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Diagnose of heavy leather industry supply chain using a system dynamics approach

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Abstract

Supply chain management is an efficient approach for reducing production costs and shortening waiting time. Field method and interview tools were used to identify variables and reference patterns, and the history and background of the issue were examined with the documentary method. This study aimed to present a model of problem-solving in the supply chain of the heavy leather industry with a system dynamics approach. The documentary method examined the reference patterns and the history and background of the problem. This study was conducted on 302 active and semi-active productions, including 162 heavy leather industry managers and business owners in Charmshahr Tabriz (Split) and 140 in cow leather. The analysis method was the simulation of system dynamics by VENSIM software. The decrease in the supply of cow rawhide increased the bargaining power of intermediaries and brokers in selling rawhide. It reduced the bargaining power of leather trimmers for the supply and purchase of rawhide. The supplier forces the buyer to sell the rawhide at any price and quality by reducing the bargaining power of supplying the rawhide. Therefore, the price of each kilo of rawhide increased thrice in the last two years due to the decrease in the supply of rawhide.

Keywords: supply chain, system dynamics, heavy leather industry
2020 MSC: 90B06

1 Introduction

The supply chain of the heavy leather industry includes cattle [1], calf [2], and buffalo breeders [3, 4, 5, 34], industrial slaughterhouses and manual harvesting, storage and distribution of heavy raw hides, manufacturers of leather and semi-finished products, and marketing, distribution, and sales, manufacturers of bags and shoes and other leather products, and the final consumer [6]. Being in the market is not enough to improve the process and flexibility, suppliers must also provide quality materials and the lowest cost [7]. Distributors should also be closely related to the manufacturer's market development policies [8]. Approaches to the supply chain and its management came into the field with such an attitude [9]. Regardless of each company's financial and managerial independence, increasing the effectiveness level in the entire supply chain is desired [10, 11, 12, 35]. Financial communication is such that all the companies or organizations that make up the chain links benefit from its results [14, 15]. Supply chain management

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is an efficient and effective approach that reduces production costs and shortens waiting time [16, 17, 18]. This approach facilitates providing better services to customers and ensures effective monitoring of transportation systems, inventory, and distribution networks [19]. In this way, the organization can exceed the expectations and demands of customers [13, 19, 23, 26]. Supply chain management using information technology integrates suppliers, manufacturers, and distributors to effectively meet customer needs [20, 21, 22, 25]. Integrated supply chain management for the provision of raw materials, movement of materials between equipment, manufacturing of goods, the final distribution of consumable goods, and after-sales support through improving the relationships of chain members and controlling and directing the flow of goods and services optimally [28, 31]. Dynamic System Modeling (DSM) has been widely used in various topics and issues, and thousands of articles have been presented in various fields [32]. System dynamics is a perspective and a set of conceptual tools that help us understand the structure and dynamics of complex systems [33]. A skilful modelling method that has given us a unique capability in understanding systems in computer simulation and has a high capacity and power for developing strategic, macro, micro, and inter-sectoral planning. Skilful modelling leads to the design of effective organizations and policies, and a large variety of components and variables can explain, predict, and monitor structures and behaviours [3].

The modelling process in systems dynamics includes five stages, and the results of each stage can lead to revision and revision in each previous stage [27]. The first step is to state the problem and choose the framework or boundary of the model [29]. Mental models are linked to the real world by formulating and forming equations. The fourth stage is to evaluate and test the model by software, and the last step is to design and assess policies and scenarios [30]. There are about 302 active and semi-active units in cow leather and split in Tabriz, and the share of Tabriz in the country's leather production is about 60%. Since the leather industry is an industry that has been around for a long time and contributes significantly to both employment and production, it is essential to identify the factors that have prevented the growth of this industry [36]. Salehi et al. [35] deals with the challenges of strategic planning of the leather industry and the position of the Iranian leather industry and examines the global trend of the leather industry with a strategic approach [37]. This study analyzed the industry environment in detail and provided strategic directions by formulating strategies and using the evaluation matrix of internal and external environmental factors. First, the strategic areas of the leather industry were identified [38].

Then the relevant information was collected and analyzed. Finally, 12 short-term, mid-term, and long-term strategies and solutions were presented. Sababi Pour Asl and Bafandeh Zendeh [34] investigated complications in five production units in Charmshahr, Tabriz, using the Enterprise Management Improvement System (EMI) methodology in three phases. First, the results of the company's performance were examined. Then, the problems and capabilities of the company were identified, and the causes of the problems were analyzed in forty different areas, including financial and economic areas, efficiency, quality, leadership, organization, systems and processes, and technology area. Finally, the strategic position of Sepaheri leather was in the position of a milking cow using the Boston Consulting Group (BCG) matrix. Despite the noticeable decrease in the market and the industry's attractiveness, the internal position of Sepaheri Leather was relatively favorable, according to the research results [24]. Two essential complications of low productivity and collection of receivables were identified, and proposed solutions were presented at the enterprise and inter-enterprise levels. Yusefzadeh [39] introduced supply chain management as a business philosophy that covers all aspects of business activity and improves and examines it to achieve a competitive advantage, including all aspects of the procurement process, production, logistics, inventory management, financial management, marketing and product development, operational management, corporate strategy, organizational behavior, new institutional economics, and public policies.

