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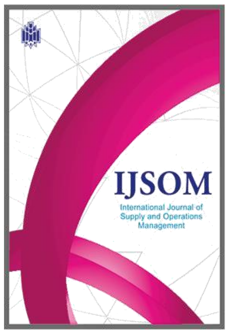

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Agent Based Modelling of Milk and its Productions Supply Chain and Bullwhip Effect Phenomena (Case Study: Kerman)

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Abstract

Simulating decision-making process of agents of supply chain is affected by various economic and social factors. The main purpose of this paper was to investigate the behavior of the agents of the milk and its products supply chain using data for the year 2016 with emphasizing on dairy farmers against the policy increasing raw milk price. In this regard, bullwhip effect is one of the important issues raised in supply chain. The present paper investigated the presence or absence of bullwhip effect in the milk supply chain and its products, using moving average method and order-up-to-level r. Improvement in supply chain performance is one of the major issues in the current world. Lack of coordination in the supply chain is the main drawback of supply chain that many researchers have proposed different methodologies to overcome it. In addition, the application of agent-based simulation has been investigated in order to improve performance indicator in supply chain. The results showed there is the bullwhip effect in the supply chain, therefore, the bullwhip effect can be reduced or even eliminated using centrality in decision-making by the agents in supply chain.

Keywords: Agent-based simulation; Bullwhip effect; Demand forecasting; Supply chain; MASQ model.

1. Introuduction

"Oliver and Weber in 1982 for the first time used the term of supply chain management and then it was used widely in the 1990s" (Behdani, 2012). The milk and its products supply chain is one of the most important supply chains, which can be effective in every economic. the average of milk per capita consumption and dairy products in urban areas in 2013 was estimated around 92 liters (Central bank of Islamic Republic of Iran). Given the importance of using milk and its products in nutrition pattern, this has always been considered by governments in different countries including Iran. In 2010, milk distribution was faced with a serious challenge". *The other hand, the supporting levels of government for this sector was practically modified and decreased. because of economic problems and increasing the production costs, in addition, the economic conditions and demand reduction for dairy products has doubled the problems of this industry*" (Faryadras and Jahedgar, 2015). Also, since 2014, the determined price by government for each liter of milk is 14400 Rail's but agents of this supply chain do not buy with this price. In this paper, is tried to investigate and simulate the behavior of various agents in milk and its products supply chain against government policies (increasing price of raw milk). Therefore, the main purpose of the present paper is to simulate the status of the structural variables of the supply chain agents under various scenarios of increasing price of raw milk. Dominguez and Cannella (2020) studied Multi-Agent Systems Applications for Supply Chain Management.Parsaiyan et al (2019) investigated to design a Green Closed-loop Supply Chain Simulation Model and Product Pricing in The Presence of a Competitor. Ajitha et al (2018) examined multi-agent based food processing supply chain management.

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The bullwhip effect is one of the most presented important issues regarding supply chains. *"The most distinctive feature of this structure is setting a material flow from suppliers to final consumers and also information flow in opposite direction* "(Movahedi and Zolfaghari, 2011). Since Bullwhip effect has an adverse effect on the efficiency of the supply chain, researchers have used simulation methods to evaluate the effect of different strategies to reduce this effect. Forester was the first researcher who studied bullwhip effect. *"In short, the bullwhip effect mentions that the fluctuations in demand of last level of customer in the supply chain increase with moving along the levels of supply chain. Strengthening demand variability from the bottom of the chain toward the top of the supply chain is called the bullwhip effect*" (Dehghan Dehnavi and Mashhadizadeh Ardakani, 2011). There are so many factors which cause bullwhip effect: Lack of supply chain coordination, Lack of information sharing, and Lack of trust among the members in SC (Garge and Srinivasan 2014).

Since Bullwhip effect has an adverse effect on the efficiency of the supply chain, researchers have used simulation methods to evaluate the effect of different strategies to reduce this effect. Among the things that should be considered are:

1- Suppliers must share information about their inventory and capacity with their customers.

2- Avoiding prediction with different information (between the chain members) policies should be used to provide the members of the downstream information to the upstream members, and both parts can predict with a series of identical information.

3- Removing all time delays as much as possible, both in the flow of goods and in the flow of information in the supply chain.

4. Exchange information about market demand with parts located at the upstream of the chain (Dehghan Dehnavi and Mashhadizadeh Ardakani, 2011).

"*Demand forecasting method is expressed as one of the influencing factor in increasing bullwhip effect. According to what is defined as supply chain, the main goal of each chain is to satisfy customers' needs, and therefore it is importance for supply chain loops to be aware of future demands. In fact, demand forecasting is considered to be the basis for all supply chain planning"* (Razavi Hajagha and Akrami, 2012).

Various studies have used different forecasting methods in order to calculate bullwhip effect. The present paper has investigated the bullwhip effect in supply chain for Pegah dairy products in Kerman city using moving average method for forecasting the expected demands (Naghavi et al.,2017) and then improving the bullwhip effect using multi-agent based simulation and information sharing. The model used for achieving goals based on agent-based modeling, which is a behavioral model based on real behaviors. We tried to use the latest simulation method for modelling the behavior of supply chain agents. the behavior of supply chain agents looks very difficult and complex due to the complex and independent nature of the components of these supply chains. On the other hand, the advancement of information technology and high-power computing and processing systems has made it possible to find reasonable solutions for these complex issues.

In this paper, a new agent-managed supply chain methodology has been proposed to improve performance indicator of supply chain. Therefore, in first, we investigate is there bullwhip effect in the milk and its dairy products? And therefore, can we improve bullwhip effect using agent based simulation? The paper highlights importance of government policies, bullwhip effect and agent-based simulation for supply chains.

The rest of this paper is organized as follows: Section 2 describes Methodology, Section 3, proposes results and analysis of this research. Section 4, conclusion based results of research.

2. Methodology

Supply chain management models are divided into simulation and optimization models. Optimization models are using mathematical program methods for solving the supply chain problems and simulation models allow policy makers to see the supply chain performance under different scenarios over time, and help them to understand the internal communications between various components (Shapiro, 1999). The most important simulation models are; Simulation Models of Supply Chain, Discrete-Event Simulation (DES), System Dynamics (SD), Agent Based Simulation (ABM). Method of dynamic systems, which are usually used in macro level which their details are not discussed, in this method, affecting factors of supply chain performance can be investigated generally. In contrast to SD, DES is dealing with high levels of details and ABM is the only method that covers details to macro levels [10]. Table1 briefly explains the three simulation methods (Behdani, 2012; Heath, et al, 2011; Schieritz and Grobler, 2003; Helal, 2007; Moradi, et al, 2015; Sumari, et al, 2015).

Agent based(ABM) models is a proper method for supply chain, because this type of environment is very complex and includes a large number of decision-making variables, parameters and restrictions (Shen et al., 2006; Macal and North, 2008). Agent based models are in micro-level which directly provides decision makers entities and their interactions with physical and social environment (Sahay and Ierapetritou, 2013). ABM allows model makers to determine behavioral and situational rules of people and finally observe the behavior of individuals and groups of the model output by implementation of modeling or simulating (Fox, 2002). Since supply chain is a complex and non-centralized environment, therefore, the use of agent based simulation to evaluate supply chain issues is recognized. The features of ABM for supply chain are as; distributed dynamic, intelligent, integrated, responsive, reactive, cooperative, and reconfigurable (Norving and Russell, 2010). Agent can have a simple reaction which merely shows predetermined reactions against external events in rules of If-Then. Given to the subject of modeling, the capabilities like learning, target-oriented and beneficial should be added to the agents (Figure1).

