A Structural Vector Auto-Regression Model of The Indonesian Economy

Siwage Dharma Negara

Abstract

This paper attempts to model the Indonesian economy using a structural Vector Auto-Regression framework. The objective of the paper is to build a model which can capture the dynamics of most of the important macroeconomic variables in the Indonesian economy. The structure of the model explicitly defines the inter-relationship between the Indonesian economy and the world economy. The fit of the model is evaluated based on its prediction about the effects of a monetary policy shock on the macroeconomic variables. In addition, the model is also evaluated on its prediction about the effect of an oil price shock on the Indonesian economy. The model is able to produce some reasonable predictions about the effects of monetary policy and oil price shock on the economy. The choice of sample period and treatment for structural breaks in the data are important for the model to produce reasonable dynamics of price and exchange rate variables with regard to the two types of shock.

Keywords: Structural VAR, Block Exogeneity, Monetary Policy, Exchange Rate, Oil Price
JEL classification: C32, E52, F31,F41
1. INTRODUCTION

Since Sims (1980) seminal paper on a Vector Auto-Regression (VAR) model, there are a great number of papers produced taking advantage of VAR's simplicity and its capacity to produce reasonable outcomes. As argued in Sims' paper, VAR model allow one to avoid "too much a priori assumptions" about the working of the economy. The model allows all variables in the system to be endogenous. And since the model is data driven, it reduces the likelihood of misspecification bias (see Sims 1980).

However, VAR models per se often do not have a solid economic interpretation. Bernanke (1986) and Sims (1986) proposed to add some structure to the VAR models. The structure is added in the form of the restrictions which can be interpreted based on economic intuition. Arguably, the so called structural VAR models have some advantages for modeling the economy, among others:

1. the structural VAR models are quite flexible, in the sense that they don’t require strong restrictions about the form of technology and preferences of the economic agents;
2. the structural VAR models make use of economic theories to construct the econometric equations, hence they can be used to test certain theories; and
3. arguably structural VAR models are relatively more powerful for forecasting compared with other macro models such as Dynamic Stochastic General Equilibrium (DSGE) models (see Sims 1986).

In Indonesia, however, this structural VAR methodology is still under developed. One of the reasons is that structural VAR models require a relatively long time series data in order to provide a reliable prediction. This paper aims to build a structural VAR model for the Indonesian economy. The structure of the model is constructed in such a way so that it can capture the characteristic of a small open economy.

Two influential papers on structural VAR application to a small open economy were written by Cushman and Zha (1997) and Kim and Roubini (2000). The two papers were meant to remedy puzzling dynamic responses of some macroeconomic variables following monetary policy shocks. It is commonly found in the VAR literature that a tight monetary policy in the form of an increase in the short term interest rate lead to an increase in price level or inflation rate, which named as the price puzzle.
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(see Sims 1992). Furthermore this tight monetary policy often produces an instant depreciation of domestic exchange rate, which then recognized in the literature as the exchange rate puzzle (Sims 1992).

Cushman and Zha (1997) and Kim and Roubini (2000) proposed ways to solve these price and exchange rate puzzles. They argue that, in a small open economy model, one has to model how monetary policy relates to the exchange rate movement. The latter was shown to be the transmission mechanism of monetary policy shocks to the price dynamic. Cushman and Zha applied their structural VAR model to the Canadian data. Their structural restrictions in both the contemporaneous and lagged relationship in the system were the novel contribution to the literature and they were able to solve the price and exchange rate puzzles.

Kim and Roubini (2000) applied their structural VAR model to a bigger set of small open economies. They covered six developed countries, namely Germany, Japan, the U.K., France, Italy, and Canada. They argued that the use of a non-recursive contemporaneous restrictions in their system was able to solve the price and the exchange rate puzzles.

Later, Brischetto and Voss (1999) extended the Kim and Roubini's structural VAR model to the Australian economy. Brischetto and Voss argued that for a small open economy like Australia, one needs to model the inter-relationships among the domestic interest rate, the foreign interest rate and the nominal exchange rate. They stated that correct specification of these three variables is important for solving the price and exchange rate puzzles.

This paper modifies and applies Brischetto and Voss (1999) model to the Indonesian economy. There are a number of reasons why this structural VAR model can possibly be applied to the Indonesian economy. First, the model (including its predecessor) has been tested in several small open economies. No one can argue that the Indonesian economy shares similar characteristics of the other small open economies under studies. Second, another thing in common is that the monetary authority in Indonesia also uses the short term interest rate (BI rate) as a monetary policy instrument in order to control the inflation rate.

