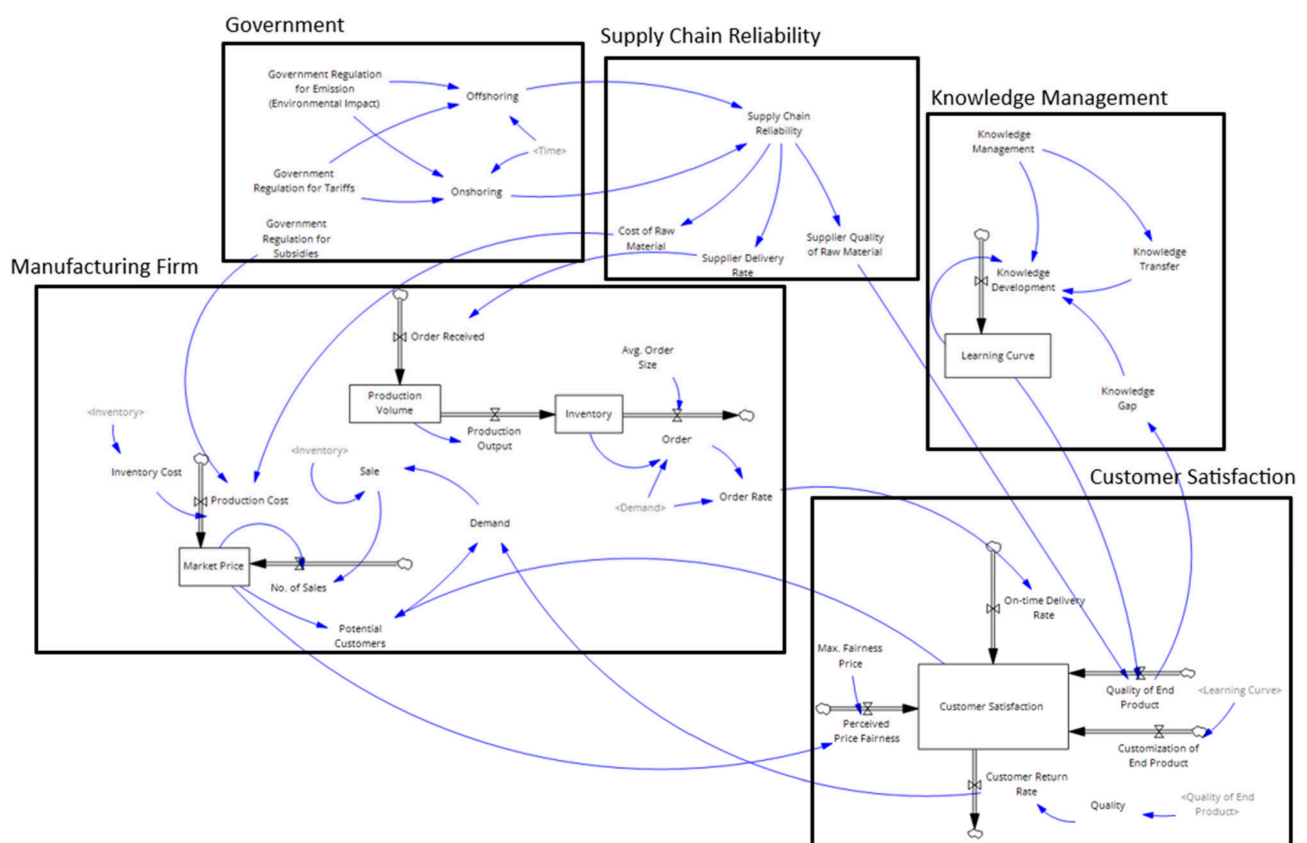


Figure 4. Stock-and-flow diagram.

Following the development of the stock-and-flow diagram, we now proceed to establish the mathematical relationships used in our modeling approach. Customer satisfaction (CS) is determined by on-time delivery (OTD), perceived price fairness (PPF), the degree of customization (CEP), and end-product quality (QED). The PPF is derived from the market

price (P_m) of the product and the maximum acceptable price fairness (PF_{max}) on the part of the firm. The quality of end product (QED) depends on the growth in learning curve (LC) and the rate (SQR) at which the supplier supplies quality raw materials. The rate of on-time delivery (OTD) is subject to the order rate (OR), while the rate of customization of end product (CEP) is influenced by learning curve (LC). Therefore,

$$PPF(t) = \min\left(1, \left(\frac{PF_{max}(t)}{P_m(t)}\right)\right); \text{ for } 0 < PPF \leq 1 \quad (1)$$

$$QED(t) = ((\alpha \times LC) \times \frac{SQR_M}{100}); \quad (2)$$

$$OTD(t) = OR; \quad (3)$$

It shows the percentage of fulfilled orders compared to the inventory

$$CEP(t) = \frac{(\alpha \times LC)}{10}; \quad (4)$$

where α = the percentage of knowledge devoted to customization

$$CRR(t) = \alpha \times (1 - Quality)^\beta \quad (5)$$

where α = scaling parameters (maximum return rate) and β = sensitivity (shape parameters). Thus,

$$CS(t) = \int_{t_0}^t (\alpha_1 \times QED(t) + \alpha_2 \times OTD(t) + \alpha_3 \times CEP(t) + \alpha_4 \times PPF(t)) - \alpha_5 \times CRR(t) \quad (6)$$

where α_n = weighting coefficients that capture the relative importance of product quality, delivery performance, customization, price fairness, and customer return rate in shaping customer satisfaction.

