

Decomposing Sources of Inflation

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Abstract

This paper aims to decompose the source of inflation in Thailand into cost-push, demand-pull, and inflation expectations to provide insights to the inflation dynamics and its implications to the monetary policy in Thailand. Cost-push inflation is mainly temporary while those of demand-pull and inflation expectations are more persistent, and it is viewed that monetary policy should not tackle temporary price instabilities from the supply side. Moreover, as the decomposition will allow the obtainment of the structural shocks to inflation; further study is made on monetary policy setting with regards to the three shocks, to see which types has the monetary policy committee (MPC) gave importance to tackle. The analysis will reflect whether policy making in Thailand is right along the lines of the theoretical frameworks. The paper found that the majority of inflationary pressure in Thailand is driven by supply and inflation expectations shocks, and the movements of monetary policy instrument is better explained by these two types of instabilities over demand shocks.

1 Introduction

Under inflation targeting regime, the central bank conducts monetary policy to balance between inflationary pressure and economic growth. Concerning price fluctuations, the source of instabilities have implications to policy setting. Hence, a central bank that aims to conduct effective monetary policy must comprehend with what is hidden behind the inflation shocks.

Many discussions regarding the decomposition of inflation source center on two types of phenomena, cost-push and demand-pull. However, another factor that plays a major role in determining the inflation level is inflation expectations, as said by Mishkin (2007), Bernanke (2007), and Clark and Davig (2008). Therefore, the aim of this paper is to decompose the source of inflation in Thailand into cost-push, demand-pull, and inflation expectations shocks to better understand the country's inflation characteristics.

Cost-push inflation refers to the rise in price level stemming from supply-side factors instabilities. For example, surges in oil price, wage, and agricultural product price can lead to surges in inflation. This type of instability does not last long, and the monetary policy should not aim to tackle temporary instabilities. Reacting to short term fluctuations would create excessive volatility in the economy, let alone the delayed effect of the monetary policy. Demand-pull inflation refers to surges in price originating from the aggregate demand. The gradual but persistent effect of demand-pull inflation favors the monetary policy's response to curb it when necessary. Lastly, inflation expectations are the public perception of the future rate of inflation. According to Macallan and Taylor (2011), expectations can have considerable impact on the actual inflation through wage-price setting mechanism. Rise in expectations could lead to workers asking for higher wage that is passed onto the price level, and monetary policy plays a role in anchoring inflation expectations through keeping inflation in tact in order to achieve price stability.

With regards to the role of monetary policy, this paper will also examine the Bank of Thailand's policy actions toward each type of shocks; whether the central bank, in practice, has acted to curb the type of inflation in accordance with the theory. The results of this analysis should give insight on practical policymaking in Thailand.

The rest of the paper is organized as follows. Section 2 introduces the literatures on decomposing sources of inflation and the hypothesis. Section 3 describes this paper's methodology and the results of the decomposition. Section 4 examines the Bank of Thailand's monetary policy actions with regards to the inflation shocks obtained from Section 3. Section 5 explains some limitations and robustness of the model. Lastly, Section 6 concludes.

2 Literature Review and Hypothesis

The existing literatures on determining the sources of inflation have adopted varied approaches. A group of works focused on the monetarist approach which exerts that inflation is related to the rate of change of the money supply in excess of the rate of increase of the domestic output, such as that of Barth and Bennett (1975), Saini (1982), and Bahmani-Oskooee (1995). Specifically, Barth and Bennett (1975) focused on the causality direction between price level and the money supply to segregate cost-push and demand pull inflation for United States in post World War II. Following Sims (1972), the test for unidirectional causality was applied and found that the inflation was primarily demand-pulled.

Another group of literature including Mio (2002) and Wehinger (2000) constructed Vector Auto Regression (VAR) models along the lines of the IS/LM or the AD/AS framework. In the work by Wehinger (2000) to decompose the inflation in Europe, United States, and Japan, a VAR was constructed with energy prices, aggregate supply, aggregate demand, wage setting behavior, exchange rate, and money market variables, each representing different types of shocks to inflation. A long run restriction as introduced by Blanchard and Quah (1989) was used to identify structural shocks and variance decomposition was applied to quantify the effect of each shock to inflation.

