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A new model for physical flow optimization in the global automotive value chain (Case study: Siba Motor Company)

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Abstract

Taking into account the economic capabilities, competitive advantages and environment dynamics, this research presents a new physical flow optimization model by considering payment period, time value of money and exchange rate fluctuations. Considering the actual circumstances of the current case study in the global value chain, a single-objective non-linear mathematical model is presented for the role of the SIBA MOTOR Company. Owing to the non-linear nature of the presented model, it has been linearized through a heuristic method. Next, by using GAMS software, the model is solved by considering the assumption of the case study. Finally, a sensitivity analysis is performed on important parameters after obtaining the numerical results to assess them. Appropriate potential location of the factory, inventory of each period, CKDs and CBUs flow of vehicles, the amount of tax and the customs expenses, and each payment method's share, are some of the outputs of the model. The results of the proposed model are appropriate for the Iranian automotive companies to participate more actively in the global value chains of the automotive industry.

Keywords: Global Value Chain, Siba Motor Company, automotive Industry, optimization model

1- Introduction

Production processes are increasingly scattered geographically around the world, and manufacturing tasks have been spread among different countries. While multinational production is in progress, a fascinating phenomenon entitled "role-playing in the global value chain" is emerging among different companies in many countries. In this study, we try to explain the current companies' position in the global value chain of the automotive industry, which create in the global value chain according to their economic capabilities, competitive advantages and environmental dynamics and requirements; and seeking to obtain an acceptable position and then improve it in the global value chain (Liu, 2014). For example, at first the Brazilian automotive industry started by assembling General Motors' cars, but it currently designs and manufactures modern cars; and so that it is among the world's largest car manufacturers (Alvarez, Buera, & Lucas Jr, 2013). There is an experience of quickly Industrialization and the growth of economic rates and the maintenance of those indicators in some Asian countries called the Asian Tigers (Hong Kong, Singapore, South Korea and Taiwan).

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For decades after World War II due to attending in global value chains, including the global value chain of the automotive industry (Ando & Kimura, 2005). To fulfill this purpose, the global automotive value chain can be considered as one of the platforms of economic growth and sustainable development in developing countries.

In this study, according to the history of research in the value chain area and focusing on the global automotive value chain, we try to provide an applied mathematical model by considering the concerns of Siba Motor Company for its role-playing in the global value chain of heavy trucks.

Additionally in this study, we try to innovate by focusing on the financial parameters and variables, including payment methods that are limited to the case study and also the use of the mixed research method.

The remainder of this paper is organized as follows: In section 2, we present the literature review and the research background. In section 3, we consider the problem definition and the expression of hypotheses and present a model for optimizing the flow of parts and goods, taking into account the time value of money and its payment period, according to the case study. Afterward, according to the data obtained from Siba Motor, the results of the model are obtained and analyzed in section 4. In section 5, we provide the discussion and conclusions. Then in section 6, managerial insights are provided, and finally in section 7, conclusions and future suggestions are presented for future research in this area.

2- Literature review and research background

In 1985, Porter classified economic activities of a company into two groups with nine general categories. The first group is the main activities involved physical activities, such as marketing, goods transportation, services provided to the buyer, input logistics, operations, output logistics, marketing, sales and services. The second one is called support activities, including: infrastructures, human resources management, technology and purchasing development, and the inputs or infrastructure required by companies to do the main and current activities. By dividing the company into a set of discrete activities, the concept of "value chain" was created to systematically analyze the cost behaviors and the relationship of activities to understand the company's cost position and the company's potential to create value (Porter, 1986).

Michael Porter, for the first time, discussed the tools and concept of the value chain in a book entitled "Competitive Advantage". In this book, he reintroduced the concept of value chain based on the information of the various countries' industries. He addressed that the value chain is a set of activities that an organization performs in order to create value for the customer. This tool shows us how all activities of the organization effect on its profit and loss, and using it we will be able to identify the sources of value in the organization.

The global value chain approach was introduced by Gereffi in 1994, who invented the term "global value chain." He developed the concept of the value chain with a global approach (Holste, 2015a). The concept of the global value chain quickly attracted attention to itself. After that, Gereffi (1999) and others (Giuliani, Pietrobelli, & Rabellotti, 2005; Humphrey & Schmitz, 2002) created a conceptual framework that combines value chain with industry globalization, while it focuses on developing countries. In 2008, Rabelotti et al. emphasized the importance of global buyers and producers as the main factors in the formation of the scattered and fragmented global value chain (Morrison, Pietrobelli, & Rabellotti, 2008).

For Kaplinsky and Morris, the value chain is a wide range of activities that are required to make and deliver a product or service through various stages of production (which includes a combination of physical changes and the input of different supplier services) to the ultimate consumer (Kaplinsky & Morris, 2001).

In 2010, Tsai in his Ph.D. thesis entitled "How can factories obtain the value in the global value chain by innovation?" has examined the mechanisms and factors that enable factories in the global value chain to obtain value through innovation from the view of the four technology-driven factories; and develop an integrated framework for obtaining value through innovation in the global value chain, and implemented it on four factories for measuring the designed framework. The findings of this study show that, how and what innovation can create value for the intended factory interacting with the global value chain. These innovations have been examined in the business model, collaboration, and matching factory with the environment (Tsai, 2010).

In 2011, Sturgeon & Van Biesebroeck in an article entitled "Global value chain in the automotive industry": What's a better role for developing countries, have reviewed the global value chain according to the recent trends in the automotive industry; and argued that the opportunities of moving upward for the emerging economies have been increased in the global value chain. Meanwhile, have mentioned the reasons for the independence and progress of the companies of developing countries in the global value chain, especially China and India, compared with the perseveration of the companies in the supplier and dependent countries such as Mexico and Eastern Europe countries (TJ Sturgeon & Van Biesebroeck, 2011).

In 2011, Oikawa in an article entitled "Distributing the value in the automotive and electronics industries in East Asian Countries: With an empirical approach to the global value chain", has investigated how to distribute the value in regional manufacturing networks of East Asian. The reason for selecting the East Asian countries in this study is their relatively successful and export-centric economies. In fact in this study, we want to answer the question "What economies have the most and least brought?" To answer this question, we calculated the economic input and output of the 10 Asia-Pacific countries and the value-added flow between these 10 countries. The performance of these countries has been assessed through value-added and their market share in global exports. The Indonesian electronics industry and the automotive industry of Indonesia, Malaysia, Taiwan, and Thailand have been studied in this study (Oikawa, 2011).

In 2011, Kagermann and others in a chapter entitled "redesigning value chain" from the book "Business models in the IT industry: changing global cases", considered the importance of the concept of the value chain on a global scale and in the IT industry and its effect on changing business models in the IT industry; and described and explained the concept of "redesigning value chain" with the help of concepts such as: globalization, expertise and aggregation, network connectivity, servicing and ecosystem management (Kagermann, 2011).

In 2013, Antras and Chor in an article entitled "Organizing the global value chain" have designed a legal ownership model for a company with continuous production. In this model, they have performed appropriate distribution of different actors' property rights during the value chain and has been reviewed the integration possibility with upstream and downstream companies in collaborative contracts (Antràs & Chor, 2013).

In 2013, UNCTAD in a report entitled "Measuring value in global value chains", by Banga, has compared the alternatives ways for measuring the participation of a country in the global value chain; and has estimated the distribution of financial brought and the share of each country value added created in the global value chain. Meanwhile, it has shown the extensive changes resulting from the connection to the global value chain, especially for developing countries and has calculated the resulting from the connection to the global value chain which has been obtained by estimating the net value added from exports of different countries (Banga, 2013).

In 2014, Liu in his Ph.D. thesis entitled "Evolution of the global value chain", provide a single framework for achieving the meaning and mechanism of global production and value chain. In this thesis, he developed the theoretical task-based models to discover the dynamics of the value chain; and this model has been confirmed using factory-level data. Also in this model, he investigated the effect of innovation on the value chain (Liu, 2014).