Similarly, the production volume of the manufacturer (PV_m) changes based on the order received (OR) and the production output (PO). OR is a function of supplier delivery rate (SDR) and is modeled to grow rapidly during production ramp-up to meet customer demand. PO references the production volume of the manufacturer. Therefore,

$$OR(t) = \beta \times \frac{SDR(t)}{100}; \quad (7)$$

where β = initial quantity of raw material that average supplier can supply daily, and 100 is a normalization factor

$$PO(t) = PV_m(t) \quad (8)$$

$$PV_m(t) = \int_{t_0}^t (OR(t)) - PO(t) \cdot dt \quad (9)$$

The inventory level is (I), as defined by Equation (9) to be dependent on the production output (as defined in Equation (8)) and orders (O) placed on finished goods inventory, which represents the inventory level (I) and is influenced by the average order size (AOS), where the average order size is assumed to be distributed about a mean value, and demand is (D). Thus,

$$O(t) = \min(I(t), (D(t) \times AOS(t))) \quad (10)$$

$$I(t) = \int_{t_0}^t (PO(t) - \min(I(t), D(t) \times AOS(t))) \cdot dt \quad (11)$$

Supply chain reliability (SCR) influences inventory availability indirectly through supplier delivery performance. A reduction in supplier delivery rate decreases the quantity of raw materials received, Equation (7), which reduces production volume, Equations (8) and (9), limits production output, and consequently lowers inventory levels, Equation (11). Therefore, disruptions in supply chain reliability propagate through inventory availability and ultimately affect customer satisfaction.

The market price (MP) at time “t” depends on the production cost (PC) from inventory cost (IC), the government regulation for subsidies (GRS), cost of raw materials (CRM), and no. of sales (NS). Hence,

$$PC(t) = (\beta \times CRM(t) + IC(t) - GRS(t)); \quad (12)$$

where β is shipment cost of raw materials

$$NS(t) = \left(S(t) \times \frac{\beta}{MP(t)} \right) + S(t); \quad (13)$$

where β is the average price of the product

$$MP(t) = \int_{t_0}^t \alpha \times \left(\beta \times PC(t) - MP(t) \times \left(\frac{NS(t)}{50} \right) \right) \cdot dt; \quad (14)$$

where α = adjustment speed, it controls how fast market price changes over time; β = the percentage of profit margin and σ = normalization factor, if sales = σ , then the effect is 1 (normal); and 50 is a normalization factor.

Equation (14) models market price as a dynamic stock that gradually adjusts toward the target price determined by production cost and the desired profit margin. The adjustment speed is governed by parameter α , while the number of sales influences how quickly market prices respond to market conditions. For the KM subsystem, the learning curve (LC) for the manufacturing team is a function of the rate at which the firm develops knowledge (KD) and KD is influenced by the firm’s investment in knowledge management (KM), knowledge transfer (KT) within the company, and the knowledge gap (KG) which is followed by an increase in the quality of end product. Conversely, LC also influences the growth of KD (since the expertise accumulated by the manufacturing team translates to knowledge development over time). Likewise, investments in KM also influence knowledge transfer (KT) between teams. Our modeling approach uses a linear weighted method to aggregate the effect of LC and KM on KD and CIPD and KM on KT and obtain the following expressions:

$$KD(t) = ((\alpha \times \beta \times KM(t)) + (\beta \times KT(t)) + (\beta \times LC(t))) \times \left(1 - \frac{LC(t)}{100} \right) \times \left(\frac{KG(t)}{100} \right); \quad (15)$$

where α and β are weighting coefficients for KM, KT and LC

$$KT(t) = \alpha \times \frac{KM(t)}{KM(t)}; \quad (16)$$

α is weighting coefficient for KM.

Hence,

$$LC(t) = \int_{t_0}^t (KD(t)) \cdot dt \quad (17)$$

4. Model Application, Results and Discussion

4.1. Case Example

To make this model more practical and realistic, we considered the case of a firm that manufactures technology-intensive products and operates in a competitive global market. This company faces challenges such as managing a complex supply chain, meeting changing customer needs, and controlling costs. The model assumes that the firm invests in KM to improve quality performance and customer satisfaction under realistic business conditions. To assess the long-term behavior of the system, we defined a simulation period of 36 months (3 years). This duration is consistent with previous modeling efforts in dynamic environments and reflects a reasonable time horizon for evaluating feedback effects, strategic changes, and performance outcomes in rapidly evolving markets where innovations and disruptions are frequent. Before introducing different scenarios, it was essential to establish a robust framework that could evaluate how internal and external factors influence delivery performance and customer satisfaction. To achieve this, the model focused on understanding the role of key variables and how they interact over time. The goal was to provide decision-makers with strategic insights by simulating different environmental conditions and internal policy responses. This approach helped identify which combinations of conditions and responses led

to optimal outcomes. Two external scenarios were designed to represent favorable and unfavorable environments, while three internal policies were tested to observe their effectiveness. This structured evaluation enabled us to understand how system performance changes across different situations and supported evidence-based policy testing.