Regarding a work on Thailand's inflation, according to Sittichaiviset, Khemongkorn, and Atipong (2012), the inflation during 2003-2011 were dominated by supply and expectations shocks. Their analysis was based on ordinary least squares method applied on the New Keynesian Phillips Curve framework. Price level was the dependent variable and related proxies for supply, demand, inflation expectations, and exchange rate were the independent variables. The coefficients of the independent variables were analyzed to arrive at the contribution of each shock to the inflation pressure.

The majority of existing literatures focused on decomposing inflation into two phenomena, cost-push and demand-pull, neglecting the expectations component. Although the work by Sittichaiviset, Khemongkorn, and Atipong (2012) paid attention to inflation expectations, the model was restrained under the New Keynesian Phillips Curve structure. In addition, the variables under study could have been endogenously related. For example, inflation may internally affect the demand variable in subsequent periods, adopting a VAR approach would allow the relationships to be more freely expressed. This paper follows the method by Kilian (2008) in decomposing the source of crude oil price shocks. In the paper, crude oil price was decomposed into oil supply shocks, aggregate demand shocks, and oil-specific demand shocks using VAR with Cholesky Decomposition. This method, when adapted for inflation will allow for the adoption of three series of supply, demand, and expectations shocks that can be used for further study.

It is hypothesized that the decomposition shows timeline of structural shocks corresponding to significant historical events that could lead to the occurrence of them. Least explanation is expected of inflation expectations shocks due to the difficult nature of how they are formed (Macallan and Taylor 2011). From previous findings, there is a possibility to see the dominance of supply and inflation expectations shocks over demand.

3 Decomposing Inflation Source

3.1 Data and Methodology

3.1.1 Structural Vector Auto Regression (SVAR) and Vector Auto Regression (VAR)

To decompose inflation source, the main aim is to obtain residuals of the Structural Vector Auto Regression (SVAR) that will represent the three shocks to inflation. Here is the framework regarding SVAR that forms the foundation for this paper's methodology.

Consider a three-variable SVAR based on monthly data from March 2002 to January 2014 for crude oil index, private investment index, and consumer price index. The study aims to start since the adoption of inflation targeting in May 2000, however the horizon is shortened due to some data limitations. Crude oil index is the average of 3 spot prices, Dated Brent, West Texas Intermediate, and Dubai Fateh. Oil Index is used to represent external supply shocks, which for

Thailand, according to Khemangkorn, Mallikamas, and Sutthasri (2008) are dominated by fluctuations in oil price. Private investment index is used as a proxy for demand pressure. Lastly, consumer price index represents the economy's inflation. All variables are estimated in yearly percentage change on monthly data with three lags as the optimum. The SVAR representation is:

$$\begin{aligned} b_{11}X_t &= a_{10} + b_{12}Y_t + b_{13}Z_t + c_{11}X_{t-1} + c_{12}Y_{t-1} + c_{13}Z_{t-1} + \dots + e_{11}X_{t-3} + e_{12}Y_{t-3} + e_{13}Z_{t-3} + \varepsilon_1 \\ b_{22}Y_t &= a_{20} + b_{21}X_t + b_{23}Z_t + c_{21}X_{t-1} + c_{22}Y_{t-1} + c_{23}Z_{t-1} + \dots + e_{21}X_{t-3} + e_{22}Y_{t-3} + e_{23}Z_{t-3} + \varepsilon_2 \\ b_{33}Z_t &= a_{30} + b_{31}X_t + b_{32}Y_t + c_{31}X_{t-1} + c_{32}Y_{t-1} + c_{33}Z_{t-1} + \dots + e_{31}X_{t-3} + e_{32}Y_{t-3} + e_{33}Z_{t-3} + \varepsilon_3 \end{aligned} \quad (1)$$

X, Y, and Z represent crude oil index, private investment index, and inflation rate respectively. ε_1 captures supply shocks, ε_2 demand, and ε_3 inflation expectations shocks; the intuition is explained in detail in the model identification section. However, since the error terms would be correlated to the endogenous variable contemporaneously (Enders 2010), a reduced form VAR must be estimated first, and then through model identification, the SVAR can be obtained. Consider the relationship between SVAR and VAR:

$$A_0X_t = B_0 + B_1X_{t-1} + B_2X_{t-2} + B_3X_{t-3} + \varepsilon_t \quad (2)$$