In 2015, Holste in a book entitled "Promoting the level of the company in the global value chain, from the view of the business model," seeks to study actions and decisions that promote a company in the global value chain. Hence, he combined the literature on the global value chain with the literature of the business model to create a new framework for studying how the company is promoted and tested the designed framework at several Taiwanese factories using a baseline or ground-based approach (Holste, 2015b.)

In 2016, Sun and Grimes prepared an article entitled "Increasing China's participation in the global value chain of the ICT Industry: An Enterprise-Based Analysis" based on evidence from the ICT industry's international business data, in Chinese companies that want to participate in the global value chain of this industry. According to the author, existing companies in the global value chain of the ICT industry are divided into three types of companies:

1. Brand Manufacturers 2. Raw materials factories and e-manufacturers 3. Main designers. The results of this study show that increasing China's participation in the global value chain of the ICT industry results from promoting in product architecture, product globalization, and outsourcing and producing inside the sea (Sun & Grimes, 2016).

In 2017, Hernandez & Pedersen in an article entitled "Global value chain configuration: A review and research agenda" review and investigate the literature on the global value chain, in order to systemize it and indicate approaches for future research. Specifically, they review the literature focusing on the concept of the global value chain and its activities, the decisions involved in its configuration, such as location, the governance modes are chosen and the different ways of coordinating them (Hernandez & Pedersen, 2017).

In 2017, Del Prete & Rungi study the organization of Global Value Chains on a sample of about 4000 manufacturing parent companies integrating more than 90,000 affiliates in 150 countries. They published their research results in an article entitled “Organizing the global value chain: A firm-level test” (Del Prete & Rungi, 2017).

In 2018, Chor in a Chapter entitled “Modelling Global Value Chains: Approaches and Insights from Economics” prepared for the Research Handbook on Global Value Chains, tried to overviews GVC literature on economic models that speak to the broad phenomenon of global production (Chor, 2018).

2-1- Research gap

The current model is similar to common logistic models in terms of variables such as inventory, transportation, procurement, distribution and supply. In this connection, the financial parameters have been used in some of the logistic models reviewed in the subject literature, but contrary to the present model which optimizes the physical flow by focusing on financial parameters in the form of a single-objective model, including tax, customs and the share of each type of triple payment methods (draft, visual letter of credits, and long-term letter of credits), in the similar models, optimizing the physical flow and financial flow are usually considered in two distinct objective functions. Meanwhile, modeling the payment method for raw material costs is unique and innovative, since it is related to the selected case study (Siba Motor Company). In addition in the literature has been used less the quantitative and qualitative methods together.

3- Problem statement

The automotive industry is a transnational and relatively global industry, which consists of a large number of communications and expertise, and is not limited to geographic locations (T. Sturgeon, Van Biesebroeck & Gereffi, 2008). The dominant trend in this industry is regional integration and cooperation. The regional component producers tend to feed assembly plants in the same area and meet the demands of the same region's markets (T. Sturgeon & Florida, 2004). Therefore, in the present article, we study important dimensions to role-playing the case study in the value chain of the automotive industry.

3-1- Importance of the problem

To achieve economic price, technological progresses, prevent of backwardness and perseveration, it is obvious and necessary to move with time and use the tools and techniques that have been chosen as solutions to problems and always create mobility and dynamic in all areas. One of the same tools and platforms is the presence in the global value chain. No organization can operate independently from other organizations. The organization must go beyond boundaries to obtain the required resources for production and gain the distribution market for its final products. Undoubtedly, the company's growth and success or losing resources are related to the environment in which it operates. Hence, according to our country's geographical location and the availability of an appropriate platform for economic cooperation with our neighbor countries, and, as shown in figure 1, the small share of Iran's $ 12.6 million from $

668 billion the value of car exchange in the global value chain of this industry in 2015 with the small share of 0.0019 percent (The Atlas of Economic Complexity, 2015), which is notable against reflective high share of developing countries such as Turkey, Thailand, India and Indonesia, we investigate the presence of an Iranian automobile company in the global automotive value chain. It should be noted that in Fig. (1), the option of other countries includes countries such as Sweden, Brazil, China, Hong Kong, UAE, Portugal, Serbia, Brazil, and ...; the share of each country is higher than Iran's share in the value chain of the automotive industry alone.

Why in this article, the automotive industry has been chosen as a case study in the global value chain?

There are several reasons for this choice:

1. The automotive industry is one of the main forces and drivers of rapid economic development in the region. Whenever this industry is one of the industries with rapid growth in production and export, that country or region has been able to increase its export share and market share (T. Sturgeon & Memedovic, 2011).
2. By developing the productions and exports in the automotive industry, this industry can play a significant role in creating different jobs, increasing value added and technological progress (Lall, Albaladejo, & Zhang, 2004).
3. The rapid development and expansion of products and exports of the automotive industry were dependent on the direct investment of developed countries. One of the results of industrialization was that these investments crossed the borders and led to create the multinational and collective production of various countries. Regional productions between neighboring countries not only meet the region’s needs, but also allow these countries and companies to enter the international markets.
4. Due to technical reasons, the automotive industry can be more fragmented and divided than other industries. This industry involves a large range of products, including high-tech products such as semiconductors, display panels and motors, or low-tech and high-volume products such as tires, keyboards, batteries, steel and metal and plastic parts (Oikawa, 2011).

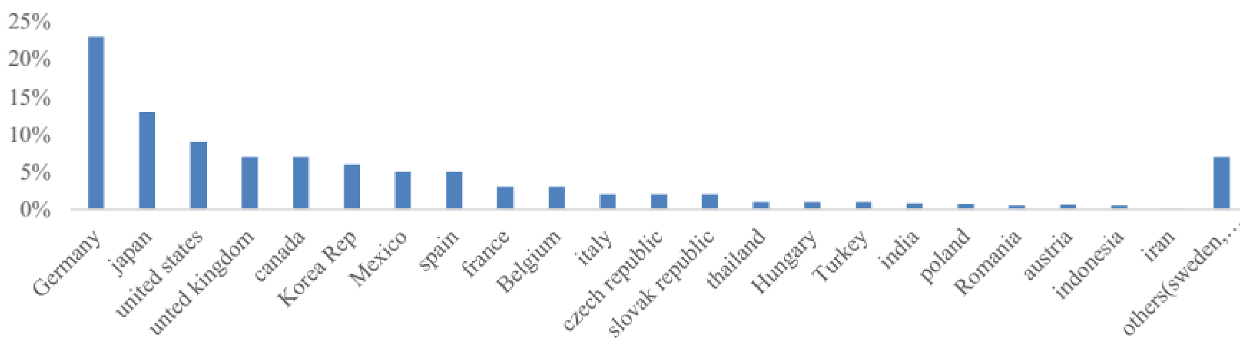

Fig1. The share of different countries from attendance in the global value chain of the automotive industry in 2015 - Source: http://atlas.cid.harvard.edu/

Why is Siba Motor elected as the selected case study?

1. Attending in the global market and role-playing in the global value chain in the automotive industry is one of the company's future strategies and perspectives with access to the capacity of neighboring countries' market.
2. This company is one of the top four companies in terms of selling heavy and semi-heavy trucks in the country.

3. Siba Motor is the largest customer of its Chinese partner (the FAW Company). Hence, it has the capacity to become the hub of the region in this product.
4. According to the FAW Co. acknowledge, the quality of Siba Motor's assembled products is more than the quality of the product assembled at FAW.
5. The country's transit capacities and access to the high seas will provide this advantage to Iranian companies compared to other geographical locations.

