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An Application of Bayesian Model Averaging for Investigating of the Relationship Between Monetary Policy variables and Asset Price Fluctuations

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Abstract:
This study aims to investigate the relationship between liquidity and asset price fluctuations in the Iranian financial market applying innovative methods of averaging. The findings are useful for policymakers because the surveys can be used in monetary policy decisions. The data used in this research are quarterly from March 2006 to April 2020. To this end, the statistics from the economic time-series database of the Central Bank of the Islamic Republic of Iran and other related sources have been used. Bayesian Model Averaging (BMA) has successfully been used in the experimental growth literature as a way to overcome the sensitivity of the results to the characteristics of different models. The variables are the real liquidity as a dependent one and fluctuations in total stock price, total housing price, central bank assets, the government debt to banks, exchange rate, and the coin price are considered independent ones.

In terms of the movable assets, the results show a positive and significant relationship between fluctuations in real total housing prices and liquidity and a negative relationship between Bahar-e Azadi Iranian Gold Coin fluctuation and liquidity. For immovable assets, the real net fluctuation of central bank assets and the government debt to banks have a positive relationship with liquidity. There is a negative relationship of real total stock price fluctuation and real exchange rate fluctuation with the liquidity.

1. Introduction

Effectiveness is one of the important issues in the implementation of monetary policy. The effectiveness of monetary policy means the degree of impact on the real economy sectors, which are investment, consumption and production in

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general. This effect is exerted through a process called the monetary transmission mechanism. In general, the monetary policy transmission mechanism can be classified into four main sections, the interest rate, the exchange rate, the asset price, and the credit. Among these sectors, asset price plays a key role. The effects of monetary policy on the price of financial assets are transmitted to the economy through the asset price channel and changes in their prices (Mishkin, 1996). Estimating the response of asset prices to changes in monetary policy is complicated by the endogeneity of policy decisions and the fact that interest rates and asset prices respond to numerous other variables. Financial market experts are interested in this issue because monetary policy has a significant impact on financial markets. Therefore, accurate estimation of asset price responsiveness to monetary policy is an important component of effective investment decisions. There are several problems in estimating the responsiveness of asset prices to monetary policy. Firstly, short-term interest rates are simultaneously affected by changes in asset prices, leading to endogeneity problems. Secondly, a number of other variables, including economic outlook news, are likely to affect short-term interest rates and asset prices. These two considerations make the identification of asset price responsiveness complicated using previously used methods (Rigobon and Sack, 2004). The mechanism through which monetary policy affects the real sector variables by changing some variables and achieves the goals of monetary policy is called the monetary policy transmission mechanism. According to Lidler (1987), monetary transmission mechanism is the process or causal relationship from monetary policy to nominal income or monetary income. This process begins with monetary policy and ends with production and prices. Among the various monetary policy mechanisms in the conventional economics literature, channels such as short-term interest rates, long-term interest rates, asset prices, credit channel, and expectations channel are discussed in the economic literature (Mishkin, 1995). Due to its role in financing and also the fluidity and high liquidity, stock market is affected more by monetary policy rather than the market of goods and services (Svensson, 2017). Housing market acts as a means of transmitting monetary policy shocks to the entire economy through various channels. For example, changes in the v housing value create the effects of total wealth and stimulate borrowing for consumption, because housing is a kind of security. Also, changes in the cost of capital consumption affect the demand for housing investment. Research shows that the collateral security mechanism further explains the impact of changes in housing prices on the macroeconomy. Housing investment is also affected more by monetary policy shocks than other components of GDP. Bernanke and Gertler (1995) and Erceg and Levin (2006) also address this issue in their articles (Ejindu Ume, 2017). Asset prices, especially stock and property, fluctuate considerably. Although we should not forget the fact that asset prices are ultimately endogenous variables, there are periods when the value of assets is not entirely separate from the current state of

the economy. As mentioned in the introduction, over the past two decades, economies around the world have experienced large boom cycles in the prices of various assets, including stocks, commercial real estate, residential housing, etc. By the economist's usual standard, a world of efficient capital markets without regulatory distortions, changes in asset prices merely reflect changes in economic fundamentals. Under these circumstances, central banks have no reason to worry about asset price fluctuations. Asset prices are only relevant to the extent that they provide useful information about the state of the economy (Bernanke, 2000).
In this study, the behavior of two different asset markets - housing and stocks - is examined. Here the price of assets is used to represent the wealth of the household. The first factor is the stock index and the other one used for household wealth is the residential property price index. Considering the growing importance of stock and housing markets and unequal developments in these two markets in the Iranian economy, in this article, the effects of liquidity on price fluctuations of these assets are examined.
In the second section, the relevant theoretical foundations and research background are reviewed. The third section is dedicated to specifying the pattern and introducing the variables. The analysis of the results is presented in the fourth section. The present study concludes with the presentation of political proposals in the fifth section.