All of the structural VAR models mentioned above attempted to identify the monetary policy rule in a small open economy. Specifically, they tried to model the inter-relationship between monetary policy instruments with other macroeconomic variables in particular with the exchange rate. It is a big challenge to specify the monetary policy rule in
Indonesia since it is not quite straightforward. The monetary authority may behave differently in response to different economic shocks. However, despite this challenge in modeling the policy rule of the monetary authority, it is interesting to see how this type of structural VAR model can be applied to the Indonesian economy.

Like in every modeling project, the ultimate objective is to build a model which can mimic the dynamics of most of the important macroeconomic variables in the Indonesian economy. Therefore, to test whether the model has succeeded in capturing the work of the economy, the model was evaluated based on its predictions about the effect of monetary policy and oil price shocks (separately) in the Indonesian economy.

The outline of this paper is as follows. Section 2 briefly reviews the framework of the VAR model and how one can impose structural restrictions in the model. Section 2 also discusses the choice of variables and the identification of the structural shocks of the model. Section 3 discusses the data and several treatments to the data before it is used in the estimation. Still in this section, I discuss some of the findings and the stability of the parameter estimates of the model. Section 4 concludes.

2. THE MODEL

2.1. VAR framework

The VAR model can be written as follows

$$Y_t = B_1 Y_{t-1} + B_2 Y_{t-2} + \ldots + B_p Y_{t-p} + u_t$$

where $Y_t$ is the vector of the endogenous variables, $E[u_t u_t'] = V$ and $u_t$ is not correlated with past values of $Y_t$. This VAR model can be estimated equation by equation using OLS in order to obtain the coefficients of $[B_j]_{i,j}$. The variance-covariance matrix $V$ can be calculated from the sample residuals using

$$V = (1/T) \sum u_t u_t'$$

For analytical purposes, the object of interest is the independent structural shocks. However, $u_t$ cannot measure these shocks due to the correlation between each elements of $u_t$. In order to back out these
structural shocks, one needs to specify an explicit relationship (represented by matrix $A_o$) between the VAR residuals $u_t$ and the structural shocks $e_t$ such that

$$A_o u_t = e_t$$  \hspace{1cm} (3)$$

Multiplying both sides of equation (1) with matrix $A_o$, one can write the VAR model above as follows

$$A_o Y_t = A_o B_1 (Y_{t-1}) + A_o B_2 (Y_{t-2}) + ... + A_o B_J (Y_{t-J}) + e_t$$ \hspace{1cm} (4)$$

Now one needs to identify matrix $A_o$ in order to calculate the impulse responses. Initially, the common strategy is to use a recursive assumption, in which the matrix $A_o^{-1}$ is made a lower triangular matrix such that

$$A_o = (A_o ^T)^{-1} V$$ \hspace{1cm} (5)$$

This method is called Choleski's decomposition (Sims 1980).

However as explained in Bernanke (1986) and Sims (1986), the Choleski's decomposition is nested within a more general restriction. An alternative and more general approach is to assume that there are enough zero restrictions such that there is only one unique matrix $A_o$, which solve equation (5). Bernanke (1986) and Sims (1986) proposed to link the restrictions in matrix $A_o$ with the economic intuitions/theories thus putting structure to the VAR model (they called it structural VAR).

Having identified the restrictions in matrix $A_o$, one can now compute the impulse responses. Multiplying both sides of equation (4) with $A_o^{-1}$, one obtain

$$Y_t = B_1 (Y_{t-1}) + B_2 (Y_{t-2}) + ... + B_J (Y_{t-J}) + A_o^{-1} e_t$$ \hspace{1cm} (6)$$

The first period impulse response of the endogenous variables with respect to shock to the $j$-th structural disturbance is

$$\Phi_j(1) = A_o^{-1} e_{tj}$$
the second period impulse response is
\[ \Phi(2) = B_1 \alpha - \epsilon \]
the third period impulse response is
\[ \Phi(3) = B_1 B_2 \alpha - \epsilon + B_2 \alpha - \epsilon \]
Plotting the values of \( \Phi(T) \) against \( T \) is useful in order to analyze the behavior of the endogenous variables in response to shocks.

