How Important are Oil and Money Shocks in Explaining Housing Market Fluctuations in an Oil-exporting Country?: Evidence from Iran

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Abstract

This paper analyzes the effects of oil price and monetary shocks on the Iranian housing market in a Bayesian SVAR framework. The prior information for the contemporaneous identification of the SVAR model is derived from standard economic theory. To deal with uncertainty in the identification schemes, I calculate posterior model probabilities for the SVAR model identified by a different set of over-identification restrictions. In order to draw accurate inferences regarding the effectiveness of the shocks in an over-identified Bayesian SVAR, a Bayesian Monte Carlo integration method is applied. The findings indicate that oil price shocks explain a substantial portion of housing market fluctuations. Housing prices increase in response to a positive credit shock, but only with a noticeably smaller magnitude when compared with the response to a positive oil price shock.

Keywords: Housing market fluctuations, Oil price shocks, Credit shocks, Bayesian Structural VAR, Bayesian model averaging (BMA), Bayesian Monte Carlo integration method.

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1. Introduction

The last decade has witnessed booms in housing markets in many oil-exporting countries. Whilst in advanced economies the stance of monetary policies has been identified as the main source of fluctuations in housing markets, in oil-exporting countries, a big swing in oil prices has been identified as a key factor causing housing market booms. Working with literature on the Dutch Disease and the Oil Syndrome can shed some light on the channels of the oil price transmission mechanism to the housing sector. The main concentration of Dutch Disease is on the distortion in the exchange rate that results from large foreign exchange inflows, in particular the tendency toward appreciation of the home currency that such inflows can induce. This appreciation in the home currency, assuming that the country is a small price taker, induces the appreciation of the real exchange rate[1]. This appreciation, in turn provides the incentive to increase consumption and decrease production of traded goods and vice versa for goods which are non-traded goods, which consist of all items which cannot be traded internationally (see Forsyth and Kay (1981), Cordan (1982) and Fardmanesh (1991), Van Wijnbergen (1984), Gylfason (2001), Torvik (2001) and Stevens (2003)). In this regard, a part of the volatility in the housing sector, as a representative of the non-tradable sector, may be attributed to oil price fluctuations, but the degree of their impact depends on the magnitude of the changes in real exchange rates and expenditure patterns.

In modern macroeconomic literature, there are some studies that have discussed the interaction between the housing sector and the macro-economy. Most of them particularly focus on the role of housing channels in the monetary transmission

[1] The real exchange rate is a proxy for the relative price of traded to non-traded goods.

mechanism and the role of wealth effects in asset markets in determining the divergence of house prices from their fundamental values (Mashkin (2001, 2007), Campbell and Coco (2007), Tan and Voss (2003), Maclenman et al. (1998), Giuliodori (2004) and Himmelberg, Mayer and Sinai (2005)). There are also some studies that use a structural vector autoregressive approach to model the housing sector and its interconnection with the macro-economy. For example, Lastrapes (2001), Jarocinski and Smets (2008), Iacoviello (2000), Aoki, Proudman and Vlieghe (2002) and Elbourne (2008) particularly focus on assessing the effect of monetary shocks on the housing sector.

As pointed out earlier, the transmission mechanism of oil prices based on the Dutch Disease literature is another important transmission for an oil-exporting country that can link the macroeconomic variables to the housing market. In this regard, an increase in oil prices may be thought to affect the housing sector in three ways. Firstly, higher oil income may increase the demand for housing, and increase prices relative to those of traded goods. Secondly, the appreciation of the real exchange rate will reallocate resources from the non-oil traded sector into the housing sector. And finally, the increase in the price of housing via Tobin's Q stimulates residential investment in new dwellings and increases wealth.

Whereas some authors have studied the effect of oil price shocks on the economy in some developing oil-exporting countries, few studies have been done to investigate the quantitative importance of the transmission of oil price shocks on the economy and particularly on the housing sector.[1] This study aims to fill this gap by providing

[1] For example, while Kuralbayeva and et al (2001) for Kazakhstan, Looney(1991) for Kuwait, Roemer(1985) for Nigeria, Mexico and Venezuela, Looney(1988) for Saudi Arabia and Jahan-Parvar and Mohammadi(2009) for six oil-exporting countries confirm the hypothesis that windfall revenues due to oil boom causes the real exchange rate to appreciate, they have not assessed the quantitative and exact effect of oil shocks on the economy. They merely generally argue that the appreciation possibly caused contraction of industrial output as compared to the non-boom is counter-factual.

an empirical model and answering the question whether oil price shocks along with credit shocks can explain a major part of fluctuations in the housing sector of a developing oil-exporting country. I think, the Iranian housing market provides a particularly interesting case study, because there have been large-scale increases in the price of owner occupied dwellings in recent years and these increases have occurred during a period of an oil price boom.

The approach adopted here is to specify a Bayesian Structural Vector Autoregressive (SVAR) model of the Iranian economy that combines the three blocks of macroeconomic interest consisting of money, goods and foreign markets with the housing market. The identifying scheme of the model is achieved by imposing enough prior restrictions derived based on a plausible illustrative over-identified model that reflects important features of an oil-exporting economy.

While the theoretical identification scheme for structural shocks turns out to be an over-identified structural VAR model, I rely on a Bayesian approach for estimating structural coefficients and deriving the posterior distribution of the coefficients to calculate error bands for the impulse responses of housing variables. As suggested by Sims and Zha (1999) and Waggoner and Zha (2000) for a relatively large and over-identified model, a Bayesian Structural Vector autoregressive method, can give a precise estimation of structural coefficients. Furthermore it can produce error bands whose possible asymmetries are justifiably interpreted as informative about asymmetry in the posterior distribution of the impulse responses.

I examine the model using Iranian data over the period 1988:1–2006:4. The results indicate that the oil price shock shows an important influence on housing prices and the housing stock. Housing prices and the housing stock increase in response to a positive credit shock, but only with a delay and with a noticeably smaller magnitude than when compared with the responses to a positive oil price shock.

The reminder of the paper is organized as follows. In section 2, I summarize the most important institutional events during the sample period. The structural VAR modeling method and identification scheme are summarized in section 3. Section 4 involves a revision of the data and time series properties and the estimation and identification process of the model. Section 5 presents simulation results based on the model. In this section, the robustness of the findings to alternative specifications is also considered. Finally, some concluding remarks are presented in section 6.

2. The Iran housing market in a birds-eye view

Since the end of the Iran-Iraq war in summer 1988, the Iranian economy has experienced several periods of rapid house price growth. I can identify three major house price booms in the Iranian housing market during 1988:1-2006:4. The first two booms exhibit sharp "spikes", but the recent boom having started in 2000 has been much more extended (Fig. 1-a). Fig.1-a also depicts three slumps that took place in 1991, 1994 and 1999. According to Fig. 1-b and Fig. 1-c, it seems that there is pro-cyclicality between the real oil price and the real price of housing and housing investment. However, Fig. 1-d shows counter-cyclicality between the real exchange rate and the real price of housing. It is worth noting that the significance of this cyclicality increased strongly after 2000, where the price of oil began to increase. This first tentative result emphasizes the crucial role of oil price shocks in driving volatility in Iranian house prices.[1]

[1] This evidence has also been seen in many members of OPEC, particularly since 2000. For example, there is strong co-movement between the house price and the world price of oil in Saudi Arabia, Kuwait, the UAE, Algeria and Qatar.

During the above mentioned period, the usual explanation for a part of the volatility in the housing market has been the rapid increase in money supply which led to high investment and/or speculative activities. Since interest rates have been set administratively during the sample period, the central bank could not set the interest rate by following a conventional monetary policy rule.[1] During this period, the deposit and loan rates in the banking system changed little in comparison to a high and rising rate of inflation. On the other hand, considering the under-developed nature of the capital and bond markets, almost all the financing needs of the public and private sectors are met through the banking system[2]. Therefore, the expansion of credit to the private and public sectors and the non-neutralized part of the country's foreign exchange reserves, which depends on the country's oil revenues, are among the most important driving forces behind money supply growth. Fig. 1-e and Fig. 1-f show the historical trend of the real price of housing and housing investment along with the real money supply, respectively. According to these Figures, there has been a moderate correlation between the real money supply and housing investment prior to 1999 and a strong correlation since 2000. In the first period, the expansion of the money supply was mainly attributable to domestic credit growth, whereas in the latter period the expansion of money supply was mainly attributable to large foreign exchange inflows (which depended on the positive trend of the world price of oil). This suggests that, in the latter period, the money supply having mainly originated from high oil prices, has been another source of rising residential investment in new dwellings.

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[1] The Taylor rule is a very popular monetary rule that indicates that monetary authorities set short run interest rates in response to movements in output and inflation rates (see Taylor 1993).

[2] For more detail see Pesaran (2000).