2. Research background

2.1 Literature

Over the past twenty years, the world's major central banks have been largely successful in controlling inflation. While it may be safe to say that inflation is no longer a matter of concern, it is entirely conceivable that the central bankers' next goals will be on a different front. One of the issues that policymakers are looking at is the increase in financial instability, one of the important dimensions of which is the increase in asset price volatility. Borio, Kennedy, and Prowse (1994) documented the emergence of major boom cycles in stock and real estate prices in a number of industrialized countries during the 1980s. Notable examples include the United States, Japan, the United Kingdom, the Netherlands, Sweden, and Finland. With the "recession" part of the asset price cycle, there were significant contractions in real economic activity in many of these cases. For example, many economists attribute, at least ,a part of the 1990s recession in the United States to previous declines in commercial real estate prices, which weakened banks 'capital position and corporate borrowers' balance sheets (Bernanke and Lown, 1991). We have recently seen falling asset prices in East Asia and Latin America, along with the continuing slump in stock and land prices in Japan, all of which have been accompanied by weak economic performance. In this article, we address the question of how central banks should respond to fluctuations in asset prices as part of an overall monetary policy strategy. Clearly, we agree that monetary policy alone is not a sufficient tool to curb the potentially destructive effects of asset price fluctuations (Bernanke et al., 2000). Liquidity is the most important monetary variable in macroeconomics, which is determined by the relations governing GDP, the velocity of money and fluctuations. The general level of prices is determined by the theory of quantity of money. The components of liquidity (M2) are money and quasi-money. Quasi-money and long-term deposits, which are the result of large-scale growth of money based on liquidity shocks (surplus money or credit that is not consistent with price stability in the long run), are one of the factors that stimulate housing prices to fluctuate, leading to housing and financial instability. In this regard, the flow of money in proportion to the real needs of society and the establishment of liquidity at the desired level is of particular importance (Gholizadeh et al., 2012).

Numerous empirical studies have been conducted concerning the investigation of the relationship between monetary policy and asset price fluctuations including those by Mishkin, Sechti, Kotner and Moser, Morsink and Biomi and Cellon in developed countries. But in the case of developing countries, this issue has not yet been sufficiently addressed. Montail, Camin, Turner, Wendak, and Khan in their study have proposed the mechanism of money transmission in developing countries and examined the commonalities and differences with that of developed countries. They consider the unstable economic structure, historical background and institutional nature of these countries as the main reasons for the difference in this mechanism. Also, the limitations of statistical data and the inability to monetary policy transmission in the ever-changing economy of these countries are considered an obstacle to a careful study of this issue. Monetary policy decisions significantly affect the stock market and enable market experts to closely monitor and thoroughly analyze the actions of central banks. These decisions have been extensively studied by central banks and their effects on interest rates, exchange rates and stock markets. This provides significant information on the dynamics and relationship between monetary policy events and asset pricing trends, thus enhancing our understanding of the monetary policy transmission mechanism. An example of this better understanding is that asset returns and asset volatility respond only to the unforeseen components of monetary policy declarations (Bomfim, 2003; Bernanke B.S, Kuttner, 2005). Another example is the heterogeneous effect of monetary policy on individual stocks (Ehrmann and Fratzscher, 2044; Maio, 2014).

In the theoretical literature on the mechanism of monetary policy transmission, monetary policy can affect stock prices in different ways. Monetary policy, which is thought to influence long-term interest rates and levels of economic activity, can impact stock prices by affecting companies' future earnings and dividend payments. Interest rates also affect the distribution of dividends, and so monetary policy is related to the expected return on stocks. In addition, lower interest rates are assumed to make stocks more attractive than securities as a way to save, resulting in demand and stock prices. Expansionary monetary policy should also encourage households to reduce their money supply, not only to increase consumption but also to increase their net assets (Mishkin, 1996). The link between monetary policy and housing prices can also be described using the concept of the cost of capital consumption (Mishkin, 2007). Rising interest rates increase the user's cost of capital and reduce demand and housing prices. As a result, housing construction and thus the total demand in the economy are declining. Waiting for interest rates to rise may rapidly increase user costs by lowering the projected real rate of increase in housing prices. There is also empirical evidence regarding monetary policy and housing prices. Using the VAR structural method, Iacoviello (2000) found that monetary policy affects housing prices in Europe. Ahearne et al (2005) studied housing prices in 18 advanced economies and also obtained results that confirm the link between monetary policy and housing prices. In particular, a period of monetary policy declines prior to the housing prices boom.

2.2 Literature review

2.2.1 Iranian Studies

Understanding the impact of monetary policy on various economic areas and paying attention to the role of asset prices in monetary policy and macroeconomic stability may help understand the behavior of households, businesses and other decision makers. Accordingly, it can be a more appropriate guide to make monetary decisions by officials and policymakers. The results of studies show that some financial market variables, such as stock prices, real exchange rates, composite indicators of asset prices, etc. can be a counterpart to the implementation of monetary policy. Thus, combining asset prices with monetary policy responses may provide information that leads to a better situation in the future (Rahmani et al, 2016).

Using seven macro-prudential tools (loan-to-value ratio, debt payment-to-income ratio, other tools of the housing sector, dynamic capital requirements, loan loss coverage requirements, consumption loan restrictions, and credit growth ceiling), Afshari et al. (2019) in accordance with Akinci and Rumsey (2018) created an overall index for macro-prudential Policies and sub-indices of housing and non-housing for the countries under study. Macro-prudential Policies (total housing) did not have a significant effect on housing price and credit growth. However, the simultaneous adoption of macro-prudential and monetary policies has been able to curb the growth of credit and, consequently, the growth of housing prices.