4.2. Definition of Scenarios and Internal Intervention Policies

In the base-case simulation (BC), external factors were assumed to be in a moderate state, as shown in Table 2. In this case, GRE, GRT, and GRS were set at \$6, \$20, and \$30 per unit, respectively. The RAMP function, which represents a steady linear growth over time, was applied to these factors to simulate a gradual increase at a rate of 5% slope. Both onshoring (ONS) and offshoring (OFFS) were kept equal in the base case and defined using the EXP (exponential) function, which captures an S-shaped behavior and allows these variables to change smoothly over time. The differences in these external factors under scenario 1 and scenario 2 are summarized in Table 2, and their impacts on SCR and on-time delivery rate (ODR) are illustrated in Figures 5 and 6.

Table 2. Defining base-case simulation case and S1 and S2 under external factors.

Ext. Factors \ Sim. Case	Base-Case Simulation (BC)	Scenario 1 (S1)	Scenario 2 (S2)
GRE	\$6 + RAMP (0.05, 1, 36)	\$3 + RAMP (0.05, 1, 36)	\$9 + RAMP (0.05, 1, 36)
GRT	\$20 + RAMP (0.05, 1, 36)	\$10 + RAMP (0.05, 1, 36)	\$30 + RAMP (0.05, 1, 36)
GRS	\$30 + RAMP (0.05, 1, 30)	\$50 + RAMP (0.05, 1, 30)	\$10 + RAMP (0.05, 1, 30)
ONS	$50 / (1 + \text{EXP}(-0.01 \times (\text{Government Regulation for Tariffs} + \text{"Government Regulation for Emissions (Environmental Impact)"}) \times (\text{Time} - 10))))$	$70 / (1 + \text{EXP}(-0.01 \times (\text{Government Regulation for Tariffs} + \text{"Government Regulation for Emissions (Environmental Impact)"}) \times (\text{Time} - 10))))$	$30 / (1 + \text{EXP}(-0.01 \times (\text{Government Regulation for Tariffs} + \text{"Government Regulation for Emissions (Environmental Impact)"}) \times (\text{Time} - 10))))$
OFFS	$50 / (1 + \text{EXP}(-0.03 \times (\text{Government Regulation for Tariffs} + \text{"Government Regulation for Emissions (Environmental Impact)"}) \times (\text{Time} - 16))))$	$30 / (1 + \text{EXP}(-0.03 \times (\text{Government Regulation for Tariffs} + \text{"Government Regulation for Emissions (Environmental Impact)"}) \times (\text{Time} - 16))))$	$70 / (1 + \text{EXP}(-0.03 \times (\text{Government Regulation for Tariffs} + \text{"Government Regulation for Emissions (Environmental Impact)"}) \times (\text{Time} - 16))))$

In Table 3, the internal intervention policies (P1–P3) are defined and compared with BC. In BC, the organization maintains a moderate KM investment of \$500 and no safety stock. In policy 1 (P1), the focus is on strengthening KM by increasing investments to enhance KD and KT. This was modeled using the RAMP function with a 5% slope. Policy 2 (P2) implements a safety stock of 10 units to ensure more reliable order fulfillment and timely delivery. Finally, policy 3 (P3) aims to control costs by reducing the inventory cost from \$5 to \$3. These internal interventions were designed to evaluate how KM, safety stock, and cost-control measures influence customer satisfaction when applied under different external scenarios. The results of these policies under each scenario are shown in Figures 7–12.

Table 3. Defining BC, P1, P2, and P3 under internal factors.

Policies \ Int. Factors	BC	P1	P2	P3
KM Investment	\$500	\$800 + RAMP (0.05, 1, 36)	-	-
Safety Stock Mgt	0 Units	-	10 Units	-
Investment				
Inventory Cost	\$5 × Inventory	-	-	\$3 × Inventory

