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## THE ASYMMETRY OF EXCHANGE-RATE PASS-THROUGH TO PRODUCER PRICES IN IRAN: MARKOV SWITCHING APPROACH

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### ABSTRACT

*The present article aims to investigate the effects of positive and negative shocks of exchange rate on the asymmetry of exchange-rate pass-through on domestic prices in Iran during 1981-2014. To this aim, first, using the Markov-Switching model, the positive and negative shocks were extracted. Then, using the co-integration test of Johansen and Juselius, the asymmetry of exchange-rate pass-through to producer prices in Iran, along with the effectiveness of nominal exchange rate variables, gross domestic production, the volume of liquidity and the trade openness of the economy were investigated. The empirical findings of the research indicated the asymmetry of the exchange-rate pass-through to the producer price. The results showed that, first, in Iran's economy, the exchange-rate pass-through on the producer price is approximately 0.5 which is incomplete. Second, the degree of passage to the producer price in the case of positive shocks of the exchange rate is significantly more than the negative shocks of the exchange.*

**Keywords:** Asymmetric Exchange-Rate Pass-Through, Markov-Switching Model, Johansen and Juselius Co-Integration, Producer Price

### INTRODUCTION

The exchange-rate pass-through (ERPT)<sup>1</sup> represents the change percent in domestic prices per one percent change in the exchange rate. If the change in the exchange rate by one percent leads to a one percent change in domestic prices, then the exchange rate is perfect, but if one percent change in the exchange rate fails to lead to one percent change in domestic prices, the exchange-rate pass-through is then partial and incomplete.

In terms of policy-making, understanding the effect of exchange rate volatilities on domestic prices is considered an adequate criterion for assessing monetary policies and nowadays, the issues on the adoption and implementation of appropriate exchange rate policies in developing countries are expanding and in order to consider the desirability or undesirability of exchange rate volatilities in an economy, it is necessary to evaluate the effects of these volatilities on internal prices. Exchange rate volatilities will affect the demand of the overall economy through importing and demand for money, as well as the total supply of the economy through the cost

<sup>1</sup>Exchange Rate Pass-Through (ERPT)

of imported intermediary goods, thus that one increase in the exchange rate can increase the price of imported final goods, the price of imported intermediary goods, the price of raw materials, as well as the price of imported machinery, equipment and technology to the country, and will increase the price of consumer and consumer and will increase inflation and reduce the welfare of the community; moreover, it can increase the demand for substitute domestic goods and also increase demand for exporting products which will consequently increase production, exports and demand for labor force and ultimately increased wages and the welfare of society, and thus the outcome of these two effects on production and prices depends on the initial conditions of the economies of the countries.

During the past four decades, the Iranian economy has always experienced volatility from the perspective of exchange rate volatilities, and has sometimes experienced extreme volatilities along with high inflationary levels, and from this perspective has caused adverse effects (including declined productivity, decreased economic growth etc.) on its economy. In addition, during this period, the exchange rate has grown incrementally and has undergone various volatilities during the period, such that, despite the slight increase in the exchange rate, prices have grown significantly, or vice versa, with a drop in the exchange rates, the rise in prices has not been stopped, which implies the asymmetry of the effects of increasing and decreasing the exchange rate on domestic prices. On the other hand, by observing Iran's economic recession and prosperity, exchange rate changes and prices in these periods, and taking into account the new literature of exchange-rate pass-through, it seems that in Iran exchange rates have different and asymmetric effects on the interior price level. Given this, the basic issue is the exchange rate effects on domestic prices during business cycles and in the context of the rise and devaluation of the national currency in Iran. Therefore, the present research seeks to answer the question of what is the effect of the exchange-rate pass-through on producer prices under the conditions of the positive and negative shocks of the exchange rate? In other words, are the effects of increasing and decreasing exchange rates symmetric on the producer price index in Iran?

In this article, in order to answer the posed questions, the organization of the research will be as follows: an introduction was stated at the beginning of the article. The first part is devoted to theoretical foundations of the research subject, and in the second part of the article, the empirical studies on the exchange-rate pass-through on producer prices are investigated. In the third section, which deals with the methodology of research, introduces Markov-Switching model, and positive and negative currency shocks are extracted using the Markov-Switching method. In Section 4, the results of the model and the findings of the research are presented, and in the fifth part, conclusions are drawn.

## **THEORETICAL FOUNDATIONS**

In this part of the research, first, the theoretical foundations of exchange-rate pass-through were discussed. Then, in short, the asymmetric effects of positive and negative shocks of the exchange rate on the exchange-rate pass-through to producer prices in Iran were studied. Early studies in the area of ERPT have begun in the field of exchange rate transfer on import prices since the 1970s (Goldberg and Knetter, 1997). However, later, the scope of these studies was extended to examine the effect of the exchange rate on domestic product prices and exports in terms of domestic currency. In fact, the fundamental link between the exchange rate and the price of internationally traded goods is generally known as the transfer of the exchange rate



(Magee, 1973). Regarding the manner of transferring exchange rate changes to the prices index, Dornbusch in 1987 accurately addressed this issue for the first time. This study became the basis of other studies on this subject. In his study, he explains the moderation in relative prices of moves and exchange rate volatilities for an industrial structure. His viewpoint was based on the methods of micro discussions and minor equilibrium, and the parameters such as the degree of market concentration, the degree of product homogeneity and its substitute capability, the relative share of domestic and foreign firms, and the market structure are employed in explaining the moderations mentioned. A considerable point in the Dornbusch discussion is the introduction of microeconomic issues in foreign exchange analyzes. Goldberg and Knetter (1997) also referred to the percent change in import prices due to a one percent change in exchange rates among the exporting and importing countries as exchange-rate pass-through. In this discussion, it has been argued that if the rate of change in the exchange rate is transferred one by one to the import prices, the exchange-rate pass-through is complete, and if it is less than one, the exchange-rate pass-through will be incomplete. The way exchange rate changes are transferred into domestic prices falls in the form of direct and indirect effects:

**A. Direct effect:** This effect reflects the change of the exchange rate to the price of imports through the foreign sector of a country. For instance, if  $E$  is the price of the exchange rate and  $P^*$  is the price of imported goods in terms of foreign currency,  $E \times P$  indicates the value of the imported goods in terms of domestic currency. Now, if  $P^*$  is constant and domestic currency weakens, the price of imported goods will increase in terms of domestic currency. Given that the imported goods are typically finished goods or intermediary goods, the former directly and the latter indirectly increase the consumer cost through increasing production costs and increasing the finished price of domestic goods. By and large, this effect reflects the transfer of exchange rate changes to the price of imported goods, that is, with the increase of the exchange rate or the weakening of the national currency, the price of imported goods increases. Goldberg and Knetter (1997) state that this effect is complete or 100% when the mark up and marginal cost are constant. Accordingly, producers do not apply any price discrimination and the imported price will change proportional to the exchange rate change, that is, if producers change prices to change markups and discriminate prices, the transfer of exchange rate changes to the prices will not be complete.

