

Designing and Analysis a Dynamic Model of World Class Manufacturing in Iranian Automotive Industry

Alireza Soloukdar

Department of Industrial Management, Central Tehran Branch, Islamic Azad University, Tehran, Iran.

E-mail: a_soloukdar@hotmail.com

Postal Address: No.136, Forsat shirazi St., North Eskandari St., Azadi Street, Tehran, Iran

P.O.Box:13185/768

Mobile :(+98)9191207902

Tel :(+98)21 22495367

Abstract

World Class Manufacturing (WCM) has attracted the attention of many manufacturing industries and operation strategists. Lack of clarification of relationships among widely spreading elements of manufacturing process and poor attention to non-linearity and time delays, all are the main reasons that some companies may be far away from developing a comprehensive and advantageous model in a WCM system. The purpose of this paper is designing and analysis a dynamic Model of WCM system to develop a proper strategy which changing the current situation into a WCM situation would be possible in the future By the Dynamic Balanced scorecard (DBSC) methodology as well as clarifying deficiencies of classical balanced scorecard, a systematic model of WCM has been presented through causal loop and stock & flow diagrams. This research has been carried out as a case study in the Iran Khodro Co. (IKCO); we've used Vensim software for designing and analyzing our model after entering related data, parameters, and equations. Some strategies have been presented through analyzing the scenario and running the simulation model.

Key words: System Dynamics, World Class Manufacturing (WCM), Dynamic Balanced Scorecard (DBSC), Iran khodro Co.(IKCO).

1. Introduction

The Term of World Class Manufacturing was born in 1982 (Schonberger, 1986). In 1990's, following the expansion of performance measurement system design and development, both Professor Robert Kaplan from Harvard Business School and David Norton from the International Strategy Consultants have generated the Balanced Scorecard (BSC). The BSC is a technique used for the performance evaluation based on an organization strategy. In this method, a strategy is divided into quantitative objectives and also a system is provided for monitoring the strategy in the four areas of growth and learning, internal processes, customers, and finance (Kaplan and Norton, 2000, p.30).

Grobler (2010) describes the elements, strategy role and production capacity as following:

"From the viewpoint of production management, strategic capability plays an important role in the success of a company, meaning that the power of a factory is based on keeping its strategy and supporting its market development. Producing, developing, and transferring of

strategic capabilities are important functions of production strategy. Often, these functions are in contrast with everyday problem solving and operations management. One of the most well-known writers in this field has outlined four strategic capabilities in manufacturing operations: (a) production capability (b) with lower cost, (c) high quality, (d) reliable delivery, (e) flexibility in assembly and Quantity supplied" (Grobler, 2010).

Referring to the fact that there are no particular definitions offered in the various definitions already provided by relevant authors and they have all introduced some new ideas and thoughts about production and the best performance, here through reviewing the available definitions and literature, we can present a comprehensive definition for WCM:

"The World Class Manufacturing is an instantaneous, integrated and systemic approach to the WCM factors and elements at Learning and Growth, Internal Processes, Customer, and Finance levels in a way that it becomes capable of responding dynamically to environmental complicated changes and organizational difficulties, so that by implementation of this dynamic model and accounting for adjoining time and delay, systematically it can react immediately in the face of quick changes, and attain the best strategies, objectives and competitive advantage at a global level." (Seyedhosseini and Soloukdar, 2007).

Richardson (1996) studied the relationship between maintaining customers and the profitability and concluded that to grow customer keeping rate is an effective way for expanding profits rather than to use a new customer-focused strategy.

More customer satisfaction or greater customer keeping rate has a significant positive effect on the firm's earnings and market share; so, it can be a key determinant of long-term performance.

In essence, this literature discusses that maintaining the customers and increasing the customer satisfaction play principle roles in reducing marketing costs, increasing profits, and having a positive face-to-face discussion. A considerable part of this research emphasizes on the quality of service as a major factor of customer satisfaction. Other factors determining customer satisfaction have less importance.

According to previous studies (Kim, 2006; Grobler, 2010; Xinyan, 2001; Bueno, 2005; Nielson, 2006) do not examine the various causal and multiple feedback relations existing in each of the realms by the help of WCM elements and causes, only just indicate a one-directional relationship (logic of cause & effect), whereas most strategic perceptive factors influence each other in the feedback cycle pattern. Furthermore, simple balanced evaluation without paying attention to Systems dynamic (SD) may lead to the incorrect and misleading conclusions regarding strategic intuition effect since the delays and dynamic major factors in each certain environment have not been accounted for. And due to its sustainable nature, the mapping system is not capable of answering questions such as "what will happen if". The disadvantage of these studies are the lacking of a comprehensive overview and consistent system with respect to the WCM model, and merely the trivial relation of a few factors may be evaluated on the basis of regression – correlation relationship, while in the SD, the concurrent relationship between factors and consistent multilateral interactions would be observed, by considering the nonlinear feedbacks and delays.

With regard to of the above mentioned perspectives, it is highly crucial to achieve a dynamic model which can cover all the aspects and primary/secondary factors including the internal and external ones, strategies, objectives and policies. So,

specifying the above factors can result in a systematic progress to support the determination of WCM performance.

The Main purpose of this research was to identify the determinants of competitive advantage and strategic goals of the WCM, and to study the relations of the elements, the level of importance, behavior of each element and the related subordinates as well in the status quo, in order to find a comprehensive appropriate model for establishing a dynamic WCM.

2. Materials and Method

For identifying factors, criteria, visions and different methods of performing a WCM, a survey research method has been used by means of library facilities and research works. Furthermore, by using research literature, a conceptual model in addition to the WCM relation has been globally designed and tested through questionnaires and interviews with experts. System Dynamics (SD)(Sterman,2000;Forrester,1961; Richardson and Pugh,1981) and Balanced Scorecard (BSC) (Kaplan and Norton,2000) methods together with a cognitive map are used to create the feedback loops of model and sub model, as well as to run and update (dynamics) model for developing appropriate strategies. Survey research method and study resources, documents and statistics for internal organization and documentation of IKCO are used to determine the mathematical relationships between elements and variables of the dynamic model of WCM. In this study, due to the complex and nonlinear nature of problem along with the time coherence, the paradigm of research is based on general theory and systems thinking approach. The methodology of describing the system recognition is in accordance with the main subject of soft systems methodology. Modeling this subject has been done by means of system dynamics technique and dynamic balanced scorecard. The software used for converting mental models into mathematical ones and simulating derived from dynamic modeling for learning expansion is Vensim. Table 1 is an image of components forming this article.

Table 1.forming four levels for this research

levels	For this dissertation
1- Paradigm	-System thinking(based on descriptive perspective)
2 - Methodology	- Soft systems methodology (understanding the problem and the world class manufacturing system)
3 - Techniques	- Combination of System Dynamics and Balanced Scorecard
4 - Tool	Vensim software-

Taking competitive advantages of WCM system in automotive industry requires a set of documented guidelines. Moreover, deploying a WCM system in Iran Khodro depends on providing a practical and executable model. The steps below have been followed in this study based on process of defined Richardson and Pugh (1981) and Sterman (2000) so that the industry owners and manufacturers can get the benefit of WCM. As following:

- 1 – Defining the problem;
- 2 – Recognizing the status quo with regard to environmental, political and economic factors, obtaining information, data and elements of various literature from libraries, observations, interviews and questionnaires;
- 3 - Providing principles, rules, and factors of WCM system (defining primary and secondary factors as well as models and sub models);
- 4 – Specifying and understanding the goals and objectives of IKCO regarding number 3 (Defining Factors and Variables of WCM);
- 5 - Determining the causal relationship between them and the structure of mental models (model conceptualization through cognitive map by Asharpour (2007));
- 6 – Referring to qualitative and verbal relations relevant to the system’s future and determination of models’ limits (Boundary Diagram);
- 7 - Evaluating the criteria, priorities, parameters and variables of WCM by establishing mathematical and quantitative relationships, and determining the degree of effectiveness amongst factors through constructing the Stock &Flow structure;
- 8 – Transferring the data of preliminary model to computers in order to do simulation and systematic control according to the reference models and the assumptions of research;
- 9 – Comparing the existing condition with the principles and factors of WCM, and determining the related differences (Test model);
- 10 - Designing and developing an overall appropriate operational and functional development strategy to realize the WCM by considering a range of changes involving the WCM implementation;
- 11 - Conducting and employing the WCM techniques (scenario building), and indicating the WCM improvement methods.
- 12 - Organizing the idea of WCM implementation.

In this article, the executive model of WCM dynamic strategy based on the theory of Sterman (2000) has been extended in figure 1.