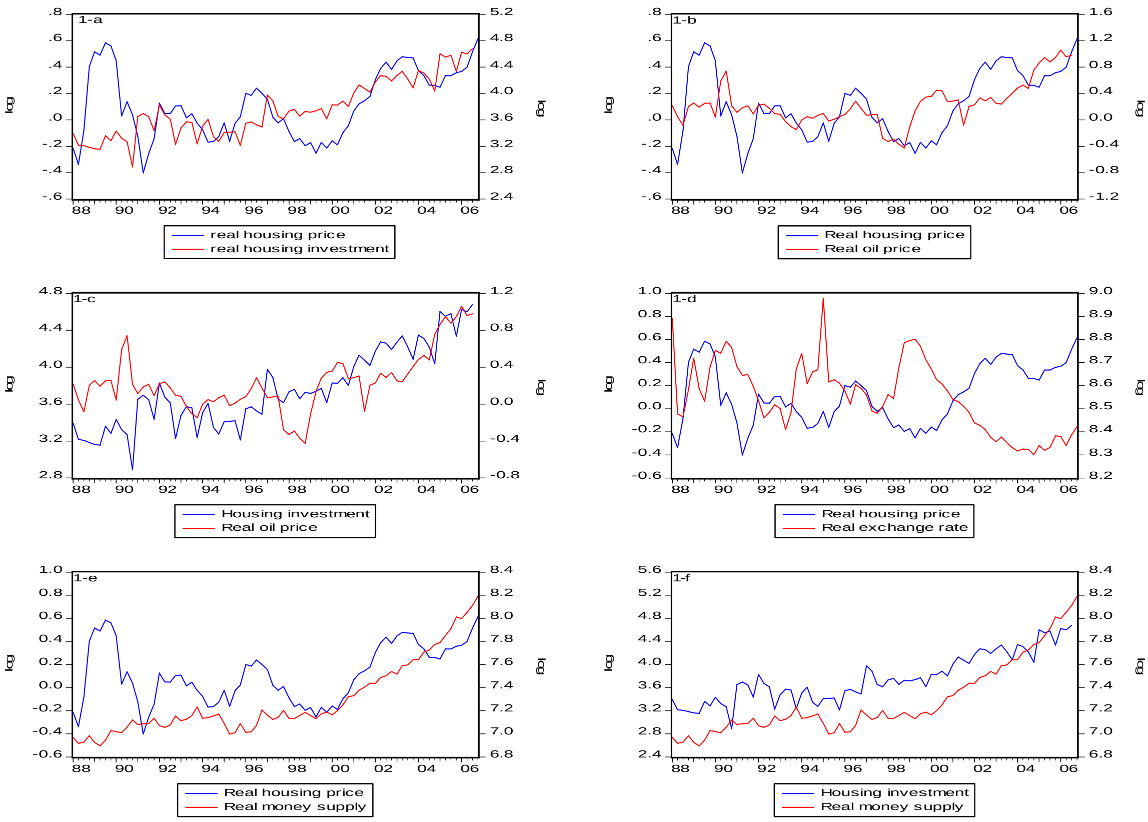

Fig.1. Variables

3. Econometrics Method

The analysis in this study is based on a stochastic, dynamic, and simultaneous model which has the general form of a system of multiple equations:

$$A(L)y_t = e_t \qquad (1)$$

where A(L) is a matrix polynomial in the lag operator L, y_t is an n$\times$1 data vector and e_t is an n$\times$1 structural disturbance vector. The properties of e_t are: $E(e_t e_t^{/}) = \Lambda$, $E(e_t e_{t+s}^{/}) = 0$; $\forall s \neq 0$ such that Λ is a diagonal matrix for which the diagonal elements are the variances of the structural disturbances and the off-diagonal elements are zero.

The reduced form for the system (1) can be written as:

$B(L)y_t=u_t$ (2)

in which $B_0=I$ and u_t , while still uncorrelated with past *y*'s, has a covariance matrix which is not in general diagonal, being given by $E(u_t u_t^{/}) = \Sigma$.

Now let A_0 be the coefficient matrix (non-singular) on L^0 in A(L), that is the contemporaneous coefficient matrix in the structural form, and also let $A_0(L)$ be the coefficient matrix polynomial in A(L) without the contemporaneous coefficient $A_{0,}$ that is: $A(L)=A_{0+}A_0(L)$.Then, the structural disturbance e_t and the reduced form residuals u_t are related by: $e_t = A_0 u_t$ which implies:

$$\Sigma = A_0^{-1} \Lambda A_0'^{-1} . \tag{3}$$

The estimation of free parameters in A_0 and Λ can be obtained by maximizing over the free parameters A_0 and Λ based on a likelihood function:

$$L(B, \Sigma) = |\Sigma|^{-T/2} \exp[\ -1/2\, trace\ \ (S(B)\Sigma^{-1})] \tag{4}$$

where $\hat{u}_t = B(L)y_t$ *and* $S(B) = \sum \hat{u}\ \hat{u}_t'$.

The impulse responses of the model are the coefficients $B^{-1}(L)A_0\Lambda^{1/2}$ that can be derived to track the average responses of the variables to one standardized innovation in the orthogonal errors. For an exactly identified VAR, driving the impulse response of the model can be easily done by imposing just enough restrictions on A_0 to make (3) a one-to-one mapping from Σ to A_0 and Λ. Since in this case the mapping defined by (3) generates a linear transformation between unrestricted and restricted parameters , standard Bayesian and classical methods can, by preserving the same distribution, correctly convert the draws from the joint distribution of unrestricted parameters B and Σ to the restricted parameters A_0 and Λ. The above properties are generally disrupted when the model is over-identified. Although for an over-identified model the maximum likelihood estimation (4) of A_0 and Λ provides an algorithm for mapping the reduced form $\hat{B}$ and $\hat{\Sigma}$ estimates into the structural estimates A_0 and Λ, it is not true that this mapping converts the posterior distribution of the unrestricted parameters correctly into the restricted parameters. In this regard, the standard Bayesian method (that Sims and Zha called the naive Bayesian method) does not work well in drawing the posterior distribution of the restrictive parameters A_0 and Λ via the mapping defined by (3).Sims and Zha (1999) argue that:

"….m*odels in which likelihoods have multiple peaks do arise in over-identified models, and they create difficulties for the naive Bayesian approach. The difficulties are both numerical – in repeatedly maximizing likelihood over thousands of draws it is impractical to monitor carefully which peak the algorithm is converging to – and analytical – when there are multiple peaks the asymptotic approximations that can justify the naive Bayesian procedure are clearly not accurate in the current sample."*

Sims and Zha (1999) suggest a new procedure for generating Monte Carlo draws from the Bayesian posterior for the parameters in (1). They reparameterized (1) by:

$$\Gamma(L) y_t = \eta_t \tag{5}$$

where $\Gamma = \Lambda^{-1/2} A$ and $\eta_t = \Lambda^{-1/2} e_t$ so that var(η_t)=I. Rewritten the likelihood function (4) as

$$\left|{}_1\Gamma_0\right|^T \exp\{-1/2 trace({}_1\Gamma_0 S(\hat{B})_1\Gamma_0^{'})\} \tag{6}$$

or

$$\left|{}_1\Gamma_0\right|^T \exp\{-1/2trace({}_1\Gamma_0^{'}{}_1\Gamma_0 S(\hat{B})) - 1/2trace((B-\hat{B})' X^{'} X(B-\hat{B})_1\Gamma_0^{'}{}_1\Gamma_0)\} \qquad (7)$$

where $\hat{B}=(X'X)^{-1}X'Y$, $S(\hat{B})=(Y-X\hat{B})'(Y-X\hat{B})$, and the τth rows of Y,X are given by y_t' and $(1,y_{t\!-\!1}',.....y_{t-p}')$, respectively. Taking the prior as flat in B and Γ_0 , and by integrating over B, the marginal posterior on ${}_1\Gamma_0$ can be obtained by:

$$p({}_1\Gamma_0) \propto \left|{}_1\Gamma_0\right|^{T-v} \exp[-1/2trace({}_1\Gamma_0 S(\hat{B})_1\Gamma_0^{'})] \qquad (8)$$

where $v=np+1$.

Using $\left|{}_1\Gamma_0\right|^v$ as an improper prior or as a consequence of starting with a flat prior on the coefficients of Γ(L) in (5), then converting to a parameterization in terms of ${}_1\Gamma_0$ and B(L) eliminates discrepancies between posterior modes and maximum likelihood estimates. These enable us to obtain the correct posterior distribution for structural parameters and to generate accurate confidence intervals for the impulse response of the coefficients.

