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Sustainable Management of Railway Companies Amid Inflation and Reduced Government Subsidies: A System Dynamics Approach

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Abstract: Sustainable transport is a critical and complex issue that the world is currently facing. Managers of railway companies in particular face significant challenges in achieving self-sustainable management of their assets. This paper introduces a new causal loop and explores the interaction among company dimensions—including financial, social, and environmental aspects—in order to assess the financially sustainable management of Raja Corporation, one of the largest railway companies in Iran. Our main contribution is the proposed system dynamics (SD) model, which can aid in policy analysis for Raja, a company that operates multiple routes within the country. The presented model compares different strategies employed by Raja using economic, social, and environmental indicators to evaluate the financial sustainability of the company. Our findings demonstrate that government subsidies may boost the company's revenue, but they also hinder the rate of profits. Additionally, we highlight the impact of inflation on the company's financial sustainability, showing that higher ticket prices may have a considerable impact on profits. The proposed approach of using the SD model may help specialists evaluate the sustainability management of transport sector corporations and significantly enhance their performance. This study highlights the importance of taking a comprehensive approach to assess the financial sustainability of railway companies, considering the interdependencies among various dimensions of each company. The findings of this study may have implications for policymakers, managers, and researchers in the transport sector, especially those who are interested in sustainable management practices.

Keywords: system dynamics; railroad passenger transportation; inflation; government subsidies; financial sustainability; raja corporation

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1. Introduction

Transport is an essential sector that encompasses various aspects of the economy and scientific fields. The decisions made in this field usually involve various factors, making them complex and multi-criteria in nature [1]. Sustainable transport, in particular, involves considering environmental, economic, and social factors in decision-making processes. These factors need to be carefully analysed and balanced to ensure that the chosen transportation options promote sustainable development [2]. The idea of sustainable transport emerged in tandem with the definition of sustainable development, as outlined in the World Commission on Environment and Development's report, "Our Common Future" [3]. Companies that transport passengers and cargo must look beyond traditional growth strategies and adopt sustainable solutions that address economic, social, and environmental issues simultaneously [4].

One of the key environmental concerns in the transportation sector is greenhouse gas emissions, which have been linked to global warming and climate change. Sustainable transportation aims to address these issues by minimizing negative impacts on society and the environment while ensuring social and economic well-being [5]. Furthermore, the transport sector is linked to eight of the United Nations' Sustainable Development Goals (SDGs), highlighting the importance of sustainable transportation in achieving these goals. Transport networks are vital to a country's economic growth and account for a significant percentage of national GDP and employment [6]. Therefore, it is crucial for companies in the transportation sector to adopt sustainable development practices and incorporate the three dimensions of economic growth, social well-being, and environmental concerns into their growth strategies. This will not only help address pressing global issues but also lead to long-term business success and societal benefits [7].

Transportation is a critical component of every country's economy, with land, water, and air transportation all playing important roles [8]. However, the economic benefits of the transportation industry come with environmental costs, particularly in the form of greenhouse gas emissions [9]. Overall, the transportation sector is responsible for an estimated 14% of all pollution, with road transport being the largest contributor [10,11]. The aviation sector is the second-largest contributor to pollution within human-caused emissions, accounting for approximately 2% to 4% of the total pollution [12]. These environmental consequences have prompted policymakers and industry leaders to focus on finding sustainable solutions for transportation, including alternative fuels, efficient practices, and investments in eco-friendly modes of transportation, such as rail [13].

Despite these challenges, there is a growing commitment to sustainability within the rail industry, with many companies investing in new technologies and implementing sustainability measures [9]. This is an encouraging trend, as rail transportation has the potential to significantly reduce carbon emissions and contribute to a more sustainable future [14]. By working together, policymakers, industry leaders, and the public can help create a transport system that is both sustainable and efficient, while also addressing the urgent need to address climate change [15,16].

Despite numerous studies on sustainable transport systems, there is a lack of proposed methods for integrating the triple bottom line (TBL) of sustainability into the assessment of rail passenger transportation [17,18]. This study aims to fill this gap by creating a benchmark framework that categorizes indicators from a thorough literature review based on various criteria. Furthermore, railway passenger companies in Iran face challenges in generating adequate profits, resulting in their inability to effectively compete with other modes of transportation. To address this gap, this study proposes the consideration of key indicators for evaluating the operations of railway passenger companies. By analysing these crucial indicators, potential strategies and interventions can be identified to improve the performance and competitiveness of these companies in the transportation market. This study utilizes a dynamic model of transportation networks, focusing on the unique features and feedback loops of rail passenger transportation management systems. The system dynamics approach is used to investigate the properties of transport systems, including the impacts of inflation and government subsidies. In the context of Iran, these two factors, inflation and government subsidies, significantly impact the sustainability of railway companies. Consequently, this study presents two pivotal scenarios aimed at achieving sustainability, with a particular emphasis on evaluating the outcomes of implementing these policies. The contributions of this study include a suggested sustainability evaluation methodology that considers TBL qualities, a detailed description of the unique features and feedback loops of rail transportation management systems, and proposed scenarios for attaining sustainability.

The contributions and advancements in this study are highlighted as follows:

- Policymakers can utilize a proposed sustainability evaluation model to assess the current level of sustainability in passenger rail transport systems. This model incorporates the triple bottom line attributes of sustainability, which encompass the financial, social, and environmental impacts of these systems. The selection of TBL characteristics was based on extensive research conducted by specialists in railway transport systems.

This methodology serves as a solid foundation for implementing sustainable measures in various passenger rail transport systems.

- The dynamic model employed in this study includes intricate details specific to rail transport management systems. Notably, the incorporation of previously overlooked factors such as inflation and government subsidies adds novel dimensions to the model.
- To validate the model, it underwent rigorous testing, including extreme condition tests.

Section 2 of this study reviews previous research on railroad transportation sustainability and system dynamics, which have highlighted the complexity of transportation models. Section 3 presents the problem statement and proposed methodology, while Section 4 includes the case study. The results of the simulation are discussed in Sections 5 and 6 provides validation of the model. This study concludes with future directions for research. This framework can be used as a foundation for policymakers to assess the sustainability of rail passenger transport systems and implement necessary sustainability measures.

2. Background of Sustainability in the Rail Transport System and System Dynamics

During this section, we review recent research concerning railway transport system sustainability and system dynamics, which have been combined to form the suggested model that has been prepared. It should be emphasized that these papers were evaluated in order to demonstrate the need for the proposed method by exhibiting similar studies and research.

2.1. The Background of Sustainability in Transport Systems

The railway transport system is a complex network that is influenced by various factors such as population growth, environmental conditions, economic factors, and other modes of transportation and cargo movement. Conventional techniques for analysing railway transport companies are unsuitable due to the intricate nature of this system [19]. Typically, traditional railway transport assessments focus on a single key indicator such as sales or revenue, without considering the significance of the system's coherence. As a result, traditional assessment methods have been strongly criticized, leading to the development of new evaluation methodologies [20]. To elaborate, the railway transport system is a significant and complex infrastructure that is not only impacted by passenger and freight demand but also by environmental conditions, demographic changes, technological advancements, and economic factors. Traditional assessment methods that prioritize sales or revenue overlook the importance of maintaining the integrity and coherence of the railway transport system [21,22]. As a result, new approaches that consider these complex factors have emerged to assess the effectiveness and sustainability of railway transport companies. These new methodologies aim to provide a more comprehensive and accurate assessment of the railway transport system's performance, thus enabling better decision-making and improving the system's overall efficiency [23].

The sustainability of transportation has been studied using multi-criteria methods (MCA), life cycle assessment (LCA), cost-benefit analysis (CBA) [19], and other approaches [24]. Various indicators are used to measure activities and trends, as well as to compare different areas, alternatives, strategies, and goals for transportation sustainability [25]. There are publications and research on transportation sustainability in the literature that provide a variety of indicators for the concept. In this context, Nicolas et al. [26] provide a set of indicators that assess the three dimensions of sustainability: economic, social, and environmental. They provide the results of exploratory research commissioned by Renault Automobile Manufacturers to evaluate the feasibility and value of generating such sustainable mobility indicators. These indicators facilitate comparisons not only between various urban contexts but also over time, allowing for longitudinal analysis. Litman and Burwell [25,27] examine the determination of indicators for comprehensive and sustainable transportation planning. Those authors propose that there is currently a lack of universally standardized indicator sets for comprehensive and sustainable transport planning. As a result, each jurisdiction or organization must develop its own set of indicators based on their specific needs and capabilities. However, they suggest that it would be beneficial for prominent planning and professional organizations to collaborate and establish recommended sets of sustainable transportation indicators, along with standardized data collection practices and evaluation methodologies. Such efforts would not only enhance sustainability planning but also enable comparisons among different jurisdictions, organizations, and time periods, promoting knowledge sharing and best practices in the field of sustainable transport. Pregl et al. [28] aim at evaluating and analysing transportation operations in the European Union using transport sustainability indicators. For analysing and monitoring transportation sustainability, several researchers suggest a country (or city)-level indicator system [24,29,30]. Refs. [31,32] investigate the sustainability of urban passenger transportation networks using data from the majority of cities. The authors emphasize the key factors that play a significant role in achieving sustainability in the field of transportation. They observe that wealthier and larger cities tend to have more sustainable transport systems in place. Additionally, they identify specific transport policies that can address existing shortcomings, such as increasing the utilization of public transport and discouraging urban sprawl. These measures have the potential to enhance the sustainability of transport systems and promote more efficient and environmentally friendly modes of travel within urban areas. There have been studies that use fewer indicators to assess the sustainability of transportation. A set of indicators was used to assess transportation sustainability, taking into account various systems such as freight transport [33,34], road transport [35,36], urban transport [37,38], transport infrastructure projects [39,40], modes of transportation in particular [41,42], public transportation [43], road and rail systems on the local scale [44], and inland transport on the local scale [32,39,45,46]. In addition, a few indicators for roads and railroads were used to assess the systems' sustainability [46].