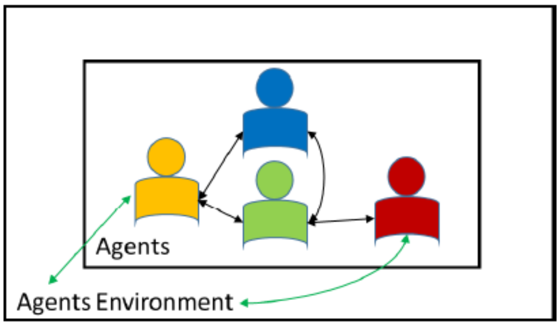

Figure 1. Heterogeneous agents interacting with each other and with the environment in a typical ABM (Blanciforti and Green, 1983).

Since the purpose of this paper is presenting a Multi Agent Based System- Supply Chain Management for supply chain and according to the comparison of the types of modeling in the field of supply chain, the reason for choosing this model is for identifying the capabilities of this model to simulate supply chain issues and recent its use in simulation of supply chain by researchers. In this model, the behavior of each agent is investigated against government policies such as changing prices of raw milk in chain environment and decisions of each agent according to the features and objectives they have in the chain and then bullwhip effect is investigated. In fact, by doing this research, the following questions will be answered:

1- How is the performance indicator of milk and its products supply chain and how can it be corrected?

2- Is there a Bullwhip effect in milk and its products supply chain in Kerman city?

3- Is it possible to improve the Bullwhip effect in supply chain using an agent-based simulation method as one of the simulation methods?

The spatial scope of the present paper is the milk and its products supply chain in Kerman city consisting of Pegah processing industry, distribution center and the government, and the time scope of the paper covered the period between 2015 to 2016. Also, the statistical sample of this research includes dairy farm units producing milk and with industrial license in Kerman in 2016. The information of these units were prepared and collected by questionnaires. In the present research, 40 dairy farm units that give their daily produced milk directly to the Pegah processing industry are selected. Also, in order to estimate the equations of the almost "ideal" system and the moving average method, the statistics and information used for the five products were collected from the market information of Pegah processing industry and its distribution center, as well as the Statistics Center of Iran and the Central Bank of the Islamic Republic of Iran. The information belongs to 1994-2016.

Agent based simulation can be used as a new computational method for modelling dynamic and complex systems in which the human plays a significant role. The modelling method establishes an artificial community of individuals and allows modelling of two vital issues that exist in most systems. These two issues are 1**)** people's heterogeneity and 2) individuals' interaction and impact on each other (Bonabeau, 2002). Agent is known as an independent, autonomous, computational unit with thinking ability and decision making and social interaction in such systems (Casti, 1997). Although there is no epidemic agreement on the accurate definition of the term *agent*, all the existing definition have in common rather than the differences still in existence. Some modelling experts consider an independent component, such as software, templates, individuals as an agent (Jennings, 2000). The agents must also have basic rules for their behaviors, and at higher level, they must have a set of rules in order to change the existing rules (McCrae and Costa, 2003). Basic rules allow agent to respond against the environment, while rules for changing the rules can cause agent's adaptation to the environment.

Agent Based Modeling has four steps:

First step: The first important step of ABM is showing a structure that indicates functions of agent mind (conceptual model).

Second step: mathematical modeling (Roozmand et al., 2012).

Third step: implementing the mathematical model. Thus the required mathematical model should be written based on proper software for implementing ABM. The most important software of ABM is Netlogo, Mason, Repast Simphony and Anylogic which the following chart shows the power of this software and how user-friendly they are (Blanciforti and Green, 1983).

In this study, Repast Simphony software is used for ABM which is based on the Java programming language.

Fourth step: running the program in the software, that provides the possibility to evaluate and validate the model and achieving the expected results (Nazari and Aghaei, 2012).

2.1. MASQ Meta model

The conceptual model of each agent is consisted of inputs perception and updating and finally agent decision. The inputs are understandable by any agent. The Perception in conceptual model is a process including the external inputs. Updating is also a process and the meaning is evaluation of each agent from the environmental conditions (Nazari and Aghaei, 2012). In MULTY AGENT SYSTEMS-SUPPLY CHAIN (MAS-SCM) model, the effects of government policies like changing the milk price on agents' decision making should be investigated so the changes of the milk and its products supply chain can be modeled.

The information of these units were prepared and collected by questionnaires. In the present research, 40 dairy farm units that give their daily produced milk directly to the Pegah processing industry are selected. Also, in order to estimate the equations of the almost "ideal" system and the moving average method, the statistics and information used for the five products were collected from the market information of Pegah processing industry and its distribution center, as well as the Statistics Center of Iran and the Central Bank of the Islamic Republic of Iran. The information belongs to 1994-2016.

The behavioral models are recognized based on MASQ model. In follows, Conceptual Models of agents have been explained, Figures2, 3 and 4.

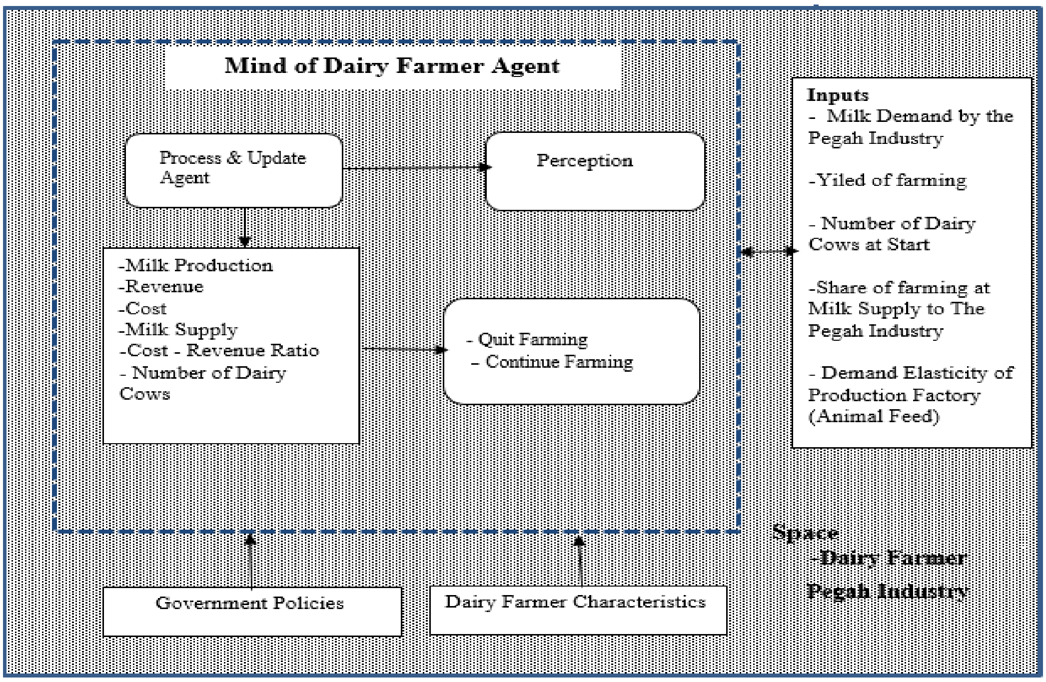

Figure 2. Conceptual Model for Dairy Farmer Agent Decision Making Process Based on MASQ

