Price-setting Behaviour and Inflation Dynamics in SEACEN Member Economies and their Implications for Inflation

Project Leaders

David Finck

Peter Tillmann

The **SEACEN** Centre

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The South East Asian Central Banks (SEACEN) Research and Training Centre

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FOREWORD

Over the past two decades, many advanced and emerging economies experienced low and relatively stable inflation rates. At the same time, inflation appears increasingly to be decoupled from economic activity. The literature largely studies the changing nature of inflation dynamics and, in particular, the shifting relationship between inflation and economic activity. This research project on "Price-setting Behavior and Inflation Dynamics in SEACEN Member Economies and Their Implications for Inflation" adds to the discussion about the changing nature of inflation dynamics in several SEACEN economies and puts forward the results of a project team under the auspices of the SEACEN Centre.

The project team consisted of representatives from the Autoriti Monetari Brunei Darussalam; Reserve Bank of India; Bank Indonesia; Bank of Mongolia; Central Bank of Myanmar; Bank of Papua New Guinea; Bangko Sentral ng Pilipinas; Central Bank of Sri Lanka; Central Bank, Chinese Taipei; Bank of Thailand and, State Bank of Vietnam. SEACEN wishes to express its sincere gratitude to the participating central banks for their support for this project.

The project was led by David Finck, PhD student in Economics, and Peter Tillmann, Professor of Monetary Economics from the Justus Liebig University Giessen, Germany. Both were appointed Visiting Research Economists at the SEACEN Centre in 2018. Sincere gratitude goes to Dr. Ole Rummel, Director of Macroeconomic and Monetary Policy Management (MMPM) at the SEACEN Centre, for his overall support, suggestions and lead role at all the stages of the project. The assistance of SEACEN staff members of MMPM, in particular Mrs. Jami'ah Jaffar, Dr. Victor Pontines and Dr. Rogelio Mercado is most gratefully acknowledged.

SEACEN is pleased to have been able to provide input for the project at a research workshop and seminar held at the SEACEN Centre where the findings of the project were presented and discussed. We would also like to acknowledge the helpful comments and suggestions from Scott Davis, Senior Research Economist and Advisor, Federal Reserve Bank of Dallas on the integrative report prepared by the project leaders. The views expressed in this study are those of the authors and do not necessarily reflect those of the SEACEN Centre or the SEACEN member central banks/ monetary authorities.

Hans Genberg
Executive Director
The SEACEN Centre

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EXECUTIVE SUMMARY

Over the past few years, Asian economies exhibited high growth and relatively low inflation rates. It is often argued that the process of inflation determination changed towards a more benign trade-off between economic slack and inflationary pressure. Factors such as global integration into goods and capital markets, the adoption of formal inflation targeting and changes in structural determinants of inflation such as oil and food prices, to name just a few candidates, potentially change the nature of inflation dynamics in small open economies.

This collaborative research project on "Price-setting Behavior and Inflation Dynamics in SEACEN Member Economies and their Implications for Inflation" studies the changing nature of the inflation process in SEACEN economies from different perspectives and draws policy conclusions.

We obtain three key findings:

1. Global as opposed to local determinants of inflation are increasingly important. Global shocks such as oil price shocks and global demand shocks explain a large share of the variation in inflation. Global determinants also change the slope of the Phillips curve.

2. The persistence of the inflation process changes over time, which in turn affects the time needed for inflation to return to the mean following a shock. Reforms in the institutional design of monetary policy such as the adoption of inflation targeting change the nature of inflation persistence.

3. The pass-through of energy prices and oil price, for example, to headline inflation is time-varying and country-specific.

Overall, our results suggest that monetary policy in small open economies, which are well integrated into global markets for goods, services and capital, should take these structural changes into account. A policy framework based on an inflation target and a flexible exchange rate is well suited to cope with the changing inflation process.

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Chapter 1

THE ROLE OF GLOBAL AND DOMESTIC SHOCKS FOR INFLATION DYNAMICS: EVIDENCE FROM ASIA[1]

By
David Finck[2] and Peter Tillmann[3]

1. Introduction

Over the past two decades, many advanced and emerging economies experienced low and relatively stable inflation rates. At the same time, inflation more and more appears to be decoupled from economic activity. The sharp drop in GDP during the Great Recession did not lead to a further drop in inflation, thus giving rise to the 'missing deflation' phenomenon. Likewise, the strong economic recovery did not go hand in hand with rising inflation rates. Based on these observations, the literature largely studies the changing nature of inflation dynamics and, in particular, the shifting relationship between inflation and economic activity. Often this research agenda is described in terms of a 'flattening' of the Phillips curve (see Coibion and Gorodnichenko, 2015, and others). A reduction in the slope of the Phillips curve relationship would have drastic consequences for monetary policy. For given inflation expectations, the argument goes, a flatter Phillips curve would require a deeper recession in order to bring inflation back to the target.

One explanation for the apparent changes in the inflation process is the ongoing global integration of financial and goods markets. However, quantifying the extent to which global driving forces explain inflation is not straightforward. In her survey article, Forbes (2018) argues that the role of global factors (commodity prices, measures of global slack, exchange rates, price competition) has changed over time. She finds that the relation between domestic output gaps and inflation rates has weakened and advocates that models of inflation such as the Phillips curve should incorporate changes in the global economy in order to provide a good account of the determinants of inflation. If global factors are indeed driving a substantive share of inflation, domestic monetary policy is less able to stabilize inflation and the real economy. As monetary policy primarily affects inflation through expanding or contracting domestic demand, the power of central banks to control inflation would be limited in a world in which global forces dominate.

1. This project was conducted while we were Visiting Research Economists at the SEACEN Centre. We thank the SEACEN Centre for its hospitality. Seminar participants at Giessen and the SEACEN Centre provided very helpful comments. We are grateful to an anonymous reviewer for very helpful suggestions.

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In this paper, we add to this literature and study six Asian emerging market countries: Indonesia, Korea, Malaysia, the Philippines, Singapore and Thailand. Countries in Asia are prototypical small open economics that are well integrated into the world economy.[4] In addition, all six economies explicitly or implicitly have a mandate for maintaining price stability.[5] Recently, IMF (2018) claims that the sensitivity of inflation rates in Asian emerging market economies with respect to real activity declined, thus leading to a flatter Phillips curve.

We proceed in three steps. First, we estimate a series of structural vector autoregressive (VAR) models, in which we use alternative sets of constraints to identify a battery of shocks. In our baseline model, we apply sign restrictions as in Corsetti et al. (2014) to identify domestic demand and supply shocks as well as global demand and supply shocks. While demand and supply shocks can be distinguished based on the responses of inflation and GDP growth being positively correlated (in the case of demand shocks) or negatively correlated (for supply shocks), we disentangle domestic from global shocks based on the relative response of domestic GDP to world GDP. Second, the identified VAR model allows the application of several structural analyses in order to address the role of the structural shocks we identify on the variability of inflation and the growth rate of real GDP. By doing so, we focus on four categories of shocks, i.e. global, domestic, exchange rate and monetary policy shocks. We first decompose the variance of forecast errors. The forecast error variance decomposition (FEVD) tells us how much of the forecast error variance can be explained due to exogenous shocks to other variables in the system. We therefore ask for the amount of information each variable contributes to the other variables in the autoregressive process. While the FEVD describes average movements in the data, it does not allow us to quantify the amount of how much of the observed variability is explained by specific shocks. Hence, we also decompose the history of inflation and GDP growth into the historical contributions of each shock in order to quantify the cumulative effects on these series. Our results of both the FEVDs as well as the historical decompositions suggest that global shocks play an important role for all six countries under investigation. In particular, global shocks are an important driver of inflation around the Great Recession, as they explain most of the increase and subsequent plunge in inflation rates during 2008/9.

We also run counterfactual simulations in order to derive the hypothetical effects of shocks in the past on today's outcomes. By changing the history of certain structural shocks, we are able to simulate counterfactual outcomes and ask how our endogenous series would have evolved in the absence of these shocks. The advantage here is that contrary to the historical decomposition of our series, we can easily visualize uncertainty around the cumulative effects and can underpin the relative role of global versus domestic shocks more easily.

In the third step, we revisit the Phillips curve relationship. The VAR model provides us with the domestic component of GDP, i.e. the fraction of GDP that is driven by all shocks other than global shocks, and global components of GDP, the part of economic activity driven by global demand and supply shocks. We estimate the Phillips curve using this decomposition of GDP. The model allows different domestic and global components to enter the Phillips curve with different coefficients and potentially different signs. Hence, the model nests the conventional Phillips curve specification if the coefficient on the global component equals the one on the domestic component. We find that for all countries, the Phillips curve is still alive with respect to pure domestic economic activity. Taking

4. Auer and Mehrotra (2014) argue that the integration of Asian economies into global supply chains matters. The correlation of inflation rates across Asian economies increases with the extent of their bilateral trade relationships.

5. See Volz (2015) for a discussion of the experience with inflation targeting in Asia.

global driving forces into account, our results suggest that for most countries, the Phillips curve became even steeper over time. However, our results also suggest that the nature of global shocks matters. In this respect, we see that global supply shocks seem to flatten the Phillips curve throughout our set of countries, while the opposite is true for global demand shocks. On aggregate, our results reveal that the effect of global demand shocks dominates the effect of global supply shocks.

Our paper connects several strands of the literature: First, a recent branch of the literature studies the co-movement of inflation rates across countries. Ciccarelli and Mojon (2010) find that for 22 OECD countries, a single common factor explains about 70% of the variation in inflation. They refer to this phenomenon as 'global inflation'. Unless real economic activity is equally well explained by a common factor, this implies a weakening of the relationship between domestic output and inflation. The evidence provided by Neely and Rapach (2011) and Mumtaz and Surico (2012) supports this finding. In contrast, Förster and Tillmann (2014) show evidence that is consistent with 'local inflation', that is inflation being primarily driven by domestic variables. Recently, Parker (2018) uses a very large data set with more than 200 countries to show that the global inflation hypothesis does not fit emerging and developing countries, in which only a subset of prices such as those for oil and food are driven by global shocks.

A second strand of research argues that conventional Phillips curve regressions that relate inflation to, among other variables, a measure of domestic slack such as the output gap, should be augmented by measures of global slack or a 'global output gap'. Borio and Filardo (2007), using a cross-section of countries, find that the explanatory power of global factors as reflected in measures of global slack increased over time. For some countries, these authors find global factors to be the dominant drives of inflation. Supportive evidence for advanced economies is provided by Milani (2009, 2010) and others, while Ihrig et al. (2010) cannot find evidence in favor of the 'globalization of inflation' hypothesis.

The concept of global output gaps, however, is not without flaws (see Tanaka and Young, 2008, and Gerlach, 2011). Jasova et al. (2018) point to the fact that for a typical small open economy, the domestic output gap should be highly correlated with the global output gap, i.e. the weighted gap of the economy's main trading partners. This correlation obscures the identification of the true structural driving forces of inflation dynamics. The approach taken in this paper, in contrast, identifies orthogonal domestic and global components of output based on the co-movement between global and domestic variables. This procedure avoids some of the weaknesses of estimates of global slack.

A third strand uses identified time series models to study the determinants of inflation dynamics together with other key business cycle variables. As mentioned before, Corsetti et al. (2014) and Bobeica and Jarocinski (2017) propose a set of sign-restrictions that allows us to quantify the response to orthogonal domestic and global shocks, respectively. Conti et al. (2017) apply a similar identification scheme to decompose euro area inflation. All three papers attribute an important role to global driving forces of inflation. As an increasing integration of goods and financial markets should make global factors more important over time, Bianchi and Civelli (2015) allow the coefficients of their VAR model to vary over time. Their evidence suggests that global slack as a determinant of inflation does not become more important over time. Eickmeier and Kühnlenz (2018) focus on the role of China for inflation dynamics in advanced and emerging economies. Estimating a factor model for 38 countries, they find that demand and supply shocks originating in China have a significant impact on inflation in other economies.

The remainder of this paper is organized as follows. Section 2 introduces our empirical framework, including the data set and the identification strategy. The results, i.e. impulse responses, forecast error variance decompositions, historical decompositions and counterfactual simulations, are discussed in Section 3. Section 4 examines the Phillips curve trade-off based on the domestic and global components of output. Section 5 draws conclusions for monetary policy.

2. Empirical Framework

The empirical analysis in this paper is based on an identified VAR model, as pioneered by Sims (1980). Much of the analysis that follows is based on the interpretations of structural shocks, i.e. disturbances that drive the dynamics of our economic variables. Therefore, we will carefully describe how the structural shocks in our analysis are identified.

2.1 The VAR Model

Our model can be written as:

$$y_t = c + A_1 y_{t-1} + \cdots + A_p y_{t-p} + \varepsilon_t, \qquad t = p + 1, \ldots, T, \qquad (1)$$

where y_t is an $n \times 1$ vector of endogenous variables, which in our case will include key macroeconomic time series. Furthermore, $A_1, \ldots, A_p$ are $n \times n$ matrices capturing the VAR-coefficients and ε_t is an $n \times 1$ vector of residuals which is assumed to follow a multivariate normal distribution $\varepsilon_t \sim N(0, \Sigma)$.