From (1) the contemporaneous terms are moved to the left hand side and the SVAR can be written in matrix form as shown in (2). A_0 is a matrix of the coefficients of the contemporaneous terms. $x_t, x_{t-1}, x_{t-2}, x_{t-3}$ are vectors of the endogenous variables at different lags. B_0 is a vector of constants, B_1, B_2 , and B_3 are matrices of coefficients of the first, second, and third lag terms. Pre multiplication by A_0^{-1} across all terms in (2) allows for the relationship in reduced form VAR:

$$x_t = C_0 + C_1x_{t-1} + C_2x_{t-2} + C_3x_{t-3} + e_t \quad (3)$$

Where $C_0 = A_0^{-1}B_0$, $C_1 = A_0^{-1}B_1$, $C_2 = A_0^{-1}B_2$, $C_3 = A_0^{-1}B_3$, $e_t = A_0^{-1}\varepsilon_t$

3.1.2 Model Identification

Focusing on the relationship of the error terms, $e_t = A_0^{-1}\varepsilon_t$, since the estimation must start from the reduced VAR, once the reduced form is estimated, one can obtain the structural errors by estimating matrix A_0^{-1} and multiplying its inverse with reduced VAR errors, e_t . To estimate A_0^{-1} , from Enders (2010), $(n^2-n)/2$ restrictions are needed where n is number of variables. The paper adopts Cholesky Decomposition, a lower triangular matrix, as shown in (4). With regards to the model and variables adopted in this paper, the restriction of A_0^{-1} has the following implications:

$$e_t = \begin{pmatrix} e^{\text{oil price}} \\ e^{\text{PII}} \\ e^{\text{Inflation}} \end{pmatrix} = \begin{pmatrix} X & 0 & 0 \\ X & X & 0 \\ X & X & X \end{pmatrix} \begin{pmatrix} \varepsilon^{\text{Supply Shocks}} \\ \varepsilon^{\text{Demand Shocks}} \\ \varepsilon^{\text{Expectations Shocks}} \end{pmatrix} \quad (4)$$

From (2), matrix A_0^{-1} represents the inverse of the coefficients matrix of contemporaneous terms of the variables in the model. Putting restriction on A_0^{-1} restrains the contemporaneous relationship between the variables to be orthogonal. Specifically, oil index is allowed to affect private investment index and inflation. Private investment index is allowed to affect inflation. However, inflation does not affect private investment index, and both variables do not affect oil index in the same period. **Because of this restriction, it can be interpreted that structural shocks to oil index represent supply shocks (ε_1). Innovations to private investment that cannot be explained by oil index would represent demand shocks (ε_2), since expectations shock do not affect private investment in the same period. Lastly, innovations to inflation that cannot be explained by oil price and private investment would represent the remaining shock, inflation expectations (ε_3).**

The intuition behind the restriction of A_0^{-1} is as follows: Supply shocks in this study are defined to be externally originated and unpredictable, therefore in the same period; crude oil index does not respond to private investment index and inflation. Private investment index does not respond to increases in inflation arising from inflation expectations shock in the same period because according to Macallan and Taylor (2011) it requires a degree of persistence to change individuals' behavior that could possibly lead to the change in investment. Finally, since the price level in an economy at a particular time is determined by three shocks, inflation is assumed to be affected by all, supply, demand, and inflation expectations shocks.

3.2 Empirical Results

Figure 1 in the appendix plots the timeline of the three shocks obtained from the model expressed as quarterly averaged for readability. From 2004 until the beginning of 2008 there were continuous supply shocks coinciding with Hurricane Katrina in the US in 2005Q2, North Korea's Missile Launch in 2006Q3, and tensions in East Turkey in 2007Q4, all contributed to the oil price hike. In 2010, the rapid growing Chinese economy has put upward pressure on the

demand for oil pushing up the price. The cases in point for demand shocks are the fiscal expansion in the beginning of 2010 following the Global Financial Crisis, and in 2012 when the government employed the first car tax rebate regime and minimum wage hike. According to Clark and Davig (2008), inflation expectations respond to a range of variables including past inflation, the state of the economy, and monetary policy actions. As Macallan and Taylor (2011) pointed out, economic agents may be rational and form expectations based on all available information, or, individuals may have their own simpler ways such as assuming inflation tomorrow will be the same as inflation today or yesterday (Brazier, Harrison, King & Yates, 2008). This leads to the difficulty in reconciling with the expectation shocks. Plotting inflation with expectations shocks obtained show some degree of co movement, however disparities remain for other factors to explain the expectations.

