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THE DETERMINANT OF CORE INFLATION IN INDONESIA

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ABSTRACT

This paper analyzes factors affecting core inflation in Indonesia. Using quarterly data, we argue that after economic crisis in 1997/1998, core inflation is significantly affected by backward-looking expectation (its lag), forward-looking expectation (consensus forecast), output gap, exchange rate (growth and volatility), and the growth of M1. Comparing to the whole sample (1992-2011), the role of lag of core inflation becomes more significant, exchange rate pass-through is smaller, and the impact of volatility of exchange rate is bigger after the crisis. Employing MV filter method, we find an output gap threshold. Econometric model shows that the role of BI rate to reduce core inflation is limited.
Using ARDL model and monthly data (year-on-year) from January 2002 to June 2011, we find that administered price inflation and volatile food inflation, to some extent, have an effect on the dynamic of core inflation. In general, the effect of volatile foods group on core inflation is bigger than the effect of administered prices group. Some commodities in administered prices basket have significant impact on core inflation, such as fuel, intercity transportation, household fuel, and telephone charge. Some commodities in volatile foods basket also have significant impact on core inflation, such as rice, beef, milk, noodles, and cooking oil.

Paper ini menganalisis faktor-faktor yang mempengaruhi core inflation *di Indonesia. Dengan menggunakan model OLS dan data triwulanan (qtoq), kami berargumen bahwa pada periode setelah krisis ekonomi tahun 1997/1998,* core inflation *dipengaruhi oleh* core inflation *masa lalu (*backward-looking*), ekspektasi inflasi* (consensus forecast)*,* output gap*, nilai tukar (perubahan dan tingkat volatilitasnya), dan pertumbuhan M1. Dibandingkan dengan* whole sample *(1992-2011), pada periode setelah krisis ekonomi peran* output gap *menjadi signifikan,* pass-through *nilai tukar berkurang, dan peran volatilitas nilai tukar menjadi lebih besar. Dengan menggunakan* output gap MV filter*, ditemukan adanya* threshold output gap *setelah periode krisis. Sementara itu, peran BI rate dalam menurunkan* core inflation *relative terbatas.*
Dengan menggunakan model ARDL dan data bulanan (yoy) dari Januari 2002 s.d. Juni 2011, kami berargumen bahwa pergerakan administered price inflation *dan* volatile food inflation *mempengaruhi pergerakan* core inflation *di Indonesia. Secara umum, dampak kenaikan* volatile foods *lebih besar dibandingkan dampak kenaikan* administered price *terhadap* core inflation*. Beberapa komoditas* administered price *yang berdampak signifikan terhadap* core inflation *adalah bensin, angkutan dalam kota, bahan bakar rumah tangga, dan tarif telepon. Sementara beberapa komoditas* volatile foods *yang berdampak signifikan terhadap* core inflation *adalah beras, daging sapi, susu, mie, dan minyak goreng.*

1. INTRODUCTION

Since inflation targeting framework was explicitly adopted by Bank Indonesia in 2005, attention of the central bank towards inflation has been dominant. Understanding the transmission mechanism as well as inflation is crucial in policy formulation and decision making process. One important aspect is the knowledge of inflation determinants and their relative contribution from time to time.

In the literature, core inflation is more relevant to monetary policy than headline inflation since core inflation is more persistent and has lower volatility. It is well accepted that monetary policy has more ability in controlling core inflation than headline inflation. Price shocks are usually originated from commodities which price is regulated by government (administered prices) and from raw food commodities due to disaster or crops failure. While demand shocks are usually rarely happened, at least for the case of Indonesia.

Based on its composition, the CPI basket consists of 774 commodities in which 60 commodities are part of volatile foods (18.69%), 21 commodities are part of administered prices (17.67%), and 669 commodities are part of core CPI (63.64%). Even though commodities in the volatile foods and in the administered prices are different with those in the core, both volatile foods and administered prices affect core inflation through: (i) commodities that being used as input for other commodities (second round effect), and or (ii) inflation expectations. For example, hike on fuel price in 2005 and 2008 had increased core inflation as high as 9.7% and 8.3%.

Studies on the measurement of core inflation have been conducted in Bank Indonesia since 2000. Various methods with their advantages and disadvantages have been reviewed. Although the previous studies have mentioned that the trim-mean method is the most robust, but the calculation of core inflation by exclusion method is the one used by Bank Indonesia. The most important reason why this exclusion method is chosen is because of its practicality and ease of communication to stakeholders. Moreover, the calculation of core inflation with this method carried out by Statistics Indonesia (BPS), so that the central bank will not be considered as cheating in determining monetary policy. The opposite is true if the trim-mean method is used where only central bank can measure.

Wimanda et al. (2010) examined the characteristics of headline inflation nationally and regionally. In their study, they summarize the results of previous studies on inflation and correlate it with the level and the horizon of inflation target of Bank Indonesia. To complete the study, this paper is intended to investigate further the behavior of core inflation. Specifically, this study tries to answer the following questions:

1. What factors affect core inflation? Do exchange rate, output gap and inflation expectations have a role in determining the dynamic of core inflation? Do the output growth gap, growth of money (M1) and exchange rate volatility also have a role?
2. Is there a threshold on the effect of output gap on core inflation?
3. How much is the impact of an increase in BI rate to the decline in core inflation?
4. Do the movement of administered prices and volatile foods influence core inflation? Which commodities among those groups have the greatest impact?

This paper will be written on following chapter. Chapter 2 describes the literature review of Phillips curve. Chapter 3 describes the methodology and data to be used. Chapter 4 analyzes the findings. And finally, chapter 5 closes with concluding remarks.

2. LITERATURE REVIEW

Started by Gali and Gertler (1999), many researchers support and estimate the hybrid closed-economy NKPC. In this hybrid version, inflation is not only influenced by marginal cost and expectations of inflation, but also by past inflation.

$$\pi_t = \lambda_b \pi_{t-1} + \lambda_f E_t\{\pi_{t+1}\} + \beta x_t. \qquad (1)$$

Further development of the NKPC is to apply it in small open economy framework. Gali and Monacelli (2005) added one more factor, namely changes in effective terms of trade (the price of foreign goods in terms of home goods) which also had a role in determining the rate of inflation. Other researchers also developed a small open economy NKPC by adding the influence of the imported goods in the consumption basket of households and intermediate goods required by the company for the production (Leith and Malley, 2003).

$$\pi_t = \lambda_b \pi_{t-1} + \lambda_f E_t\{\pi_{t+1}\} + \beta x_t + \eta z^*, \qquad (2)$$

where $z^*$is an external or foreign price measure.