In a small open economy case, the variables in the VAR model can be grouped into two blocks, separating foreign variables and domestic variables. In this case, the vector \( Y_t \) can be written as:

\[ Y_t = \begin{bmatrix} Y_t^f & Y_t^d \end{bmatrix} \]

where \( Y_t^f \) and \( Y_t^d \) denote the vector of the foreign and domestic variables, respectively. Meanwhile, matrix \( B_j \) can then be partitioned with respect to \( Y_t \) such that

\[ B_j = \begin{bmatrix} B_{11} & B_{12} \\ B_{21} & B_{22} \end{bmatrix} \]

for \( j=0,1,2,\ldots,J \). In some papers, they use restriction such that \( B_{12} = 0 \) for \( j=0,1,2,\ldots,J \). In this case, the foreign variables contained in \( Y_t^f \) are assumed to be block exogenous with respect to the domestic variables in \( Y_t^d \).

Using the partition vectors and matrices, equation (6) can be written as follows

\[
\begin{bmatrix} Y_t^f \\ Y_t^d \end{bmatrix} = \begin{bmatrix} B_{11} & B_{12} \\ B_{21} & B_{22} \end{bmatrix} \begin{bmatrix} Y_{t-1}^f \\ Y_{t-1}^d \end{bmatrix} + \begin{bmatrix} B_{11} & B_{12} \\ B_{21} & B_{22} \end{bmatrix} \begin{bmatrix} Y_{t-2}^f \\ Y_{t-2}^d \end{bmatrix} + \ldots + \begin{bmatrix} B_{11} & B_{12} \\ B_{21} & B_{22} \end{bmatrix} \begin{bmatrix} Y_{t-j}^f \\ Y_{t-j}^d \end{bmatrix} + A_0 \epsilon_t \ldots (9)
\]
One can then test this block exogeneity restriction by using the likelihood ratio test as follows

\[(T-c)(\log |\Sigma_r| - \log |\Sigma_u|)\]

where \(T\) is the number of observations, \(c\) is the number of parameters estimated in each equation of the unrestricted system, \(\log |\Sigma_r|\) is the log of the determinant of the variance and covariance matrix of the residuals from the restricted model, and \(\log |\Sigma_u|\) is the log of the determinant of the variance and covariance matrix of the residuals from the unrestricted model. This statistic has a \(\chi^2\) distribution with degrees of freedom equal to the number of restrictions.

2.2. Variables

The structural VAR model of the Indonesian economy is constructed by considering two important features of the economy. First, it is explicitly designed to account for the stylized facts of the Indonesian economy, such as its dependency on oil and commodity exports. Second, it explicitly models the inter-relationship between the world output, the international monetary policy and the domestic economy.

There are seven variables chosen to represent the economy. Of course, it is desirable to include more variables in the system like the model in Dungey and Pagan (2000), in which they have eleven variables in their model. However, due to the data limitation, each additional variable will quickly consume the degrees of freedom.

The choice of the variables in the system followed several previous structural VAR models, which incorporate both foreign and domestic sectors. In general, the framework of the model is very similar to Brischetto and Voss (1999) model. The Brischetto and Voss model consists of seven variables, representing foreign variables (oil price, the US Federal Funds Rate) and domestic variables (real GDP, CPI, monetary aggregate, nominal interest rate, bilateral exchange rate between the US and Australia).

In the structural VAR model of Indonesia, there are three foreign variables; 1) the oil price (OIL), which is chosen as it affects the Indonesian economy through fluctuations in foreign prices that directly affect domestic production and consumption; 2) the US interest rate
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(USR), which represents the world interest rate. This variable captures changes in the world capital markets. Since Indonesia has an open capital market, changes in the world interest rate directly affect the domestic capital market, which in turn affect domestic investment and output; 3) Export (EXP), which is important variable given Indonesia’s position as a commodity exporting country.

In addition to the three foreign variables, the structural VAR model of Indonesia has four domestic variables commonly used in the structural VAR models for a small open economy. These variables are the real GDP (GDP), the inflation rate (INF), the domestic interest rate (INDR) and the exchange rate (XCH).

It is important to note several main differences with regard to the choice of the variables in the structural VAR model of Indonesia compared to the Brischetto and Voss (1999) structural VAR model. First, for the Indonesian economy, oil price is an important variable as it determines the behavior of the other macroeconomic variables. Shocks in the price of oil will be transmitted to the cost of production and the price level in general. Therefore, the inclusion of this variable is important in order to reflect the inflationary pressure from the world market. However, Brischetto and Voss found in the case of the Australian economy, both the oil price and the monetary aggregate are not significant variables in their system, excluding these two variables can still produce similar dynamics without the price and the exchange rate puzzles.