A major challenge when dealing with impulse responses from VAR models with Σ being unrestricted a-priori is that they arise from shocks that are correlated. Put differently, the variance-covariance matrix Σ of the reduced form VAR as in (1) is typically not diagonal. In that case, the interpretation of impulse responses is likely to be misleading and meaningless given the fact that shocks typically arise simultaneously. To overcome this issue, we derive structural VARs (SVARs) for each country as they allow us to obtain the responses of variables to distinct orthogonal shocks.

To do so, note that (1) can be formulated in a structural form that reads:

$$D_0 y_t = F + D_1 y_{t-1} + \cdots + D_p y_{t-p} + \eta_t,$$

where $\eta_t \sim N(0, \Gamma)$ is the vector of structural shocks we are interested in. Since the SVAR model as above is now augmented by the structural matrix D_0, Γ will be a diagonal identity matrix, i.e. structural disturbances in η_t are mutually independent. This is reasonable from a theoretical point of view as it makes sense to assume that structural disturbances are uncorrelated and arise independently.

In our estimation, we rely on a Bayesian framework, where the coefficients as well as the residual variance-covariance matrix are understood as random variables and characterized by some probability distribution. The basic principle of Bayesian analysis is to combine our subjective prior information with the likelihood function according to the Bayes rule in order to derive a posterior distribution which combines both sources of information. Let θ be the vector which contains all parameters of interest, also let y be the data set. The Bayes rule therefore reads:

$$\pi(\theta|y) = \frac{f\ (y|\theta)\pi(\theta)}{f(y)}.$$

The Bayes rule says that the posterior distribution, $\pi(\theta|y)$, is equal to the product of the likelihood function $f\ (y|\theta)$ with the prior distribution $\pi(\theta)$, which is normalized by the posterior density $f\ (y)$. In our benchmark model, we use $p\ =\ 2$ lags. We rely on a normal-Wishart prior, where it is assumed that both β and Σ are unknown. We follow standard literature and set the overall tightness to $\lambda_1\ =\ 0.1$ and the lag decay to $\lambda_3\ =\ 2$. Each country-specific benchmark estimation relies on 5000 draws, where the first 3000 draws are discarded as the first draws of the joint posterior are likely to be not representative for the target distribution we are looking for.

2.2 Data and Shock Identification

We estimate the model for six Asian emerging market economies: Indonesia (IDN), Korea (KOR), Malaysia (MAL), the Philippines (PHL), Singapore (SGP) and Thailand (THA). The vector of endogenous variables includes the oil price, real GDP, consumer prices, the short-term interest rate as a measure of monetary policy, the real effective exchange rate and the share of domestic real GDP in world real GDP. The latter variable will be particularly important in order to separate global from domestic shocks.[6] All variables other than the share in world GDP and the interest rate are included in year-on-year growth rates in percentage points. The data covers the sample period 2001Q1 to 2018Q1 and the frequency is quarterly. Our choice of year-on-year growth rates is motivated twofold: first, the seasonal pattern in the data might be different compared to advanced economies, i.e. due to the Chinese New Year and other regional effects. Using year-on-year rates allows us to ignore seasonal adjustment. Second, inflation targeting monetary policy is typically formulated in year-on-year inflation rates. Our policy counterfactuals presented below are thus in line with definitions used by central banks.

The share in world GDP is included in differences (percentage point change from year ago). An increase in the real effective exchange rate corresponds to a real appreciation of the domestic currency.[7]

6. We use headline inflation instead of core inflation. This is because central banks typically use the growth rate of the overall price index as a target variable. Moreover, data on core inflation is not available for all six countries under consideration.

7. The data GDP, prices and the interest rate is taken from the CEIC database. Oil prices are drawn from the FRED database at the St. Louis Fed. For the real effective exchange rate, we use the data provided by the BIS pertaining to a broad set of trading partners. The share in world GDP is drawn in annual frequency from the world economic outlook (2018) and interpolated (cubic spline interpolation method) in order to get quarterly data.

To identify structural shocks, we use three sets of alternative restrictions, see Table (1). The first two sets impose alternative sign restrictions onto the variables (Uhlig, 2005), while the third imposes a Cholesky ordering.

I. Baseline Sign Restrictions

Our first identification strategy follows Corsetti et al. (2014), who impose a mixture of sign and zero restrictions in order to distinguish domestic shocks from global shocks as well as supply shocks from demand shocks. The key variable in this identification pattern is the share of real domestic GDP in world real GDP, as it allows us to distinguish disturbances that hit the global economy more than the domestic economy and vice-versa.

Both a domestic as well as a global demand shock are supposed to raise both domestic prices as well as domestic real GDP. The imposed positive sign on the GDP share means that domestic real GDP increases more than real GDP in the rest of the world does, i.e. the effect of a domestic demand shock has a stronger effect on domestic GDP. In contrast, a global demand shock leads a drop in the share of domestic real GDP relative to the rest of the world GDP, meaning that a global demand shock has a stronger effect on the rest of the world, though domestic real GDP and domestic consumer prices are assumed to increase.

In order to further distinguish global demand shocks from domestic demand shocks, we also assume that a global demand shock leads to an increase of the oil price, while both the interest rate as well as the exchange rate remain unrestricted. Because we focus on small open economies, domestic demand shocks leave the oil price unchanged (i.e. unrestricted), but the interest-rate is assumed to increase in order to reduce inflation pressure.

An oil supply shock, which is intended to represent a global supply shock, is restricted to decrease domestic real GDP and increase inflation, while the immediate response of domestic short-term interest rate is restricted to zero.[8] This is due to the fact that the central bank does not contemporaneously respond to oil shocks.[9] In contrast to a domestic demand shock, a domestic supply shock leads to opposite responses of output and prices. In order to get distinct global and domestic supply shocks, the domestic supply shock is also assumed to increase domestic real GDP relative to real GDP of the rest of the world. The restrictions on the monetary policy shock imply that variables other than the exchange rate respond with at least one-month delay to an increase in the interest rate. An exchange rate shock is surprise change in the exchange rate that contemporaneously keeps all other variables unchanged.[10]

8. Indonesia is a net oil importing country, although the country also had net oil exports in the past. Malaysia is a (small) net oil exporting country. These potential limitations should be kept in mind when discussing the results for oil price shocks.

9. For a further discussion, see Bobeica and Jarocinski (2017) and Corsetti et al. (2014).

10. Singapore operates a system of a managed exchange rate against a basket of currencies. Hence, an exchange rate shock as identified here could also be interpreted as monetary policy shock.

II. Alternative Sign Restrictions

An alternative set of sign restrictions follows Bobeica and Jarocinski (2017), who adopt a mixture of the sign restrictions proposed in Corsetti et al. (2014) and Baumeister and Benati (2013). The identification scheme differs from the baseline set of restrictions only with respect to the identification of the monetary policy shock. It is assumed that real activity and inflation immediately respond to a monetary policy shock in a way that is consistent with standard theories of monetary transmission. Since the monetary policy tightening has a stronger effect on the domestic economy than the rest of the world, the GDP share is also assumed to drop immediately after the shock hits the economy. In addition, the domestic currency appreciates in real terms following a policy tightening.

III. Cholesky Ordering

For robustness purposes, the last identification strategy is based on a Cholesky approach, where the variance-covariance matrix is decomposed into a product of a lower triangular matrix and its transpose. We order the oil prices first, followed by the share of domestic real GDP relative to GDP of the rest of the world. The domestic short-term interest rate is ordered after domestic real GDP and inflation, respectively, while the exchange rate is ordered last. Note that this ordering assumption relies on a timing restriction, i.e. it is assumed that global shocks (oil supply and global demand) are assumed to immediately affect all other variables, while domestic shocks do not affect global variables (oil price and GDP share) contemporaneously. Ordering the short-term interest rate after domestic real GDP and inflation delivers a distinct monetary policy shock, as is standard in the literature (see, for instance, Christiano et al., 1999). Ordering the exchange rate last implies that all structural shocks immediately affect the exchange rate, but the contrary does not hold. Note also that the exchange rate shock is common to all three identification strategies I-III.

All results reported throughout this paper are based on the baseline identification strategy I, i.e. the Corsetti et al. (2014) identification.[11]

3. Results

3.1 Impulse Responses

The impulse responses are shown in Figures (1) to (12). Each figure presents the response of inflation or GDP growth, respectively, to each of the six identified shocks. The shock size is normalized to one standard deviation. Since the VAR model is heavily restricted, we do not emphasize the interpretation of the responses too far. Note, however, that most responses are persistent, though the restrictions on the sign of the responses are imposed on impact only. Take Korea as an example. The responses of inflation, see Figure (4), to domestic and global demand shocks is quite persistent. Inflation returns to its mean two or three years after the shock. Hence, the sign restrictions do not seem to overly stretch the data. We also find that monetary policy shocks and exchange rate shocks give rise to an insignificant response of inflation. These results will turn out to be important below.

11. The results based on identification strategies II and III lead to qualitatively similar results, which are available on request.

3.2 Forecast Error Variance Decomposition

A decomposition of the forecast error variance tells us how much of the forecast error variance is due to exogenous shocks and thus indicates the amount of information each variable contributes to the other variables in the autoregressive process. Notice that our VAR model in the reduced form can be rewritten as a moving average that reads:

$$y_t = A(L)^{-1}c + \varepsilon_t + \Psi_1 \varepsilon_{t-1} + \Psi_2 \varepsilon_{t-2} + \cdots,$$

where Ψ_k for $k = 1, \ldots, \infty$ captures the series of impulse function matrices. By exploiting the fact that $\Psi_k \varepsilon_{t-k} = \Psi_k D_0 D_0^{-1} \varepsilon_{t-k} = \tilde{\Psi}_k \eta_{t-k}$, it is possible to write a system in terms of structural disturbances:

$$y_t = A(L)^{-1}c + \sum_{k=0}^{\infty} \tilde{\Psi}_k \eta_{t-k}.$$

We can decompose the forecast y_{t+h} into three components:

$$y_{t+h} = A(L)^{-1} + \sum_{k=0}^{\infty} \tilde{\Psi}_k \eta_{t+h-k} + \sum_{k=0}^{h-1} \tilde{\Psi}_k \eta_{t+h-k},$$

where the last term describes the contribution of unknown future shocks. The forecast errors for variable i in the VAR therefore reads:

$$y_{i,t+h} - E_t y_{i,t+h} = \sum_{k=0}^{h-1} \tilde{\psi}_{k,i1} \eta_{1,t+h-k} + \cdots + \sum_{k=0}^{h-1} \tilde{\psi}_{k,in} \eta_{n,t+h-k}.$$

Denote by $\sigma^2_{y,i}(h)$ the forecast error variance of y_i h stepts ahead and $\sigma^2_{\eta,1}, \ldots, \sigma^2_{\eta,n}$ the variance of structural disturbances. Since our structural disturbances are, by construction, uncorrelated, taking the variances on both sides and dividing by $\sigma^2_{y,i}(h)$ yields:

$$1 = \frac{\sigma^2_{\eta,1}}{\sigma^2_{y,i}(h)} \sum_{k=0}^{h-1} \tilde{\psi}^2_{k,i1} + \cdots + \frac{\sigma^2_{\eta,n}}{\sigma^2_{y,i}(h)} \sum_{k=0}^{h-1} \tilde{\psi}^2_{k,in}.$$

Each term on the right-hand side tells us the contribution of the underlying structural shocks on the forecast error variances. Throughout the paper, we summarize the contributions of all shocks into four main categories, namely (i) monetary policy shocks, (ii) exchange rate shocks, (iii) domestic shocks and (iv) global shocks. Thereby, we exploit 'domestic' shocks as the umbrella term for both domestic demand as well as domestic supply shocks. Meanwhile, 'global' shocks summarize both global demand and oil supply shocks, while monetary policy shocks and exchange rate shocks are the remainder.

Table (2) reports the results of the forecast error variance decomposition for inflation and GDP growth for different horizons, i.e. for $h = 4{,}8$ and $h = 12$. As expected, small open economies in Asia are very much exposed to global driving forces of inflation. Our results suggest that global shocks drive a large fraction of inflation dynamics. Over a horizon on $h = 8$ quarters, global shocks explain between 35% (Indonesia) and 70% (Malaysia) of inflation. That is, whenever we try to forecast inflation, a large portion of the forecast error occurs because global shocks push inflation above or below the predicted value. The remaining part of inflation dynamics is driven by domestic shocks, with exchange rate and monetary policy shocks playing a minor role. For GDP growth, we find that global shocks explain between 34% (Thailand) and 59% (Philippines) of output growth over a two-year horizon.

3.3 Historical Decomposition

While structural forecast-error-variance decompositions and structural impulse response functions describe average movements in the data, they do not allow us to quantify the amount of how much of the historically observed fluctuations of a variable is explained by one specific shock. Even though our results so far suggest that both global and domestic shocks are an important driver for inflation and GDP growth, we do not know anything about the effect of past (known) shocks on the fluctuation of these variables. Hence, to establish the contribution of structural shocks to the dynamics of our data series, we depart from unconditional expectations and derive the posterior distribution of historical decompositions for every endogenous variable. Contrary to the average contribution of our identified shocks to the variability of inflation and GDP growth from 2001 to 2018, we are now interested in the cumulative effects of past shocks. Similar to the previous section, we will only report the results for inflation and GDP growth.