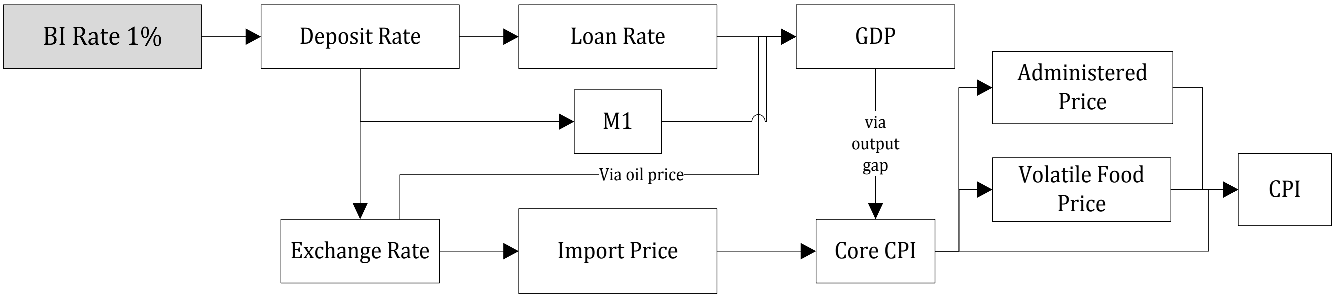
Adam and Padula (2003) estimated the New Keynesian Phillips Curve (NKPC) for the United States by using survey data from professional forecaster as a proxy for inflation expectations. They got significant estimates for all of the coefficient of independent variables either by using output or unit labor costs as a measure of marginal costs. Expectations survey shows that the identification of expectations that generally uses orthogonally of forecast errors by referring to the output can be distorted, which explains why the NKPC estimated with survey data have a better outcome than under the assumption of rational expectations.

In another study, Henzel and Wollmershaeuser (2006) prove the suitability of the hybrid NKPC for certain European countries, the United States and Britain. The study did not impose rational expectations and estimating the Phillips Curve with General Method of Moments, but followed Robert (1997) and Adam and Padula (2003) and using direct measurement of inflation expectations. Source data used is the Ifo World Economic Survey, which collects quarterly inflation expectations in the future. The main findings of this study were: (i) as compared with the rational expectations approach, backward-looking behavior is more relevant for most countries in the sample used. (ii) The use of inflation expectations survey data produce a positive slope of the Phillips Curve as the output gap is used as a measurement of marginal cost.

Norman and Richards (2010) estimated the interval of the single-equation model of inflation for Australia. This study found that the rate of unemployment or growth in marginal costs (unit labor costs and import prices) provide a more conformity better than the output gap or the level of marginal costs. The study also found that both commodity prices and the growth rate of money inflation directly affect Australia.

Moccero et al. (2011) conducted a study of determinants of core inflation in the OECD countries (Organization for European Economic Co-operation) using the approach of Gordon's (1997) Triangle model. They found that the determinants of core inflation are the output gap, past inflation, and external price shock. They also noted that changes in economic activity represented by the change of the output gap can also affect inflation. Although the output gap is still

Figure 1. Transmission Mechanism in SSMX 2009 Model



relatively low, but the pace of change in the output gap can also put pressure on inflation. The argument offered is that there is a possibility of a supply bottleneck for both physical and human capital as a result of economic growth was rapid. The time required in order to develop the capacity of temporary supply constraints led to an increased demand faster than capacity. Supply constraints may also occur from the side of the future workforce where employees lost their jobs the economic downturn will require retraining before they can be rehired. Another argument offered is related to the skills mismatch in sectors that are experiencing growth.

In line with research conducted by Debelle and Wilkinson (2002), and Kara and Nelson (2002), Moccero et al. (2011) include nominal import prices as a measure of external shock affecting core inflation. Import prices are considered to represent the effect of exchange rate changes and changes of import prices that are denominated in foreign currencies.

3. METHODOLOGY AND DATA

3.1. Methodology

To answer the first question, we use the Hybrid New Keynesian Phillips Curve for the small open economy model. We also include several other variables that based on previous empirical studies have an influence on the dynamics of core inflation, following the approach taken by Moccero et al (2011). Our hypothesis, beside output gap, exchange rate, exchange rate volatility, and money supply, inflation expectation (backward looking and forward looking) also become determinant of inflation. All determinant variables above are expected to have a positive impact on inflation. The empirical model used is as follows:

$$\pi_t = \gamma_{\pi b}\pi_{t-1} + \gamma_{\pi f}\pi_{t+1}^{e.cpi} + \gamma_y\widetilde{y}_t + \gamma_{p^*}\Delta P_t^* + \gamma_m(L)\Delta M_t + \gamma_{fx}(L)\sigma_t^{fx} + \gamma_{\Delta y}(L)\Delta\widetilde{y}_t + \varepsilon_t \quad (3)$$

Variables on the right hand side consist of lag of core inflation (π_{t-1}), expectations of inflation derived from the Consensus Forecast ($\pi_{t+1}^{e.cpi}$), the output gap ($\widetilde{y}_t$), a change in import price or import deflator (ΔP_t^*) or exchange rates, money supply growth (ΔM_t), exchange rate volatility (σ_t^{fx}), output growth gap or a change in the output gap ($\Delta\widetilde{y}_t$).

Estimating the NKPC equation by using survey data as a measure of inflation expectations has some advantages as follows (Moccero et al., 2011):

1. No need to explicitly specify the function of inflation expectations of economic agents, as far as the survey data is assumed to be capable of measuring inflation expectations.
2. Estimation can be done with the OLS method, because it does not need to impose the orthogonality restriction. The restriction is needed in estimating NKPC with rational expectation assumption.

To answer the second question, our hypothesis believes there is a threshold for the output gap that will affect core inflation. We use the threshold model as follows:

$$\begin{aligned}\pi_t &= c + \alpha_1\pi_{t-1} + \alpha_2\pi_{t+1}^e \\ &+\beta_1(1-d_t)[(gap_t)I(gap_t > gap^*)] \\ &+\beta_2 d_t[(gap_t)I(gap_t \le gap^*)] + \gamma er_t \\ &+\theta m_t + \delta_1 crisis + \delta_2 fuel + \delta_3 fitri + \varepsilon_t\end{aligned}, \quad (3)$$

Where

$$d_t = \begin{cases} 1 & if \;\; gap_t \le gap^* \\ 0 & if \;\; gap_t > gap^* \end{cases}.$$

Estimation and testing procedures used in this paper is based on those in Hansen (1997, 2000).