**B. Indirect effect:** The effect of the transfer of exchange rate changes (exchange-rate pass-through) is related to the competitiveness of commodities in international markets. An increase in the exchange rate and the devaluation of the domestic currency will lead to cheaper domestic commodities for foreign purchasers, leading to an increase in exports and total demand, and despite the surplus demand on the domestic market, domestic prices will rise (Hufner and Schroder, 2002).

In addition to direct and indirect effects, Taylor also mentioned the expected effect for the first time. According to him, the change transfer of the exchange rate is high when the changes in the exchange rate continue as already expected and the prices become adjusted due to general expectations (Khoshbakht and Akhbari, 2007).

Sachs (1985) also divides the indirect and direct effects of exchange rate changes on domestic prices into two categories of competitive effects and wage inflation. The competitive effect occurs when the exchange rate changes change the demand for the domestic product. He believes that



lowering exchange rates will lead to higher exporting prices and lower importing prices. With constant domestic costs, due to lower prices of their competitors caused by reduced prices and / or reduced profit margin, the domestic producers react to the lower import prices. An increase in the exchange rate followed by an increase in import prices lead to an increase in demand for domestic goods. Hence, an upward pressure on the price of such commodities will increase consumer prices. According to Sachs, simultaneously, the devaluation of the domestic currency could lead to more competitive exports in global markets. Also, rise in the export demand will lead to a rising pressure on the price of exchangeable domestic goods and will help to raise consumer prices. The latest effect of exchange rate changes is the effect of wage inflation; this effect works through the moderation of nominal wages that have a direct effect on production costs; in this way, an increase in the exchange rate and the devaluation of the national currency increase the price of imported consumer goods which will reduce the purchasing power of workers. In order to compensate for this decline, employers raise nominal wages, which will increase production costs and thus increase product prices (Sachs, 1985).

The producer price index reflects the prices received by domestic producers, thus any factor that affects the prices received by these producers will change the producer price index. In general, this is the cost transfer that transfers the price, thus exchange rate changes can be considered given its effect on the cost of imports as one of the cost change sources; the exchange rate affects the price of imported goods and will increase production costs, especially for the industries, the production of which relies on imported raw materials. When manufacturers are faced with rising production costs, they typically transfer this pressure to consumers by increasing the price of the final goods and services to retain their former profit. Of course, this price transition is interrupted and the consumer price is moderated at different intervals depending on the firm's pricing strategy and market conditions. Therefore, the relationship between the producer price index and the consumer price index depends on the behavior of determining the producer's markup and the degree of market competition (Shamsfakhr, 2009).

The rate of transfer of exchange rate changes to the consumer price index is largely dependent on the share of imported goods in the household's consumer basket. The higher the share of imports in consumer goods, the higher the rate of transfer of exchange rates, and the exchange-rate pass-through will have more effect on the consumer price index, such that with an increase in the share of imports in consumption expenditures, it is expected that the import price trend enjoy a high share in explaining the internal inflation (McCarthy, 2000).

In the distribution chain of exchange rate shocks, the import price index is followed by the exchange rate, which is then followed by the producer / consumer price index. In such a way that exchange rate changes cause a change in the import price index, and the price index of imports will change the producer price index by changing production costs. Changing the producer price index changes the price of consumer goods and changes the consumer price index as well. In Figure (1), the direct and indirect effects of exchange rates on domestic prices are shown:



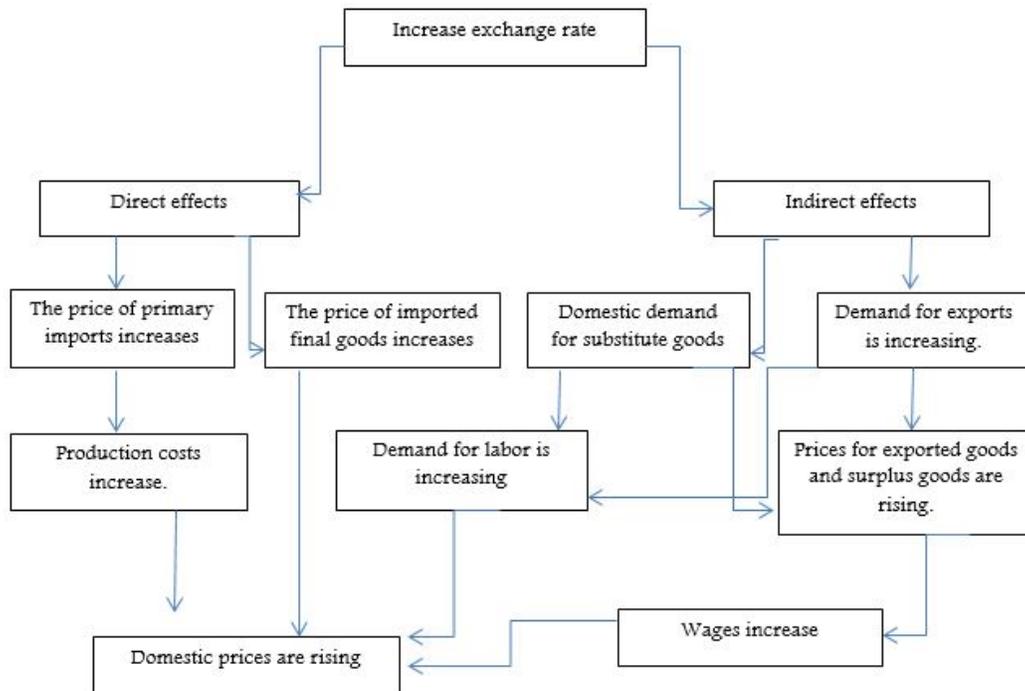


Figure1. Direct and indirect effects of increase in exchange rates on domestic prices (La Fleche, 1996)

Martinez and Air (2011) hold that an increase in the degree of openness of the economy can help to reduce the general level of domestic good prices by increasing the competitiveness in manufacturing exchangeable domestic goods. Therefore, in the absence of tariff barriers and other trade restrictions on the importation of exchangeable goods, imports of these types of goods into the country will increase and competitiveness in the production of domestic exchangeable goods will increase. Hence, domestic producers will have to increase the quality of goods and services or reduce production costs in order to retain the competitiveness of their products, thereby assisting in reducing the general level of prices and inflation. In fact, there is a convergence between the exchange rate changes and its transfer to the price index of exporting goods (Tamizi, 2015). Literature on exchange-rate pass-through usually falls into three categories: the first category of studies is the pass of the exchange rate to import prices for specific industries.