2 Materials and methods

The systems dynamics approach is a method for analyzing, solving problems, and simulating the system. This technique is considered a way to analyze complex systems and issues with the help of computer simulation. The system dynamics technique was first developed in the late 1950s by a group of researchers led by Forrester at MIT [10, 15]. For the first time, Forrester used system dynamics to model and simulate a long-term decision-making method in industrial management dynamics. Then, the system dynamics were used for different businesses' strategy development and policy making [36].

The science of system dynamics is used to recognize, understand, and analyze the behavior and movements of system components. The ability of this science is such that it can be used to model various simple and complex problems. The change caused by the interaction of variables and the identification of their behaviors can be investigated over different periods [18].

Systems dynamics is based on model construction with a Statement of the problem (framing), Dynamic hypothesis, formulating, model testing, and policy design and evaluation.

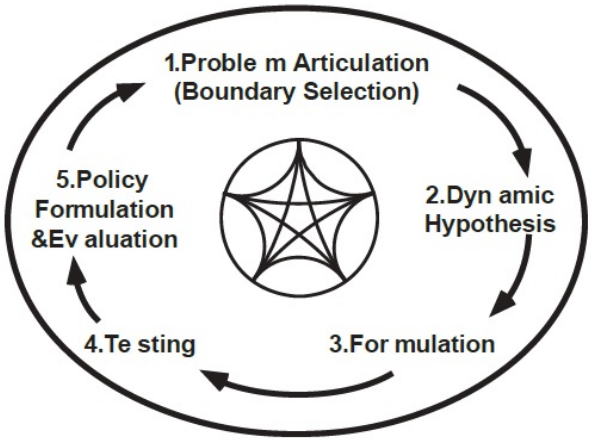

Figure 1: System dynamics modeling process [36]

In this research, the field method and interview tools were used to identify the variables and the relationships between the variables. In addition, the reference patterns and the history and background of the issue have been investigated by the documentary method. There is no significant and reliable background about the leather industry and this research field. On the other hand, there is a significant need for the opinions and experiences of professionals and business people. Planned, structured, semi-structured, and free interviews were conducted with unit managers to gain access to the best and highest level of information for summarizing and analyzing data. A combination of studies of articles, books, and interviews was used to collect data. Interviews were held regularly over months and reviewed by industry and science experts. This study aimed to present a model of problem-solving in the supply chain of the heavy leather industry with a system dynamics approach. The field method and interview tool were used to identify the variables and the relationships between the variables, and the reference patterns and the history and background of the problem were investigated with the documentary method. This study was conducted on 302 active and semi-active productions, including 162 heavy leather industry managers and business owners in Charmshahr Tabriz (Split) and 140 in cow leather. The analysis method was the simulation of system dynamics by VENSIM software.

3 Results

The internal environment of the leather industry can be analyzed using five competitive forces Bargaining power of customers, the Bargaining power of suppliers, Competitors, new entrants, and the Threat of substitute goods. The supply of heavy rawhide in the country is limited. On the other hand, there are many leather trimmers in the country, which created intermediaries and brokers in raw leather. The leading suppliers of the leather industry in the country are intermediaries and dealers of raw hides. For this reason, the bargaining power of heavy rawhide suppliers is high. The leather trimmer is also responsible for the transportation costs of the rawhide. As a result, leather is purchased in cash, which causes the price of the finished leather to rise because the bargaining power of the suppliers is high.

In the leather cluster of Tabriz, about 302 active units are producing heavy leather, which shows that the intensity of competition is high. The supply of leather is high, and the demand for leather has decreased due to the importation of leather and leather smuggling, as well as the unused capacity of factories and alternative goods. As a result, leather trimmers have been forced to sell their leather on credit and have a long period of collection of claims. Due to many demands, leaving the industry has become more challenging and should be performed so that the company's survival and profitability do not suffer a crisis. Leather manufacturers should create a competitive advantage; in this case, the price will be the primary word. A successful company strategy can make a competitive advantage by offering better payment terms to the customer.

A dynamic hypothesis was designed as the internal result of system feedback. The dynamic hypothesis of the problem is compiled using tools such as causal-loop diagrams, subsystem diagrams, model boundary diagrams, and flow-accumulation diagrams. This dynamic hypothesis significantly differs from the hypotheses of other research methods, which are formulated dynamically. Dynamic means adding knowledge in every stage of the research, with feedback to the hypothesis, and if necessary, the hypothesis undergoes changes and transformations. At any time of

