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A System Dynamic Model for Analyzing Bullwhip Effect in Drug Supply Chain Considering Targeted Subsidy Plan

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Abstract

Objectification of subsidy plan could be described as one of the best government plans and policies. According to perspective document 2025 that consider the first place in economy for Iran and regarding to government financial limitation on national economy, the reform of economic policies is a part of economic necessity for Iran. In this paper, by establishing a suitable system dynamics model, we plan to represent the efficacy of the direct subsidy distribution on level satisfaction of people from drug price changes and also consider the efficacy of this subsidy distribution on total profit of drug supply chain. First, a system dynamics of drug supply chain by considering the direct subsidy distribution have modeled. Then, the model is simulated. To do this, the casual loop diagram is depicted and then with its help, the stock and flow diagram constructed. The simulation results show the unsuitable performance for implementing the subsidy objectification. As a result, two strategies have been suggested to improve the situation.

Keywords: Bullwhip effect, drug supply chain, Human Menopausal Gonadotropin (HMG), System dynamics, Targeting subsidy plan

JEL Classification: A13, C54, C63, I18, I38.

1. Introduction

Today's economic climate has affected the country and is known as the largest economic development plan, is implementation of targeted subsidies (Khodabakhshi & Karami, 2016). Bullwhip effect as one of main issues in reducing of supply chains efficiency, occurs when the change of the demand in supply chain is faced with large fluctuations. Awareness of the causes and effects of supply chain whip helps organizations to adopt policies to reduce the intensity of its occurrence and its damaging effects (Kumar & Teruyuki, 2007).

The aim of this paper is designing a proper model to investigate the effect of pecuniary subsidy distribution on medicine supply chain to describe medicine price, producer interest and the level of people satisfaction. In the model both of

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the impact of the bullwhip effect and reducing bullwhip effect on whole medicine supply chain have been analyzed. A dynamic medicine supply chain has been first modeled; this model mainly concentrates on case study of Human Menopausal Gonadotropin (HMG). After that, causal loop diagram has been plotted and then finally system's flow chart has been drawn. Indeed, the proposed model mainly concentrates on case study of Human Menopausal Gonadotropin. It is worth mentioning that Menotropin (also called human menopausal gonadotropin or hMG) is a hormonally active medication for the treatment of fertility disturbances. Frequently the plural is used as the medication is a mixture of gonadotropins. Menotropins are extracted from the urine of postmenopausal women (Oehninger, 2011). Moreover, simulation results have been discussed, and at the end of the paper three policies for improving current situation have been suggested.

2. Paper Methodology

In this paper, we use system dynamics (SD) approach to understanding bullwhip effect in drug supply chain considering targeted subsidy plan. Indeed, system dynamics is a methodology and mathematical modeling technique to frame, understand, and discuss complex issues and problems with nonlinear behaviour of complex systems over time using stocks, flows, internal feedback loops, table functions and time delays. System dynamics as a computer-aided approach is applied in complex social, managerial, economic, or ecological systems — literally any dynamic systems characterized by interdependence, mutual interaction, information feedback, and circular causality (Abdollahiasl et al., 2014).

The system dynamics approach involves (Hassanzadeh et al. 2012):

- Defining problems dynamically, in terms of graphs over time.
- Striving for an endogenous, behavioral view of the significant dynamics of a system, a focus inward on the characteristics of a system that themselves generate or exacerbate the perceived problem.
- Thinking of all concepts in the real system as continuous quantities interconnected in loops of information feedback and circular causality.
- Identifying independent stocks or accumulations (levels) in the system and their inflows and outflows (rates).
- Formulating a behavioral model capable of reproducing, by itself, the dynamic problem of concern. The model is usually a computer simulation model expressed in nonlinear equations, but is occasionally left unquantified as a diagram capturing the stock-and-flow/causal feedback structure of the system.
- Deriving understandings and applicable policy insights from the

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resulting model.

- Implementing changes resulting from model-based understandings and insights.

3. Finding

3.1. Flow diagram of bullwhip effect problem in drug supply chain

In this paper, the Flow diagram of bullwhip effect problem in drug supply chain is depicted as Figure 1.