Source: MASQ Model

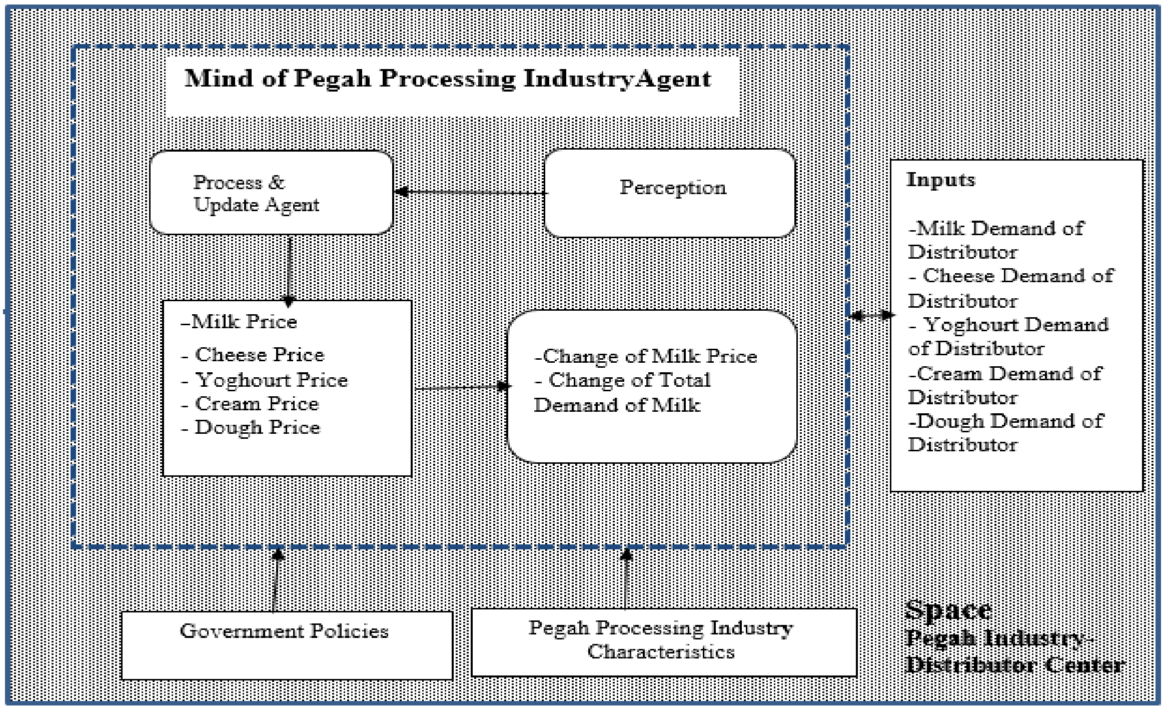

Figure 3. Conceptual Model for Pegah Processing Industry Agent Decision Making Process Based On MASQ.
Source: MASQ Model

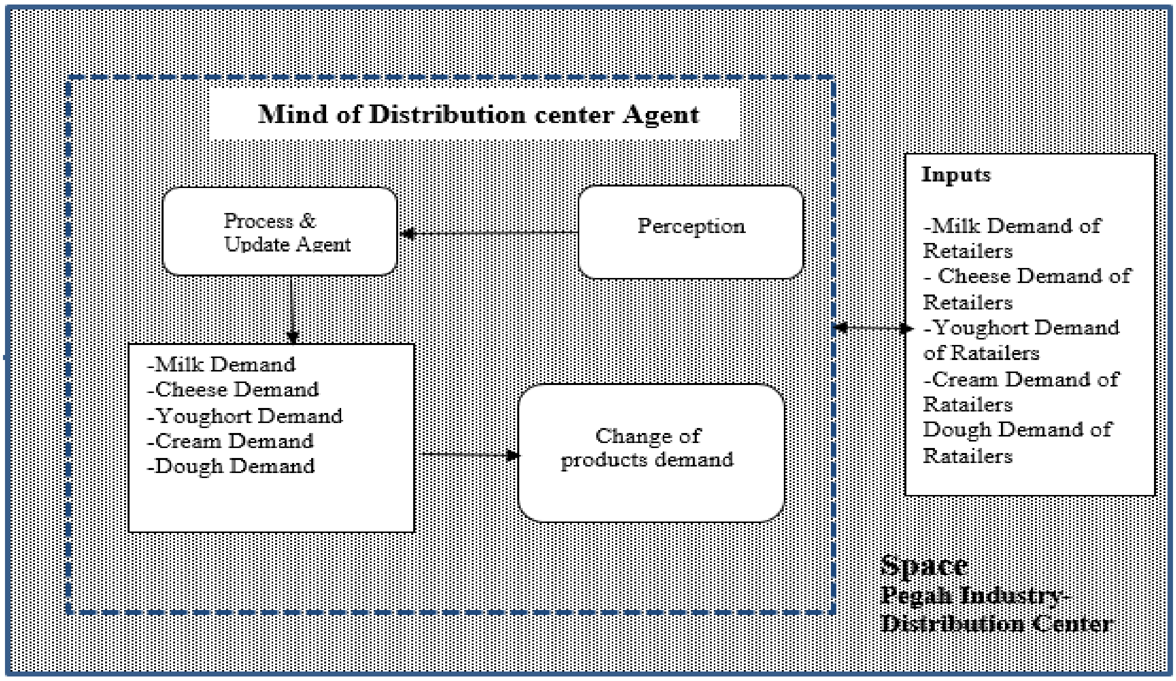

Figure 4. Conceptual Model for Distribution Center Agent Decision Making Process Based On MASQ
Source: MASQ Model

Before explaining the rest of modeling it needs to be mentioned that in ABM, the interaction between agents should be considered. In Repast Software, the transmission of messages between agents follows a specific structure. The fields that should be included in the message are presented in the following table1.

Table 1. Transactions between agents in the supply chain

Number	Variable	Explanation
1	Sender_Name	The name of the sender; it can be the dairy farmer, Pegah processing industry, distribution center or government
2	Sender_ID	The number of the sender; the unique number that is assigned to each agent and the variable is containing the number of the sender
3	Receiver_Name	The name of the receiver; it can be the dairy farmer, Pegah processing industry, distribution center or government
4	Receiver_ID	The number of the receiver; the unique number that is assigned to each agent and the variable is containing the number of the receiver
5	Transaction_type	Transaction type: this variable can determine what transaction is happening between agents. The following values can be considered: demand of changing price by the government, demand of changing price by Pegah processing industry, demand of changing milk amount by Pegah processing industry from dairy farmers
6	Content	The content of the message from sender to receiver

Source: research findings

In this model many interactions and transactions happen between model agents, which in following lines are briefly mentioned: first it should be noted that, in this study because two policies of increasing the price of raw milk and reducing the price of animal feed have been investigated, thus in Repast Software, the simulation process is done separately which the general steps of both policies are briefly mentioned.

In this study, is used the study of Chen et al (2000) and Cannella and Ciancimino (2010) to investigate the bullwhip effect and Statistical Approach to calculate the variance of product demand. they investigated the bullwhip effect on a very simple model of two levels supply chain and the effects of the demand estimation and lead time on the bullwhip effect and showed that if the manufacturer have complete information of buyer order to retailer and know the mean and variance of buyers' demands, the bullwhip effect will greatly decrease. Also if the central warehouse is not aware of the mean and variance of retail demand, it is necessary to estimate that and it will greatly increase the bullwhip effect. In three levels supply chain, the bullwhip effect is:

$$BE = \frac{Var(q_t)}{Var(D_t)} \quad (1)$$

Which $Var(Q_t)$ is, the variance distribution center orders to manufacturers and $Var(D_t)$ is, the variance of retailer demands (Chen et al, 2000). Cannella and Ciancimino (2010), presented another equation;

$$OVR = \frac{Var(Q)/\mu_Q}{Var(D)/\mu_D} \quad (2)$$

In fact, OVR shows the instability orders in the supply chain. $Var(Q)$ And $\mu_Q$shows variance and mean of order distribution center. $Var(Q)$ And $\mu_D$shows variance and mean of retailers' demand. If the amount of this equation is less than or equal to one, the bullwhip effect will be removed from supply chain and this happens when the demand and order fluctuations are close to each other (See the article Naghavi., et al 2017).