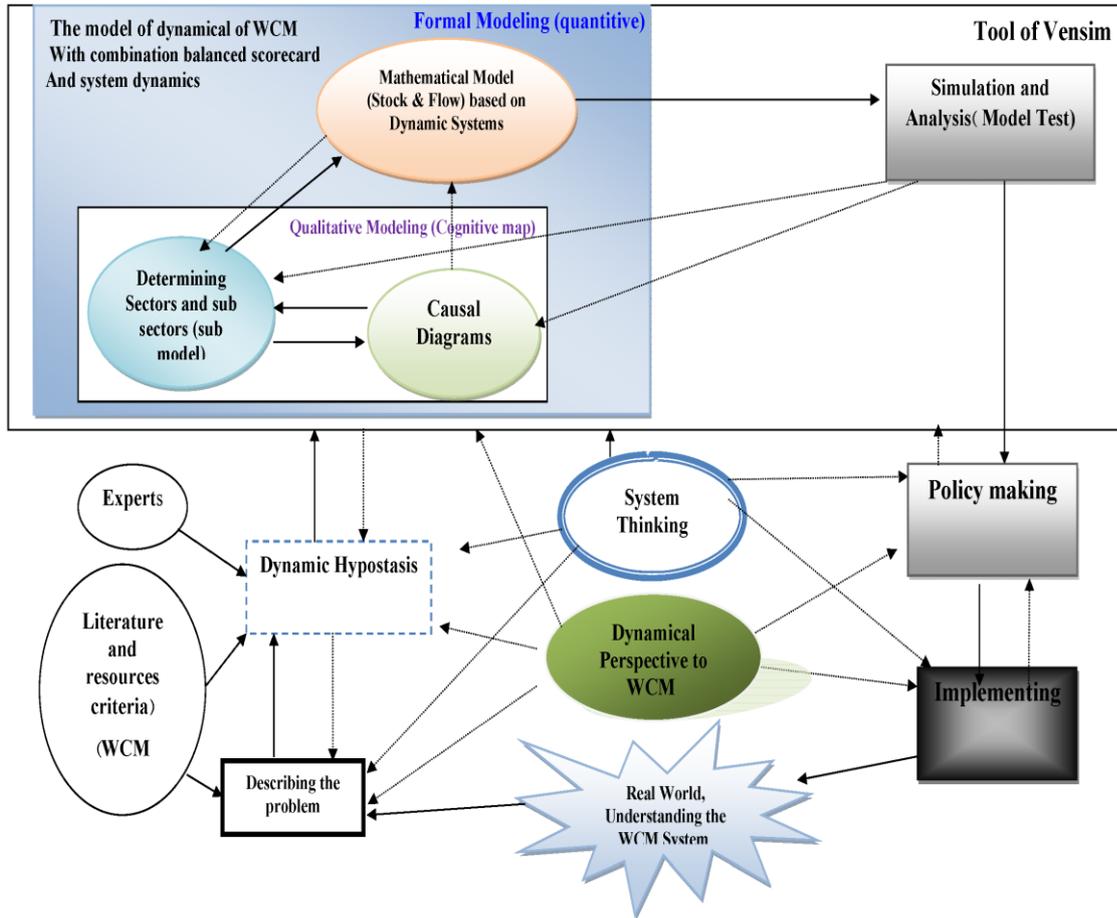


Figure.1 Implementation Model of Strategy of Dynamic WCM

3. Results

In the result section, as the steps of executive model of WCM dynamic strategy mentioned in last section, we've offered following sections:

3.1 Problem Definition

The main issues of IKCO on its way to achieve a world class automotive industry include the drop of domestic market share, the decrease in profit margin, and the reduction in the number of sales (customers) (Fig. 2).

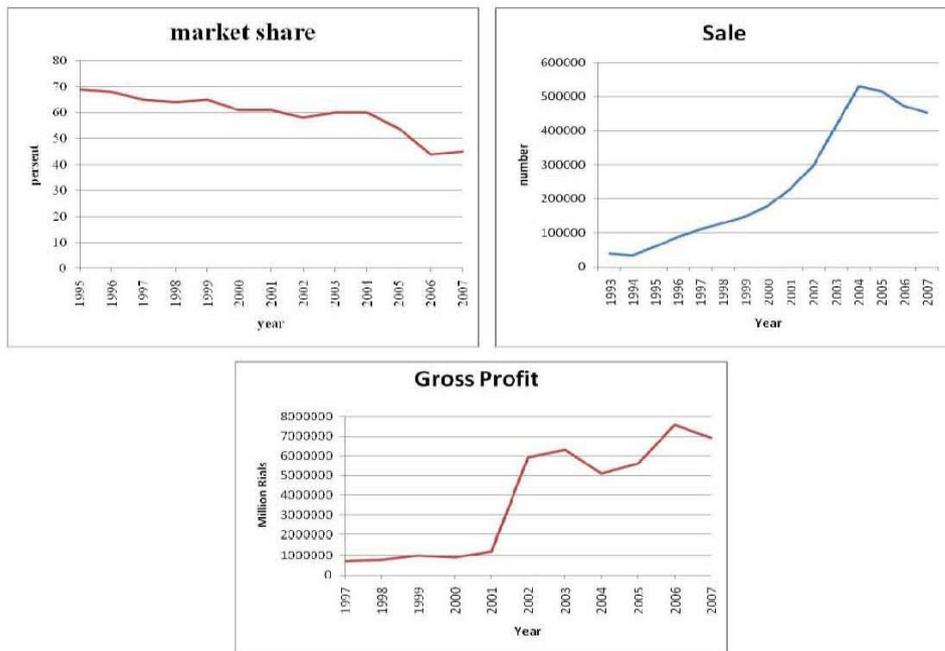


Figure 2. Trend of dropping market share and gross profit and customer (sale)

The falloff in market share and customers has been caused by some factors as demanders reduction rate, growing increase in domestic competitors and in price, and customer satisfaction reduction rate (the presence of new competitors with greater diversity and new products has led to an upward trend in the number of competitors and in the supply as well, and because of that Iran's market has plummeted downward. Analysts predicate that below 50% of the vehicles' future market because of rapid diversity, innovation, high quality, reasonable price will be seized by competitors and imported vehicles (Fig. 3). Customer satisfaction reduction has been caused by the unacceptable quality levels of vehicles, sales and after-sales service.

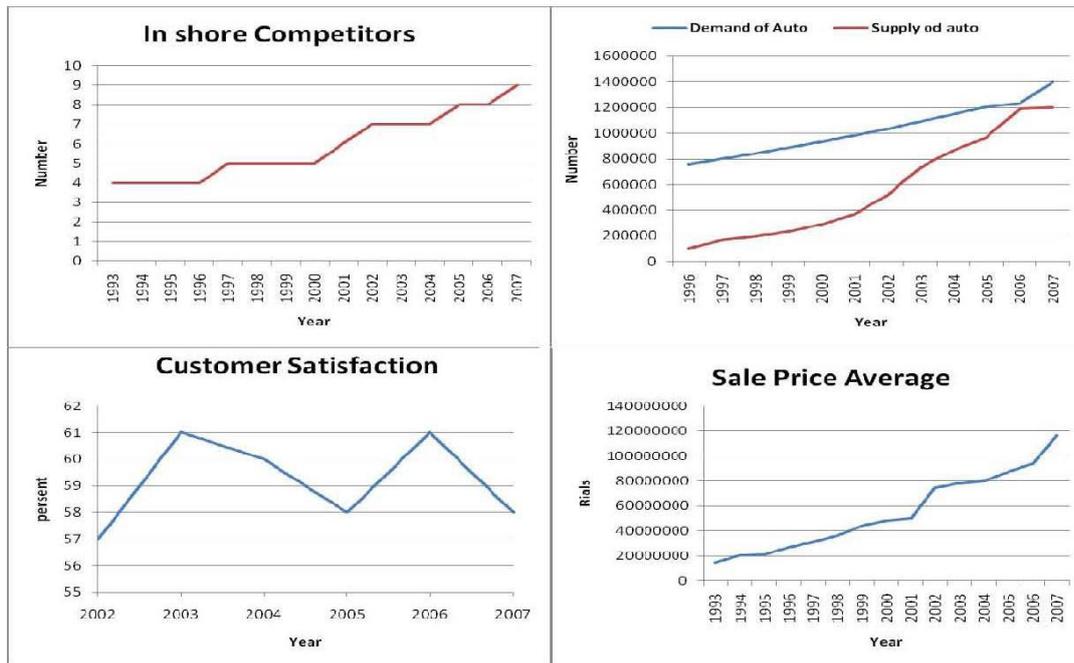


Figure 3. Trend of Increasing competitors and Supply within decreasing in demand rate and Customer Satisfaction

On the other hand, the increase in sale price resulted in decrease in sales and market share has been because of cost price growth. Also, the increase in production cost price is the result of increase in material and overhead costs. Growing rate of cost price has been caused by the operational costs derived from administrative costs (because of the increase in the wages of non-productive employees), as well as sales & distribution costs. High overhead and operational costs caused by slow progress in the construction of manufacturing sites have resulted in lowering products diversity rate. Personnel's low rate of learning and teaching has led to a decrease in innovative suggestions. Simultaneously, it has lessened the speed of innovation trend and new technology development for varying the products. Decrease in the speed of new technology replacement has diminished the quality and diversity of products and consequently resulted in customer satisfaction reduction, low demand, less profit, and market share falloff.

The R & D division has not had sufficient budget to improve the knowledge and skills of employees; so, the training effectiveness and manpower productivity have come down. In other words, the cuts in research and development investment may slow the speed of site construction as planned earlier for producing the products diversity and increasing the automobile quality and customer satisfaction in the market.

Because of the rapid changes of elements, IKCO. needs a dynamic model to adjust and respond to them. By designing and implementing the model, the company can analyze its behavior in order to control some elements as competitors, domestic

market, and international market, and to choose effective and optimized policies for reaching to a global vehicle market.