3-2- Problem description

To implement the model, we choose the value chain of Siba Motor. This company is an assembler of heavy and semi-heavy trucks whose mission is to produce heavy and semi-heavy commercial vehicles and provide valuable customer-related services, focus on job creation and the promotion of the country's industry, generating sustainable profits and benefits for all shareholders, business partners and suppliers as well as a reliable professional future for employees. Because one of Siba Motor's missions is to create sustainable benefits and profits, thus the organization can achieve this goal by creating a sustainable financial flow using exports to neighboring countries, including Middle Eastern countries (Iraq, Jordan, Pakistan, Egypt, Niger, etc.) and the Caucasus countries (Azerbaijan, Georgia, Armenia, etc.) and in other words, the role-playing in the global value chain of the automotive industry. There are four reasons for choosing these countries as export destinations: first, the existence of the advantage of regional chains in the automotive industry, second, creating the export channels in the automotive industry by part manufacturers and other Iranian automakers with some of the countries in the region from the past; figure (2), third, the presence of some customers of Siba Motor's Chinese partner in the region (such as Pakistan), and Fourth, survey, and interview with experts in the automotive industry.

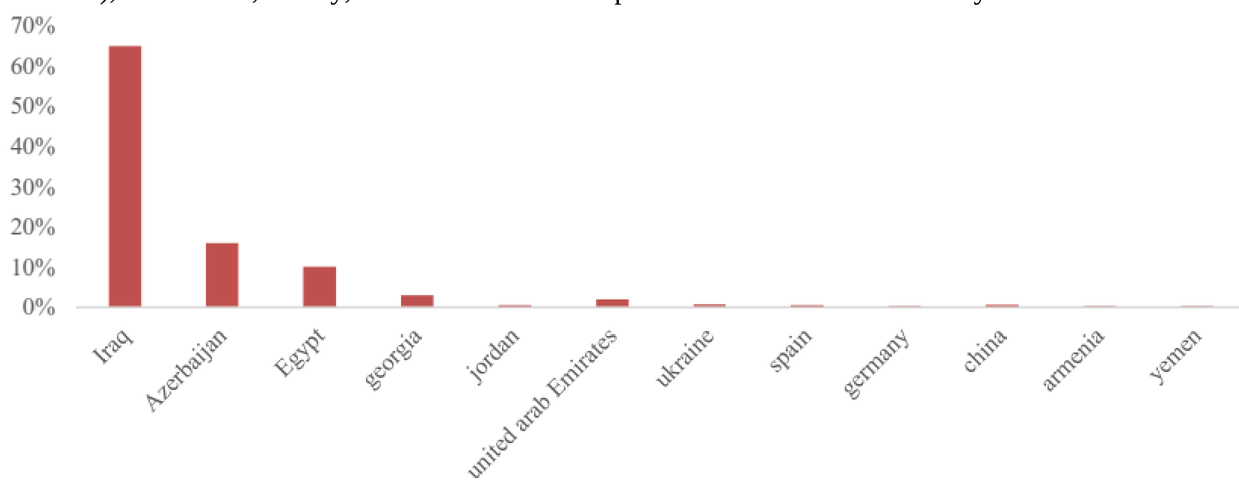

Fig 2. What countries and what amount does Iran export car and spare parts in 2015? -Source: http://atlas.cid.harvard.edu/

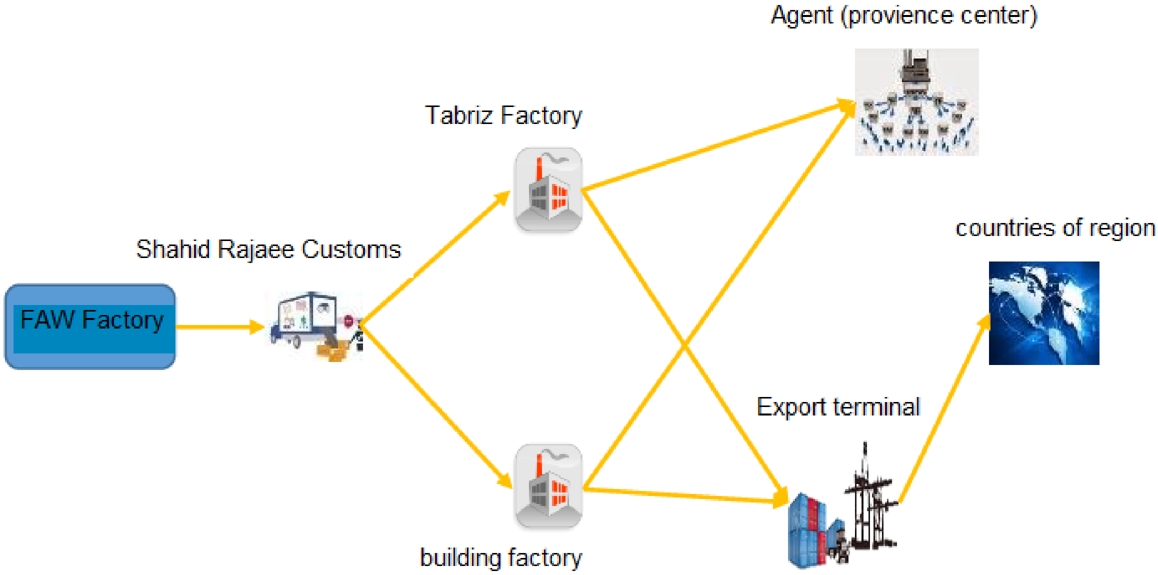

Fig 3. Siba Motor's value chain

Therefore, using the mathematical optimization model, it has been attempted to create a framework for cooperation between the Chinese partner of FAW and Siba Motor in order to play a role in the global value chain of the industry. It should be noted that FAW is the main supplier of Siba Motor's parts.

Figure 3 illustrates the structure of the designed value chain for Siba Motor Company. In this chain, a supplier (FAW Company) sends the parts as CKD (complete knock-down) to the Shahid Rajaee customs of Bandar Abbas. Then, the parts are delivered to the Tabriz factory or if a new factory establishment, the parts will be sent to that factory.

Then, the mentioned factories send them to domestic agents or export terminals by performing various operations on them and turn them into the final product (CBU).

The products sent to export terminals are exported to destination countries. It should be noted that the transportation process in this value chain is based on the Cost and Freight (CFR). In this method, the possibility of the seller is ended when goods pass the fence (is loaded). The buyer must pay the costs of the insurance and the customs. The seller must pay the cost of transportation. The buyer is responsible for the contract of insurance and the seller is responsible for the contract of carriage.

4- Mathematical modeling

In this section, we consider an optimization model for designing the Siba Motor Company's global value chain. In the following, we introduce the symbols used in the mathematical model and express the mathematical model.

Index:

i Building a possible factories
j foreign countries
k internal cities
r export terminals

Continuous decision variables

GH^t The parts transferred from customs to Tabriz factory in period t
${GH^t}_i$ The parts transferred from customs to factory i in period t
${IGH^t}_i$ The number of imported parts to the Shahid Rajaee customs in the period t for transferring to the factory i
$car^{\,t}$ The amount of Production in Tabriz factory in period t

car_i^t The amount of production in i factory in period t
$car^t{}_{ir}$ The number of exported cars to export terminals from i factory
car_r^t The number of exported cars to export terminals from Tabriz factory
$car\ {}_k^t$ The number of distributed cars from Tabriz factory to domestic cities in the period t
$car\ {}_{ik}^t$ The number of distributed cars from i factory to domestic cities
car_{rj}^t The number of transferred cars from exported terminals to foreign countries in the period t
car_{rj}^t Remaining budget at the beginning of period t
ICT^t Car inventory at Tabriz factory in period t
$IC^t{}_i$ Car inventory at i factory in period

Binary decision variables

X_i The variable for building a new factory is 1 and The variable of non-building a new factory is 0.
y The export variable, if there, is 1, and if there is not export is 0.
$\rho 1^t$ (Decision variable) Type 1 payment, if used, is 1, otherwise, it is zero.
$\rho 2^t$ (Decision variable)Type 2 payment, if used, is 1.2, otherwise it is zero.
$\rho 3^t$ (Decision variable) type 3 payment, if used, is 1, otherwise it is 0.