We can decompose the vector of endogenous variables y_t into a vector of contributions from deterministic variables $d^{(t)}$ and historical contributions of structural shocks as:

$$y_{i,t} = d_i^{(t)} + \sum_{k=0}^{t-1} \tilde{\psi}_{k,i1}\eta_{1,t-k} + \sum_{k=0}^{t-1} \tilde{\psi}_{k,i2}\eta_{2,t-k} + \cdots + \sum_{k=0}^{t-1} \tilde{\psi}_{k,in}\eta_{n,t-k} \quad (2)$$

where $\tilde{\psi}_{k,i1}$ denotes the entry of row i and column k of the structural impulse matrix $\tilde{\Psi}_k$, i.e. the impact of shock k on variable i.

The historical decomposition in (2) shows that, for example, a positive contribution of structural shock k to variable i means that shock k pushes variable i above the deterministic component, i.e. the unconditional forecast in the absence of any shocks.

Figures (13) and (14) show the historical contributions of structural shocks for the inflation rates for all countries. The black line reflects the difference between the unconditional forecast (i.e. the deterministic part) generated by the VAR and the actual data series, while the colored bars highlight the fraction of this series explained by each of the four groups of shocks.

When interpreting the historical contribution of structural shocks, it is important to note that negative values do not correspond to period of disinflation, but negative contributions that push the inflation rate below the deterministic component which is non-negative for all countries throughout the entire sample.[12]

Four key results stand out for all countries.[13] First, while for some countries the effect of domestic shocks dominates, global shocks (as contributions of oil supply shocks plus global demand shocks) play an important role for inflation. Both sources of inflation dynamics, i.e. domestic and global shocks, are typically positively correlated, that is they jointly push inflation up or down. There are only very few episodes in which both forces push inflation into opposite directions. This finding has important consequences for the design of monetary policy as we will discuss below. If both domestic and global shocks were negatively correlated, shocks would partly offset domestic driving forces. However, the results suggest that global shocks exacerbate inflation fluctuations, thus requiring a more aggressive monetary policy response.

Second, global shocks are particularly important in 2008/9. They drive inflation up before the global financial crisis and contribute to the fall in inflation during the subsequent Great Recession. Third, the very low levels of inflation observed more recently are partly due to global driving forces. In countries such as Korea, Singapore and Thailand global shocks put downward pressure on inflation after 2014.

Fourth, both exchange rate and monetary policy shocks contributed relatively little to the fluctuation of the inflation rate. While monetary policy shocks play some noteworthy role around the Great Recession in Singapore, the Philippines and Korea, they have almost no role on the dynamics of inflation in Malaysia and Thailand. This result suggests that central bank effectively stabilize the economy with only small deviations of monetary policy from its systematic component.

Exogenous fluctuations in the real exchange rate play a minor role for inflation dynamics. This is particularly interesting in light of the strong exchange rate movements in emerging economies around the adoption and the unwinding of the Federal Reserve's Quantitative Easing. It is, however, important to keep in mind that the historical decomposition dissects inflation into structural shocks, i.e. into exogenous changes of the exchange rate. Hence, the finding that exchange rate shocks play a small role only is consistent with the notion that of central banks being effective in stabilizing inflation in light of exchange rate movements.

Summing up our findings, our historical decompositions support our findings from the FEVDs insofar as global and domestic shocks seem to be the main drivers of inflation throughout our set of countries. However, they also uncover that global shocks are primarily important in 2008/9 by explaining most of the increase in inflation in 2008 and the subsequent fall thereafter. Finally, our results in this section suggest that global shocks account for much of the recently observed low inflation rates, especially in Korea, the Philippines, Singapore and Thailand.

12. That is, even when structural shocks contribute negatively to inflation dynamics, we can still observe positive inflation rates when the deterministic component is greater than the overall contribution of all structural shocks.

13. It is worth noting that the other identification strategies II and III yield very similar results. Hence, our results are robust with respect to the identification scheme used.

3.4 Counterfactual Analysis

Now that we have already learned about the contributions of structural shocks to the dynamics of inflation, we will go a step further in this section and run simulation exercises to investigate how the dynamics of our endogenous variables would have evolved in different scenarios. We run a battery of counterfactual experiments in order to shed light on the role of alternative drives of inflation and the business cycle.

We separately show how inflation and real GDP would have looked like in the absence of either domestic, global, monetary policy or exchange rate shocks. The previous analysis provides us with everything in order to derive these counterfactual paths, because these counterfactuals are the difference between the actual data and the contributions of structural shocks we have already derived before.[14]

In a first scenario, we study inflation in the absence of selected structural shocks. For that purpose, we suppress, one at a time, the four groups of structural shocks as aggregated in the previous section, i.e. (i) monetary policy shocks, (ii) exchange rate shocks, (iii) domestic shocks, as well as (iv) global shocks to zero.

This experiment follows, among others, Sims and Zha (2006) and can be summarized as follows: given the data, it is possible to draw all parameters from the joint posterior distribution. It is then easy to recover a sequence of unit-variance structural shocks (as described in section 2) and simulate a series that would have been observed, given the vector that contains the suppressed structural shocks. This is straightforward as we already have derived the historical decomposition.[15]

Each variable of our vector y_t can be rewritten as:

$$y_{i,t} = d_i^{(t)} + \sum_{k=0}^{t-1} \tilde{\psi}_{k,i1}\eta_{1,t-k} + \sum_{k=0}^{t-1} \tilde{\psi}_{k,i2}\eta_{2,t-k} + \cdots + \sum_{k=0}^{t-1} \tilde{\psi}_{k,in}\eta_{n,t-k},$$

where the sums on the right-hand-side corresponds to the contributions of structural shocks, as in the previous subsection. We can then simulate counterfactual paths by setting an arbitrary shock to zero or, equivalently, subtracting the contribution of this shock. Given that η_1 corresponds to the vector of monetary policy shocks, for example, means that $\tilde{\eta}_{1,t}$ is equal to zero in every period. We construct counterfactual paths for inflation and GDP growth by separately suppressing each shock for the entire sample, i.e. separately setting $\eta_{1,t}, \eta_{2,t}, \eta_{3,t}$ and $\eta_{4,t}$ to zero. In order to save

14. Nevertheless, the derivation of the counterfactual paths makes sense for two reasons. First, it is much easier to visualize uncertainty surrounding the counterfactual. We can now say whether the contributions of structural shocks have led to significantly different results. Second, and more importantly, we now see the overall effects more clearly. Since the result of deriving the simulated paths is nothing more than subtracting the contribution of structural shocks from the observed series, we now see how a series of shocks in the past propagates through the system and affects today's dynamics.

15. Even without deriving the historical contributions of each structural shocks, one could also construct the same counterfactual data as follows: for each draw of our estimation procedure, recover the VAR coefficients as well as the structural matrix as in section 2. Then derive the vector of structural shocks η_t. Setting different shocks to zero results in a vector $\tilde{\eta}_t$ that can be used to construct the counterfactual paths. This is done by simulating the vector of counterfactual data as $y_t^{CF} = c + B_1 y_{t-1}^{CF} + \cdots + B_p y_{t-p}^{CF} + D_0^{-1}\tilde{\eta}_t$.

space, we mainly discuss the counterfactuals for Korea, see Figures (17) and (18), which depict the simulated paths for inflation and GDP growth, respectively, in counterfactual scenarios in which the aggregate global shock, the monetary policy shock, the aggregate domestic structural shock as well as the exchange rate shock are suppressed. The red solid paths correspond to the median counterfactual paths, while the shaded areas enclose the 16th and 84th percentiles.

Two things are noteworthy. First, similar to our results from the historical decomposition, our results suggest that the role of both monetary policy shocks (panel II) and exchange rate shocks (panel IV) is small, as in the absence of both structural shocks GDP growth and inflation would have looked very much like the observed series.

Second, suppressing either the global shock (i.e. the oil supply shock plus the global demand shock) or the domestic shock (domestic demand plus domestic supply shock) does make a difference. Starting with GDP growth, our results suggest that in the absence of global shocks, we would have observed lower GDP growth during 2003-2005 but higher growth rates, or a smaller recession, respectively, during the global financial crisis. Domestic shocks, however, seem to have a more important role for Korean GDP. From 2001Q3-2003Q2, our counterfactual growth paths remain at about 4% on average. However, since we observed higher growth rates in reality (peaking at about 8% in 2002Q3), we conclude that it is primarily domestic shocks that pushed up GDP growth. A similar argumentation holds for the rest of the sample, i.e. domestic shocks kept inflation low from 2002Q4-2004Q2 as well as in the aftermath of the global financial crisis. Summarizing the results for Korean GDP growth, we conclude that global shocks as well as domestic demand shocks seemed to have had a more important role than monetary policy shocks and exchange rate shocks. During times of financial turmoil, global shocks have a more important role than domestic shocks.

In the aftermath of the financial crisis, the counterfactual path for inflation in the absence of domestic shocks lies above the actual inflation rate, see Figure (18). Thus, domestic shocks kept Korean inflation rates low. The impact of global shocks goes into the same direction, though its magnitude is smaller. Again, monetary policy shocks and exchange rate shocks play a minor role for the determination of inflation as the respective counterfactuals are indistinguishable from observed inflation.

Robustness Check

So far, our results suggest that monetary policy shocks have little effect on the dynamics of real activity. Therefore, we now ask whether the same is true for the systematic part of monetary policy.

In order to do so, we follow, among others, Gordon and Leeper (1994), and Leeper and Zha (2003) who base the specification of monetary policy behavior on the information available to the central bank within the quarter. Recall that under our benchmark identification strategy, both demand and supply structural disturbances have simultaneous effects on the interest-rate equation. In order to impose an alternative systematic monetary policy behavior, we therefore restrict the corresponding coefficients in the structural matrix D to zero such that both demand and supply shocks do not have a contemporaneous impact on the short-term interest rate. The results (not presented) are qualitatively and quantitatively for all countries very much the same as in the benchmark case. This also reflects our previous results, i.e. that departures from the policy rule have only limited effects on inflation dynamics.

4. How Global Shocks Affect the Phillips Curve Trade-off

Much of the discussion about the changing nature of inflation is framed in terms of the Phillips curve relation between inflation and real activity. It is often argued that the process of inflation determination has changed. Not only advanced economies, but also many emerging market economies have experienced declines in inflation that were lower than expected. A flattening of the Phillips curve could have important consequences for monetary policy as disinflation policy becomes more costly in terms of foregone economic activity.

In this section, we estimate simple Phillips curves for our six countries under investigation and see if the Phillips curve is still 'alive' in general or whether shifts have occurred that led to a flattening or steepening of the Phillips curve. We further investigate whether these changes stem from domestic factors or from global factors. In contrast to much of the literature, we do not add additional variables to the Phillips curve such as oil prices of measures of global output gaps in order to assess these variables' effects on the slope of the output-inflation trade-off. Instead, we decompose the observed series of output growth into components attributable to domestic and global shocks, respectively. Thus, we can show whether global and domestic factors equally affect the Phillips curve, or whether global (or domestic) factors lead to a steepening or a flattening of the Phillips curve.

By decomposing economic growth into domestic and global components, we can also avoid an econometric problem faced by studies which extend the Phillips curve by measures of global slack. Global output gaps are typically highly correlated with the domestic output gap (see Jasova et al., 2018). Hence, the studies have difficulties separating the true effects from domestic and global forces. Instead, our decomposition is based on orthogonal structural shocks.

Note that up to now, we summarized the contributions of oil supply shocks and global demand shocks which we referred to as the contributions of 'global shocks'. That is, we ignore whether the contribution of oil supply shocks and global demand shocks can have different signs. We account for this possibility by splitting up the global component into its single parts, i.e. the parts that stems from oil supply shocks and global demand shocks.

Our baseline regression relies on a hybrid Phillips curve that reads:

$$\pi_t = b_{x,CF} x_t^{CF} + b_{x,j} x_t^j + b_\pi \pi_{t-1} + \varepsilon_t, \qquad (model\ A)$$

where π_t is the observed year-on-year inflation rate, x_t^{CF} is the counterfactual path of the growth rate of domestic real GDP in the absence of global shocks, i.e. the domestic component of economic growth. x_t^j for $j = \{oil, dem, global\}$ denotes the contribution of either oil supply, global demand shocks or the sum of both to the growth rate of real GDP. Technically, this contribution corresponds to the distance between the actual data (black line) and the median of our counterfactual data (red solid line) in our simulation exercise where we simulated global shocks away, see Figures (15) to (26). We further add past inflation as a proxy of today's expectations of future inflation. For $b_{x,CF} = b_{x,j}$, the distinction between domestic and global components of activity becomes obsolete. Hence, the model nests the conventional specification which regresses actual inflation on actual output growth.

Our sample includes observations from 2001Q3-2018Q1. In order to test for a structural break, we estimate the model not only for the full sample, but also for a sample starting in 2008Q1. Our estimation results are reported in Table (3).

Let us highlight a few key results. First, across all countries, the coefficient on x_t^{CF}, i.e. the effect of the domestic component of GDP growth is significantly positive. Our results suggest that the Phillips curve trade-off remains valid and has the expected sign. An increase in the domestic part of growth is inflationary.

Second, our results suggest that the Phillips curve became steeper since 2008, as in many cases $b_{x,CF}$ for the *post 2007* sample is higher (and still significant) than for the *full* sample.

Third, the effects of the global component are different across specifications of global shocks but equal across countries (except Malaysia). Starting with oil supply shocks, for example, we find that for all countries other than Malaysia and Singapore, including the GDP component stemming from oil supply shocks seem to flatten the Phillips curve. Interestingly, this coefficient is significant at the 1% level for Thailand and the Philippines and becomes stronger over time. For the other countries, our results suggest that this effect was significant up to 2008 for Indonesia, while the opposite is true for Korea, where $b_{x,oil}$ is estimated to -0.35 for the full sample and -1.05 (significant at the 1% level) for the short sample. While the negative sign also prevails for the estimation results for Singapore, the coefficients are not distinguishable from zero.

