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Dynamic Modeling of Economic System in Iran

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ABSTRACT: The long term goal attaining of economic system managing requires establishing a dynamic framework such as system dynamics to integrate multiple perspectives. This article considers the problem of economic development in macro level. Since that economic development has a dynamic and multidimensional nature, here to be used of system dynamics method. In this regard, main economic development indicators are utilized for dynamic measurement modeling. This model assesses economic development in Iran over the period 1989-2009 and predicts it to 2019. The results indicate relationships between economic development components.

Keywords: *Economic system, Development, System dynamics, GDP, Inflation, Saving, Investment*

INTRODUCTION

Economic systems, being complex adaptive systems, are composed of numerous numbers of components which have the specific internal relationships. Economic systems are also teleological systems that define the new aims as well as incorporating the consequences of their fulfillment into the present decisions; thus, they are regarded as being anticipatory.

These systems are capable to learn from mistakes and from present developments, and react by changing both the actions undertaken and the aim defined as they are self-reflexive. They also have the ability to adapt to new changing boundary conditions (a property also shown by non-human systems), but they may consciously alter the boundary conditions. This is why the economic system, as a human system, can be understood as a complex, adaptive, self-reflexive, and self-aware system (Kay and Regier, 2000).

Therefore, thermodynamic equilibrium, and neo-classical environmental economics are not the best ways to describe the behaviors of such systems (Martin, 2003); therefore, it is natural to use a system approach in modeling the relationships among components of economic growth and development. The main feature of this approach is to avoid of endogeneity bias. The use of this approach also makes it possible to examine a variety of channels that affect the relationship between these components. It also provides a key step towards the better understanding of the interactions between these variables (Ang, 2008).

While cross-country studies, which are useful in detecting general empirical regularities, do not capture and account for the complexity of the economic histories of each individual country (Ang, 2008). It is believed that integration of economic and system dynamics methodology are likely to enhance the policy impact of both methodologies (Smith and van Ackere, 2002).

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The aim of this paper is modeling the economic evaluation in macro level using a system dynamics approach. The components of this model consist of Gross Domestic Product (GDP), saving, investment, and inflation. This model evaluates Iran's economic system and demonstrates how it is possible to integrate a simple static economic model within a dynamic framework using the systems dynamics methodology.
This paper is organized as follows:
Section 2 provides a brief review of the literature.
Section 3 outlines the model specification, explains the methodology and highlights the data and reports the empirical results and their interpretation.
Section 4 is the conclusion to the study.

Theoretical Linkages Between the Components of Economic System

Macro economists have tried to develop those macroeconomic indicators which reflect the performance of national economies since the 1930s. The inherent notion in Keynesian economics that is the possibility of preventing economic fluctuations depends upon the ability to foresee when policy action is required as well as the nature and magnitude of the necessary intervention. At the national level, economic indicators have seldom preformed well, but in some cases they move in the opposite directions, often as fundamental changes are taking place in the economy (Button, 2002).

At the macroeconomic level there are a number of widely used standard indicators of economic performance, including Gross Domestic Product (GDP), capital investment, public sector borrowing and inflation level (Button, 2002).

In addition, it has been found that the clarity of the causality between the two variables may differ from country to country and over time. Some of the variables, which have been found to be important in the finance-growth nexus, include the degree of openness, saving, investment and inflation, among others (Odhiambo, 2008). In the following sections, empirical studies on relationships among indicators are considered.

Relationship between GDP, Saving and Investment

Economic growth is at the centre of economic analysis, the political agenda and public debate. Positive rates of GDP per capita growth are taken as a physiological feature of contemporary economies. Gross domestic product is said to equal the sum of consumption, investment, government expenditures, and net exports (Hsiao and Hsiao, 2006).
In this study, the choice of saving as a main variable in the dynamic framework has been largely influenced by the theoretical links between saving and economic growth, on the one hand, and saving and investment on the other.