4. The theoretical framework

This section considers a modified dynamic aggregate demand-supply framework that incorporates some important aspects of an oil-exporting economy. Oil price shocks and oil revenues play a major role in this economy. Financial and capital markets are underdeveloped, capital mobility is limited and the interest rates for bank liabilities are controlled. There are four fundamental markets in the economy: goods, money, foreign assets and housing. The goods market is specified with an emphasis on the role of oil revenues in the economy. In the money market, while I adopt money demand in the usual way, money supply is characterized by the role of domestic credit and oil price shocks. In the foreign asset market, I consider two equations that have crucial roles in tracking external shocks, particularly oil price and risk premium shocks, on the domestic economy. These shocks can affect the domestic economy through their influences on the nominal interest rate and the real exchange rate. The former effect is based on imperfect capital mobility and the latter effect is based on purchasing power parity. The housing market is identified by modeling the demand and supply sides of the market. And finally, the inflation rate is determined by shocks driven from the money and goods markets and changes in both the real exchange rate and real housing prices.

Oil price process

I assume that the real price of oil is an exogenous variable in response to instantaneous shocks in the economy. This assumption is justifiable, as Iran's economy is small in magnitude and doesn't have a large share of the world production of oil.

$$o_t = \varepsilon_t^o \tag{9}$$

Inflation process

In an open economy, the consumer price level is defined as a geometric average of the price of non-traded and traded goods:

$$p_t^c = (1-\beta_2)\, p_t^N + \beta_2 (e_t + p_t^*) \tag{10}$$

where p_t^c is the logarithm of the consumer price level, p_t^N is the logarithm of the price of non-traded goods, e_t is the logarithm of the nominal exchange rate and p_t^* is the logarithm of the foreign price level.

I also distinguish between house prices and prices of other non-traded goods (that I call domestic output prices) and define p_t^N as a linear combination of the logarithm of house prices, p_t^h ,and domestic output prices, p_t ,:

$$p_t^N = (1-\beta_2)\, p_t + \beta_2\, p_t^h , \tag{11}$$

By substituting (11) into (10) we obtain:

$$p_t^c = p_t + \beta_2(e_t + p_t^* - p_t) + \beta_3(1-\beta_2)(p_t^h - p_t) \tag{12}$$

$$p_t^c = p_t + \beta_2 re_t + \beta_3(1-\beta_2)rp_t^h \tag{12'}$$

where $re_t = e_t + p_t^* - p_t$ and $rp_t^h = p_t^h - p_t$ are the logarithms of the real exchange rate and the real house price level, respectively. Taking the differences of (12') yields an inflation equation that can be written as:

$$\Delta p_t^c = \Delta p_t + \beta_2 re_t + \beta_3(1-\beta_2)rp_t^h - \beta_2 re_{t-1} - \beta_3(1-\beta_2)\, rp_{t-1}^h \tag{13}$$

Note that we must now model the rate of domestic output price inflation, Δp_t , the logarithm of the real exchange rate and also the real house price level on the right hand side of (13) to complete the inflation rate specification. At this stage, I discuss the determination of domestic output inflation and leave the discussion the determinations of the real exchange rate and real house prices to later when I model the foreign and housing markets.

To model the rate of domestic output inflation, I assume Δp_t can be affected by shocks originating in the goods and money markets. Specifically, the rate of domestic output inflation is assumed to be related to contemporaneous shocks to output and money growth. Thus, normalizing in units of the money growth shock, we have:

$$\Delta p_t = \beta_1 \varepsilon_t^y + \varepsilon_t^m \tag{14}$$

where ε_t^y and ε_t^m are real and money shocks, respectively. By substituting (14) into (13), we can eliminate explicit consideration of the rate of domestic output inflation from the analysis. With these modifications, Eq. (13) may now be rewritten as:

$$\Delta p_t^c = \beta_1 \varepsilon_t^y + \varepsilon_t^m + \beta_2 re_t + \beta_3(1-\beta_2)rp_t^h - \beta_2 re_{t-1} - \beta_3(1-\beta_2)\, rp_{t-1}^h \quad . \tag{15}$$

Note that ε_t^y and ε_t^m can be identified in the goods and money markets, which are specified below.

Goods market

To specify behavior in the goods market, I assume that the logarithm of real output is given by:

$$y_t = \beta_4 \varepsilon_t^o + \varepsilon_t^y \qquad ; \beta_4 > 0 \tag{16}$$

where y_t is the logarithm of real output and ε_t^y is a real shock which can be interpreted as a supply or demand shock. With this specification, monetary shocks are allowed to affect the real output with a lag only, as is consistent with conventional views of the monetary transmission mechanism.

Money market

We assume a conventional money demand function. The demand for real money is contemporaneously correlated to interest rates, as well as to output shocks:

$$m_t - p_t^c = \beta_5 \varepsilon_t^y + \beta_6 i_t + \varepsilon_t^{md} \qquad ; \beta_5 > 0, \ \beta_6 < 0. \tag{17}$$

where m_t is the logarithm of money supply, i_t is the interest rate and ε_t^{md} presents money demand shocks.

As mentioned in section 1, whilst conventional interest rate policies have not been the instigator of effective and significant monetary policies in Iran's economy, changes in the level of aggregate liquidity directly depends on domestic credit channels and the non-neutralized part of the country's foreign exchange reserves. In this regard, we are not able to define a conventional reaction function for the monetary authority, which sets the interest rate after observing the current value of money and other macroeconomic variables (Kim and Roubini 2000). Instead, I define money supply growth as monetary shocks which are correlated with oil price and credit shocks:

$$\Delta m_t = \varepsilon_t^m = \beta_7 \varepsilon_t^o + \varepsilon_t^{dc} \qquad ; \beta_7 > 0 \tag{18}$$

where ε_t^{dc} is a credit shock.

Foreign market

I assume a general specification for the balance of payments that seems to be suitable for an oil-exporting country.

$$\kappa(i - i^* - \Delta e_t^s + \varepsilon_t^a) + (\beta_8 re_t + \beta_9\, o_t + \varepsilon_t^b) = 0 \quad ; \beta_8 > 0\,, \beta_9 > 0 \qquad (19)$$

where i^* is the foreign interest rate, ε_t^a is a risk premium shock , ε_t^b is a trade balance shock, e_t is the logarithm of nominal exchange rate and the "s" superscript indicates the expected value next period. In (19) the first term determines the behavior of capital inflows whereas the second term determines the behavior of trade balance. The parameter κ denotes the degree of capital mobility assumed to be influenced by different measures of capital control or by prevailing institutional rules on internal financial markets, which can be modified to limit the speed of capital movements.

I also assume that expectations on exchange rates are formed rationally:

$$\Delta e_t^s = \Delta e_t + u_t \qquad (20)$$

where u_t is a random prediction error.

Rewriting (19) in terms of the domestic interest rate, substituting 20 into 19 and using the definition of the real exchange rate $(\Delta e_t = \Delta re_t + \Delta p_t + i_0)$:

$$i = i_0 + \Delta p_t + (1 - \beta_8 / \kappa) re_t - (\beta_9 / \kappa) o_t - re_{t-1} + \varepsilon_t^{bop} \qquad (21)$$

where $\varepsilon_t^{bop} = i^* + u_t - \varepsilon_t^a + \varepsilon_t^b / \kappa$, is the balance of payment shock. As mentioned in section 2, a particular problem with data in the economy of Iran is that we have little confidence that the available interest rates reflect market forces.

Therefore, I use the equation above to eliminate the interest rate from all equations in the housing and money markets.

I next model the behavior of the real exchange rate in order to complete the specification of the foreign market. Equation (22) postulates that the logarithm of the real exchange rate is contemporaneously correlated with oil price shocks, output shocks, monetary shocks and its own shock, ε_t^{re}.

$$re_t = \beta_{10}\varepsilon_t^o + \beta_{11}\varepsilon_t^y + \beta_{12}\varepsilon_t^m + \varepsilon_t^{re} \ ; \beta_{10} < 0, \beta_{11} < 0, \beta_{12} > 0. \tag{22}$$

We expect that an expansionary monetary policy will lead to contemporaneous real depreciation. Although theory does not impose particular a priori restrictions on the sign of the output shocks in the real exchange rate equation, the negative expected effect of output shock on the real exchange rate seems to be sensible. The inclusion of a real oil price term in the real exchange rate equation can be justified by the effect of the oil price on the traded and non-traded sectors in an oil-exporting country (see Pasaran 2000). As discussed above, the real exchange rate channel has a crucial role in the Dutch Disease context in transferring the oil price shock to the housing sector.

Housing Market

In this market, I concentrate on the behavior of three variables: housing stock, housing price and composite real construction cost. As shown in Miles (1994, 2002), the demand for housing can normally be derived from maximizing utility subject to an intertemporal budget constraint in a multi-period or "life-cycle" approach:

$$h_t = \beta_{13}\varepsilon_t^y + \beta_{14}(i_t - \Delta p_t^c) + \beta_{15} rp_t^h + \varepsilon_t^h \ ; \ \beta_{13} > 0, \beta_{14} < 0, \beta_{15} < 0 \tag{23}$$

The anticipated theoretical signs of the partial derivative of housing stock indicate that the housing stock is negatively related to the real price of housing and is positively related to the output shock. In addition, based on theoretical arguments alone, the housing stock is also a negative function of user cost of capital which is generally defined by the difference between nominal mortgage rate and inflation (Meen 1990, 2002).