We identify relevant examples in the literature when it comes to methodologies and methods for analysing the sustainability of railway transport systems, as well as their consequences and correlations. Research [37] has explored structural equation modelling and statistical tests given by Shiau et al. [30] for analysing indicators of transport sustainability. Chou et al. [47] investigated the cause-and-effect connection between high-speed rail performance indicators. Saleem et al. [48] studied how air and rail transportation factors influenced environmental degradation indicators. Social media was utilized in research to analyse sustainable urban transportation indicators [49].

2.2. System Dynamics Modelling

The dynamics of systems, which is a framework for studying and regulating complex feedback systems, is one of the fields of system theory. Business, economics, the environment, energy management, urban concerns, and other social and human challenges are all examples of these systems [50,51]. The business world is evolving and growing more competitive. As a result, in order to keep pace with the ever-changing environment, businesses must be more adaptive and agile, providing them with an advantage over their competitors [52]. J. Forrester from M.I.T. established the first system dynamics method in the early 1960s [53]. Fundamentally, the system dynamics (SD) approach is capable of formulating complex decision model systems in which:

- Because of the system's complexity and breadth, the analyst's amnesia, or the element's casual relationships, certain components are omitted.
- For many scenarios, a comparative approach is used.
- The system cannot be restarted from the beginning.
- It takes time for the effects of changes to show in the system [54].

System dynamics procedures include outlining issues, generating theories, constructing the model's simulation, analysing the model, and devising evaluation and policy criteria. As a general approach, Figure 1 displays the various steps necessary in running an SD model. This model, which simulates the flow of resources and the measures taken, includes stock elements and flow elements, as well as auxiliary and consonant variables [54].

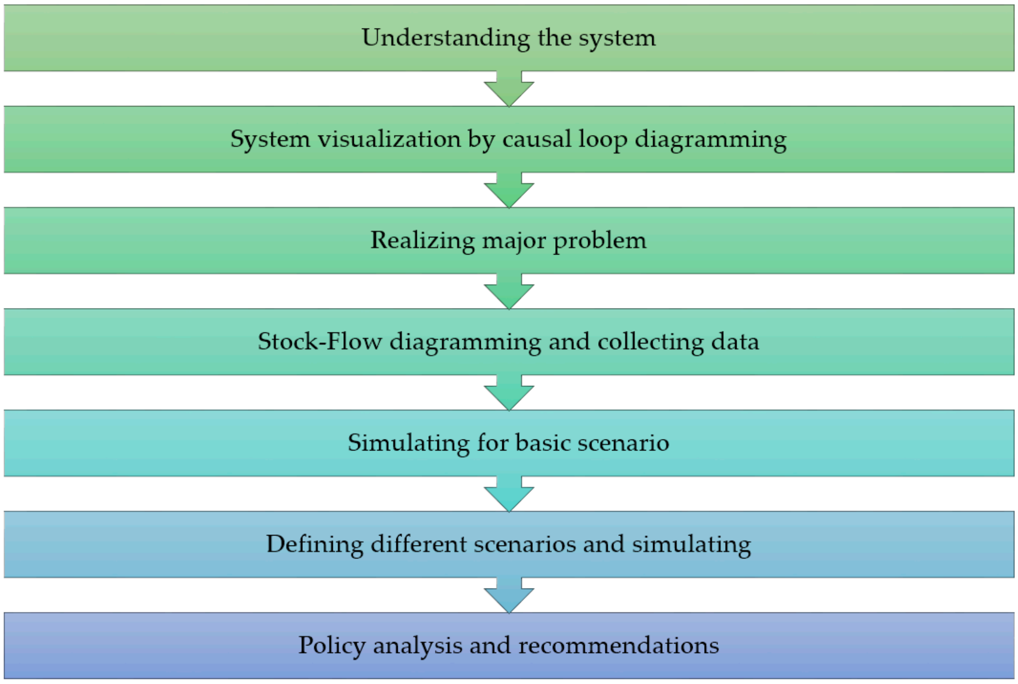

Figure 1. General steps for executing an SD model [55].

Railway transportation is a complex system influenced by a variety of elements such as the environment, the economy, and society. A complete railway transport assessment should be integrated with the development of railway transport systems [56].

3. Proposed Method

3.1. Problem Definition and Proposed Model

Railway transport plays an essential role in the economic growth and social development of a country [17]. However, this mode of transportation is also a source of air pollution and energy consumption [10]. What is important is that both negative and positive aspects of railroad transportation should be balanced to achieve sustainability [57]. That way, sustainable railroad transportation does not do any harm to the ecosystem and public health. Moreover, it can adjust itself to the needs of future generations. In spite of the fact that several studies focusing on defining sustainability and its aspects in rail passenger transportation have been conducted, a unified method that simultaneously assesses the sustainability performance condition and identifies the challenges and impediments that are reducing total sustainability is urgently needed [31,58]. The motivation behind the need for restructuring railway companies in the last decade has been the desire to enhance the efficiency and competitiveness of rail transport in relation to other modes of transportation [58]. Unexpected changes in various sectors of the government, i.e., revenues, population fluctuations, general policy-making, sanctions, energy consumption, urban development, etc. have put unprecedented pressure on railroad companies in Iran. The proposed method will assist in filling these gaps and relieving strain on passenger railroad companies. First, based on data collected from multiple dimensions of sustainability in rail passenger transport systems, a novel measuring tool is developed. It allows us to create a system dynamics model. Second, the relationship between key indicators linked to various aspects of sustainability is simulated, and their effects on one another are assessed. This method simulates cause-and-effect relationships between major variables like inflation and government subsidies. Third, some scenarios are offered based on expert views. As a result, the suggested method integrates the use of SD for model construction and scenario simulation with the evaluation.

3.2. Key Indicators and Concepts of Railway Sustainability

The sustainability metrics used in transportation should include indicators that indicate different impacts, goals, and targets, according to [25]. Indicators must be simple to calculate, understand, compare, measure, and use. They must also be beneficial to stakeholders and pertinent to decision- and policy-makers. Additionally, it should be mentioned that the indicators' relative significance and mutual causation are crucial components [59,60]. To enhance the strategies of companies, it is essential to select the most significant indicators that align with their unique characteristics. In order to achieve this objective, we have identified the crucial indicators for the railway company by consulting railway transportation experts and conducting a thorough literature review. During this process, a wide range of indicators were considered. However, to create a simulated model and ensure its coherence with the principles of system dynamics, only the most important indicators were retained for the simulation. A variety of factors, divided into themes, are necessary for a railroad firm to remain sustainable (Table 1). The three dimensions of sustainability—financial, social, and environmental—can also be used to group these factors. In order to ensure a railroad company's sustainability, a balance between these factors needs to be achieved.

Table 1. Selected rail company sustainability themes and corresponding indicators.

Financial Dimension	Society Dimension	Environmental Dimension
Renting Wagon's Income [61]	Number of Satisfied Passengers [38,62]	Energy Consumption [62,63]
Selling Tickets' Income [61,64]	Quality of Services [62,65]	CO2 Emission from Railway Passenger Transport [66]
Energy Cost [67,68]	Advertising [62]	-
Operating Cost [61,64]	Company's Reputation [62,69]	-
Non-Operating Cost [67,70]	Number of Complaints [62,71]	-
Buying New Wagons and Locomotives [Raja's strategy map]	Number of Passengers [62]	-
Profit [61,64]	-	-
Income [61,64]	-	-
Cost [67,70]	-	-
Government Subsidies [Raja's strategy map]	-	-
Inflation [Raja's strategy map]	-	-

Within the range of proposed indicators, two particular indicators hold great significance in this study: the inflation rate and government subsidies in the financial dimension. These indicators have a unique and critical role as they profoundly impact railway companies across various countries. Many railway companies face challenges in enhancing their financial sustainability, and addressing these factors becomes imperative for their success.

The inflation rate directly affects the operating costs, ticket prices, and overall financial performance of railway companies. It necessitates careful consideration in order to mitigate its adverse effects and maintain a healthy financial position. Additionally, government subsidies play a pivotal role in supporting railway operations, but their reduction or withdrawal can significantly impact the financial stability of these companies. Thus, striking a balance between managing inflation and optimizing government subsidies becomes crucial for sustainable financial management in the railway industry.

Given the broad impact of these indicators on railway companies globally, understanding and effectively addressing their effects on financial sustainability is of paramount importance. It requires strategic planning, prudent decision-making, and adaptive measures to ensure long-term viability in an ever-changing economic landscape.

3.3. Cause Loop Diagram

For the research purposes, causal loop diagrams (CLD) of the sustainability dimensions have been constructed to analyse the characteristics of the railway passenger company and to elucidate the linkages of the key variables in the system. The reciprocal im-pacts and interactional relationships between the system's variables are depicted in these diagrams. A "+" indicates a positive relationship, whereas a "−" indicates a negative link. Positive arrows represent changes as occurring in the same direction, while negative ar-rows indicate changes as occurring in the opposite direction. As an illustration, rising en-ergy consumption led to rising energy costs, and vice versa. An even number of negative linkages make up a positive reinforcement loop, denoted by the symbol ″⊕″ A negative feedback loop features an unequal distribution of negative linkages, in contrast to the pos-itive feedback loop [72].