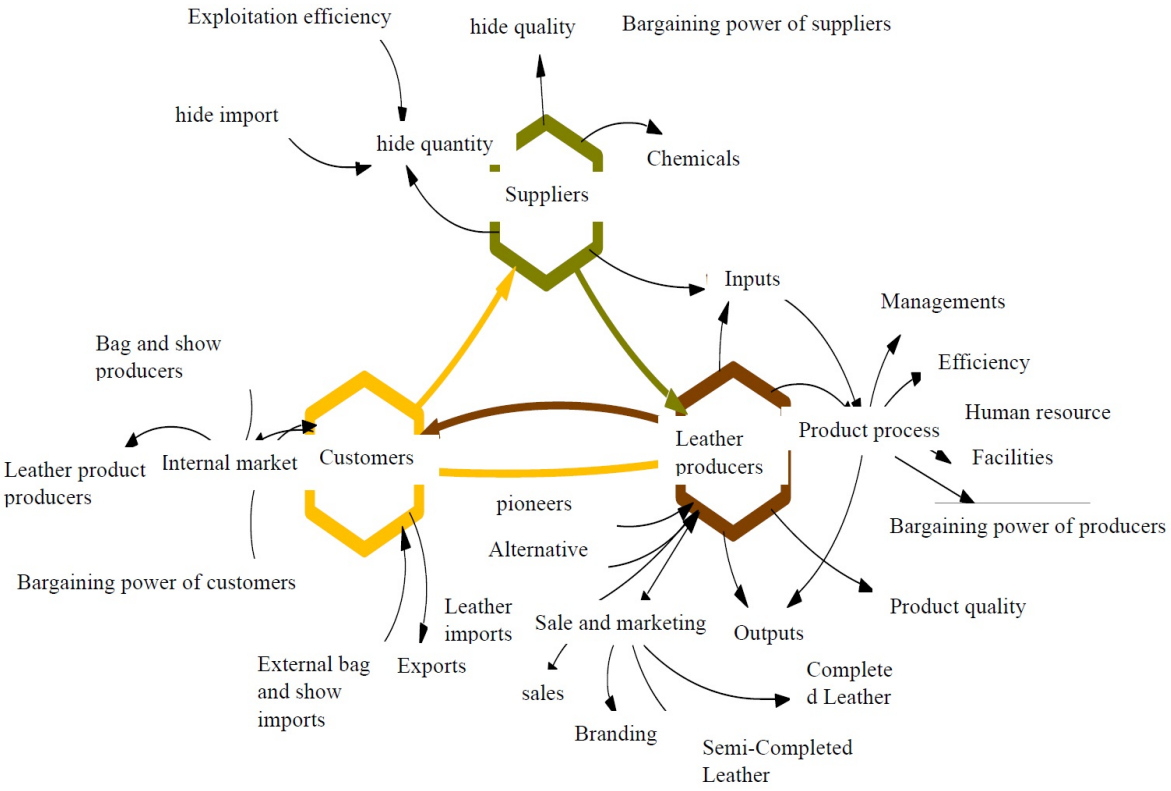

Figure 2: Leather industry supply chain factors

the research stages, it is possible to review and change in each stage of change as well as the dynamic hypothesis. At this stage, first, the initial hypothesis of the theories is determined, and what are the current theories of problematic behavior? At this stage, the tools that come to our aid are model boundary diagrams, subsystem diagrams, causal-loop diagrams, state and flow diagrams, policy structure diagrams, and other facilitation tools.

This part explains the circular causal diagrams of the main variables. The main variables are the supply of rawhide, the cost of leather, sales, leather production, demands, productivity, machinery, the supply of chemicals, liquidity and working capital, the bargaining power of the buyer, the bargaining power of the seller, competitors, and substitute goods. Below is an interpretation of their relationships with other variables:

The chart below shows the supply loops of rawhide, import, price of rawhide, and liquidity.

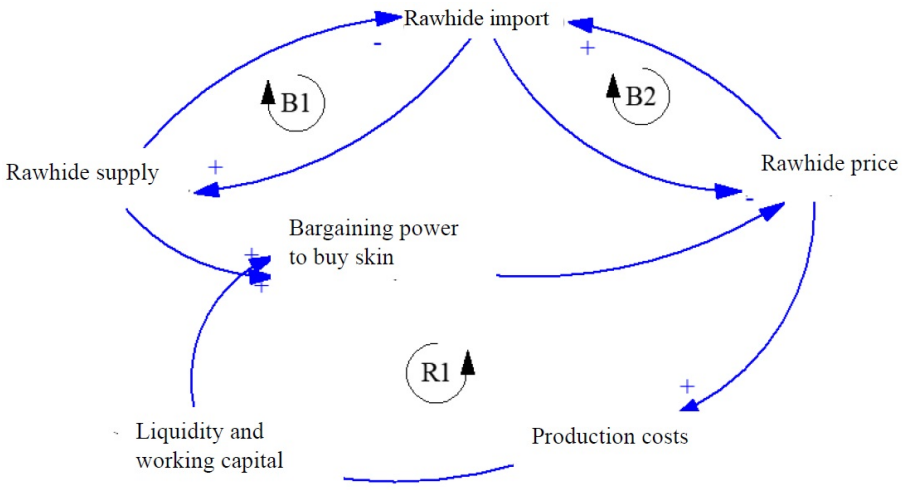

Figure 3: Cause-effect diagram of the supply of heavy rawhide

Loop (B1) supply of raw cow skin - import of raw cow skin: This loop consists of two variables of supply of rawhide and import, which shows the effect of these variables on the other. This loop shows that an increase or decrease in the supply of rawhide will cause an increase or decrease in the negative direction and vice versa in the imported variable of rawhide. The increase in the supply of raw cow skin means that the rawhide required for leather production units is supplied from within the country, and there is no need to import raw cow skin from other countries. As the supply of rawhide increases, the import of rawhide decreases. An increase in the import of rawhide causes an increase in the supply of rawhide, i.e., the relationship between them is in a direct and positive direction. In general, the behavior of the loop will be balanced and modulated. The polarity of this loop is negative.