To answer the third question, we used three models, namely SSMX 2009, SOFIE 2010 and simple model consisting of core inflation (Phillips curve) and the output gap (IS curve) equations. Our hypothesis believes that policy rate (BI rate) will give effect to core inflation dynamics.

The transmission of BI rate shocks in SSMX model is as shown in Figure 1. The increase of the BI rate will immediately be responded with an increase in deposit rates and lending rates. Because the SSMX model has no disaggregation of GDP, then the modeling of BI rate transmission to GDP is represented by the influence of the dynamics of lending rates. In addition, transmission BI rate to GDP also occurs through changes in exchange rates and M1 due to the increase of deposit rates.

Figure 2. Transmission Mechanism in SOFIE 2010 Model

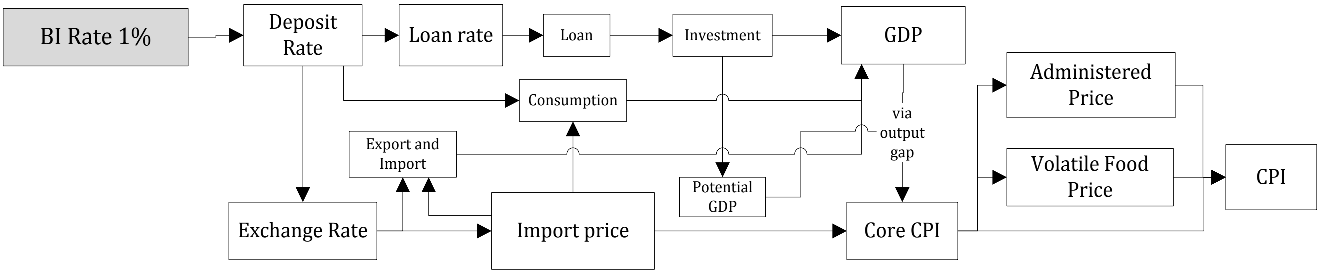


Figure 2 shows the transmission of BI rate to core inflation in SOFIE 2010. The increase of BI rate will cause an increase in deposit rates. This will be transmitted directly to the real sector through changes in consumption levels. In addition, changes of this deposit rates will affect the exchange rate through changes in the interest rate differential. The increase in deposit rates would also lead to changes in lending rates which will then be transmitted to the investment through its effect on lending by banks. Changes in exchange rates also cause changes in the dynamics of exports and imports. Because SOFIE models the complete disaggregation of GDP, the transmission of BI rate to GDP goes through each component of GDP. It is also modeled the dynamics of aggregate supply (potential GDP) based on the Cobb Douglas Production Function. This makes the changes in investment will also affect potential output through changes in capital stocks. Changes in the output gap, together with changes in prices of imported goods caused by changes in exchange rates will affect the dynamics of core inflation.

Other model to be used is a model that combines the two equations, namely core inflation and output gap. Core inflation equation used is equation (8). Output gap equation, as shown in equation (10) is modeled as a function of the output gap the previous period, real interest rates and import prices. To model the interaction between these two equations, we calculate real interest rates by reducing the nominal interest rate by core inflation.

$$gap_t = \alpha_1 gap_{t-1} + \alpha_2(i_t - \pi_{t+1}) + \alpha_3 z_t + \varepsilon_t, \qquad (4)$$

where z_t is import price.

To answer the fourth question, our hypothesis believes there are some commodities that drive the dynamics of core inflation. We use auto-regressive distributed lag (ARDL) model as follows:

$$Y_t = \alpha + Y_1 Y_{t-1} + Y_2 Y_{t-2} + \cdots + Y_k Y_{t-j} + \beta_0 X_t + \beta_1 X_{t-1} + \beta_2 X_{t-2} + \cdots + \beta_k X_{t-k} + +\theta_0 Z_t + \varepsilon_t, \qquad (5)$$

where Y_t is core inflation, X_t is administered price inflation or volatile food inflation, and Z_t are control variables, namely exchange rates and output gap.

To find the best model, the length of lag j and lag k is selected based on minimum Akaike Information Criteria (AIC). We choose 6 for the maximum lag length for Y and X. The magnitude of the impact or influence of variable X to variable Y is to look at the time of maximum impact of shocks is given by 1% at t = 0. Only significant β are considered.

3.2. Data

We use monthly and quarterly data from 1990 until 2011, namely:

Table 1. Data

No	Data	Sources
1	Core inflation	Statistics Indonesia
2	Volatile foods inflation and its commodities	Statistics Indonesia
3	Administered price inflation and its commodities	Statistics Indonesia
4	Real GDP	Statistics Indonesia
5	Exchange rate and its volatility	Bloomberg
6	M1	Bank Indonesia
7	BI rate	Bank Indonesia
8	Potential output (multivariate, HP filter, peak-to-peak method)	Author calculation
9	Inflation expectations.	Consensus Forecast

4. EMPIRICAL RESULTS

4.1. Determinants of Core Inflation

The estimation period are based on the availability of inflation expectation data from Consensus Forecast (2000Q4-2011Q1). One quarter a head inflation expectation data reported in Consensus Forecast is the average of year on year (y-on-y) inflation rate in a certain quarter. We make the following assumptions regarding the data:

1. The average (y-on-y) inflation expectation in a certain quarter is used as a proxy for end of period (y-on-y) inflation expectation in that quarter. This is in accordance with Tjahjono et al (2010) which stated that the variation of y-on-y inflation rate in a certain quarter is not so high that the inflation expectations of the consensus forecast can provide a fairly good proxy when used as a measure of end of period inflation expectation.
2. Since consensus forecast survey is conducted in March, July, September and December, we

assumed that the respondents already have complete or nearly complete information regarding the price level on those months (which coincide with the end period of each quarter) so that y-on-y inflation expectation can be converted into q-to-q inflation expectation. First, we transform y-on-y inflation expectation into expectation of Consumer Price Index. Quarter to quarter inflation expectations is then obtained by calculating the growth of CPI using the current and expected CPI.

Inflation expectation from Consensus Forecast is CPI inflation expectation, which is a weighted average of core, administered and volatile food inflation. The use of such data in estimating core inflation equation makes the resulting coefficients cannot be compared with the coefficient of lag variables of core inflation for comparative analysis of backward versus forward looking.