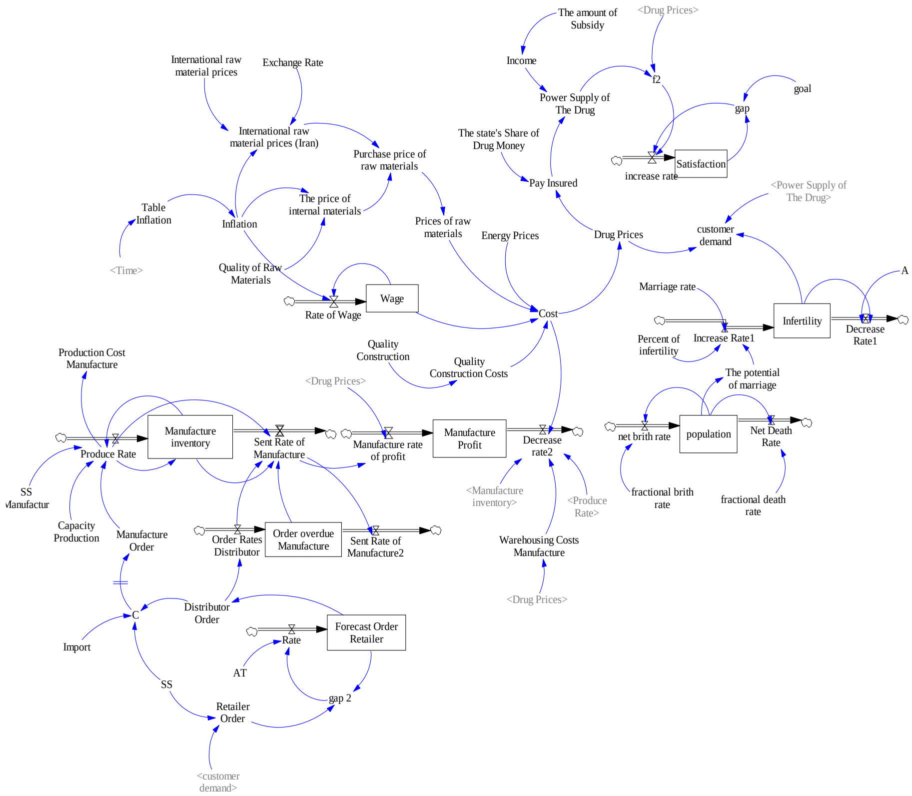

Figure 1. Flow diagram of bullwhip effect problem in drug supply chain

3.2. Important mathematical formulation

In continue, the important mathematical formulations of bullwhip effect problem in drug supply chain are mentioned.

Produce rate: MAX (MIN (Manufacture Order-Manufacture inventory +SS Manufacture, Capacity Production))
Manufacture's Order: DELAY1(C, 0.5)

Manufacture inventory: Produce Rate-Sent Rate of Manufacture 100
Sent Rate of Manufacture: MIN (Order overdue Manufacture+ Order Rates Distributor, Manufacture inventory)
Order rates distributor: MAX (0, Distributor Order)
*C: (1-Import)*Distributor Order+ SS*
Cost: Prices of raw materials+ Energy Prices+ Wage+ Quality Construction Costs
*F2: LN (Power Supply of The Drug/Drug Prices)*0.01*
*Increase rate: f2*MAX (0, gap)*
*Customer demand: Infertility*IF THEN ELSE (Power supply of the drug* Infertility -Infertility*drug prices>0, 1.1, IF THEN ELSE (Power supply of the drug* Infertility -Infertility*drug prices=0, 1, IF THEN ELSE (Power supply of the drug* Infertility <drug prices*Infertility: AND: Power supply of the drug* Infertility >=0.5*drug prices*Infertility, 0.5, 0.2)))*
*Retailer Order: RANDOM UNIFORM (-1, 1, 0)*customer demand+ SS*
*International raw material prices (Iran): (International raw material prices*Exchange Rate+ (International raw material prices*Exchange Rate*Inflation))*
*The price of internal materials: EXP (Quality of Raw Materials+ Quality of Raw Materials*Inflation)*
Purchase price of raw materials: "International raw material prices (Iran)"+the price of internal materials

3.3. Analysing the senarioes

In this paper, we analyze and suggest three policies for improving current situation of drug supply chain based on manufacturer profit, drug price and customer satisfaction level. This model mainly concentrates on case study of Human Menopausal Gonadotropin (HMG). Fore more illustration, in continue we present the result of scenario 3 according the Vensim software results.

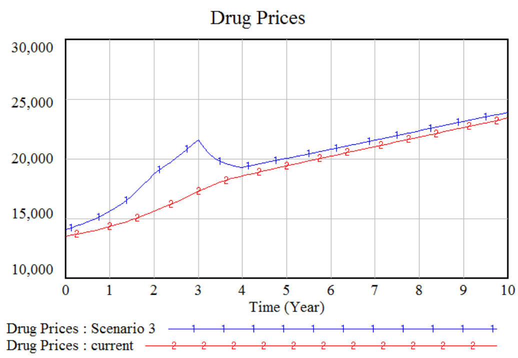

Figure 2: Drug price of HMG before and after targeted subsidy plan

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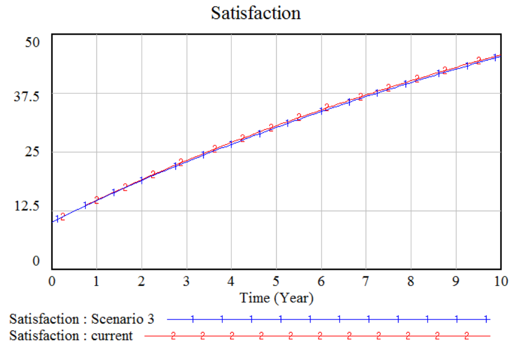

Figure 3: Customer satisfaction level before and after targeted subsidy plan

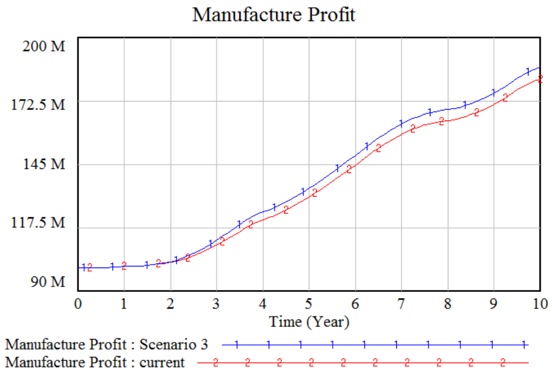

Figure 4: Manufacturer profit before and after targeted subsidy plan

4. Conclusion

This paper analyzed and modeled the efficacy of the direct subsidy distribution on level satisfaction of people from drug price changes and also considered the efficacy of this subsidy distribution on total profit of drug supply chain by system dynamics approach. First, a system dynamics of drug supply chain by considering the direct subsidy distribution modeled and the model is the simulated. To do this, the casual loop diagram was depicted and then with its help, the stock and flow diagram constructed. Three policies for improving current situation of drug supply chain based on manufacturer profit, drug price and customer satisfaction level were suggested.

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