The second category of studies is the study of the exchange-rate pass-through to the total import prices (Hooper & Mann, 1989; Campa & Goldberg, 2005). The third category is the study that examines the passage of the exchange rate to wholesale and consumer prices. The study on exchange-rate pass-through at the macro level examines the passage of the exchange rate from the perspective of the effect of exchange rate changes on various price indices, such as the import price index, producer / consumer price indices (Tandrayen-Ragoobur and Chicooree, 2012).

## RESEARCH LITERATURE

There are many studies on the transfer and pass of exchange rate in the world literature. The degree of exchange-rate pass-through is based on internal prices in both symmetric and

asymmetric terms, which are examined both in symmetric and asymmetric ways by external and internal studies. Some of these studies are briefly reviewed:

### *Previous Studies*

In his study, Kandil (2000) investigated the asymmetric effects of exchange rates on production levels and prices in developing countries. Based on the results of this research, the hypothesis of the asymmetric effects of the exchange rate volatilities in the price and production levels has been confirmed. The devaluation of the domestic currency (positive shocks of the exchange rate), through its effect on the cost of imported intermediary goods, has led to a decrease in the level of production and an increase in prices, also an increase in the value of the domestic currency (negative shocks of the exchange rate) by reducing exports, reduced the level of production, but had no effect on the price level.

Campa and Goldberg (2002) studied the factors affecting the exchange rates in the 25 OECD countries during the years 1975-2003. In this study, the price index of imported goods was used as an alternative variable for the exchange-rate pass-through and the effect of the variables of the rate of growth of money, the volatility of exchange rate and inflation on the exchange-rate pass-through was examined. They also tried to identify short-term effects and long-term effects of foreign exchange rates for the import goods. They came to the conclusion that in the long-term the exchange-rate pass-through on imported goods is more specific and more visible than the short-term.

Hoffner and Schroeder (2002) examined the transfer of exchange rates on the consumer price index for the Eurozone and the countries of Germany, France, Italy, the Netherlands and Spain during the period 1982-2001 using the error correction model. The results of their studies show that the exchange rate transfer on the Harmonized Index of Consumer Prices (HCPI) is incomplete.

Heydar and Shah (2004) studied the exchange rate transfer on domestic prices (wholesale price index and consumer price index) in Pakistan during the period 1988-2003 using the VAR model. The results of the study show that the transfer of exchange rate on domestic prices is very low.

Ito and Sato (2007) also used a self-explanatory model to investigate exchange-rate pass-through and domestic inflation in comparison made between Latin America and East Asia. Based on the results, the higher rates of exchange rates in Latin America and Turkey than East Asia were confirmed.

Ghosh and Rajan (2009) studied the effect of exchange rate volatility on the index of prices for imported goods in Korea and Thailand during the years 1980-2006 using Johansen and Juselius method. The results of model estimation showed that exchange rate volatility has a positive and significant effect on the price index of imported goods and increases with the increase of the exchange rate volatility of imported goods.

Jaffri (2010), using the OLS model during the period 1995-2009, examined the transfer of foreign exchange rates to consumer prices in Pakistan under different currency regimes, taking into account the deviation of the real exchange rate. The results indicate that the exchange rate transfer in Pakistan occurs incompletely.

Sanusi (2010) explored the exchange rate transfer on consumer prices in Ghana. The results of the study during the period 1983-2006, using the SVAR model, indicated that the exchange rate



is incomplete, but it is worth noting that an increase in the exchange rate is a potential source of inflation in Ghana.

Dramani and Tando (2011), using autoregressive co-integration with distributed lag, investigated the factors determining the transition rate of exchange rate effect in terms of price index of imported goods in Ghana during 1990-2010. The results of the model estimation show that in the short-term the transition rate of exchange rate effect is low, while in the long-term the price volatility of consumer goods is higher than exchange rate changes compared to short-term.

Tandrayen-Ragoobur, and Chicooree (2012), in an article using their structural self-explanatory model, examined the exchange rate and internal prices on Mauritius Island. The results of their studies show that higher transfer of exchange rate changes leads to inflation of consumer prices than other indices.

Lin and Wu (2012) studied the effects of exchange rate volatility and inflationary environment on the transition rate of exchange rate effect in Taiwan during 1980-2008. In this research, two high and low volatility systems are considered for nominal exchange rate instability and the empirical model was estimated by the threshold auto-regression method. The results of the model estimation showed that by transferring to the high instability system, the transition rate of the exchange rate effect is increased and the inflationary environment has a positive and significant effect on the price index of imported goods.

Mario (2012) in his study, using the data from OECD countries, examined the factors influencing the transition rate of exchange rate effect on the price index. The results of this research indicated that there is a positive relationship between the inflationary environment, the inflation instability and the exchange rate volatility with the transition rate of exchange rate effect on the price index.

Masha and Park (2012), using the VAR model, examined the transition rate of exchange rate effect on the producer price index and consumer price index in the Maldives during the 1994-2010. The results indicated that the degree of transition rate is significant but incomplete for both indices.

Jimborin (2013), in a study using the Vector Auto-Regression model, examined the transition rate of exchange rate effect on consumer goods prices in the EU countries during 1996-2010. For this purpose, the research model is estimated dynamically and by the generalized torque estimation. The results of this study indicated that the effective nominal exchange rate changes have a positive and significant effect on the price index of imported goods in this group of countries, but this effect is not statistically significant on two price indices of producer and consumer.