Variance decomposition of inflation reports around 52% attributed to supply shocks, 1% to demand, and 47% to inflation expectations. Although the rather low percentage of demand shocks could be due to the adoption of private investment index as the proxy for aggregate demand, the analysis confirms the previous finding by Sittichaiviset, Khemongkorn, and Atipong (2012) that the two major shocks driving the economy are supply and inflation expectations shocks, while demand shocks play a minor role.

4 Monetary Policy

4.1 Model and Methodology

This section test whether MPC has tackled just demand and inflation expectations shocks. The three shocks obtained from previous analysis are utilized as independent variables in an OLS regression with the policy interest rate as the dependent variable. Other factors that may influence the policy rate are included to control for the results. Consider the following regression:

$$\Delta i = \alpha + \beta_1 \Delta i_{t-1} + \beta_2 YGAP_{t-1} + \beta_3 \Delta ER_{t-1} + \beta_4 \Delta UNEMP_{t-1} + \beta_5 Z_t + \beta_6 Z_{t-1} + \beta_7 Z_{t-2} + \beta_8 D \quad (5)$$

All variables are stationary in first difference apart from output gap and the shocks variables, Z , which are stationary in levels. The model is run on monthly data to match the frequency of the shocks obtained. The period observed is March 2002-January 2014.

The policy rate before 16 January 2007 was 14-day repurchase rate but was later changed to one-day repurchase rate. The data used is adjusted for this change and it is in yearly differenced. The lagged policy rate is included to represent instrument smoothing as seen in Mohanty and Klau (2004), McCauley and Klau(2006), and Mehrotra and Sanchez-Fung (2011). Manufacturing production index is used to proxy gross domestic product. Its gap is calculated as the percentage difference of the default series and a trend series constructed using Hodrick-Prescott Filter as used by Mehrotra & Sanchez-Fung (2011). The exchange rate adopted is the nominal effective exchange rate. An increase means appreciation, and it is in yearly growth, as well as the rate of unemployment. The dummy variable D is included to control for the 1% drop in the policy rate during the Global Financial Crisis.

Model (5) is experimented to be the optimum regression. It is found that there is a backward looking characteristic of the central bank. The intuition is the fact that policy makers may not be able to observe all the variables influencing the policy at the time it is made. For the shocks variables, it is found that two lags is optimal with the contemporaneous terms found to be important as well.

The model is estimated with each shock series substituted as the independent variable and the significance of $\beta_5 - \beta_7$ between the estimation of each shock is observed to show the importance of each of them in influencing the movement of the monetary policy.

The expected signs of the coefficients are positive for β_1 and β_2 . β_3 and β_4 are expected to be negative. For β_3 , increase in nominal effective exchange rate means the exchange rate has appreciated. The appreciation would affect exports in a negative manner, calling for an economic stimulation. Finally, the hypothesis expects to find some significance for demand and inflation expectations shocks in explaining the movements of the policy rate, in which case the relationship should be positive.

4.2 Empirical Results

Table 1

Z \	c	Δi_{t-1}	$YGAP_{t-1}$	ΔER_{t-1}	$\Delta UNEMP_{t-1}$	Z	Z_{t-1}	Z_{t-2}	D1
Supply	-17.054*** (4.941)	0.962*** (0.019)	0.015*** (0.003)	-0.190*** (0.055)	-0.001 (0.001)	0.037* (0.020)	0.051** (0.020)	0.015 (0.020)	-0.752*** (0.228)
Demand	-15.988*** (5.334)	0.957*** (0.021)	0.015*** (0.004)	-0.178*** (0.059)	-0.002* (0.001)	0.007 (0.020)	-0.021 (0.020)	0.010 (0.020)	-0.775*** (0.229)
Expectations	-16.391*** (5.137)	0.955*** (0.020)	0.014*** (0.003)	-0.182*** (0.057)	-0.002* (0.001)	0.006 (0.020)	0.018 (0.020)	0.043** (0.020)	-0.729*** (0.230)

*, **, *** represents significance at 10%, 5% and 1%, respectively
Standard Errors are presented in parentheses