Loop (B2) import of rawhide – the price of rawhide: As the import of rawhide increases, the price decreases, and the relationship between these two variables is negative and vice versa. With the decline in the price of rawhide inside the country, the desire to import raw hide disappears due to the import barriers and its long process. The desire to buy from inside the country increases due to the decrease in the price of rawhide. Rawhide prices are rising within the country, which increases the desire to import and supply from abroad. This loop is balanced, and the polar tendency of this loop is negative.

Loop (R1) price of rawhide - production costs - liquidity and working capital - bargaining power of the leather trimmer in buying rawhide: The price increases due to the lack of supply in rawhide and the increasing bargaining power of suppliers. This increase causes an increase in production costs, i.e., any increase in the price of rawhide causes an increase in production costs. The relationship between these two variables is positive and direct, i.e., any increase (decrease) in the price of rawhide causes an increase (decrease) in production costs. Increasing production costs require more liquidity and working capital, and as financial resources are absorbed into production costs, we are facing a decrease in financial resources and operating capital. The relationship between these two variables is negative, indirect, and opposite and decreases with the increase in the production costs of operating capital and liquidity. The leather trimmer cannot buy the rawhide at any price, as the number of financial resources and working capital, and liquidity of the leather trimmer decreases. The bargaining power of purchasing raw leather trimmers decreases. The relationship between these two variables is opposite and negative, and in general, this loop has balance and negative polarity.

In general, the bargaining power of intermediaries and brokers in the sale of rawhide increases with the decrease in the supply of raw cowhide, and vice versa, the bargaining power of leather trimmers for the supply and purchase of rawhide decreases. Reducing the bargaining power of supplying raw hides forces the supplier to sell his raw hides at any price and quality. Therefore, the price of each kilo of rawhide has increased thrice in the last two years due to the decrease in the supply of rawhide. Considering that the primary raw materials for leather production are raw hides, with the increase in the price of raw hides, the production costs and, consequently, the total price of leather production increase. As production costs increase, production decreases. The import of rawhide increases the supply of rawhide and reduces the bargaining power of the leather suppliers, and as a result, the price of rawhide decreases.

Figure 4 shows leather supply loops, leather trimmer's bargaining power, sales, production, and credit sales.

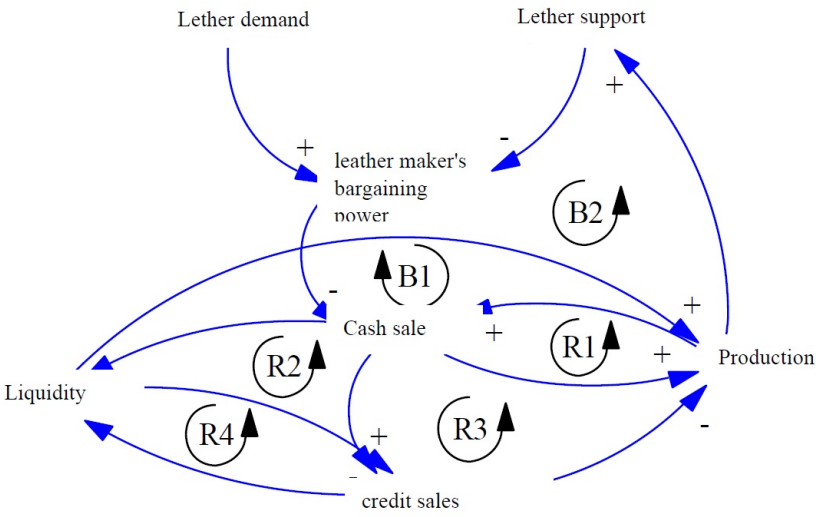

Figure 4: Cause-effect diagram of production, supply of leather, bargaining power, sales

Loop (B1) production - supply of leather - bargaining power of leather trimmer - cash sale - liquidity - credit sale is given below.

In this loop, the supply of leather increases with the increase in production, which means is a positive and direct relationship between these two variables. The greater the bargaining power of the leather trimmers for sales, they turn to cash sales and short-term credit sales, claims are reduced, and the period of collection of claims is reduced. The liquidity of the unit increases by reducing the receivables collection period. The greater the bargaining power of the leather trimmers for sales, they turn to cash sales and short-term credit sales, the claims are reduced, and the period of collection of claims is reduced. The liquidity of the unit increases by reducing the receivables collection period. The bargaining power of leather trimmers for cash sales and sales with their desired terms decreases with the increase in the supply of leather in the market. Lether trimmer is forced to reduce the amount of production due to the decrease in liquidity and working capital of the producer by reducing the bargaining power and increasing credit sales.

The loop (B2) of leather supply - leather trimmer's bargaining power - cash sale - production shows that with more leather supply, the leather trimmer's bargaining power decreases due to the increase in supply. The relationship between these two variables is negative and vice versa. Any increase in the supply of leather in the market causes a decrease in the bargaining power of the tanner to determine his desired conditions for sale. As the tanner's bargaining power in selling decreases, the cash sales the tanner can make will drop. Reducing cash sales results in an increase in receivables and accounts receivable, reducing liquidity and working capital. An increase (decrease) in direct and positive jet occurs in production with an increase (decrease) in cash sales. In this loop, the polarity was generally positive and self-increasing.