Shintani et al. (2013) also, in a paper using the self-explanatory smooth transition model, examined the exchange-rate pass-through and inflation (domestic prices) in the United States in a non-linear time series analysis. The results of their studies indicated that there is a correlation between the decrease in exchange rate and inflation in the 1980s and 1990s.

Caselli and Roitman (2016) in an article investigated the asymmetric and non-linearity of the exchange-rate pass-through on consumer prices in emerging markets, focusing on the lack of linear relationships and asymmetry in the transition of exchange rate volatilities. The results of their studies indicated that there is a significant evidence of a lack of linear relationship during periods with amortization of more than 10% and 20%. More precisely, they found that, after a



month, the exchange rate coefficient applied to consumer prices equaled to 18% and 25%, respectively, compared to the linear 6% coefficient. They also examined the role of temporary and permanent shocks and the adoption of the inflation-targeting approach in transition from exchange rates to prices.

Using the VAR model, Shajari et al. (2005) examined the transitional effects of exchange rate in Iran in the short and long-term. The results of this study showed that in Iran, the transitional effect of exchange rate is incomplete in the short-term and is gradually increased with a longer period of time, however, in the long-term, the transitional effect of exchange rate remains incomplete.

Mousavi Mohseni and Sobhanipour (2008) also investigated the effect of the exchange rate change of inflation on import prices and the inflation of domestic prices. The results of this study indicated that the transitional effect of exchange rate to the import price index is larger than the wholesale and consumer price indices, and its effect on the wholesale price is higher than the consumer price. However, the exchange rate effect is always incomplete and exchange rate shocks explain, in part, the variability of inflation.

Asgharpour et al. (2011), in a study using the ARDL technique, tested the transition rate of exchange rate effect on the non-oil export prices of Iranian economy during the period 1971-2007. The empirical findings of the research showed that there is a positive and significant relationship between the exchange rate and the export price index, such that during the period under study, with the increase of the exchange rate (the devaluation of the national currency), the export price index has significantly increased. Consequently, the transition rate of exchange rate effect to the country's export price is almost complete and is zero at the import price of the country of destination. In other words, the empirical results of the research indicate that in the Iranian economy, exporters in the face of the devaluation of the national currency (increase in exchange rates) increased export prices and, thus, the exchange rate did not have much effect on the country's destination price.

Kazerouni et al. (2012) used the TVP approach to investigate the effect of exchange rate volatility on exchange-rate pass-through in Iran. The results suggested that the positive effect of the exchange rate volatility on the exchange-rate pass-through and the positive and significant effect of the Gross Domestic Product gap is the cost of business partners and the nominal exchange rate on the index of imported goods.

Kazerouni, Salmani and Feshari (2012) in another study entitled "The Effect of the Currency System and Inflationary environment on the exchange-rate pass-through in Iran using the TVP Approach", indicated that the variables of the foreign exchange system and the high inflationary environment had a positive and significant effect on the exchange-rate pass-through in Iran.

Asgharpour and Mahdilou (2014), using the Markov-Switching approach studied the inflationary environment and the effect of the exchange-rate pass-through to the import price level in Iran during the period 1971-2006. The results of their studies indicated that in the Iranian economy, the exchange-rate pass-through is incomplete, and the inflationary environments have an asymmetric effect on the exchange-rate pass-through to the import price level, such that in high inflationary environments, the exchange-rate pass-through is higher than the low inflationary environment, and the results also showed that the final cost variable of the business partners has a positive and significant effect, and the degree of openness of the economy has a negative and significant effect on the price index of imported goods.



Heidari and Ahmadzadeh (2014) studied the changes in the exchange rate and its effect on the price chain in Iran using time series data during the years 1991-2008. Based on the results of their studies in the ARDL method, following the increase of the exchange rate in Iran, relative prices change in such a way that the prices of imported goods increase more than the prices of domestic goods.

Asgharpour et al. (2015) studied the effect of inflationary environment on the transition rate of exchange rate effect on the import price index in Iran during the period 1350-2012. The results indicated an incomplete transition relationship of exchange rate effect on the effect of the exchange rate index of the import price index. The results also showed that in the high and medium inflationary levels, the exchange rate effect of the exchange rate increases to the import price index, but this level is lower than the medium inflationary levels at high inflationary levels. Sadeghi et al. (2015), in a paper using the GMM estimation method, examined the exchange-rate pass-through and internal inflation in dollarized economies (case study of Central Asia and North Africa) during the period 1994-2012. The results of their study indicated that there is a positive and significant relationship between the exchange-rate pass-through and domestic inflation, and this effect is bigger than the high dollarized economies.

Tayyebi et al. (2015) studied the effect of exchange-rate pass-through on inflation in Iran during the years 1991-2012. The approach used in this study was a vector autoregressive model. The results of model estimation in the form of effect-response functions and analysis of variance indicated that although the exchange-rate pass-through was incomplete to the inflation of various price indices, the exchange rate changes caused volatility in different price indices and explained part of the variability of the domestic inflation in the period under study. Also, the share of imported inflation in explaining the volatility of domestic inflation indicates the dependence of the country's economy on imports.

Kazerooni and Soleimani-al-Wanegh (2015) studied the transition rate of exchange rate on the consumer price level under the conditions of deviation of the real exchange rate using the data of the time series during the years 1973-1974. The results of their studies using the ARDL method indicate a positive and significant relationship between the deviation of the real exchange rate and the consumer price index.

Lashkari et al. (2015) also in a study analyzed the effect of the exchange rate transition on the export price index and the effect of inflation and income on it in Iran and the trading partners during the period 2000-2010 using the Generalized Method of Moments (GMM). The results of their studies indicate that the rate of exchange rate transfer to the export price is incomplete and close to one, so a large part of the exchange rate changes are transited to the export price. The results also show that GDP has a reverse and significant effect on ERPT, which means that lower income will lead to higher exchange rate effect on export prices. Inflation rate also has a positive and significant effect on the exchange rate transfer to export prices.

As seen, most of the studies carried out examine the exchange rate transfer on import and export prices, and reviewing the history of research within the country suggests that little studies have been conducted on the asymmetric effects of exchange rates on domestic prices, and the asymmetric rate of exchange in Iran has not been investigated in different situations. Also, the study of the conducted studies shows that so far the exchange rate has not been investigated and analyzed by Markov switching approach and for positive and negative shocks. Therefore, this study examines the effects of asymmetric effects of positive and negative shocks on the



exchange-rate pass-through to domestic prices in Iran for producer prices, and the results can contribute to exchange rate policy makers and macroeconomic planners in analyzing the effects and the results of exchange rate volatilities.