Second, another main difference is the inclusion of export in the structural VAR model of Indonesia. As a commodity exporting countries, export plays an important role in determining the fluctuations in the Indonesian economy. The inclusion of export variable is in line with the Dungey and Pagan (2000) structural VAR model.

Finally, the structural VAR model of Indonesia uses the inflation rate rather than the CPI variable. The choice of the inflation rate instead of the CPI is based on the idea that the Central Bank targets the former rather than the latter. This is similar to Dungey and Pagan (2000) and Berkelmans (2005), who argue that many Central Banks set the inflation rate as their target rather than the price level itself. In Indonesia, the short term interest rate is widely believed to be the main instrument of the monetary policy since the floating of the Indonesian rupiah in the late of 1997.
2.3. Identification

The variables are ordered as follows; oil price (OIL), the US interest rate (USR), export (EXP), real GDP (GDP), the inflation rate (INF), the interest rate (INDR), and the Indonesian - US exchange rate (XCH), hence

\[ Y_t' = [\text{OIL}_t, \text{USR}_t, \text{EXP}_t, \text{GDP}_t, \text{INF}_t, \text{INDR}_t, \text{XCH}_t]' \]

In order to identify the structural shocks from the data, I set restrictions on the coefficients of the contemporaneous matrix (matrix \( A_0 \) of equation 3). In general, the restrictions imposed still keep a recursive structure.

\[
\begin{bmatrix}
\varepsilon_{\text{oll}} \\
\varepsilon_{\text{usr}} \\
\varepsilon_{\text{exp}} \\
\varepsilon_{\text{gdp}} \\
\varepsilon_{\text{inf}} \\
\varepsilon_{\text{indr}} \\
\varepsilon_{\text{xch}}
\end{bmatrix} =
\begin{bmatrix}
1 & 0 & 0 & 0 & 0 & 0 & 0 \\
a_{(2,1)} & 1 & 0 & 0 & 0 & 0 & 0 \\
a_{(3,1)} & a_{(3,2)} & 1 & 0 & 0 & 0 & 0 \\
a_{(4,1)} & a_{(4,2)} & a_{(4,3)} & 1 & 0 & 0 & 0 \\
a_{(5,1)} & 0 & 0 & a_{(5,4)} & 1 & 0 & 0 \\
a_{(6,1)} & a_{(6,2)} & 0 & 0 & a_{(6,5)} & 1 & 0 \\
a_{(7,1)} & a_{(7,2)} & a_{(7,3)} & 0 & a_{(7,5)} & a_{(7,6)} & 1
\end{bmatrix}
\begin{bmatrix}
u_{\text{oll}} \\
u_{\text{usr}} \\
u_{\text{exp}} \\
u_{\text{gdp}} \\
u_{\text{inf}} \\
u_{\text{indr}} \\
u_{\text{xch}}
\end{bmatrix}
\tag{10}
\]

\( a_{ij} \) denotes the contemporaneous effect of variable \( j \) on variable \( i \) (for instance \( a_{(7,1)} \) is the contemporaneous effect of oil price on the exchange rate). The diagonal coefficients are normalized to one and the zero entries are the restrictions imposed on the contemporaneous link between two variables.

The first four rows of matrix \( A_0 \) assume a recursive structure with the ordering, OIL, USR, EXP, and GDP. Domestic output (GDP) is assumed to be affected contemporaneously by oil price, the US interest rate and export. The fifth row is the inflation rate (INF) equation, which represent a Phillips curve specification as in most modern models. As such it does not include the interest rates directly as this is not a measure of inflationary pressure. The interest rate affects on the inflation rate through its effect on output, therefore it has no direct effect on inflation. The inflation rate is affected contemporaneously by oil price and output. It is useful to consider an individual equation of the model in detailed to
make the notation in equation (10) more obvious. For instance, the inflation rate equation can be written explicitly as follows

\[ \text{INF}_t = a_{(5,1)} OIL_t + a_{(5,2)} GDP_t + A_1 Y_{t-1} + ... + A_p Y_{t-p} + u_{\text{INF}_t} \]

The other equations of the system can be similarly expanded.