Turning to global demand shocks, our results suggest that for all countries, global demand shocks significantly steepen the Phillips curve. Put differently, ignoring the fraction of GDP growth driven by global demand shocks leads to a flatter Phillips curve. The effect of global demand shocks on inflation becomes stronger over time in Korea, Malaysia and weaker in the other countries.

We can conclude that the effect of global driving forces on the Phillips curve trade-off critically depends on the nature of these forces. While global factors in terms of oil supply shocks lead to a flattening of the Phillips curve, the opposite is true for global shock in terms of global demand shocks. We derive these results because our identification strategy is not only able to distinguish global shocks from domestic shocks in general, but also global oil supply shocks from global demand shocks.

In this respect, however, it is important to account for the relative share of inflation fluctuations explained by these shocks. Our results of the lower block that summarizes the contributions of both oil supply shocks and global demand shocks suggests that these two global shocks jointly lead to a steepening of the Phillips curve.

For robustness purposes, we also add control variables into the baseline regression. The reason is that the component of output growth driven by oil supply shocks is highly correlated with a fall in the price of oil. Including the growth rate of the oil price thus allows the capture of the effect of domestic output growth following an oil price shock on domestic inflation, while controlling for the actual effect on the price of oil. Hence, our alternative regression B reads:

$$\pi_t = \beta_{x,CF} x_t^{CF} + \beta_{x,oil} x_t^{oil} + \beta_{x,dem} x_t^{dem} + \beta_\pi \pi_{t-1} + \beta_{oil} \Delta oil_t + \varepsilon_t, (model\ B)$$

where everything is equal to model (A) and Δoil_t is the annual growth rate of the oil price. As can be seen in Table (4), our results do not change too much. Except for Malaysia, the coefficient $b_{x,CF}$ is significant at the 1% level for all countries. The coefficients on the components of output growth driven by oil price shocks and global demand shocks are still significant in most cases and have the same sign as before, although the coefficient $b_{x,oil}$ is not different from zero for Korea, Malaysia and Singapore.

Our results remain robust if we add country i's GDP relative to the world GDP as a second control variable, as is done in model (C). While the coefficient on the component of output growth driven by oil price shocks is still not significant for Malaysia, the qualitative results are very much the same as in both our baseline model (A) and in (B). We conclude that our results do not suffer from an omitted variable bias, which can potentially occur because of the correlation between the fall in oil prices and the growth component driven by oil price shocks.

5. Conclusions

This paper adds to the discussion about the changing nature of inflation dynamics in six Asian emerging market economies. We estimate a series of VAR models, in which we identify a battery of demand and supply shocks using sign restrictions. Focusing on the co-movement between domestic and global variables, our identification strategy also allows us to distinguish between global and domestic shocks. Relying on forecast error variance decompositions and historical decompositions, we find that (1) global factors play an important role for both inflation and the growth rate of real GDP across all countries under consideration and (2) the role of monetary policy is limited. While global factors can explain the sharp increases and the subsequent plunges around the Great Recession, they also contribute much to the low inflation rates that have been recently observed. Since global factors are driving a substantive share of inflation, domestic monetary policy is increasingly less able to stabilize inflation and the real economy.

We also revisit the Phillips curve relation between inflation and real activity. This is particularly important for policymakers as monetary policy in the short-run induces movements along the Phillips curve, thus stimulating the economy by controlling domestic demand. By decomposing the observed growth rates of domestic real GDP into components attributable to domestic and global shocks, we investigate whether potential shifts in the relationship between inflation and economic activity have led to a flattening (steepening) of the Phillips curve. Our results suggest that for all countries considered, the Phillips curve is still alive when estimated using the domestic component of GDP growth. Including the components of growth due to oil price shocks and global demand shocks, respectively, changes the Phillips curve trade-off. While GDP growth due to oil supply shocks seem to flatten the Phillips curve in all countries, the contrary is true for the fraction of GDP

due to global demand shocks. In the latter case, the Phillips curve becomes steeper once we include the part of GDP driven by global demand. Hence, we show global integration affects the Phillips curve and that the nature of global shocks determines whether the curve steepens or flattens.

Our results highlight the difficulties facing inflation targeting central banks in the region. While monetary policy affects domestic demand, global demand, which drives the bulk of inflation, is not under the control of monetary policy. To mitigate the role of imported inflation, exchange rates should be allowed to adjust more flexibly. Furthermore, monetary policy should not respond to oil price shocks directly. While being accommodating to first-round effects of oil price changes, policy should focus on stabilizing second-round effects of imported inflation.

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Appendix

Table 1: Identification of Structural Shocks

Variable \ shock	*oil supply*	*global demand*	*domestic demand*	*domestic supply*	*monetary policy*	*exchange rate*
I. Sign restrictions, Corsetti et al. (2014)						
Oil price	+	+				0
GDP share		-	+	+	0	0
Real GDP	-	+	+	+	0	0
Consumer prices	+	+	+	-	0	0
Interest rate	0				+	0
Exchange rate	+			+		+
II. Alternative sign restrictions						
Oil price	+	+			0	0
GDP share		-	+	+	-	0
Real GDP	-	+	+	+	-	0
Consumer prices	+	+	+	-	-	0
Interest rate	0		+		+	0
Exchange rate	+			+	+	+
III. Cholesky						
Oil price	+	0	0	0	0	0
GDP share		+	0	0	0	0
Real GDP			+	0	0	0
Consumer prices				+	0	0
Interest rate					+	0
Exchange rate						+

Notes: Blank cells indicate unconstrained impulse responses. A positive or negative reaction is denoted by + and -. A zero restriction is denoted by 0. All restrictions are imposed on impact only.

Table 2: Forecast Error Variance Decompositions

		IDN	KOR	MAL	PHL	SGP	THA
Inflation							
h = 4	exchange rate	1.49	1.02	0.75	0.66	1.02	1.32
	monetary policy	1.86	0.36	0.91	0.38	1.26	0.41
	global	23.64	50.75	73.30	66.53	39.40	55.76
	domestic	73.00	47.86	25.04	32.42	58.32	42.51
h = 8	exchange rate	2.55	1.86	1.61	1.84	2.17	3.46
	monetary policy	2.95	1.19	1.70	1.44	3.45	1.13
	global	35.37	45.75	69.29	60.66	34.92	50.31
	domestic	59.13	51.20	27.40	36.06	59.47	45.10
h = 12	exchange rate	3.70	2.89	2.00	2.32	2.77	4.22
	monetary policy	3.36	2.01	2.11	2.16	4.73	1.57
	global	38.90	44.09	66.69	58.86	35.92	48.34
	domestic	54.04	51.01	29.20	36.66	57.47	45.87
GDP growth							
h = 4	exchange rate	4.96	3.45	1.29	0.72	0.93	1.26
	monetary policy	3.84	0.35	0.65	0.78	0.53	0.61
	global	45.27	40.50	48.43	60.42	51.36	33.38
	domestic	45.93	55.71	49.63	38.07	47.18	64.75
h = 8	exchange rate	7.89	6.96	2.44	1.57	1.61	2.35
	monetary policy	6.76	0.97	2.48	1.96	1.18	1.39
	global	40.86	40.21	48.60	58.62	51.12	34.42
	domestic	44.49	51.86	46.48	37.85	46.08	61.94
h = 12	exchange rate	8.56	7.53	2.96	2.08	1.94	2.84
	monetary policy	7.01	1.59	3.27	2.79	1.98	1.78
	global	40.47	40.91	47.84	57.26	48.58	35.24
	domestic	43.96	49.96	45.93	37.88	47.50	60.15

Notes: Median shares (in %) of forecast error variance for inflation (upper block) and GDP growth (lower block) due to structural shocks for different forecast horizons. The shares for global shocks comprise the contributions of global demand and oil supply shocks, while the shares of domestic shocks comprise the contributions of domestic demand and supply shocks, as explained section 2. All results rely on the Corsetti et al. (2014) identification.

Table 3: Phillips Curve Regression Results (Baseline Specification)

Coef. country		IDN	KOR	MAL	PHL	SGP	THA
oil supply shock							
$b_{x,CF}$	*full*	0.16^{*}	0.11^{***}	0.11^{**}	0.19^{***}	0.09^{***}	0.14^{***}
	post 2007	0.20^{*}	0.14^{***}	0.17^{**}	0.20^{***}	0.08^{***}	0.16^{***}
$b_{x,oil}$	*full*	-2.89^{*}	-0.35	0.33	-0.78^{***}	-0.04	-1.03^{***}
	post 2007	-1.11	-1.05^{***}	0.37	-0.92^{***}	-0.05	-1.11^{***}
b_{π}	*full*	0.85^{***}	0.82^{***}	0.74^{***}	0.72^{***}	0.85^{***}	0.70^{***}
	post 2007	0.78^{***}	0.74^{***}	0.69^{***}	0.65^{***}	0.85^{***}	0.61^{***}
R^2	*full*	70%	76%	44%	75%	86%	69%
	post 2007	62%	83%	42%	73%	88%	69%
global demand shock							
$b_{x,CF}$	*full*	0.19^{**}	0.08^{**}	0.11^{***}	0.07^{**}	0.06^{***}	0.12^{***}
	post 2007	0.21^{**}	0.05	0.15^{***}	0.07	0.09^{***}	0.12^{**}
$b_{x,dem}$	*full*	1.85^{***}	0.27^{***}	0.50^{***}	0.56^{**}	0.32^{***}	0.93^{***}
	post 2007	1.68^{***}	0.39^{***}	0.54^{**}	0.46	0.32^{***}	0.87^{***}
b_{π}	*full*	0.82^{***}	0.85^{***}	0.72^{***}	0.87^{***}	0.85^{***}	0.69^{***}
	post 2007	0.80^{***}	0.90^{***}	0.73^{***}	0.89^{***}	0.85^{***}	0.71^{***}
R^2	*full*	71%	79%	53%	70%	91%	73%
	post 2007	69%	84%	51%	65%	93%	70%
aggregate global shock (oil supply + global demand)							
$b_{x,CF}$	*full*	0.17^{**}	0.08^{***}	0.11^{***}	0.12^{**}	0.06^{***}	0.11^{***}
	post 2007	0.24^{**}	0.06	0.11^{***}	0.12^{**}	0.09^{***}	0.13^{**}
$b_{x,global}$	*full*	0.63	0.19^{***}	0.31^{***}	-0.07	0.12^{***}	0.24^{*}
	post 2007	1.15^{**}	0.27^{**}	0.36^{**}	-0.13	0.05^{***}	0.20
b_{π}	*full*	0.83^{***}	0.86^{***}	0.74^{***}	0.82^{***}	0.88^{***}	0.76^{***}
	post 2007	0.77^{***}	0.90^{***}	0.74^{***}	0.80^{***}	0.88^{***}	0.73^{***}
R^2	*full*	69%	78%	50%	69%	88%	63%
	post 2007	67%	83%	49%	65%	91%	60%