## METHOD

The research model was explained based on theoretical foundations and empirical studies of Bada *et al.* (2016) and Jane (2012), and in the following the corrected equations for the producer price index are shown:

$$LPPI = \alpha_0 + \alpha_1 LEX + \alpha_2 LM_2 + \alpha_3 D_1 LEX + \alpha_4 D_2 LEX + \alpha_5 LGDP + \alpha_6 L Openness + \varepsilon_t$$

In which:

*LPPI* : is a price index that measures the average changes in prices received by domestic producers for their output.

*LEX* : represents the logarithm of the nominal exchange rate of free-market that measures the value of a country's currency in terms of a weighted average of the currency of other countries, in which weights reflect the contribution of each country to its international business.

*LGDP* : represents the logarithm of GDP at constant prices, which is equal to the total Rial value of final products produced by economic units resident in the country during a given period (seasonal). Gross domestic product is calculated from the sum of private consumption, investment, government expenditures and net exports.

*LM<sub>2</sub>* : represents the logarithm of the liquidity volume obtained by the total amount of money (*M<sub>1</sub>*) and pseudo-money (*T*).

*LOpenness* : The logarithm of the degree of openness of the economy which is obtained by the ratio of total exports and imports to GDP.

It should be noted that *GDP* and *Openness* variables were entered into the model as control variables.

The statistical source of all the research variables is the time series data of the Central Bank and the study period is from 1981 to 2014. The Markov switching method was used to derive positive and negative shocks for which Oxmetric7 software was used. In order to estimate the coefficients of the model, co-integration tests were used. In order to ensure that the regressions are not false, before estimating the model, the reliability and non-reliability of the research variables were investigated and because the degree of co-integration of all the model variables are of order I (1) Johansen and Juselius co-integration was used and the Stata 13 software was used to estimate the model.

### *Model estimation method*

In order to investigate the effect of the negative and positive shocks of the exchange rate on the exchange-rate pass-through to producer prices, foreign currency shocks should be extracted in the first step. In Markov-switching model, variable behavior varies in different regimes and transition cannot be observed in regimes, thus using this model, we can examine the behavior of currency shocks in recent years and obtain the types of currency shocks.

Markov-switching model was first introduced by Quant (1972), Quant and Goldfeld (1973), and then developed by Hamilton (1989) to extract commercial cycles. In general, in nonlinear



models, it is assumed that the behavior of the variable on which the modeling is done varies in different situations and changes. Nonlinear models fall into two main groups, in terms of the speed of change from one state to another. In some of these nonlinear models, the change from one state to another takes place slowly (such as STAR<sup>2</sup> models and artificial ANN<sup>3</sup> network); in some of these nonlinear models, this transition takes place rapidly and that the Markov-Switching model is one of these models (Enders, 2004).

One of the advantages of this method to other methods is the endogeneity separation of the observations of a variable, as well as the endogeneity separation of the relationships between the observations of the variables, and in this regard, the Markov-Switching method is completely different from the models based on structural failure and virtual variables. In structural failure models, structural failure years are determined in the time series variables as exogenous or endogenous regardless of probabilities, while in the Markov-switching model, in order to distinguish between time series variables or the relationships between variables into two or more regimes, Probabilities are used and the probability of transfer from one regime to another is calculated. But regarding the structural failure, such discussions do not matter, and the probability of predicting the transition from one state to another is unknown. Also, in structural failure models, there is no possibility of predicting changes in variables, but in the Markov-switching model, it is possible to predict changes in variables from one regime to another (Asgharpour et al., 2011).

In Markov's models, first, there is a possibility of a permanent change or several temporary changes, and these changes can take place numerous and for a short time. However, in this model, the exact times of structural changes and defects are determined endogenously. Second, the variance differences can also be considered as features of these models. In other words, the Markov transformation model uses several equations to explain the behavior of variables in different regimes. Third, this model imposes fewer assumptions on the distribution of model variables and also enables simultaneous estimation of changes in independent and dependent variables if the state of the economy is endogenous at each stage of time (different regimes) (Yingfu, 2007).

In the Markov-switching model, it is assumed that a regime that occurs at time  $t$  cannot be observed and depends on the invisible process of  $s_t$ . In a two-regime model, one can easily assume that  $s_t$  takes the values 1 and 2. A two-regime model can be shown as follows:

$$y_t = \phi_{0,2} + \phi_{1,2}y_{t-1} + \varepsilon_t \text{ if } s_t = 2$$

$$y_t = \phi_{0,s_t} + \phi_{1,s_t}y_{t-1} + \varepsilon_t$$

Or in brief we can write:

$$y_t = \phi_{0,s_t} + \phi_{1,s_t}y_{t-1} + \varepsilon_t$$

To complete the model, we need to specify the characteristics of the  $s_t$  process. In the Markov-switching model,  $s_t$  is considered a first-degree Markov process. This assumption implies that  $s_t$

<sup>2</sup> .Smooth Transition Auto Regressive

<sup>3</sup> .Artificial Neural Network

only depends on the previous regime,  $s_{t-1}$ . In the following the model is completed with the introduction of transition probabilities from one state to another:

$$p(s_t = 1 | s_{t-1} = 1) - p_{11}$$

$$p(s_t = 2 | s_{t-1} = 1) - p_{12}$$

$$p(s_t = 1 | s_{t-1} = 2) - p_{21}$$

$$p(s_t = 2 | s_{t-1} = 2) - p_{22}$$

In the above equations,  $p_{i,j}$  represents the probability of the Markov chain movement from the state  $i$  at time  $t-1$  to the condition  $j$  at time  $t$ .  $p_{i,j}$  must be non-negative and have the following condition:

$$p_{11} + p_{12} = 1$$

$$p_{21} + p_{22} = 1$$

To estimate the Markov transformation models, a common probability function is used between  $y_t$  and  $s_t$  occurrences, such that based on the feature of the maximum exponential of ML function features in order to maximize the probability of occurrence of the sample in the statistical population, the probability of the occurrence of random quantities in the sample is maximized. In this way, based on the common probability function, the maximum likelihood method is used to estimate all random quantities of Markov transformation models (Chung, 2002).