The interest rate (INDR) equation is commonly viewed as the policy reaction function for the monetary authority. It is affected contemporaneously by oil price, the US interest rate and the inflation rate. This is different from the Brischetto and Voss model specification, in which they assume that the exchange rate may affect the interest rate as well. The exclusion of export and domestic output from the policy reaction function of the monetary authority is often justified by the information lag with respect to these variables. Information about export and output are often not available at the time the Central Bank wants to set the interest rate.

The exchange rate (XCH) is affected contemporaneously by all the variables in the system except output. The exclusion of output from the exchange rate equation again is justified on the ground of the information lag. Unlike Dungey and Pagan (2000), who argue that the exchange rate does not react to export at all, I assume that since export is internationally affected, it may have an impact on the exchange rate to some degree.

Furthermore, following Joiner (2001), I assume that there is a lagged effect of the change in the interest rate on the economy, in particular on output and the inflation rate. It is assumed that a monetary policy shock in the form of an increase in the short term interest rate can affect output only after two quarters. This is in line with Dungey and Pagan (2000), in which the interest rate shock has a lagged effect on aggregate demand and aggregate output. However, they assume that the interest rate has no effect at all on the inflation rate. In their specification, the interest rate affects the inflation rate indirectly through the aggregate demand. In the specification proposed above (see matrix A_{q}), I assume that the interest rate has a semi-direct effect on the inflation rate, i.e., after one quarter of the shock.

\[ 1 \quad \text{Brischetto and Voss (1999) and Dungey and Pagan (2000) are among others who use this information lag in the policy reaction function of the central bank.} \]
Finally, the model assumes a small open economy case. This assumption implies a block exogeneity restriction such that the variables in the domestic block have no effects whatsoever to the variables in the foreign block. Equation (9) can then be written as

\[ Y_f = B_f Y_f + B_k Y_k + \ldots + + A_i \epsilon_t \] (11)

This is a similar strategy followed by Cushman and Zha (1997) and Dungey and Pagan (2000). The model can be estimated equation by equation using OLS in GAUSS 7.0\(^2\).

Now, the system is clearly over-identified since there are more restrictions in the contemporaneous matrix than are needed to just identify the system. The over-identifying restriction test cannot reject the null, which means the restrictions are not rejected.

3. ESTIMATION AND RESULTS

3.1. Data

The model is estimated using the Indonesian quarterly data over two samples period. The first sample covers period 1990:Q1 - 2007:Q2 (70 observations). The other sample covers period 1997:Q1 - 2007:Q2 (42 observations). These two different samples period are chosen in order to test the stability of the prediction of the model in regard to a structural break during the period of the financial crisis in the 1997. The lag length for the structural VAR model is three. The choice about the lag length is taken as a compromise between the need for degrees of freedom and the need for lag structure. Given the relatively small number of observation, the choice of three lags is justified as adequate.

All variables are in natural logarithms with the exceptions of the inflation rate and the interest rate. The source of the data is the International Financial Statistics. For further detail of the data see the Appendix: Data.

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\(^2\) I am grateful to Mardi Dungey for providing her GAUSS program and data in order to estimate the SVAR model in Dungey and Pagan (2000) paper. The code used in this paper is a modified version of Dungey’s version.
Inspecting the data in Figure 1, one can see that variables such as oil price, export and real GDP show a clear deterministic trend. It is reasonable to remove the trend from these variables before the estimation. By detrending these variables, practically one is interested in measuring deviation of the variable such as output from its long run potential. This may arguably be interpreted as measure of output gap in the economy. The latter is important according to Giordani (2004) in order to solve the price puzzle in the structural VAR model.

Figure 1
Plot of macroeconomic data used in the estimation
1990:Q1-2007:Q2
Another characteristic of the data that may possibly cause instability in the estimation of the model is the presence of structural breaks. This can be seen in the real GDP which experiences downward shifts both in the level and the growth rate during the period of the financial crisis. In this case, simple detrending per se may not produce a stable system. Characterizing this structural break in the GDP data is necessary in order to render stability to the model.

Structural break has also characterized the interest rate and exchange rate data. In Indonesia, the monetary policy has experienced a significant change in the beginning of 2000. Previously, it has no clear target regarding the direction of any economic variables. In 2000, the monetary policy is explicitly targeted to control the inflation rate. I use a deterministic dummy variable to capture this regime change in the interest rate and the inflation rate data.