Also the variance of distribution center orders to supplier (Pegah industry) is calculated by this equation3, (Cannella and Ciancimino, 2010):

$$Var(q_t) = \left(1 + \frac{L}{N}\right)^2 Var(D_{t-1}) + \left(-\frac{L}{N}\right)^2 Var(D_{t-N-1}) + z^2 L(Var(\widehat{\sigma_t}) + Var(\widehat{\sigma_{t-1}})) \quad (3)$$

In this study, we collected statistics for five products of urban households' budgets, data of the Central Bank, the Statistical Center of Iran, the statistic of milk and milk products price of Pegah industry. The under study time period is 1994-2016.

3. Results and Analysis

Supply chains consist of a number of organization – beginning with suppliers, who provide raw materials to manufacturers, which manufacture products and keep those manufactured goods in the warehouses which are connected through upstream and downstream linkages to produce value in the form of products and services Demand forecasting and decision making processes are among the key activities which directly affect the performance of this complex systems. The bullwhip effect can be regarded as one of the obstacles to achieve the expected results in supply chains. It is important to be aware of the factors which can cause the bullwhip effect in organizations and supply chain that help reduce the severity of its occurrence and its destructive effects.

In this paper, a new agent-managed supply chain methodology has been proposed to improve performance indicator of supply chain. Therefore, in first, we investigate is there bullwhip effect in the milk and its dairy products? And therefore, can we improve bullwhip effect using agent based simulation?

Before using agent based simulation in reducing this effect in the given supply chain, the simulation results of the policy increasing price for raw milk were first examined in the supply chain. As it is noted above, many interactions and transactions can occur between the model agents which are briefly referred to in the following. In the next section, we examine the effect of each of the above policies on the variables related to agents of Pegah industry and distribution center using Repast Simphony software.

First the agents of government, dairy farmers, Pegah processing industry, and distribution center created. According to the determined price by government for each liter of milk is 14400 Rials and also the purchase price of milk from dairy farmers, the Pegah industry reaction for increasing milk price each liter of milk is as follows:

1) Policy of dpmilk:

$\text{if dpmilkg} = 30\% \quad , \text{dpmilkg} = 20\%$

Pegah processing industry sends the message of changing price through Message handler to the distribution center. Two treatments are considered for the Pegah processing industry here:

1) The Pegah processing industry increases the price of dairy products based on the price of raw milk.

2) The Pegah processing industry increases the price of dairy products less than the determined price of government.

Each agent will update its status. For computing the model in this section, first by using the Almost Ideal Demand System (*AIDS*) and Seemingly Unrelated Regression, the elasticity of demand for dairy products is obtained and by using the elasticity, the changes amount and product sale is upgraded. The desired model for Almost Ideal Demand System (AIDS) for five dairy products is Equation 4, (Blanciforti and Green, 1983):

$$w_{it} = \alpha_i + \tau_{i1}\text{Ln}(p^t_{milk}) + \tau_{i2}\text{Ln}(p^t_{yogurt}) + \tau_{i3}\text{Ln}(p^t_{cheese}) + \tau_{i4}\text{Ln}(p^t_{cream}) + \text{Ln}\tau_{i5}(p^t_{dough}) + \beta_i\text{Ln}\left(\frac{M_t}{p^*_t}\right) + \gamma_i w_{i(t-1)} + \mu_t \quad (4)$$

w_{it} indicates the cost share of i dairy product for consumer in t time of dairy products total cost.

$\text{Ln}(P^t_{milk})$ is milk price in t year, $\text{Ln}(P^t_{yogurt})$ is yogurt price in t year, $\text{Ln}(P^t_{cheese})$ is cheese price in t year, $\text{Ln}(P^t_{cream})$ is cream price in t year, $\text{Ln}\tau_{i5}(p^t_{dough})$ is dough price in t year, M_t is total expenditures by households for dairy products in t year andp^*_t is Stone index price for households in t time.

μ_i is income elasticity, ε_{ii} is own price elasticity, and ε_{ij} is cross-price elasticity, ε^h_{ij} is compensation elasticity (Hixy), σ^a_{ij} is Alan alternative elasticity, AIDS is calculated by following equations (5).

$$\mu_i = \frac{\beta_i}{w_i} + 1 , \qquad \varepsilon_{ij} = \frac{\tau_{ij}}{w_i} - \beta_i\left(\frac{W_i}{W_j}\right), \qquad \varepsilon^h_{ij} = \frac{\tau_{ij}}{w_i} + W_j - \delta_{ij}$$

$$\varepsilon_{ii} = \frac{\tau_{ii}}{w_i} - \beta_i - 1 , \qquad \delta^h_{ij} = \frac{\tau_{ij}}{w_i w_j} + 1 \quad (5)$$

In the above equations, budget shares (W_i) is not visible and their mean is calculated in circle length. Also $\delta_{ij}$was a Kronecker delta, which for insider elasticities was equal to one and for outsider elasticities was equal to zero. In AIDS, the equations are estimated by using Stone price index with linear approximation.

Therefore:

$$e^{d}_{milk} = -0.45,\ e^{d}_{cheese} = -0.51,\ \mathrm{e}^{\mathrm{d}}_{\mathrm{yogourt}} = -1.29, e^{d}_{cream} = -2.56, e^{d}_{dough} = -2.1 \quad (6)$$

$\mathrm{e}^{\mathrm{d}}_{\mathrm{creame}}$ -Elasticity of cream demand, $\mathrm{q}^{\mathrm{d}}_{\mathrm{dough,t}}$ - dough demand, $\mathrm{q}^{\mathrm{d}}_{\mathrm{dough,t+1}}$ - dough demand, $\mathrm{e}^{\mathrm{d}}_{\mathrm{dough}}$ - elasticity of dough demand.

For each agent updated variables are as follows:

1) Pegah Processing industry

$$\mathrm{p}^{milk}_{t+1} = \mathrm{f}\,(\mathrm{p}^{milk}_{t}, dp_{milk})$$
$$\mathrm{p}^{cheese}_{t+1} = \mathrm{f}\,(\mathrm{p}^{cheese}_{t}, dp_{cheese})$$
$$\mathrm{p}^{yogurt}_{t+1} = \mathrm{f}\,(\mathrm{p}^{yogurt}_{t}, dp_{yogurt})$$
$$\mathrm{p}^{\mathrm{cream}}_{\mathrm{t+1}} = \mathrm{f}\,(\mathrm{p}^{\mathrm{cream}}_{\mathrm{t}}, \mathrm{dp}_{\mathrm{creame}})$$
$$\mathrm{p}^{dough}_{t+1} = \mathrm{f}\,(\mathrm{p}^{dough}_{t}, dp_{dough}) \quad (7)$$

p^{milk}_{t} - Milk price in t time, p^{milk}_{t+1}- Milk price in t+1 time, p^{cheese}_{t} - Cheese price in t time, $\mathrm{p}^{cheese}_{t+1}$ -cheese price in t+1 time, p^{yogurt}_{t} - Yogurt price in t time, $\mathrm{p}^{yogurt}_{t+1}$ -yogurt price in t+1 time, $\mathrm{p}^{\mathrm{cream}}_{\mathrm{t}}$ - Cream price in t time, $\mathrm{p}^{\mathrm{cream}}_{\mathrm{t+1}}$ - Cream price in t+1 time, p^{dough}_{t} - Dough price in t time, p^{dough}_{t+1} - Dough price in t+1 time, dp_{milk} - Change of milk price, dp_{cheese} − Change of cheese price, dp_{yogurt} -change of yogurt price, $\mathrm{dp}_{\mathrm{creame}}$ −Change of cream price, dp_{dough} - change of dough price.