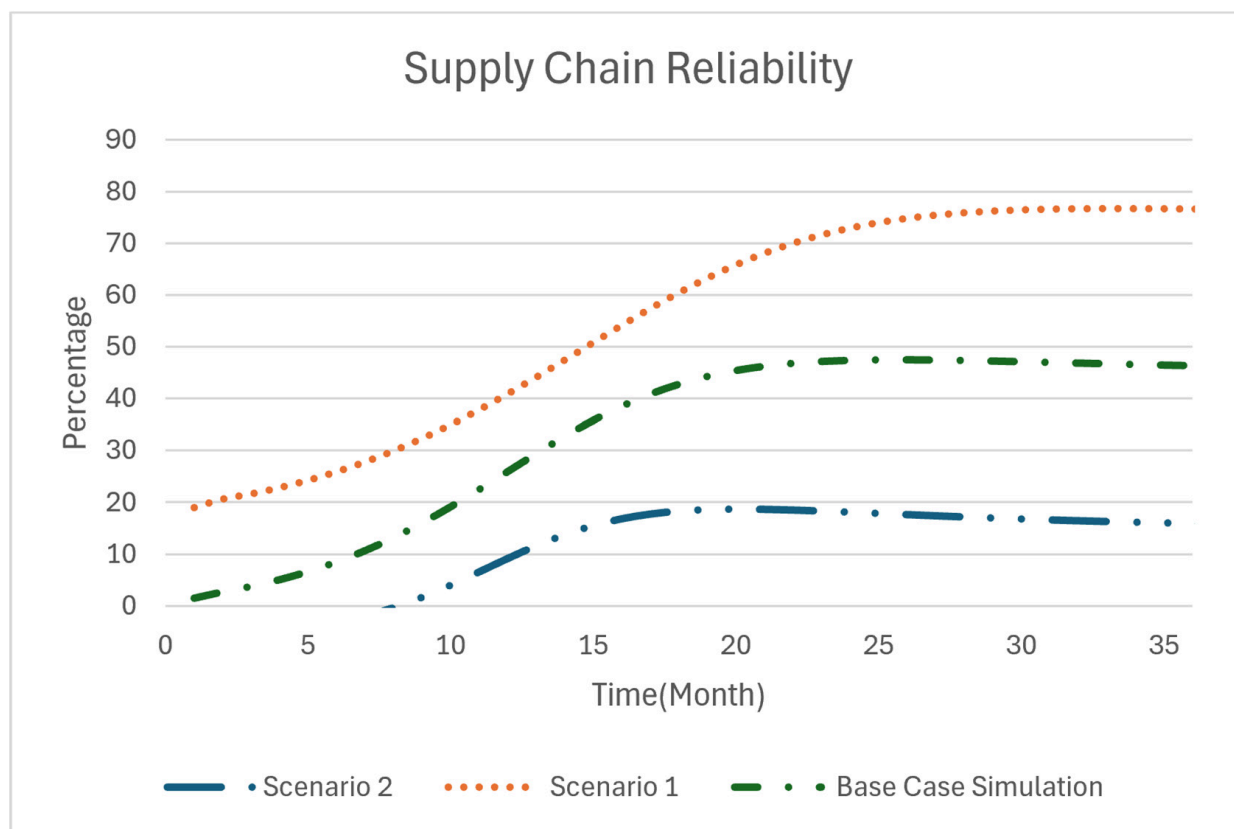


Figure 5. Supply chain reliability under scenario 1, scenario 2, and base simulation.

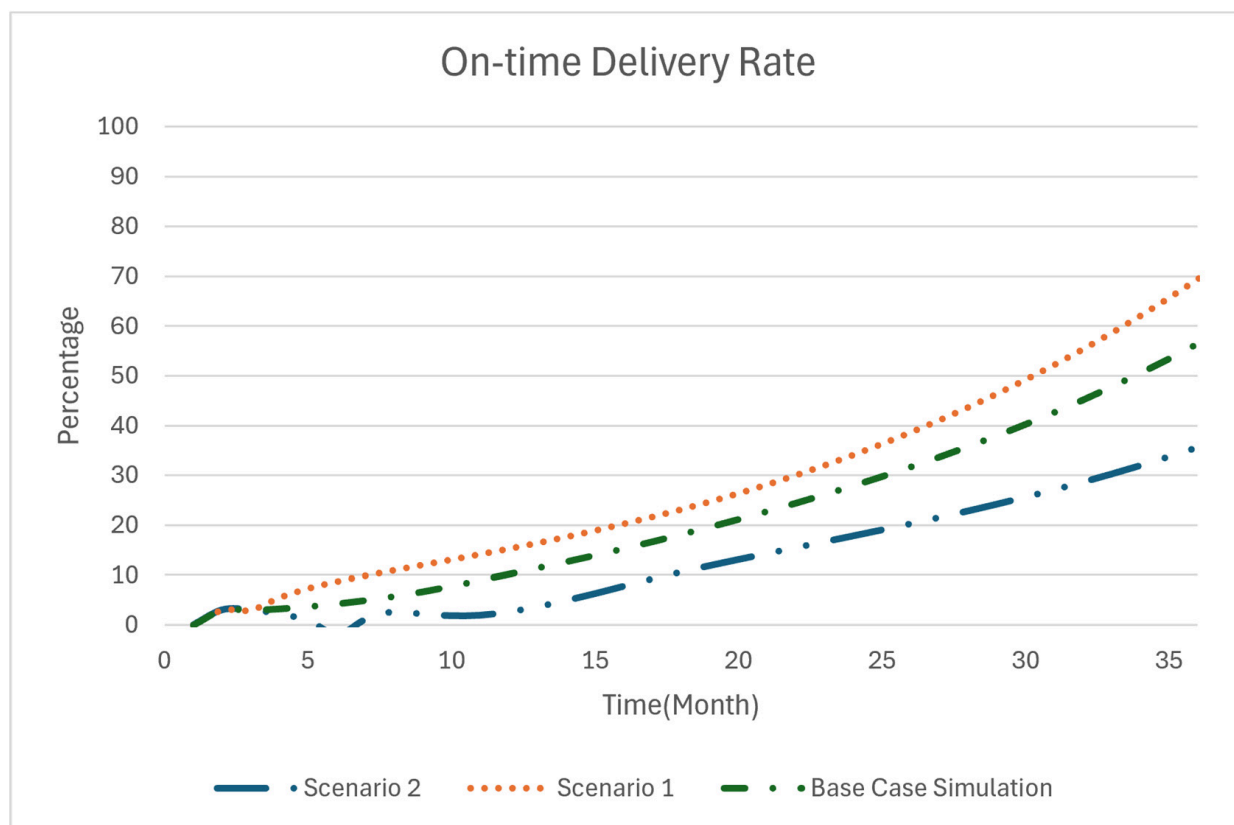


Figure 6. On-time delivery rate under scenario 1, scenario 2, and base simulation.



Figure 7. Customer satisfaction under scenario 1 and policy 1.



Figure 8. Customer satisfaction under scenario 1 and policy 2.



Figure 9. Customer satisfaction under scenario 1 and policy 3.



Figure 10. Customer satisfaction under scenario 2 and policy 1.



Figure 11. Customer satisfaction under scenario 2 and policy 2.