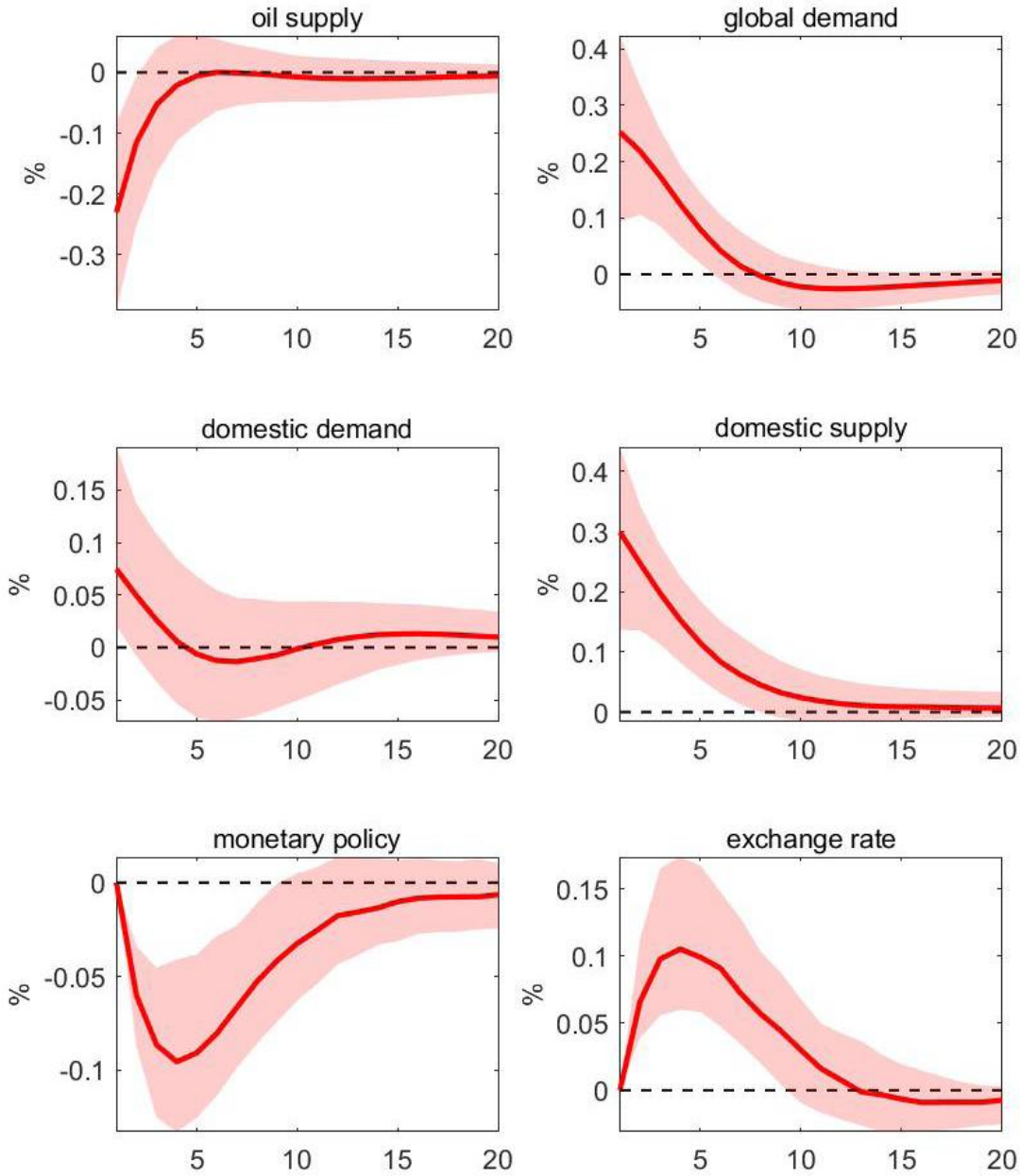
Notes: Estimation results (model A) for the baseline specification of the Phillips curve. x_t^{CF} represents the coefficient on counterfactual GDP growth that excludes the component driven by oil-supply shocks (first block), global demand shocks (second block) and the sum of both shocks (third block). $b_{x.j}$ for *j=oil, dem, global* is the coefficient on the component of GDP growth driven by oil-supply shocks, global demand shocks or the sum of both shocks, respectively. The lagged inflation rate enters with the coefficient b_{π}. The table also distiguishes between results for the full sample period (2001Q3 – 2018Q1) and the post 2007 sample (2008Q1 – 2018Q1). R^2 reports the proportion of the variance in the dependent variable that is predictable from the independent variables. Asterisks indicate significance at the 10 percent (*), 5 percent (**) and 1 percent level (***), respectively. All results rely on identification strategy I (Corsetti et al., 2014).

Table 4: Phillips Curve Regression Results (Alternative Specification with Control Variables)

Coef. \ country	IDN	KOR	MAL	PHL	SGP	THA
control variables: oil price (model B)						
$b_{x,CF}$	0.26^{***}	0.13^{***}	0.08	0.21^{***}	0.08^{***}	0.23^{***}
$b_{x,oil}$	-4.87^{***}	-0.48	-0.01	-0.81^{***}	-0.07	-1.40^{***}
$b_{x,dem}$	2.81^{***}	0.30^{**}	0.34^{*}	0.72^{***}	0.34^{***}	1.27^{***}
b_{π}	0.80^{***}	0.79^{***}	0.77^{***}	0.68^{***}	0.81^{***}	0.54^{***}
b_{oil}	-0.01	0.00	0.01^{***}	0.01^{***}	0.00	-0.01
R^2	76%	82%	59%	87%	92%	87%
control variables: oil price and share of world GDP (model C)						
$b_{x,CF}$	0.20	0.19^{***}	0.02	0.17^{**}	0.029^{**}	0.24^{***}
$b_{x,oil}$	-4.50^{**}	-1.42^{***}	0.05	-0.75^{***}	-0.37^{***}	-1.30^{***}
$b_{x,dem}$	3.13^{***}	0.57^{***}	0.37^{**}	0.70^{***}	0.61^{***}	1.14^{***}
b_{π}	0.80^{***}	0.73^{***}	0.75^{***}	0.70^{***}	0.64^{***}	0.53^{***}
b_{oil}	-0.00	-0.00^{*}	0.01^{***}	0.01^{***}	-0.02^{***}	-0.00
b_{share}	0.07	0.13^{***}	0.36	0.11	1.07^{***}	-0.08
R^2	76%	85%	60%	88%	97%	87%

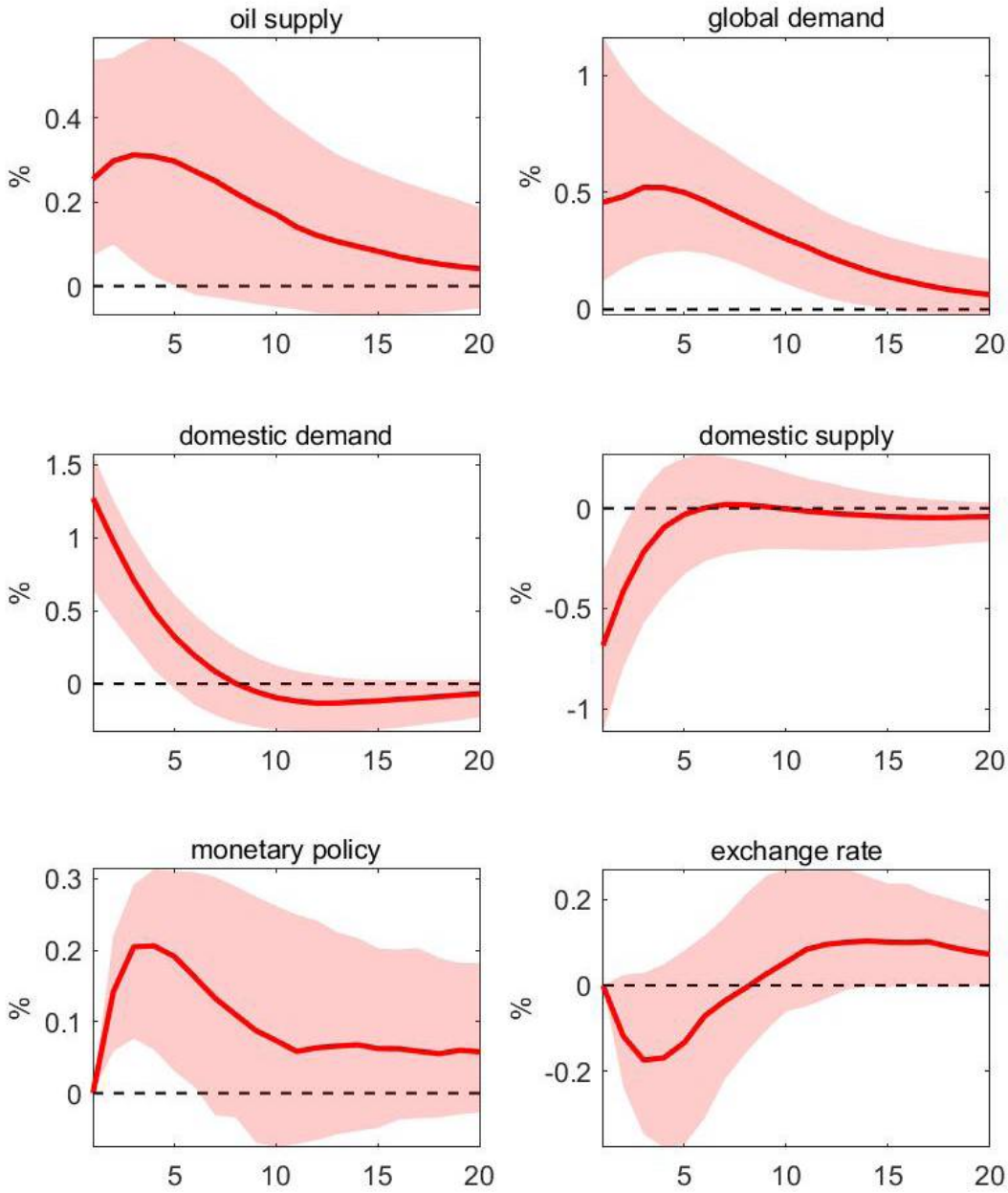
Notes: Estimation results (models A, C) for Phillips curve specifications with additional control variables. x_t^{CF} represents the coefficient on counterfactual GDP growth that excludes the sum of oil-supply and global demand shocks $b_{x.j}$ for *j=oil, dem* is the coefficient on the component of GDP growth driven by oil-supply shocks, or global demand shocks, respectively. The lagged inflation rate enters with the coefficient b_{π}, oil-price growth enters with the coefficient b_{oil} and the share of domestic GDP to world GDP enters with the coefficient b_{share}. R^2 reports the proportion of the variance in the dependent variable that is predictable from the independent variables. Asterisks indicate significance at the 10 percent (*), 5 percent (**) and 1 percent level (***), respectively. All results rely on identification strategy I (Corsetti et al., 2014).

Figure 1: Impulse Response of GDP Growth – Indonesia



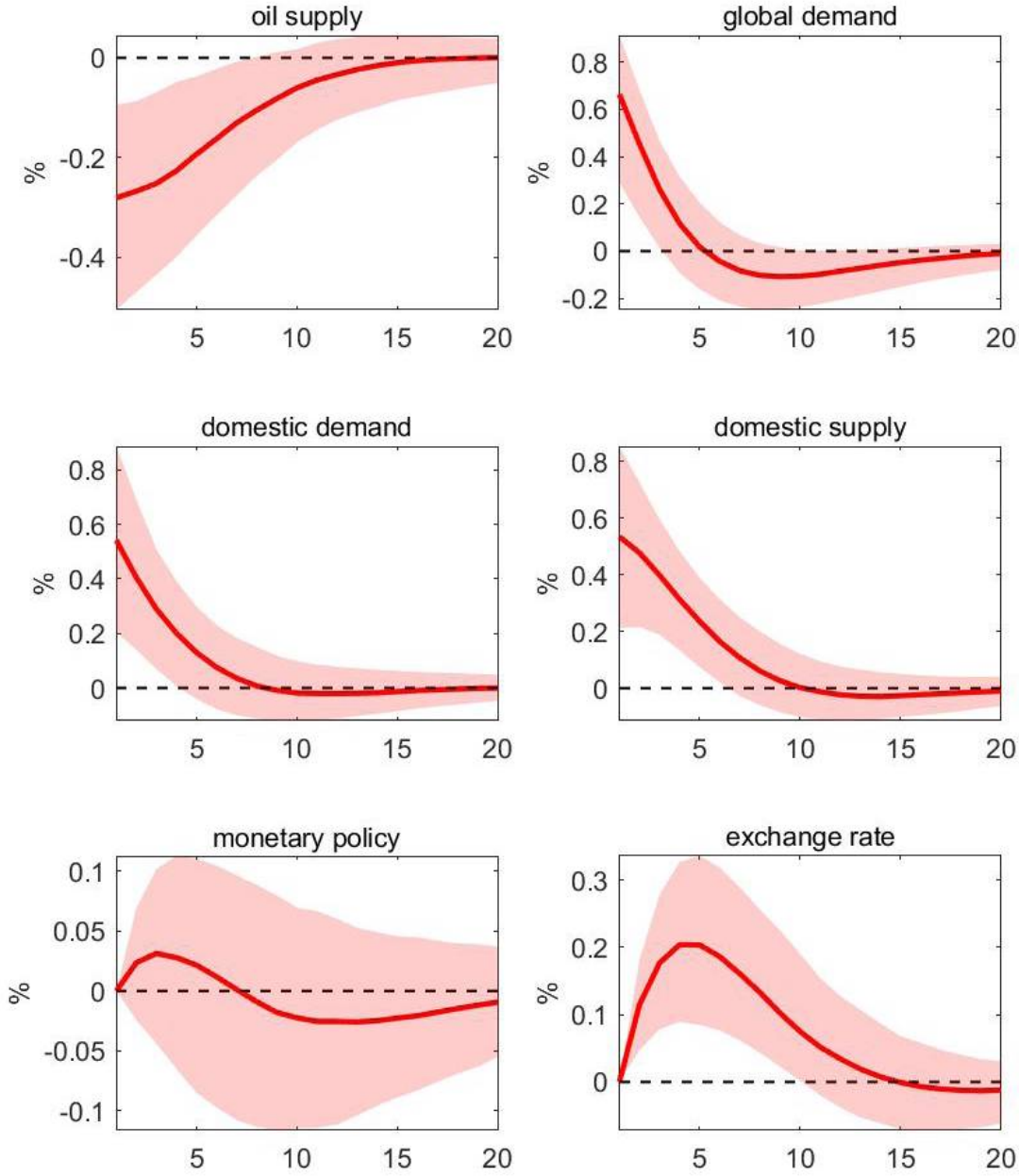
Notes: Median impulse response (red solid path) with 16th and 84th percentiles (red-shaded area). The sign restrictions are imposed on impact only. The identification of shocks relies on the Corsetti et al. (2014) identification.