3.3.1. Financial Subsystem

Inter- and intra-relationships as well as feedback are shown in the causal loop diagram for the financial dimension in Figure 2. R1, R2, R3, and R4 reinforce feedback loops. Government subsidies and the rate of inflation both affect ticket pricing. The justification for price of tickets is that government regulations allowing railroad passenger companies to reach ticket prices should be modified to take into account the impact of government subsidies and inflation.

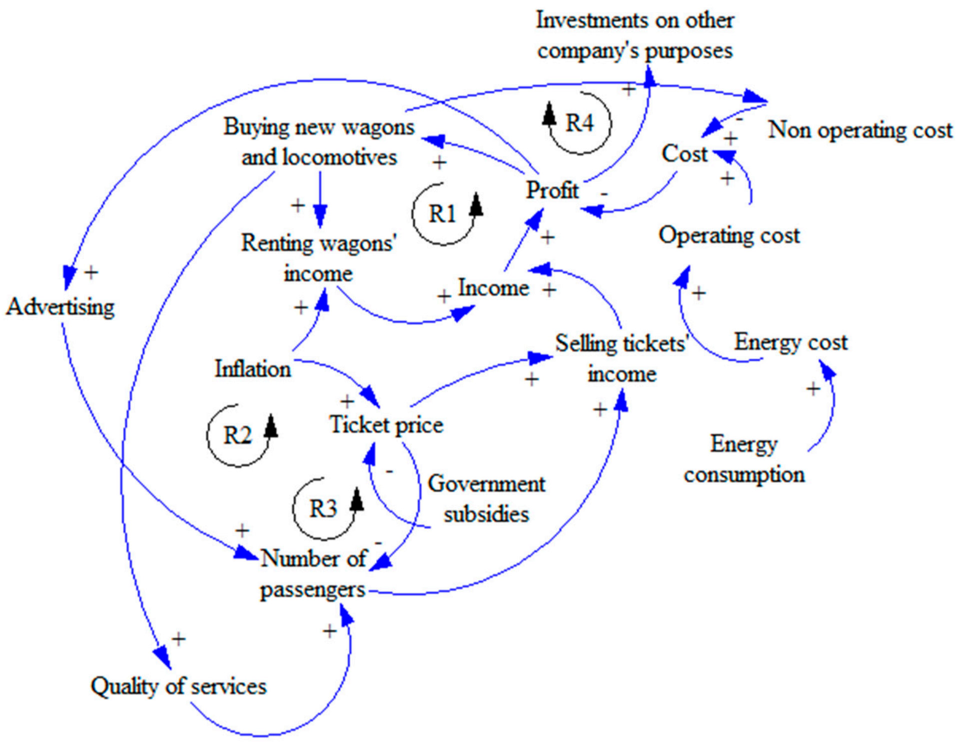

Figure 2. Causal loops in the financial dimension.

R1 is a reinforcing loop, which means that each indicator in the loop has a similar impact on the others ($\xrightarrow{+}$). The revenue from renting wagons swings in the same direction as the indicator of new wagon purchase whenever the railway company decides to purchase new wagons and locomotives. In truth, as more new wagons are purchased, more wagons are also rented out. Additionally, as the income from renting wagons changes, the income of the overall business also moves in the same way, creating a positive arrow between these two indications. The company's profit fluctuates in the same direction as the income as the last indication in this loop. Profit should generally increase along with revenue in most cases. As a result, when the last indicator, profit, is changed and all of the arrows between indicators turn positive, the reinforcing loop is complete.

The second reinforcing loop is R2, which signifies that when the advertising improves, the number of passengers rises ($\xrightarrow{+}$). Whenever the number of passengers varies, the revenue from ticket sales changes in the same manner ($\xrightarrow{+}$), which affects both the company's revenue and the revenue from ticket sales. As a result, the causal loop's ultimate indicator, profit, changes in the same direction as income.

The third reinforcing loop is R3. Similar to R1, if the number of new wagons and locomotives is altered, the quality of services is also changed in the same direction ($\xrightarrow{+}$). As a result, the number of passengers also changes along with these indicators in this loop. In actuality, the number of passengers rises as the quality of services improves and declines when the quality of services declines. The income from selling tickets and the company's income both change in tandem with changes in the number of passengers, which affects the company's profit.

In the financial dimension, R4 is the last reinforcing loop. Every time the number of new wagons and locomotives changes in this loop, non-operating costs fluctuate in the other manner ($\xrightarrow{-}$). In fact, non-operating costs decline as more new wagons and locomotives are supplied. When non-operating costs vary, the company's costs also move in the same direction ($\xrightarrow{+}$), which causes the profit indicators to shift in the opposite way ($\xrightarrow{-}$). Due to the even number of negative arrows in this loop, it follows that this loop is a reinforcing loop.

3.3.2. Social Subsystem

Figure 3 shows a clear correlation between the number of passengers and the number of satisfied customers, advertising, complaints, and corporate reputation. A company must certainly draw in more customers if it wants to raise income, which is greatly influenced by the quality of its services and ticket costs.

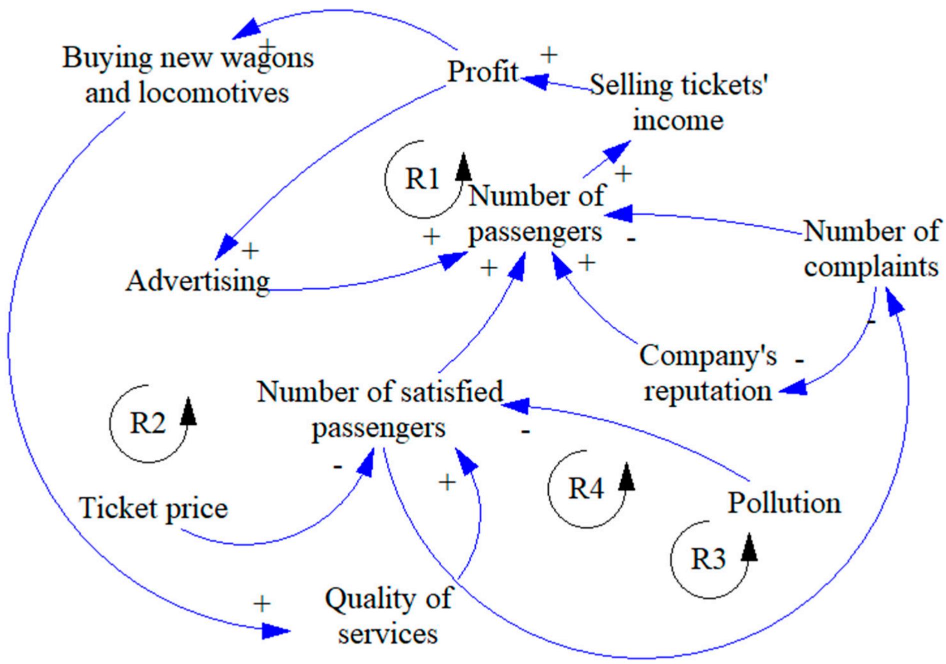

Figure 3. Causal loops in the social dimension.

The indicator for the number of passengers moves in the same direction ($\xrightarrow{+}$) as the policy for the company's advertising in R1 once it has been modified, indicating that as the advertising policy improves, the number of passengers rises. The revenue from selling tickets fluctuates ($\xrightarrow{+}$) when the number of passengers changes. The last indication in the loop, profit, shifts in the same direction ($\xrightarrow{+}$) as the income from ticket sales when that indicator changes.

According to Loop R2, if there are more new wagons and locomotives, it may be able to improve service quality ($\xrightarrow{+}$), which would therefore raise customer satisfaction ($\xrightarrow{+}$). The number of passengers is altered ($\xrightarrow{+}$) once the percentage of satisfied users has changed. The income from ticket sales and profit, being the final indications, move in the same direction ($\xrightarrow{+}$) as a result of changes in the number of passengers.

The quality of services and the number of satisfied customers are two indicators that are modified in the same direction ($\xrightarrow{+}$) in loop R3 once the number of new wagons and locomotives is adjusted. The number of passengers should change in the opposite direction ($\xrightarrow{-}$) as the number of complaints, meaning that if the number of complaints rises, the number of passengers falls. This is because it is obvious that when the number of satisfied users changes, the number of complaints changes in the opposite direction. Therefore, the revenue from ticket sales and profits, which are final indicators like R2, vary in tandem with the number of passengers.

The quality of services and the number of satisfied customers shift in the same way ($\xrightarrow{+}$) in the final reinforcing loop (R4) as they did in R3 whenever the number of new wagons and locomotives is adjusted. When the number of satisfied customers is altered, the number of complaints follows suit in the other way ($\xrightarrow{-}$), which has the opposite effect ($\xrightarrow{-}$) on the company's reputation as the number of complaints is changed. Due to this dynamic, the number of passengers, revenue from ticket sales, and profit all shift in line with the company's reputation indicator ($\xrightarrow{+}$).

3.3.3. Environmental Subsystem

Operating costs are strongly influenced by energy usage as well as energy cost, as illustrated in Figure 4. The company's costs fluctuate in the same direction ($\xrightarrow{+}$) as operating cost changes when operational costs vary. Purchasing new wagons and locomotives modifies the profit in the same way as buying them since a change in the cost indicator causes the profit to move in the other direction ($\xrightarrow{-}$). Thus, the loop R1 is created.