All estimations are free of autocorrelation, heteroscedasticity, and multicollinearity problem. The significant coefficients have the expected sign. In general, first, the results show importance of instrument smoothing. This coincides with previous work by McCauley and Klau (2006) in estimating Taylor's Rule in Thailand. The coefficients for the lagged policy rate are almost 1 and all significant at 1%. The output gap shows small effect on the policy rate, although are highly significant. Nominal effective exchange rate is found to be important in policy setting with the coefficients of almost -0.2. The unemployment rate has very little influence on policy setting and is only slightly significant in two of the three estimations. Focusing on the shocks variables, surprisingly, the supply shocks equation reveals significance contemporaneously and in one lag, with the coefficient of 0.037 and 0.051 while demand shocks have no significant relationship with policy setting. Finally, as expected, expectations shock is found to have significant positive influence on the policy rate but in two periods after, with the coefficient of 0.043.

The results show that policy setting in the case of Thailand could divert from the theoretical frameworks. Possible reason for why the MPC may react to supply shocks in this manner, according to Inflation Report (2006), is that when the shocks occur in the economy with strong demand, they could lead to the increase in wage demanded by strong labor unions. If so, the economy could end up in a wage price spiral. The higher wage could in turn leads to higher inflation. As described in Wide-angled Economic-Monetary Policy Group (2008), labor unions in Thailand are rather strong, strengthening the possibility of the wage-price spiral phenomena.

Furthermore, recent supply shocks, such as that of 2010, originate from the increase in oil demand. Unlike most historical oil price shocks which were due to production cuts, those due to demand could be more long lasting. This change in nature of the oil price could call for a tightening monetary policy and possibly explain the stronger and more significant effect on the policy rate compared to other types of shocks. The result suggests the need for further studies of the supply side to better understand the inflation implications to the monetary policy.

Although it was expected that MPC should tackle demand shocks, its insignificance could be the result of low contribution of demand shocks to the inflation pressure as shown in variance decomposition. In which case, it could be hard to find relationship with the policy instrument.

Unsurprisingly, expectations shocks are treated by the monetary policy. From Macallan and Taylor (2011), increases in inflation expectations can contribute to having more persistent levels of inflation. Therefore, central banks try to keep inflation expectations anchored by having inflation under control through monetary policy. A possible reason why it is found that MPC may respond stronger and faster to supply shocks than expectations is the supply's aggressive and obvious nature when compared to the subtle behavior of inflation expectations.

5 Limitations and Robustness

The exceptionally low demand shocks in variance decomposition of inflation could have been due to a flaw of private investment index as a proxy for demand. Many literatures have used gross domestic product (GDP) to proxy this factor. However, the need to estimate VAR on monthly data to observe shocks in highest frequency has led to the adoption of private investment index which is available monthly. Private consumption index has been considered, however, it is stationary in second difference, manipulating the data as such would have low economic implications. The remaining components of aggregate demand, government spending and net exports, intuitively reflect intermittent stimulus and the external economy, and so do not stand to compete with investment index in representing domestic demand. Despite this limitation, the results support previous work that the main shocks to inflation in Thailand are supply and expectations shocks, not demand.

To check for robustness of the VAR model, Mio (2002) has examined other alternative lags of the VAR. Therefore, model (1) has been estimated with 6,8,12 lags included as well and the results show similar structure of the shocks decomposed, variance decomposition, and same conclusion of the response of monetary policy as when 3 lags were adopted.