Saving depends on the incentives to save and the ability to save. Per capita income, growth of per capita income, age structure of the population and distribution of income are factors that determine the ability to save. The rate of interest, the rate of inflation and the degree of financial deepening are factors that determine the incentive to save. All studies find that the level and the growth rate of per capita income are significant positive determinants of the saving rate (Swaleheen, 2008).

There are many empirical evidences about relationship between saving and investment (De Vita and Abbott, 2002; Plagidis and Mastroyiannis, 2003; Corbin, 2004; Narayan, 2005).

Chakrabarti considered relationship between saving and investment in 126 countries and show that there is significant and robust positive association between the ratio of gross domestic investment to gross domestic product (GDP) and the ratio of gross domestic saving to GDP (Bahmani and Chakrabarti, 2005; Chakrabarti, 2006).

Realizing correlation between saving and investment is crucial, because the more capital accumulation depends on the more saving that can be mobilized domestically or obtained from foreign countries (Ang, 2008).

The construction of infrastructure, buildings and the installation of new equipment has been recognized as an important engine of economic growth. Such investment should continue at least at a level required to replace physical capital that wears out. Replacement of worn out capital provides opportunities for continual improvements in efficiency (Victor and Rosenbluth, 2007).

Trade freedom affects the relationship between saving and investment (Eslamloueyan and Jafari, 2010),which is the more robust in close economies than open economies (Bahmani and Chakrabarti, 2005).

In the last decade or so, researchers emphasized the role of economic freedom as an important determinant of economic growth (Berggren, 2003; Berggren and Kurrild-Klitgaard, 2004; De Haan et al., 2006; Doucouliagos and Ulubasoglu, 2006; Justesen, 2008).

There are some evidence on the causal relation between economic freedom and economic growth (Carlson and Lundström, 2002; Vega-Gordillo and Álvarez-Arce, 2003; Dawson, 2003). Moreover, the effect of economic freedom on investment has become the focus of attention (Dawson, 2003; Gwartney et al., 2006).

According to Gwartney and Lawson (2004, 2007) economic freedom as a concept consists of these dimensions: size of government, government spending, taxes and government enterprises, property rights and legal structure, sound money, monetary and inflationary policies,international trade and trade policies, regulation of business, labour and credit markets.

Hanke and Walters consider relationship between political freedom and economic growth as they state that political and civil liberties yield unambiguous results believing that there is a positive and highly significant correlation between income and both of these measures (Hanke and Walters, 1997).

There is positive feedback loop in interaction among democratization, technological waves and economic growth (Coccia, 2010).

Relationship between Inflation and Economic Growth

Inflation and growth have always been among the most widely analyzed topics as well as being the subject of interest to macroeconomic forecast researchers (Hendry, 2001; Bonerjee and Russell, 2001). These two concepts constitute the general performance indicators of macroeconomics; therefore, macroeconomic policies are configured mostly based on their forecasted values (Sahin, 2006).

In the economic literature, the models that help to explain the dynamics of inflation were initially developed for Latin American countries. As a result of economic policies developed by Latin American countries in accordance with the IMF, it was possible to decrease the inflation to one-digit levels toward the end of the 1980s and the goal of researches during this period was a reduction in inflation (Mishkin and Savastano, 2001; Rigobon, 2002, Sahin, 2006).

Generally, all these models were causal models that used regression for estimation.

These models are used especially to understand the structure and dynamics of inflation. Due to the restricted and weak estimation power of causal regression models, time-series approaches such as the ARIMA and VAR models are generally preferred (Moshiri and Cameron, 2000).

The relationship between inflation and growth has been investigated widely on theoretical foundations in economic literature (Arýn and Omay, 2006).

Relationship between inflation and output growth is non-linear and that there exists a threshold level below which inflation has no effects on growth (Khan et al., 2001; Khan and Senhadji, 2001; Drukker et al., 2005; Vaona and Schiavo, 2007; Bick, 2010).