Figure 2: Impulse Response of Inflation – Indonesia



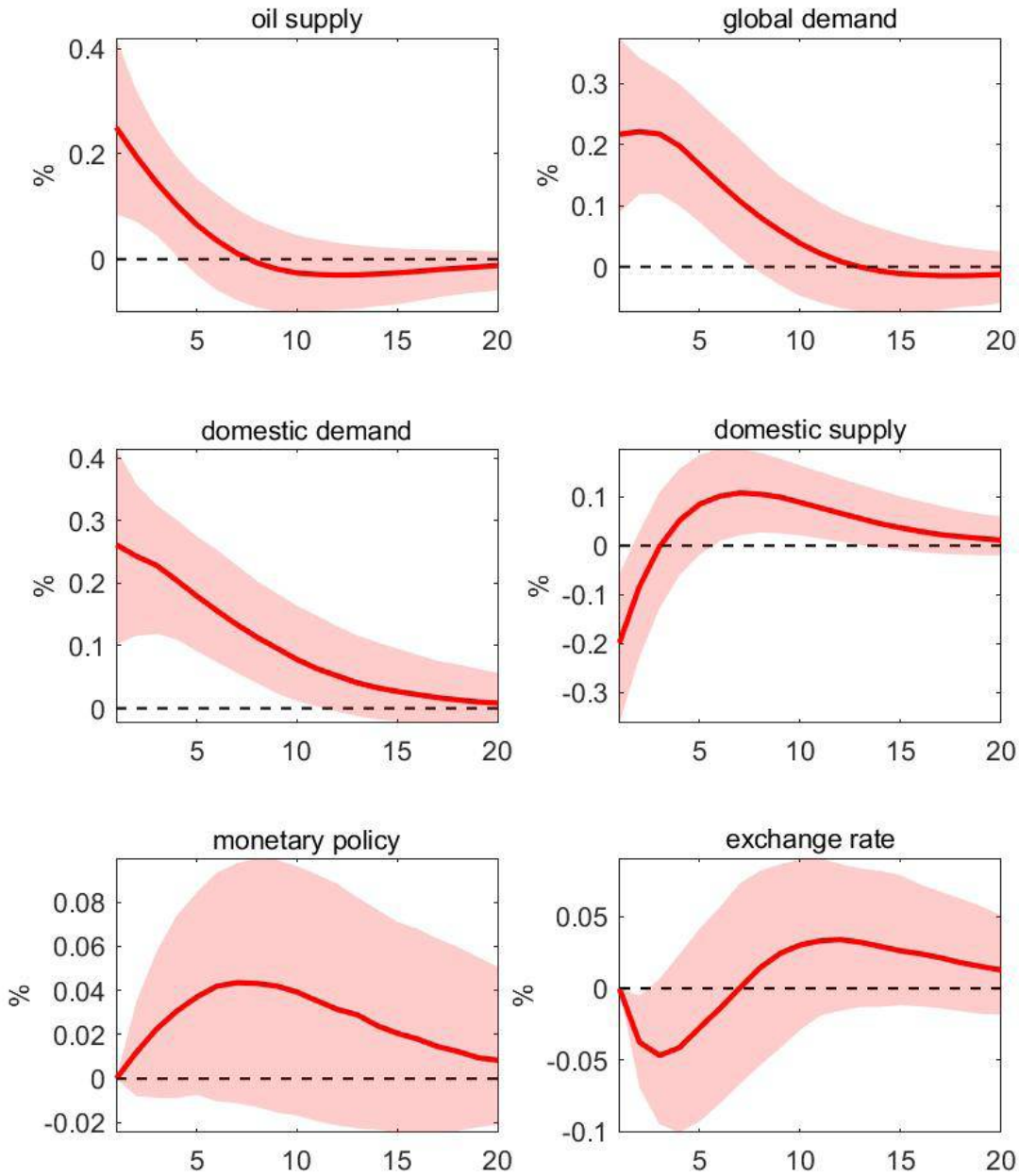
Notes: Median impulse response (red solid path) with 16th and 84th percentiles (red-shaded area). The sign restrictions are imposed on impact only. The identification of shocks relies on the Corsetti et al. (2014) identification.

Figure 3: Impulse Response of GDP Growth – Korea



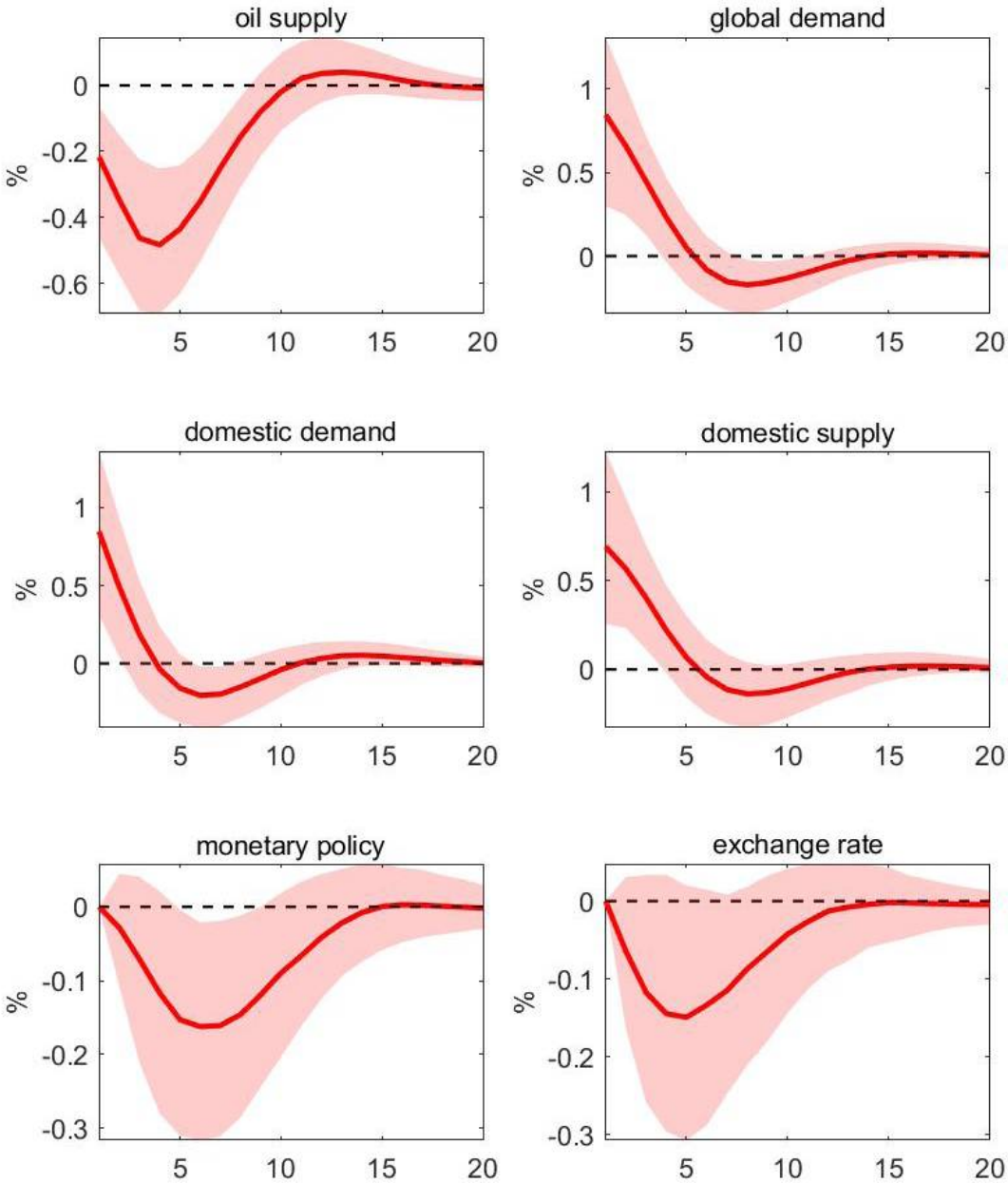
Notes: Median impulse response (red solid path) with 16th and 84th percentiles (red-shaded area). The sign restrictions are imposed on impact only. The identification of shocks relies on the Corsetti et al. (2014) identification.

Figure 4: Impulse Response of Inflation – Korea



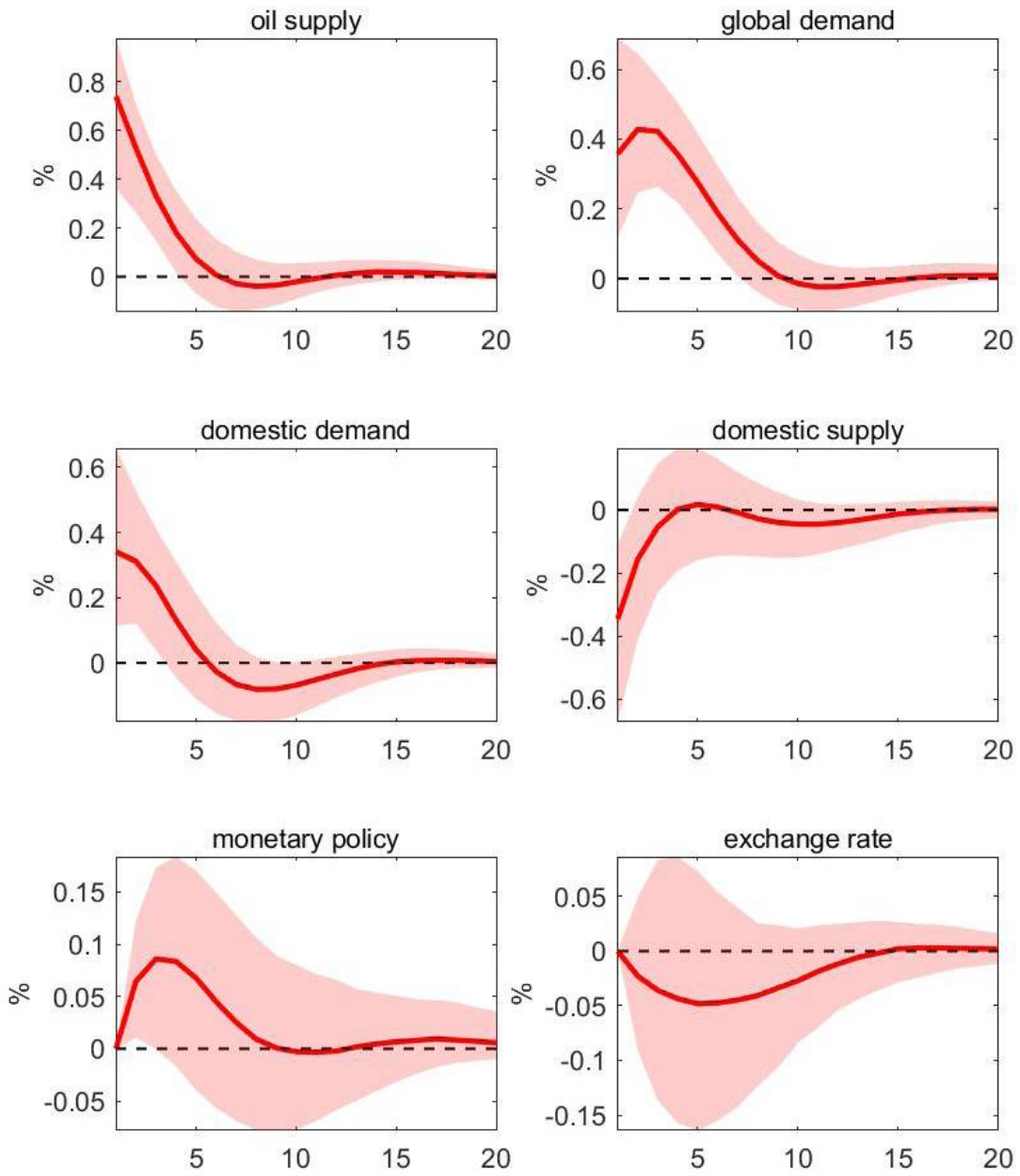
Notes: Median impulse response (red solid path) with 16th and 84th percentiles (red-shaded area). The sign restrictions are imposed on impact only. The identification of shocks relies on the Corsetti et al. (2014) identification.