Mehrara et al. (2015) studied the effect of stock index, housing price, exchange rate and liquidity on business cycles using linear model and nonlinear LSTR model and quarterly data for the period of 1991-2017. In the nonlinear model, which is more suitable than the linear model to explain the relationship between variables, the cyclical component of the exchange rate was selected as the transmission variable, and the value of the transmission parameter was estimated to be -83.89 IRR. The results show that, in both regimes, rising stock prices and liquidity boost the economy. Also, the increase in housing prices and the decrease in the exchange rate in the first regime put the economy in the stage of prosperity and in the second regime, the economy in the stage of recession.

Hassanzadeh et al. (2011) examined the effect of monetary policy shock on the stock market price index in Iran. To achieve this goal, the legal deposit ratio, bank debt to the central bank and private sector debt to banks have been used as criteria for measuring monetary policy. Also, the total stock market index was used as an indicator of stock market changes. The asset price channel and portfolio theory form the theoretical perspective on the subject. Therefore, housing price index and exchange rate have been added to the model due to their role and importance in people's assets. Quarterly data from 1991 to the third quarter of 2010 and statistical methods, especially the concept of co-integration and Vector Error Correction Model (VECM) have been used for statistical inference.

Shokouh et al. (2017) used the autoregressive distributed lag (ARDL) to estimate the effects of monetary policy on the stock market in the period 2011 to 2017 on a monthly basis. The coefficient related to the logarithm of the exchange rate in the long run is 2.06 and shows the strong impact of the exchange rate on the petrochemical stock index. The logarithm coefficient of liquidity (-1.3) shows the negative elasticity of the petrochemical stock index to liquidity in the long run. And it shows that the increase in liquidity does not lead to the market of petrochemical products in the stock market. The elasticity of the stock index to the interest rate of -0.17 and the exchange rate of 0.24 show that the petrochemical stock price index is less elastic to the exchange rate. In the case of liquidity, it has a low elasticity index and a weak inverse relationship. Today, the role of monetary policy on financial market fluctuations and macroeconomic performance is a matter of concern. Monetary policies cause fluctuations in financial markets through changes in liquidity, exchange rates and interest rates.

2.2.2 Studies in other countries

Dong et al(2022) provide a model of rational bubbles in a DNK framework. Entrepreneurs are heterogeneous in investment efficiency and face credit constraints. They can trade bubble assets to raise their net worth. The bubble assets command a liquidity premium and can have a positive value. Monetary policy affects the conditions for the existence of a bubble, its steady-state size, and its dynamics including the initial size. The leaning-against-the-wind interest rate policy reduces bubble volatility, but could raise inflation volatility. Whether monetary policy should respond to asset bubbles depends on the particular interest rate rule and exogenous shocks.

Paul (2020) investigated that how monetary policy jointly affects asset prices and the real economy in the United States. I develop an estimator that uses high-frequency surprises as a proxy for the structural monetary policy shocks. This is achieved by integrating the surprises into a vector autoregressive model as an exogenous variable. I use current short-term rate surprises because these are least affected by an information effect. When allowing for time-varying model parameters, I find that compared to the response of output, the reaction of stock and house prices to monetary policy shocks was particularly low before the 2007–2009 financial crisis.
Auer (2019) evaluated the transmission of monetary policy in a Bayesian large-scale auto-regression based on the method proposed by Banbura et al. (2010). This study analyzes the impact of monetary policy shocks in the United States and Canada not only on the range of gross domestic product, trade flows and exchange rates, but also on foreign investment income. The analysis presents three main results. Firstly, the sudden contraction of monetary policy has a statistically significant impact on the gross and net income flow of foreign investment in both countries. As a result of the growth of foreign wealth and investment income, this result indicates the initial evidence that foreign balance sheet channels may increasingly play an important role in money transmission. Secondly, the impact of monetary policy on the flow of foreign investment income varies considerably across asset groups over time, indicating that investment tools and the value of foreign assets and liabilities in a country has a potential impact on how monetary policy affects the domestic economy. Finally, the results and evidence support the effectiveness of large auto-regression and Bayesian minimization approach in eliminating exchange rate and price puzzles.
Hur(2017) Estimates a Markov-switching dynamic stochastic general equilibrium model by incorporating stock prices in monetary policy rules in order to identify the Federal Reserve's stance toward them. Based on the data from 1984:Q1 to 2009:Q2, he find that historical evidence of the policy reaction toward stock prices is weak except for the stock market bubble of the 1990s. A counterfactual exercise shows that the rapid growth in stock prices during that period would have been significantly higher if monetary policy had been independent of the stock market. However, unconditional macroeconomic volatility increases with the degree of policy responsiveness toward stock prices.
Bordo et al(2013) Investigate the relationship between loose monetary policy, low inflation, and easy bank credit with asset price booms. Using a panel of up to 18 OECD countries from 1920 to 2011 we estimate the impact that loose monetary policy, low inflation, and bank credit has on house, stock and commodity prices. They review the historical narratives on asset price booms and use a deterministic procedure to identify asset price booms for the countries in our sample. They show that "loose" monetary policy - that is having an interest

rate below the target rate or having a growth rate of money above the target growth rate - does positively impact asset prices and this correspondence is heightened during periods when asset prices grew quickly and then subsequently suffered a significant correction. This result was robust across multiple asset prices and different specifications and was present even when we controlled for other alternative explanations such as low inflation or "easy" credit.