3-2. System Boundary and Identification WCM Factors

Here, by using the cognitive map technique, the recognition of factors, relations, and effective variables have become possible. The application of a specific mathematical model in this technique, for reviewing the individuals' (or experts') opinions about the elements of a given system, facilitates the data organization and the study of relationships and dependencies existing among the elements of that system. The concepts of graph theory (such as path, cycle, etc) have been used in this technique, for organizing multiplex connections in a specified system. Balanced and labeled graphs have been used to organize and study the system. Additionally, the existing relations between two stations (two elements) have been featured by positive, negative or zero signs (the positive sign may denote agreement, interest, or incremental and positive effect of element A on element B, and the inverse may be true regarding the negative sign) (Asgharpour, 2007).

Some techniques for creating a cognitive map include:

1-Using the resources, theories, and available documents and records.
2-Using the questionnaires and sending them to the experts who are able to judge the dependency causal relations (this method is based on a collective agreement and the access to a broader and more objective data is more possible than the use of documents).

3-Doing open and informal interviews (this method leads to make comparable diagrams of interviewees, and the interaction between the interviewer and interviewees is possible). Essentials of a cognitive map in this study involve two main elements: fundamental concepts and dependency causal relations.

The factors and variables affecting the demand and market share of Iran Khodro Co. are concisely illustrated in Table 2, in primary and secondary parts of a dynamic and BSC and by including the factors of WCM:

Table 2. System Boundary and level Relations within Effective Variables.

Levels	Endogenous Variables	Exogenous Variables	Excluded Variables
Customer and Market	<ul style="list-style-type: none"> - Market Share - Customer Satisfaction - Sale Price - Volume of Sales 	<ul style="list-style-type: none"> - Supply - Demand - Domestic Competitors and Import 	<ul style="list-style-type: none"> - Vehicle Price Index - Consumer goods price - Export - The public's Perception - Competitors' Price - competitors' quality - Gasoline Consumption - Gasoline Ration - popularity (brand familiarity) - Volume of advertizing and marketing - Gasoline Import - Average time of rendering vehicles - Environmental rules and principles - Security principles - Air Pollution - Non-oil Goods exports - political threats
Internal processes (Manufacturing)	<ul style="list-style-type: none"> - Vehicle Replacement rate - Products Lifetime - Inventory - Production Capacity - Delivery Time - Process Quality (Technology and Automation level) - Machinery depreciation - Volume of New Products(Products Diversity and Flexibility) - Products Quality - Production Rate - Operations Time Period (production cycle) 	<ul style="list-style-type: none"> - Cost of a made unit - Products lifetime - Depreciation Rate - Cost of a unit of training - Number of R&D programs - Overhead Cost - Process Quality elevation rate - Rate of Change in Manufacturing Investment 	<ul style="list-style-type: none"> - Project Completion date - Flexibility in the processes (office automation) - work volume in Manufacturing Process - Wastage volume - Gross Domestic product(GDP) - replacement goods conditions (public transportation)
Learning and Growth	<ul style="list-style-type: none"> - Employees' knowledge level - Number of innovations and recommendations - Labor productivity - Employment 	<ul style="list-style-type: none"> - Level of knowledge and skill - Rate of knowledge loss 	<ul style="list-style-type: none"> - Morality - Labor participation rate - Labor flexibility - Capabilities - Rate of ceded responsibility - Unemployment rate
Finance	<ul style="list-style-type: none"> - Operating Profit - Net Profit - Revenue - Cost price - Manufacturing costs (wages and materials) - Overhead costs - Operating costs: <ul style="list-style-type: none"> a-general and administrative b- Sales and Distribution c- R&D - Capital budget - Investment in manufacturing technology - Investment in Human Resource - Investment in sales and distribution networks 	<ul style="list-style-type: none"> - Customs Tariff and Tax - Government Support (domestic loans) - Investment in R&D - Foreign Funds. 	<ul style="list-style-type: none"> - Investment in marketing and advertizing - Stockholders value - Growth of per capita income - People's median income - Vehicle ownership costs (insurance, tax, maintenance, and gasoline) - Inflation rate - Growth of liquidity - Economic Development - Investment in Information Technology

3.3 Model Conceptualization through Cognitive Map

After recognizing system's limitations and identifying endogenous and exogenous factors in the four levels of customer, learning and growth, internal processes and finance, a unified and comprehensive model was designed (figure 4) displaying the major and minor factors (model and sub models). Regarding the technological, social, political and economic changes as well as the time changes, the deletion of ineffective factors and addition of effective and important factors are possible in this model. And by setting it in software, the model updating can be possible.

3.4 Stock and Flow Model

The structure of causal loop diagram and the BSC model are based on each dimension and section of this article. Describing the dynamics hypothesis with the stock and flow diagrams in this section are four main levels of learning and development, internal processes, customers and our financial markets between four main levels strategic objectives:

A - Sector of learning and Growth

In this sector, the stock and flow model of learning and development is shown (Figure 5).

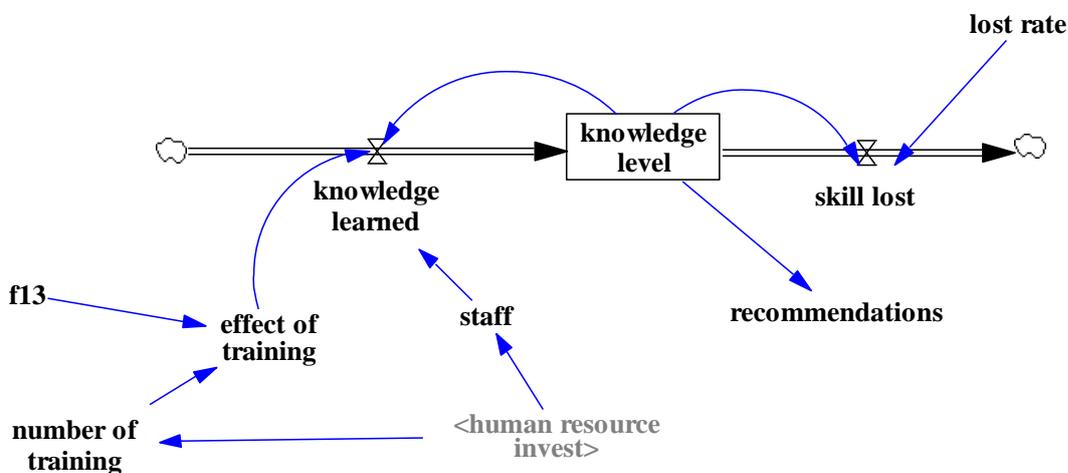


Figure 5. Stock and Flow Model of Learning and Development Sector

Investment in the human resources and training center has increased the level of skills and knowledge. Making use of old and new employees has an effect on the level of personnel's knowledge. The knowledge level growth has an influence on the number of recommendations (innovation), in a manner that it elevates the quality of processes and the number of new lines (Automation & Technology); also it leads to an increase in the product quality and consequently has some impacts on the relations of other parts.

B -Sector of internal processes

In this sector, we've focused our studies on the core issues of manufacturing processes. Also, the dynamic assumptions are discussed in two parts of the process and product quality (figure 6).

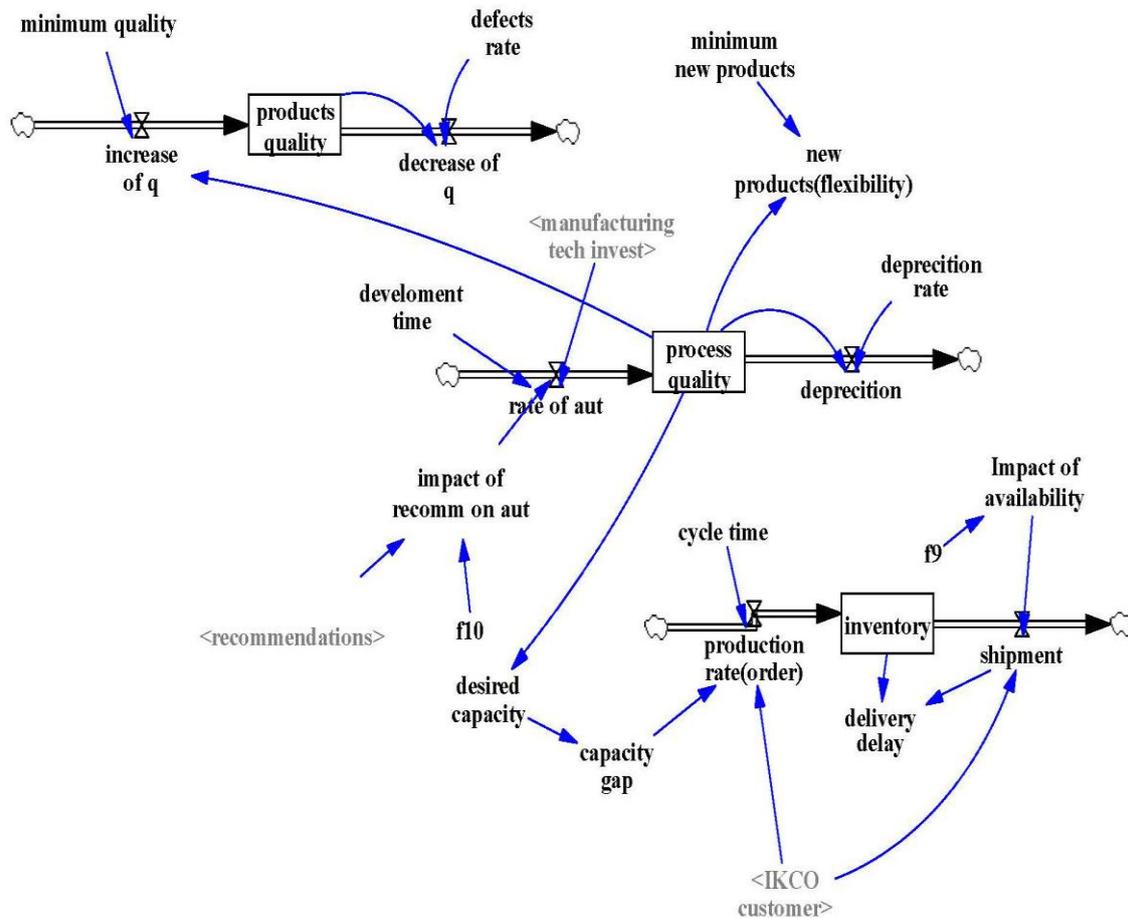


Figure 6. Flow and Stock diagram of the Internal Process sector

B-1- Process Quality

Investment in productive sector (manufacturing) and fixed assets has increased the number of new lines (process quality), but the trend of growth has been slow (with delay). The slow growth of new lines has increased the production rate and production capacity which somewhat led to the decrease in production time as well as in delivery time, although it has increased the number of new products (flexibility) and the number of brands. And the growth of new lines with the modern technology improve product quality which causes the growth of sales (customers) and influences the income, profit margins and net profit, and finally leads to the public funds.