parameters

p^{tEx} The export prices of exported cars to foreign countries in period t
p^{tIM} The domestic price of the car for distribution within the country in period t
IGH^t The number of imported parts to Shahid Rajaee Customs in the period t
FC_i The fixed cost of establishment i factory includes: Establishment permit, Operation license, environmental license, Labor Office license, ISO certificate, Certification of vehicle type, Certificate of car manufacturing in the country
$TRCGH$ The cost of transporting parts from Shahid Rajaee customs to Tabriz factory
$TRCGH_i$ The cost of transporting parts from Shahid Rajaee Customs to the factory i
dis The distance between Tabriz Factory and Shahid Rajaee Customs
dis_i The distance between i factory and Shahid Rajaee Customs
$TRCC_k$ The cost of car transportation from the Tabriz factory to the domestic cities
$TRCC_r$ The cost of car transportation from Tabriz factory to export terminals
$TRCC_{ir}$ The cost of car transportation from i factory to export terminals
$TRCC_{ik}$ The cost of car transportation from i factory to domestic cities
$TRCC_{rj}$ The cost of car transportation from export terminals to foreign countries
dis_r The distance of Tabriz factory to export terminals
dis_k The distance of Tabriz factory to domestic cities
dis_{ir} The distance of i factory to export terminals
dis_{ik} The distance of i factory to domestic cities
dis_{rj} The distance of export terminals to foreign countries
pc The production cost in Tabriz factory
pc_i The Production cost in i factory
δ The conversion rate of parts to the car
CAP The production capacity of Tabriz factory
CAP_i The production capacity of I factory
$d_j{}^t$ The demand of foreign countries in period t
$d_k{}^t$ The demand for domestic cities in period t
Pack value The value of each packet imported into the customs
$\emptyset$ The coefficient for calculating the goods value
∂ The ratio of external price to domestic price
γ The unit rate of Income tax
β The unit rate of value added tax

Cost car	The expired cost per unit of domestic product
Added	The rate of value added
B^0	The early budget available at the beginning of period 0
i	Interest rate
PP1	Percentage of increasing raw material purchase costs due to changes in the exchange rate in method 1
PP2	Percentage increase in raw material purchase costs due to changes in the exchange rate in method 2
PP3	Percentage increase in raw material purchase costs due to changes in the exchange rate in Method 3

4-1- Problem formulation

The proposed mathematical model for the defined problem is expressed as follows. This model has been proposed based on the actual conditions in Siba Motor Company.

$$\text{Max Income} - \text{Cost} \tag{1}$$

The objective function of the present model is the maximization type and results from subtracting income from the cost.

$$\sum_{t}^{T}\sum_{r}^{R}\sum_{j}\mathrm{car}_{rj}^{t}\,.\,\mathrm{p}^{\mathrm{tex}} + \left(\sum_{t}^{T}\sum_{k}^{K}\mathrm{car}_{k}^{t} + \sum_{t}^{T}\sum_{i}^{I}\sum_{k}^{K}\mathrm{car}_{ik}^{t}\right).\,\mathrm{p}^{\mathrm{tim}} \tag{2}$$

The term 2 is the function of income, representing the expected income from selling the product within the country and revenue from exporting to the selected countries (if exported). It is worth noting that the export price of the product is 0.84 the domestic price. It is worth noting that the export price of the product is equal to 0.84% domestic price, and domestic and foreign prices increase 10% annually; and also the demand rate of export destination countries increases by 10% every year. Meanwhile, the final products are the output of the Tabriz factory and the potential factory or factories.

$$\sum_{t}^{T}\text{Procurement cost}.\left(IGH^{t}\right).\left(pp1^{t}.\rho 1^{t} + pp2^{t}.\rho 2^{t} + pp3^{t}.\rho 3^{t}\right) \tag{3}$$

Expressions 3 to 9 represent the cost values of the objective function. Expression 3 represents the cost of purchasing raw materials from FAW Company, taking into account all three payment methods and possible costs from exchange rate fluctuations in each method.

$$\sum_{\mathrm{i}}^{\mathrm{I}}\mathrm{FC_i}.\mathrm{X_i} \tag{4}$$

Expression 4 represents the fixed cost (Establishment permit, Operation license, environmental license, Labor Office license, ISO certificate, Certification of vehicle type, Certificate of car manufacturing in the country).

$$\sum_{t}^{T} \mathrm{TRCGH.GH^{t}.dis} + \sum_{t}^{T}\sum_{i}^{I} \mathrm{TRCGH_i.IGH^{t}{}_i.dis_i} + \sum_{t}^{T}\sum_{k}^{K} \mathrm{TRCC_K.car_k^t._{dis_k}}$$
$$+ \sum_{t}^{T}\sum_{r}^{R} \mathrm{TRCC_r.car_r^t.dis_r} + \sum_{t}^{T}\sum_{r}^{R}\sum_{i}^{I} \mathrm{TRCC_{ir}.car_{ir}^t.dis_{ir}}$$
$$+ \sum_{t}^{T}\sum_{k}^{K}\sum_{i}^{I} \mathrm{TRCC_{ik}.car_{ik}^t.dis_{ik}} + \sum_{t}^{T}\sum_{j}^{J}\sum_{r}^{R} \mathrm{TRCC_{rj}.car_{rj}^t.dis_{rj}} \quad (5)$$

Expression 5 shows all transportation costs: transportation of separated parts from the customs to Tabriz factory and a possible factory, and CBU and assembled vehicle from Tabriz factory and a possible factory to the domestic distribution centers and export terminals, and from the export terminals to countries of destination export;

$$\sum_{t}^{T} \mathrm{pc.car^t} + \sum_{i}^{I}\sum_{t}^{T} \mathrm{pc_i.car_i^t} \quad (6)$$

Expression 6 indicates the cost of production (welding, painting, assembling and manpower) in Tabriz factories and potential factory or factories.

$$\sum_{t}^{T} \emptyset.\,\mathrm{Pack\ value}\,.\,igh(t) \quad (7)$$

Expression 7 indicates the customs cost.

$$\gamma.\sum_{t}^{T}\left(p^{tIM} - \mathrm{Cost\ car}\right).\left(\sum_{k}^{K}\sum_{t}^{T} car_k^t + \sum_{i}^{I}\sum_{k}^{K}\sum_{t}^{T} car_{ik}^t\right).(1-y) \quad (8)$$

Expression 8 represents the cost of income tax. The organization will be exempted from paying this cost if it exports.

$$\beta.\,\mathrm{Added\ value}\,.\left(\sum_{k}^{K}\sum_{t}^{T} car_k^t + \sum_{i}^{I}\sum_{k}^{K}\sum_{t}^{T} car_{ik}^t\right).(1-y) \quad (9)$$

Expression 9 indicates the cost of the value added tax. The organization will be exempted from paying this cost if it exports.

Constraints

Considered constraints include the following cases. Constraint 10 indicates being smaller or equal the total imported parts to the Tabriz factory and the possible factory with the number of imported parts to the Shahid Rajaee Customs. Constraints 11 and 12, respectively, indicate the conversion rate of parts to CBU in Tabriz factory and possible factory. In the current problem, every 1,000 parts are converted into a car. Constraints 13 and 14, respectively, indicate the capacity constraint of the Tabriz factory and the possible factory (if built). Constraints 15 and 16 represent, respectively, the inventory of the Tabriz factory and the possible factory in the period t, resulting from subtracting the total inventory of the previous period and the production rate of this period from the total number of transferred cars to domestic cities and export destinations. Constraint 17 represents that the equality of exported cars to the destination countries with the total number of exported cars from the Tabriz factory and the possible factory to export terminals. Constraint 18 indicates the need to meet the demand of the countries of destination export by exported cars from export terminals in each period. Constraint 19 also shows the need to meet the demand of domestic distribution centers by cars produced by the Tabriz factory and the possible factory. Constraints 20 and 21 indicate the export or non-export of the company. The constraint 22 shows the payment methods for the costs of purchasing raw materials from method 3 in the first period; the first method is the payment by draft, in which 100% of the goods value is paid in currencies. At least 10% of all company purchases must be paid by the draft. The second method is the payment of the visual letter of credits, in which 10% of the goods value is paid first and 90% of the remaining is paid when goods arrive at the port. The third method is the payment of the long-term letter of credits, in which 10% of the goods value is paid first, 10% is paid when goods arrive to the port and 80% of the remaining is paid two subsequent periods.