Apart from the demand side, the other fundamental relationship suggested by economic theory is a Tobin's Q-theory of investment. In this approach suggested by Poterba (1984) and Madsen (2007), a model of optimizing firm behavior is used to show the factors that determine house prices. Construction costs, land prices and the interest rate are the main factors that determine house prices in this approach. Within this framework, the investment decision of firms is based on the comparison of the current real price of housing and the production costs of housing. When the price of housing rises relative to that level which provides a "normal" profit to firms in the construction industry, then this induces an increase in the quantity of dwellings supplied to the market. The nominal interest rate is also a crucial factor in explaining house prices in the short and long run, while the nominal interest rate measures the financing costs during the period in which the house is being built[1]. Eq. (16) shows the supply of housing, in which the price of housing is contemporaneously related to the real construction cost (including the land cost), the nominal interest rate and housing supply shocks.

$$rp_t^h = \beta_{16} i_t + \beta_{17} cc_t + \varepsilon_t^{rp^h} \; ; \beta_{16} > 0, \beta_{17} > 0 \tag{24}$$

In the equation, cc_t is the real composite construction cost. I expect that $\beta_{16} > 0$ and $\beta_{17} > 0$. The former assumption can be driven from the housing literature which shows that construction costs have a positive and crucial role in increasing house prices in the short and particularly in the long run (Mandson 2007). The latter

[1] The nominal, as opposed to the real, interest rate is used because financing costs are not related to discounting of a real income flow but are a direct expense (for more detail see Madsen (2007)).

assumption can be interpreted as a cost-push factor for the average firm in the building sector for housing . The equation also implies that $\varepsilon_t^{rp^h}$ can be interpreted as any contemporaneous shock that affects rp_t^h but is uncorrelated with construction cost shocks. In this regard, we are able to decompose construction cost shocks from other housing supply shocks.

I next model the behavior of the real composite construction cost to complete the specification of the housing market. As shown in Eq.(14), the real construction cost cc_t is contemporaneously affected by the output shock, ε_t^y, and its own shock, ε_t^{cc}.[1] It is worth noting that, I assume the construction cost to be contemporaneously exogenous to the other housing variables. This assumption is justifiable since the response of construction cost to the other housing variables is delayed due to an inertia effect discussed in many housing studies about Tobin's Q theory (Mishkin 2007; Mandson 2007, Kenny 1999).

$$cc_t = \beta_{18}\varepsilon_t^y + \varepsilon_t^{cc} \qquad \beta_{18} > 0 \tag{25}$$

Now using (21) to eliminate explicit consideration of the interest rate from (17), (23) and (24) and rewriting (15) using (16) and (18); (16) using (9); (17) using (16); (22) using (9), (16) and (18); (23) using (16) and finally (25) using (16), we can obtain:

[1] I also examine an alternative specification that allows that the interest rate to enter directly into the construction cost equation. The evaluation of this alternative choice model is done in sub-section 5-3.

$$
\begin{aligned}
&o_t = \varepsilon_t^o \\
&\Delta p_t^c = \gamma_{21} o_t + \gamma_{23} y_t + \gamma_{25} re_t + \gamma_{27} rp_t^h + \varepsilon_t^{dc} \\
&y_t = \gamma_{31} o_t + \varepsilon_t^y \\
&m_t - p_t = \gamma_{41} o_t + +\gamma_{42} \Delta p_t^c + \gamma_{43} y_t + \gamma_{45} re_t + \varepsilon_t^A \\
&re_t = \gamma_{51} o_t + \gamma_{52} \Delta p_t + \gamma_{53} y + \gamma_{57} rp_t^h + \varepsilon_t^{re} \\
&h_t = \gamma_{61} o_t + \gamma_{63} y_t + \gamma_{65} re_t + \gamma_{67} rp_t^h + \varepsilon_t^B \\
&rp_t^h = \gamma_{71} o_t + \gamma_{72} \Delta p_t^c + \gamma_{75} re_t + \gamma_{78} cc_t + \varepsilon_t^C \\
&cc_t = \gamma_{81} o_t + \gamma_{83} y_t + \varepsilon_t^{cc}
\end{aligned} \tag{26}
$$

where:

$$
\begin{aligned}
&\gamma_{21} = \beta_7 - \beta_1\beta_4;\ \gamma_{23} = \beta_1;\ \gamma_{25} = \beta_2;\ \gamma_{27} = \beta_3(1 - \beta_2);\ \gamma_{31} = \beta_4; \\
&\gamma_{41} = \beta_6(\beta_9/\kappa) - \beta_4\beta_5; \gamma_{42} = \beta_6; \gamma_{43} = \beta_5;\ \gamma_{45} = \beta_6(1 + (\beta_8/\kappa); \\
&z = 1 + \beta_1\beta_{12};\ \gamma_{51} = (\beta_{10} - \beta_{11}\beta_4 + \beta_{12}\beta_1\beta_4)/z;\ \gamma_{52} = \beta_{12}/z; \\
&\gamma_{53} = (\beta_{11} - \beta_{12}\beta_1)/z;\ \gamma_{57} = -\beta_{12}\beta_3(1 - \beta_2)/z;\ \gamma_{61} = \beta_{14}(\beta_9/\kappa) - \beta_{13}\beta_4; \\
&\gamma_{63} = \beta_{13}; \gamma_{65} = \beta_{14}(1 + (\beta_8/\kappa));\ \ \gamma_{67} = \beta_{15};\ \gamma_{71} = \beta_{16}(\beta_9/\kappa); \\
&\gamma_{72} = \beta_{16};\ \gamma_{75} = \beta_{16}(1 + \beta_8/\kappa);\ \gamma_{78} = \beta_{17};\ \gamma_{81} = \beta_{18}\beta_4;\ \gamma_{83} = \beta_{18}; \\
&\varepsilon_t^{A} = \varepsilon_t^{md} + \beta_6\varepsilon_t^{bop};\ \varepsilon_t^{B} = \varepsilon_t^{h} + \beta_{14}\varepsilon_t^{bop};\ \varepsilon_t^{C} = \varepsilon_t^{rp^h} + \beta_{16}\varepsilon_t^{bop}.
\end{aligned} \tag{27}
$$

Identification

The dynamic representation of the theoretical model (26) for the eight variables y=$\{o_t, \Delta p_t, m_t - p_t, re_t, h_t, rp_t^h, cc_t\}$ can be written in term of a vector representation of the simultaneous equation model (5). The restrictions embodied in ${}_1\Gamma_0$ are summarized as:

$$
{}_1\Gamma_0 = \begin{bmatrix}
\gamma_{11} & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
\gamma_{21} & \gamma_{22} & \gamma_{23} & 0 & \gamma_{25} & 0 & \gamma_{27} & 0 \\
\gamma_{31} & 0 & \gamma_{33} & 0 & 0 & 0 & 0 & 0 \\
\gamma_{41} & \gamma_{42} & \gamma_{43} & \gamma_{44} & \gamma_{45} & 0 & 0 & 0 \\
\gamma_{51} & \gamma_{52} & \gamma_{53} & 0 & \gamma_{55} & 0 & \gamma_{57} & 0 \\
\gamma_{61} & 0 & \gamma_{63} & 0 & \gamma_{65} & \gamma_{66} & \gamma_{67} & 0 \\
\gamma_{71} & \gamma_{72} & 0 & 0 & \gamma_{75} & 0 & \gamma_{77} & \gamma_{78} \\
\gamma_{81} & 0 & \gamma_{83} & 0 & 0 & 0 & 0 & \gamma_{88}
\end{bmatrix}. \tag{28}
$$

While a maximum of $\frac{(n=8)((n=8)+1)}{2}$ =36 free parameters in the system (28) makes it just-identified, the existence of 31 parameters in the model imply that the system is over-identified. Using these elements, the structural parameters $(\beta_1, \beta_2, ..., \beta_{18})$ can thus be written as:

$$
\begin{aligned}
&\beta_1 = \gamma_{23};\ \beta_2 = \gamma_{25};\ \beta_3 = \gamma_{27}/(1\text{-}\gamma_{25});\ \beta_4 = \gamma_{31};\ \beta_5 = \gamma_{43};\ \beta_6 = \gamma_{42};\\
&\beta_7 = \gamma_{21} + \gamma_{23}\gamma_{31}; \beta_8 / \kappa = (\gamma_{45}/\gamma_{42}) - 1;\ \ \beta_9 / \kappa = (\gamma_{41} + \gamma_{43}\gamma_{31})/\gamma_{42};\\
&\beta_{10} = \gamma_{51} + (\gamma_{51}+1)(\gamma_{52}\gamma_{25}) + \gamma_{53}\gamma_{31} + \gamma_{23}\gamma_{52}\gamma_{31}/(1-\gamma_{25}\gamma_{52});\\
&\beta_{11} = (\gamma_{53} + \gamma_{23}\gamma_{52})/(1-\gamma_{25}\gamma_{52});\ \ \beta_{12} = \gamma_{52}/(1-\gamma_{25}\gamma_{52});\ \beta_{13} = \gamma_{63};\\
&\beta_{14} = \gamma_{65}\gamma_{42}/\gamma_{45};\ \beta_{15} = \gamma_{67};\ \beta_{16} = \gamma_{72};\ \beta_{17} = \gamma_{78}; \beta_{18} = \gamma_{83}.
\end{aligned}
\tag{29}
$$