The production-sales loop (R1) shows that this loop is self-increasing and reinforcing. Sales increase with every increase in production and decrease with every decrease in output. The relationship between these two variables is direct and positive, and this loop's polarity is o positive.

The loop (R2) of production - cash sales - liquidity - credit sales show that with each increase in production, the amount of cash sales increases due to the increase in bargaining power. As cash sales increase, working capital and liquidity increase. The company tries to increase its capital and liquidity by selecting its customers from the premium customers, increasing its cash sales, and reducing its credit sales. The producer is encouraged to produce more, and this causes more production by decreasing credit sales and increasing cash sales, which is a reinforcing loop, and the polarity of this loop is positive.

The loop (R3) of production - cash sales - liquidity - credit sales show that cash sales increase with the increase in production. With the rise in cash sales, the share of credit sales decreases. This loop is self-reinforcing, and its polarity is positive.

Loop (R4) liquidity - credit sales show that in this loop, any increases or decreases in liquidity increase or decrease the credit sales in the opposite direction. The relationship between these two variables is opposite and negative, and the polarity of this loop is positive.

Figure 5 shows the chemical material supply loops, chemical material imports, overhead costs, and liquidity.

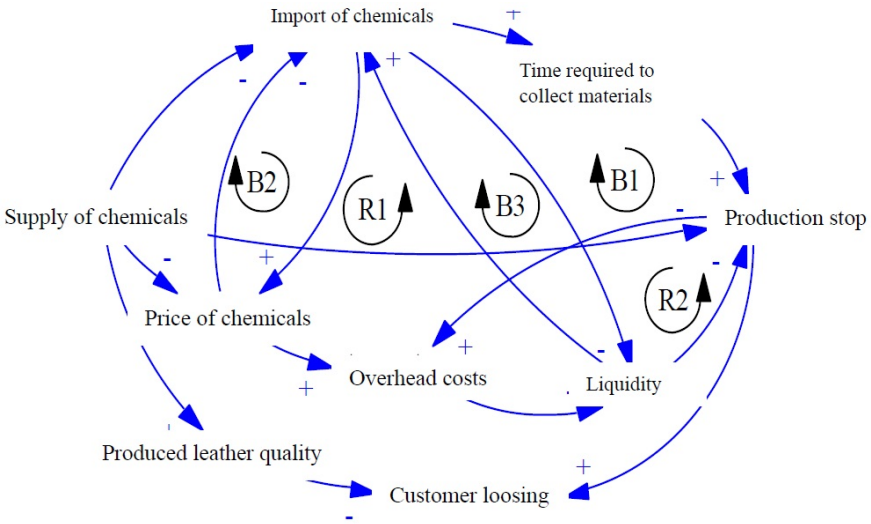

Figure 5: Cause-effect diagram of production, supply of leather, bargaining power, sales

The loop (R1) of import – the price of chemical materials - overhead costs - liquidity shows that the supply of raw materials for the chemical industry faced a problem with the imposition of sanctions. On the other hand, the quality of chemicals inside is not good, and the supply of quality chemicals is facing problems. This lack of supply of chemicals has encouraged the leather manufacturer to import chemicals. Importing chemicals increases the cost of chemicals and the purchase price of chemicals. This increase causes an increase in overhead costs and, consequently, in the total cost of leather. With the rise in overhead costs and production costs, liquidity and working capital of the tannery decreases. A decrease in liquidity will lower the power of supplying leather materials, and on the other hand, it will reduce the import of chemical materials. This loop has positive and self-reinforcing polarity.

The loop (R2) production interruption - overhead costs - liquidity shows that the lack of supply of chemical materials makes the leather manufacturer more willing to import chemical materials. However, the expected time to receive chemicals increases due to the country's many bureaucracies and import barriers. On the one hand, this increase in the time of receiving chemical materials and forcing the leather maker to use unusual alternative materials causes production interruptions and slows production. All of these increase rework, production time, and overhead costs. An increase in overhead costs reduces liquidity. The polarity of this loop is positive and self-increasing.

Loop (B1) production interruption - overhead costs - liquidity - import of chemical materials - expected time to receive materials - production interruption shows that production interruptions increase overhead costs. On the other hand, an increase in overhead costs causes a decrease in liquidity, and this causes a reduction in import power. The import decreases by reducing the import of chemical materials and turning the tanners into an internal supply of chemical materials. The expected time to receive chemical materials is reduced, and the interruption in production is reduced by reducing the import and increasing the domestic supply of materials. The polarity of this loop is negative and modulating.

The price of chemical substances is shown in loop (B2) import of chemical substances. An increase or decrease in imports causes an increase or decrease in the price of chemicals in a direct direction. The relationship between these two variables is positive and direct. With the rise in the price of chemical materials, the desire for domestic supply increases, and over time, imports decrease. The relationship between these two variables will be negative and vice versa. In general, this modulating loop and the polarity of this loop are negative.

Loop (B3) import of chemical materials - liquidity shows that due to the low value of the national currency, the cost of supplying materials increases with increased imports. As the purchase price of materials increases, liquidity decreases. On the other hand, the decrease in liquidity is faced with a decrease in the supply of materials, which generally causes a reduction in imports. The polarity of this loop is negative and modulating.