If the exchange rate is assumed to be fixed, it is natural that the firm performs all its payments (except for the last two) by the third method because it pays more volume of money later; but this does not happen due to the volatility of the exchange rate in Iran and its fluctuations during the different periods does not happen in practice. Constraint 23 represents the allowed use of all three methods of payments in different periods, except for the first period and the last two. Constraint 24 indicates the allowed use of the payment method 1 in the last period and the impossibility of usage the payment methods 2 and 3 in this period. Constraint 25 indicates the allowed use of the payment methods 1 and 2 in the period on before the last and the impossibility of usage the payment method 3 in this period. It should be noted that in Constraints 22 to 25, because of the long and bulky constraints, the word English A has been used instead of using the objective function (income-cost); and this cost has been added once in order to not dropped twice the cost of purchasing raw materials. Constraint 26 indicates that the method of payment must be one of the three methods mentioned above in each period for paying the cost of purchasing raw materials. Constraint 27 indicates that all payments for the cost of purchasing raw material should be one of these three payment methods throughout the periods.

$$\mathrm{IGH}^{t} \geq \mathrm{GH}^{t} + \sum_{i} \mathrm{IGH}^{t}{}_{i} \qquad \forall t \tag{10}$$

$$\mathrm{car}^{t} = \delta.\mathrm{GH}^{t} \qquad \forall t \tag{11}$$

$$\mathrm{car}_{i}^{t} = \delta.\mathrm{IGH}^{t}{}_{i} \tag{12}$$

$$\mathrm{car}^{t} \leq \mathrm{CAP} \qquad \forall t \tag{13}$$

$$\mathrm{car}_{i}^{t} \leq \mathrm{CAP}_{i}.\mathrm{X}_{i} \forall i,t \tag{14}$$

$$\mathrm{ICT}^{t} = \mathrm{ICT}^{t-1} + \mathrm{car}^{t} - \sum_{k} \mathrm{car}_{k}^{t} - \sum_{r} \mathrm{car}_{r}^{t} \tag{15}$$

$$\mathrm{IC}^{t}{}_{i} = \mathrm{IC}^{t-1}{}_{i} + \mathrm{car}^{t}{}_{i} - \sum_{r} \mathrm{car}_{ir}^{t} - \sum_{k} \mathrm{car}_{ik}^{t} \tag{16}$$

$$\sum_{i} car_{ir}^{t} + car_{r}^{t} = \sum_{j} car_{rj}^{t} \qquad \forall t, r \tag{17}$$

$$\sum_{r} car_{rj}^{t} \geq d_{j}{}^{t} \tag{18}$$

$$\sum_{k} car_{ik}^{t} + car_{k}^{t} \geq d_{k}{}^{t} \tag{19}$$

$$\sum_{j}^{J} car_{rj}^{t} \leq M.Y \tag{20}$$

$$Y \leq \sum_{j}^{J} car_{rj}^{t} \tag{21}$$

$$
\begin{aligned}
&B^0 + A + \sum_{t}^{T} Procurement\ cost.(IGH^t).(pp1^t.\rho1^t + pp2^t.\rho2^t + pp3^t.\rho3^t) \\
&- \rho1^t\ .IGH^t\ .Procurement\ cost - 0.1.IGH^t.\rho2^t.Procurement\ cost \\
&- 0.9\ .IGH^t.\rho2^t\ .Procurement\ cost.\frac{1}{1+i} - 0.1\ .IGH^t.\rho3^t\ .Procurement\ cost \\
&- 0.1\ .IGH^t.\rho3^t.Procurement\ cost.\frac{1}{1+i} - 0.8.IGH^t.\rho3^t.Procurement\ cost.(\frac{1}{1+i})^2 \\
&= B^{t+1}.\frac{1}{1+i} \quad \forall t = 1
\end{aligned} \tag{22}
$$

$$
\begin{aligned}
&B^t + A + \sum_{t}^{T} Procurement\ cost.(IGH^t).(pp1^t.\rho1^t + pp2^t.\rho2^t + pp3^t.\rho3^t) \\
&- \rho1^t\ .IGH^t\ .\text{Procurement cost} - 0.1.IGH^t.\rho2^t.\text{Procurement cost} \\
&- 0.9\ .IGH^t.\rho2^t\ .\text{Procurement cost}.\frac{1}{1+i} - 0.1\ .IGH^t.\rho3^t\ .\text{Procurement cost} \\
&- 0.1\ .IGH^t.\rho3^t.\text{Procurement cost}.\frac{1}{1+i} - 0.8.IGH^t.\rho3^t.\text{Procurement cost}.(\frac{1}{1+i})^2 \\
&= B^{t+1}.\frac{1}{1+i} \qquad \forall\, T-2 \geq t \geq 2
\end{aligned} \tag{23}
$$

$$
\begin{aligned}
&B^t + A + \sum_{t}^{T} Procurement\ cost.(IGH^t).(pp1^t.\rho1^t + pp2^t.\rho2^t + pp3^t.\rho3^t) \\
&- \rho1^t\ .IGH^t\ .\text{Procurement cost} \geq 0\ \forall t = T
\end{aligned} \tag{24}
$$

$$
\begin{aligned}
&B^{T-1} + A + \sum_{t}^{T} Procurement\ cost.(IGH^t).(pp1^t.\rho1^t + pp2^t.\rho2^t + pp3^t.\rho3^t) \\
&- \rho1^{T-1}\ .IGH^t\ .\text{Procurement cost} - 0.1.IGH^t.\rho2^t.\text{Procurement cost} \\
&- 0.9\ .IGH^t.\rho2^t\ .\text{Procurement cost}.\frac{1}{1+i} = B^T.\frac{1}{1+i} \qquad \forall\ t = T-1
\end{aligned} \tag{25}
$$

$$
\rho1^t + \rho2^t + \rho3^t = 1 \qquad \forall t \tag{26}
$$

$$
\sum_{t=1}^{T} \rho1^t + \sum_{t=1}^{T} \rho2^t + \sum_{t=1}^{T} \rho3^t = |T| \tag{27}
$$

4-2- Linearization of the model

According to the non-linearity of the model, which creates by multiplying the 0 and 1 variables of export with continuous variables of the number of cars transferred from factories to domestic cities in the income tax and value-added tax equations, we linearize the model using an innovative method from the literature (Abbasi, 2018). In the linearization by adding the variable, the non-linear model converts to the linear one. This method is used when two variables are multiplied together; and lead to non-linearity. Now if one of the variables is 0 and 1, the model is linearized by defining and replacing the new variable instead of multiplying the two variables. For example, in linearization of A * B, if A is a 0 and 1 variable, and B is a continuous positive variable, then a variable named c is defined and is assumed equivalent to C = A * B. After defining the variable c, the following constraints are added (The up expression represents the upper limit of the variable B, and the low expression represents the lower limit of the variable A.) (Chen, Batson, & Dang.).

$$C \leq B \tag{28}$$

$$C \leq up * A \tag{29}$$

$$C \geq up * A + B - up \tag{30}$$

$$C \geq 0 \tag{31}$$

5-Solving model and numerical results

In this section, the mathematical model presented in section 3.4 is coded in the GAMS software and solved by the Cplex and its results are analyzed. After obtaining the results of the solving model, the sensitivity analysis is performed on the most important parameters of the problem in order to examine their effect on the model's objective functions.