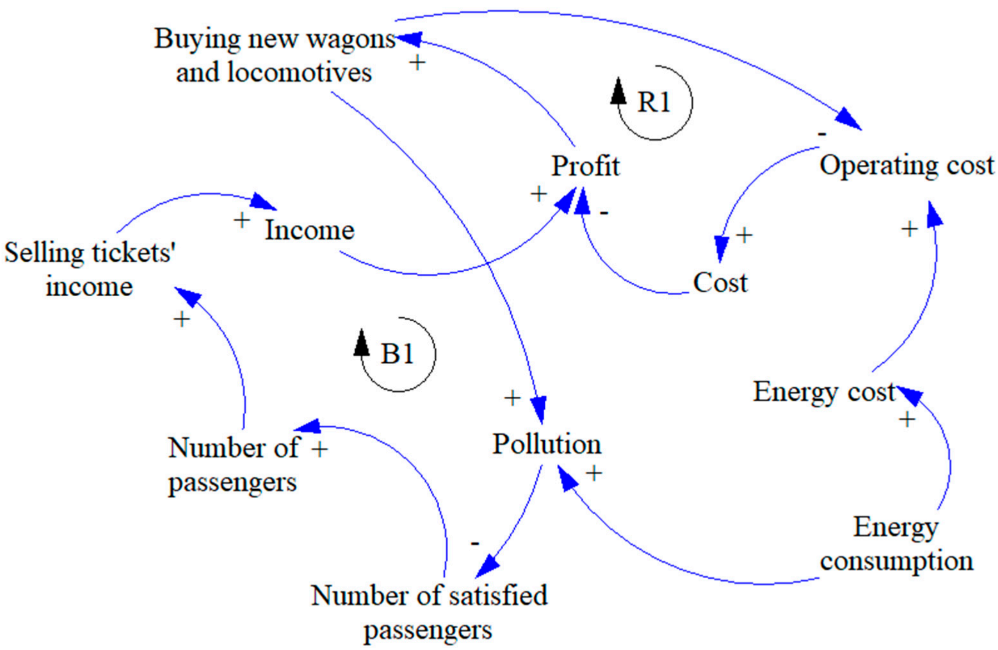

Figure 4. Causal loops in the environment dimension.

After altering the amount of wagons and locomotives, the balance loop (B1) is created. It goes without saying that when more new wagons and locomotives are added, the pollution will vary in the same way ($\xrightarrow{+}$). However, the number of satisfied users changes in the reverse way ($\xrightarrow{-}$) once the pollution indicator changes. Additionally, when the number of satisfied users changes, so do other indicators, like the number of passengers, ticket sales revenue, company income, and profit.

Designing and analysing system dynamics requires explaining and illustrating the cause-and-effect graph of a system. Vensim P.L.E is the software utilized in this study. In cause and effect interactions, variables usually have reciprocal relationships, which implies that one variable has an impact on the dynamic growth and decrease of other variables The design and quantitative calculations carried out by the Vensim simulation software, as well as the use of the functions mentioned in the next section, take these effects and predicted delays into account in accordance with the concept of system dynamics. The cause and effect graph is changed into a state and flow diagram that is simple for computers to understand as the next stage in developing a system dynamics model.

3.4. Passengers Railway Transport Flow Diagram

Although the CLD is able to explain the fundamental structure of feedback linkages, it is unable to differentiate between the many variables. Therefore, to describe the accumulated reactions for various levels of variables, we constructed a flow diagram (FD). The Level variable in the SD model indicates how the system will behave over time when more material, energy, and information are added to it. The symbol “ ” designates this variable. Rate variable, which represents the rate of change in the system or the magnitude of a choice, defines the speed of the system’s cumulative effect and reflects changes in Level variables over time. It is represented by the symbol “ ”. The intermediate variables that are used throughout the whole decision-making process are known as auxiliary variables.

Equation (1) depicts the stock formula’s overall condition.

$$\text{Stock(t)} = \int [\text{Inflow(t)} - \text{Outflow(t)}]\text{dt} + \text{Stock}(\text{t}_0) \quad (1)$$

A generic structure of the stock-flow diagram is shown in Figure 5.

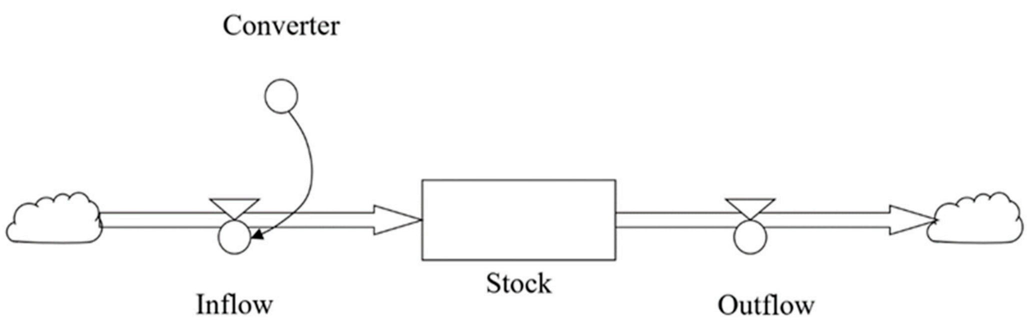

Figure 5. Stock and Flow Diagram (SFD)—generic structure.

Two levels, four rate, and nineteen auxiliary variables comprise Figure 6. Level variables (rectangular boxes) accumulate, such as profit. Other components include regular auxiliary variables, which might be constant, independent, or rate-based variables. The system, which can handle statistical data, is introduced with rates, constant variables, and independent components. Calculations for dependent variables are made in light of how they interact with other system components. In complex systems, there are many variables and components, but we should only take into account and concentrate on the variables and factors that are indicators of an issue that one desires to research. A complex system like the one discussed in the case study in this work may be divided into a number of subsystems, as shown in Figures 2–4.

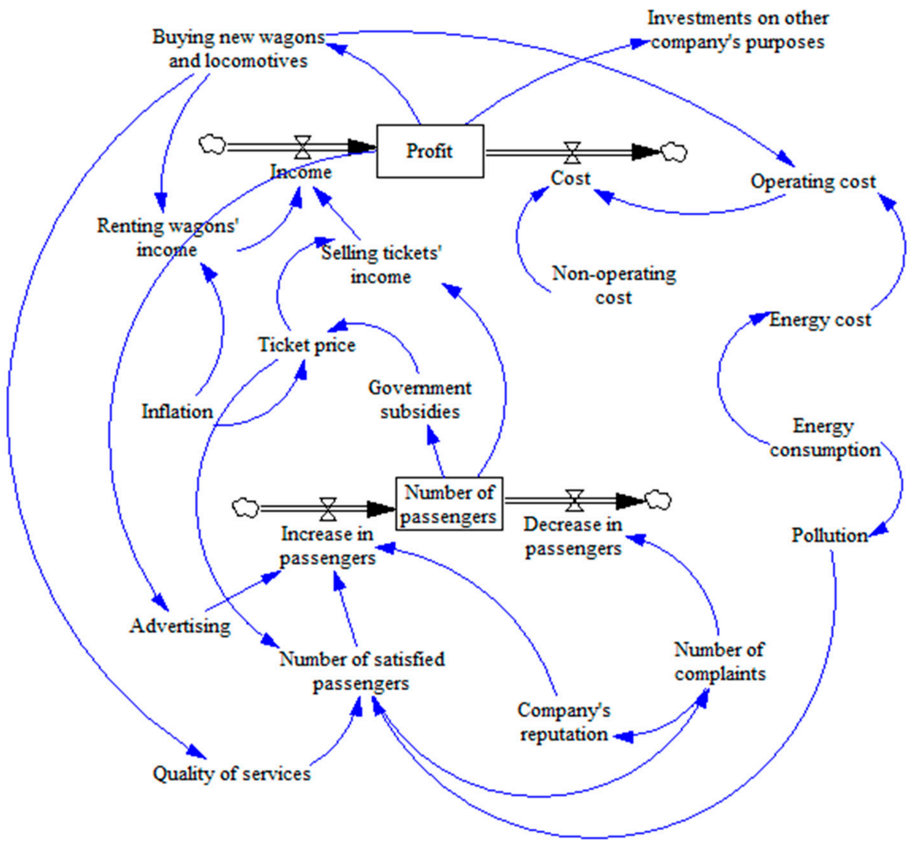

Figure 6. All model dimensions in Vensim.

Three aspects of self-sustainable management for railroad companies are financial, social, and environmental. All the dimensions that have causal feedbacks on one another are shown in Figure 6. All dimensions have interactions with one another that might result in gains or losses. The important factors, such as the impacts of inflation and government subsidies, are thought to clearly illustrate the links between the various dimensions. Government subsidies and the impacts of inflation can influence income and ticket pricing. The entire spending and revenue of transportation companies, along with the cost of tickets, serve as indicators of how sustainably managed a particular corporation is overall. These factors significantly impact other variables that affect how quickly profits and losses occur.

4. Case Study

To aid in comprehending the proposed methodology, a real-world example was provided using the Raja Railway Transport Corporation (RRTC) in Iran. As the country's largest passenger rail corporation, RRTC serves over 12 million passengers annually and has a strong commitment to maximizing facility usage, continuous improvement, and enhancing passenger service quality [73]. The case study serves as a practical demonstration of the proposed methodology's effectiveness in assessing organizational performance, and its application in a real-world scenario provides valuable insights for future research.