The Markov-Switching model can be described for the self-explanatory coefficients for the  $m$  regime and the  $p$  interruption as follows:

$$MSAX(m) - ARX(p): \quad y_t = c(st) + \sum_{i=1}^p a_i(st)(y_{t-i}) + \varepsilon_t$$

$$MSA(m) - AR(p): \quad y_t = c + \sum_{i=1}^p (a_i(st)(y_{t-i}) + \varepsilon_t)$$

In the first equation, in addition to self-explanatory coefficients, the  $y$ -intercept is also dependent on the regimes<sup>4</sup>. In the second equation, only the self-explanatory coefficients depend on regimes. Between these two models, each one with the highest amount of likelihood is selected and is estimated for obtaining positive and negative shocks after determining the intervals and the number of optimal regimes and the model selection.

As mentioned above, in the first stage, the number of optimum lags is determined using the criteria of the Akaike and Schwartz and Henan-Quinn criteria. The table below indicates the values of the Akaike and Schwartz statistics and Henan-Quinn statistics for the number of lags zero to four:

<sup>4</sup> The dependence on the regime means that in different regimes, it will have different effects on the depending variable. Thus, depending on the number of regimes, the effects of explanatory variable vary on the dependent variable.



**Table 1. Results of the Akaike and Schwartz criteria and Henan-Quinn criteria in determining the optimum lag of the model**

Lag	AIC	SC	HQ
0	20.99405	21.04076	21.00899
1	18.29709	18.39050*	18.32697
2	18.26267	18.40279	18.30749*
3*	18.25170*	18.43853	18.31147
4	18.31836	18.55189	18.39307

\*Optimal lag

Source: Research results

The results obtained in Table (1) show that, based on all three criteria of the Akaike, Schwartz and Henan-Quinn, the optimal lag for estimation is the three-lag model, which is obtained by the Akaike criterion. After selecting the number of optimal lags, the number of regimes is determined using the Akaike criterion. The Akaike criterion is a more appropriate index for the number of regimes compared with the value of the likelihood function. The table below shows the values of the Akaike statistics and the value of the likelihood function for the number of regimens two to four:

**Table 2. Determining the number of regimes using the Akaike criterion**

Number of regimes	AIC	ML
2	13.7829	-232.687
3*	13.6031*	-228.8568*
4	13.8418	-236.7891

\*Optimal lag

Source: Research results:

The results of Table (2) show that the optimal number of regimes for estimation is the three-regime model, so that the value of Akaike in the three-regime is the lowest and in terms of maximum likelihood (ML) has the highest value among other states. As mentioned, the Markov-switching model has different states, each of which is a specific component of the regime-dependent equation, and the Akaike statistics was used to choose the best statistics, and the model with Akaike statistics is selected as the optimized model.

**Table 3. The results of the optimal model of currency shocks**

Variable	Regime 0		Regime 1		Regime 2	
	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value
wide from origin	46.20	1.77	-615.2	-7.30	-41.69	-0.49
EX <sub>t-1</sub>	1.44	0.169	4.83	23.3	1.37	16.50
EX <sub>t-2</sub>	-0.43	-28.5	-10.33	-30.40	1.22	2.93
EX <sub>t-3</sub>	0	0.41	7.07	-64.30	-1.35	-3.54
Linearity test	0.87	0.07	0.65	0.20	0.22	0.19

\*The confidence level is one percent

Source: Research results

Based on the R test, the linearity of the relationship between the shock and its past values can be rejected, thus the value of this test confirms the existence of a nonlinear relationship, and it can be concluded from the model output that in both the zero and second regime, y-intercept had no significant effect on the current value of the shock. Also, the first lag of shock in all three regimes had a positive and significant effect on the current value of shock, so that the effects

with the currency shocks lags in the regime one had the highest effect and in the regime two had the least effect compared to the other two regimes. The exchange rate shocks with two lags were statistically significant in all three regimes. However, the effect of this variable was negative in zero and one regimes and positive in the second regime. The exchange rate shocks with three lags were also negative and significant in each regime 1 and in the second regime it was positive and significant. The Table 4 shows years which are placed in each of the regimes:

**Table 4. Years of placement in each of the regimes**

Regime 0	1979-1980-1981-1982-1983-1984-1985-1986-1989-1990-1991-1992-1997-2001-2002-2003-2004-2005-2006-2007-2008-2009-2010-2013-2014
Regime 1	1988-1994-1995-1996-2000-2012
Regime 2	1987-1993-1998-1999-2011

Source: Research results

Table 4 shows the place of data related to each year in each regime. By accurate consideration of the value of shock per year, it can be found that years with a rise in the exchange rate were placed in the regime zero, and the years in which the exchange rate has fallen is placed in the first regime, and the years in which the exchange rate is almost constant, they are placed in the second regime.

**Table 5. Features of each regime**

	Number of years' in each regime	The probability of being in each regime	Continuity period each regime
Regime 0	25	69.44%	5
Regime 1	6	16.67%	1.5
Regime 2	5	13.89%	1.25

Source: Research results

Table 5 indicates the features of each regime. The first column shows the number of observations; such that how many are placed in each of the regimes among the 36 investigated observations. The second column shows the probability of being in the desired regime. For instance, if one of the observations is randomly selected, with a probability of 13.89%, this observation can be said to be in the second regime. The third column also shows the average period that observations are consistently in that regime. For instance, if the exchange rate moves from regime zero to regime 1, then on average 1.5 periods remain in this regime.