B-2 Product quality

Product quality is also an important factor that causes increases and/or decreases in the quantities of demand, sales, and customer. Product quality depends on the quality of piece parts and the raw material used to make them. In IKCO, the low quality of piece parts on one hand, and less spending on R & D regarding the high quality and product diversity on the other hand, have had some major impacts on the product quality, new product development, and new production line.

C –Sector of market and customer

This sector shows the relations of market share, service quality, and customer attractiveness (Figure 7).

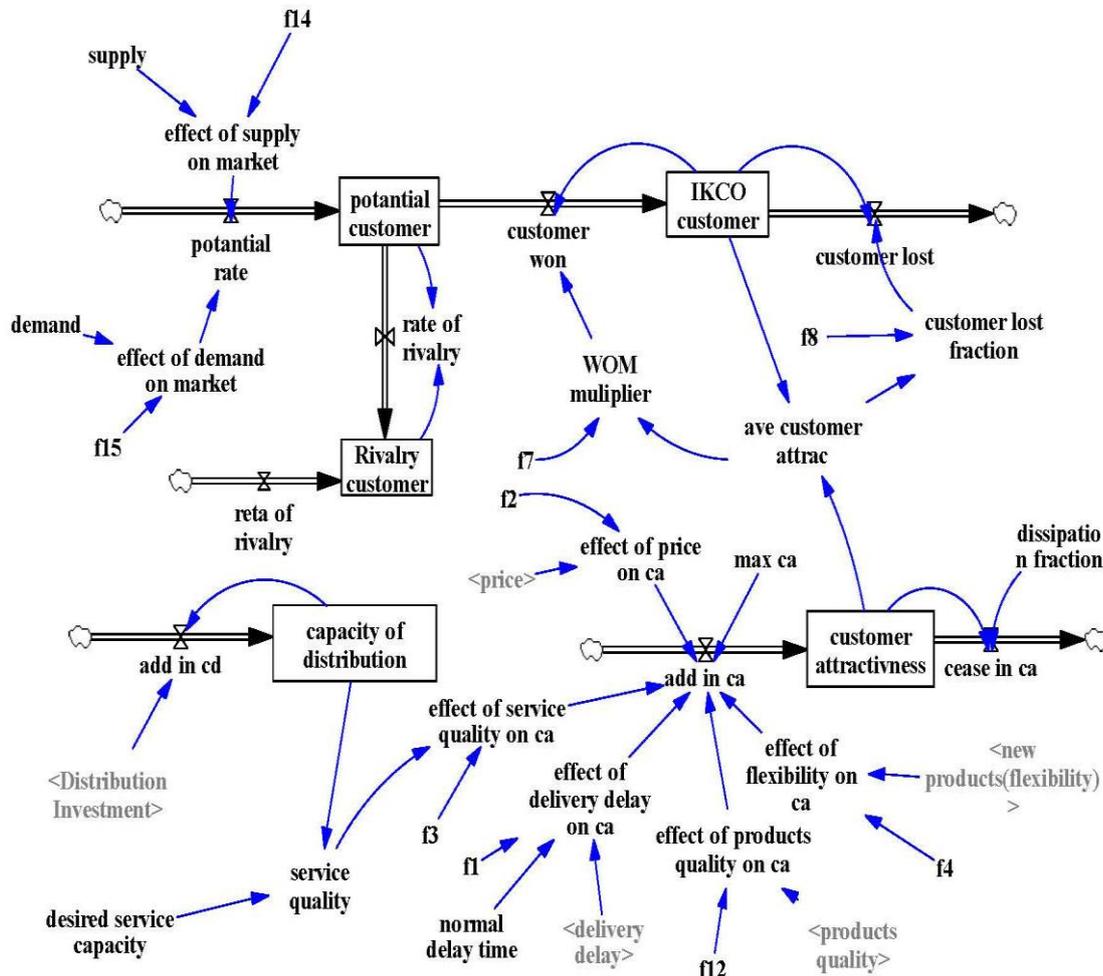


Figure 7. Stock & Flow Model of Market and Customer Sector

C -1 Market Share

The decrease in market share has been because of sales deduction and competitor's addition; and the decrease in sales (customers) has caused by decreasing customer attractiveness, during 2002-2004. This falloff has happened due to the low quality of finished products, sales services, and after-sales service. In addition, the sales reduction has occurred because of the sale price growth resulted from the increase in operational costs and cost price. The raised cost price and the lowered net sales have led to gross profit (margin) reduction. Meanwhile, increasing numbers of domestic competitors and brands in the market as well as increasing volume of import (foreign competitors) have resulted in the IKCO's sales reduction (market share), as in the society due to the limited growth of population and demand, there has been a

narrow gap between supply and demand. Reduced demand and sale have had some negative effects on IKCO production and its capacity.

C-2 service quality (customer satisfaction)

Service quality (customer satisfaction) always depends on the customer satisfaction of sales service, after sales service and Products' qualitative service. In IKCO, although this factor during 2001-2002 grew for the high quality of sales services as well as qualitative products, during 2003-2005 the service quality diminished due to the downfall of sales service and after-sales service, and inflexible quality. But, after 2005, there have been some slight and fixed improvements in the service quality as well as the vehicle quality. Furthermore, the increase and decrease in these three factors, i.e. sale service, after sales service and products quality, are the outcome of investing in the sale and distribution, since the investment in sales, distribution, and advertising have an important role in service quality improvement.

C -3 Customer Attractiveness

Customer attractiveness acts as a key factor that reflects IKCO's performance; so the five elements of customer attractiveness (product quality, service quality, product diversity, sale price, and delivery date) may have great impacts on the performance of IKCO Investments in manufacturing technology, R & D, and process quality improvement lead to the higher quality of product. Since the R & D in IKCO has had a downward tendency, the product quality has not developed adequately so it has had a deterrent effect on customer attractiveness. Also, for the reason that the investment trend in fixed assets, including new machinery, has sloped, product diversity rate has not increased enough to supply new products during 2006-2008. The only factor which may have an effect on the customer attractiveness is the growth in domestic brands (variants) of IKCO. Also, the increase in cost price affected the sale price upwardly, in such a way that, during 2001-2005, the tendency of clients to buy IKCO's products has drained away. Finally, by increasing rate of production and delivery, and the low quality of sales and distribution services, the company was not able to provide after-sales service regarding the flood of new cars into the market; and because of that, the customer satisfaction was affected negatively. But in recent years, the capacity of sales and distribution services has expanded, in such a way that has caused some limited growth in the after-sales service and customer satisfaction. However, the fixed rate of capacity expansion during 2006-2007 has partially lowered the customer satisfaction.

D – Financial Sector

The financial Sector is an important consideration in evaluating the performance of WCM system in IKCO. By analyzing the criteria and statistics of financial sector, the following model in figure 8 has been designed in the two parts of general budget and sold goods cost price. The related assumptions have been also under examination.