$$TMD = f(CR_{mm}, CR_{my}, CR_{mch}, CR_{mcr}, CR_{mdo}, \mathrm{q}^{\mathrm{d}}_{\mathrm{milk}}, \mathrm{q}^{\mathrm{d}}_{\mathrm{cheese}}, \mathrm{q}^{\mathrm{d}}_{\mathrm{yogourt}}, \mathrm{q}^{\mathrm{d}}_{\mathrm{creame}}, \mathrm{q}^{\mathrm{d}}_{\mathrm{dough}}) \quad (8)$$

TMD is the total input of raw milk to the Pegah processing industry, CR_{mm} is the conversion ratio of raw milk to processed milk, CR_{my} is the conversion ratio of raw milk to yogurt, CR_{mch} is the conversion ratio of raw milk to cheese, CR_{mdo} is the conversion ratio of raw milk to dough, CR_{mcr} is the conversion ratio of raw milk to cream, so the factory upgrade the demand of milk from dairy farmers.

$$\mathrm{TMDF_t} = \alpha * TMD_{\mathrm{t}} \quad (9)$$

$\mathrm{TMDF_t}$ is the Pegah processing industry demand for milk from dairy farmers and α is the percentage of demanded milk from dairy farmers of the region.

2) Distribution Center

$$\mathrm{q}^{\mathrm{d}}_{\mathrm{milk},t+1} = \mathrm{f}(\mathrm{q}^{\mathrm{d}}_{\mathrm{milk},t}, dp_{milk}, \mathrm{e}^{\mathrm{d}}_{\mathrm{milk}})$$
$$\mathrm{q}^{\mathrm{d}}_{\mathrm{cheese,t+1}} = \mathrm{f}(\mathrm{q}^{\mathrm{d}}_{\mathrm{cheese,t}}, dp_{cheese}, \mathrm{e}^{\mathrm{d}}_{\mathrm{cheese}})$$
$$\mathrm{q}^{\mathrm{d}}_{\mathrm{yogourt,t+1}} = \mathrm{f}(\mathrm{q}^{\mathrm{d}}_{\mathrm{yogourt,t}}, dp_{yogurt}, \mathrm{e}^{\mathrm{d}}_{\mathrm{yogourt}})$$
$$\mathrm{q}^{\mathrm{d}}_{\mathrm{cream,t+1}} = \mathrm{f}(\mathrm{q}^{\mathrm{d}}_{\mathrm{cream,t}}, dp_{cream}, \mathrm{e}^{\mathrm{d}}_{\mathrm{cream}})$$
$$\mathrm{q}^{\mathrm{d}}_{\mathrm{dough,t+1}} = \mathrm{f}(\mathrm{q}^{\mathrm{d}}_{\mathrm{dough,t}}, dp_{dough}, \mathrm{e}^{\mathrm{d}}_{\mathrm{dough}}) \quad (10)$$

Where:

$\mathrm{q}^{\mathrm{d}}_{\mathrm{milk},t}$ - Milk demand in t year

$\mathrm{q}^{\mathrm{d}}_{\mathrm{milk},t+1}$- Milk demand in t+1 year

$\mathrm{e}^{\mathrm{d}}_{\mathrm{milk}}$ - Elasticity of milk demand

$\mathrm{q}^{\mathrm{d}}_{\mathrm{cheese,t}}$ - cheese Demand in t year

$\mathrm{q}^{\mathrm{d}}_{\mathrm{cheese,t+1}}$ - Cheese demand in t+1 year

$\mathrm{e}^{\mathrm{d}}_{\mathrm{cheese}}$ - Elasticity of cheese demand, $\mathrm{q}^{\mathrm{d}}_{\mathrm{yogurt,t}}$ - Yogurt demand, $\mathrm{q}^{\mathrm{d}}_{\mathrm{yogurt,t+1}}$ - Yogurt demand, $\mathrm{e}^{\mathrm{d}}_{\mathrm{yogurt}}$ - Elasticity of yogurt demand, $\mathrm{q}^{\mathrm{d}}_{\mathrm{cream,t}}$ - Cream demand, $\mathrm{q}^{\mathrm{d}}_{\mathrm{cream,t+1}}$ - Cream demand, $\mathrm{e}^{\mathrm{d}}_{\mathrm{creame}}$ -Elasticity of cream demand, $\mathrm{q}^{\mathrm{d}}_{\mathrm{dough,t}}$ - Dough demand, $\mathrm{q}^{\mathrm{d}}_{\mathrm{dough,t+1}}$ - Dough demand, $\mathrm{e}^{\mathrm{d}}_{\mathrm{dough}}$ - Elasticity of dough demand.

Receiver- Message: Dairy Farmers Agent

$$MP_i = f(MS_i, \beta_i)$$

$$MS_i = f(Sh_i, TMD)$$

$$ncows_i = f(MP_i, MY_i)$$

$$dcows_{i,t+1} = ncows_{i,t+1} - ncows_{i,t} \quad (11)$$

MP - Produced milk of the dairy farmer in each period

Sh_i -The share of each dairy farmers of milk given to Pegah processing industry

MS_i - The given milk of each dairy farmer to Pegah processing industry

$ncows_i$ - The number of the cows in each dairy farm

$dcows_{i,t+1}$ - The difference of the numbers of cows in each period, compared to previous period

MY_i - The mean yield of per unit of dairy farm and β is the given milk to milk production of per unit of dairy farm.

$$TR_i = Milk\ Production_i * P_{milk} + number\ of\ dairy\ cows(a+b) + subsidy$$

$$\ln(TC_i) = Exp[\beta_0 + \beta_1 \ln(Milk\ Production_i) + \beta_2 \ln(Milk\ Production_i{}^2) + \beta_3 ln(M_i) + \beta_4 \ln(M_i{}^2) + \beta_5 \ln(Milk\ Production_i * M_i) \quad (12)$$

TR_i is the total revenue of dairy farm, Milk Production_i is the produced milk of ith dairy farmer in each period, $\text{number of dairy cows}(a+b)$ is the other revenue of fertilizers and meat, government subsidy (if it is paid), TC_i is the cost of dairy farm and M_i is management variable of dairy farm (oudendag et al,2014).

After applying policy of increasing milk prices, dairy farmers evaluate their variables and according to the income and expenses functions (Translog cost function) and Cost Revenue Ratio (CRR) evaluates their situation in each period and to make decision for continuing or giving up the dairy farm, according to the specifics of the dairy farmer like number of cows, the experience of management and the performance of dairy farm, the final decision is investigated. It needs to be mentioned that all the rules are according to interviews with dairy farmers and experts of agriculture ministry and dairy farmer's union and Pegah processing industry.

$$\text{decision of dairy farmers} = \begin{Bmatrix} quiet & if\ \ (CRR \geq 1;\ experience \leq 5;\ Management\ is\ low) \\ Continue & Else \end{Bmatrix}$$

It should be noted that, since the farmer may decide to increase the size of their dairy farm unit, in the under study region first the optimal size of dairy farm units was estimated using two-stage model of Hubbard and Dawson (1987) and Hubbard et al (2007) and ridge regression(Appendix). the results of the optimal size of dairy farm units in the 456 heads according to mean level of management proxy variable (Appendix A).