Note from (29) that we need only 26 of 31 elements γ_{ij} to estimate the 18 coefficients β . This results in imposing 5 more cross-equation restrictions among the γ_{ij} elements:

$$
\begin{aligned}
&\gamma_{57} = -\gamma_{52}\gamma_{27}\ ;\\
&\gamma_{61} = -\gamma_{63}\gamma_{31} + \gamma_{65}(\gamma_{41} + \gamma_{43}\gamma_{31})/\gamma_{45}\ ;\\
&\gamma_{71} = \gamma_{72}(\gamma_{41} + \gamma_{43}\gamma_{31})/\gamma_{42}\ ;\\
&\gamma_{75} = \gamma_{72}\gamma_{45}/\gamma_{42};\\
&\gamma_{81} = -\gamma_{83}\gamma_{31.}
\end{aligned}
\tag{30}
$$

4-2- Bayesian structural model estimation

I examine the above eight-variable quarterly VAR model of the Iran economy over the period 1988:1–2006:4. Complete seasonal dummies are used in estimation. Furthermore to account for the shifts in the series, I include two impulse dummies I95Q2 and I01Q2 and a shift dummy S97Q1 in the model[1]. Before I estimate the structural coefficients of the model, I first, in order to specify the VAR model correctly, asses the unit root properties of the variables and then, determine the

---

[1] The dummy variables are defined as follows: D95Q1=1 in 1995:1, 0 otherwise; I01q2=1 in 2001:2, 0 otherwise; and S97Q1=0 before 1997:1, 1 otherwise.

optimal lag length of the VAR. Using an Augmented Dickey-Fuller approach and Schwarz criteria for choosing the optimal lag, all of the variables are found to have unit roots[1].

Since the true order of the VAR in level is unknown, I have employed VAR order selection criteria. To determine the lag length, the maximum likelihood ratio test, Akaike and Schwarz criteria are used. In this regard, the maximum likelihood ratio admits the existence of four lags whereas, Akaike and Schwarz criteria reached their minimum at six and two lags, respectively. As each of these three criteria determines a different lag length, it is essential to check the whiteness of the VAR residuals to distinguish the optimal lag length. Choosing 2 and 4 lag lengths is generally supported by the usual diagnostic tests (results for 2 lag lengths are reported in table 2). For other lag lengths using the conventional significance level of five percent, I found the evidence of serial correlation and heteroscedasticity in the residuals for some of the VAR equations. In order to save degrees of freedom in estimating the model, I have therefore chosen 2 lags for the subsequent investigation.

Table 1: Reduced Form Diagnostic Tests forVAR(2)

	O	M	c	Y	Re	c	h	Ph
AR(2)	.38	1.7	1.6	1.2	.2	1.2	1.3	2.2
F	(.68)	(.19)	(.19)	(.29)	(.81)	(.29)	(.26)	(.11)
AR(4)	1.19	1.9	1.2	2.2	.73	1.9	1.7	2.4
F	(.32)	(.11)	(.28)	(.07)	(.57)	(.11)	(.16)	(.06)
ARCH(2)	.47	.78	1.9	.26	.67	.70	.11	.45
F	(.75)	(.53)	(.12)	(.89)	(.61)	(.59)	(.97)	(.76)
ARCH(4)	.47	.78	1.9	.26	.67	.7	.11	.45
F	(.75)	(.53)	(.12)	(.89)	(.61)	(.59)	(.97)	(.76)
Normality	2.8	.0001	4.1	.93	.51	2.8	4.1	.96
(2)	(.23)	(1.0)	(.12)	(.62)	(.77)	(.23)	(.12)	(.61)
$\chi^2(2)$								

Note: Marginal significance levels for statistics are in parentheses.

The estimation procedure can be evaluated in two stages. In the first stage I rely on the maximization of concentrated likelihood (7) and the Maximum likelihood ratio test to check the validity of the set of over-identifying restrictions. The maximization

[1] -The result of unit root test for the variables is not reported here due to space limitations.

of concentrated likelihood (7) for the coefficients in (28) and imposing 5 restrictions in (30) is obtained by using a numerical optimization procedure. To select optimal initial values for parameters in ${}_1\Gamma_0$, the simplex method is adopted. After setting up the initial values, the parameters are obtained using the BFGS method. The LR test results indicate that the chi-square statistic with $\frac{8(8+1)}{2} - 31 + 5 = 10$ degree of freedom is 14.6, and the significance level is 0.15. Therefore, the over-identifying restrictions are not rejected at one percent.

In the second stage, taking into account that the over-identified restrictions in (28) and (30) cannot be rejected at the 1 percent level, I rely on a Bayesian Structural Vector autoregressive method to estimate Γ_0 and derive impulse responses and error bands. While our model is relatively large and over-identified, a Bayesian Structural Vector autoregressive method, suggested by Sims and Zha (1999) and Waggoner and Zha (2000), can give a precise estimation of ${}_1\Gamma_0$. Furthermore, it can produce error bands whose possible asymmetries are justifiably interpreted as informative about asymmetry in the posterior distribution of the impulse responses.

The maximization of the marginal posterior density for the free coefficients in ${}_1\Gamma_0$ and the restrictions (30) can be obtained by taking a flat prior on B and Γ and using the same numerical optimization procedure in stage 1. The parameter estimates of γ_{ij} and the associated *t*-statistics are reported in table 2. The estimates are plausible, and most of them are significant at the 5 and 10 percent levels. I use these estimates and (31) to derive the coefficients, which are also represented in table 2. Most of the parameters are correctly signed and well determined.

The coefficients β_1 (=-.24), β_2 (=.23) and β_3 (=.24), respectively, measure the contemporaneous effects of the real shock, real exchange rate and real price of housing on inflation. The negative sign of β_1 suggests that ε_t^y may be interpreted as an aggregate supply shock that contemporaneously affects inflation. The estimated coefficients of output shocks β_5 (=.25) and β_6 (= -.65) suggest a plausible money demand relationship. The coefficient β_7 (=.05) is a reasonable estimate of the contemporaneous effect of the price of oil shock on money growth. The real exchange rate equation includes the coefficients β_{10} (= -.3), β_{11} (= -.34) and β_{12} (= 1.2) in which the first two coefficients imply that the positive shocks of oil price and output lead to a contemporaneous real appreciation and the last one implies that monetary expansion leads to a contemporaneous real depreciation, as would be expected.

The economic intuition for Iranian housing data are conveniently represented in the estimated parameters of the housing equations. The coefficients β_{13} (=.04), β_{14} (= -.005) and β_{15} (= -.001), respectively, measure the contemporaneous effects of income shock, user cost of capital and real price of housing on the real stock of housing. Note that the coefficient of the real price of housing is not significant at the 10 percent level. As discussed in Miles (1994) in an economy with binding quantitative restrictions imposed on borrowers, the stock of housing is no longer necessarily a decreasing function of the price of housing $(\beta_{15} \geq 0)$. The coefficients β_{16} (= 4.8) and β_{17} (= 1.3) show the significant contemporaneous effects of the interest rate and of the real construction cost on the real price of housing. Since the nominal interest rate is positively related to the inflation rate and negatively related to the real exchange rate $(1-\beta_8/\kappa = -.13)$ in (21), the positive response of house prices to the nominal interest rates may capture the effect of inflation risk premia in asset markets and the effect of the appreciation of the real exchange rate in foreign markets. And finally, the coefficient β_{18} (=.38) shows the positive effect of output shocks on the real construction cost.

