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Extending system dynamics simulation and lean thinking for enhancing operational efficiency: a food industry case study

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ABSTRACT

This study examines the operational problems that a mid-sized food production factory faces. It utilizes system dynamics (SD) and lean thinking approaches to analyze various challenges that these companies encounter. Through extensive data analysis and managerial meetings, this study identifies several factors affecting the company's performance: cash management, delivery delays, product quality impact on customer satisfaction, debt burden from raw materials purchase, and poor product planning. Various scenarios are simulated to significantly improve sales' stability and liquidity. This paper offers insights into how effective cash flows can be attained, as well as customer satisfaction, managing debts, and strategic plans that lead to business success. Additionally, the potential for extending SD to address similar challenges in the food industry is explored through detailed financial modeling and actionable plans.

***Keywords**: System dynamics; supply chain; efficiency; lean thinking; customer satisfaction.*

1 Introduction

Lean thinking is a concept that focuses on creating better businesses. One tool used in lean thinking is the Value Stream Map (VSM), which visually represents waste-creating and non-value-adding activities in an enterprise (J. P. Womack and Jones, 1996b). This allows managers to analyze each process for potential pitfalls and remove the identified value wastes to improve the system. Henceforth, a new chart should be drawn to implement the substituted process. However, putting this method into practice along with subsequent remedies may be time-consuming and costly as it involves a lot of organizational efforts (Cavdur et al., 2019). Even though the short-run performance improvements can be huge but still the strategies put into action can lead to dysfunction across the entire value chain in future. There are situations in which improving one process makes the overall process worse. For instance, a company can have its production capacity outdone by market expansion due to significant promotions introduced in sales processes. Consequently, there may be a big backlog, leading to failure to meet customer demand, which ruins the company's reputation, thereby losing customer loyalty. These failures stem from an error in taking on board long-term performance considerations at different units within the corporation so that they work together as a system. This study investigated the challenges a mid-sized food production factory faces. In fact, many organizations and companies have tried to adopt lean thinking, but most of them find it difficult to apply effectively to their complex systems (Singh et al., 2020). This study aims to identify and analyze the key and interconnected factors such as cash management and delivery delays hindering the performance of such companies and to develop practical solutions. This study uses a mix of SD and lean thinking to reach these objectives. SD models how different factors affect the company's performance, while lean thinking finds and removes waste in production. The study identifies challenges and tests solutions by analyzing data and holding meetings. The given approaches work towards minimizing logistic cost or maximizing profit while taking into account different aspects associated with transportation and logistics being parts of complex logistic systems. Although significant developments have been made toward understanding the dynamic nature of production management, combining methodologies that analyze these dynamics with the lean manufacturing concept remains a gap that needs further investigation.

The remaining paper is organized as follows: Section 2 presents the literature review, followed by the methodology of the presented study in Section 3. Section 4 explains the case study. Section 5 presents the results. Finally, Section 6 discusses the study's conclusion.

2 Literature Review

Lean thinking was first used by Womack and Jones (1996) and implemented for the first time by Toyota Motor Corporation, among other leading Japanese firms (J. P. Womack and Jones, 1996a). The main purpose of lean thinking is to study the procedures, identify waste, and suggest steps to change it. Lean has produced a range of tools such as 5S, VSM, kanban, kaizen, total productive maintenance (TPM), single-minute exchange of dies (SMED), cellular layout, and pull production systems which many projects have applied (Abdulmalek and Rajgopal, 2007; Doolen and Hacker, 2005). VSM acts as a key instrument for designing and mapping an improved process that can manage the flow of work well and deliver better service to the customer. Normally lean management is implemented through process mapping using VSM (Cavdur et al., 2019). Many researchers have used it as a graphical map showing information and material flows and activities, among other things, that define a process (Lasa et al., 2008; Michael et al., 2013). A need-based management system is what scholars and practitioners have referred to as the Toyota Production System (TPS), or lean manufacturing. The intention of lean is to create value, which means getting rid of waste to cut costs while simultaneously improving efficiency, productivity, and quality. "Anything that does not add value to the end customer" constitutes wasteful steps in a process; hence, organizations need to eliminate these types of steps in order to provide maximum value for their customers (Singh et al., 2020). Lean also supports a continuous improvement cycle through process enhancement, in addition to customer value creation. Although primarily tried out in the automotive industry, lean thinking has yielded positive results when applied in other service industries, including tourism, banking, and healthcare. However widely it is used across different sectors globally, one major problem organizations face while adopting lean thinking is how managers can effectively implement it within their companies during lean manufacturing. It has sometimes led to expensive failures where there was no strategic or pragmatic way of using this idea; for example, complex organizational systems having interrelated processes and functional areas may create multiple operational interfaces, yet most lean applications concentrate on individual operations only (Chiarini and Kumar, 2021).

In recent years, many studies have emphasized the importance of lean manufacturing to provide customers with high-quality production and services at the lowest time and cost. To establish this concept, five pillars of lean principles were proposed: 1) identifying value for the customer, 2) identifying the VSM, 3) creating flow-oriented activities, 4) establishing pull as a demand-driven mechanism, and 5) pursuing the continuous enhancement (J. P. Womack and Jones, 1996b). The implementation of lean aims to eliminate waste value through both quantitative methods (such as improving the time and space of processes) and qualitative methods (such as improving customer and employee satisfaction, loyalty, and safety) (Lizarelli et al., 2023; Psomas, 2021). According to the literature review, lean research methodologies can be categorized into qualitative and quantitative studies. Qualitative inferences are drawn from observation and hypothesis-making, and several studies have developed qualitative methods for lean, including Action Research and Grounded Theory (Myers, 2019). Survey studies and measurements of financial and production performance can also be associated with qualitative studies (Gupta et al., 2024). Qualitative methods help understand complex problems, though statistical techniques supplement quantitative approaches. In lean studies, there is a lack of empirical research (Badhotiya et al., 2024). Nevertheless, quantitative and qualitative methods have been used to implement lean principles across different organizational levels, from the supply chain to manufacturing (Alinezhad et al., 2019; Karoum and Elbenani, 2018; Lou et al., 2020). In contrast to traditional supply chains, lean supply chain management comprises several basic practices. These are relationship patterns, time horizon for supply chain setup, supplier choice and number of suppliers, technical support, information sharing, and delivery practices (Kosasih et al., 2023). Lean supply chain management refers to the control of material and information flows as well as cooperation among activities along the supply chain to remove waste, decrease costs and business risks, enhance quality, and foster flexibility in all processes throughout the supply chain (Januszek et al., 2024; Leite et al., 2022). Therefore, different studies have concentrated on applying lean thinking in different areas of organizations' value chains or supply chains toward achieving sustainable development within their contexts.