Gylfason and Herbertsson (2001) find that the relationship between inflation and growth is non-linear and the threshold inflation rate to be around 10% while Khan and Senhadji (2001) find the threshold to be around 1% for industrialized and 11% for developing countries.

Thus the primary objective of macroeconomic policies is to attain high and sustainable growth rates along with low and stable inflation rates. So, the relationship between output growth rate and inflation rate is vital in policymaking. If growth and inflation rates are interrelated, then policymakers would be a means to control these variables depending on the structure of such a relationship (Omay and Kan, 2010).

RESEARCH METHOD

This section describes the system dynamics methodology and the empirical analysis.

System Dynamics as a Method for Investigating Relationships

We used causal loop diagramming methods to test our model within the context of our objectives. Conceptual models that sometimes called mental maps facilitate discussion and comparison of different interpretations of the system's structure, which variables are involved and how they are linked including identification of reinforcing and balancing feedback loops and delays that affect system dynamics (Sterman, 2000).

Sendzimir et al. believed that in complex adaptive systems, sudden, non-linear shifts in behavior surprise conventional expectations based on belief in linear causality. The factors and structure (patterns of interaction between factors) associated with such counter-intuitive behavior can be explored using causal-loop diagrams to describe the interplay between reinforcing and balancing feedback loops. Frequently non-linear behavior can be ascribed to shifts in

dominance between different feedback loops or different sets of feedback loops (Sendzimir et al., 2007).

Feedback or interaction is what makes system dynamics; without such feedback, the system is static. On the other hand, the greater the interaction among the components of a system, the more dynamic it is. In a system with built-in feedback mechanisms, the behavior of a structure which is composed of components, attributes and relationships is constantly changing over time (Lee and von Tunzelmann, 2005).

Data Collection and Reference Modes

Gross domestic product, saving, investment and inflation have been chosen in this study. These indicators are the stocks of model. System dynamics modeling seek to describe problem dynamically, that is the problem detects as a behavioral pattern during the time. This section provides reference modes of key variables (figures 1-4). Data for this study collected from databases such as Statistics Center of Iran, economic reports of Iran Central Bank, and IMF. Time horizon of this study is 1989-2019, thus, basic time is 1989.

Causal Loop Diagram

Causal loop diagram is the best tool for expressing causal relationships between variables and systems feedback. This section shows causal loop diagram of economic system (figure 5).

Stock-flow Diagram

Figure 6 show stock-flow diagram of economic system. This model constitutes of four stocks that every one has inflow and outflow. In this step, stock-flow diagram enters in Vensim Software and is written their formulations.

Validity Test

There are several tests in order to test of dynamic models validity. In the present study the extreme conditions test and the behavior anomaly test are used.

In the extreme conditions test, models should be robust in extreme conditions. Robustness under extreme conditions means the model should behave in a realistic fashion no matter how extreme the inputs or policies imposed on it may be. Extreme condition tests ask whether models behave appropriately when the inputs take on extreme values such as zero or infinity (Sterman, 2000).