Figure 6 shows leather supply loops, leather demand, production costs, production, and alternative goods.

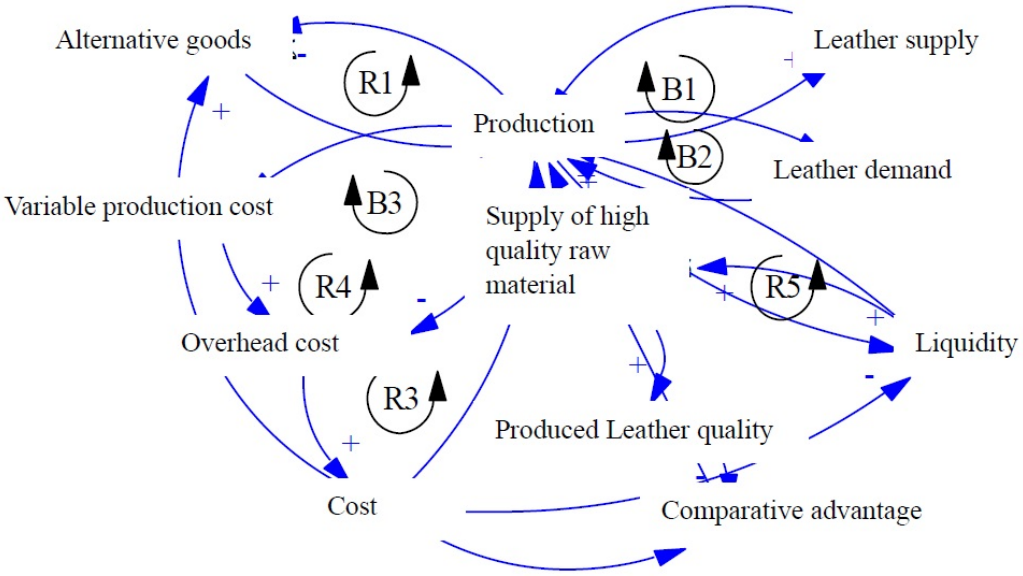

Figure 6: Cause-effect diagram of leather supply, import of chemicals, overhead costs, liquidity

In the loop (R1) of production - substitute goods, the increase in production will cover the demand for leather, maintain the market share of natural leather, and reduce the share of synthetic leather production. An increase

in the production of alternative goods reduces the share of natural leather production, and this loop has a positive and self-reinforcing polarity.

Loop (R2) of production - overhead costs - cost price - competitive advantage - production shows that overhead costs are reduced with increased production. The total price of each unit of leather production decreases by lowering overhead costs. The producer has a competitive advantage, and the competitive power of the producer increases by lowering the cost price. The desire to produce increases, and the polarity of this circle is positive with the increase of competitive advantage.

Loop (R3) liquidity - supply of quality raw materials – the quality of the leather - competitive advantage - production - liquidity shows that the increase in the liquidity of the producer unit can buy and supply quality materials and raw leather. The use of quality raw materials increases the quality of the leather product. The producer has competitive power and increases the competitive advantage in terms of having a quality product by improving the quality of the produced leather. This increase in competitive advantage also increases production. Increasing production increases sales and liquidity, and the polarity of this loop is positive.

Loop (R4) of production - overhead costs - cost price - substitute product - production shows that with the increase in production, the overhead costs of each unit decrease. The cost of products is reduced by reducing overhead costs. A more appropriate selling price can be considered for the items, reducing the desire to use synthetic leather by lowering the price. The increased demand for natural leather causes production to grow with the decrease in the demand for synthetic leather. Generally, this loop's polarity is positive, self-increasing, and reinforcing.

Figure 7 shows the circles of machines, productivity, liquidity, production costs, human power, and production

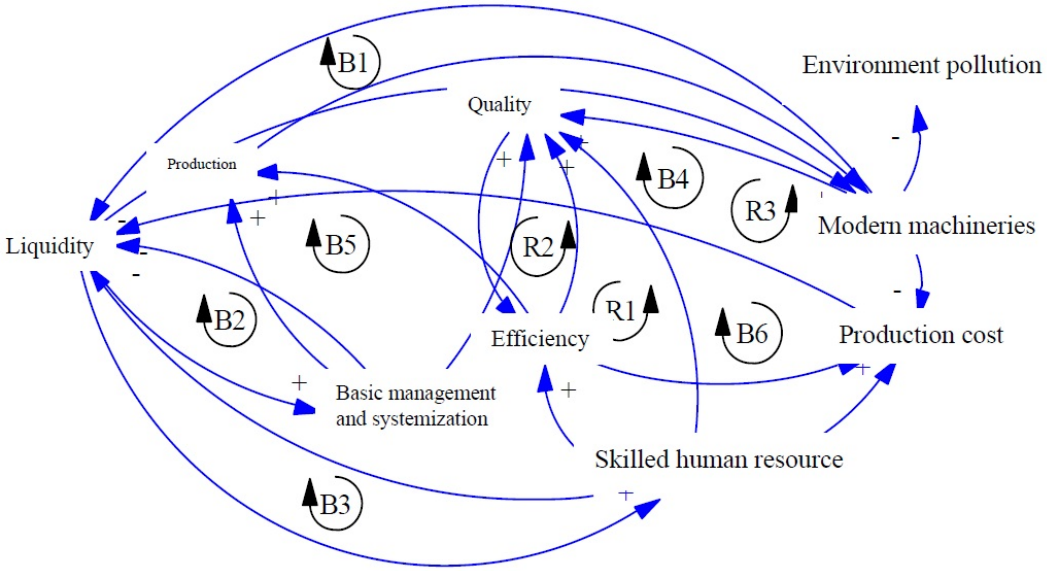

Figure 7: Cause-effect diagram of liquidity, modern machines, productivity, principled management, skilled human resource of systemization