Production planning is important in a lean manufacturing environment to establish an integrated customer service system and production system; it also reduces work-in-process inventory and production line labor (Choi et al., 2023). The organizational culture is like DNA for all human social systems, where values are shared among staff members who connect with each other based on common beliefs and history, thereby shaping their identity through traditions, ways of thinking, and doing things (Badi, 2024). Many references have shown how lean transformation can be connected to organizational culture to create a conducive environment for change and effective social systems (Kerguenne et al., 2023; Leso et al., 2022; Melanie Pfaff et al., 2023). Moreover, researchers' attention has been drawn toward applying concepts related to lean thinking and lean manufacturing on production lines by using simulation techniques to improve efficiency along the assembly line (Aksar et al., 2022). For instance, through simulation methods supported by ARENA software, Murugesan et al. (2021) developed a lean postal service system, thus minimizing the complexity of systems while optimizing operational parameters (Murugesan et al., 2021). To measure the failure and success of organizations in applying lean practices, researchers have made numerous attempts to create appropriate indices. As an example, Khodaei et al. (2014) suggest nine main factors that can help support the implementation of lean production planning based on empirical research (Khodaei et al., 2014). The reason why lean fails is often because they use the wrong tool to solve their problem (Chiarini et al., 2023). These studies do not cover sufficient ground and fail to test hypothetical policies or solutions within an organization's different processes. In fact, these findings can only be experienced and understood when put into practice. Additionally, some adopted solutions may not produce the desired results due to unintended consequences resulting from complex systems (Sterman et al., 2012). Thus, a simulation model provides experimental scenarios for testing and a better understanding of solutions implementations because we can only know them through experiencing them. Some simulation techniques used in this area include discrete event simulation (DES), SD, and agent-based modeling (ABM), which various scholars have employed by conducting research in this field (Gomez Segura et al., 2020; Noto and Cosenz, 2021). SD and ABM modeling approaches consider the complexity of social systems. In ABM, it is about an "agent," while SD is oriented towards feedback. Recently, strategic management research has been focusing on feedback loops and systems behavior understanding as a means for gaining powerful strategic views (Noto and Cosenz, 2021). This view allows managers and decision-makers to see the whole production system dynamically rather than just one process statically, thus addressing the misapplication of lean manufacturing. Therefore, this study examines the application of SD in lean production within manufacturing processes, time, and space management and considers how lean dynamics are integrated across supply chains.

3 Methodology

This study focuses on considering different parts of the supply chain as a complex system and applying lean manufacturing in various segments, along with SD simulation and analysis. Identifying bottlenecks in many companies and enhancing their efficiency can be complex. Therefore, this study applies SD to examine the main aspects of medium-sized companies. This section provides a description of the features and applications of SD in this context. Consequently, we conducted many interviews and data collection activities across the company to gather real information about the challenges this company faces. Furthermore, we extensively designed causal loop diagrams to present and address potential difficulties that lie ahead for the company, with the finalized and abbreviated feedback loops proposed in the following.

3.1 System dynamics (SD)

The basic concepts of SD were first presented by Jay W. Forrester in 1960 (Forrester, 1968). Generally, SD is used to model dynamic problems and incorporate feedback thinking or causal loops, which help users understand the structure and dynamics of complex systems by utilizing system thinking (Sterman et al., 2012). Once the causal feedback relationships between various elements are extracted, SD provides an environment for users to conduct formal computer simulations of the complex system. The structure of an SD model consists of feedback among different sections and variables, characterized by stocks and flows that represent storage, input-output transfers, acquisitions, and so on. These relationships can be either positive (reinforcing) or negative (balancing) closed loops. A negative causal loop demonstrates goal-seeking behavior, in which the system opposes changes in a specific direction or seeks to return to an equilibrium situation after a change is made in that direction (Garzia et al. 2024). On the other hand, a positive causal loop shows that creating a disturbance can lead to further changes in the same direction, and a single positive loop can result in exponential growth over time. Feedback loops are considered a critical factor in every SD model, as they provide a framework for systemic hypotheses and simplify the presentation of the model.

Identifying ambiguity is the primary step in defining the problem. We need to investigate what we do not know about the problem that has hindered companies from growing or limiting their revenue. Once the ambiguity of the problem is determined, it is necessary to choose the appropriate variables for the problem. Choosing the right variables is the first step in constructing a model that resolves this ambiguity. The key aspect of selecting the right variables is that they must have a strong relationship with the identified ambiguity.

Since we develop the model based on these variables, it must effectively address the ambiguity in our problem. So far, we have explained the attributes that the main variables possess. This aspect is considered complete when we clarify how such variables can be selected. There are two techniques to accomplish this: One proper way to determine the main variables is to start with ambiguity and proceed with hypothesis generation. It is important to note that this is a technique, not our goal. Therefore, our hypotheses do not need to be perfect or completely precise (Mashayekhi and Ghili, 2012). We can express multiple possibilities without knowing which of them will occur. Through hypothesis generation, we may discover variables that are hidden within our hypotheses. Another technique is to investigate policies that can be proposed to solve the problem. These policies can stem from our own thoughts or from a literature review. Examining policies implemented in different studies can be effective in understanding their implications. This technique helps guide our thinking in identifying the main variables (Mashayekhi and Ghili, 2012).