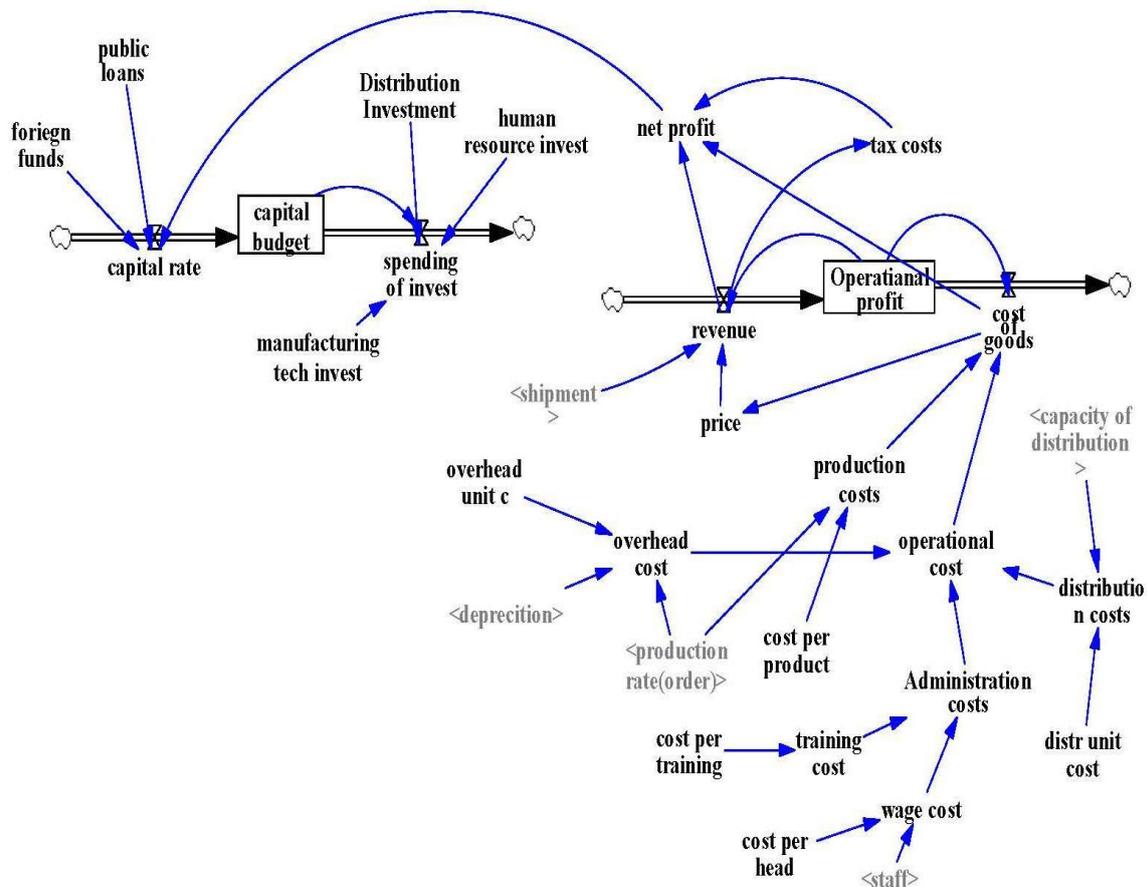


Figure 8. Stock & Flow of Financial Sector

D-1-General Budget (capital)

As a rule, a negative working capital intensifies the financial risk. The liabilities of company has mounted because of increased short-term and long-term loans, while this increase has occurred due to the productive and fixed assets for the investment in production capacity and product development which, during 2001-2005, were on the increase. But, the amount of short term loan was much more than the amount of long term loan. Consequently, the current liabilities (short term) have added, while the non-current liabilities and its increase rate in comparison with the current liabilities are much less. In recent years, it seems that all the attempts of the organization have been focused on the sale and production development, and some issues like profitability and resources limitation have been taken unimportant. The excessive expansion of the firm's size and property has led to increased costs, including materials, overhead, wages, fixed assets, general, administrative, and operating costs. During 2002-2007, the financial condition was not good, and its graphs have represented a critical situation. The increased cost of materials will result in the growth of cost price and sales price.

Growing wages and overhead costs has resulted from employees' salary and promotion increase. Additionally, the costs of facilities, due to a major increase in their

rates, have become more than before. The costs of overhaul and corrective maintenance and have been also added.

The increased costs of sales and distribution primarily caused by the enlargement of the sales number and increases in sales commission and cost of carrying vehicle to the representatives. From 2004 to 2005, increasing in sales and distribution costs was because of the increased public costs such as warranty, service costs and special services costs.

D-2- cost price

Because of increases in the production cost price and the operational costs during 1997-2007, the cost price grew exponentially. Higher costs of materials, wages and overhead caused the escalation of production cost price. Obviously, rising rates of inflation and exchange produced an increase in the materials cost price, considering the fact that the major purchases of IKCO have been made through the foreign markets of car parts. From 2005 to 2006, for tackling the problem of how to decrease the cost price, the company has taken some measures, under a project, to maximize cost-cutting and self-sufficiency. Yet, due to the increases in the euro value and in the inflation rate as well, besides the replacement of domestic car parts by foreign ones to enhance the quality, since 2006 the cost price has grown again. Moreover, the escalation in production cost price in parallel with the growth of selling costs and selling price have affected the sales (customers) in such a way that lessened the income level, gross profit, and net profit; the facts which may be followed by a decrease in the capital budget.

After the accumulation of all four sectors of financial, customer, internal and learning and growth, a diagram of stock and flow model comes on the figure 9.

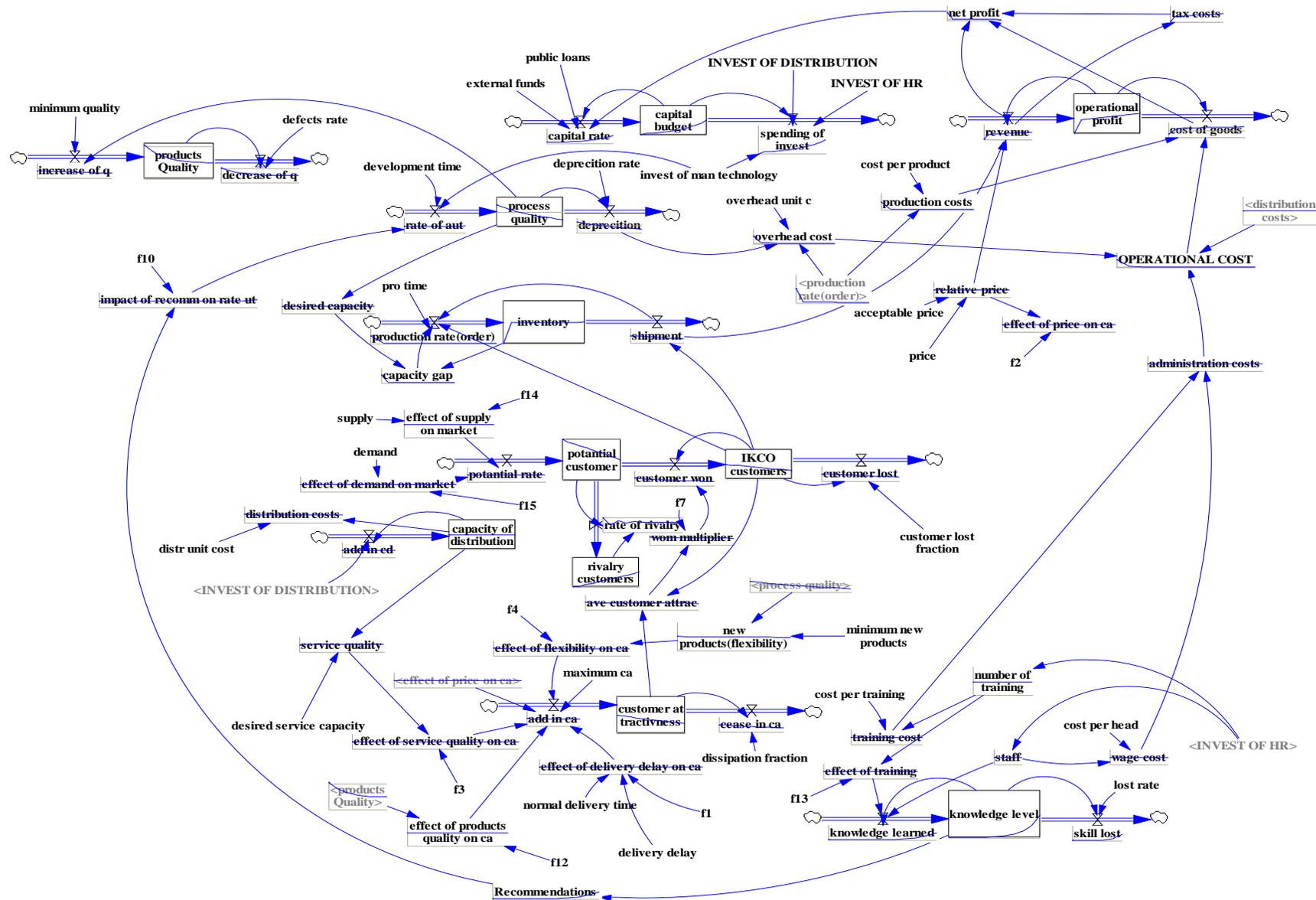


Figure 9. Running the model of Stock and Flow for all of four sectors with viewpoint on WCM Factors.

3.5 Scenarios

Analysis Results are on the basis of developed scenarios and policies as following:

A- The policy of elevating the level of organizational knowledge and skills

The First scenario, Altering the Rate of training efficiency: in this scenario, altering the coefficient of 0.2 to 0.9 (WCM desirable condition) causes an increase in the level of acquired knowledge, which may result in elevating number of suggestions, and consequently in the improvement of process quality (automation level) and product quality as well (Figure10(a)).

B- The Policy of elevating the level of Product and Process Quality

The Second scenario, Altering the rate of product quality: in this scenario, the percentage of training allocated investment is zero, and its related components, meaning R&D, and machinery, regarding their real number, are stable and unchangeable, and the alteration of the minimum quality standards from 0.4 has been reached to 0.9, meaning an increase in the level of product quality, besides its effects on the process quality and the sales are obvious. The level of employees' knowledge together with the made parts quality are determinative factors of the company's products quality. The investment for elevating the product quality level may be performed by investing on the improvement of employees' learning level as well as on the development of process technology (figure 10(b)).