Loop (B1) of modern machines - liquidity shows that with the increase in liquidity, the purchasing power of modern machines increases. Up-to-date machines and up-to-date equipment can be purchased, and more cash is spent by purchasing modern machines. This is a balance ring with negative polarity.

Loop (B2) of liquidity - principled management and systemization shows that with the increase of liquidity, the producer can use tools and correct management and increase the use of principled management and systemization. Liquidity decreases as the cost of hiring capable people and implementing systems increases. This ring is balanced and self-controlled and has a negative polarity.

Loop (B3) Liquidity - Skilled human resources show that the producer can use and hire skilled human resources with increased liquidity. Costs rise, and liquidity decreases as recruitment costs increase. This ring is balanced and self-controlled and has a negative polarity.

Loop (B4) of productivity - production costs - liquidity - principled management - production - modern machines - quality shows that production costs decrease with increasing productivity. Liquidity increases by reducing production costs. Liquidity increases the possibility of investing in essential management and systemization

tools within each department. Production increases with the rise of principled and correct management. The ability to purchase and supply modern machines increases with increased production. The quality of production increases with the height of modern machinery. This loop has negative polarity.

The cycle (R1) of productivity - production - modern machinery - liquidity - skilled human resource shows that productivity increases production. The increase in production leads to the purchase of modern machinery. Increasing the purchase of modern machinery reduces liquidity. A decrease in liquidity will facilitate the recruitment of skilled human resources. The polarity of this loop is positive and self-increasing.

Loop (R2) of productivity quality shows that the increase (decrease) of productivity causes an increase (decrease) in rate in a direct and positive direction. The polarity of this loop will be positive and self-increasing.

Loop (R3) productivity-production-modern machinery-quality shows that increasing productivity increases production. The relationship between these two variables is positive and in a direct direction. The increase in production leads to the purchase and growth of modern machines. Increasing the number of modern machines and equipment improves the quality of production. The polarity of this loop is positive, and this loop is self-increasing.

The flow-accumulation diagram and computer simulation model are shown below.