After determining the main variables, it is time to depict their behavior over time. These trends and behaviors serve as the foundation of our modeling. In SD modeling, we emphasize the patterns of behavior rather than their exact values. Therefore, we do not exclude variables for which we lack precise information because by eliminating these variables, we would assume they have no effect on the problem. Our model acknowledges their presence by including them, making it more effective. We then present hypotheses to explain how and why these behaviors occur. Dynamic hypotheses are based on feedback loops, allowing us to explain how trends and behaviors are created through causal relationships among relevant variables rather than attributing everything to exogenous factors (Haji Gholam Saryazdi et al., 2020). To test our hypotheses, we must determine whether they can effectively address our problem. In the conceptualization and formulation phase, the modeling process begins. The variables identified in previous sections should be used to create a model that produces the reference behaviors, enabling us to propose policies to shift behaviors toward desired outcomes. Formulating causal loops between variables involves using dynamic hypotheses, followed by formulating relationships between variables (Widiaswanti et al., 2024). During this process, we should improve the constructed model and our understanding of the problem and potential solutions. Each conceptual and mathematical model contains unique insights and agents that may not be present in others, resulting in a bi-directional process of improving the model. As mentioned earlier, the structure of SD models includes stocks (representing accumulations such as inventories) and flows (representing rates such as order rate and discard rate). The final model can be represented through stock-flow diagrams, illustrating interactions among variables. Once mathematically modeled, the stock-flow equations and related equations can be solved numerically through simulation. This study uses Vensim PLE as a simulation tool.

3.2 Data collection

In this study, we collected data based on qualitative and quantitative approaches for a real-world case study. The case study focused on a company that produces high-quality meat products, which are considered among the leading luxury and high-quality products in Iran.

In order to collect the data, we conducted in-depth interviews and a review of technical documents. Data collection and inter-organizational interviews involved various departments of the company, including the production line, packaging segment, inventory, sales department, quality and control department, procurement, accounting, and finance unit. Due to difficulties in distributing questionnaires to different groups within the company, semi-structured and oral interviews were conducted with a range of participants, from managers to workers. Given that the major issues faced by the company revolved around customer retention, customer loyalty, the negative impact of recruiting an inexperienced workforce, and insufficient liquidity, the questions were designed to gather data specifically related to these issues. Many businesses become inefficient due to these challenges, eventually leading to bankruptcy. Such being the case, then, it follows that what needs to be discovered through inquiries is respondents' awareness concerning such matters depending on their work experiences as well as understanding risk perceptions and risk management strategies applied during different processes. Examples include: 1) What causes ordering and product supply delays? 2) How do teams interact among themselves within an organization? 3) For how long does product delivery take? 4) Weekly, how many mistakes are made? etc. To prevent unintended misunderstandings, some interviews were repeated thrice throughout the four-month duration, while others were not duplicated at all because they yielded similar findings too soon. These interviews became the basis for this research and subsequent steps towards solving the problems identified. To get a complete understanding of this company's problems, the study also collected technical documents along with interview data. These records were divided into two types. One type is report-based documents, including weekly production line reports, sales reports, inventory records, etc.; another type is result-based documents, such as technical schemes, production documents, instructions, and checklists etc. Additionally, it took 32 products' information into consideration when analyzing faults in production lines and packaging lines. More than 45 files were used as raw data selection in order to find out causes that contribute to difficulties met by the corporation and understand them deeply.

3.3 Dynamic lean implementation

This company implemented lean practices in three steps: preparing for lean, SD analysis, and lean operation and control. The first step involved all the prerequisites and initial actions required to apply lean principles. The second step encompassed the analysis of the developed model, diagnosis of the results of initial actions, and assessment of the current state of the system to prescribe remedies for the identified issues. In the third step, the actual implementation of lean practices took place after dynamic evaluation and analysis of the consequences of the prescribed actions. Figure 1 illustrates the dynamic lean approach used in this company. This study aims to reconstruct and develop lean actions. The initial response included replacing the sales manager, implementing alternative management strategies for the sales team, and improving collaboration between the production and marketing teams. However, the presence of inexperienced personnel in the marketing team and inconsistency with other departments led to human errors and jeopardized the company's reputation. These challenges were viewed as an opportunity to adopt a new approach to management with a focus on waste reduction. Therefore, a tool was created to analyze production line errors, sales, and inventory, and a continuous control and analysis of the required ingredient quantities for weekly production was implemented. These actions aimed to reduce waste in the production process and identify the underlying causes of inefficiencies in the system. The pre-preparation phase of the lean implementation also involved work studies to measure the time required for various manufacturing procedures, including the packaging system, production line, and other parts of the internal supply chain. The objective was to achieve the highest quality output in the minimum possible time and identify the most effective utilization of industrial resources, such as workers, materials, machinery, and finances. As a result, several inefficiencies in the production line and packaging process were identified.