Figure 12. Customer satisfaction under scenario 2 and policy 3.

Figure 5 compares the two scenarios with the base-case simulation in SCR. After 36 months, SCR in the base-case simulation reaches almost 40% while in the optimistic scenario it grows to nearly 80%. On the other hand, in the pessimistic scenario, SCR drops to under 20%. This figure shows the impact of government regulations on SCR.

Figure 6 compares customer satisfaction across the three simulation scenarios. At month 36 of simulation, customer satisfaction increases to almost 60% in the base-case simulation, while it reaches approximately 75% and 20% in the optimistic and pessimistic scenarios, respectively.

4.2.1. Implementing Internal Intervention Policies Under Scenario 1

To evaluate the influence of internal policy interventions under varying external conditions, Table 4 presents a comparison of key performance indicators across the BC, two external scenarios (S1, optimistic, and S2, pessimistic), and three policy strategies (P1, P2, and P3). Under S1, which represents favorable conditions such as supportive government regulations and high supply chain reliability, policy 1 (P1), which involves investing in KM, produced the most substantial improvements across all indicators. Customer satisfaction increased to 82%, and product quality reached 99%; however, the on-time delivery rate remained the same at 13%. On the other hand, the market price increased to \$695, which is acceptable because as shown in Figure 3, higher customer satisfaction leads to higher demand, and increase in demand causes an increase in market price.

Table 4. Summary of results.

Variables	BC	S1	S2	P1S1	P2-S1	P3-S1	P1-S2	P2-S2	P3-S2
Customer Satisfaction	59.63%	73%	37.52%	82%	74.87%	77.84	42%	39.12%	41.17%
Quality of product	58%	58%	58%	99%	84%	84%	27%	23%	23%
On-time delivery rate	13%	35%	13%	13%	15%	13%	7%	7%	7%
Market price	\$559	\$695	\$400	\$695	\$642	\$522	\$400	\$347	\$340

Figure 7 compares the customer satisfaction degree in scenario 1, policy 1 under scenario 1, and the base-case simulation. At month 36 of the simulation, customer satisfaction increases to almost 60% in the base-case simulation, while it reaches approximately 70% and 80% in scenario 1 and policy 1 under scenario 1, respectively. This result shows that investing in KM can increase customer satisfaction by 10%.

Figure 8 shows the results of policy 2 under scenario 1. Adding a safety stock to the model only increases customer satisfaction by 1%. Figure 9 shows the results of policy 3 under scenario 1. Decreasing inventory cost increases customer satisfaction by 4% in the optimistic scenario.

4.2.2. Implementing Internal Intervention Policies Under Scenario 2

In contrast to S1, S2 reflects unfavorable external conditions with stricter regulations, higher costs, and lower reliability. Under these conditions, policy 1 (P1), which involves investing in KM, proved to be the most beneficial intervention. Although performance remained lower overall, P1 effectively minimized negative impacts: customer satisfaction improved to 42%, product quality decreased to 27%, and the on-time delivery rate, though modest, reached 7%. Most notably, the market price decreased significantly to \$400, helping maintain competitiveness despite adverse conditions. Overall, the results suggest that P1 is most effective in both favorable and unfavorable environments, enhancing reliability, quality, and satisfaction through improved delivery performance.

Figure 10 compares customer satisfaction degree in scenario 2, policy 1 under scenario 2, and base-case simulation. In month 36 of simulation, customer satisfaction increases to almost 60% in base-case simulation, while it reaches 37% in scenario 2. With policy 1 (investing in KM), customer satisfaction improves by almost 5% and reaches 42%. Figure 11 shows that policy 2 (adding safety stock) increases customer satisfaction to 39%.

Figure 12 shows policy 3 under scenario 2. Decreasing inventory cost increases customer satisfaction by 4% in the pessimistic scenario, from 37% to 41%.

4.3. Discussion

Table 4 presents the outcomes of each scenario, combining different internal policies with optimistic (S1) and pessimistic (S2) external conditions. The results are compared against the base case (BC) as well as across scenarios. If the firm's primary goal is to enhance customer satisfaction (CS), P1-S1 represents an optimistic external environment and investing in KM in S1 causes better results. In this case, CS reaches 82%, which reflects an increase of approximately 9% compared to S1 alone (73%). This finding is consistent with the finding of [35], which reported that effective knowledge management practices positively influence customer satisfaction, with tacit knowledge producing stronger effects than explicit knowledge. Similarly, the finding of [34] showed that knowledge management enhances customer relationship management, which subsequently improves customer satisfaction. While these studies establish the positive relationship between knowledge management and customer satisfaction, our SD model extends these findings by demonstrating that investments in knowledge management remain effective under both optimistic and pessimistic external conditions through dynamic interactions with supply chain reliability and manufacturing performance. Although implementing a safety stock (P2) under both external conditions decreases the market price, it does not result in the highest satisfaction compared to other policies. This suggests that while product price is important, it may not be the only or most decisive factor in influencing customer satisfaction. P3, which focuses on reducing inventory costs, shows a considerable impact on market price. In both S1 and S2, it leads to a significant reduction in the final price of end products dropping to \$522 in P3-S1 and \$340 in P3-S2. This outcome suggests that under unfavorable external conditions (S2), the firm can still improve competitiveness by lowering internal costs and offering more affordable products. Unlike previous studies, which examined the relationship between knowledge management and customer satisfaction using empirical or statistical approaches, our SD model captures the dynamic interactions among knowledge management, manufacturing performance, supply chain reliability, and government policies over time, providing managers with a decision-support tool for evaluating alternative policies under changing external conditions.