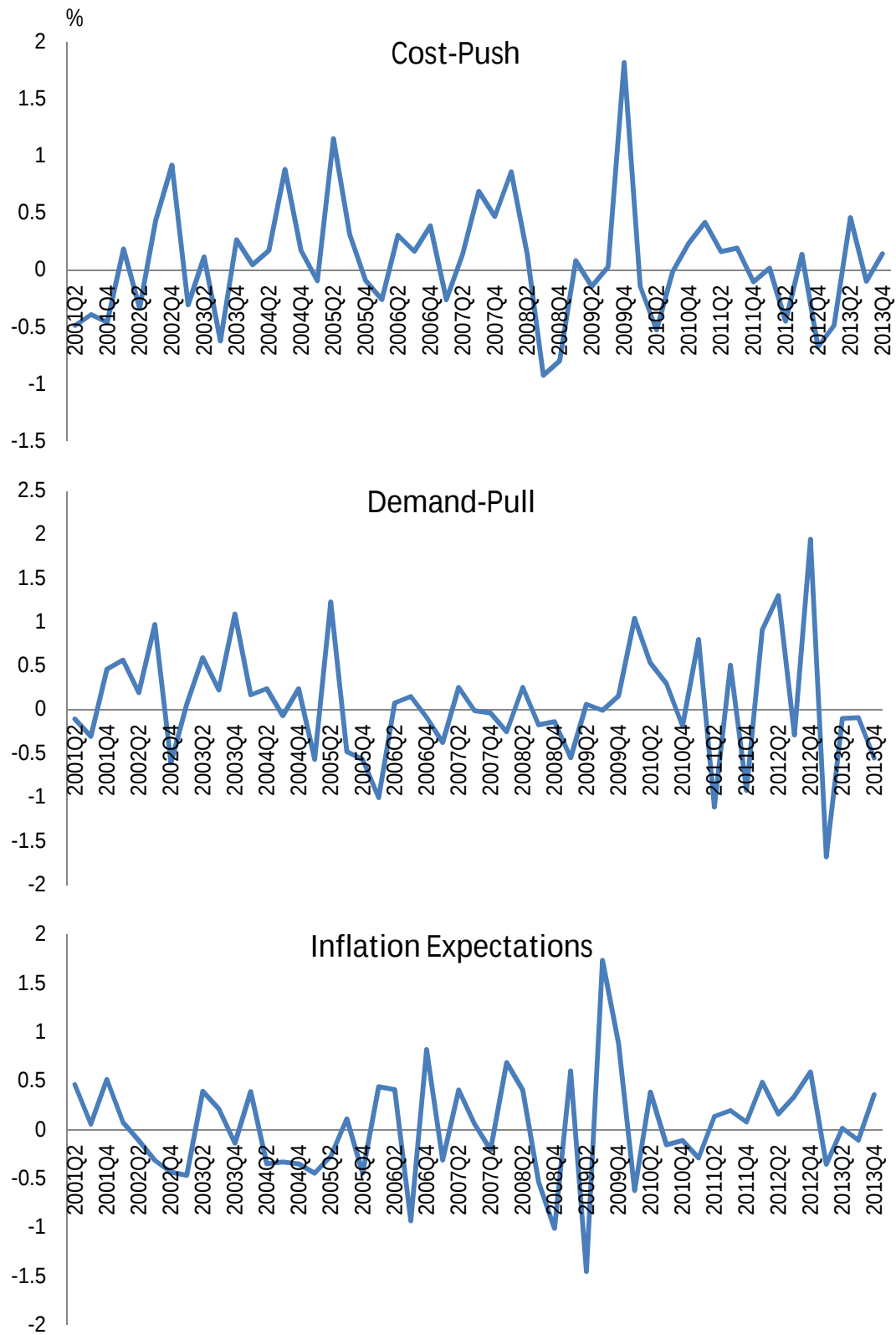
For the study on monetary policy, other control variables that have been considered for model (5) include business sentiment index, terms of trade, capital account, financial account, and the federal funds rate. Industrial production index for United States and China were also experimented. These variables were left out due their lack of influence on the results.

6 Conclusion

The three shocks to inflation, supply, demand, and inflation expectations are decomposed in this paper. Further analysis is made regarding the behavior of the MPC towards these shocks. First, the decomposed series of shocks are generally consistent with the historical incidents for both supply and demand side and shows main shocks in inflation expectations in 2009 and 2011-2012. Moreover, it has been found that the majority of surges in inflation in Thailand are from supply and inflation expectations shocks.

The results for the monetary policy analysis suggest that policy setting has responded to supply shocks and expectations shocks over demand. The possible reason for this finding could be because supply shocks may trigger the increase in wage demanded by strong labor unions that could ultimately lead to wage price spiral. Furthermore, recent supply shocks originate from the increase in world crude oil demand which is rather persistent compared to crude oil price shocks originating from production cuts. Both reasons would lead to the worsening of inflation conditions, therefore, the monetary policy may want to tackle supply shocks. This finding is also suggestive of the need for further analysis of the supply side to better understand the inflation implications to the monetary policy. Surprisingly, demand shocks were not significant; a possible explanation is the low contribution of demand-pulled inflation in Thailand. Finally, the importance of expectations shock to policy setting was found as expected. Unanchored expectations will take effect on raising inflation persistence and any action to put inflation back to target must be exemplified, therefore, MPC may try to keep expectations in tight by maintaining low inflation with the appropriate policy stance.

Appendix 1 : Figure 1



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