Figure 5: Impulse Response of GDP Growth – Malaysia



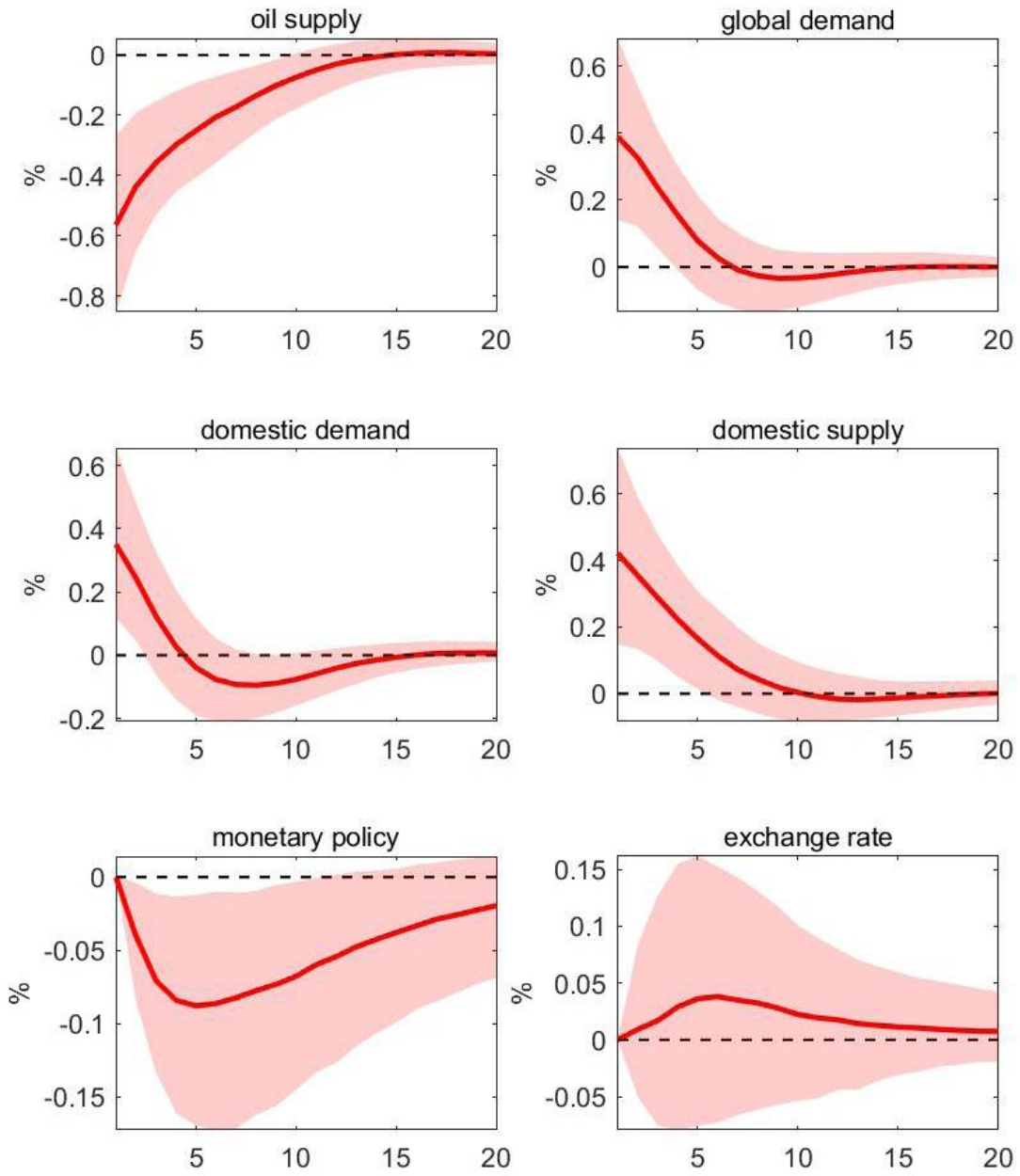
Notes: Median impulse response (red solid path) with 16th and 84th percentiles (red-shaded area). The sign restrictions are imposed on impact only. The identification of shocks relies on the Corsetti et al. (2014) identification.

Figure 6: Impulse Response of Inflation – Malaysia



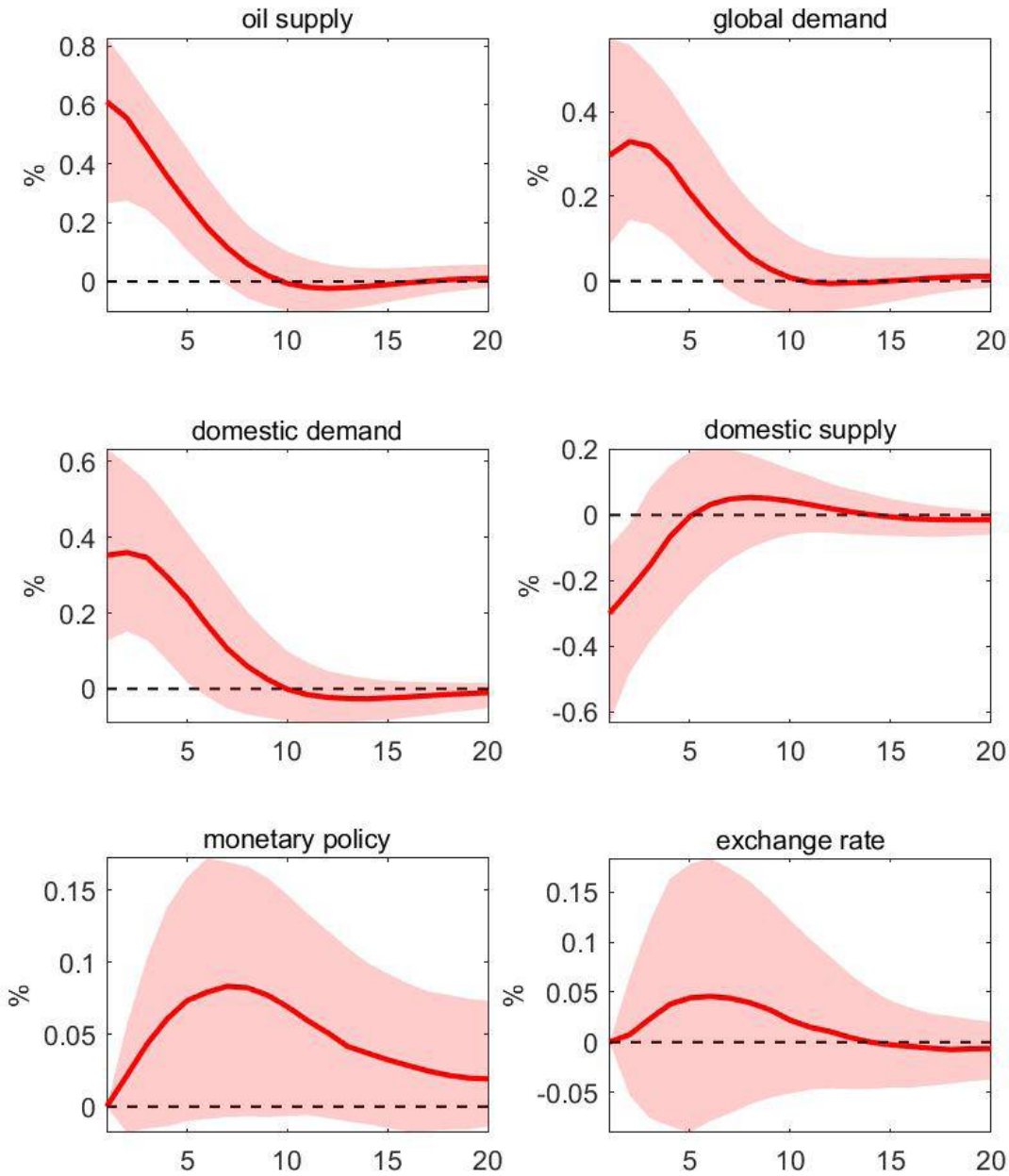
Notes: Median impulse response (red solid path) with 16th and 84th percentiles (red-shaded area). The sign restrictions are imposed on impact only. The identification of shocks relies on the Corsetti et al. (2014) identification.

Figure 7: Impulse Response of GDP Growth – Philippines



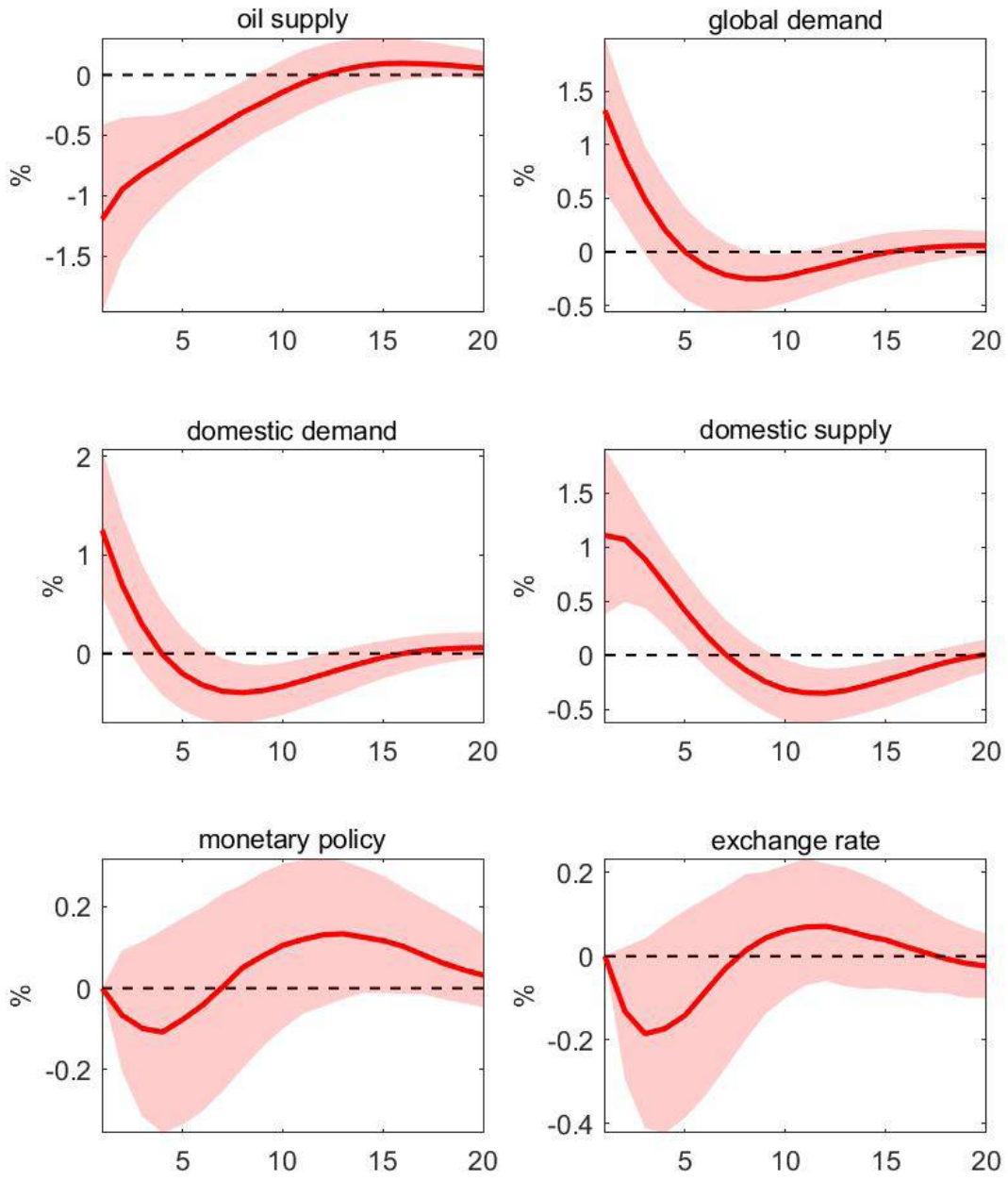
Notes: Median impulse response (red solid path) with 16th and 84th percentiles (red-shaded area). The sign restrictions are imposed on impact only. The identification of shocks relies on the Corsetti et al. (2014) identification.

Figure 8: Impulse Response of Inflation – Philippines



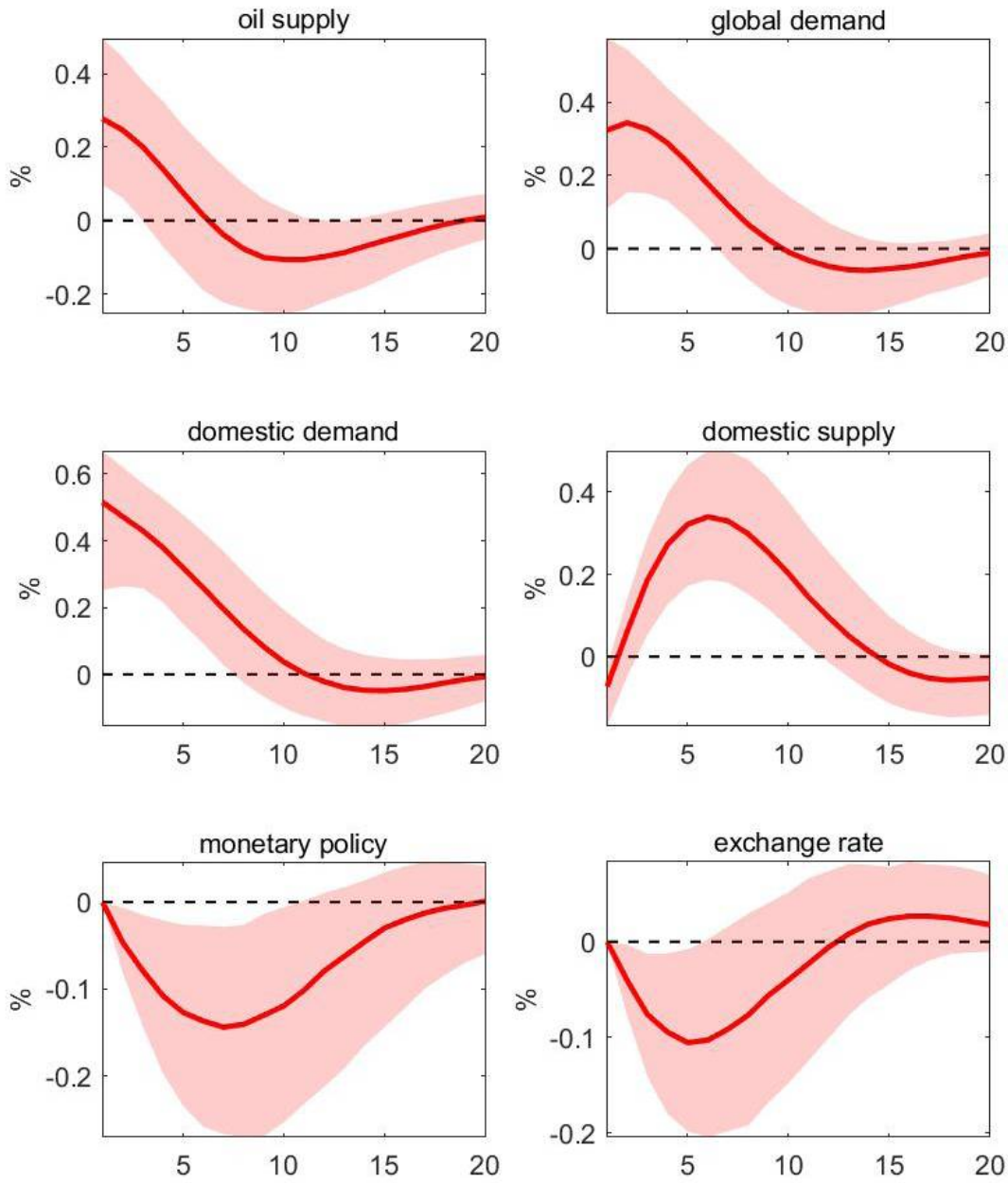
Notes: Median impulse response (red solid path) with 16th and 84th percentiles (red-shaded area). The sign restrictions are imposed on impact only. The identification of shocks relies on the Corsetti et al. (2014) identification.