**Table 6. The probability of transition from one regime to another – percentage**

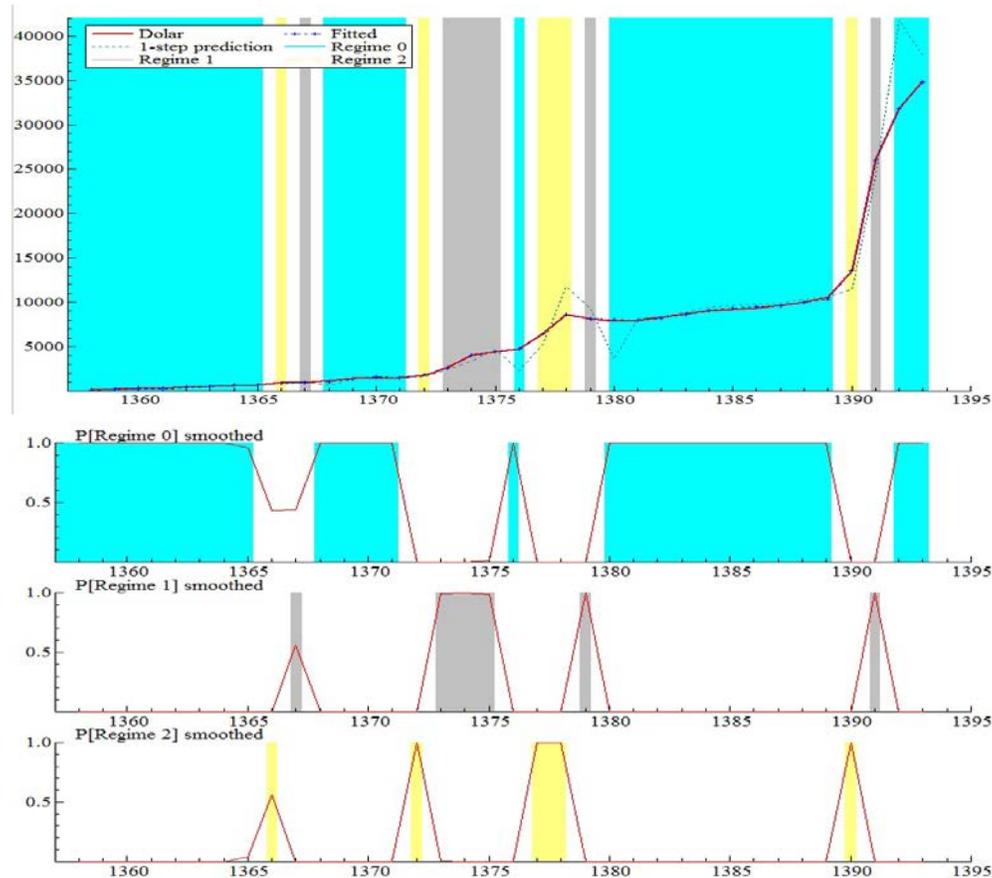
t \ t-1	Regime 0	Regime 1	Regime 2
Regime 0	86.7	65.1	0
Regime 1	0	34.8	78.0
Regime 2	13.14	0	22.2

Source: Research results

Table 6 shows the probabilities of transition from one regimen to another. This table shows the degree of stability and instability of regimes relative to other regimes. Based on the findings in the table above, the stability of the regime zero is more than the other regimes. The second regime is also more unstable than the other two regimes, as a result of which the stability of the exchange



rate regime, which is a zero regime feature will cause stability, and in the next few years it leads to a constant trend. The reason why the second regime has less stability and duration than the other two regimes can be attributed to severe exchange rate volatilities, or in other words due to rising exchange rate changes during the period under study, which is mainly due to instability in earnings made by oil exports.



**Figure 2. The actual and estimated currency shock and the probability of the placement of each year in different regimes**

Source: Research results

In the first part of the Figure, the nominal values of the exchange rate are illustrated as a solid red line and the estimated values of different exchange rate regimes. As seen, the estimated model was able to accurately with little error estimate the amount of shock. Now, in order to investigate currency shocks of the years placed in the zero regime we consider the exchange rate increased in these years compared to the previous years as high currency shocks and years in the regime 1 where the rate of currency shock is reduced in these years as a low currency shock. The virtual variable for the positive and negative shocks of the exchange rate is defined as:

It is worth noting that the virtual variable for the zero regime is considered as 1 and 2 for other regimes (regimes 1 and 2). Regarding the nature of the zero 1 regime, where the exchange rate has increased compared to the previous year, it is possible to consider the years of this regime equal to the increase of the exchange rate and, thus, the years of regime 1 and 2 equivalent to the decline and the stability of the exchange rate.

## MODEL ESTIMATION AND RESEARCH FINDINGS

The first step in estimating time series is to examine the status of variables. In this section, the stasis of variables was investigated using the generalized Dickey-Fuller unit root (ADF) test and the results were reported in the following table. The results show that all of the integrated model variables are rated first, and therefore the co-integration tests can be used to examine the long-term relationship between the model variables.

**Table 7. Stasis test of variables using the generalized Dickey-Fuller test**

Variable	ADF	ADF with a difference in time
LCPI	-0.5872	-3.2212
LEX	-0.7940	-3.3731
LGDP	0.3647	-2.9807
LM	2.4706	-1.1390
LOPEN	-1.3312	-5.3852
LPPI	-0.62343	-3.2908

Source: Research results

In the co-integration analysis, first, the number of optimal lags for the vector autoregressive model should be determined, then, the co-integration vectors are extracted based on the optimal vector autoregressive model. The following table illustrates the Akaike, Schwartz and Henan-Quinn criteria for intervals of zero to two:

**Table 8. Determining the Optimal lag of VAR model**

Lag	AIC	SC	HQ
1	18.29	18.39	18.32
2	18.24	18.40	18.30
3	18.25	18.43	18.31

\*optimal lag

Source: Research results

Based on Table (8), the number of optimal lags for the vector autoregressive model is determined based on the three information criteria of the Akaike, Schwartz and Henan-Quinn 2. Based on the results of the Table, the vector autoregressive model is estimated for two lags, then the co-integration vector is obtained. Due to set of all first-rank variables, the Johansen and Juselius test is used to prevent the false regression fitting. At this stage, using the effect test statistic and the maximum-eigenvalue test, we examined the existence or absence of vector or co-integration vectors among the model variables. The maximum-eigenvalue test examines the existence of the cumulative  $r$  vector with respect to the existence of the  $r + 1$  co-integrating vector. The co-integrating vector is accepted when the test statistic quantity is less than its critical value. The effect test examines the existence of maximum co-integrated  $r$  vector versus the existence of more  $r$  co-integrated vector. The results of the Johansen and Juselius co-integration test are reported for variables in Table (9):