According to the results of the model solution for a selected case study, there are many benefits for the company by attending in the global value chain of the automotive industry and having an export. This result obtain by taking into account all the costs from the role-playing the intended company in the global value chain, such as the fixed cost of establishing a new factory (including costs such as: Establishment permit, Operation license, environmental license, Labor Office license, ISO certificate, Certification of vehicle type, Certificate of car manufacturing in the country), increasing the cost of raw materials, budget constraints, the cost of transportation from the factories to the export terminals and from the export terminals to the destination countries, etc. Taking into account the conditions of the problem in 20 time periods, the obtained earnings for the company will be about $442 billion that is an affordable and considerable figure. It represents earnings of 88 billion per year. While the model is selected from the cities of Bandar Abbas, Isfahan, Arak and Mashhad, each of which has advantages such as: Bandar Abbas (the proximity and ease of access to the African and Afghanistan and Pakistan market), Isfahan and Arak (the proximity and ease of access to the markets of Central Asia countries, Iraq and Afghanistan) and Mashhad (the proximity and ease of access to the Central Asian market) as the potential options of site of establishing the new factory, Mashhad city has chosen as the site of building a new factory. This factory will send cars only to domestic sales centers of the provinces: South Khorasan, Razavi Khorasan, Yazd, Kerman, Hormozgan, Chaharmahal and Bakhtiari and Kohgiluyeh and Boyer Ahmad; and other domestic sales centers are supplied by Tabriz factory including: East Azarbaijan, Fars (three sales centers) , Isfahan, Khuzestan, Tehran, Markazi, Hamadan, Lorestan, Kordestan, Qazvin and Ardebil. In fact, seven provinces are supplied by Mashhad factory with a total volume of 525 vehicles per year and 11 provinces are supplied by Tabriz factory with a volume of about 905 vehicles per year. Fig.4 shows how to supply the sales centers by the factories.

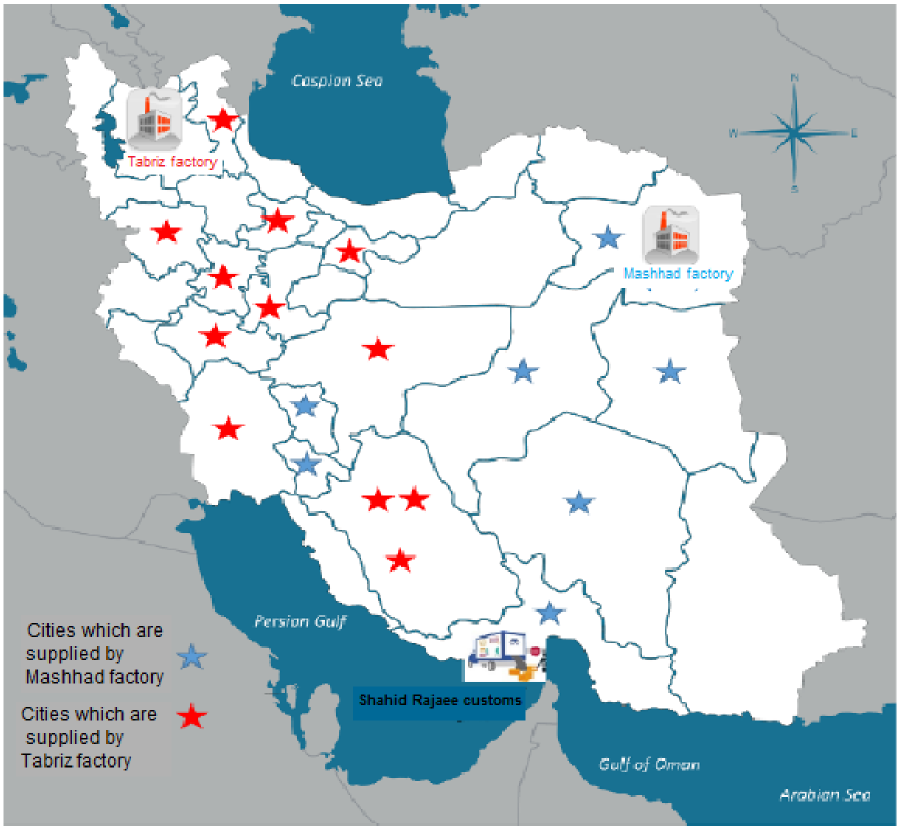

Fig 4. How to allocate domestic cities to factories

In the field of transferring cars to export terminals for export to selected countries, Tabriz factory covers Jolfa, Pishin, Shalamche and Bandar Abbas terminals; Mashhad factory also covers Dogharoon terminals. Also, in allocating export terminals to the countries of export destination, the counties of Azerbaijan, Iraq, Pakistan, Afghanistan and Egypt are supplied, by the terminals of Bandar Abbas, Shalamcheh and Jolfa, by the terminals of Pishin and Dogharoon, by the terminal of Dogharoon, respectively.

Table 1. How to allocate payment methods to time periods

Payment methods	Time																				total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
$\rho1^t$	■																			■	2
$\rho2^t$		■			■	■			■	■			■	■			■	■	■		10
$\rho3^t$			■	■			■	■			■	■			■	■					8

In addition, in order to pay the cost of raw materials (parts), based on the time value of money and the percentage of increasing costs due to exchange rate changes that have been obtained through the study of the exchange rate changes over the past three years, a coefficient between 1 and 2 has been assigned in the form of parameters pp1, pp2, pp3 in the form of a qualitative method of structured exploratory interview, according to the expert opinions in the automotive industry and according to the payment risk of each method in each of the 20 time periods; Which it indicates the imposed cost for using each of the payment methods in addition to the cost of raw materials. In this way, optimal methods for paying the cost of raw materials in different time periods, has been selected by the model according to the constraints of the problem. As shown in table 1, it is certain the way of this allocation, the organization uses the methods of 1, 2 and 3 in 10, 50 and 40 percent of cases, respectively. Other values of the cost of the objective function are displayed in the table 2.

Table 2. Cost values of the objective function

Fixed cost	**Purchase cost**	**Raw materials**	**Production cost**	**Inventory**	**Customs**
3.5 E+10	1.02 E+13	1.47 E+12	1.60 E+11	6.08 E+10	5.5 E+11

5-1- Sensitivity analysis

In this section, we carry out the sensitivity analysis on some of the problem parameters in order to examine the accuracy of the model's behavior and the effect of different parameters on the results. In each of the graphs, a greater gradient indicates higher sensitivity.

Sensitivity analysis of price

As it is determined in the proposed mathematical model, according to the current mechanism of the studied organization (Siba Motor Company), the domestic and export price of the product should increase of 10% per year. Table 3 represents the changes in values of the profit objective function for a various increase in domestic and export price. As can be seen in the table 3, to study the effect of an increase in domestic and export price on the objective function, three patterns are considered. In the first pattern, increase in export price is fixed, but the amount of increase in domestic price is increased. In the second pattern , the value of increased internal prices is assumed to be constant but the values of increase in the export prices of are increased . In the third and the last , both export and domestic prices are on the rise.

Table 3. The values of the profit objective function for different amounts of increase in price

Increase in p^{tim}, $\mathrm{p}^{\mathrm{tex}}$ is fixed.	Increase in price (rate)	$\mathrm{p}^{\mathrm{tex}} = 10\%$ $p^{tim} = 0\%$	$\mathrm{p}^{\mathrm{tex}} = 10\%$ $p^{tim} = 3\%$	$\mathrm{p}^{\mathrm{tex}} = 10\%$ $p^{tim} = 5\%$	$\mathrm{p}^{\mathrm{tex}} = 10\%$ $p^{tim} = 7\%$	$\mathrm{p}^{\mathrm{tex}} = 10\%$ $p^{tim} = 10\%$
	Profit (Rials)	-8,54 E+11	-5,48 E+11	-3,16 E+11	-2,35 E+11	3,67 E+11
Increase in $\mathrm{p}^{\mathrm{tex}}$, p^{tim} is fixed.	Increase in price (rate)	$\mathrm{p}^{\mathrm{tex}} = 0\%$ $p^{tim} = 10\%$	$\mathrm{p}^{\mathrm{tex}} = 3\%$ $p^{tim} = 10\%$	$\mathrm{p}^{\mathrm{tex}} = 5\%$ $p^{tim} = 10\%$	$\mathrm{p}^{\mathrm{tex}} = 7\%$ $p^{tim} = 10\%$	$\mathrm{p}^{\mathrm{tex}} = 10\%$ $p^{tim} = 10\%$
	Profit (Rials)	2,96 E+11	3,35 E+11	3.62 E+11	3.66 E+11	3,67 E+11
Increase in p^{tim}& $\mathrm{p}^{\mathrm{tex}}$	Increase in price (rate)	$\mathrm{p}^{\mathrm{tex}} = 0\%$ $p^{tim} = 0\%$	$\mathrm{p}^{\mathrm{tex}} = 3\%$ $p^{tim} = 3\%$	$\mathrm{p}^{\mathrm{tex}} = 5\%$ $p^{tim} = 5\%$	$\mathrm{p}^{\mathrm{tex}} = 7\%$ $p^{tim} = 7\%$	$\mathrm{p}^{\mathrm{tex}} = 10\%$ $p^{tim} = 10\%$
	Profit (Rials)	-1,02 E+12	-6,60 E+11	-3,95 E+11	-2,84 E+11	3,67 E+11