The Third scenario, concurrent alterations of training quality rate, product quality rate, and delivery rate: simultaneous elevation of training, quality, and delivery rates has resulted in the improvement of knowledge level, product quality, in parallel, will be resulted in the process quality, customer attractiveness, and customer satisfaction.

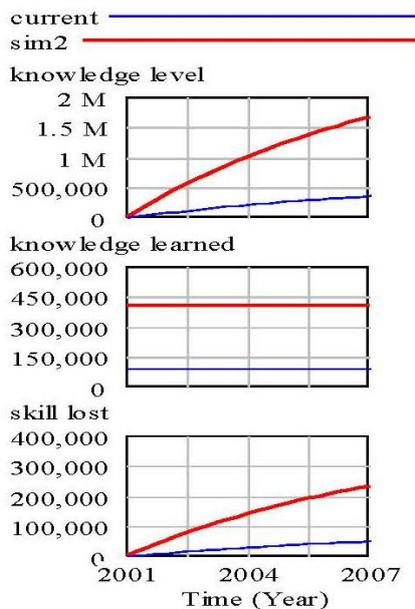


Figure 10(a)

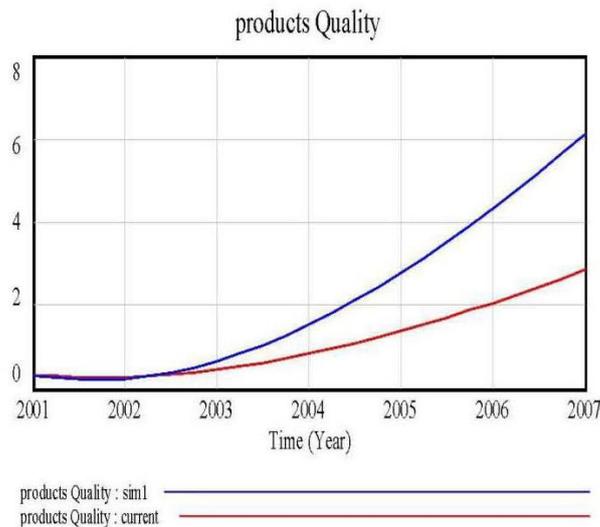


Figure 10(b)

C- The policy of Decreasing Costs and sale price

The Fourth scenario, increasing investments to decrease the costs strategically:

After joining the WTO, IKCO will use this opportunity to decrease its selling price so as to play a greater role in the marketplace. It would be possible by way of reducing the costs of overhead and efficient manpower. Also, the realization of this aim is dependent on the directors' decisions to employ advanced production technologies (that raises the level of automation), to develop the expertise, and to train effective personnel. Additionally, any reduction in costs of car parts and raw materials by means of company's supply chain, and the control of inflation by the government, may have significant impacts on the company's reduced costs and also its increased market share.

The Fifth Scenario, Increasing investment to develop customer service sector and to lift the level of services:

Funding for the company's service development in domestic market may increase its market share in long time.

The fifth scenario (micro level) - Increasing investment to cut delivery time. IKCO's delivery time reduction has had a slowdown trend, it is essential that this scheduling to be coincided with the expanded capacity of company's production. Finally, table 3 presents a comparison between the status quo and the improvement plans and objectives (WCM level).

Table 3. Strategies for the WCM system development and related plans

Levels	Goals	Criteria	Target (WCM)	Status qua	Plans
Learning and Growth	<ul style="list-style-type: none"> - To improve employees' skills & knowledge levels - To enhance the company's perspective through the satisfaction of stockholders 	<ul style="list-style-type: none"> - Training Efficiency Ratio - Training ratio (average annually training man hour) - Innovation (recommendation)rate - Indicator of company perspective for Stockholders Satisfaction - Services Quality index - Employees Satisfaction Index 	<ul style="list-style-type: none"> 0.9 120 0.90 0.96 0.86 0.89 	<ul style="list-style-type: none"> 0.2 66 0.61 0.86 0.56 0.45 	<ul style="list-style-type: none"> - Investment in Training and Skills development of employees - Investing in the Sale and Distribution - Increasing the methods of sales and the representatives of distribution and after-sale services - Evaluating and Improving representatives' manpower - Monitoring the satisfaction of sales and after-sale services employees
Internal processes	<ul style="list-style-type: none"> - To improve the quality level of product - To increase the process level - To enhance R&D 	<ul style="list-style-type: none"> - Product quality ratio (percentage) - Rate of Automation and new Site number - Production rate 	<ul style="list-style-type: none"> 0.90 0.85 1500000 	<ul style="list-style-type: none"> 0.4 0.5 1000000 	<ul style="list-style-type: none"> - Improving the information and engineering process - Investment in Manufacturing Technology - Increasing new businesses through establishing Joint Venture - Developing qualitative and quantitative services of sales - Managing the chain of Supply and Distribution
Customer and Market	<ul style="list-style-type: none"> - To intensify the will to purchase (Customer Attractiveness) - Increasing in Customer Demand - To enhance customer satisfaction through services level and response time 	<ul style="list-style-type: none"> - Average Indicator of Customer Attractiveness and satisfaction - demand completion portion (market share) 	<ul style="list-style-type: none"> .89 0.80 	<ul style="list-style-type: none"> 0.52 0.48 	<ul style="list-style-type: none"> - Services Quality Control - Managing in Marketing and advertising in Domestic and International level.
Finance	<ul style="list-style-type: none"> - To intensify profitability through a decrease in costs and an increase in profits - Decrease sale price - To stabilize cost price - To increase Investment in Manufacturing 	<ul style="list-style-type: none"> - Average growth of annual net income - Average of gross margin - Capital Costs 	<ul style="list-style-type: none"> 6% 19.2% 6.2% 	<ul style="list-style-type: none"> 3% 1% 0 	<ul style="list-style-type: none"> - Developing a comprehensive model of Cash Statement. - Self-sufficiency and Value Engineering - Financial control - Cost engineering

4. Discussion and Conclusion

It is highly crucial to achieve a dynamic model which can cover all the aspects and major/secondary factors including the internal and external ones, strategies, objectives and policies. Therefore, determination of WCM factors can bring about a systematic movement helping specify the performance condition of WCM that the studies resulted support the findings of Shabahang and Ebrahimi, (2005); Noori and Ali Askari(2003),Muda and Hendry(2002); Grobler(2010); Safaee Ghadikalaei,(1999)) And the execution backdrop and institutionalization of a dynamic model is to design a proper mental and conceptual model in a way that incorporates the effective key factors and causes.

After analyzing these scenarios in light of the status quo, the government's supportive policy and its investment in R & D for achieving a production process technology towards the realization of WCM strategy, are fundamentally crucial for the future of IKCO. Moreover, the company's training policy with the coming of support to elevate the information technology in an extended period of time has a significant role in the system performance improvement. Actually, world class manufacturing is a status that concerned organizations attempt to reach. Therefore, moving towards obtainment of this status requires expertise and constructive mentality as base of dynamic model and this paper have discussed this very issue.

The proposed model of this article has the following advantages and attributes:
1 - The research seems to be one of the first studies on the unification, integration, and validation of the WCM system's dimensions and sectors.

2 - The model has the potentiality to simplify the complexity of relationships and feedbacks in any place and organizations. Even in comparison with the multiple regression and lisrel structural equations, the model of WCM strategy in conjunction with the system dynamics and balanced Scorecard has the ability to process all linear and nonlinear equations, inputs and outputs simultaneously and jointly with intervals and without any interruption, and also to conduct a careful analysis of an effective strategy selection in the real world.

3-The research methodology and findings can be generalized to other industries and manufacturing processes. Transferring the research results and findings to small businesses is also possible, in such a way that provides some linkages among a given enterprise management, strategy and performance, via a dynamic balance Scorecard.

4 – The model has shown the managers and stakeholders how to follow movements towards achieving a WCM, so implementing the needed strategies, measures, and operations to modify and improve the processes would be possible by using managerial expediency methods.

5 – The research methodology brings about a dynamic and integrated learning model by which the realization of the WCM effectiveness will be possible, since all the relations of model and its cycles as well will be learned practically, and the organization's individuals will be able to know the facts.

6 - Finally, the model predicts how the company will face its competitors and the situation, while implementing the WCM in the coming years. Also, this model may be an appropriate reaction against any change and chaos. This model may cause ordered disorders/irregularities (chaos theory) that lead the organization to a suitable direction.

For more researches, the following subject matters are available:

A - Designing a more itemized and comprehensive model of causal loop relationships by addressing the problem of excluded variables, and adding the variables and an additional element to the model to really generalize it and to develop the sub systems of model in other organization's departments;

B – Using dynamic fuzzy comprehensive software to gather qualitative information of experts and specialists;

C – Inserting Verbal and fuzzy relations into mathematical relations and making a model of dynamic fuzzy with fuzzy verbal connections;

D – Aggregating and using other methods of measurement including artificial intelligence, genetic algorithms, fuzzy control systems, dynamic multiple criteria decision-makers.

E- Expanding each of the following parts of a model with recognizing the problem and its goals: Dynamic modeling of Sectors in the supply chain, Information Technology, Knowledge Management, Human Resources Management, Quality Management, manufacturing processes and customer.

Certainly, this is not a static situation but a dynamic one that is being changed by customers, consumers and rivals constantly. Thus, it can be said that the ideal functional conditions for an organization or WCM is a target by itself which is not a static goal but a dynamic one. In other words, this objective constantly gets transformed in line with changes in the conditions of customers and rivals. The dynamics and high level performance of world class organizations compel them to persistently pursue "superior goals" within their real time

References

Asgharpour M J (2007). *Group Decision Making*, Tehran University Press, Tehran.