Raja Corporation is a government organization receiving subsidies and other types of financial assistance. According to the insights of the transport professionals consulted at Raja, since Raja benefits from various government subsidies, it is extremely hard for the corporation to determine actual ticket costs. Therefore, Raja cannot make appropriate profits. Moreover, the inflation rate in Iran is rather high. As a result, companies should be highly flexible in terms of adjusting their expenses and revenues so as to be in line with the ever-rising inflation. Raja is not at liberty to increase its ticket prices because of government policies imposed on it by the rules and regulations in effect, but the incurred costs of the corporation increase due to inflation. Thus, Raja struggles to create a balance between its expenses and revenues. Actual ticket prices can also be a sign of the reputation and popularity of railway transportation companies. However, government subsidies obstruct from reaching the public correct information about real ticket prices that should be paid and more importantly limit how knowledge of real prices can affect passengers' choices as well as the quality of services that they receive. Owing to the fact that Raja cannot make a large enough profit from selling tickets, the only option left is making an effort to reduce costs which affects the services negatively. Low ticket prices naturally result in low quality of services. With the continued lowering of the quality of services, the public becomes less willing to choose railway transportation among other available modes of transport such as travelling by bus, flying, or using a personal or rental car. In a nutshell, Raja has to cope with economic challenges directly related to inflation and government subsidies.

Every level of railway transportation service such as express trains, first-class or business-class service, etc. has its own price, so passengers can choose the type of ticket that best suits their needs. If this is implemented, Raja will probably be able to make profits and even compensate for some of its previous losses in the long run. Financially sustainable management depends on blocking subsidies and considering the impact of inflation rates on ticket prices.

The fixed values of individual parameters have been provided in Table 2.

Table 2. Fixed values assumed for the model [67].

Lower Limit	Variable	Upper Limit
30,000	Energy consumption (thousands of litres)	35,000
18,000	Non-operating costs (million Rials (Iran's Current Currency))	42,000
60	Quality of services (percent)	70
2500	Ticket price (thousand Rials)	5500

After the fixed values had been determined, specific formulae were constructed for the independent variables. The financial sub-model flips the Profit variable, as seen in Table 3. The average profit, according to Raja's yearly report, is 2,000,000,000 Rials.

Table 3. Financial sub-model equations.

Type	Variable	Equation	Unit
Stock	Profit	Income − Cost + Profit (t_0)	Million Rials
Flow	Income	Renting wagons' income + Selling tickets' income	Million Rials
Flow	Cost	Non-operating cost + Operating cost	Million Rials

The ticket price variable is included in another significant equation. In this sense, it is crucial to take into account government subsidies and the inflation rate when determining ticket pricing. Equation (2) is used to calculate the price of the ticket. Moreover, we will utilize two ranges for this equation based on the set pricing for tickets [15].

$$\begin{gathered}\text{Ticket price} = \text{RANDOM UNIFORM } (2500, 5500) + \text{Inflation} \times \text{Ticket price} + \\ \text{Government subsidies} \times \text{Number of passengers}\end{gathered} \quad (2)$$

Another significant sub-model, the social dimension, includes the number of passengers, which is greatly influenced by advertising, the number of complaints, the number of satisfied customers, and the reputation of the company. The stock and flow formula for this significant sub-model is shown in Table 4. The average number of passengers is 10 million, hence the number of passengers (t_0) is 10 million, as shown in Table 4. In addition, according to experts, 85% of delighted passengers want to utilize Raja for their next trip plans. Additionally, based on the relationship between profit and advertising, this variable is entirely dependent on profit. Reputation of the company is another crucial factor that influences the growth in passenger numbers. Experts believe that if a company's reputation rate is greater than 70%, two million new passengers are added each year, whereas if it is less than 70%, only one million new passengers are added.

Table 4. Social sub-model equations.

Type	Variable	Equation	Unit
stock	Number of passengers	Increase in number of passengers—Decrease in number of passengers + Number of passengers (t_0)	Million People
Flow	Increase in number of passengers	(Number of satisfied passengers × 0.85) + Advertising × Number of passengers + IF THEN ELSE (Company's reputation > 70, 2, 1)	Million People
Flow	Decrease in number of passengers	Number of complaints × 3	Million People

The most significant factor in the last sub-model, the environmental dimension, is energy consumption. The average energy usage, according to Raja's annual report, is between 30,000 and 35,000 thousand litres, hence Equation (3) is as follows:

$$\text{Energy consumption (Thousand Liters)} = \text{RANDOM UNIFORM } (30{,}000, 35{,}000) \quad (3)$$

To accomplish sustainability, Equation (4) calculates the energy cost variable, which affects Raja's expenses. A litre costs 30,000 Rials.

$$\text{Energy cost (Million Rials)} = \text{Energy consumption} \times 3 \quad (4)$$

5. Results

Several important variables and performance indicators were used to demonstrate the simulation findings and assess the system behaviour elicited by the interactions between the financial, social, and environmental dimensions. More importantly, the consideration of inflation rates as well as removing government subsidies in the formation of system behaviour has been discussed to articulate significant implications for the management of railroad transportation in terms of financial sustainability. In order to alleviate the financial crises which railroad transportation companies in Iran have to cope with, the management should change its mode from reactive to proactive managing. Dynamic interrelations should be identified in order to assist railroad transportation managers in solving the problem instead of reacting to it. As a result, in order to achieve financially sustainable management and sustainable transport in general for Raja, the following policies are proposed: 1. taking into consideration the impact of inflation on the model's dimensions, 2. reducing government subsidies that make it difficult for Raja to determine real ticket prices.

5.1. The First Scenario

The impact of the inflation rate is estimated at 20%, 30%, and 40% in the first scenario, in the opinion of transportation experts. Critical aspects including the number of passengers, the revenue from ticket sales, and the profit all vary when the impact of inflation rates is taken into account. The model was run via simulation until 2025, taking into account the alterations listed above.

Following the first scenario, the number of passengers falls when the influence of inflation on ticket costs is taken into consideration (Figure 7). It goes without saying that some passengers may decide not to purchase tickets when the pace of inflation results in rising ticket prices. Raja will not lose many passengers with this new policy because the number of passengers is comparable to the present policy when the twenty percent effect is taken into account. Raja would lose between 5 and 10 million passengers in 2025 compared to the existing policy if the impact on ticket costs is taken into account to the extent of 30% and 40%, respectively, on ticket prices.

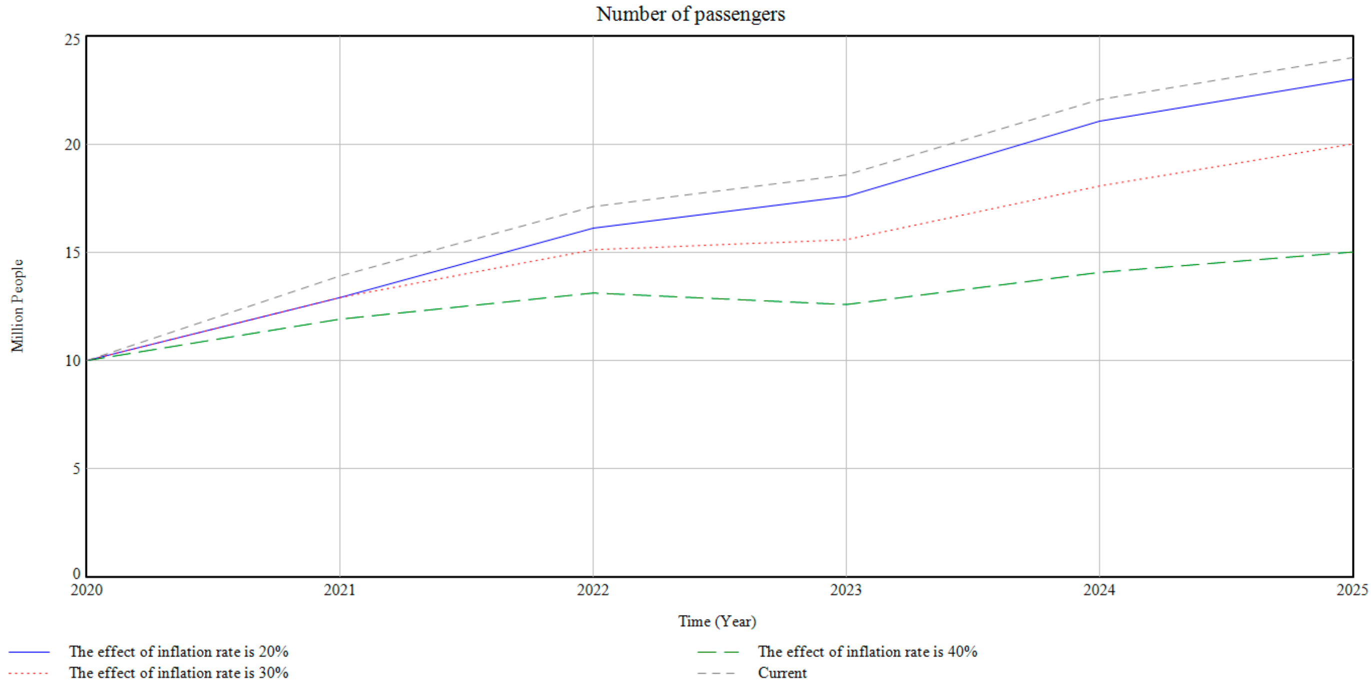

Figure 7. The first scenario—The number of passengers.