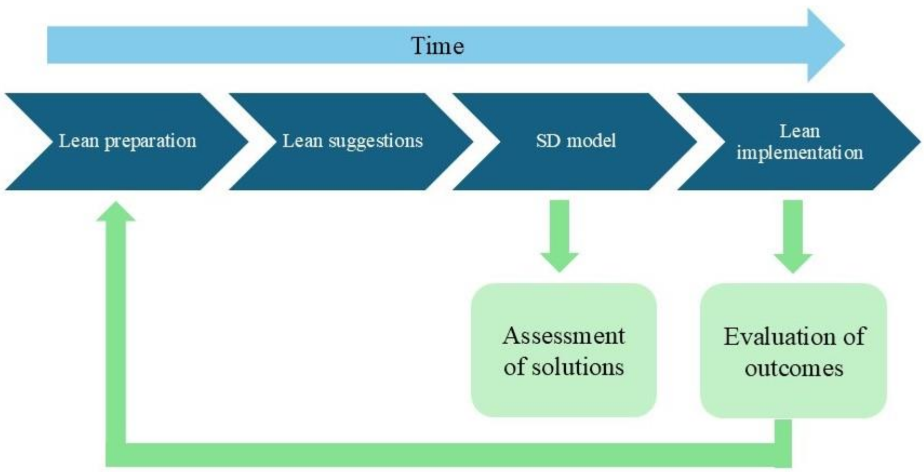

Figure 1. Schematic of methodology used for implementing lean practices

3.4 Causal loop diagrams

Figure 2 illustrates a closed-loop diagram and factors that affect customer satisfaction. Understanding customer loyalty has been known as one of the key factors for management and marketing. Customer satisfaction and, as a result, customer retention are considered the aim of businesses that are completely linked with the profitability of an enterprise. Customer satisfaction is almost based on customers' positive attitude towards the company (Noone et al., 2016). In order to measure customer loss, we have taken four factors that have major effects on customer satisfaction. These factors include the quality of products, delivery delays, promotion, and the efficiency of the workforce. Investigations and interviews provide some evidence that delivery delay contributes to customer dissatisfaction, and reducing delivery duration might result in a favorable outcome. Therefore, not focusing on this factor can diminish the company's revenue (Hesamamiri and Bourouni, 2016). Better-quality products increase customer satisfaction and, consequently, customer loyalty. On the other hand, increasing the order can put excessive stress on the production unit and decline production quality, affecting customer satisfaction (Saputra and Djumarno, 2021). In turn, the impact of excessive order on the efficiency of workers can be considerably tangible, and it might be intensified due to recruiting an inexperienced workforce. Thus, customer dissatisfaction is affected by successive errors that staff make, causing a loss of profitability. Promotion and advertising can effectively change customers' attitudes towards the company's image. The lack of income impresses the decision of the manager to allocate the budget to promotion costs, and it brings about the decreasing sales.

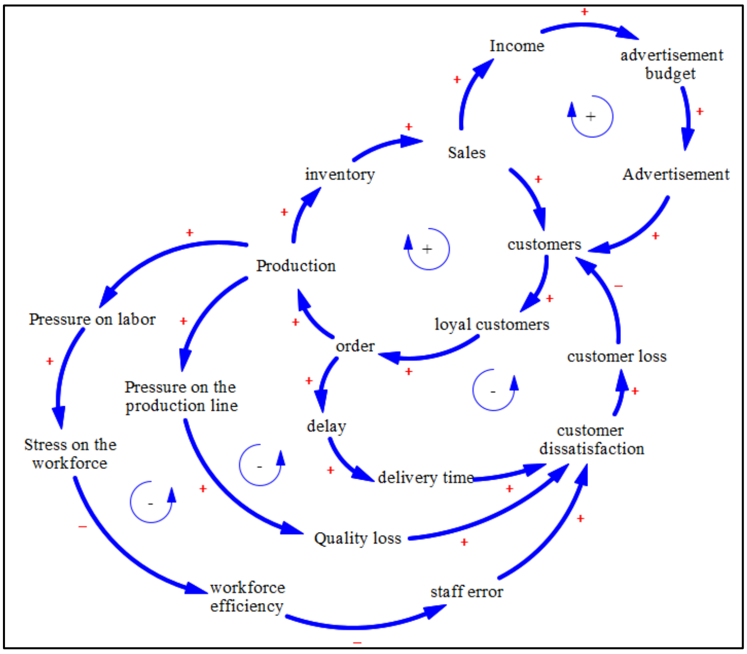

Figure 2. Customer satisfaction causal loops

Figure 3 shows the effect of having access to cash resources on the supply-chain part of the company and following that sale rate. Companies' cash flow can be influenced by changes in demand and the number of customers. So, increasing demand from new or loyal customers raises the production rate so that in case of a lack of cash flow, the company can counter a lot of different financial requests (Schaarschmidt, 2016). From a social perspective, customer satisfaction highly depends on their expectations in the sense that increasing the customers' expectations directly results in the gap increase, which stems from a difference between the expectation and the perceived service (Yeon et al., 2006). Furthermore, increasing the number of customers means that the quality of services is lessened because of the underinvestment archetype. In return, both changed expectations and low service quality create a significant gap and, consequently, a decline in customer satisfaction. The initial causal loop diagram that we produced before selecting and modeling some of its elements is presented in the appendix.

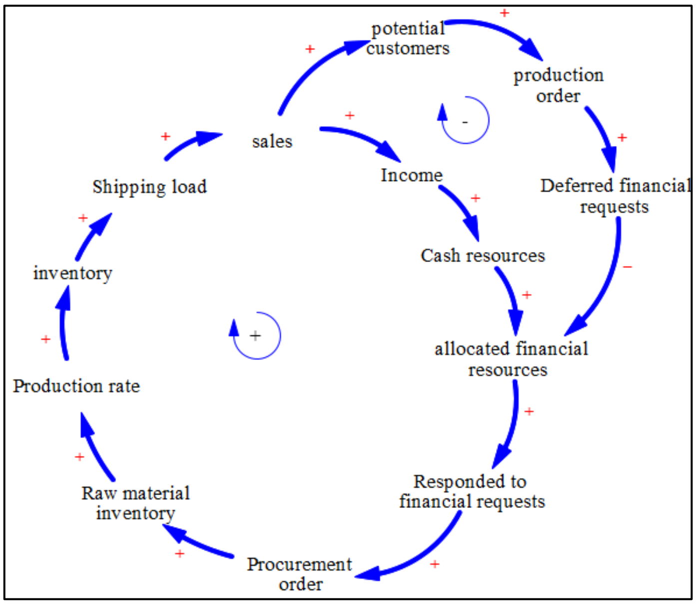

Figure 3. Supply chain and liquidity causal loops

4 A Real-World Case Study

The presented research approach and methodology have been applied in a management system of a company in the meat products industry in Iran. In 2019, Toutia Fard Zanjan was established as a company that produces high-quality processed meat. The firm sought to carve a niche for itself in the Iranian food industry by capitalizing on this vision of satisfying the ever-increasing demand within the market. Although they had big ambitions, there were many difficulties faced by Toutia Fard Zanjan:

1. Marketing and Sales: One of the biggest problems they have is their marketing strategy or sales process - how do we get our products out there? This includes things like reaching out to who would buy from us most effectively and where we should place ads so people can see them. These are all areas that need to be addressed if this goal is going to come true.

2. High Production Costs: Always trying to keep costs down while still maintaining quality standards is something that does not end. Therefore, this company tries its best to have good enough processes in order not only to produce top-notch processed meats but also to optimize every step thereof.

3. Product planning: Having a wide range of products on offer often calls for careful thought during the conception stages. What does each target customer want? What is currently trending in these markets? Such questions must guide Toutia's selection procedure for new additions to its already existing lineups since they desires nothing short of aligning consumer needs with prevailing market dynamics at any particular time.

4. Liquidity Problems: Adequate working capital is necessary to achieve long-term goals characterized by sustainable development. However, due to limited cash flow, situations may arise, thereby impeding normal operations within Toutia Fard Zanjan.