Bueno N P (2005). *Stabilization Policy Debate, Control Theory and System Dynamics Methodology*, Proceeding of 23th Int. Conference System Dynamic Society.

Forrester JW (1961). *Industrial Dynamics*. MIT Press: Cambridge, MA.

Großler A (2010). *An Exploratory System Dynamics model of strategic capabilities in manufacturing*, J. Manufacturing Technology Management, 21(6): 651-669.

Kaplan RS, Norton DP (2000). *Translating strategy into action .the balanced scorecard*, Harvard Business School press.

Kim et al(2006). *On Building a Dynamic BSC Model for Strategic Performance Measurement in Public Sector*, The 24th In. Conference of the System Dynamics Society.

Muda S, Hendry L (2002). *Proposing a World Class Manufacturing Concept for The Make to order Sector*, In. j. Production & Research, Taylor & Francis Publication, 40 (2):353 -373.

Musaphir H (1997). *A System Dynamics Approach to studying Manufacturing*. Ph.D.Thesis, University of Manitoba, Department of Mechanical & Industrial Engineering, Manitoba, Canada.

Nielsen S, Nielsen E(2006). *System Dynamic Modeling for a Balanced*

Scorecard :With a Special Emphasis on Skills, Customer Base, and WIP, Management Accounting Research Group.

Noori S, Ali Askari A (2003). *Attitude, Definitions and Features World Class Manufacturing and provide a Conceptual Model*, Int. J. Engineering Science International, 15 (5):127-141.

Richardson G,Pugh A(1981) .*Introduction to System Dynamics Modeling With Dynamo*. MIT Press: Cambridge, MA.

Richardson G (1996). *Feedback Thought in Social Science and Systems Theory*, Phildelphia University Press.USA.

Safae Ghadikalaei A (1999). *Designing and Implementing World Class Manufacturing System in Small and big Companies: Case study in Automotive Industries*, Ph.D Thesis, Tarbiyat Modares University, Tehran.

Schonberger R (1986). *World Class Manufacturing : the lessons of Simplicity Applied*, free press, New York.

Seyyedhosseini SM, Soloukdar A (2007). *Review of Different perspectives on the Dynamic Model of World Class Manufacturing*, the 5th Int. Management Conference, Tehran, Iran.

Shabahang R, Ebrahimi Sarveolia MH (2005). *Design and Implementation of BSC as the Performance Assessment System*, J. Economics and Management, 67:1-11.

Sterman JD(2000) . *Business Dynamics: Systems Thinking and Modeling in complex world*, McgrawHill publication, First Edition.

Xinyan W(2001). *A definition of World Manufacturing and an Empirical Analysis of Practice Performance Relationship in Manufacturing*, Ph.D Thesis, Michigan State University.USA.

Appendix 1. Describing and Documenting Mathematical equations

Equations	Describing the equations
add in ca=effect of delivery delay on ca*effect of flexibility on ca*effect of price on ca*effect of service quality on ca*maximum ca*effect of products quality on ca	Rate of increased customer attraction is effect of delays in delivery and flexibility, price and service quality and product quality that this rate is between 0 and 1.
Add in cd= invest of distribution /capacity of distribution Units :Dmnl	Distribution capacity rate is ratio of investment in distribution and distribution capacity that this distribution is base on car numbers.
administration costs=training cost+wage cost	Administrative costs has been made of total salary costs and training.
ave customer attrac=customer attractiveness/IKCO customers	Average customer attractiveness is equal the ratio of total customer attraction to Irankhodro customers that this ratio is between 0 and 1.
capacity gap=desired capacity-inventory	Capacity Difference accounts in terms difference between the ideal capacities with inventory.
capacity of distribution= INTEG (-add in cd,100)	Stock of distribution capacity is Integration of negative rate distribution Capacity within initial rate of 100 vehicles a month.
capital budget =INTEG(capital rate-spending of invest, (57000 Units :million Rial/Year	capital budget is Continuous integration of capital funding dispute with the rate of capital investment spending in terms of million Rial and the initial rate of inventory budget is 57,000 milion Rial.
capital rate=net profit+public loans+external funds	Input rate of capital is The total net profit, government loans (short and long term) and foreign loans.
cease in ca=customer attractiveness*dissipation fraction	Output Rate (cease in customer attractiveness) is the amount customer attractiveness multiplied by dissipation fraction that the output ratio of 0.05 is considered.
cost of goods=operational cost+production costs	Finished product cost = operating costs + production costs
cost per head =300000	cost per head is 300,000 rial per hour
cost per product5=e+006	Average cost of each product is the average RLS 50000000.
cost per training =50000	Cost per person in an hour is 50,000 Rial
customer attractivness= INTEG (-add in ca-cease in ca,0.35)	Stock of Customer attraction is integral of the negative input rate of attraction minus the charm reduce (output) in Customer Attractiveness. The initial rate of attractions for Iran Khodro is 0.35.
customer lost=IKCO customers*customer lost fraction	Rate of customers lost is multiplied by the output percentage of customers to Iran Khodro customers.
customer lost fraction=0.05	Customer lost fraction is 0.05.
customer won=IKCO customers * wom multiplier	Customer attraction is multiple by irankhodro customers to word of mouth.

decrease of $q = \text{defects rate} * \text{products Quality}$	Reduced rate of the quality is obtained by multiple of product defects rate on the product quality that it is between 0 and 1.
defects rate =0.2	defects Rate is 0.2 in vehicles
delivery delay=1.5 Units: month	Delay in delivery is 1.5 in a month.
Demand =0.1	Demand rate is 0.1 in the automotive industry.
depreciation=depreciation rate*process quality	Depreciation is obtained multiplied by rate of the depreciation to the process quality (automation degree of production line)
depreciation rate =0.12	Depreciation rate is 0.12.
desired capacity=IF THEN ELSE(process quality<=0.4,500000 ,1e+006) Units :machine/Year	Desired capacity is 500,000 vehicles a year if the process quality is less than or equal to 0.4, otherwise the capacity of 600,000 vehicles per year is desirable.
desired service capacity =840000	Desired capacity after sales service is 840000 in a month.
development time =5 Units :Year	Development time is 5 years.
dissipation fraction =0.05	Dissipation fraction is 0.05.
distr unit cost=600000	Distribution average cost is 600,000 rials per vehicle.
distribution costs=capacity of distribution*distr unit cost	Distribution and selling costs are multiplied by distribution capacity to the cost of a unit distribution.
effect of delivery delay on $ca = f1(\text{delivery delay}/\text{normal delivery time})$	The Effect of delivery Delay on customer attractiveness is a function of ratio of delivery delay to normal delivery time.
effect of demand on market= $f15(\text{demand})$	The Effect of Market demand is a function of demand in the automotive industry.
effect of flexibility on $ca = f4(\text{"new products(flexibility)"})$	The Effect of flexibility on customer attraction is a function of new products (diversity and flexibility).
effect of price on $ca = f2(\text{relative price})$ Units: milion Rial/Year	The effect of price on customer attractiveness is a function of vehicle prices based on the million rials in the year.
effect of products quality on $ca = f12(\text{products Quality})$	The Effect on product quality on customer attractivness is a function of products quality.
effect of service quality on $ca = f3(\text{service quality})$	The effect of service Quality on customer attractiveness is a function of service quality.
effect of supply on market= $f14(\text{supply})$	The Effect of supply on market is a function of supply.
effect of training= $f13(\text{number of training})$ Unit :percent	The effect of training is a Function of the amount of training in month that will be displayed as percentage.
external funds= 100000 Units :million Rials/Year	Foreign loans are 10 000 million rials in the year as a constant factor.
$f1([(0,0.5)(9,1)],(0,1),(1,0.95),(2,0.85),(3,0.78),(4,0.7),(5,65),(6,0.64),(7,0.61),(8,0.6),(9,0.5))$	Look-up function (Lookup) shows the amount of delay is considered from 0 to 10 days that based on the graph, increasing the amount of days of delay will be less attractive.