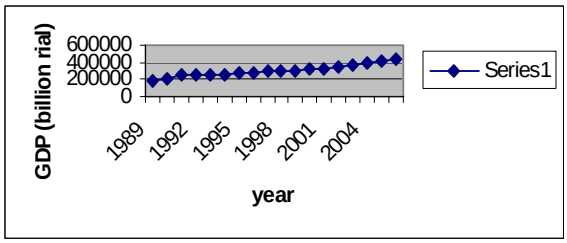

Figure 1: Reference mode of GDP

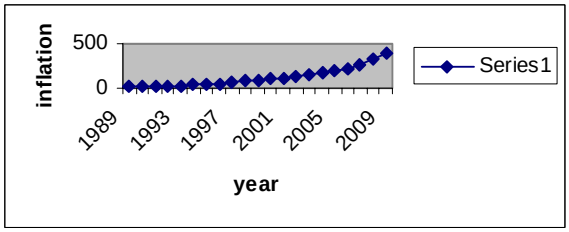

Figure 2: Reference mode of inflation

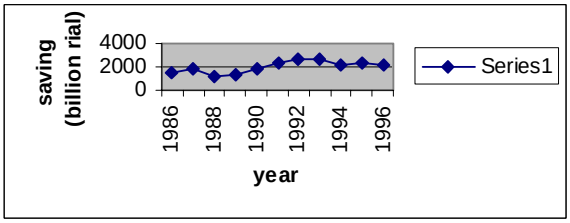

Figure 3: Reference mode of saving

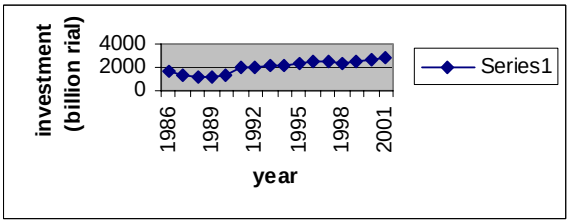

Figure 4: Reference mode of investment

In this paper, inflation rate to be seen zero and consequently inflation stock reduces and moves to zero (figure 7).

Loop knockout analysis is a method for investigating anomaly behavior and can be revealing when the model is operating under historical conditions but is particularly effective in conjunction with extreme condition tests. If a loop knockout test generates bizarre or physically impossible behavior under extreme conditions, there is evidence that the relationship is important and must be included (Sterman, 2000).