To address these issues, Toutia Fard Zanjan conducts frequent managerial meetings. These sessions are forums for brainstorming, problem-solving, and devising effective solutions. By analyzing data, exploring innovative approaches, and collaborating across departments, the company seeks to overcome obstacles and enhance its performance. After conducting thorough investigations, it appears that various factors, such as inventory management, production planning, and liquidity management, significantly impact the improper performance of the system. Ultimately, we have identified more influential factors, which we will delve into below. In addition to improving inventory management and project management, rising customer satisfaction has been considered one of the main purposes of constructing the proposed stock flow in Figure 4 (block 1). In order to measure customer satisfaction, four effective features that can change customers' perceptions have been weighed. These factors include quality of production, delivery delays, promotion, and the efficiency of the workforce. The intensity of each one was extracted through questionnaires. Understanding customer satisfaction can be challenging for companies. Due to the fact that the nature of customer behavior is dynamic and survey research is incapable of accurately anticipating the actions of customers and their effect on the performance of the company, the research has been severely complicated (Noone et al., 2016). Traditional methodologies have applied econometrics methods to show consumer loyalty and satisfaction; however, we presume that these models are insufficient for studying the complexity of such systems. Figure 4, block 1, illustrates the constructed model for the manufacturing process, in which material is ordered based on demand forecast along with the customer satisfaction that affects the orders during each period. In the real world, the distribution networks send their orders to the production segments to receive their goods according to the given order. So, until the delivery of an order, they remain in the procedure.

Figure 4 (block 2) demonstrates the simulation of backlog and market reaction to delivery delay. The resources of a company can be paired with the desires of customers through marketing. It acts as an interface across which services, data, money, and staff can be transferred. However, these transitions are the efficacy of interactions within the company and the market (Forrester, 1968). In this section, we aim to identify the underlying causes of stagnation in sales growth despite having access to an unlimited market. In fact, we are coping with a system where sale stagnation stems from delivery delays, indecision over investment policy, and customer satisfaction. Delivery delays have an adverse effect on the sales effectiveness and can make the sales effectiveness impotent in the sense that the revenue generated from sales is no longer able to exceed the current expenses. The criterion of delivery delay in this study is given by the ratio of backlog to the order in production. Indeed, the time that is required to fulfill an order is represented by a comparison between the delivery rate and the order backlog. However, this lag normally does not reach the attention of managers within the system. The delivery delay identified by the company is the shortage of just-in-time inventory which can be seen as an outcome of the ratio of inventory to sending goods. Cash management has proved to be one of the main factors that directly influence all aspects of a company. In this system, liquidity control is considered a bottleneck that should be rectified. The lack of liquidity in this system has resulted in the company's insufficient ability to fulfill short-term obligations. Creating a cash budget is of great importance for managing and predicting short-term financial issues. Modeling the cash budget as input and output flows allows us to determine the courses that company encounters surplus or shortage of cash (Hou et al., 2011). In this way, the effectiveness of solutions can be scrutinized, and optimal policies can be withdrawn to confront this problem.

Figure 4 (block 3) shows the stock flow diagram of planning and organizing the cash flows. From a system analysis view, the cash flow depends on not only the financial unit but also the project management unit, procurement unit, and sales unit, which are all coupled together. Facing an inadequate cash budget might give rise to the postponement of payments for the workforce and buying materials. This raises a lack of motivation for workers and creates a delay in the system that intensively affects consumer satisfaction, and following that, it can alter the efficiency of the workforce. In these circumstances, inexperienced staff have a negative effect on the performance of experienced staff, and consequently, it can decline the total efficiency of workers and increase their errors.

5 Results

The results of this study encompass trends in the sales and liquidity of the company on a weekly basis. The x-axis shows Time (Week), and the y-axis shows Kilogram (Kg) and Toman, representing sales and liquidity, respectively. Figures 5 and 6 indicate the trends in sales and liquidity during different weeks of the study. According to the simulation, sales are estimated to remain at about 2000 kg per week which is expected to rise up to 3000 kg slowly under the current conditions. Nevertheless, in the 40th week and later, sales will decrease by 1000 kg, thereby making production uneconomical. Following the sale result, the liquidity also fluctuates around 200 million Toman before week 40.

Consequently, liquidity will steadily decline due to a lack of input cash flow. Considering what is demonstrated in the results, continuing the current conditions, including maintaining the market in current areas, lack of production capacity increase, and production unplanning, lead the trend to decline entirely. Any sudden drops in sales are not only due to decreased demand but can also reflect issues in inventory management or supply chain disruptions. The declining trend can also raise concerns about customer retention. It could be beneficial to investigate if customers are not returning or if customer satisfaction is decreasing.

In addition to the cause-and-effect relationships associated with customer satisfaction that affect sales, two vital factors have also been identified in the system: receivables and the repayment rate of debts resulting from purchasing raw materials. These two factors directly impact liquidity and, ultimately, access to raw materials. To improve this, it is suggested to enhance the receivables turnover time by reviewing contracts with buyers. Additionally, whenever possible, purchasing raw materials on credit is proposed. Implementing this scenario and improving these two factors in the model results in overall trends similar to those depicted in Figures 5 and 6. Although the trend remains downward due to other influential factors in the system causing sales and liquidity to weaken, this action will delay the system's failure and significantly revive liquidity within the system. Figures 7 and 8 represent the level of sales and liquidity under conditions of improved receivables turnover time and the possibility of purchasing raw materials on credit.