f10([(0,0)(50000,1)],(1345.29,0.0916667),(3587.44,0.102778),(7735.43,0.186111),(14349.8,0.263889),(20291.5,0.369444),(25560.5,0.444444),(30605.4,0.513889),(34080.7,0.6),(37443.9,0.669444),(41255.6,0.783333),(43273.5,0.819444),(45739.9,0.880556))	No. 10 Function indicates that increasing the number suggestions and innovations of employees is added automation that this effect is shown by lookup function. Number of suggestions is from 0 to 50,000 in months.
f12([(0,0)(1,1)],(0.3,0.05),(0.35,0.08),(0.4,0.15),(0.45,0.2),(0.5,0.3),(0.55,0.35),(0.6,0.4),(0.690045,0.469444),(0.75,0.55),(0.8,0.6),(0.9,0.75))	No. 12 Function represents the influence of product quality on customer attraction that suggests that by Iran khodro Co. efforts on improving vehicle quality leads to the effect customer attraction.
f13([(20000,4)(1.5e+006,10)],(20000,4),(450000,5),(650000,6),(1.5e+006,8))	No. 13 function represents the influence of the number of training on input of knowledge level. The number of training hours are between 0 and 1.5 million people in work that increasing the number of hours were also increased levels knowledge.
f14([(1375,0)(1385,1.19e+006)],(1375,102000),(1376,168429),(1377,198071),(1378,231140),(1379,287747),(1380,370227),(1381,520098),(1382,731516),(1383,868018),(1384,968482),(1385,1.19e+006))	No. 14 function represents the influence of supply in the years between 1996(1386 bas on shamsi calender in iran) to 2006(1384) on the car market is going forward in time, the number of vehicles in the market offer more and in 2006 came to 1.19 million vehicles in a year.
f15([(75,0)(85,1.5e+006)],(75,760943),(76,800993),(77,843150),(78,887527),(79,934239),(80,983409),(81,1.03517e+006),(82,1.08965e+006),(83,1.147e+006),(84,1.204e+006),(85,1.23e+006))	Function of No. 15 is the effect of demand trend in the years 1996 to 2006 that it has faced increasing number of demands, but this increases is not constant of supply growth as such that in 1996 the amount of car demand was around 760,943 and in 2006 reached to 1.23 million vehicles.
f2([(6000,0)(30000,1)],(6000,0.9),(8690.58,0.813889),(10950.7,0.708333),(13479.8,0.602778),(17192.8,0.538889),(20152.5,0.488889),(23865.5,0.369444),(25372.2,0.319444),(27363.2,0.275),(28600.9,0.244444),(29677.1,0.227778))	Function of No.2 is the effect of growth of car price on the customer attractiveness that this trend of car prices were between 6000 Rials million to 30,000 Rials million as this increase lead to reduce the percentage of the customer attraction.
f3([(0.4,0.1)(1,1)],(0.444395,0.1),(0.530493,0.152778),(0.611211,0.233333),(0.663677,0.341667),(0.709417,0.422222),(0.713453,0.419444),(0.773991,0.519444),(0.847982,0.627778),(0.889686,0.75),(0.946188,0.919444))	Function of No. 3 is the effect of the service quality on customer attractiveness that is the primary effect is 0.4 percent, also Attraction percent led to increase in service quality of Iran khodro Co. during the years related to the range of model.
f4([(1,0.55)(20,1)],(1,0.55),(2,0.7),(3,0.75),(4,0.78),(5,0.79),(6,0.8),(7,0.81),(8,0.82),(9,0.82),(10,0.82))	Function of No.4 is the effect of flexibility on customer attraction that flexibility dynamics base on the number of new products have from number of a new products to 20 new products that increase the number of new products varies attraction percentage from 0.55 to 0.82
f7([(0,0)(100,0.35)],(0,0),(10,0.012),(20,0.026),(30,0.042),(40,0.066),(50,0.1),(60,0.134),(70,0.176),(80,0.216),(90,0.27),(100,0.35))	Function of No. 7 is the effect of word of mouth on input rate of Irankhodro customers that this effect is because of number of invited people in advertising who were from 0 to 100 that if person 100 have advertised ,is resulted to increase the rate of 0.35 New Customer .
FINAL TIME =2007 Units :Year The final time for the simulation.	The final year for the simulation area is 2007.
IKCO customers= INTEG (-customer lost-customer won,32897)	Stock of number of Iran Khodro customers is the integral of the difference in rate of output and input, the initial value in 1997 was 32,897.
impact of recomm on rate ut=f10(Recommendations)	The influence of recommendations on automation rate is the function of number of proposals (innovations).

increase of $q = \text{minimum quality} + (\text{process quality} * 0.6)$	Increase of quality rate is equal total of Minimum quality and sixty percent of process quality.(The quality and optimization process can be added to the minimum quality)
INITIAL TIME =1997 Units :Year The initial time for the simulation.	Start year in the scope of the simulation is 1997
Inventory= INTEG ("production rate(order)"-shipment,10000)	Inventory is the Integral of the input rate of production (order) and shipment. The initial rate is 10,000 vehicles.
Invest of Distribution=0.3	The constant of investment in distribution is 0.3
Invest OF HR=0.1	The constant of investments in human resources is 0.1.
Invest of man technology=0.3	The constant of investments in technology manufacturing is 0.1.
knowledge level =INTEG (knowledge learned-skill lost,5)	Stock of knowledge level is the integral of Input rate of knowledge learned to skill lost. the initial rate is 5 hours. (unit: person an hours)
knowledge learned=10/effect of training*staff+knowledge level	Input rate of knowledge learned is equal to the sum of multiplied effect of training on staff and knowledge level .the unit of knowledge level is between 0 to 10
lost rate = 0.05 Units :Year	Rate of customers lost is 0.05
maximum ca=1	maximum customer attractiveness is 1
minimum new products=2	Minimum number of new products in the market is two cars per year.
minimum quality=0.8	Minimum Quality is 0.8.
net profit=(revenue)-(cost of goods+tax costs)	Net profit is equal subtracting total income and sum of cost of goods & tax costs.
"new products(flexibility)"=process quality*0.2+minimum new products	Number of new products are equal the quality of the process multiplied by 0.2 plus the minimum number of new products based on the number of car units.
Normal delivery time=1 Units :month	Normal delivery time is considered a month.
Number of Training=Invest of HR/500000	Number of training is equal to the amount of investment in human resource divided to 500,000 people in an hour annually.
Operational Cost=administration costs+overhead cost+distribution costs	Total operating cost can be achieved from sum of administrative costs, overhead costs, and distribution costs.
operational profit= INTEG (+revenue-cost of goods,400000) Units :million Rial/Year	Operating profit is the Integral of Revenue rate and cost of goods with the initial amount of 400,000 million Rials.
overhead cost=depreciation*overhead unit c*"production rate(order)"	An overhead cost is equal to the depreciation rate multiplied by the overhead unit cost multiplied by the rate of production.
overhead unit c=500000 Units :Rial	Cost of an Overhead unit is 500,000 Rials.
potential customer= INTEG (-customer won-potential rate-rate of rivalry,600000)	The stock of potential customer is the integral of input rate of potential customer to output rate of the negative customers of IranKhodro and competitors rate.
potential rate=effect of demand on market*effect of supply	Input rate of competitors is based on the effect of

on market	demand on market and the effect of supply on market.
price=8e+007 Units: million Rial/Year	Price is added on 8e+007 cost of goods.
pro time=1 Units :day	process time took an average of one day
process quality= INTEG (-depreciation-rate of aut,0.3)	Process Quality (Grade of Process Optimization) is the integral of the automation input rate to the output rate of depreciation that it's given based on zero to one is given. The initial rate is 0.3.
production costs="production rate(order)"*cost per product	Production costs are production (order) Rate multiplied by cost per product.
"production rate(order)"=(capacity gap+IKCO customers-shipment)/pro time	production rate is equal to sum of difference between capacity and iran khodro customers divided to process time
products Quality= INTEG (-decrease of q-increase of q,0.3)	The stock of Products Quality is the Integral of input rate of quality (increase) to output rate of quality (reducing). Initial level of product quality in the year 1997 was 0.3.
Public loans=5e+007 Units :million Rial/Year	Government loans both short and long term are equal to 5000000 million rials in years.
Rate of aut=(1/invest of man technology/development time)*impact of recomm on rate aut	The rate of Automation affecting the quality of the process is ratio of investment of manufacturing technology to development time multiplied by the impact of recommendations to automation rate that is considered Based on the percentage so that is based on 1.
Rate of Rivalry=0.54*potential customer+rivalry customers	The Input rate of Rivalry is equal multiplied sum of potential customers and Rivalry customers to the coefficient of 0.54 (share of competitors).
Recommendations=knowledge level*1	Recommendations rate is multiplied knowledge level to 1.
Relative price=price/acceptable price	Relative price is multiplied by the price to acceptable price
revenue=relative price*shipment+operational profit	Total income is equal to the Relative price multiplied to shipment plus operating profit.
Rivalry Customers =INTEG(-rate of rivalry,100000)	Rivalry Customers is the integral of input rate of rivalry with the initial amount of 100,000 people.
SAVEPER =TIME STEP Units :Year The frequency with which output is stored.	Time step to simulate is the annual or based on year.
Service quality=capacity of distribution/desired service capacity* -50	Service Quality is equal to distribution capacity equal divided to the desired capacity multiplied -50. - 50 is the negative coefficient of quality of after sales service in Iran Khodro.
Shipment=IKCO customers	Shipment rate (output rate) is equal to the number of customers who have bought Iran Khodro cars.
lost Skill =lost rate*knowledge level	Output rate of lost skills is obtained by multiplying the percentage of lost rate to knowledge level.
Spending of invest=(capital budget*Invest of Distribution)+(capital budget*Invest of HR)+(capital budget*invest of man technology)	Total amount of investment spending is achieved by the sum of multiplied capital budget to the coefficient of investment in distribution, human resources, manufacturing technology. The unit is million Rials in the year.
Staff=Invest of HR/5e+006 Units :person	Staffing levels IS in terms of investment in human resources to 500,000 people a year.

Supply=0.25	The Coefficient and percentage of supply is 0.25.
Tax costs=revenue*0.1	Tax costs are equal to amount of Revenue multiplied by 0.1 (tax rate).
Training cost=cost per training*number of training	Training cost is multiplied cost per training to number of training that is based on million Rials in the year.
Wage cost=cost per head*staff	Wage cost is equal to the cost per head multiplied by the number of staff.
WOM multiplier=f7(ave customer attract)	Effect of Word of mouth multiplier is a function of the average customer attractiveness.