As shown in the table 3, in the first pattern, the annual domestic price increase for 3, 5, and 7 percent and the export price is constantly increased, causes a negative annual profit for Siba Motor Company; once the organization reaches a positive balance, it has an annual increase of 10 percent; and this Indicates the sensitivity of the objective function towards this parameter. Figure 5 shows the upside growth of the objective function for different amounts of this parameter. In the second pattern, the annual export price increase of 3, 5, and 7 percent and the domestic price is constantly increased, as shown in figure 6, the objective function increases for different values of the rate of increase in export prices. But the objective function does not change much compared to the change in the internal price values. This means that the objective function is more sensitive to domestic price than the export price. In the last pattern, the annual export and domestic price increase for 3, 5, and 7 percent, cause a negative annual profit for Siba Motor Company; once the organization reaches a positive balance, it has an annual increase of 10 percent; and this Indicates the sensitivity of the objective function towards these parameters. Figure 7 shows the upside growth of the objective function for different amounts of these parameters.

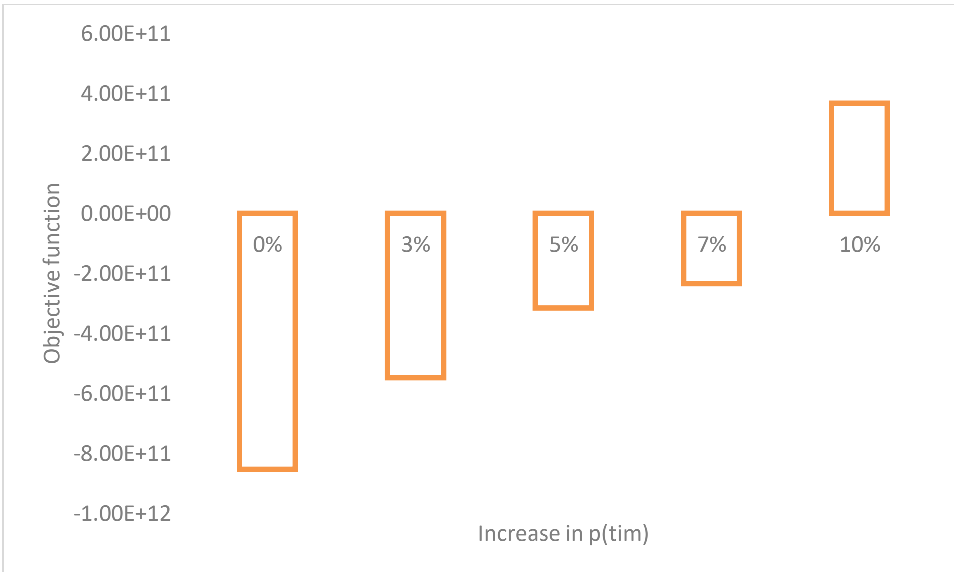

Fig 5. The values of the objective function of profit for different amounts of increase in domestic price (p^{tim})

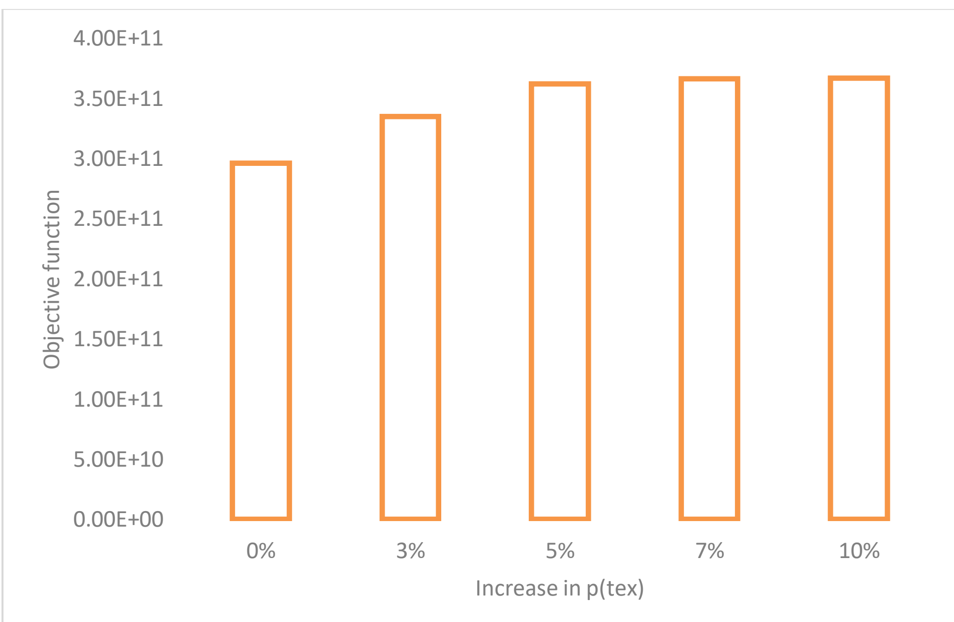

Fig 6. The values of the objective function of profit for different amounts of increase in export price (p^{tex})

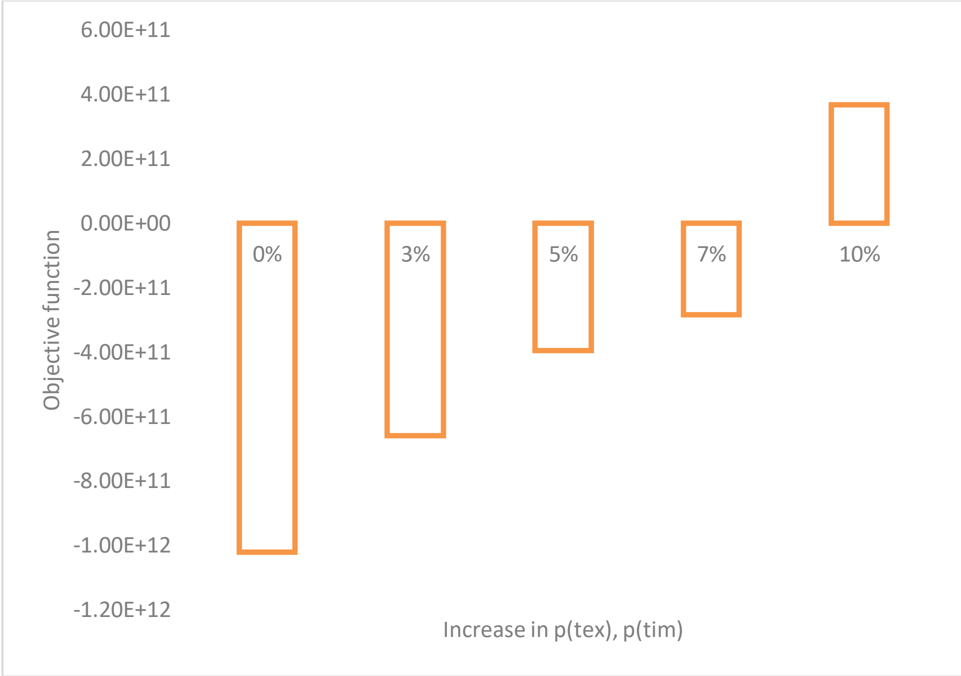

Fig 7. The values of the objective function of profit for different amounts of increase in domestic and export price (p^{tim}, p^{tex})

Sensitivity analysis of demand

In this section, we carry out the sensitivity analysis on this parameter in order to investigate the accuracy of the model's behavior and the effect of the demand parameter on the results. Table (4) represents the different amounts of the objective function of profit on the parameter of increasing demand.