Unlike previous studies, which have typically investigated customer satisfaction factors in isolation or by examining only two or three dimensions together, this study integrates government policy, supply chain reliability, manufacturing firm performance, and knowledge management into a unified system dynamics framework. By incorporating knowledge management into this integrated model, the study demonstrates how interactions among internal and external factors evolve over time rather than operating independently. In addition, the proposed framework evaluates three alternative managerial policies under both optimistic and pessimistic external conditions, providing a decision-support approach that helps managers adapt their internal strategies to external environmental changes while sustaining customer satisfaction and organizational competitiveness.

5. Conclusions and Future Work

This study uses a system dynamics approach to examine the relationships among factors affecting customer satisfaction and to analyze how organizational policies influence it in manufacturing enterprises. In this research, we considered customer satisfaction drivers such as government policies, supply chain reliability, knowledge management, and manufacturing performance criteria. The interactions between these factors were established using the concepts of SD modeling and a realistic case example was used to test various scenarios and policies. The insights obtained from this study suggest that applying SD modeling to customer satisfaction enables manufacturing enterprises to evaluate the dynamic interactions among government policy, supply chain reliability, knowledge management, and manufacturing performance. The simulation results demonstrate that investments in knowledge management consistently improve customer satisfaction under both optimistic and pessimistic external conditions, while inventory and pricing policies provide additional mechanisms for mitigating unfavorable external environments. Unlike previous studies, which examined these factors individually or in limited combinations, this study integrates them into a unified dynamic framework, providing both a theoretical contribution to the customer satisfaction literature and a practical decision-support tool for evaluating alternative managerial policies under changing external conditions.

Although the customer satisfaction drivers used in this work make significant contributions to this research domain, there are other factors that influence customer satisfaction in practical cases that were not considered in this work. For instance, the impact of “number of competitors” and “number of suppliers” were not considered. In real-life situations, number of suppliers may decrease the raw material prices and increase delivery rate while number of competitors influences the market price. To this end, the extension of the current SD framework to cater for the impact of the number of competitors and suppliers, and its interactions with other established customer satisfaction drivers will be of interest in future research. Furthermore, with regard to the methodology used in this work, our main focus in this research is on SD modeling. While the results in this research portray SD modeling as a useful tool in understanding and analyzing customer satisfaction dynamics, recent research suggests that the analytical strength of SD models can be greatly improved by the integration of SD modeling approach with other advanced techniques such as machine learning techniques, optimization techniques, and agent-based modeling. Since research on customer satisfaction is currently limited to independent models, as in this study, pursuing the integration of hybrid modeling approaches will make an immense contribution to the customer satisfaction literature.

Hence, future work will focus on extending the customer satisfaction framework to cater to other factors that drive customer satisfaction and developing an SD-based hybrid model that integrates SD modeling concepts with advanced analytical techniques to better improve the capabilities for analyzing customer satisfaction patterns under varying scenarios.

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References

1. Jiang, H.M.; Kwong, C.K.; Ip, W.H.; Wong, T.C. Modeling customer satisfaction for new product development using a PSO-based ANFIS approach. *Appl. Soft Comput.* **2012**, *12*, 726–734. [\[CrossRef\]](#)
2. Chai, K.Y.S.; Li, Y.Y.; Lim, W.L.; Ong, S.P. Factors Influencing Consumer Satisfaction in Online Shopping. Dissertation Thesis, UTAR, Kampar, Malaysia, 2018.
3. Zanetta, L.D.A.; Xavier, M.C.; Hakim, M.P.; Stedefeldt, E.; Zanin, L.M.; Medeiros, C.O.; da Cunha, D.T. How does the consumer choose a restaurant? An overview of the determinants of consumer satisfaction. *Food Res. Int.* **2024**, *186*, 114369. [\[CrossRef\]](#) [\[PubMed\]](#)
4. Zandi, P.; Ekhtiari, N.S.; Sorooshian, S. From taste to price: Comparative analysis of customer satisfaction factors in three food products. *J. Retail. Consum. Serv.* **2025**, *87*, 104378. [\[CrossRef\]](#)
5. Yuan, L.W.; Iqbal, S.; Hussain, R.Y.; Ali, S. Impact of price on customer satisfaction: Mediating role of consumer buying behaviour in telecom sector. *Int. J. Res.* **2019**, *6*, 150–165.
6. Masuch, S.; Landwehr, J.R.; Flath, C.M.; Thiesse, F. The faster, the better? The impact of short delivery times on product returns in online retailing. *J. Retail.* **2024**, *100*, 475–485. [\[CrossRef\]](#)
7. Kullolli, T.; Trebicka, B.; Fortuzi, S. Understanding customer satisfaction factors: A logistic regression analysis. *J. Educ. Soc. Res.* **2024**, *14*, 218–231. [\[CrossRef\]](#)
8. Varriale, V.; Cammarano, A.; Michelino, F.; Caputo, M. Knowledge management in high-tech products and customer satisfaction: The smartphone industry. *J. Open Innov. Technol. Mark. Complex.* **2023**, *9*, 100012. [\[CrossRef\]](#)