Similarly, the exchange rate also experienced a change in regime in the mid of 1997, the managed floating exchange regime was replaced by a free-floating exchange rate arrangement. I use a deterministic dummy variable to capture this regime change in the exchange rate data, i.e., before and after the free floating of the Indonesian rupiah.

3.2. A monetary policy shock

The model is evaluated based on the impulse responses with regard to a one standard deviation shock to the short term interest rate. It is assumed that the Central Bank uses the interest rate as a policy variable in order to achieve its ultimate target, the inflation rate. Brischetto and Voss (1999) argued that at a minimum a VAR model that includes a monetary authority's reaction function should have no price and exchange rate puzzles.

The model is stable as none of the eigenvalues of the companion matrix is greater than one in absolute value. It is important to note that the stability of the model is sensitive to the treatment of the data before the estimation. In this case, oil price, export and GDP are all detrended (assuming these variables are stationary around a deterministic trend).

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3 Stability of the model is achieved if none of the eigenvalues of the companion matrix is greater than one in absolute value. Practically, a stable model produces impulse responses, which are converging to zero in the long run (non explosive system). I do not perform the standard unit root ADF and PP test in the data for reason of low power of these tests against the significant alternative hypothesis (see Maddala and Kim 1998, pp. 81-92).
Different stationary inducing method such as differencing may produce different results. In this paper, however, the object of interest is in the level of output not the growth rate of output.

It is important to note that the inflation rate and the interest rate have a deterministic dummy allowing for a structural break in the period of the financial crisis. Meanwhile, the exchange rate has a deterministic dummy allowing for a structural change after the exchange rate regime switch to a free floating regime.

Figure 2 presents the point estimates of the impulse response functions of output, the inflation rate and the exchange rate to a one standard deviation shock to the interest rate.

The solid line represents the impulse response from the sample period 1997:Q1 - 2007:Q2 (hereafter "sample 1") while the dotted line represents the impulse response from the sample period 1990:Q1 - 2007:Q2 (hereafter "sample 2").

The standard error bands for the impulse responses are not shown. The reason is that due to small samples, the classical standard error bands are inaccurate and unreliable. Kilian (1999) shows that the accuracy of standard error bands in small samples is poor and erratic. He finds that for reasonable coverage accuracy at least 500 observations are needed for the symmetric percentile-t interval. Furthermore, Kilian (1998) points out that small sample performance of confidence interval bands in a large dimensional VAR is unknown. Brischetto and Voss (1999) showed, for Australian data, these bands were very wide due to the problem of small samples. They argue that the focus should be on the point estimates because they represent the response of the model to shocks.
In general, the model produces quite sensible dynamics of aggregate output in regard to a monetary policy shock in the form of an increase in the interest rate. The first panel of Figure 2 shows that GDP decreases after the interest rate increased. Intuitively, when a monetary policy is contracted, i.e., the central bank increases the short term interest rate, the increase in the interest rate will increase the cost of investment. As the level of investment decreases, aggregate demand and output are expected to decrease.

The effect of an increase in the interest rate on the inflation rate, however, is not quite in line with the theory. The second panel of Figure 2 shows that an increase in the interest rate lowers the inflation rate only in the first quarter after the shock. However, sample 1 (1997:Q1 - 2007:Q2) cannot produce a lower inflation rate in the subsequent quarters.

Meanwhile sample 2 (1990:Q1 - 2007:Q2) can produce a lower inflation rate in the sixth quarter after the shock. The problem is that this lower inflation rate is preceded by a much higher inflation in the third quarter after the shock. In view of this result, the model still suffers from
the price puzzle. It may be the case that the interest rate equation does not represent the monetary policy rule in Indonesia. In other words, interest rate is not a good measure of policy variable in the monetary policy. It is interesting to see whether different monetary policy instrument, such as base money, may produce different impulse responses.

Sample 1 (1997:Q1 - 2007:Q2) produces reasonable prediction about the effect of a monetary policy shock on the exchange rate. Intuitively, an increase in the domestic interest rate leads to an appreciation of the domestic exchange rate in the short run. Subsequently, the domestic exchange rate will depreciate such that interest rate parity holds. Sample 1 produces an appreciation of the exchange rate right after the shock in the interest rate. This appreciation however, is reverted by depreciation after the fifth quarter. Sample 2 (1990:Q1 - 2007:Q2), however, produces an initial depreciation followed by an appreciation after the monetary policy contraction, which is contrary to the theory. The result is problematic since most studies (see Brischetto and Voss (1999), Dungey and Pagan (2000), Berkelmans (2005)), all find that an interest rate shock produces an instantaneous domestic exchange rate appreciation.