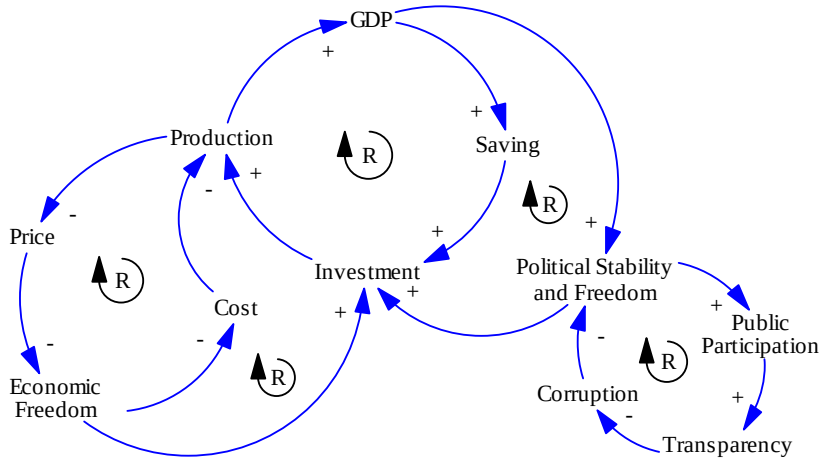

Figure 5: Causal loop diagram

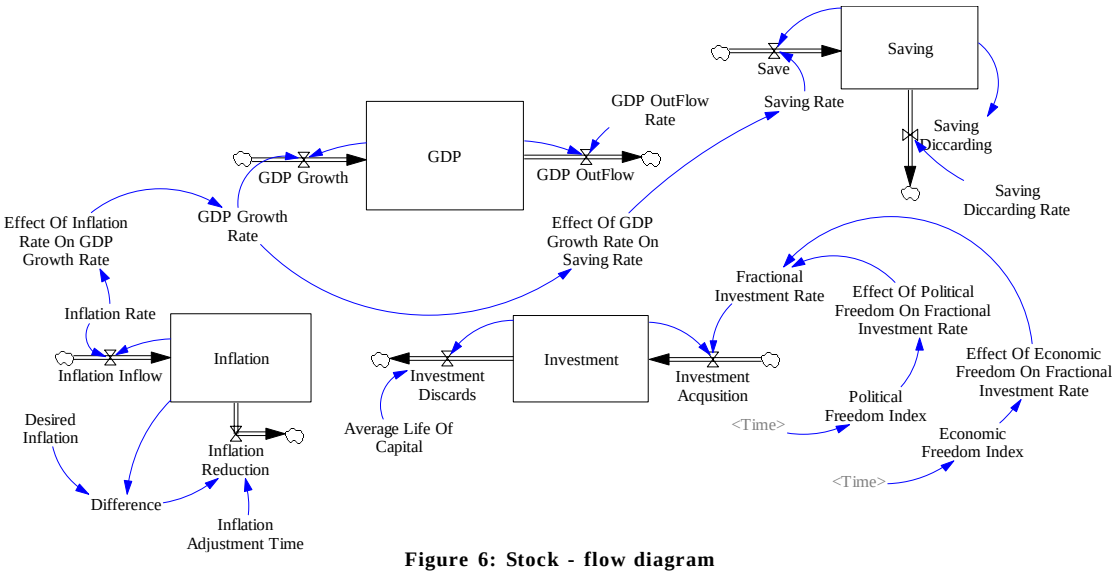

Figure 6: Stock - flow diagram

In this paper, effect of economic freedom loop is eliminated in the model; consequently, stock of investment shows anomaly behavior and increases. It indicates the important of this loop (figure 8).

RESULTS AND DISSCUSSION

This section shows the results of model simulation after designing the stock-flow diagram and model performs.

In this research, GDP, saving and investment are the stocks of model. In saving stock, saving rate is an increasing factor and saving discarding rate is a decreasing factor. As to be seen, saving depends on income. Different economic and political factors such as corruption, political rights and civil liberties as effective factors on investment consider by means of lookup function. Simulated behavior of indicators in comparison with their reference modes emphasize that indicators do not show unexpected behavior and relationships are correct (figure 9).

Results indicate that GDP is 191503 billion rails in 1989 and is 419607 billion rails in 2009 and predict 621120 billion rails in 2019. Saving is 1495 billion rails in 1989 and is 1540 billion rails in 2009 and predicts 1563 billion