Table 4. The values of the objective function of profit for different amounts of increase in demand

Increase in demand (rate)	0%	10%	20%	30%
Profit (Rials)	3,67 E+11	3,71 E+11	3,73 E+11	3,73 E+11

As shown in the table above, the percentage of increase in demand for values of 0, 10, 20 percent, increases the annual profit for Siba Motor, but a 30 percent increase in demand has no difference in the profitability of an organization, according to the company's restrictions on imports, production, equipment, maintenance of inventory, etc., compared to a 20% increase in demand. So, according to the current situation of the problem and Siba Motor, this indicates an increase in demand up to 0, 10 and 20 percent increases the profitability of the organization; but increase in demand more than 20 percent, does not change much in the profitability of the organization. Figure 8 shows the trend of the objective function for different amounts of this parameter.

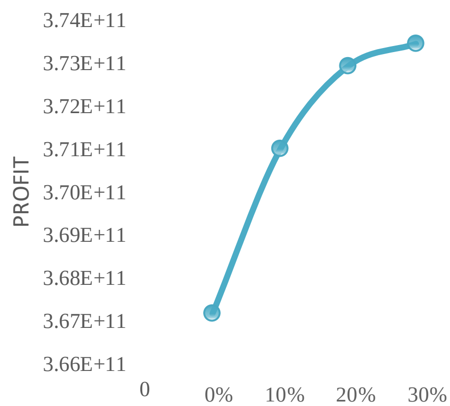

Fig 8. The values of the objective function of profit for the different amounts of increase in demand

Sensitivity analysis of payment methods

In this section, we carry out the sensitivity analysis on Payment Method variable in order to examine the accuracy of the model's behavior as well as the effect of binary variables for payment methods on the objective function of organization profitability. Table 5 shows the different amounts of the objective function of profit for using different payment methods in 20 time periods. The first row represents the amount of profit using the optimal payment methods which were obtained from the output of optimal solutions in each period. The second row shows the value of the objective function using the payment method 3 in all periods; the reason for investigating the objective function, in this case, is that the third method is optimal when the problem is not taking into account exchange rate fluctuations. Because the more volume of the value of raw material (80%) is paid later. Rows 3 to 5 also represent the objective function of profit using the triple payment methods in 20 periods randomly.

Table 5. The amounts of the objective function of profit for using different payment methods for the cost of raw materials in 20 time periods

How to pay for raw materials in 20 time periods	Profit
Selected methods of the model (optimal method)	3,670E+11
Method 3 in all courses	3,6634E+11
The methods are randomized (1)	3,6623E+11
The methods are randomized (2)	3,6629E+11
The methods are randomized (3)	3,6618E+11

As shown in table 5, the profitability by using the proposed payment methods for the cost of raw materials is significantly improved when the selection of these proposed methods is optimal. In the next priority, according to use the method 3 in all periods, Random 2, Random 1 and Random 3 have the most profitability, respectively. Figure 9 indicates the behavior of the objective function for using different algorithms of payment method. Interesting point from the results is the greater profitability for using the payment method 3 in all periods compared with using Random 1, 2 and 3. Thus, it can be concluded that if there is no a systematic algorithm and model to use the different payment methods, only method 3 is used.

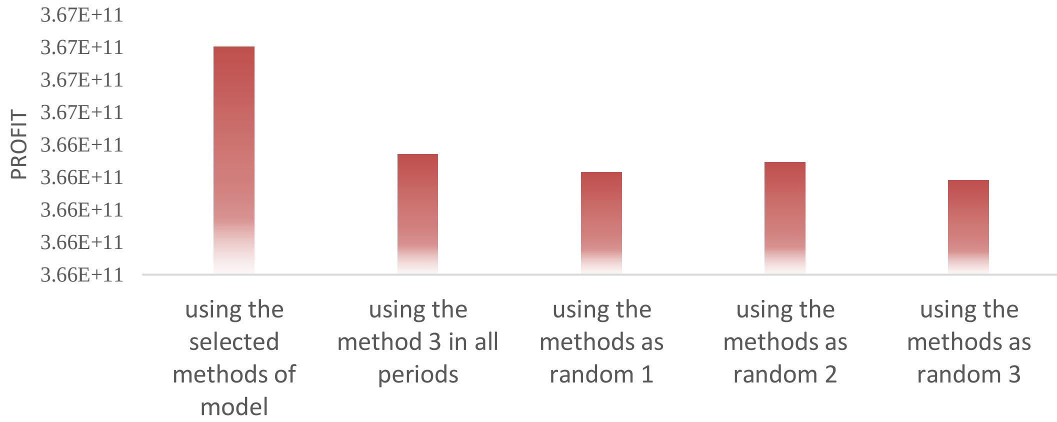

Fig 9. The values of the objective function of profit for using different algorithms of payment method

6- Managerial insights

The present mathematical optimization model is concerned with the automotive global valve chain in which investigate Siba Motor Company case study. In the proposed model, regarding the considerable importance of the financial issues in the global value chain, especially in our case study due to the fluctuation of the exchange rate, financial considerations (time value of money, payment period and costs from exchange rate fluctuations) are incorporated into the model as well as procurement, production and assembly, distribution and location decisions. As regards the obtained results from the proposed model, the following suggestions are proposed to improve the performance of the automotive value chains' members:

- Increase in the selling price of products per year doesn't make economic unless more than 10% owing to the increase in the costs.
- Regarding the sensitivity analysis on demand, by increasing the level of demand the value of profit also increase until +30% changes in demand and after that the amount of profit doesn't change due to the production capacity constraint. Therefore it seems reasonable to extend the production capacity to meet more demand either domestic or foreign.
- Regarding the proposed payment methods for raw materials, the best selection of them is the output of the optimal solution. In the next step, if the optimal solution is not available, the third methods can be implemented for all periods.

In line with the above suggestions, following tips are provided especially for Siba Motor Company:

- As determined in the Siba Motor vision, this company should provide structures and infrastructures for cooperation in the form of Joint venture agreement with its Chinese partner, i.e., FAW Company. This process will begin with initial negotiations with the Chinese partner to develop the infrastructure of cooperation in the automotive industry.
- According to increasing the use of semi-heavy trucks beside reducing the sale of heavy trucks in Iran, it is suggested Siba Motor Company spend a larger share of its budget to produce semi-heavy trucks and also to reduce the production of heavy trucks. The reason for using light trucks is to increase the share of small cargo transportation in Iran.
- According to the policy of setting a single-rate currency, it is expected that Siba Motor will perform most of its purchases by method 3 to pay the cost of raw materials because currency fluctuations are

reduced after the implementation of this law and the risk of setting a single-rate currency does not threaten the company.

7- Conclusion and future suggestions

In this study, we provided a physical flow optimization model by taking into account the time value of money and the period of payment in the global value chain of the automotive industry in order to maximize the earnings of the assembler company (Siba Motor). Additionally, we integrated the decisions related to procurement, production and assembly, distribution, site selection of establishing a potential factory with financial considerations (time value of money, payment period and costs from exchange rate fluctuations). Moreover, the financial (tax and customs), capital and infrastructural constraints are considered to approach the reality. The features of the present model are to focus on financial indicators as well as engineering economics issues. Since the present model is a non-linear model, we linearized the model through an innovative method and then obtain the exact solution by GAMS software, which is widely used to solve optimization models. Finally, we investigated the efficiency of the proposed model and its applicability using the documentary and actual data derived from the selected case study.

For future suggestions, regarding the great importance of social and environmental issues through the world, these considerations could be added to the optimization model in the global value chain. Moreover, to provide an optimization model more compatible with reality, we can consider all members of the value chain as an integrated manner to decide about the in common decision variables rather than considering only one member of the global value chain.

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