3.3. An oil price shock

It is useful to test the model in other dimension. In this section, the model is evaluated on whether it can produce a reasonable prediction about the recent oil price shock. Figure 3 and 4 show the effect of a one standard deviation shock to the oil price. The solid line represents the impulse response from the sub sample 1997:Q1 - 2007:Q2 (sample 1) while the dotted line represents the impulse response from the full sample 1990:Q1 - 2007:Q2 (sample 2).

The two sample periods produces quite different dynamics of aggregate output in regard to an oil price shock. The first panel of Figure 3 shows that GDP increases then decreases after an oil price shock in sample 1 (1997:Q1 - 2007:Q2). However, sample 2 (1997:Q1 - 2007:Q2) produces a different dynamics, in which GDP increases persistently after the oil price shock. Intuitively, when the oil price increases the revenue from the oil export increases. This intuition is confirmed by the last panel of Figure 3, i.e. export increases. At the same time, the cost of production increases as a result of the oil price shock. This may reduce the growth rate of output through less investment and less consumption. The net effect of these two conflicting effects is not clear. In this case different sample period produces a different result.
The effect of an increase in the oil price on the inflation rate can be seen in the first panel of Figure 4. The inflation rate increases after the oil price shock about fourth to fifth quarter after the shock, which is consistent with an increase in the cost of production.

Finally, the last panel of Figure 4 shows the effect of an increase in the oil price on the exchange rate. Intuitively, if Indonesia is an oil exporting country, Indonesia should experience an appreciation of its currency due to an increase in the oil price. However, the two sample periods produce a different story. In general, an increase in the oil price leads to a depreciation of the domestic exchange rate. Sample 1 (1997:Q1 - 2007:Q2) produces an initial appreciation of the exchange rate right after the shock in the oil price. This appreciation however, is reverted quickly by depreciation in the subsequent quarters and reach maximum after the fourth quarter. In contrast, sample 2 (1990:Q1 - 2007:Q2) produces a depreciation of the domestic currency following an oil price shock. This result suggests that Indonesia is likely to be an oil importer than oil exporter country.
Figure 3
The effects of an oil price shock on output and export

Poil shock on gdp

Poil shock on xp
4. CONCLUSION

The paper has shown an application of a structural VAR model to the Indonesian economy. From the impulse response analysis, it can be seen that different sample period produces different dynamics of the model. In general, using sample 1 (1997:Q1 - 2007:Q2), the model produces a more reasonable predictions about the working of the economy than that out of sample 2 (1990:Q1 - 2007:Q2). This can be partly explained that the longer sample period (sample 2) may have some significant structural breaks remaining.
This exercise has shown that a structural VAR model can in fact be applied to the Indonesian economy and produces reasonable predictions about the working of the economy with respect to both a monetary policy shock and an oil price shock. However, there are scopes for improvement. It would be interesting to see the effect of other type of monetary policy variable such as a shock to the base money to the economy. As the result suggests, the short term interest rate is not enough to rid the model of the prize puzzle. Further extensions to the model can also be taken by incorporating a role of financial variables in the economy. It is widely recognized that the financial market and the real sector are somehow connected. How to make use of this information from the financial market remains an open issue.

Appendix: Data

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Mnemonic</th>
</tr>
</thead>
<tbody>
<tr>
<td>OIL</td>
<td>World price of oil in US dollar per barrel</td>
<td>00176AAZZF...</td>
</tr>
<tr>
<td>USR</td>
<td>Federal Funds Rate</td>
<td>11160B.ZF...</td>
</tr>
<tr>
<td>XP</td>
<td>Exports FOB - Goods &amp; Services</td>
<td>53678AADZF...</td>
</tr>
<tr>
<td>GDP</td>
<td>Real GDP</td>
<td>53664...ZF...</td>
</tr>
<tr>
<td>INF</td>
<td>Rate of change of the CPI</td>
<td>53660B.ZF...</td>
</tr>
<tr>
<td>INDR</td>
<td>Call money rate</td>
<td>536..RF.ZF...</td>
</tr>
<tr>
<td>XCH</td>
<td>US dollar rate in Ind. rupiah (average)</td>
<td>536...ZF...</td>
</tr>
</tbody>
</table>

Source: The International Financial Statistics online resources.
REFERENCES


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