**Table 9. Co-integration test among the model variables for producer price (PPI)**

Trace $\lambda$				$\lambda_{Max}$			
Zero hypothesis	The opposite hypothesis	Amount	Critical amount at 5%	Zero hypothesis	The opposite hypothesis	amount	Critical amount at 5%
$r=0^*$	$r \geq 0$	133.0951	95.7536	$r=0$	$r=0$	60.8077	40.0775
$r \leq 1^*$	$r \geq 1$	72.2873	69.8188	$r \leq 1$	$r=1$	30.8547	33.8768
$r \leq 2$	$r \geq 2$	41.4326	47.8567	$r \leq 2$	$r=2$	22.8578	27.5843
$r \leq 3$	$r \geq 3$	18.5747	29.7970	$r \leq 3$	$r=3$	10.8956	21.1316
$r \leq 4$	$r \geq 4$	7.6791	15.4947	$r \leq 4$	$r=4$	6.9982	14.2646
$r \leq 5$	$r \geq 5$	0.6808	3.8414	$r \leq 5$	$r=5$	0.6808	3.8414

\*The confidence level is 5%

Source: Research results

Regarding the results represented in table 9, it can be found that based on both statistics of maximum specific amounts and the null hypothesis effect test, the test of lack of accumulation relationship between model variables in a meaningfulness level of 0.05 is rejected. Also this state has been approved regarding three other effect test hypotheses and two maximum specific amounts test to include a co-accumulation vector. Next, it is required to select and analyze the optimal co-accumulation vector from among the present co-accumulation vectors based on the adjustment of coefficients with theoretical foundations and statistical realities. Accordingly, the normalized optimal co-accumulation vector has been estimated considering maximum precision which has been reported in table 10.

**Table 10. The normalized co-integration vector to producer prices (PPI)**

Co-integration vector					
LPPI	LEX	LM	D1LEX	LGDP	LOPEN
1	0.4809	0.6817	0.0101	-0.9870	-0.1718
	(0.0219)	(0.0264)	(0.0023)	(0.0850)	(0.0231)

Source: Research results

Based on the results of the normalized vector, the relationship between the explanatory variables and the producer price can be as follows:

$$LPPI = 0.4809 LEX + 0.6817 LM + 0.0101 D1LEX - 0.9870 LGDP - 0.1718 LOPEN$$

The obtained results indicate that, given the exchange rate variable coefficient, the exchange-rate pass-through on the producer price is incomplete, such that the exchange-rate pass-through in the zero regime is almost 0.5, which means that if the exchange rate increases by 10%, the producer price will increase by as much as 5%. Also, with respect to the intersection variable factor of the exchange rate and the virtual variable D1, it can be inferred that exchange-rate pass-through varies in different regimes, such that the exchange-rate pass-through in conditions of exchange rate increase is approximately 1% higher than the situation in which the exchange rate has been stable or declined. Although in terms of mathematics, there is no significant difference in exchange-rate pass-through in different regimes, this 1% difference (0.01) has been statistically significant. In fact, the exchange-rate pass-through on the producer price of the exchange rate in the zero regime (positive currency shocks) would be about 0.49 This is while the exchange-rate pass-through on producer prices was 0.48 These results indicate

that the effects of positive and negative shocks on the producer price are asymmetric and the exchange rate positive shocks cause significant increase of the exchange rate.

Also, the results of estimated coefficients for liquidity indicate that liquidity has had a positive and significant effect on producer prices, so that per 10% increase in liquidity, the producer price increases by about 6.8%. This effectiveness is according to theoretical expectations.

Also, the results of the model estimation show that GDP has had a negative and significant effect on the producer price index. Based on the obtained coefficient, it can be argued that due to the increase of real GDP by 10%, the general level prices (producer index) decrease by approximately 9.8%. This conclusion is in accordance with theoretical expectations. Because, based on the theory of development, production means increased supply, which reduces prices through supply and demand mechanisms.

The results of the estimated coefficient for the degree of openness of the economy also indicate a negative and significant effect on producer prices. In fact, the coefficient of this variable shows that for a 10% increase in the openness of the economy, the general level of prices is reduced by approximately 1.7%. Perhaps the most important reason for this is the transfer of technology and the effects of its overflow on production and, consequently, a decline in the general level of prices.

The empirical findings of the research indicate the asymmetry of the exchange-rate pass-through on the producer price. The results show that, first, in Iran's economy, the rate of exchange-rate pass-through on the producer price is approximately 0.5 and therefore it is incomplete. Second, the exchange-rate pass-through on the producer price in the case of positive shocks of the exchange rate is significantly higher than the negative shocks of the exchange rate.



## CONCLUSION

The analysis of the exchange rate on producer prices can be important in policy making. Awareness of the exchange-rate pass-through and its reaction to various currency shocks can help policy-makers to adopt appropriate currency policies. The Iranian economy experienced severe currency volatilities due to its strong dependence on oil revenues, which in turn triggers various currency regimes that could affect the exchange-rate pass-through. In this regard, in this research, attempts were made to evaluate the effects of positive and negative shocks of exchange rate on producer price using the time series data of the Iranian economy during 1971-2014. To this aim, first, using Markov switching technique, the exchange of currency shocks is analyzed in three different regimes, and then the effects of currency shocks on producer prices and the asymmetry of exchange-rate pass-through in two states of positive and negative shocks were estimated and analyzed using Johansen and Juselius co-integration technique.

The results show that the exchange-rate pass-through is significantly different in different currency regimes, such that positive currency shocks increase exchange-rate pass-through and negative shocks reduce the exchange-rate pass-through to producer prices. The results also showed that the exchange-rate pass-through in the foreign exchange regime is incomplete and is approximately 0.5. Therefore, it is suggested that the government should pay attention to the asymmetry of the exchange-rate pass-through to the producer prices in various foreign exchange regimes. In a situation where the exchange rate is on the rise, the general level of prices as well as the exchange-rate pass-through will further increase. This conclusion somehow confirms the hypothesis of Taylor (2000). In a situation where the currency is in a stable

situation or it tends to decrease, the exchange-rate pass-through will slightly decrease. Hence, the government must reduce the effects of exchange-rate pass-through changes to the producer prices and, as a result of inflation, adopt appropriate policies to put exchange rate in a stable condition, or control the increase of the exchange rate.

The results of model estimation also showed that GDP and the degree of openness of the economy had a negative and significant effect on producer prices. Therefore, in order to control the general level of prices, it is recommended that the government provide the appropriate policies to lay the groundwork for increasing production and expanding business-economic relations with the world.

Considering the positive and significant effect of liquidity on producer prices, the government needs to control the liquidity and prevent its uncontrolled expansion so that the economy does not suffer with the excessive spread of liquidity and thus inflation.

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