In following, first the dairy farmers are divided into two groups based on the number of cows by cluster analysis method and the results of simulation of increasing milk price and different conditions were investigated (table2).

Table 2. Features of dairy farmers

Variable		**quantity**
Average Number of dairy cows(head of cattle)	Group1	281
	Group2	195
Average Milk Supply(ton)	Group1	2373.96
	Group2	833.35
Average Milk Production(ton)	Group1	2967.45
	Group2	1041.68

Source: Research Findings

Table 3. The results of simulation of output policy on related variables of dairy farm units

Variable		Scenario1	Scenario2	Scenario3	Scenario4
Number of dairy cows	Group1	1204	1973	1348	2075
		-67%	-46%	-82.3%	-43%
	Group2	561	1123	817	1304
		-75.8%	-51.5%	-83.3%	-44%
Milk Supply(ton)	Group1	12076	19745	13617	20950
		-61%	-36%	-55.8%	-32%
	Group2	5852	11617	8372	13479
		-70.3%	-41.1%	-57.5%	-32%
Milk Production(ton)	Group1	12799	20928	14504	22224
	Group2	6108	12200	8790	14079

Source: Research Findings

Table3, shows the results of simulation of increasing raw milk price on related variables of dairy farm units and Table6, shows Results of the policy of increasing price of raw milk for the assignment or no assignment of the dairy farm units.

According to table3, it can be seen that in the three scenario and in the second group the highest decrease (83.3%) is in the size of dairy farm units. and in the first scenario and in the second group the highest decrease (70%) is in the given milk of dairy farm to Pegah processing industry (Figure5). It should be noted that the dairy farmers' decisions are determined based on the rules and characteristics such as; experience, management Index and the number of cows and calculated CRR.

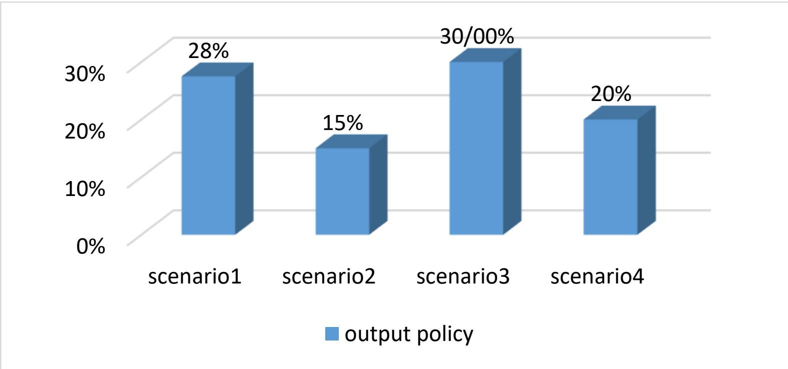

Figure 5. Comparing of policy Scenario

In following, this policy investigated for agents of distribution center and Pegah industry.

One of the variables related to Pegah processing industry is the total amount of milk received by the industry from the dairy farms units, milk collection station and dairy farms units outside the province, that the changes have been examined for four scenarios of price-increasing policy for raw milk.

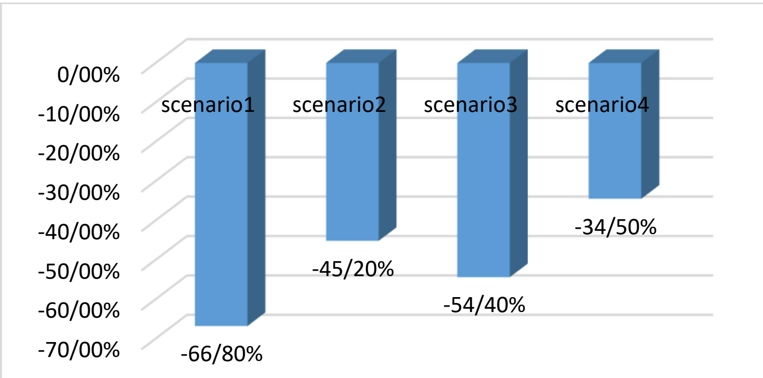

Figure 6. Change percentage in total milk of the farm units
Source: Research Findings

figure 6 indicate in the first scenario of Pegah processing industry's behavior in price-increasing policy for raw milk (30%), there is the highest level of reduced percentage (66.8%) in the total amount of input milk to the Pegah industry.

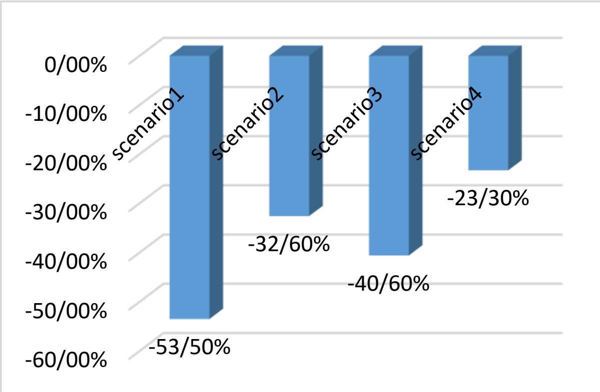

Figure 7. Change percentage in milk product consumed by consumers.
Source: Research Findings

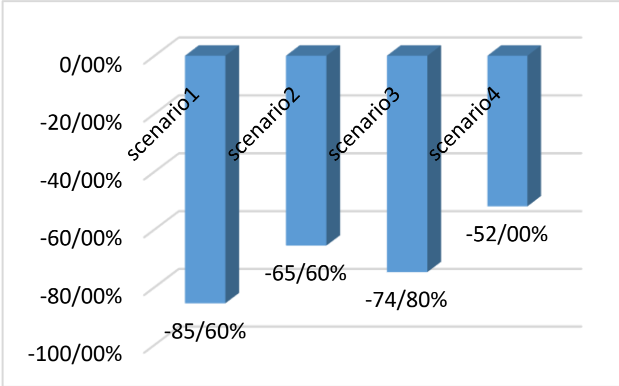

Figure 8. Change percentage in yogurt product consumed by consumers.
Source: Research Findings

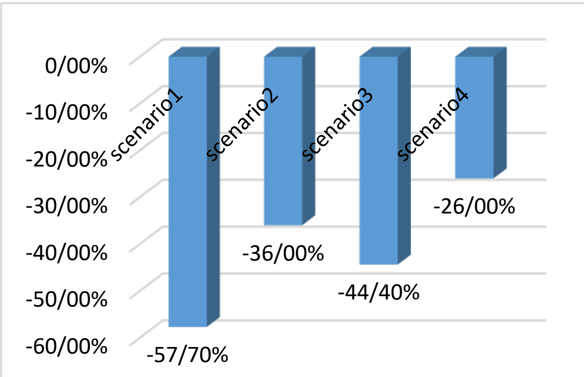

Figure 9. Change percentage in cheese product consumed by consumers
Source: Research Findings