3. Methodology

3.1 Measuring asset price fluctuations

There are different methods for extracting fluctuations that have been mentioned in many studies. One of these methods is to use the absolute mean of the difference between the actual values of the variable relative to its trend. Another way is to use the average squares of the real value of the variable relative to its trend. Also, the arithmetic mean of the absolute of changes in a time series relative to the time trend is the third method of calculating the fluctuation of variables (Sahabi et al, 2011). Generalized Heterogeneous Autoregressive (GHAR) Model is used in this study. The results show the GARCH model (1,2) for the housing and gold fluctuation model, stock returns and the GARCH model (2,2) for the other models. The results of the heterogeneity test also indicate the similarity of the variances in both models.

3.2 Unit Root Test

Considering that the data used in this research are seasonal time series and according to the theory of aggregation, the static status and degree of aggregation of time series should be determined first. KPSS has been performed in this study to investigate the stationery of variables.

Table 1: Unit Root Test by KPSS

Series	LM stat.	Critical Values			Descriptions
		1%	5%	10%	
Real Liquidity	0.660	0.739	0.463	0.347	This is stationery.
Real stock price fluctuations	0.147	0.216	0.146	0.119	It becomes stationery after one time differencing.
Total housing price fluctuations	0.147	0.216	0.146	0.119	It becomes stationery after two times differencing.
Real net fluctuation of central bank assets	0.500	0.739	0.463	0.347	It becomes stationery after one time differencing.
Real net fluctuation of government debt to banks	0.530	0.739	0.463	0.347	This is stationery.
Real exchange rate fluctuations	0.148	0.216	0.146	0.119	This is stationery.
Bahar-e Azadi Iranian Gold Coin fluctuation	0.728	0.739	0.463	0.347	This is stationery.

Source: Research Findings

As the results in Table 1 show, real liquidity, real net fluctuation of government debt to banks, fluctuation of real exchange rate, and fluctuation of real price of Bahar-Azadi gold coin are stationery. Fluctuation of real total stock price and net real of central bank assets became stationery after one-time difference and fluctuation of real housing price after two times of differences.

3.3 Granger causality test

The next step after examining the significance and determining the co-integration vector is to evaluate the Granger causality test among the variables. In applied models related to time series data, Granger's causal hypothesis is based on predicting the direction of Granger, or more simply, determining the effect of variables is one-way, two-way or neutral. Thus, the causality test helps us to examine whether the change in each series can be explained by the other two series. In this study, the criterion of Granger causality test is F statistic. Because the importance of statistical hypotheses for certain groups of explanatory variables for each function is examined separately with the F-statistic (Islam and Ali Meerza, 2018).

Table 2: Causality test results

Alternative Hypothesis	F- Stat.	P-value
Real stock price towards the liquidity	3.65	0.0058
Liquidity towards the real total stock fluctuations	0.727	0.630
Fluctuation of real housing price of housing towards the liquidity	3.43	0.0085
Liquidity towards real total housing price fluctuations	0.547	0.768
Real net fluctuation of central bank assets towards liquidity	203.8	0.0099
liquidity towards the real net fluctuation of central bank assets	0.183	0.979
Real net fluctuation of government debt to banks towards liquidity	5.07	0.0243
liquidity towards the real net fluctuation of government debt to banks	5.12	0.0771
Real exchange rate fluctuations towards liquidity	28.25	0.0000
Liquidity towards real exchange rate fluctuations	0.453	0.9133
fluctuation of real price of Bahar-Azadi gold coin towards the liquidity	34.09	0.0000
Liquidity towards the fluctuation of the real price of Bahar-Azadi gold coins	1.54	0.1825

Source: Research Findings

As can be seen in Table 2, the results of the Granger causality test show a one-way causality relationship from the independent variables to the dependent variable of liquidity.

3.4 Bayesian Model Averaging (BMA)

In econometric models, two categories of variables are used. The first category is the focus variables that are supported based on formal and strong theories of their

presence in the model. The second category are auxiliary variables that, based on informal theories, provide justifications for their presence in the model and are less certain about their presence in the model (Danilov and Magnus, 2004).
The statistical framework under study is a linear regression model as shown in (1).

$$y = X_1\beta_1 + X_2\beta_2 + u \tag{1}$$

Where y is a $n \times 1$ vector of dependent variable. $X_j\,(j = 1,2)$ is a $n \times k_j$ matrix of observations of explanatory non-random variables. X_1 contains focus variables, and X_2 has auxiliary variables. u is also a random vector of error terms, whose components are assumed to have an $i.i.d\; N(0,\sigma^2)$ distribution. Since pattern uncertainty is limited to the $k_2$variables out of X_2, the number of possible patterns to be examined (number of models in the model space) based on the presence or absence of each of the auxiliary variables is$I = 2^{k_2}$. From now on, $M_i$represents the ith model of the model space. An average estimation of the model of $\beta_1$as a coefficient of one of the explanatory variables is in Eq. (2) (De Luca and Magnus, 2011):

$$\hat{\beta}_1 = \sum_{i=1}^{I} \lambda_i \hat{\beta}_{1i} \tag{2}$$

where λ_i is the random non-negative weights with a sum of one. The Bayesian averaging method was introduced by Jeffriey in 1961 and developed by Limer (1978). The basic principle in this method is to treat the models and related parameters as random factors and to estimate their distribution based on previous information (Dropper, 1995). Considering the two random events A and B, Bayesian law, as the main element of Bayesian econometrics, is written as Eq.(3):