9. Özkan-Seely, G.F.; Gaimon, C.; Kavadias, S. Dynamic knowledge transfer and knowledge development for product and process design teams. *Manuf. Serv. Oper. Manag.* **2015**, *17*, 177–190. [\[CrossRef\]](#)
10. Mubarak, M.F.; Jucevicius, G.; Shabbir, M.; Petraite, M.; Ghobakhloo, M.; Evans, R. Strategic foresight, knowledge management, and open innovation: Drivers of new product development success. *J. Innov. Knowl.* **2025**, *10*, 100654. [\[CrossRef\]](#)
11. Huo, B.; Li, D.; Gu, M. The impact of supply chain resilience on customer satisfaction and financial performance: A combination of contingency and configuration approaches. *J. Manag. Sci. Eng.* **2024**, *9*, 38–52. [\[CrossRef\]](#)
12. Cheng, F.; Wang, W. Research on the relationship among government regulations, strategy preference and manufacturing performance. *J. Serv. Sci. Manag.* **2012**, *5*, 37–43. [\[CrossRef\]](#)
13. Taheri, S.G.; Navabakhsh, M.; Tohidi, H.; Mohammaditabar, D. A system dynamics model for optimum time, profitability, and customer satisfaction in omni-channel retailing. *J. Retail. Consum. Serv.* **2024**, *78*, 103784. [\[CrossRef\]](#)
14. Zhang, H.; Deng, H.; Sun, Q.; Zhu, L. Customer satisfaction in online-to-offline commerce: A fresh product perspective. *Br. Food J.* **2025**, *127*, 284–300. [\[CrossRef\]](#)
15. Cardozo, R.N. An experimental study of customer effort, expectation, and satisfaction. *J. Mark. Res.* **1965**, *2*, 244–249. [\[CrossRef\]](#)
16. Anderson, R.E. Consumer dissatisfaction: The effect of disconfirmed expectancy on perceived product performance. *J. Mark. Res.* **1973**, *10*, 38–44. [\[CrossRef\]](#)
17. Oliver, R.L. A cognitive model of the antecedents and consequences of satisfaction decisions. *J. Mark. Res.* **1980**, *17*, 460–469. [\[CrossRef\]](#)
18. Surprenant, C.; Churchill, G. An investigation into the determinants of customer satisfaction. *J. Mark. Res.* **1982**, *19*, 491. [\[CrossRef\]](#)
19. Cadotte, E.R.; Woodruff, R.B.; Jenkins, R.L. Expectations and norms in models of consumer satisfaction. *J. Mark. Res.* **1987**, *24*, 305–314. [\[CrossRef\]](#)
20. Oliver, R.L.; DeSarbo, W.S. Response determinants in satisfaction judgments. *J. Consum. Res.* **1988**, *14*, 495–507. [\[CrossRef\]](#)
21. Woodside, A.G.; Frey, L.L.; Daly, R.T. Linking service quality, customer satisfaction, and behavior. *Mark. Health Serv.* **1989**, *9*, 5.
22. Fornell, C.; Johnson, M.D.; Anderson, E.W.; Cha, J.; Bryant, B.E. The American customer satisfaction index: Nature, purpose, and findings. *J. Mark.* **1996**, *60*, 7–18. [\[CrossRef\]](#)
23. Babae, A.; Shank, D.B. Trust and procedural justice mediate the effects of AI hiring on organizational attraction and intent to apply. *Discov. Artif. Intell.* **2025**, *5*, 375. [\[CrossRef\]](#)
24. Babae, A.; Shank, D.B.; Canfield, C.; Hall, J.G.; Lentine, K.L.; Randall, H.; Schnitzler, M. Five tensions of artificial intelligence adoption for organ allocation: Applying the technology–organization–environment framework. *Digit. Health* **2026**, *12*, 20552076261425344. [\[CrossRef\]](#) [\[PubMed\]](#)
25. Duong, Q.H.; Zhou, L.; Meng, M.; Dang, L.T.A.; Nguyen, T.D. Striking the right balance: Customising return policy leniency for managing customer online return proclivity and satisfaction. *J. Retail. Consum. Serv.* **2025**, *85*, 104315. [\[CrossRef\]](#)
26. Monfort, A.; López-Vázquez, B.; Sebastián-Morillas, A. Building trust in sustainable brands: Revisiting perceived value, satisfaction, customer service, and brand image. *Sustain. Technol. Entrep.* **2025**, *4*, 100105. [\[CrossRef\]](#)
27. Schultz, C.D.; Paetz, F. The way out—customer benefits and self-service satisfaction in cashierless shopping systems. *J. Retail. Consum. Serv.* **2025**, *85*, 104280. [\[CrossRef\]](#)
28. Murdock, M.; Ngo, T.; Richie, N. Customer satisfaction and vertical integration. *N. Am. J. Econ. Financ.* **2025**, *80*, 102498. [\[CrossRef\]](#)
29. Madanchi, F.; Maghroor, H.R.; O’Neal, T. *A Systematic Review of the Internet of Things Contribution to Obtain Supply Chain Integration*; SSRN: Rochester, NY, USA, 2024.
30. Gao, F.; Cui, S.; Cohen, M. Performance, reliability, or time-to-market? Innovative product development and the impact of government regulation. *Prod. Oper. Manag.* **2021**, *30*, 253–275. [\[CrossRef\]](#)
31. Yuan, P.; Dong, X.; Xu, J.; Lin, X. How Government Regulations and Consumer Behavior Influence Manufacturers’ Product Green Degree Decision-Making: An Agent-Based Model. *Wirel. Commun. Mob. Comput.* **2021**, *2021*, 5582140. [\[CrossRef\]](#)
32. Hafezi, M.; Zolfagharinia, H. Green product development and environmental performance: Investigating the role of government regulations. *Int. J. Prod. Econ.* **2018**, *204*, 395–410. [\[CrossRef\]](#)
33. Liu, Z.; Nishi, T. Government Regulations on Closed-Loop Supply Chain with Evolutionarily Stable Strategy. *Sustainability* **2019**, *11*, 5030. [\[CrossRef\]](#)
34. Khair, H.; Tirtayasa, S.; Trisna, F.E. Effect of Service Quality on Consumer Satisfaction Moderated by Government Policy During the COVID-19 Pandemic. *Int. J. Sci. Technol. Manag.* **2022**, *3*, 1314–1320. [\[CrossRef\]](#)
35. Guchait, P.; Namasivayam, K.; Lei, P.W. Knowledge management in service encounters: Impact on customers’ satisfaction evaluations. *J. Knowl. Manag.* **2011**, *15*, 513–527. [\[CrossRef\]](#)
36. Gazi, M.A.I.; Al Mamun, A.; Al Masud, A.; Senathirajah, A.R.B.S.; Rahman, T. The relationship between CRM, knowledge management, organization commitment, customer profitability and customer loyalty in telecommunication industry: The mediating role of customer satisfaction and the moderating role of brand image. *J. Open Innov. Technol. Mark. Complex.* **2024**, *10*, 100227. [\[CrossRef\]](#)