Table 1. Unit Root Test

Variables	t-stat	Prob
Core inflation	-2.979318	0.0462
Inflation Expectation	-5.499515	0.0000
Output Gap-Multivariate	-2.703423	0.0081
Output Gap-HP Filter	-2.896480	0.0562
Output Gap-Peak to Peak	-3.808935	0.0065
Growth Import Price	-3.348777	0.0205
Growth Exchange Rate	-4.217027	0.0001
Growth of M1	-2.620558	0.0988
Exchange Rate Volatility	-4.614540	0.0000

For completeness of analysis, we estimated equation (8) in the following variations:

1. Small open economy features:
   a. Import price (model 1)
   b. Nominal exchange rate (model 2)
2. Output gap measurements:
   a. Multivariate filter (model A),
   b. Adjusted HP filter (model B),
   c. Peak to peak (model C).

Before constructing the model, we test each variable whether it is stationer or not. Based on augmented Dickey Fuller test, all variables are stationer (Table 2).

Table 3 shows that core inflation is significantly influenced by past inflation (backward-looking expectations), import prices or exchange rates, growth in money supply (M1), and the volatility of the exchange rate of the previous period. If we use import price as variable that represent characteristic of small open economy, inflation expectation from consensus forecast do not contribute to the increase of measure of fitness of the model. But if we use nominal exchange rate instead of import price, inflation expectation is significantly influence the dynamics of core inflation and increase the adjusted R2 of the model. In addition we also find that the output gap is significantly influence core inflation when we use nominal exchange rate as variable that represents small open economy characteristic.

For completeness of analysis, we also estimated equation (8) in two different time period: full sample (1992-2011) and after crisis period (2000-2011). Since inflation expectation from Consensus Forecast only available starting from 2000, we cannot include inflation expectation for this comparison purposes. The complete results are presented in Appendix 1. From the result we can see that if we compare with the full sample, in the after crisis period there is a decrease in the coefficient of variable that represents characteristics of small open economy: import price and nominal exchange rate. The same is true for the coefficient of M1 growth. On the other hand, there is an increase in the coefficient of exchange rate volatility.

Table 2. Estimation Results of Hybrid NKPC (2000Q4 - 2011Q1)

Independent Variable	Model 1A	Model 1B	Model 1C	Model 2A	Model 2B	Model 2C
Core Inflation (t-1)	0.472447***	0.430736***	0.468024***	0.518981***	0.45271***	0.500099***
Inflation Expectation (t+1)	0.001154	0.000693	0.000952	0.002317***	0.00154**	0.001989***
Output Gap						
Multivariate	0.001016	-	-	0.002348*	-	-
HP Filter	-	0.003266*	-	-	0.003484**	-
Peak to Peak	-	-	0.001044	-	-	0.001122
SOE variables						
Import Price	0.053218***	0.04358**	0.05516***	-	-	-
Exchange Rate	-	-	-	0.083464***	0.066618***	0.075222***
Other Variables						
Growth of M1 (-1)	0.038484***	0.037911***	0.038078***	0.05199***	0.047577***	0.050046***
Exchange Rate Volatility (-1)	0.002673***	0.003667***	0.00309***	0.00139	0.002672***	0.001893*
Output Gap Growth	-0.014612	0.033559	0.093357	-0.066767	0.026639	0.089079
Time Dummies						
Idul Fitri	0.000844	0.001264	0.000765	0.001704	0.001345	0.001053
Fuel-Adm Shocks	0.030836***	0.030509***	0.030972***	0.029993***	0.031006***	0.03134***
Crisis (2008/2009)	-0.010498*	-0.007065	-0.0072	-0.022556***	-0.015438**	-0.020031***
Adjusted R-square	**0.550154**	**0.59378**	**0.556675**	**0.637554**	**0.658552**	**0.614063**

Note: *,**,*** indicate significant level at level 10%, 5%, and 1%, respectively.

Table 3. Estimation Results of Threshold Model (2000Q4 - 2011Q1)

Variables	MV Filter			AHP			PTP		
	Coeff.	SE	Prob	Coeff.	SE	Prob	Coeff.	SE	Prob
Core Inflation (t-1)	0.447869	0.08047	***	0.437536	0.070964	***	0.437052	0.075702	***
Inflation Expectation (t+1)	0.002021	0.000682	***	0.001289	0.000675	*	0.002013	0.000628	***
Output Gap ≤ Threshold	0.000378	0.001633		0.007025	0.002764	**	0.000141	0.001309	
Output Gap > Threshold	0.007629	0.003094	**	0.002355	0.001646		-0.08639	0.033112	**
Exchange Rate	0.070396	0.018567	***	0.057426	0.018481	***	0.072493	0.016393	***
Output Gap Growth	-0.07651	0.064709		0.065865	0.076822		0.067901	0.076773	
Growth of M1 (-1)	0.050368	0.011434	***	0.042509	0.011712	***	0.049144	0.011055	***
Exchange Rate Volatility (-1)	0.001334	0.000694	*	0.00385	0.001215	***	0.001417	0.001061	
Idul Fitri	0.001427	0.001917		0.000912	0.001874		0.001433	0.001843	
Fuel-Adm Shocks	0.030449	0.004953	***	0.030439	0.004799	***	0.032302	0.004861	***
Crisis	-0.01815	0.006477	***	-0.01409	0.006724	**	-0.01958	0.006198	***
Adjusted R-square	0.663598			0.671728			0.674962		
S.E. of Regression	0.004517			0.004462			0.00444		
Sum Squared Resid	0.000633			0.000617			0.000611		
Log Likelihood	173.5777			174.0915			174.2994		
Durbin-Watson stat	2.558028			2.364277			2.671794		
Threshold	0.148			-0.92			-0.136		
P-value	0.106			0.29			0.206		

Note: *,**,*** indicate significant level at level 10%, 5%, and 1%, respectively.

4.2. Threshold Effect of Output Gap on Core Inflation

The analysis in this section is focused on the after crisis period since in the full sample period, the estimation result shows that output gap do not affect the dynamic of core inflation significantly. Table 4 shows the results of threshold model estimation. Since we have three different measure of output gap, there are three different thresholds for each measure.

The minimum Sum of Square Residual (SSR) for multivariate filter measures of output gap is found at the level of 0.15%. If the output gap is over 0.15%, it will have significant influence to the dynamics of core inflation with the coefficient of 0.008. On the other hand, if output gap is less than 0.15%, it will not have significant impact on the dynamics of core inflation. Simulation using bootstrap with 1000 repetition shows that this threshold is marginally significant (p-value 0.105).