The varied impacts of the inflation rate on ticket pricing results in varying ticket sales revenues, as shown in Figure 8. Raja makes a sizable income from selling tickets each year, especially in 2025, when inflation is estimated to be 20%. In contrast to Raja's existing approach, this firm can achieve almost 1,600,000 million Rials in 2025. Nevertheless, taking into account impacts of 30%, Raja may see gains in the initial years up to 2023, but there wouldn't be a significant difference in earnings between the existing policy and the proposed policy in subsequent years. It is certain that the firm would lose a significant number of passengers as well as a significant amount of government subsidies under the proposed forty percent inflation rate, meaning Raja will lose a significant amount of money.

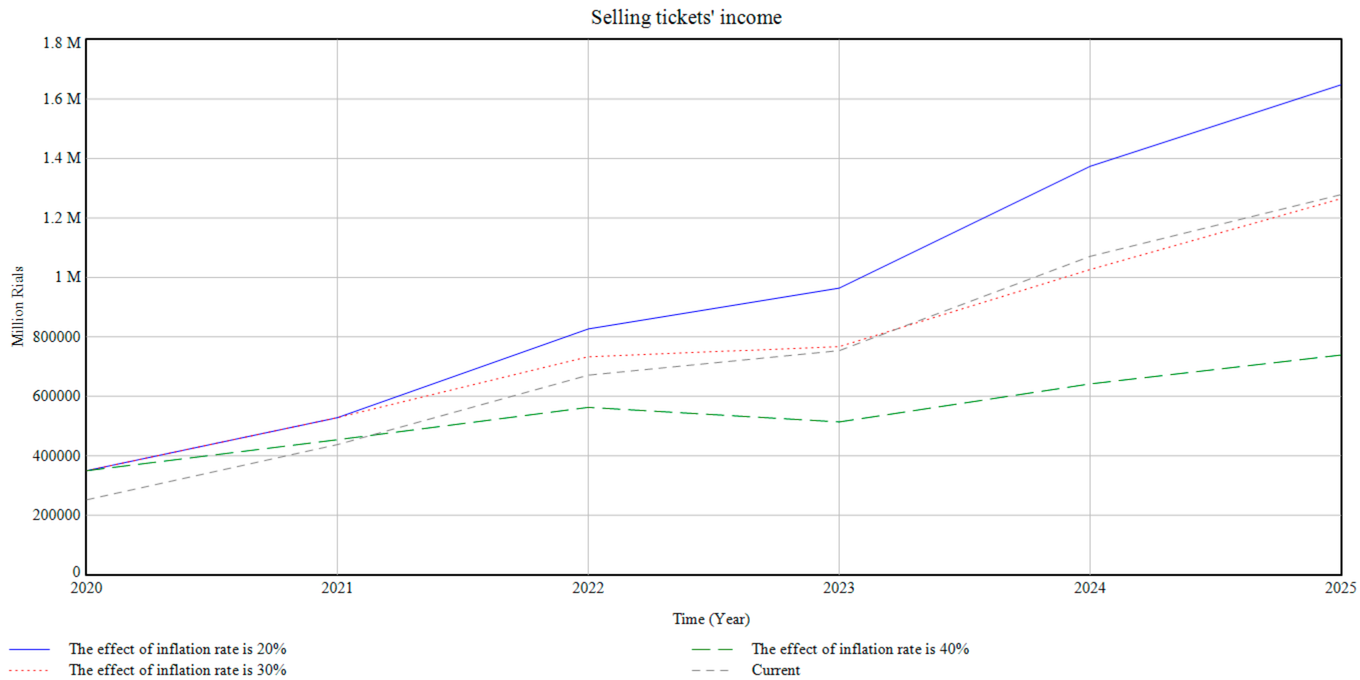

Figure 8. The first scenario—The income of selling tickets.

Profit is the most essential indicator for achieving financial sustainability. For Raja, there would be a significant distinction between various policies. Raja can reach around 5,500,000 million Rials in 2025 if it takes the impacts of inflation on ticket prices into account, as shown in Figure 9. Raja may only expect to benefit in 2025 with the sum of 4,500,000 million Rials with the existing policy, nevertheless. Raja may also generate different profits with the existing strategy by taking the impacts of inflation on ticket prices of 30% into account, but the difference between them is not too great because Raja will continue to lose many passengers. In 2025, Raja can only expect to turn a profit of around 3,000,000 million Rials, so it is clear that the firm would lose plenty of money if it takes the impacts of inflation on ticket prices into account, which is expected to be 40%.

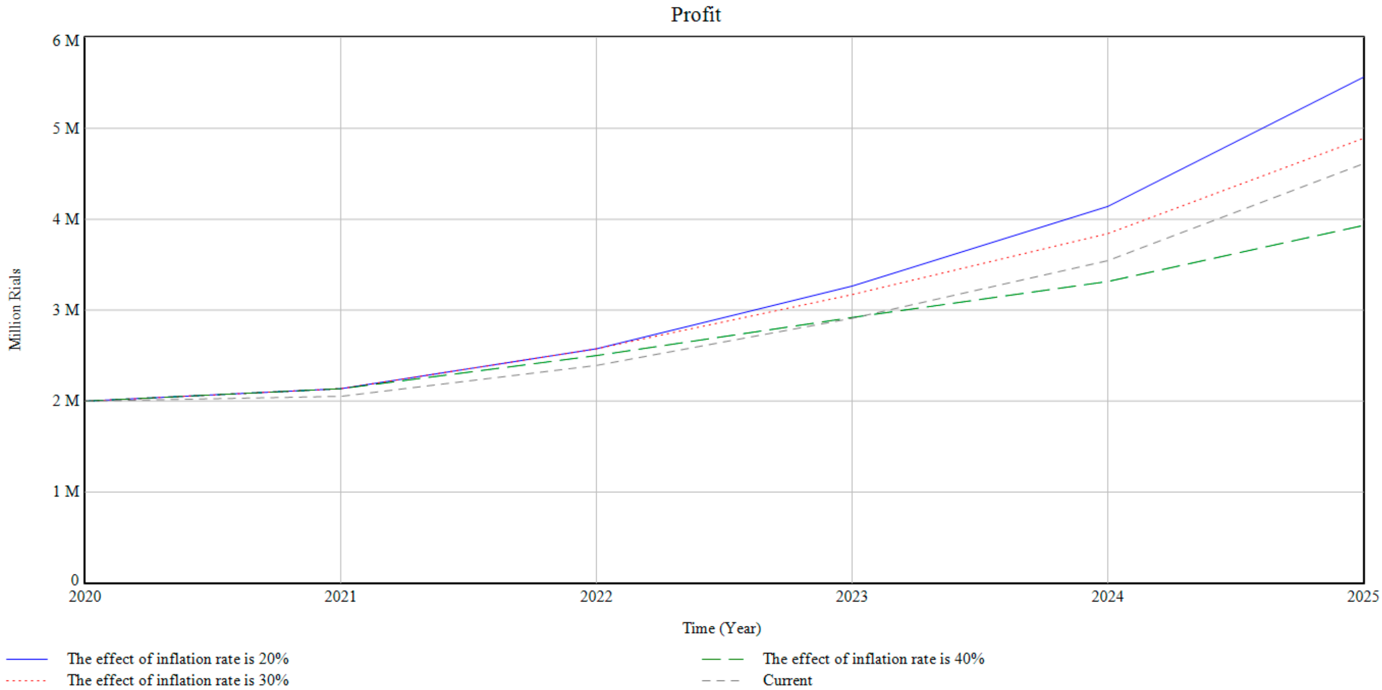

Figure 9. The first scenario—Profit.

According to the findings of the first scenario, Raja can increase earnings in the near future by taking into account the impact of an inflation rate of roughly 20% when determining ticket prices in order to achieve financial sustainability. The impact of inflation rates of 30% and 40%, however, means that other policies will not be able to significantly impact this company's ability to earn profits in the coming years. In addition, one of these policies may result in more losses than the present strategy's ability to generate profits. Table 5 provides a more complete picture of the future occurrence in 2025.

Table 5. The results of the first scenario in 2025.

Indicator / Policy	Number of Passengers (Million People)	Selling Tickets' Income (Million Rials)	Profit (Million Rials)
Current	24	1,270,000	4,610,000
The effect of the inflation rate is 20%	23	1,640,000	5,560,000
The effect of the inflation rate is 30%	20	1,260,000	4,890,000
The effect of the inflation rate is 40%	15	738,898	3,930,000

5.2. The Second Scenario

In the second scenario, another important element that influences profits in considerable amounts is government subsidies. Raja's financial management needs to occlude the increase of government subsidies according to railroad transportation specialist opinions. Subsidies provided to Raja by the government cannot compensate for the losses that the corporation incurs. In order for Raja to be profitable, it is highly advisable to determine ticket prices in actual amounts. In light of this observation, experts believe that government subsidies in this scenario would be reduced by 30%, 40%, and 50%.

According to Figure 10, if government subsidies are dropped by 30%, the number of passengers will decrease by the equivalent of 50% fewer subsidies. The number of passengers decreases by the same amount between 2020 and 2021, but after that, with a 40% drop in government subsidies, the number of passengers exceeds other planned policies. These findings demonstrate that Raja is unable to provide appropriate services at fair prices whenever government subsidies are reduced by 30% and ticket prices rise. As a result, both the number of dissatisfied users and the total number of passengers decrease, much like when government subsidies are reduced by 50%. The number of passengers is quite similar to the number with the existing strategy, though, whenever government subsidies drop by 40%. This outcome demonstrates Raja's ability to set reasonable ticket pricing anytime government subsidies drop by 40%.