$$P(A|B)\,\frac{P(B|A)P(A)}{P(B)} \tag{3}$$

Where P(A|B) is the probability A occurs under conditions B and P (B) is the marginal probability of B. Now, assuming that Y is the accessible data set (explanatory and dependent variables) and θ is a parameter vector, Bayes's law can be rewritten as Eq. (4):

$$P(\theta|Y) = \frac{P(Y|\theta)P(\theta)}{P(Y)} \tag{4}$$

$P(\theta)$ is the prior Function which is not dependent on the data, and represents the distribution of the researcher's mental probability of the parameters before viewing the data. $P(Y|\theta)$ is the likelihood function, which indicates the density of data on the model parameters and refers to the data generation process. $P(\theta|Y)$ is also the output of Bayesian estimation which is derived based on the prior function and the likelihood function. In fact, $P(\theta|Y)$is the conditional distribution of the parameters after viewing the data. Hence it is called the posterior distribution function. In Bayesian averaging method, the researcher's previous information about the unknown parameters of the model is combined with the information obtained from the data. But it is unlikely to have information about all possible variables and potential models. The parameters related to the prior function cannot be written for all 2^{K_2}. Therefore, it is practically impossible to use the informative prior function for the parameters of the Bayesian model

One solution to this problem is to use non-informative prior function for all models. If the model M_i is assumed to be correct, then the likelihood function used by the model can be written as Eq. (5):

$$P(y \mid \beta_1, \beta_{2i}, \sigma^2, M_i) \sim (\sigma^2)^{-n/2} \exp\left(-\frac{\varepsilon_i^T \varepsilon_i}{2\sigma^2}\right) \quad (5)$$

Prior information about the parameters M_i considering a non-informative prior function for the parameter β_1, error variance σ^2, and an informative function for auxiliary parameter of β_{2i} lead to a conditional prior function as shown in Eq. (6):

$$P(\beta_1, \beta_2, \sigma^2 \mid M_i) \sim (\sigma^2)^{(k_{2i}+2)/2} \exp\left(-\frac{\beta_{2i}^T V_{0i}^{-1} \beta_{2i}}{2\sigma^2}\right) \quad (6)$$

Where V_{0i}^{-1} is the variance-covariance matrix of the β_{2i} prior distribution. The standard form proposed by Zellner (1986) and Fernandez et al. (2001) is presented in Eq. (7):

$$V_{0i}^{-1} = g X_{2i}^T M_1 X_{2i} \quad (7)$$

$g = 1/\max(n, k_2)$ is a constant coefficient for each model. In Bayesian inference, the likelihood function is combined with the conditional prior distribution to obtain the conditional posterior distribution of Eq. (8). After calculating the conditional posterior distribution, the conditional estimates for β_{1i} and β_{2i} for the M_i model are equations (8) and (9) (Mgnus et al , 2010).

$$\hat{\beta}_{1i} = \mathrm{E}(\mathrm{B}_1 \mid y, M_i) = (X_1^T X_1)^{-1} X_1^T \left(y - X_{2i} \hat{\beta}_{2i}\right) \quad (8)$$

$$\hat{\beta}_{2i} = \mathrm{E}(\beta_{2i} \mid y, M_i) = (1+g)^{-1} (X_{2i}^T M_i X_{2i})^{-1} X_{2i}^T M_1 y \quad (9)$$

The researcher's information and ideas about the model space are provided by the hypothesis that each model is weighed according to its posterior probability according to Eq.(10).

$$\lambda_i = P(\mathrm{M}_i \mid y) = \frac{P(M_i) P(y \mid M_i)}{\sum_{j=1}^{I} P(M_j) P(y \mid M_j)} \quad (10)$$

Where $P(M_i)$ is prior probability for M_i model, and $P(y \mid M_i)$ is marginal likelihood function of y for M_i model. By assigning the same prior probability to each model and applying the above hypotheses to the prior distribution, it can be shown that:

$$\lambda_i = P(y \mid M_i) = c(\frac{g}{1+g})^{k_{2i}/2}(y^T M_1 A_i M_1 y)^{-(n-k_1)/2} \quad (11)$$

where c is is a value and is chosen so that the sum of λ_i is equal to one. A_i is also:

$$A_i = \frac{g}{1+g}M_1 + \frac{1}{1+g}[M_1 - M_1 X_{2i}(X_{2i}^T M_1 X_{2i})^{-1} X_{2i}^T M_1 \quad (12)$$

After the conditional estimates β_{1i} and β_{2i} for the regression parameters of the model M_i and the model weights are obtained, the unconditional BMA estimates for β_1 and β_2 are calculated according to Equations (13) and (14):

$$\hat{\beta}_1 = E(\beta_1 \mid y) = \int_{i=1}^{I} \lambda_i \hat{\beta}_{1i} \quad (13)$$

$$\hat{\beta}_2 = E(\beta_2 \mid y) = \int_{i=1}^{I} \lambda_i T_i \hat{\beta}_{2i} \quad (14)$$

Where T_i is $k_2 \times k_{2i}$ matrix defined by $T_i^T = (I_{k_{2i}}, 0)$ (Di Luca and Mgnus, 2011).