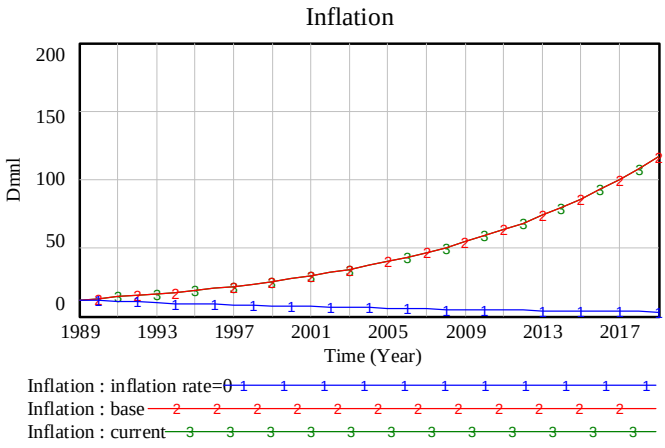

Figure 7: Extreme conditions test of model

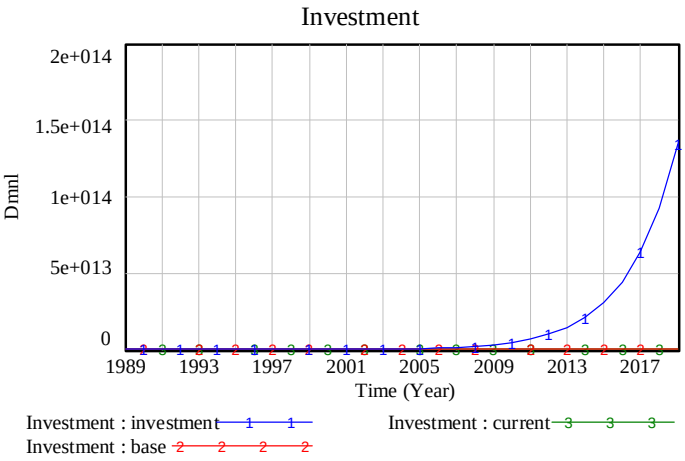

Figure 8: Behavior anomaly test of model

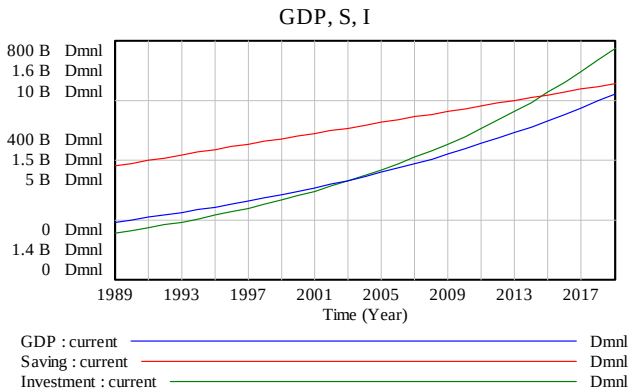

Figure 9: Simulation of GDP, saving and investment

rails in 2019. Investment is 1942 billion rails in 1989 and is 3014 billion rails in 2009 and predicts 5148 billion rails in 2019.

This research considers the relationship between GDP and inflation through system dynamics approach as stock indicators. The effect of inflation rate on GDP growth rate is studied by the means of lookup function. Simulated behavior of indicators in comparison with their reference modes emphasize that indicators do not show unexpected behavior and relationships are correct (figure 10). Results indicate that inflation is 11.5 in 1989 and is 53.8 in 2009 and predicts 116.2 in 2019.

CONCLUSION

Economic system is a complex adaptive system that is complicated of various components and their relationships. This article investigates the causal relationship among gross domestic product, saving, investment and inflation in Iran over the period of 1989-2009 and predicts it to 2019.

Bi-variate framework has two major limitations. First, the cross-sectional data itself cannot satisfactorily address the country-specific issues. Secondly, the inference drawn from the bi-variate causality framework may be invalid due to the omission of an important variable in the causality model (Odhiambo, 2008). Therefore, this study provides multi variate causal relationship in economic system and uses system dynamics method. Inflation rate have an increasing trend from 1989 and arrive to high extent in 1994, then it is reduced. Generally, GDP growth rate have a frequent state in the period of 1989-2009. Since, there is not perfect adaptability between Inflation rate and GDP growth rate, their relationship is studied by system dynamic approach in this paper.

There is a similar situation for the relationship between GDP growth rate and saving rate. Empirical results show causal relationships between indicators.Theory of non linear dynamics and feedback control is the basis of system dynamics approach. Simulation helps to understanding complexities and more effective decision making. System dynamics indicate that how structures are interrelated.

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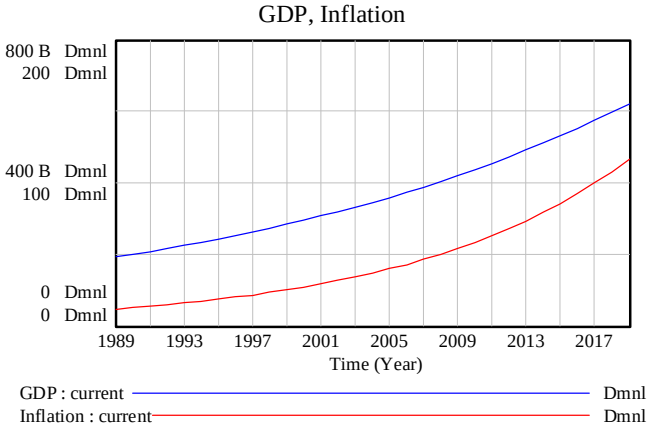

Figure 10: Simulation of GDP and inflation

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