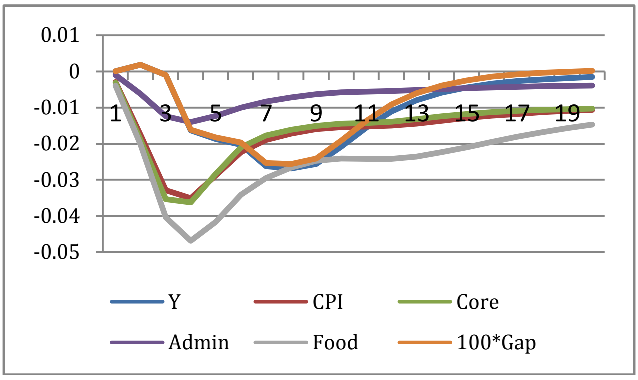
For adjusted HP filter measures of output gap, minimum SSR is found in the level of -0.92%. Estimation result shows that the level of output gap that is above this threshold will not have significant result on the dynamic of core inflation. This result is intuitively difficult to accept. Bootstrap simulation gave us the p-value equal to 0.29.

The threshold value for peak-to-peak measures of output gap is -0.14%. Estimation result shows that if the value of output gap is above -0.14%, it will have significant impact on the dynamic of core inflation. Intuitively, this negative threshold value is quite acceptable, since for this method the value of output gap is always below zero. Unfortunately, the coefficient found is negative which is not in accordance with theory. Bootstrap simulations also show that this threshold is not significant (with p-value of 0.21).

4.3. The Impact of BI Rate Shocks on Core Inflation

Using SSMX 2009 model, 1% BI rate shock will decrease core inflation as much as 0.035% at its lowest point which happened at the fourth quarter after the shock (Figure 3).

Figure 3. Simulation Results of SSMX 2009 Model



Based on SOFIE 2010 model simulation, 1% BI rate shock will result in a 0.015% decrease in core inflation at its lowest point, at the 6th quarter after the shock. Different result found with the SSMX model is mostly because aggregate supply is endogenously determined in SOFIE. This will result in a lower impact of BI rate shock to the core inflation (Figure 4).

Figure 4. Simulation Results of SOFIE 2010 Model

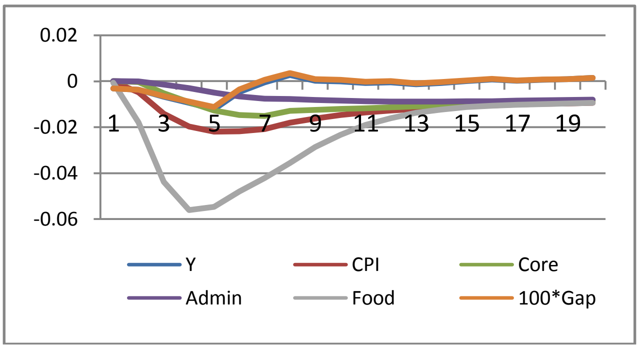


Table 4. Estimation Result for Household Fuel (BBRT), Gasoline (Bensin) and Inter City Transportation (Adako)

Variables	X_Y=BBRT			X_Y=Bensin			X_Y=Adako		
	Coeff.	SE	Prob	Coeff.	SE	Prob	Coeff.	SE	Prob
C	2.358	0.712	***	0.452	0.212	**	0.474	0.217	**
CORE_Y(-1)	0.901	0.172	***	1.071	0.098	***	1.066	0.100	***
CORE_Y(-2)	-0.243	0.185		-0.150	0.096		-0.150	0.098	
CORE_Y(-3)	.0.202	0.161							
CORE_Y(-4)									
CORE_Y(-5)									
CORE_Y(-6)									
X_Y	0.035	0.007	***	0.040	0.013	***	0.045	0.016	***
X_Y(-1)	-0.004	0.009		-0.032	0.013	**	-0.041	0.018	**
X_Y(-2)	0.002	0.008							
X_Y(-3)	-0.019	0.008	**						
X_Y(-4)	-0.001	0.008							
X_Y(-5)	0.027	0.007	***						
X_Y(-6)	-0.005	0.007							
ER	0.016	0.006	**	0.013	0.005	**	0.013	0.006	**
GAP(-9)	-0.177	0.082	**	-0.075	0.082		-0.091	0.085	
Adjusted R2	0.986			0.914			0.984		
SE Regression	0.188			0.418			0.199		
Prob (F-stat)	0.000			0.000			0.000		
AIC	-0.231			1.441			-0.143		
DW stat	2.214			2.042			2.165		

Note: *,**,*** indicate significant level at level 10%, 5%, and 1%, respectively.

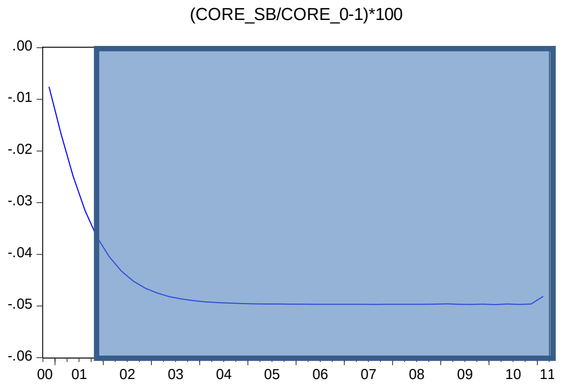
Table 5. Estimation Result of IS Curve Equation

Independent Variable	Coefficient
Output gap (t-1)	0.6137***
(nominal BI rate–core inflation(t+1))	-13.119*
Import Price	3.5048*
Adjusted R-square	**0.467**

Note: *,**,*** indicate significant level at level 10%, 5%, and 1%, respectively.

The last model that we use in this section is a simple model that consists of only 2 equations: Hybrid New Keynesian Phillips Curve (as estimated in Table 3) and IS curve. We use equation (10) as the IS Curve equation and the result of the estimation is shown in Table 5 above.

Figure 5. Simulation Results of Hybrid NKPC + IS Curve Model



Given the magnitude of model simplification, the analysis of the simulation result is limited to a period of up to 1 year. The reason for this is because we don't explicitly model the dynamic of aggregate supply in this model which will also be influenced by changes in the BI rate by influencing the growth of investments that will be felt after 4 quarters since the shock. Deviation of core inflation path from the baseline at the 4th quarter is approximately 0.037%. This result is not much different with the result from SSMX 2009 model that assumed that aggregate supply is growing with a constant trend (Figure 5).