3.4.1 BMA in normal linear regression model

Suppose there are R models and M_r represents r^{th} model so that (r = 1,2,… R). Each model includes a vector of the parameters, shown by θr. These parameters have the prior functions p $p(\theta_r|M_r)$,the likelihood function $P(Y|\theta_r, M_r)$and the posterior function $P(\theta_r|Y, M_r$, which the posterior function will be as follows:

$$P(\theta_r|Y, M_r) = \frac{P(Y|\theta_r, M_r)P(\theta_r|M_r)}{P(Y|M_r)} \quad (15)$$

By these functions and calculating the probability ratio of the posterior function (PO), the probability of the posterior model $P(M_r|Y)$can be obtained. According to Bayesian law, the probability of any desired model (such as Mr) can be represented as follows:

$$P(M_r|Y_r) = \frac{P(Y|M_r)P(M_r)}{P(Y)} \quad (16)$$

Where $p(M_r)$ is the prior probability of M_r model, meaning that it calculates the probability that M_r is the correct model without considering the data. $p(Y|M_r)$ is the likelihood function of M_r model, which is obtained by integrating from both sides of equation 1 and $\int P(\theta_r|Y, M_r)d\theta_r = 1$.

$$P(Y / M_r) = \int P(Y/\theta_r, M_r)P(\theta_r/M_r)d\theta_r \quad (17)$$

With above values, the probability of prior function is calculated for comparing two models of i and j as follows:

$$PO_{ij} = \frac{P(M_i|Y)}{P(M_j|Y)} = \frac{P(Y|M_i)P(M_i)}{P(Y|M_j)P(M_j)}) \quad (18)$$

Now suppose φ is a vector of common parameters in all models, that is, φ is a function of θr. In this case, Bayesian econometric logic says that everything we know about these parameters can be summarized in its posterior function of P(φ |Y).

$$P(\varphi|Y) = \sum_{r=1}^{R} P(\varphi|Y, M_r)P(M_r|Y) \quad (19)$$

In fact, the posterior probability function for these parameters is the mean weighted of posterior probability function of other models in which these parameters are present. Therefore, in order to calculate the final likelihood and posterior function for all models, the average Bayesian model can be calculated. However, since calculating these two values is very time consuming for all models if r is large, algorithms are usually used to calculate these values, which do not require all models.

3.4.2 Prior, posterior, and likelihood functions

If the dependent variable is affected K the potential explanatory variables, the $R=2^k$ econometric model can be explained using the combinations of the present variables. All these models have intercepts, but have different combinations of explanatory variables. If the number of observations available to estimate these patterns is N, the general form of these econometric models with matrix symbols can be represented as follows:

$$Y = \alpha L_N + X_r \beta_r + \varepsilon \qquad (20)$$

L_N is a N×1 vector, and X_r is a N×K_r matrix, which is a combination of K number of potentially explanatory variables. The likelihood function of each model can be calculated using a suitable algorithm that can be written in software. But the parameters of the prior distribution cannot be specified for all 2^k models. Obviously, having prior knowledge of all possible parameters and models seems unlikely. Therefore, it is practically impossible to use the prior function containing information for all parameters in all the mentioned patterns. One solution to this problem is to use the non-informative prior distribution (uniform distribution) for all models. However, since using this type of prior function makes it possible to calculate the probability ratio of the posterior function only for the parameters present in all models, non-informative prior (uniform) distribution can be used for intercept and variance (h^4). Using non-informative prioe function greatly increases the likelihood of incorrect estimation of the coefficients. For this reason, for other parameters of βr, another prior function called g-prior is used. One of the features of this prior function is that it can be calculated and used automatically by all algorithms for all models. In the following, we will explain this type of prior function. Conjugate prior function is considered as follows:

$$\beta_r | h \sim \left(\underline{\beta_r}, h^{-1} \underline{v_r}\right) \qquad (21)$$

Since many explanatory variables can be dealt with, many of which are probably irrelevant and have no effect on the dependent variable, we assume:

$$\underline{\beta_r} = 0$$

However, we use g-prior to calculate $\underline{v_r}$:

$$\underline{v_r} = [g_r X'_r X_r]^{-1} \qquad (22)$$

Thus, to use g-prior, we only need to specify the value of gr. This numeric parameter is between zero and one, so that by setting gr = 0, the prior distribution function is completely non-informative. In contrast, if we want to give the same weight to the prior function information and sample information, gr = 1. Of course, most researchers believe that gr = 1 is a very large value for this parameter. After multiple simulations with fictitious data for large values of N, some researchers like Fernandez and Steele (2001) Suggested the following:

$$g_r = \begin{cases} \frac{1}{K^2} & N \leq K^2 \\ \frac{1}{N} & N > K^2 \end{cases} \quad (23)$$