Table 2: The Estimation of Parameters [a]

Coff.	γ_{21}	γ_{23}	γ_{25}	γ_{27}	γ_{31}	γ_{41}	γ_{42}	γ_{43}	γ_{45}	γ_{51}	γ_{52}	γ_{53}
	.06 (.02)	-.24 (.07)	.2 (.08)	.18 (.06)	.04 (.03)	-.01 (.01)	-.7 (.15)	.17 (.08)	.09 (.04)	-.09 (.05)	.9 (.4)	-.7 (.2)
Coff.	γ_{57} [b]	γ_{61} [b]	γ_{63}	γ_{65}	γ_{67}	γ_{71} [b]	γ_{72}	γ_{75} [b]	γ_{78}	γ_{81} [b]	γ_{83}	γ_{11}
	-.17	-.001	.04 (.01)	-.001 (.006)	-.001 (.004)	.03	4.8 (2.5)	-.66	1.3 (.54)	-.01	.38 (.18)	9.9 (.9)
Coff.	γ_{22}	γ_{33}	γ_{44}	γ_{55}	γ_{66}	γ_{77}	γ_{88}					
	72 (7)	46 (3.5)	73 (5.5)	28 (2.3)	516 (41)	14 (1.3)	29 (2.2)					
Coff.	β_1	β_2	β_3	β_4	β_5	β_6	β_7	β_8/κ	β_9/κ	β_{10}	β_{11}	β_{12}
	-.24	.23	.24	.04	.17	-.7	.05	1.13	.007	-.3	-.34	1.2
Coff.	β_{13}	β_{14}	β_{15}	β_{16}	β_{17}	β_{18}						
	.04	-.005	-.001	4.8	1.3	.38						

a The numbers in parentheses are standard errors.
b The parameters are indirectly calculated from cross restriction equations in (30).

5. Simulations

After identifying and estimating the SVAR, I estimated impulse response functions and variance decompositions for the eight variables in order to investigate the dynamic interactions among them. As mentioned in section 2, whilst the posterior function (8) is not in the form of any standard pdf, in order to generate error bands for the impulse responses I use a version of the random walk Metropolis algorithm for Markov Chain Monte Carlo (MMCMC). The algorithm uses the multivariate normal distribution for the jump distribution on changes in parameters in ${}_1\Gamma_0$. I first simulate 15000 draws using a diagonal covariance with diagonal entries .000001 in the jump distribution. These draws are then used to estimate the posterior covariance matrix of parameters ${}_1\Gamma_0$ and scale it by the factor to obtain an optimal covariance matrix for the jump distribution; see Gelman et al (2004).

5.1. Impulse responses

Responses of selected variables to a one-standardized-innovation in the world price of oil and the money supply with .84 flat-prior probability bands are shown in Fig. 2. A one-standard-deviation positive shock to the price of oil causes the real exchange rate to gradually start to appreciate. It reaches its minimum point (the maximum appreciation point) at 5 quarters and after that it reverts to its baseline in 14 quarters. The inflation response to the shock is negative. It declines to below its original steady state level and reaches its minimum point (by about -7%) at 2 quarters, then reverts to its baseline. Output reacts with a lag, rising above its original steady state (by about 0.3%) 5 quarters after the shock, then receding to zero.

The graph depicts a strong response of the price of housing following a positive shock to the price of oil. Immediately after the original shock, the price of housing reaches its maximum point (by about 4%), then gradually falls along this path to its steady-state level. The impact of the shock on the housing price is persistent after 14 quarters. The stock of housing increases sluggishly and permanently in response to the shock. The stock of housing reaches a steady-state level in above 10 quarters that is higher than its preshock value. All responses are statistically significant. Our results show how closely the responses accord with economic intuition. An increase in the price of oil through which the appreciation of real exchange rates leads to a price boom in the housing sector and stimulate residential investment in new dwellings.

The graph also shows that a shock to the price of oil induces a rise in the price of housing relative to the cost base of an average construction firm. Whereas the price of housing immediately increases following a positive shock to the price of oil, the construction cost starts its increases after a one-quarter lag and continues until it reaches its long run equilibrium. It can be seen from the graph that it takes approximately 14 quarters before the equilibrium ratio of house prices to construction costs is restored. It is worth noting that the sluggish upward adjustment of construction costs indicates a crucial role in restoring the equilibrium ratio of house prices to construction costs. This role might be attributed to land prices where supply is severely constrained due to a lack of available land for housing development. This result can be interpreted by a Tobin's Q effect that opens up an enhanced scope for earning profits in the house building sector due to stimulated residential investment in new dwellings.

The response of the selected variable to the credit expansion is shown in Fig. 2.

The impact of a credit shock on the real output is not statistically significant. The inflation response to the credit shock is positive, statistically significant and sizable in impact.

Housing prices increase in response to a positive credit shock, but only with a noticeably smaller magnitude when compared with the response to a positive oil price shock. The responses are statistically significant for about 10 quarters. These results are consistent with the view that credit expansion has an expansionary effect on house prices. However, a justifiable interpretation for these responses in Iran perhaps is the high inflation rate or the high inflation uncertainty associated with credit expansion, since, the housing market is generally perceived to provide a good hedge against future inflation.

Another channel for following the effect of credit expansion on the housing market is the real exchange rate channel. The impact of credit expansion is a significant depreciation of the real exchange rate. However, after the initial depreciation impact, the real exchange rate starts to appreciate quite quickly. This in turn can amplify the effect of credit expansion on housing prices.

5-2- Variance decompositions

As a final point of concern, tables 3 and 4 show the variance decompositions of the housing stock and the price of housing, respectively.

The variance decomposition of the housing stock is shown in table 3. The results indicate that 77% of variability in housing stock is attributable to its own shock at the peak. However, the influence of the shock reduces over time and accounts for less than 6% of the variance after 8 quarters. On the other hand, the shocks of oil price and construction costs become much more important with time and each of them accounts for more than a third of the housing stock variance after 2 years.

The credit shock contributes a moderate proportion of the variance in the short run(about 20% for the first year). The contribution of the shock, however, is negligible in the long run (about 8% after 2 years).

Table 4 shows that oil price and real exchange rate disturbances together contribute about 32 percent of housing price volatility after the initial year. This result again supports the hypothesis that oil price shocks bear significant responsibility for variability in the housing market in Iran’s economy. This may give us a preliminarily sense of the explanation for housing market fluctuations in other exporting countries in recent years.

The credit shock has a moderate effect on the price of housing. The credit disturbance contributes 11% of the variance at 4 quarters and 10% of the variance over the long run. The role of innovations in construction costs in explaining the variance of the price of housing is only 1% at one quarter. 12 quarters in the future however, the estimate becomes 10% and at 24 quarters, 25% of the variance is attributed to construction cost innovations. This result is consistent with the evidence of a Tobin's Q model of house prices, which indicates that house prices in the long run are determined by land prices and construction costs (Madson 2007).

Another important component of variability in the price of housing is explained by its own structural disturbance. Looking at the share of this in the housing price, it can be concluded that the changes in the current price play an important and persistent role in forming the expectation of house prices in the future.

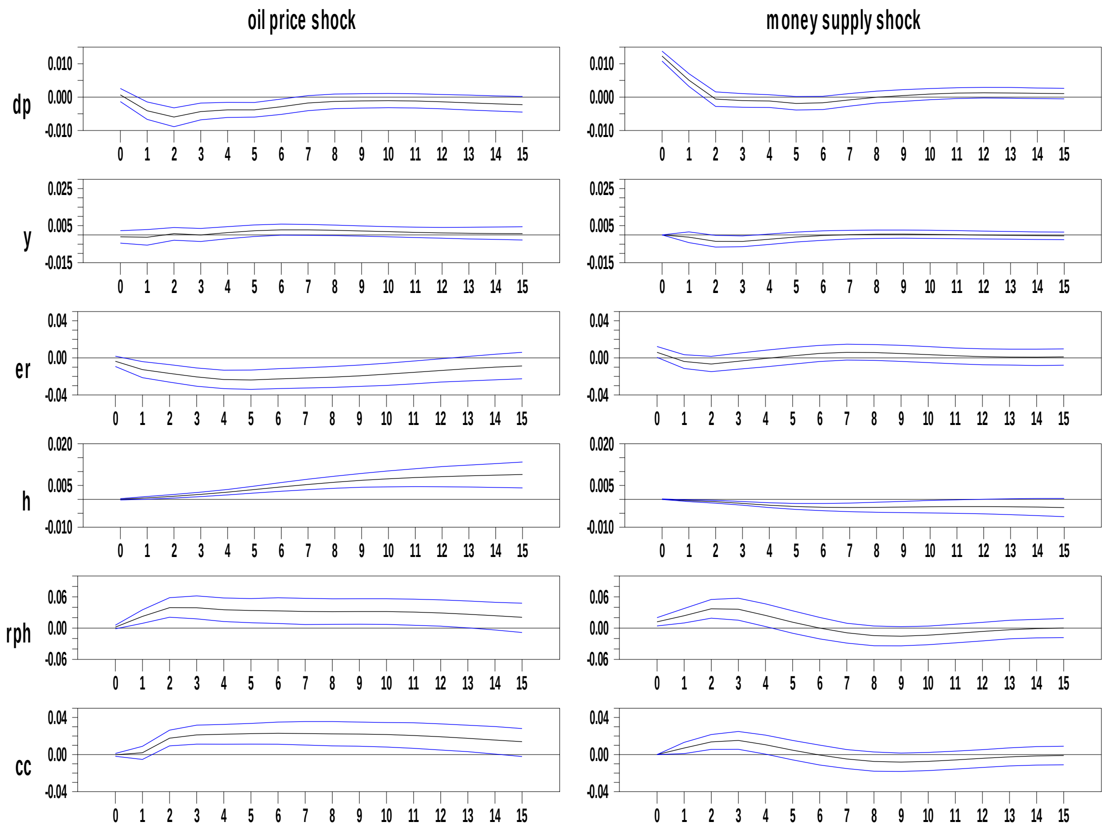

Fig.2.Impulse Responses of oil price and money supply shocks

Table 3: forecast error variance decomposition of h

Quarter	O	Δp	y	m-p	re	H	rph	Cc
1	0	14	4	0	2	77	0	0
4	12	20	14	7	14	28	1	5
8	32	17	7	7	15	6	1	16
12	40	10	2	4	12	2	2	27
16	40	8	2	3	10	1	2	34
20	38	7	2	3	10	1	2	39
24	38	7	1	3	9	1	2	39