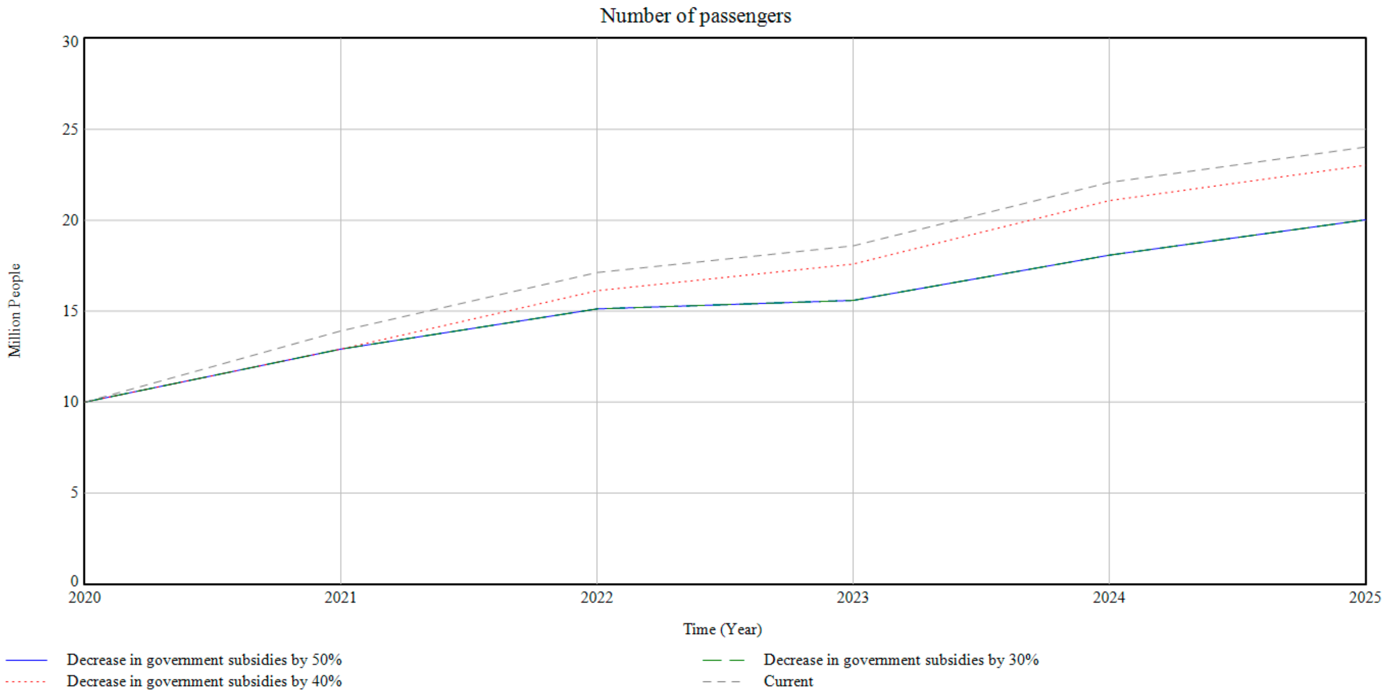

Figure 10. The second scenario—The number of passengers.

Figure 11 demonstrates that until 2022, whenever government subsidies fall by 40%, the income from ticket sales is lower than when they decline by 30%. However, between 2022 and 2025, whenever government subsidies decrease by 40%, the income from ticket sales is greater than other policies. These findings indicate that anytime government subsidies fall by 50%, new ticket prices are presented to passengers, and their amount will be large. As a result, many passengers may lose interest in purchasing tickets at the higher prices, and the profits from selling tickets would fall accordingly.

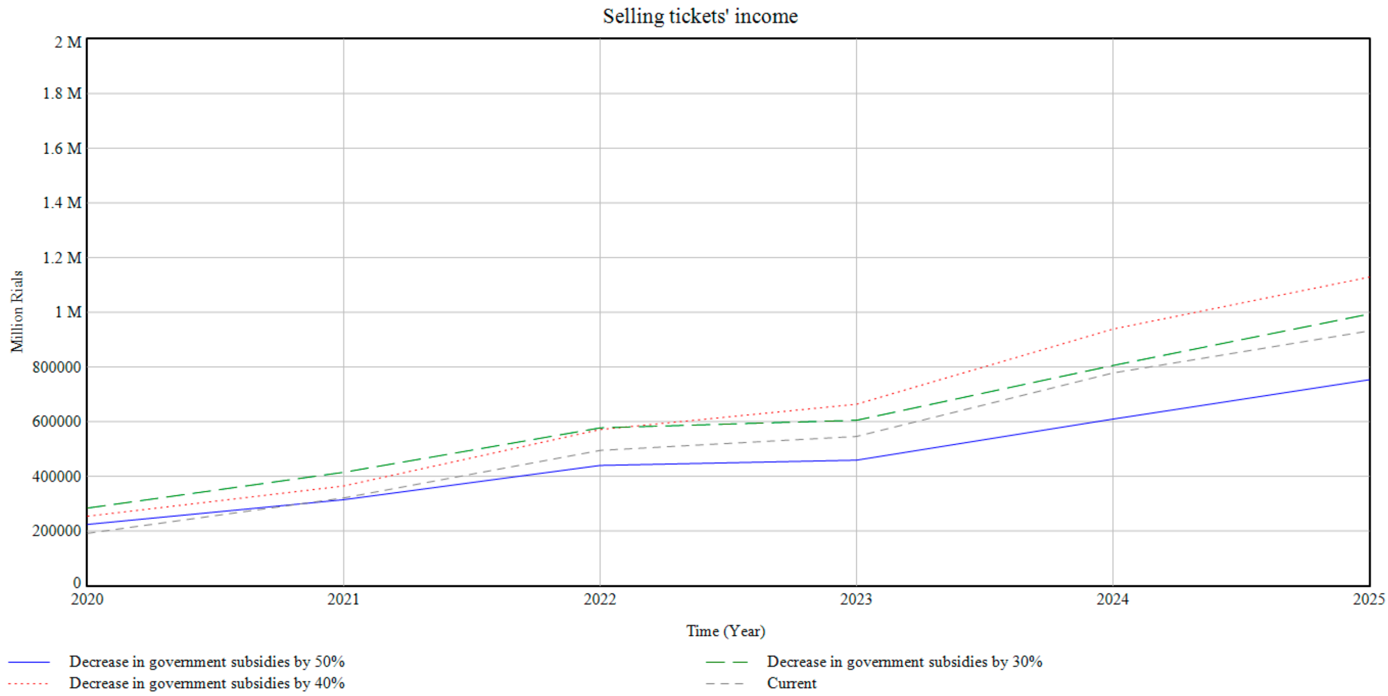

Figure 11. The second scenario—The income of selling tickets.

Figure 12 illustrates that Raja may still turn a profit by reducing government subsidies between 30% and 40%. In 2025, the profit will be around 4,100,000 million Rials if the government subsidies are reduced by 40%, compared to 3,650,000 million Rials with the existing policy. In 2020 to 2025, Raja's ability to make money after cutting government subsidies by 30% and 40% is so close to each other. However, if Raja cuts back on government subsidies by 50%, its profit would be decreased. In actuality, this company's profit in 2025 will be close to 3,340,000 million Rials.

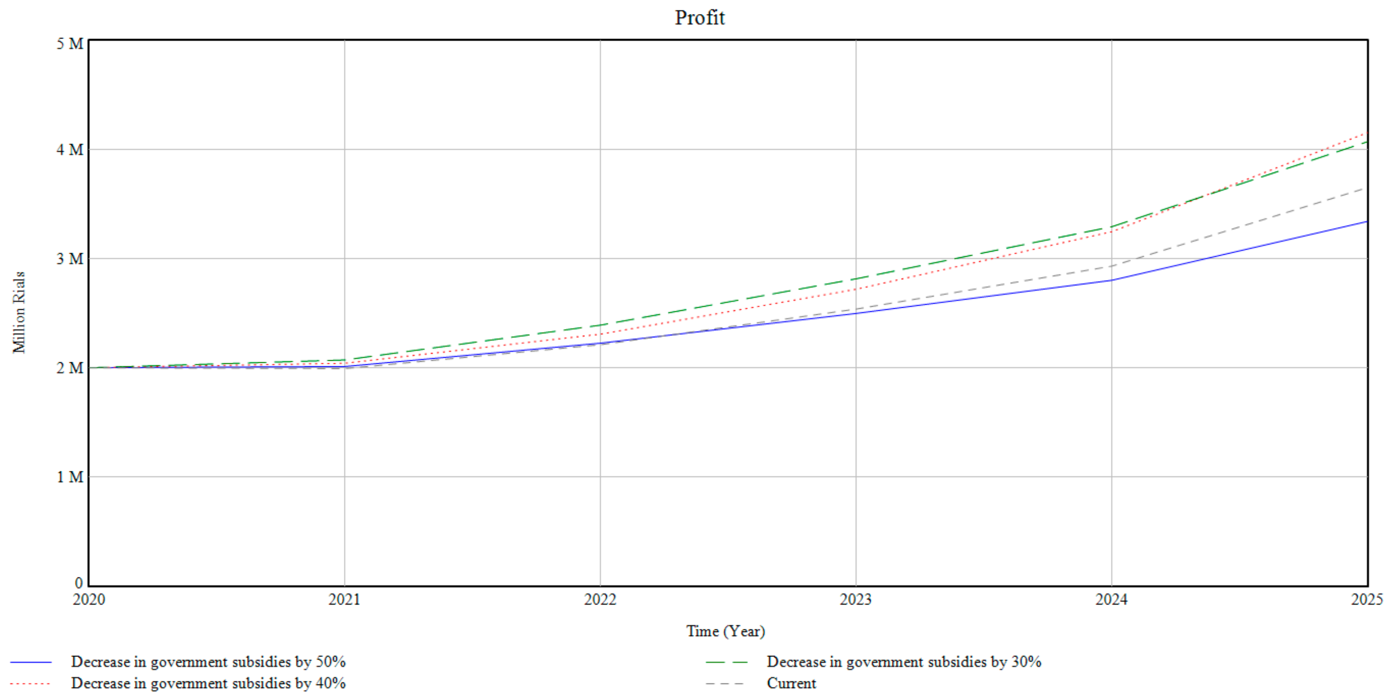

Figure 12. The second scenario—Profit.