The above numerical value is between zero and one and is the basis for determining gr in the present study. But the parameters of the posterior function can be obtained by combining the probability functions and its prior distribution as follows. Here β has a distribution t with the following mean and variance:

$$E\ (\beta_r|Y, M_r) \equiv \beta_r = \bar{V}_r \acute{X}_r Y \quad (24)$$

$$var(\beta_r|Y, M_r) = \frac{v s_r^2}{v-2} \bar{V}_r \quad (25)$$

Where

$$V_r = [(1 + g_r)X_r' X_r]^{-1}$$

$$S_r^2 = \frac{\frac{1}{g_r+1} Y' P_{xr} Y + \frac{g_r}{g_r+1}(y - \bar{y}|_N)'(y - \bar{y}|_N)}{\bar{v}} \quad (26)$$

$$\bar{v} = NP_{xr} = I_N - X_r(X_r' X_r)^{-1} X_r' \quad (27)$$

Marginal likelihood function for each model is as follows:

$$P(y|M_r) \propto \left(\frac{g_r}{g_r+1}\right)^{\frac{kr}{2}} \left[\frac{1}{g_r+1} y' P_{xr} y + \frac{g_r}{g_r+1} |(y - \bar{y}\iota_T)'(y - \bar{y}\iota_T\right]^{\frac{N-1}{2}} \quad (28)$$

Posterior probability for each model is calculated as following:

$$P(M_r|y) = cp(y|M_r)p(M_r) \quad (29)$$

Where c is a constant and similar for all models. $\sum_{r=1}^{R} P(M_r|y) = 1$ can be calculated. Prior probability is similar for all models, $P(M_r) = \frac{1}{R}$. If we neglect the prior probability of $P(M_r) = \frac{1}{R}$, the posterior probability of any desired model (r) can be obtained as follows:

$$P(M_r|y) = \frac{p(y|M_r)}{\sum_{j=1}^{R} p(y|M_j)} \quad (30)$$

4. Model estimation

The general model used is $y = a + X_1 b + X_2 c + e$ where X_2, X_1, and y are liquidity, the set of main regressors (the total index of the stock exchange and housing) and auxiliaries (net real variables of central bank assets, real net government debt to banks, real exchange rate and real price of Bahar-Azadi gold coin). Table 2 shows the results of estimating Bayesian averages for movable assets, ie fluctuations in real total housing prices and fluctuations in real prices of Bahar Azadi gold coins. Table 3 shows these results for the immovable property, including Fluctuations in real total stock prices, real net fluctuations in central bank assets, fluctuations in real government debt to banks, fluctuations in real exchange rates using Stata.

Table 3: Results of model estimation for moveable assets using Bayesian averaging method

Variable	Coefficient	pip	t-stat.	confidence interval	
Constant	54010.4	1	11.59	58671.93	49348.87
Real housing price fluctuations	7.638284	1	3.40	9.888004	5.388565
Real price fluctuations of Bahar Azadi gold coins	-3230000000000	1	-10.06	-2910000000000	-3560000000000

Source: Research Findings

Table 4: Results of model estimation for immoveable assets using Bayesian averaging method

Variable	Coefficient	pip	t-stat.	confidence interval	
Constant	41829.22	1	3.68	53198.68	30459.76
Real stock price fluctuations	-0.0012343	1	-1.04	-0.0000507	-0.0024179
Real net fluctuations in central bank assets	0.0001416	0.22	0.40	0.0004984	-0.0002151
Real net fluctuations in government debt to banks	0.0057898	0.49	0.81	0.012965	-0.0013855
Real exchange rate fluctuations	-0.0365493	0.93	-2.31	-0.0207505	-0.0523482

Source: Research Findings

In Bayesian averaging method, the probability of the presence of a variable in the pip model (Posterior Inclusion Probability) is a strong criterion and the strong relationship between the explanatory and the dependent variables. Following Raftery (1999), each variable with pip greater than 0.5 is considered strong in this study. In the first column of Tables (3) and (4), the variables are arranged according to the probability of their presence in the model. The second column shows the weighted average of the posterior coefficients of each of the explanatory variables in all the estimated models. The third, fourth and fifth columns are pip, t-stat and confidence interval, respectively.

According to the results of Bayesian averaging, the probability of constant in the estimated model for moveable assets (Real housing price fluctuations and Real price fluctuations of Bahar Azadi gold coins) is equal to one. Housing is one of the important macroeconomic variables that, in addition to affecting real markets, will influence financial markets (Mohammadzadeh et al., 2015). The results of this study show that the variable coefficient of fluctuations in real total housing prices is positive, so that a one percent increase in fluctuations in real total housing prices increases liquidity by 7.638284 percent. As a result, it can be said that the liquidity in Iran is strongly affected by fluctuations in the real total housing price. In the study by Mahdilou et al. (2019), the share of the price in the transmission of monetary policy is significant in the same period of this study. Also, in the study of Komijani et al. (2013), housing prices play a role in the transmission of monetary policies. In the study by Gholizadeh et al. (2009), monetary policy has a significant share of housing price fluctuations. In the studies of Joznald and Jacobsen (2008), Gupta and Kabundi (2009), Sharifi Renani et al. (2011), contradictory results have been obtained, and the monetary policy shock through the housing price index has little effect on the price level. Fluctuations in the world' gold price have attracted the attention of many economists and policymakers due to its significant effect on the global economic variables. These fluctuations are effective, and in particular in gold prices, in different countries. The price of gold is determined based on the free exchange rate. Regarding the price of gold coins, it should be noted that this price consists of two components. One component of the gold coin price is its metal value, which is the the world price multiplied by the exchange rate, and the exchange rate is the free market exchange one. The second component is mintage or the right to quality, which is normally estimated to be a small amount. But in the conditions of increasing demand in the market, it is even more than 100,000 IRR. In the last 10 years, the price of gold has faced sharp changes (Raispour et al., 2015). The research results show a negative relationship between the real liquidity and fluctuations in the real price of the Bahar Azadi gold coin. In other words, increasing liquidity reduces the demand for gold and consequently the gold price. In a study by Komijani et al. (2014), this positive relationship was obtained.