4.4. The Impact of Administered Price and Volatile Foods Inflation on Core Inflation

4.4.1. The Impact of Administered Price Inflation on Core Inflation

We employ all variables in growth (y-o-y) form, which is I(0). Table 6 shows the estimation result of ARDL model for household fuel (Bahan Bakar Rumah tangga – BBRT), gasoline (Bensin) and inter city transportation (Adako).

Table 7 shows the impact of 1% administered price and 21 commodities price shock on core inflation. From this table, parking cost has the highest sensitivity value, 0.18. But after we normalize[1] the value with the weight of each commodity in administered price basket, the highest sensitivity value is for gasoline and inner city transportation. The total impact of all administered price commodities on core inflation is 0.07.

[1] Total administered price weight is 17.67% and normalized into 100. For gasoline which have original weight of 2.94% will have normalized weight of 16.65%, and ASDP which have original weight of 0.006 will have normalized value of 0.034%.

Table 6. The effect of Administered Price and Its Commodities

No	Commodities	Max	T-Max	Weight	Weight-N	Max x Weight	x Factor
0	Administered Price	0.0695	0	17.67	100.00	0.02626	0.06955
1	Gasoline	0.0400	0	2.94	16.65	0.00667	0.01766
2	Inter City Transportation	0.0448	0	2.62	14.84	0.00665	0.01762
3	BBRT	0.0352	0	2.89	16.39	0.00577	0.01528
4	Landline Telephone	0.0482	0	1.22	6.90	0.00332	0.00880
5	Parking cost	0.1803	1	0.15	0.85	0.00153	0.00406
6	Cigarettes (White)	0.0392	0	0.46	2.62	0.00103	0.00272
7	Water	0.0183	0	0.73	4.13	0.00076	0.00200
8	Train	0.0435	1	0.09	0.52	0.00023	0.00060
9	Solar	0.0557	0	0.07	0.37	0.00021	0.00055
10	Diesel Fuel	0.0276	0	0.02	0.13	0.00003	0.00009
11	ASDP	0.0737	0	0.01	0.03	0.00003	0.00007
12	Sea Transportation	0.0107	0	0.03	0.17	0.00002	0.00005
13	Mailing Cost	0.0219	0	0.01	0.08	0.00002	0.00004
14	Driving License Cost	0	0	0.02	0.13	0	0
15	Vehicle Registration	0	0	0.49	2.80	0	0
16	Clove Cigarettes	0	0	1.13	6.42	0	0
17	Filtered Clove Cigarettes	0	0	2.01	11.40	0	0
18	Toll road tariff	0	0	0.05	0.30	0	0
19	Electricity	0	0	2.61	14.75	0	0
20	Community health Centre Cost	0	0	0.02	0.13	0	0
21	Taxi	0	0	0.07	0.41	0	0

Note: *,**,*** indicate significant level at level 10%, 5%, and 1%, respectively.

There are 13 commodities (62%) in administered price basket that significantly influence the dynamic of core inflation, among them are gasoline, inner city transportation, household fuel, landline telephone, parking cost, white cigarettes, train and diesel fuel. Meanwhile, driving license tariff, vehicle registration renewal service, clove cigarette, filtered cigarette, toll road tariff, electricity tariff, community health centers tariffs, and taxi fare do not have significant impact on core inflation.

For electricity tariff, we did not manage to get a significant coefficient either through ARDL model or with models that also include dummy variable. There are two explanations that we propose: (i) model misspecification or (ii) electricity tariff do not have effect on core inflation dynamics but have direct effect on administered price and CPI. Further research is needed to answer this question.

Table 7. Estimation Result for Beef (Daging Sapi), Rice (Beras) and Milk (Susu)

Variables	X_Y=Daging Sapi			X_Y=Beras			X_Y=Susu		
	Coeff.	SE	Prob	Coeff.	SE	Prob	Coeff.	SE	Prob
C	0.531	0.215	**	0.420	0.201	**	0.236	0.198	
CORE_Y(-1)	0.853	0.046	***	1.085	0.092	***	1.092	0.093	***
CORE_Y(-2)				-0.177	0.090	*	-0.155	0.088	*
CORE_Y(-3)									
CORE_Y(-4)									
CORE_Y(-5)									
CORE_Y(-6)									
X_Y	0.150	0.031	***	0.068	0.015	***	0.186	0.036	***
X_Y(-1)	-0.059	0.046		-0.061	0.015	***	-0.165	0.038	***
X_Y(-2)	-0.051	0.030	*						
X_Y(-3)									
X_Y(-4)									
X_Y(-5)									
X_Y(-6)									
ER	0.004	0.005		0.012	0.005	**	0.005	0.005	
GAP(-9)	-0.286	0.104	***	-0.139	0.080	*	0.014	0.076	
Adjusted R2	0.924			0.921			0.927		
SE Regression	0.455			0.463			0.444		
Prob (F-stat)	0.000			0.000			0.000		
AIC	1.329			1.366			1.279		
DW stat	1.896			2.093			1.957		

Note: *,**,*** indicate significant level at level 10%, 5%, and 1%, respectively.

4.4.2. The Impact of Volatile Foods Inflation on Core Inflation

Table 8 presents the estimation result of ARDL model for beef, rice and milk. For other commodities, the estimation results are not shown here.

Table 8 shows the impact of 1% volatile food (total) and 60 commodities price shock on core inflation. From this table we can see that milk have the highest sensitivity of 0,19. Although rice have maximum sensitivity of only 0.07, but since it has 25% weight of all volatile food than the normalize sensitivity value is dominant[2].

There are 35 commodities in volatile foods basket that significantly influence the dynamic of core inflation, among them are rice, beef, milk, noodles and cooking oil. Meanwhile live chicken, broiler chicken meat, garlic, tofu and eggs do not have significant impact on core inflation[3].