The results of the second scenario show that Raja may improve earnings in the near future by cutting back on government subsidies by 30% and 40% and basing ticket prices on that reduction in order to attain financial sustainability. Additionally, reducing government subsidies by 50% would cause larger losses than the current approach is able to make. Table 6 conveys a clearer picture of what will happen in 2025.

Table 6. The results of the second scenario in 2025.

Indicator / Policy	Number of Passengers (Million People)	Selling Tickets' Income (Million Rials)	Profit (Million Rials)
Current	24	932,238	3,650,000
Decrease in the government subsidies by 30%	20	994,122	4,070,000
Decrease in the government subsidies by 40%	23	1,120,000	4,150,000
Decrease in the government subsidies by 50%	20	753,507	3,340,000

6. Discussion

The system dynamics (SD) model designed for enhancing sustainability in railway company strategies integrates a multifaceted network of interconnected processes, individuals, and protocols, among other elements. To effectively manage these factors, a multitude of policies can be established, classified into various categories, and implemented either independently or in conjunction with one another, in parallel or sequentially. Rigorous testing under extreme conditions was conducted to validate the robustness and structural integrity of the model [74]. To evaluate the behaviour of the model under various extreme scenarios, the variable inputs to the model were each set to zero or infinite (about 10,000 times greater than other variable inputs). The model functioned as predicted, according to the results of the testing under severe circumstances. Two tests are provided as examples in this section. Condition 1 assumed that all government subsidies should be stopped, while the other conditions remained the same as in the case study. In these conditions, ticket prices fluctuate greatly. Condition 2 anticipated that the impacts of inflation should be 10,000%, demonstrating a significant shift in ticket pricing. The case study's findings were used as a reference (marked as Condition 0). The results of the two tests are shown in Figures 13 and 14. The income from ticket sales is decreased under Condition 1, but it is still not zero. Furthermore, if this condition started in 2020, the profit would not change much from Condition 0 due to the steady reduction in profit seen in Figure 14. Given that passengers do not want to purchase tickets when Condition 2 has an effect on ticket pricing, Condition 2 would result in a loss of all revenue from ticket sales. Additionally, profit is drastically reduced compared to Condition 0, and if Condition 2 were to begin in 2020, profit would shift to a loss in just less than a year.

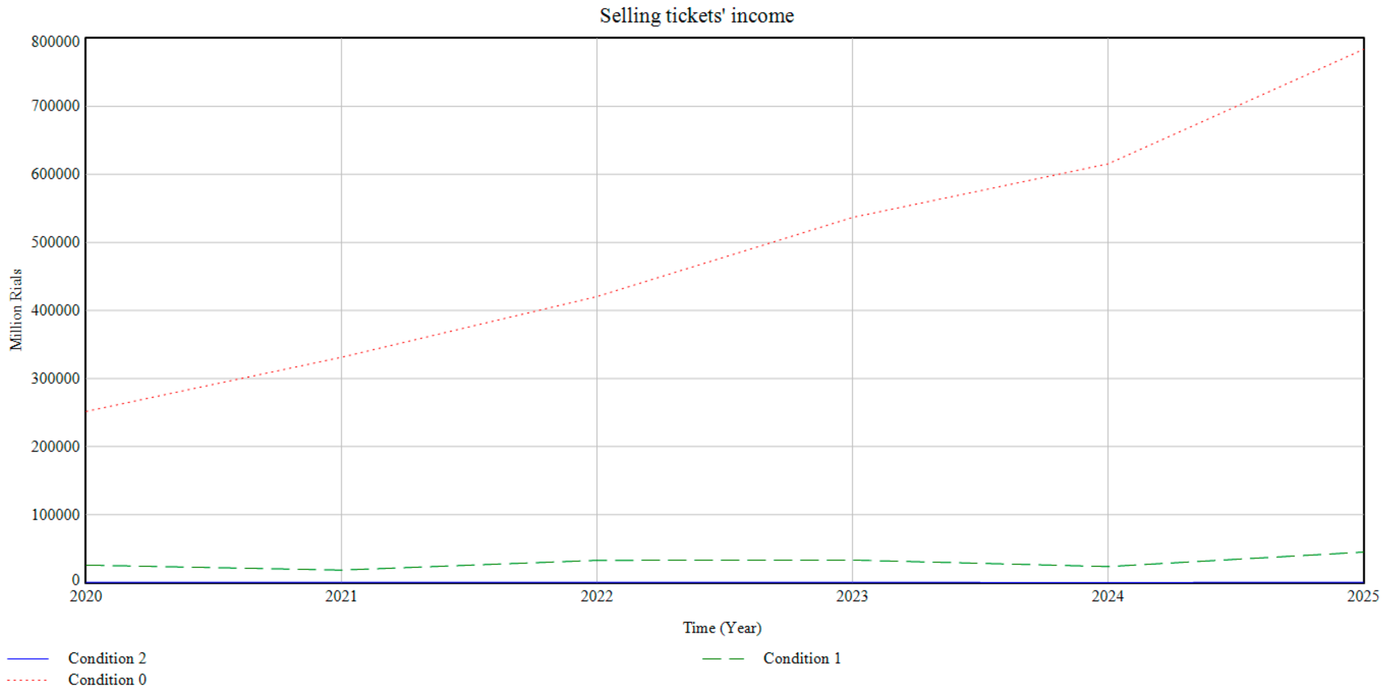

Figure 13. Results of extreme condition test—Selling ticket's income.

Figure 14. Results of extreme condition test—Profit.

7. Conclusions and Future Research Directions

Railroad passenger transportation supports economic and social development which will, in turn, positively influence the quality of life in general. However, in certain countries, particularly in Iran, railroad passenger companies struggle to attain financial sustainability due to specific government policies and a lack of consideration for crucial indicators such as the inflation rate. These factors hinder the ability of these companies to establish a solid financial foundation and impede their progress towards long-term sustainability. The financial issues that Raja faces have multiplied because of inflation and government policies, so what the corporation is in dire need of is sustainable financial management. This approach to management is vital for the effective running of railroad passenger companies. While numerous studies have focused on various transportation dimensions, limited efforts have been made to develop models that can both evaluate and analyse financial strategies within a self-sustaining financial model by incorporating system dynamics into the social, financial, and environmental dimensions. Due to the complexity of the transportation industry, interdisciplinary studies are required to fully comprehend this complexity. This research indicates the role of an increasing inflation rate, its effects on ticket prices and costs, along with reducing government subsidies so as to achieve the financially sustainable management of railroad passenger companies. This study effectively employed system dynamics (SD) modelling to identify and simulate the impact of feedback loops on the management strategies of these companies, showcasing both qualitative and quantitative capabilities. This study illustrates the sustainable financial management of Raja and its complexity because of feedback loops, which show the effects of the role of perspectives on strategies. Causal loops are developed to illustrate the interactions between, the complexity of, and the feedback loops in social, environmental, and financial dimensions in order to model the importance of feedback loops and complex interconnections in management decisions. The impacts of these interactions between elements can be evaluated by using mathematical formulae. The developed and complex system dynamics model for assessing the performance of railroad passenger companies is novel in this study. Different financial scenarios have been conducted to investigate the effect of feedback loops and dynamic interactions on Raja's performance and finances.

The results of the system dynamics model show that considering inflation and government subsidies which have not been considered before plays a significant role in the sustainable financial management of railroad passenger companies. According to the first scenario, the inflation rate, which was formerly not considered to have any effects on ticket prices, has been taken into account in this study in order to determine the real price of tickets. In this scenario, the effects of the inflation rate on ticket prices are 20%, 30%, and 40%, respectively, and the result of this scenario indicates that a 20% increase in the effect of the rate of inflation will lead to conditions in which Raja will achieve a large profit in 2025. As for the second scenario, government subsidies decrease by 30%, 40%, and 50%, respectively, so Raja has to determine actual ticket prices. As a result, if government subsidies decrease between 30% and 40%, Raja will lose some customers, yet profits will be achievable in 2025. However, for considering these scenarios and financially sustainable management, Raja and other railroad passenger transportation companies need to consider new policies. With new policies, Raja's management will be more efficient and practical.

As for future research, reviewing government policies and their impacts on the performance of transportation companies as well as analysing the results should be taken into consideration for effective decision-making, which will lead to the betterment of the reputation of these organizations.

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