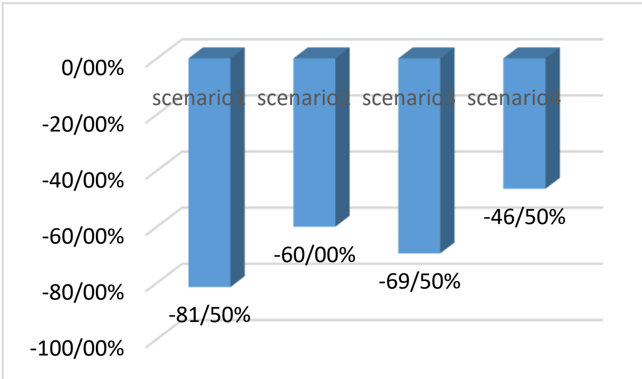

Figure 10. Change percentage in dough product consumed by consumers
Source: Research Findings

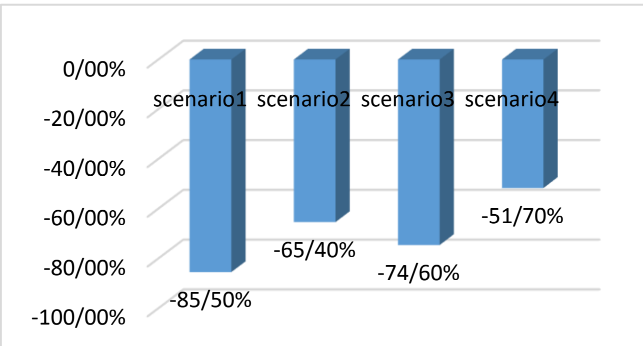

Figure 11. Change percentage in cream product consumed by consumers
Source: Research Findings

According to figures (7), (8), (9), (10) and (11), it is obvious that due to the price-increasing policy for raw milk (30 % and 20%), the highest level of reduction in various dairy products in the first mode is (– 53.5 %), (-85.6 %), (-57.7 %), (-81.5 %) and (-85.5%)for milk, yogurt, cheese, dough and cream, respectively.

In this section, we examine the bullwhip effect in dairy products including milk, yogurt, cream and dough using moving average method. The results are indicated in Table 7. It should be noted that the agents in supply chain including retailers, distribution center and Pegah Processing industry in Kerman city have been considered in order to calculate the bullwhip effect.

Considering both equations since the bullwhip effect is bigger than 1, therefore it can be concluded that there is the bullwhip effect phenomenon in the milk and dairy products supply chain. After presenting the simulation results for price-increasing policy for raw milk, the bullwhip effect is examined using agent based simulation. It should be noted that in the previous section without using agent based simulation, the bullwhip effect has been investigated in supply chain. r in the present study, the bullwhip effect in supply chain improved using intelligent agents (agent based simulation) and then both results are compared. One of the main factor in producing bullwhip effect in supply chain is local decision – making and lack of information sharing in supply chain. Agent based simulation is considered as one of the ways to reduce this effect in supply chain. Centrality in decision-making is regarded as one of the mechanisms which can be used in a new model using this type of simulation. Since the ability to transfer information and communication between different agents are the features of the agents in agents based simulation, therefore, the information of different agents can be shared using this type of simulation.

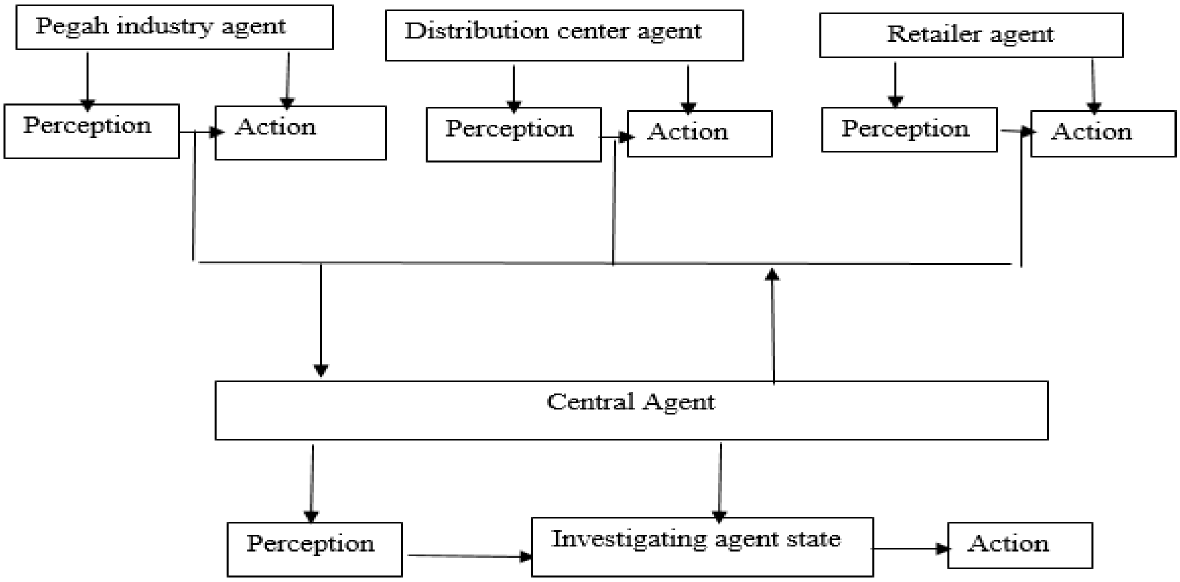

Figure 12. Structure of agent based modelling to improve bullwhip effect in supply chain Based On MASQ

According to figure12, distribution the retailers, distribution center and the processing industry have been considered in order to reduce the bullwhip effect using agent based simulation, then, each agent in the chain can have access to the final customer's demand using central agent which makes decision on the order of distribution center. In the new model, the demands have been considered using the reviewed scenario. In addition, an initial supply chain is considered for the given agents. It is assumed that none of the agent has overdue order and the bullwhip effect is to be investigated according to the available information. (table 8).

Table 4. Bullwhip effect for the milk and its products supply chain based agent based simulation

Product	30%	30%	20%	20%
	Scenario1	Scenario1	Scenario1	Scenario4
Milk	0.97	0.92	0.93	0.89
Cheese	0.95	0.94	0.95	0.92
Yogurt	0.998	1	0.99	0.99
Cream	0.998	1	0.99	0.998
Dough	0.996	0.997	0.99	0.995

Source: Research Findings

As it is determined in Table 8, the values for bullwhip effect have been significantly reduced in the new model. In policy for increasing price for raw milk, this effect was generally less than 1, which reveals that there is no bullwhip effect in the supply chain. In fact, this effect has been significantly reduced and eliminated here using agent based simulation and centrality in decision-making in the supply chain. Kumar& Keswani (2016), Bray and Haim (2012) and Etebari et al (2011), in their study used multi agent model in order to reduce bullwhip effect in supply chain and the results of their study are consistent with the present study.

Using centrality in decision-making in the supply chain and agent-based simulation, the results indicated that bullwhip effect is reduced or eliminated for the dairy products. Such results highlight the importance and high potential of agent-based simulation in improving the performance indicator of supply chain. Therefore, we can have better estimation of consumer demand and targeted production programs of dairy products and consequently the variance of issued orders compared to consumer's demand will decrease. On the other hand, by targeting productions of supply chain will improve the conditions of chain agents.