5. CONCLUSIONS

From the above discussions, several conclusions can be drawn, namely:

1. As a small-open economy, inflation in Indonesia is affected by both domestic factors and external factors. It is found that core inflation, which is a head line inflation excluding the administered price and volatile food components, depends on past inflation (backward-looking inflation expectations), consensus forecast (forward-looking inflation expectations), the exchange rate, output gap, the growth of M1, and exchange rate volatility. Our findings are consistent with the studies of determinant of inflation in many countries. Compared to the estimates of the whole period, the effects of the past inflation and exchange rate volatility are found to be higher after the crisis. However, the impact of exchange rate pass-through becomes smaller. As found in European countries, US, and UK (Henzel and Wollmershaeuser, 2006), the backward-looking inflation expectation in Indonesia is still dominant.
2. This paper contributes to policy makers that the impact of output gap to inflation is not linear. We found that there is a threshold effect of output gap (using MV filter) to core inflation, which amounted to 0.15%. If the value of the MV filter output gap is greater than 0.15%, then the output gap will give effect to core inflation. Conversely, if the output gap is under 0.15%, then the output gap does not give effect to the core inflation significantly.
3. The results of model simulations show that the effect of BI rate to the core inflation is very limited. This can be understood as the transmission of BI rate to core inflation is modeled only through the output gap. Further knowledge of the influence of BI rate to the persistence of core inflation and inflation expectations need to be explored. Although the impact of BI rate of core inflation is limited, but based on the estimation results show that Bank Indonesia has the opportunity to influence the dynamics of core inflation through exchange rate changes and its volatility.
4. From the results of ARDL model, it is indicated that the administered prices and volatile foods affect core inflation with a sensitivity of respectively 0.07 and 0.18. A total of 13 commodities (62%) in the group administered prices are significantly affecting core inflation, such as gasoline, transportation within the city, household fuel, phone rates, parking fee, white cigarettes, railway tariffs, and diesel. In the volatile foods baskets, there are 35 commodities (58%) that significantly affect the core inflation, such as rice, beef, milk, noodles, and cooking oil.

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[2] Normalize weight. The total weight of all volatile food commodities is 18.69 and normalizes into 100. For rice, which have original weight of 4.83 will have normalize weight of 25.83%.

[3] Analysis using m-to-m data also shows the same result.

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APPENDIX

Table 8. The Effect of Volatile Foods and Its Commodities

No	Commodities	Max	T-Max	Weight	Weight-N	Max x Weight	x Factor
0	Volatile Foods	0.1824	0	18.69	100.00	0.0384	0.18239
1	Rice	0.0679	0	4.83	25.83	0.0175	0.08338
2	Beef	0.1496	0	0.82	4.36	0.0065	0.03101
3	Milk	0.1858	0	0.44	2.38	0.0044	0.02100
4	Noodles	0.0673	0	0.52	2.80	0.0019	0.00895
5	Squid	0.1072	0	0.12	0.66	0.0007	0.00335
6	Mas	0.0571	0	0.21	1.10	0.0006	0.00299
7	Coconut	0.0452	0	0.25	1.33	0.0006	0.00287
8	Catfish	0.0707	0	0.15	0.79	0.0006	0.00267
9	Banana	0.0316	0	0.32	1.72	0.0005	0.00257
10	Bandeng (fish)	0.0324	0	0.31	1.66	0.0005	0.00256
11	Oil	0.0076	0	1.29	6.92	0.0005	0.00249
12	Spinach	0.0353	0	0.25	1.33	0.0005	0.00223
13	Papaya	0.0418	3	0.16	0.87	0.0004	0.00174
14	Mujair (fish)	0.0411	0	0.16	0.83	0.0003	0.00163
15	Water Spinach (kangkung)	0.0308	0	0.21	1.11	0.0003	0.00162
16	Eggs	0.0088	0	0.72	3.85	0.0003	0.00161
17	Grapes	0.0705	3	0.09	0.48	0.0003	0.00160
18	Peanuts	0.0843	0	0.06	0.34	0.0003	0.00134
19	Mustard	0.0355	0	0.11	0.60	0.0002	0.00102
20	Brown Sugar	0.0699	0	0.05	0.29	0.0002	0.00098
21	Tempe	0.0071	0	0.53	2.82	0.0002	0.00095
22	Red Onion	0.0057	0	0.46	2.45	0.0001	0.00066
23	Tomato (vegetable)	0.0166	2	0.15	0.81	0.0001	0.00064
24	Sardines	0.0259	0	0.08	0.43	0.0001	0.00053
25	Cakalang (fish)	0.0197	0	0.09	0.49	0.0001	0.00046
26	Layang (fish)	0.0144	0	0.09	0.47	0.0001	0.00032
27	Corn (young)	0.0153	0	0.06	0.30	0.0000	0.00022
28	Melon	0.0130	0	0.06	0.33	0.0000	0.00021
29	Cayenne	0.0031	0	0.26	1.40	0.0000	0.00020
30	Water Melon	0.0074	4	0.10	0.54	0.0000	0.00019
31	Gabus (fish)	0.0161	0	0.03	0.18	0.0000	0.00014
32	Cabbage	0.0157	0	0.03	0.17	0.0000	0.00013
33	Cayenne Pepper	0.0017	0	0.19	0.99	0.0000	0.00008
34	Green Chili	0.0066	0	0.03	0.14	0.0000	0.00004
35	Katuk (fish)	0.0134	0	0.01	0.03	0.0000	0.00002
36	Apple	0	0	0.23	1.21	0	0
37	Live Chicken	0	0	0.09	0.50	0	0
38	Garlic	0	0	0.42	2.25	0	0
39	Native Chicken Meat	0	0	0.07	0.38	0	0
40	Broiler Chicken Meat	0	0	1.36	7.29	0	0
41	Emping	0	0	0.05	0.27	0	0
42	Sweet Corn	0	0	0.09	0.47	0	0
43	Orange	0	0	0.57	3.06	0	0
44	Long Bean	0	0	0.15	0.82	0	0
45	Kembung (fish)	0	0	0.35	1.90	0	0
46	Potato	0	0	0.24	1.29	0	0
47	Cucumber	0	0	0.08	0.43	0	0
48	Pumpkin	0	0	0.03	0.18	0	0
49	Jackfruit	0	0	0.05	0.28	0	0
50	Patin (fish)	0	0	0.05	0.25	0	0
51	Twisted Cluster Bean (petai)	0	0	0.03	0.18	0	0
52	Lettuce	0	0	0.00	0.01	0	0
53	Selar	0	0	0.07	0.37	0	0
54	Serai	0	0	0.02	0.11	0	0
55	Tofu	0	0	0.46	2.46	0	0
56	Teri	0	0	0.25	1.32	0	0
57	Tomato (fruit)	0	0	0.08	0.43	0	0
58	Cob	0	0	0.28	1.47	0	0
59	Shrimp	0	0	0.33	1.77	0	0
60	Carrot	0	0	0.09	0.47	0	0

Note: *,**,*** indicate significant level at level 10%, 5%, and 1%, respectively.