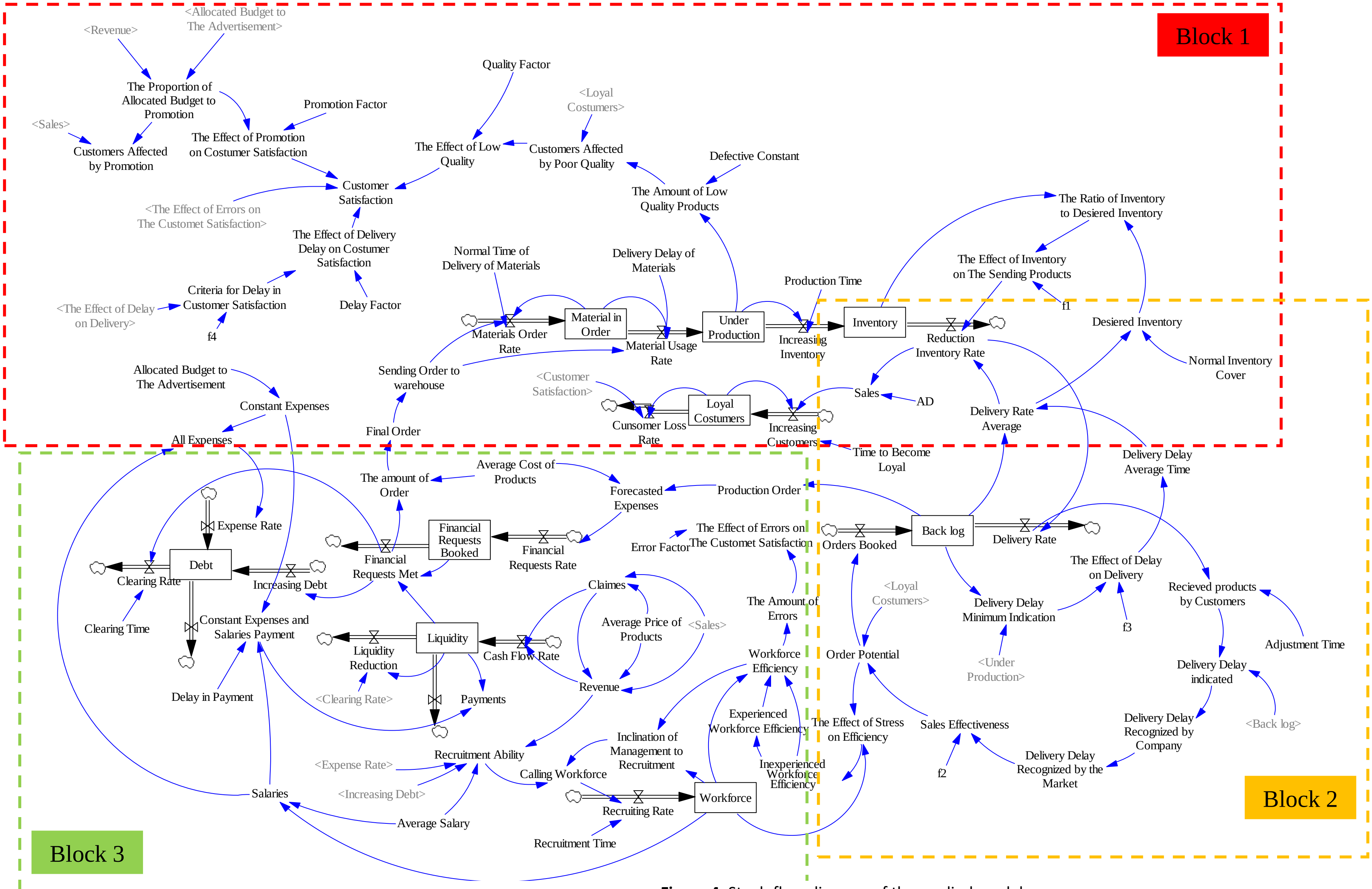

Figure 4. Stock-flow diagram of the applied model.

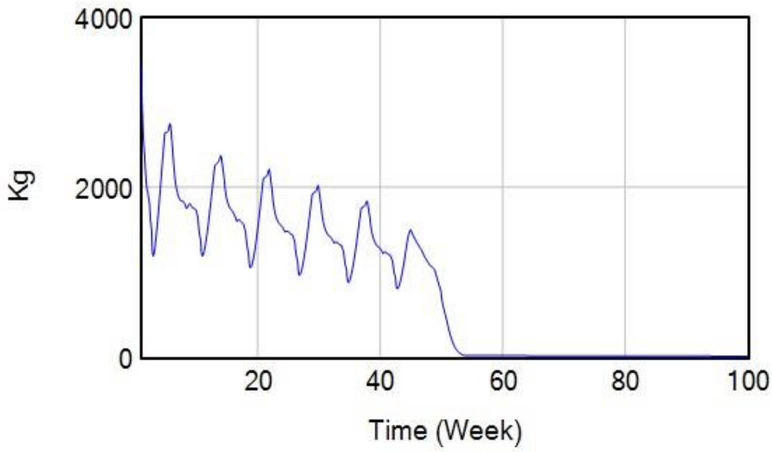

Figure 5- Forecasting sales assuming the continuation of the current trend

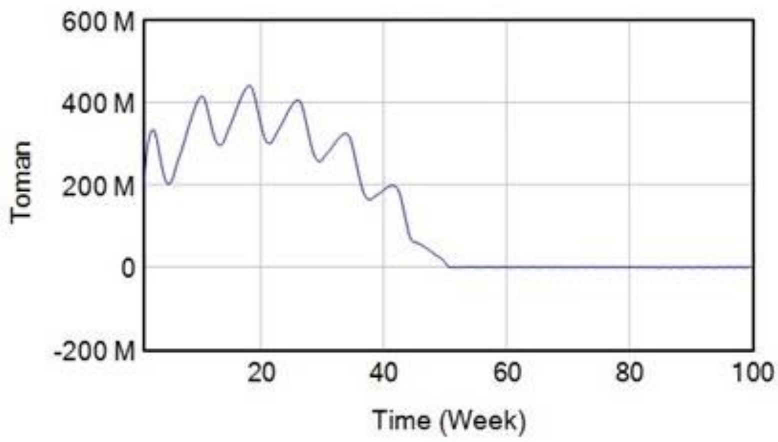

Figure 6. Forecasting liquidity assuming the continuation of the current trend

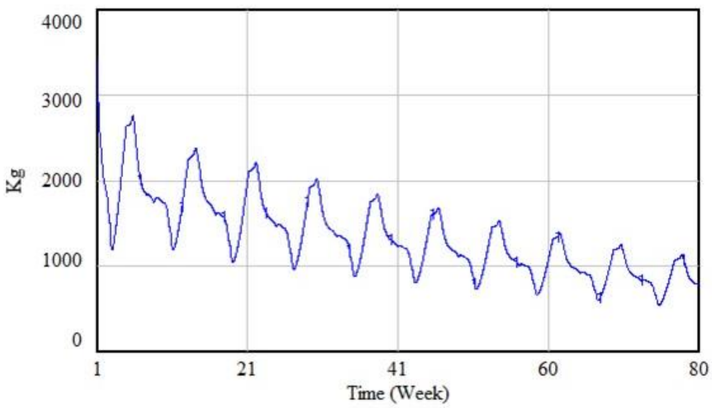

Figure 7. Forecasting sales assuming improvement in payment conditions, accounts receivable recovery, and raw material purchase.