According to the results of Bayesian averaging, the posterior probability of the constant in the estimated model is one for the immoveable assets. The coefficient of fluctuations of the real total stock price was negative and equal to -0.0000343. In the study of Shokouh et al. (2017), Rezaei et al. (2017), monetary policy has no significant effect on the total stock index. The studies of Hassanzadeh et al. (2011), Sedighiyan et al. (2015), Bahmani et al. (2015) and Chetzi Antonio (2013) showed that there is a positive relationship between monetary policy and stock price index changes. In recent years, the implementation of certain policies such as currency unification and increased oil revenues has significantly changed the monetary base structure. Net government debt to the central bank, and net assets of the central bank have been the most important factors in increasing the monetary base (Fitras et al., 2014). A positive and significant relationship was found between these two variables, which also confirm the partial monetary basis of these variables. There is a negative and significant relationship between liquidity and real exchange rate fluctuations, confirming the findings of Bovaki and Norman (2009), Carlos and Bernardo (2008), Stefan (2009) and Jalili et al. (2017). Given the importance of the exchange rate in the economic development of any country, it is necessary to study the factors affecting it (Anwar, 2002). According to the results of this study, real exchange rate fluctuations can be adjusted with appropriate monetary policies and proper control of liquidity.

5. Conclusion and Recommendations

This study aims to investigate the relationship between liquidity and asset price fluctuations in the Iranian financial market using BMA and seasonal data from 2006 to 2020. The results show that the relationship between liquidity and real housing price fluctuation is positive and significant. However, the relationship between liquidity volume and the real price fluctuation of Bahar -Azadi gold coin is negative and significant. These two assets are classified as movable assets. Immoveable assets include fluctuations in real total stock prices, real net fluctuations in central bank assets, fluctuations in real government debt to banks, and real exchange rate fluctuations, which are related to the liquidity and fluctuations in real total stock prices and exchange rate fluctuations. The point about the positive relationship between the liquidity and the fluctuation of the real housing price is to pay attention to the motivation to increase effective demand in this sector because speculative demand in this sector is to use the fluctuations in the market and increase the value of assets. In such a situation, the implementation of any policy in the housing sector without considering this issue will fail and the need to control speculative demand becomes more necessary than ever. Although the relationship between the liquidity and the fluctuation of the real total stock price in this study was negative, policymakers should pay attention to the fact that the stock index has a strong relationship with housing prices, so that housing market can be controlled by strengthening alternative markets, including the stock market. Considering the relationship between the two variables of liquidity and real exchange rate fluctuations, appropriate monetary policies can be adopted to adjust for real exchange rate fluctuations. Asset markets can be considered as one of the important channels for the impact of monetary policy on the real economy by policymakers and they should consider coordination with this sector in adopting monetary policy.

Conflicts of interest disclosure

The authors declare that there are no conflicts of interest regarding this article

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کاربرد میانگین‌گیری مدل بیزی برای بررسی رابطه بین متغیرهای سیاست پولی و نوسانات قیمت دارایی

چکیده:
هدف این پژوهش بررسی رابطه بین نقدینگی و نوسانات قیمت دارایی در بازار مالی ایران با استفاده از روش‌های بدیع میانگین‌گیری بیزین می‌باشد. یافته‌های این پژوهش برای سیاست‌گذاران مفید خواهد بود زیرا این نتایج می‌توانند در تصمیم‌گیری‌های مربوط به سیاست پولی مورد استفاده قرار گیرند. داده‌های مورد استفاده در این تحقیق به صورت فصلی (1385:1 تا 1399:12) می‌باشد و برای این منظور از آمارهای بانک اطلاعاتی سری‌های زمانی بانک مرکزی جمهوری اسلامی ایران، بورس و سایر منابع مرتبط استفاده شده است. میانگین‌گیری مدل بیزی (BMA) با موفقیت در ادبیات تجربی به عنوان راهی برای غلبه بر حساسیت نتایج به ویژگی‌های مدل‌های مختلف استفاده شده است. متغیر نقدینگی حقیقی به عنوان متغیر وابسته و نوسانات قیمت کل سهام، قیمت کل مسکن، دارایی‌های بانک مرکزی، بدهی دولت به بانک ها، نرخ ارز و قیمت سکه به عنوان متغیرهای مستقل در نظر گرفته شده‌اند. از نظر دارایی‌های منقول، نتایج حاکی از وجود رابطه مثبت و معنادار بین نوسانات قیمت کل حقیقی مسکن و نقدینگی و رابطه منفی بین نوسانات سکه طلای بهار آزادی با نقدینگی می‌باشد. برای دارایی‌های غیرمنقول، نوسان خالص واقعی دارایی‌های بانک مرکزی و بدهی دولت به بانک‌ها با نقدینگی رابطه مثبت دارد. بین نوسانات قیمت کل حقیقی سهام و نوسان نرخ حقیقی ارز با نقدینگی رابطه منفی وجود دارد.

واژه‌های کلیدی: میانگین‌گیری مدل بیزی، نقدینگی، نوسانات قیمت دارایی‌ها، دارایی‌های منقول و غیرمنقول.

طبقه بندیJEL: C11, G33, G12, N1, E52.