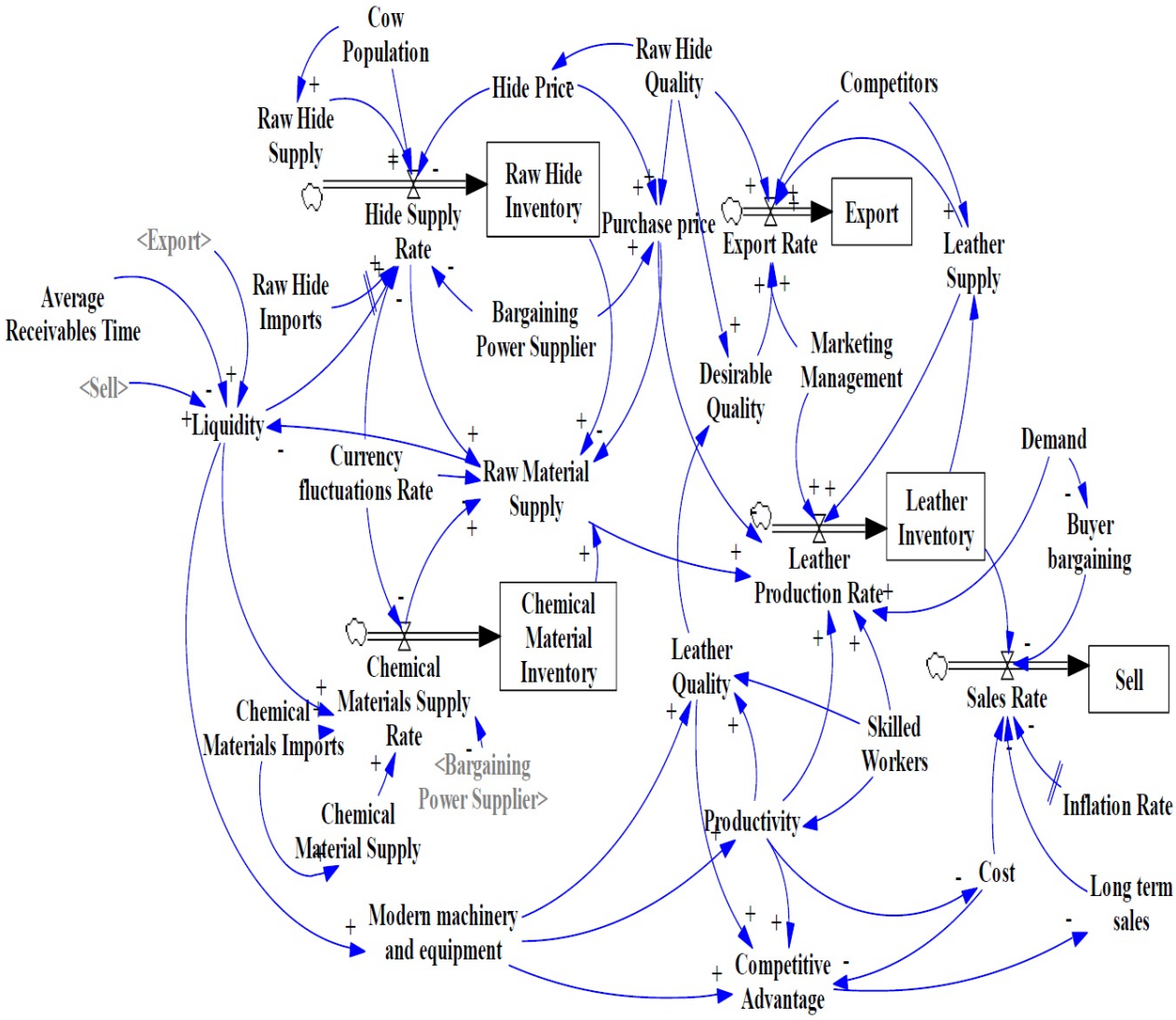

Figure 8: Diagram of state–flow

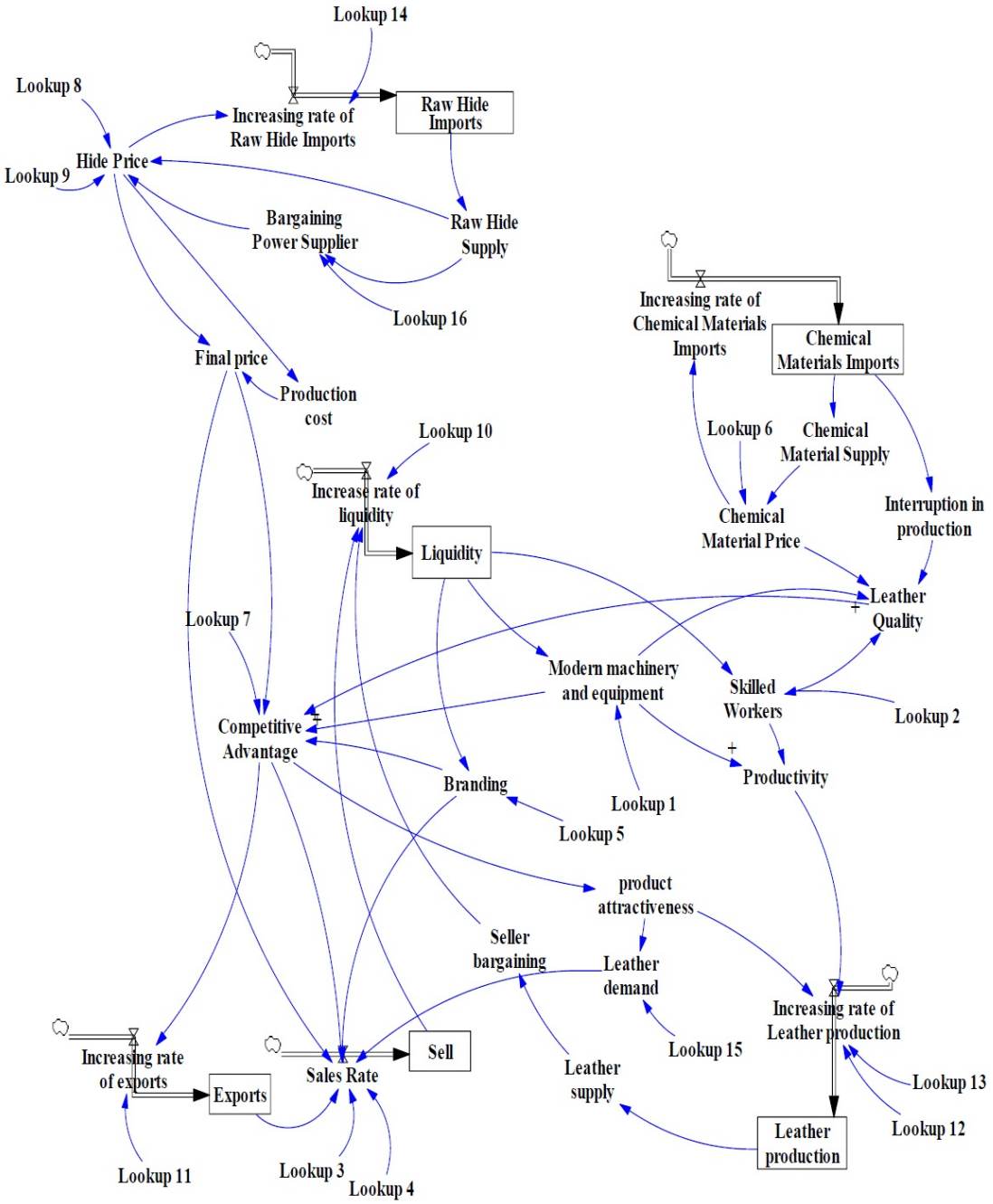

Figure 9: Flow accumulation - diagram for diagnosis of heavy leather industry supply chain

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