4. Conclusion

The inefficiencies of supply chain in Iran's agricultural sector have been proven and annually it allocates a significant cost from a small amount of resources of the country. The heterogeneous agents in this chain resulted in its lack of integrity. In this paper, the policy of increasing raw milk price in the milk and its products supply chain investigated by using ABM and MASQ conceptual model and the effect of this policy on related variables of supply chain agents investigated. The results showed the supporting policy of government about increasing raw milk price to 14400 Rials alone is not a proper policy, because increasing the price of raw milk, the processing industry reacted to that and the outcome was decreasing the dairy products. A brief look at the supporting government policies in the field of milk products in Iran, the results indicate the effectiveness of the government support, subsidies for milk and dairy products and it was beneficial for the producers, the dairy industry and consumers. According to the results of this paper it is recommended that since the consumer of dairy products is one of the important agents of this chain, and the fluctuation of his consumption has significant effect on chain, therefore certain activities should be done to motivate them to use more milk and dairy products.

In answer to the first and second questions of the research, retailer's demand in the expected time has been forested in order to calculate the orders, using moving average method in addition, the existence of bullwhip effect has been investigated, considering the level of servicing for Pegah's dairy products and the lead time. The results obtained from the present study indicated that there is the bullwhip effect in the supply chain, given that the ratio of distribution canter' order variance to dairy retailers' demand variance is greater than 1. Then, the agent managed supply chain has been proposed in order to improve one of the performance indicators in the supply chain.

For responding to three question, we used agent based approach. The results indicated that agent based method have reduced the bullwhip effect in various scenario and even in some cases, this effect has been eliminated. The results of this section point out to the importance of sharing information in supply chains and high potential of agent-based simulation in improving the performance of supply chain. Therefore, the bullwhip effect can be reduced or even eliminated using centrality in decision-making by the agents in supply chain and decision-making on the ordering in all levels in supply chain based on the final consumer's demand. Therefore, the supply chain agents must try for clarifying the information flow and confronting phenomena like Bullwhip effect. The coordination and confidence among the supply chain members increases the effectiveness of the performance, because when the members of the chain trust each other, they also consider the goals of others at the time of making decisions.

Research Limitation

Although this research was carefully prepared, we are still aware of its limitations and shortcomings. This research was conducted for 40 dairy farmers, one Processing Industry and one distribution center. It would be better if it was done for more agents.

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Appendix A

Table 1. The computed parameters using ridge regression in milk production functions types in Kerman (kr=0.0002)

Variable	Cobb-Douglas		Translog		Generalized Leontief		Generalized Quadratic		Transcendental	
	Coefficient	t-statistic	Coefficient	t-statistic	Coefficient	t-statistic	Coefficient	t-statistic	Coefficient	t-statistic
Constant	-0.009	0.01	-0.093	-4.14	0.031	1.80	0.099	7.71	0.00004	0.15
lnl	0.056	1.68	0.029	1.11	0.06	1.76	0.014	0.48	0.106	1.7
lnk	0.010	0.35	0.030	1.76	0.017	0.93	0.074	4.81	0.045	0.85
lne	0.002	0.06	0.017	0.76	0.035	1.42	-0.005	-0.29	-0.22	2.76
lnvs	0.12	3.16	0.079	5.60	0.16	3.85	-0.10	-2.05	0.68	7.25
lnf	0.73	7.92	0.97	13.92	0.83	19.26	1.17	25.29	0.51	5.46
lnm	0.16	6.10	0.37	12.33	0.24	9.18	0.41	20.49	0.10	2.78
Ln(lk)	-	-	-0.034	-0.48	0.022	0.18	0.55	5.87	-	-
Ln(le)	-	-	0.043	0.84	0.004	0.08	0.10	1.69	-	-
Ln(lvs)	-	-	-0.214	-1.36	0.101	0.72	-1.46	-6.59	-	-

Table 1. Continued

Variable	Cobb-Douglas		Translog		Generalized Leontief		Generalized Quadratic		Transcendental	
	Coefficient	**t-statistic**	**Coefficient**	**t-statistic**	**Coefficient**	**t-statistic**	**Coefficient**	**t-statistic**	**Coefficient**	**t-statistic**
Ln(lf)	-	-	0.11	0.55	-0.177	-0.97	1.06	5.30	-	-
Ln(lm)	-	-	0.38	4.88	0.20	2.66	0.30	3.93	-	-
Ln(ke)	-	-	0.09	1.80	0.047	0.61	0.004	0.08	-	-
Ln(kvs)	-	-	-0.059	-0.49	-0.13	-1.14	-0.08	-0.74	-	-
Ln(km)	-	-	0.16	3.74	0.14	2.81	0.19	6.37	-	-
Ln(kf)	-	-	0.37	4.16	0.17	1.45	-0.0006	-0.01	-	-
Ln(evs)	-	-	0.037	0.42	-0.11	-0.72	-0.32	-2.27	-	-
Ln(em)	-	-	0.10	1.93	0.020	0.33	0.17	3.64	-	-
Ln(el)	-	-	0.043	0.84	0.004	0.08	0.10	1.69	-	-
Ln(mvs)	-	-	0.55	2.86	0.39	3.76	0.13	1.69	-	-
Ln(ft)	-	-	-0.69	-2.36	0.005	0.05	-1.69	-6.65	-	-
Ln(mf)	-	-	-0.93	-4.14	-0.32	-2.14	0.028	0.24	-	-
Ln(kk)	-	-	-0.17	-4.39	-	-	-0.029	-1.34	-	-
Ln(ff)	-	-	0.11	0.57	-	-	0.38	3.33	-	-
Ln(ll)	-	-	-0.050	-1.01	-	-	0.046	1.09	-	-
Ln(mm)	-	-	0.049	1.27	-	-	-0.103	-7.53	-	-
Ln(vsvs)	-	-	0.53	4.14	-	-	1.24	6.7	-	-
Ln(ee)	-	-	0.055	1.21	-	-	0.024	0.49	-	-
l	-	-	-	-	-	-	-	-	-	-
k	-	-	-	-	-	-	-	-	-	-
e	-	-	-	-	-	-	-	-	-	-
m	-	-	-	-	-	-	-	-	-	-
vs	-	-	-	-	-	-	-	-	-	-
f	-	-	-	-	-	-	-	-	-	-
	GVC=0.0476 AIC=0.046 $RMSE_{Ridge}$=0.1052 $RMSE_{OLS}$=0.1053		GVC=0.0247 AIC=0.009 $RMSE_{Ridge}$=0.0861 $RMSE_{OLS}$ =0.08612=		GVC=0.0246 AIC=0.015 $RMSE_{Ridge}$=0.0861 $RMSE_{OLS}$ =0.0861 2		GVC=0.0093 AIC=0.0034 $RMSE_{Ridge}$=0.0528 $RMSE_{OLS} = 0.05290$		GVC=0.0453 AIC=0.0395 $\boldsymbol{RMSE_{Ridge}} =$ 0.1052 $\boldsymbol{RMSE_{OLS}}$ $= \mathbf{0.10521}$	

Table 2. Cost function estimation results using weighted ridge regression (ridge parameter kr=0.0005)

Variable	**Coefficient**	**Standard Error**	**t-Static**	$P > \|t\|$
Constant	-0.036	0.008	-4.30	0.000
y_p	-0.905	0.0196	-46.16	0.000
y_p^2	0.105	0.0098	10.64	0.000
m	-0.155	0.019	-7.98	0.000
m^2	-0.0522	0.0118	-4.39	0.000
$y_p m$	0.116	0.017	6.50	0.000
$RMSE_{Ridge} = 0.4884$ $RMSE_{OLS} = 0.5115$ GVC=0.2806 AIC=0.2737				

Table 3: Optimal size at various levels of management proxy variable

Mean	Min	Mean	Max
Optimal capacity of milk production	2730tons	4876tons	8886tons
Optimal size of dairy farms	255 heads	456 heads	832 heads