Table 4: forecast error variance decomposition of rph

Quarter	o	Δp	Y	m-p	re	h	rph	cc
1	2	0	0	0	8	0	87	0
4	14	11	3	1	18	0	45	6
8	18	11	3	2	18	1	36	12
12	18	10	3	2	17	1	33	14
16	18	10	3	2	16	1	31	18
20	18	10	3	2	15	1	30	20
24	18	10	2	2	13	1	30	25

5-3- Robustness Checks

As pointed out in Stock and Watson (1996, 2001), impulse response functions in SVARs can be quite sensitive to changes in lag length, sample period and identification restrictions. I check the robustness of our model in each of the above three ways. Firstly, with the same identification restrictions, the impulse responses for 2, 4 and 5 lags are depicted in Fig.3. In contrast to the sensitivity of some VAR models to the lag length, the impulse responses to all variables have the same shape and very similar timing. Secondly, the sensitivity of the results with respect to the sample period is tested by estimating the model for 4 truncated samples. The sub-samples cover 1990:Q1-2006:Q4, 1993Q4-2006:Q4, 1988:Q1-2004Q4 and 1988-2002Q4 periods.[1] Fig.4, regarding these sub-samples and the full sample shows the impulse responses of the system variables with respect to oil price and money supply shocks. The general patterns of the responses in the sub-samples are the same as in the full sample and we don't observe a significant difference in sign and timing of the responses over all samples. Finally, I examine the robustness of our results to changes in the identifying restrictions of the model. I started the examination with two alternative sensible identifying restrictions. Firstly, I allowed the money shock to enter directly into the output equation in (16). Secondly, since builders construct houses relatively quickly, the cost of financing house construction may be contemporaneously related to the nominal interest rate (Mishkin 2007). To examine this hypothesis, I entered the nominal interest rate in the construction cost equation. These two alternative modeling choices alter the restrictions on γ_{ij} coefficients in (28) and cross restrictions (30). I illustrate these new identifications scheme as follow:

$$
{}_2\Gamma_0 = \begin{bmatrix}
\gamma_{11} & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
\gamma_{21} & \gamma_{22} & \gamma_{23} & 0 & \gamma_{25} & 0 & \gamma_{27} & 0 \\
\gamma_{31} & \gamma_{32} & \gamma_{33} & 0 & \gamma_{35} & 0 & \gamma_{37} & 0 \\
\gamma_{41} & \gamma_{42} & \gamma_{43} & \gamma_{44} & \gamma_{45} & 0 & 0 & 0 \\
\gamma_{51} & \gamma_{52} & \gamma_{53} & 0 & \gamma_{55} & 0 & \gamma_{57} & 0 \\
\gamma_{61} & 0 & \gamma_{63} & 0 & \gamma_{65} & \gamma_{66} & \gamma_{67} & 0 \\
\gamma_{71} & \gamma_{72} & 0 & 0 & \gamma_{75} & 0 & \gamma_{77} & \gamma_{78} \\
\gamma_{81} & 0 & \gamma_{83} & 0 & 0 & 0 & 0 & \gamma_{88}
\end{bmatrix}
\quad , \quad
\begin{aligned}
&\gamma_{35} = -\gamma_{25}\gamma_{32} \\
&\gamma_{57} = -\gamma_{52}\gamma_{27} \,; \\
&\gamma_{61} = -\gamma_{63}\gamma_{31} + \gamma_{65}(\gamma_{41} + \gamma_{43}\gamma_{31}) / \gamma_{45} \,; \\
&\gamma_{71} = \gamma_{72}(\gamma_{41} + \gamma_{43}\gamma_{31}) / \gamma_{42} - \gamma_{83}\gamma_{31} \,; \\
&\gamma_{75} = \gamma_{72}\gamma_{45} / \gamma_{42}; \\
&\gamma_{81} = -\gamma_{83}\gamma_{31} \\
&\gamma_{37} = -\gamma_{25}(\gamma_{27} /(1-\gamma_{25})\gamma_{32}.
\end{aligned}
$$

[1]-It is necessary to note that, the shorter sub-samples are not really practical because of the large number of parameters there are to estimate.

$$
{}_3\Gamma_0 = \begin{bmatrix} \gamma_{11} & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \gamma_{21} & \gamma_{22} & \gamma_{23} & 0 & \gamma_{25} & 0 & \gamma_{27} & 0 \\ \gamma_{31} & 0 & \gamma_{33} & 0 & 0 & 0 & 0 & 0 \\ \gamma_{41} & \gamma_{42} & \gamma_{43} & \gamma_{44} & \gamma_{45} & 0 & 0 & 0 \\ \gamma_{51} & \gamma_{52} & \gamma_{53} & 0 & \gamma_{55} & 0 & \gamma_{57} & 0 \\ \gamma_{61} & 0 & \gamma_{63} & 0 & \gamma_{65} & \gamma_{66} & \gamma_{67} & 0 \\ \gamma_{71} & \gamma_{72} & 0 & 0 & \gamma_{75} & 0 & \gamma_{77} & \gamma_{78} \\ \gamma_{81} & \gamma_{82} & \gamma_{83} & 0 & \gamma_{85} & 0 & 0 & \gamma_{88} \end{bmatrix}, \quad
\begin{aligned}
&\gamma_{57} = -\gamma_{52}\gamma_{27}\,; \\
&\gamma_{61} = -\gamma_{63}\gamma_{31} + \gamma_{65}(\gamma_{41} + \gamma_{43}\gamma_{31})/\gamma_{45}\,; \\
&\gamma_{71} = \gamma_{72}(\gamma_{41} + \gamma_{43}\gamma_{31})/\gamma_{42}\,; \\
&\gamma_{75} = \gamma_{72}\gamma_{45}/\gamma_{42}\,; \\
&\gamma_{81} = -\gamma_{83}\gamma_{31} + \gamma_{82}(\gamma_{41} + \gamma_{43}\gamma_{31})/\gamma_{45}\,; \\
&\gamma_{85} = \gamma_{72}\gamma_{45}/\gamma_{42}\,.
\end{aligned}
$$

To compare the above restriction schemes with our main restriction scheme in ${}_1\Gamma_0$, I utilized Bayesian model averaging (BMA) methods introduces by Garratt et al. (2007). Bayesian methods use the rules of conditional probability to make inference about unknown models given known data. If $Data$ is the data and there are k competing models, M_1, M_2 *and* M_3 presented by the matrix restriction schemes ${}_1\Gamma_0$, ${}_2\Gamma_0$ and ${}_3\Gamma_0$, then the posterior model probability can be given by:

$$
p(M_k \mid Data) = \frac{p(Data \mid M_k)\,p(M_k)}{\sum_{k=1}^{4} p(Data \mid M_k)\,p(M_k)}, \tag{18}
$$

where the marginal likelihood of the model is defined as

$$
p(Data \mid M_k) = \int p(Data \mid \varphi_k, M_k)\,p(\varphi_k \mid M_k)\,d\varphi_k\,.
$$

φ_k is a parameter vector that refers to Eq. (5) identified with ${}_k\Gamma_0$ restrictions. $p(Data \mid \varphi_k, M_k)$ and $p(\varphi_k \mid M_k)$ are the likelihood function and the prior density function of φ_k, respectively. In line with Garratt et al. (2007), I set a noninformative prior for $p(M_k)$ that is the same for all four SVAR models and use an asymptotic approximation to the marginal likelihood of form:

$$\log p(data \mid M_k) \propto l - \frac{K \log(T)}{2} \tag{19}$$

which was proposed by Schwarz (1978). Where l denotes the log of the likelihood function (6) evaluated at maximum likelihood estimates (MLE), K denotes the number of parameters in the model and T is the sample size. I calculate the posterior model probabilities in Eq.(18) by maximizing the likelihood function (6) based on the four restriction schemes ${}_k\Gamma_0$, k=1,2,3. The posterior model probabilities are reported in table (5). It emerges from Table 5 that our first identification schemes specified by the restrictions ${}_1\Gamma_0$ are best supported by the data in comparison with the other restrictions ${}_k\Gamma_0$, k=2, 3. I also derive the impulse responses of the model for the two alternative identification schemes. The results of the responses turn out to be consistent with our earlier results and do not affect the qualitative nature of our results in general[1].