Backward-Looking Phillips Curve Estimation

Backward-Looking Phillips Curve Model:

$$\pi_t = \gamma_\pi \pi_{t-1} + \gamma_y \widetilde{y_t} + \gamma_{p^*} \Delta P_t^* + \gamma_m(L)\Delta M_t + \gamma_{fx}(L)\sigma_t^{fx} + \gamma_{\Delta y}(L)\Delta\widetilde{y_t} + \varepsilon_t$$

Table 9. Full Sample Period (1992Q1-2011Q1)

Independent Variable	Model 1A	Model 1B	Model 1C	Model 2A	Model 2B	Model 2C
Core Inflation (t-1)	0.16877**	0.204665***	0.191292**	0.347988***	0.336903***	0.315482***
Output Gap						
Multivariate	0.001641	-	-	0.001462	-	-
HP Filter	-	0.000889	-	-	0.000884	-
Peak to Peak	-	-	-0.000762	-	-	-0.001022
SOE variables						
Import Price	0.195032***	0.208569***	0.216563***	-	-	-
Exchange Rate	-	-	-	0.146482***	0.150618***	0.154533***
Other Variables						
Growth of M1 (-1)	0.08802**	0.073211*	0.079296**	0.072762**	0.086661**	0.071478*
Exchange Rate Volatility (-1)	0.003363***	0.00318***	0.001993***	0.00256*	0.002192*	0.001483*
Output Gap Growth	0.008088	0.001861	-0.012194	-0.093028	-0.084968	-0.078022
Time Dummies						
Fuel-Adm Shocks	0.030032**	0.03091**	0.032956**	0.031086*	0.032325**	0.034362**
Idul Fitri	0.003919	0.003077	0.002226	0.003173	0.002902	0.001818
Crisis (2008/2009)	0.002291	0.00405	0.007479	-0.015772	-0.017233	-0.011456
Adjusted R-square	**0.854449**	**0.85264**	**0.851181**	**0.835339**	**0.832997**	**0.836858**

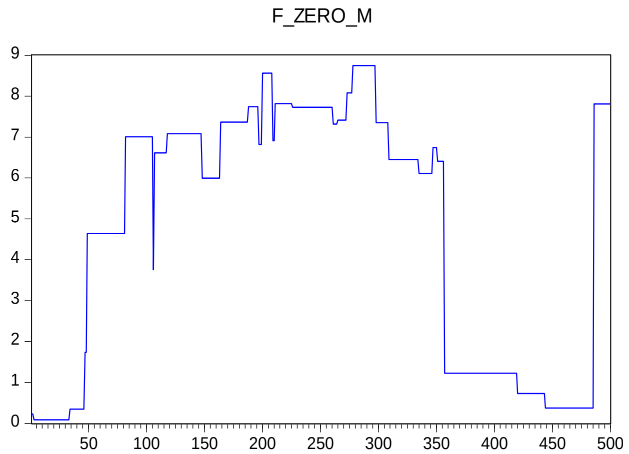
Note: *,**,*** indicate significant level at level 10%, 5%, and 1%, respectively.

Table 10. After Crisis Period (2000Q4-2011Q1)

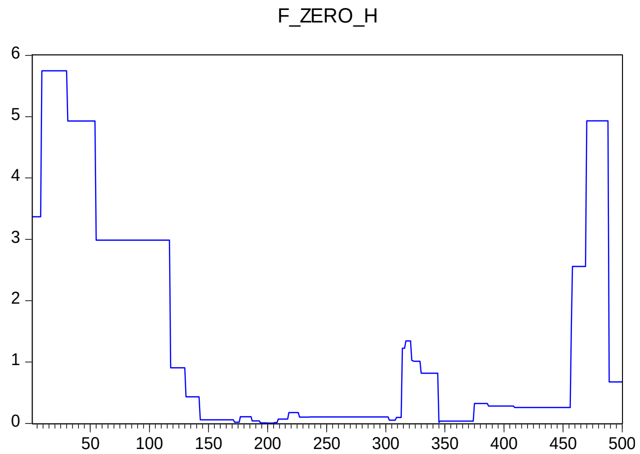
Independent Variable	Model 1A	Model 1B	Model 1C	Model 2A	Model 2B	Model 2C
Core Inflation (t-1)	0.523002***	0.493415***	0.509724***	0.586613***	0.514659***	0.57936***
Output Gap						
Multivariate	-0.000757	-	-	0.000647	-	-
HP Filter	-	0.002781	-	-	0.004346***	-
Peak to Peak	-	-	0.000144	-	-	0.001444
SOE variables						
Import Price	0.068508***	0.05097**	0.064558***	-	-	-
Exchange Rate	-	-	-	0.059899	0.050164***	0.054447***
Other Variables						
Growth of M1 (-1)	0.048627**	0.03095	0.049043**	0.058413**	0.030402	0.050812**
Exchange Rate Volatility (-1)	0.002329**	0.003574***	0.002323***	0.002607**	0.004231***	0.00362**
Output Gap Growth	0.019193	0.058349	0.067941	-0.04984	0.0288	0.078342
Time Dummies						
Fuel-Adm Shocks	0.031187***	0.029132***	0.030554***	0.031171***	0.029603***	0.030605***
Idul Fitri	0.00031	0.001287	0.000766	-0.000711	0.000208	-0.000691
Crisis (2008/2009)	-0.005765	-0.005678	-0.003724	-0.01485**	-0.013249**	-0.015997**
Adjusted R-square	**0.473169**	**0.508256**	**-0.003724**	**0.468692**	**0.569331**	**0.478031**

Note: *,**,*** indicate significant level at level 10%, 5%, and 1%, respectively.

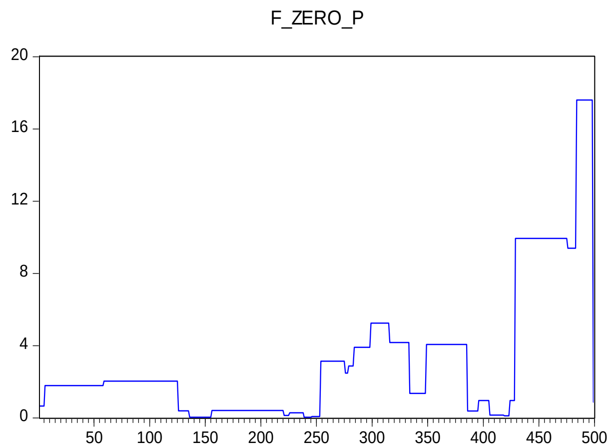
Figure 6. Output Gap Threshold



Multivariate Filter
Found Threshold = 0.148 at 287



Adjusted HP Filter
Found Threshold = -0.92 at 20 (245 - 276)



Peak-to-Peak
Found Threshold = -0.136 at 491 (308-313)