37. Idrees, H.; Xu, J.; Haider, S.A.; Tehseen, S. A systematic review of knowledge management and new product development projects: Trends, issues, and challenges. *J. Innov. Knowl.* **2023**, *8*, 100350. [[CrossRef](#)]
38. Chen, H.H.; Kang, H.Y.; Xing, X.; Lee, A.H.; Tong, Y. Developing new products with knowledge management methods and process development management in a network. *Comput. Ind.* **2008**, *59*, 242–253. [[CrossRef](#)]
39. Sterman, J.D. System dynamics modeling: Tools for learning in a complex world. *Calif. Manag. Rev.* **2001**, *43*, 8–25. [[CrossRef](#)]
40. Cui, A.S.; Zhao, M.; Ravichandran, T. Market uncertainty and dynamic new product launch strategies: A system dynamics model. *IEEE Trans. Eng. Manag.* **2011**, *58*, 530–550. [[CrossRef](#)]
41. Hosseinzadeh, A.; Esmaili, H.; Soltani, R. Providing a system dynamics model to evaluate time, cost, and customer satisfaction in omni-channel distribution: A case study. *Iran. J. Manag. Stud.* **2021**, *14*, 291–310. [[CrossRef](#)]
42. Chomiakow, D. Generic Pattern for Modelling Manufacturing Companies. In *Proceedings of the 2007 International Conference of the System Dynamics Society and 50th Anniversary Celebration*; System Dynamics Society: Littleton, MA, USA, 2007; Volume 29, p. 71.
43. Xu, J.; Cao, L. Optimal in-store inventory policy for omnichannel retailers in franchising networks. *Int. J. Retail. Distrib. Manag.* **2019**, *47*, 1251–1265. [[CrossRef](#)]
44. Naim, M.; Towill, D. System dynamics and learning curves. In *International System Dynamics Conference*; System Dynamics Society: Littleton, MA, USA, 1994; pp. 164–173.
45. Daugherty, P.J.; Bolumole, Y.; Grawe, S.J. The new age of customer impatience: An agenda for reawakening logistics customer service research. *Int. J. Phys. Distrib. Logist. Manag.* **2019**, *49*, 4–32. [[CrossRef](#)]
46. Liu, P.; Hendalianpour, A.; Hafshejani, M.F.; Yaghoobi, F.; Feylizadeh, M. System dynamics model: Developing model for supplier selection with a focus on CSR criteria. *Complex Intell. Syst.* **2023**, *9*, 99–114.
47. Lucero Hurtado, L.E.; Sigüenza Guzmán, L.C.; Arcenales Carrión, R.N.; Reino Chérrez, F.S.; Tapia Quezada, B.S. *Analysis of Production Costs: An Approach to Decision-Making*; FEMIB: Setúbal, Portugal, 2023.
48. Badhotiya, G.K.; Soni, G.; Mittal, M.L. Fuzzy multi-objective optimization for multi-site integrated production and distribution planning in two echelon supply chain. *Int. J. Adv. Manuf. Technol.* **2019**, *102*, 635–645. [[CrossRef](#)]
49. Drake, D.F. Carbon tariffs: Effects in settings with technology choice and foreign production cost advantage. *Manuf. Serv. Oper. Manag.* **2018**, *20*, 667–686. [[CrossRef](#)]
50. Adegbola, A.; Allada, V. Analysis of factors influencing new product launch: A system dynamics approach. In *IISE Annual Conference Proceedings*; Institute of Industrial and Systems Engineers (IISE): Norcross, GA, USA, 2025; pp. 1–6.
51. Darestani, S.A.; Ismail, M.Y.; Ismail, N.; Yusuff, R.M. Quantifying suppliers' product quality: An exploratory product audit method article. *S. Afr. J. Ind. Eng.* **2010**, *21*, 149–159.

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