[1] -I also checked the robustness of the model to different definitions of some variables. For example, I substituted the multilateral real exchange rate (measured based on the weighted wholesale price index of trading partners and the consumer price index for the home country) for the bilateral real exchange rate with and M1 for M2. None of these robustness checks altered the patterns of the impulse responses.

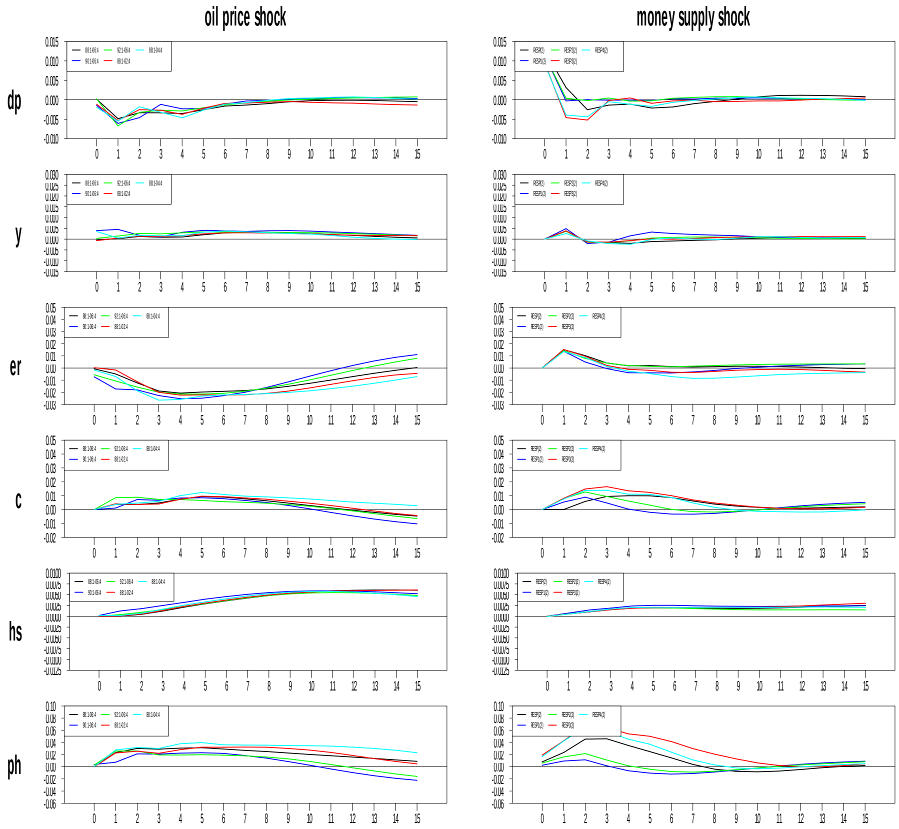

Fig.3.Impulse Responses of oil price and money supply shocks

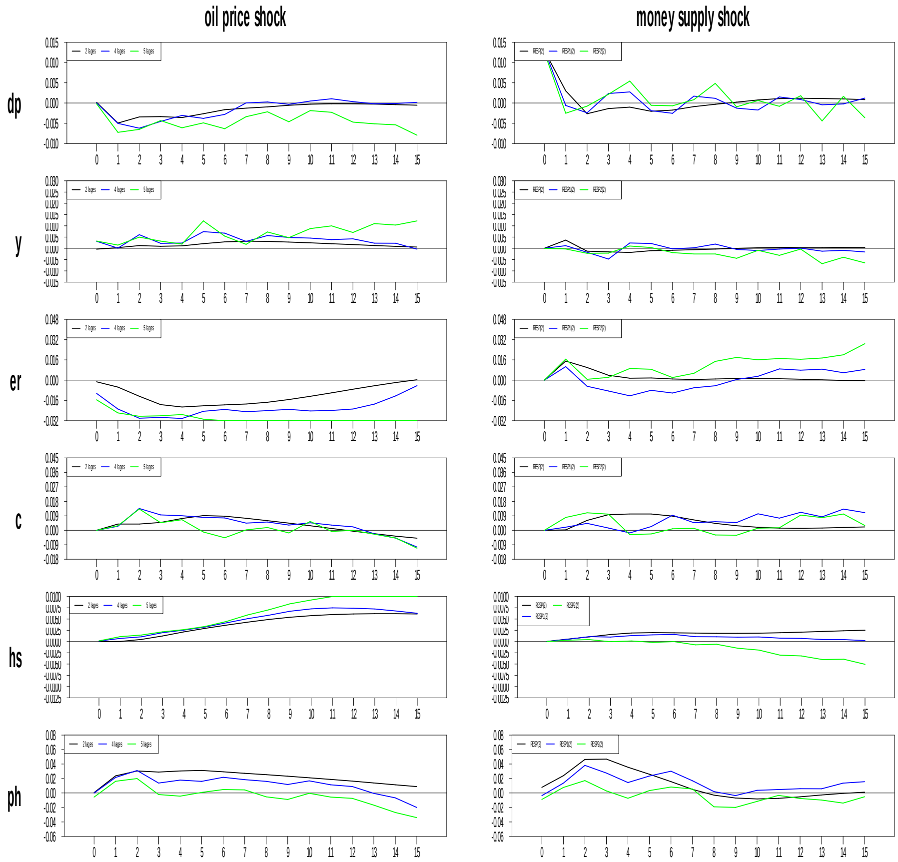

Fig.4.Impulse Responses of oil price and money supply shocks

Table 5: Posterior Model Probability

Identification scheme	${}_1\Gamma_0$	${}_2\Gamma_0$	${}_3\Gamma_0$
Probability	**.73**	.2	.1

Note: The most probable value is shown in bold.

6. Concluding remarks

The overall objective of this study is to identify the channels for the transmission of oil price and credit shocks to the housing sector in oil-exporting countries. As representative for these countries, I focused on Iran's economy and studied the behavior of the housing sector in response to oil price and money supply shocks. I set up a SVAR model with eight variables. The prior information for identification was derived based on economic theory proposed in the housing, money, foreign asset and goods markets. In order to draw accurate inferences regarding the effectiveness of the shocks in an over-identified Bayesian structural VAR, I applied a Bayesian Monte Carlo integration method introduced by Sims and Zha (1999) and Waggoner and Zha (2000).

The findings indicate that an oil price shock explains a substantial part of housing market fluctuations. I find that the oil price operating via the real exchange rate channel, has a crucial role in determining the behavior of house prices and the volume of the housing stock over time. This result is consistent with Dutch Disease stylized facts for an oil-exporting country.

Our result also confirms the hypothesis of Tobin's Q in the Iranian housing market. While the equilibrium ratio of house prices to construction costs is restored in the long run, it follows a different behavior in response to an oil price shock in the short run. House prices immediately jump up to a new equilibrium whereas construction costs show a sluggish upward adjustment behavior in reaching equilibrium.

Credit expansion is another important shock in explaining a part of housing market fluctuations, particularly in the short run. Housing prices increase in response to a positive credit shock, but only with a noticeably smaller magnitude when compared with the responses of these to a positive oil price shock.

Finally, while some recent studies in housing economics emphasize the important role of land prices and construction costs as long run determinants of house prices (Madson 2007) , the results of this paper indicate that the oil price - along with the variables above - is another important variable in determining the long run behavior of real housing prices in an oil-exporting country.

Appendix A:

The sample period starts in 1988:1 because the Central Bank of Iran started to publish quarterly national account data in1988.

o_t: World price of oil deflated by using the U.S.'s consumer price index (1996=100).

m_t: Money supply M_2 deflated by Iran's consumer price index (the Central Bank of Iran).

Δp_t: Inflation rate measured by Iran's CPI.

y_t: Gross domestic product at 1996 price, (Quarterly National Accounts, the Central Bank of Iran).

er_t: Bilateral real exchange rate vis-a-vis the US dollar (its' increase leads to the depreciation of the Rial versus the U.S. dollar). The indicator was calculated by dividing nominal exchange rate (based on the market rate) to Iranian CPI (the Central Bank of Iran).

cc_t : Construction cost index was calculated by weighting together the housing building cost index published by the Central Bank of Iran and an index of the price of land per housing unit taken from Ministry of Housing and Urban Development of Iran. The composite index is deflated by Iran's CPI.

h_t: Housing stock that was computed using data on housing completions published by the Central Bank of Iran. The measure was calculated using the perpetual inventory methodology assuming a constant annual rate of housing depletion of 5% per annum.

rph_t : Housing price deflated by Iran's CPI. The housing price was taken from the Ministry of Housing and Urban Development of Iran.

p_t^c : Iran's Consumer Price Index (Central Bank of Iran).

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