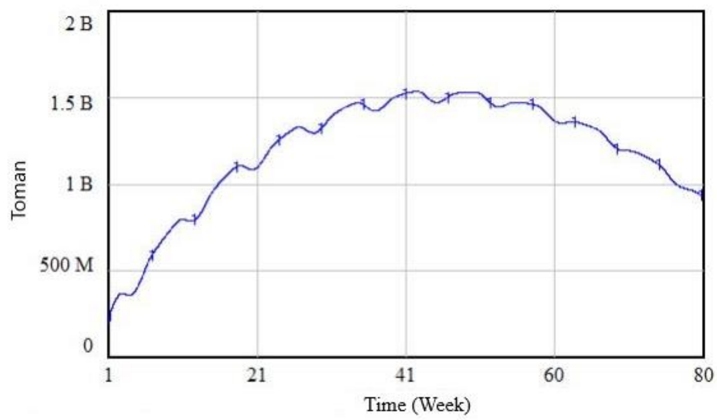

Figure 8. Forecasting liquidity assuming improvement in payment conditions, accounts receivable recovery, and raw material purchase.

Given that among the influential factors on customer satisfaction, two factors, namely delay in delivery and the quality of the products produced, have a greater impact on customer satisfaction than other factors, improving the situation of these two factors can lead to better results, which requires improving production planning and also planning to improve periodic precautionary reserves. Therefore, to achieve these solutions, capacity is needed to improve production conditions. Implementing this scenario will result in more sustainable customer satisfaction and even lead to an upward trend in sales conditions and the future trajectory of the company, as illustrated in Figures 9 and 10. On the surface, establishing a warehouse in Tehran might seem like a solution to the delivery problem. However, our analysis of the model suggests this will not be a permanent fix. Simply shifting the issue from Zanjan to Tehran (roughly 400 kilometers away) will not address the root cause. It will only lead to a temporary increase in production, with similar problems resurfacing soon after. While a Tehran warehouse is necessary, a more permanent and cost-effective solution requires two fundamental changes not currently considered in the model. These are, based on our analysis, suggestions for improvement:

- Define a periodic safety stock for each product.
- Implement production planning.

Prioritizing customer retention necessitates focusing on resolving cargo delivery delays and controlling product quality. Figures 9 and 10 illustrate the impact of improving these customer satisfaction factors on sales and liquidity, assuming scenarios with 30%, 40%, and 50% improvement.

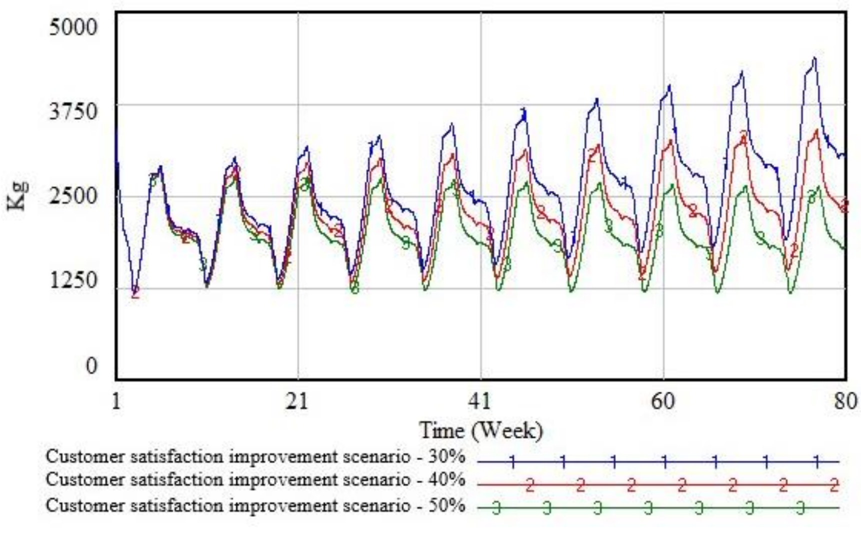

Figure 9. Forecasting sales under customer satisfaction factors improvement scenarios

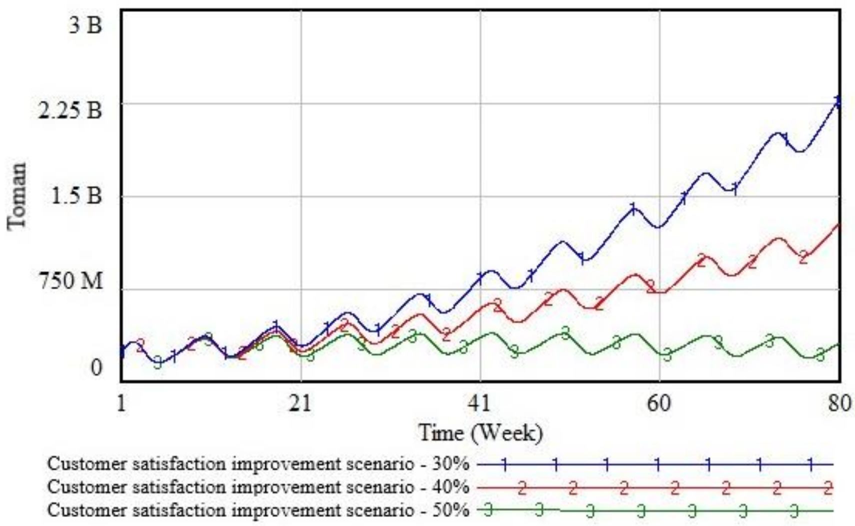

Figure 10. Forecasting liquidity under customer satisfaction factors improvement scenarios

6 Conclusion

In this paper, we employed SD methodology to investigate the challenges experienced by a mid-sized production industry, one of Iran's leading processed meat producers. The company had many problems, which ranged across various dimensions. Our findings revealed that five related factors impeded the company's performance:

1. **Cash Management and Liquidity Control:** The organization's entire operations were constrained by a cash flow shortage and liquidity problems, which were identified as a foundational drawback. Sustainable financial health requires adopting effective cash management practices.

2. **Delivery Delays and Product Quality Impacting Customer Satisfaction:** A negative feedback loop has been discovered in which delivery delays compromise product quality, leading to unhappy customers and possibly lower sales. For trust in buyers and customer loyalty, it is vital that this problem be rectified.

3. **Debt Burden from Raw Material Purchases:** The company's reliance on raw material acquisition through borrowing was established to be unviable, potentially able to curb liquidity for other essential areas. Ensuring financial processes are well organized is important for the organization's stability and progress.

4. **Low Sales Leading to Low Income:** One factor contributing to insufficient sales volume is the lack of funds for reinvestment in areas such as marketing and product development, which perpetuates low sales rates. Strategies to increase marketing coverage and sales volumes were needed.

5. **Inadequate Product Planning due to Limited Sales Infrastructure:** The lack of sales infrastructure that is well established has a hampering effect on effective product planning, hence possibly limiting the company's ability to meet market demands. In order for planning to be effective, there must be adequate infrastructure and strategic foresight.

By applying SD and lean thinking methods, we simulated the system and problems under two distinct scenarios designed to achieve a significant "game change." These scenarios aimed to address the identified issues and achieve improved sales volume and enhanced liquidity. This research offers valuable insights not only for Toutia Fard Zanjan but also for the broader Iranian food industry and potentially the global market. By employing the SD method to understand the interconnected nature of business challenges, food producers can develop more holistic and sustainable solutions for improved cash flow, customer satisfaction, debt management, and strategic planning. This research enables other researchers to investigate the precise methods of applying the suggested scenarios. Dynamic food firms can maintain growth and avoid eventual collapse by actively dealing with triggers and making systematic enhancements. Moreover, more future studies could elaborate on the financial modeling of these cases in more detail as well as develop complete action plans for their implementation. In addition, this SD research approach can be used to analyze similar issues faced by other companies in the food sector. We hope this paper will be a launch pad for positive changes in the Iranian food industry, encouraging further studies to enhance global market success in food.

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Appendix

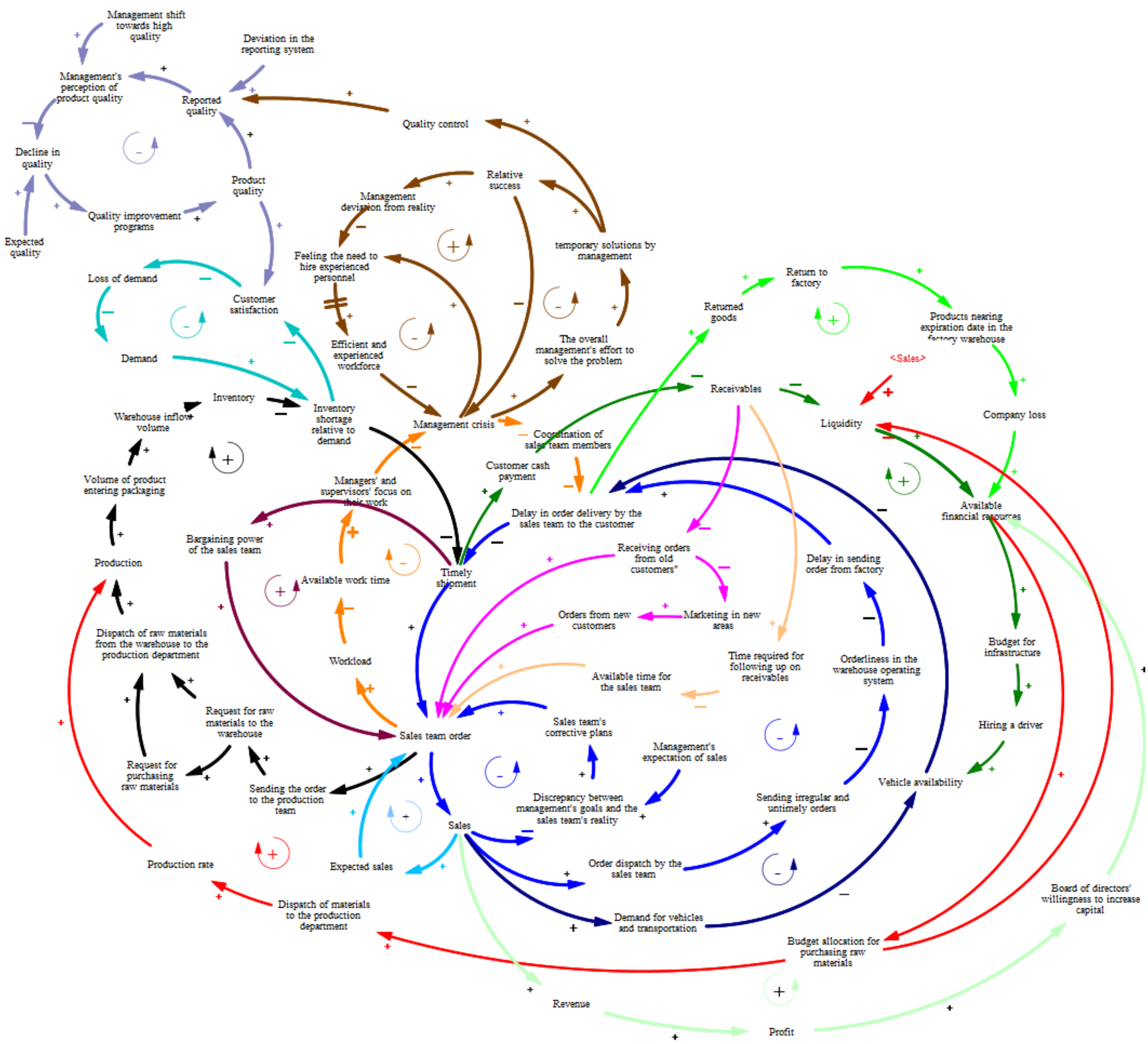

Figure A1. An initial causal loop diagram developed to formulate the problem and provide an overview of the company's system