Figure 9: Impulse Response of GDP Growth – Singapore



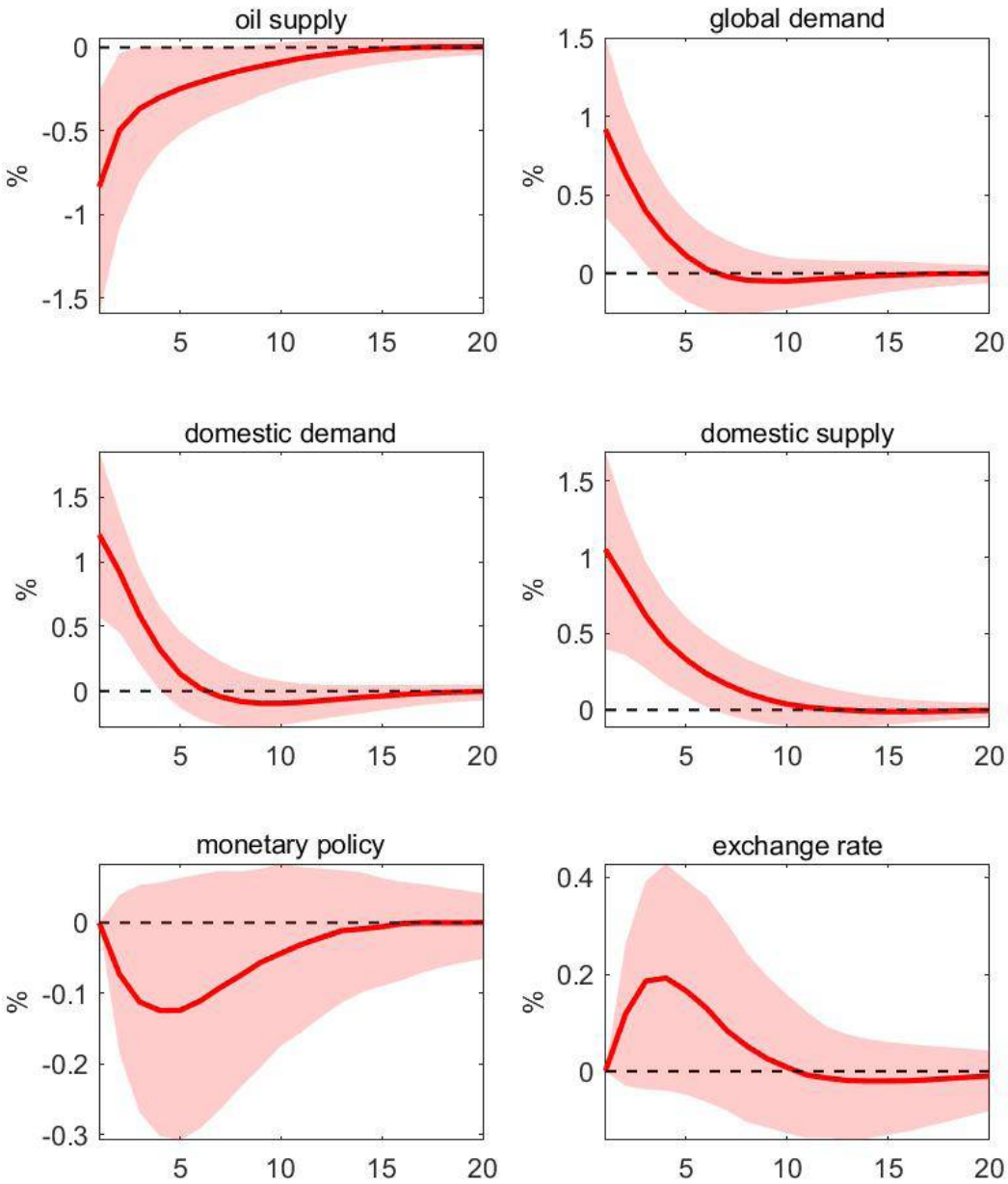
Notes: Median impulse response (red solid path) with 16th and 84th percentiles (red-shaded area). The sign restrictions are imposed on impact only. The identification of shocks relies on the Corsetti et al. (2014) identification.

Figure 10: Impulse Response of Inflation – Singapore



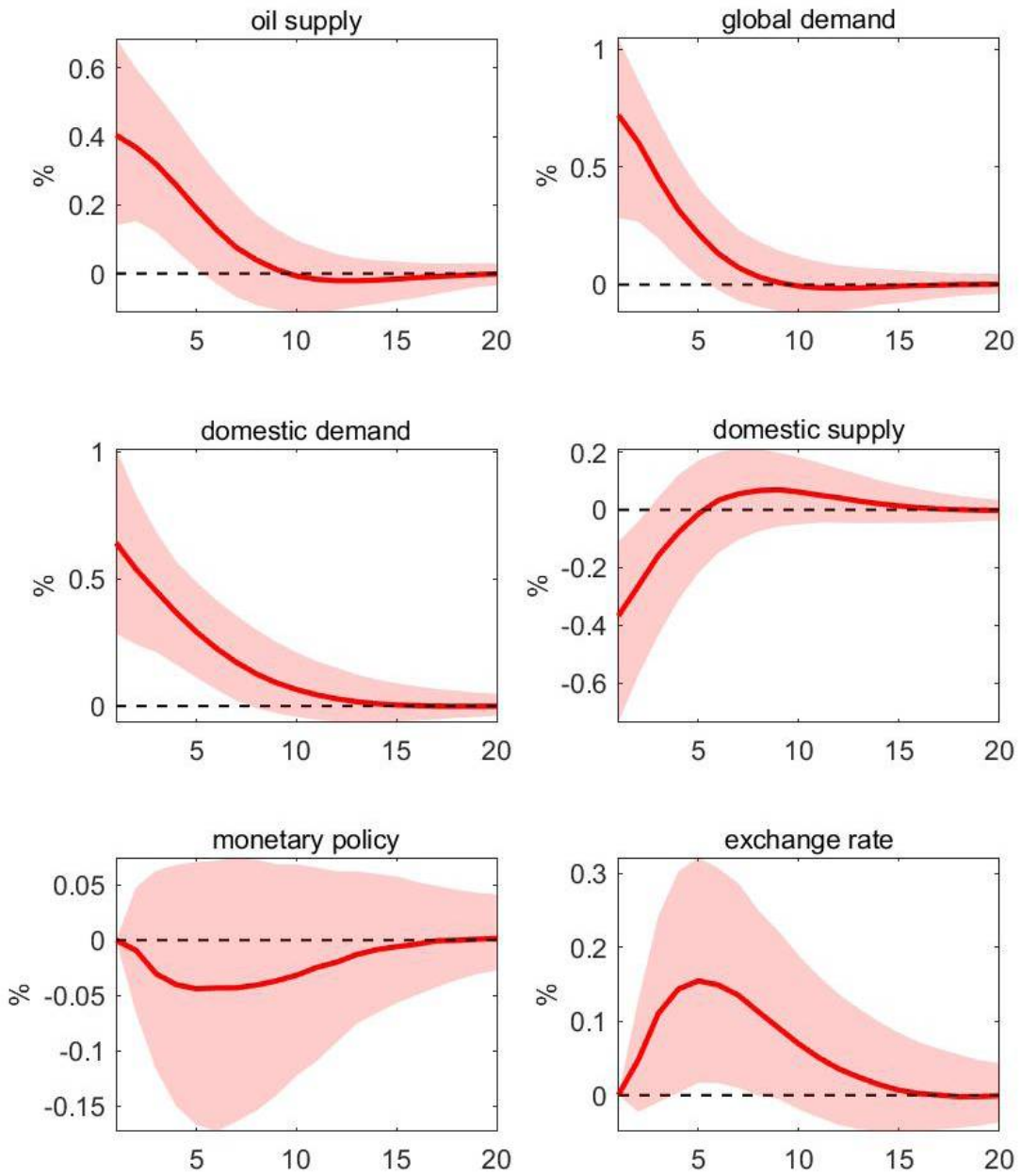
Notes: Median impulse response (red solid path) with 16th and 84th percentiles (red-shaded area). The sign restrictions are imposed on impact only. The identification of shocks relies on the Corsetti et al. (2014) identification.

Figure 11: Impulse Response of GDP Growth – Thailand



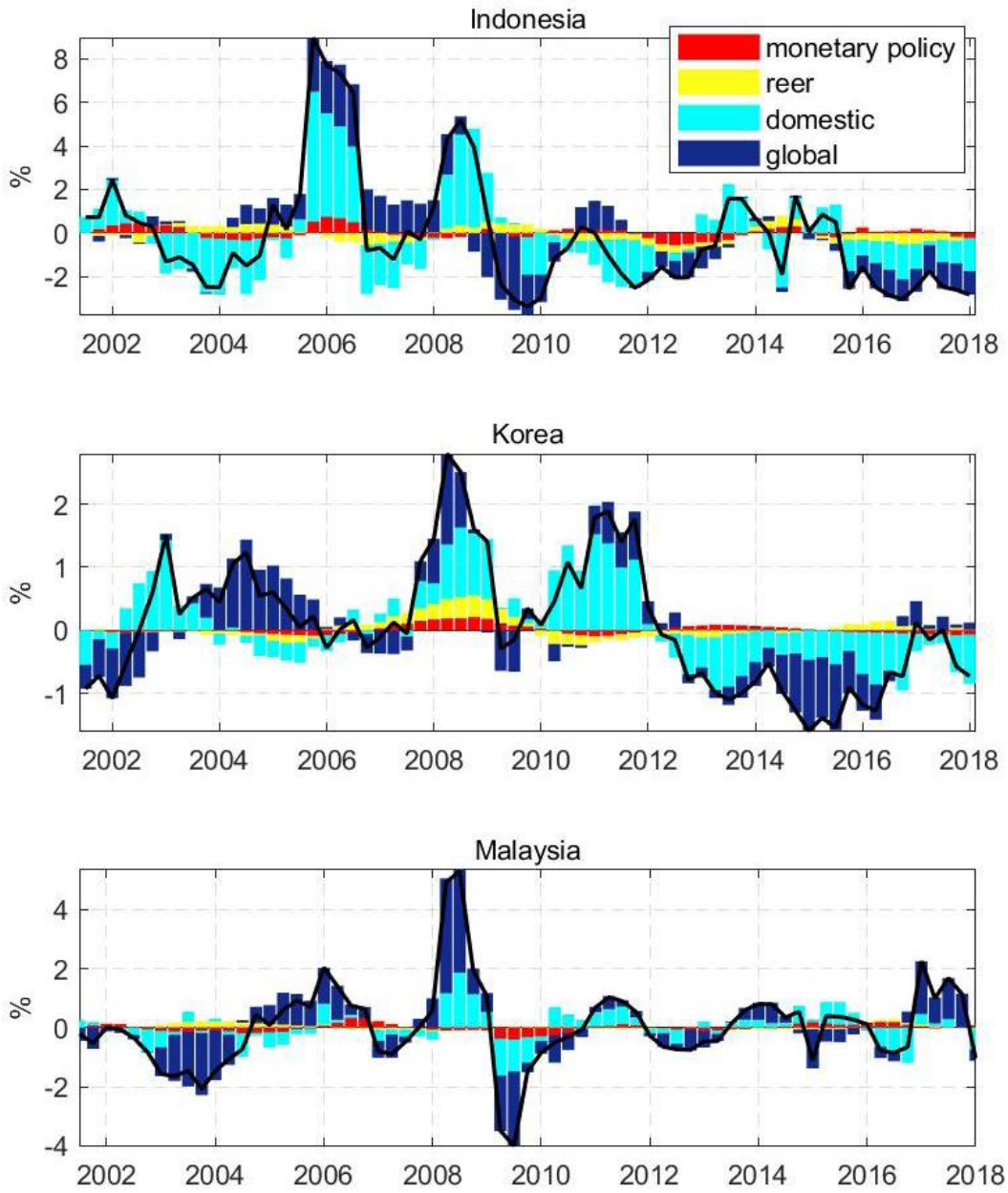
Notes: Median impulse response (red solid path) with 16th and 84th percentiles (red-shaded area). The sign restrictions are imposed on impact only. The identification of shocks relies on the Corsetti et al. (2014) identification.

Figure 12: Impulse Response of Inflation – Thailand



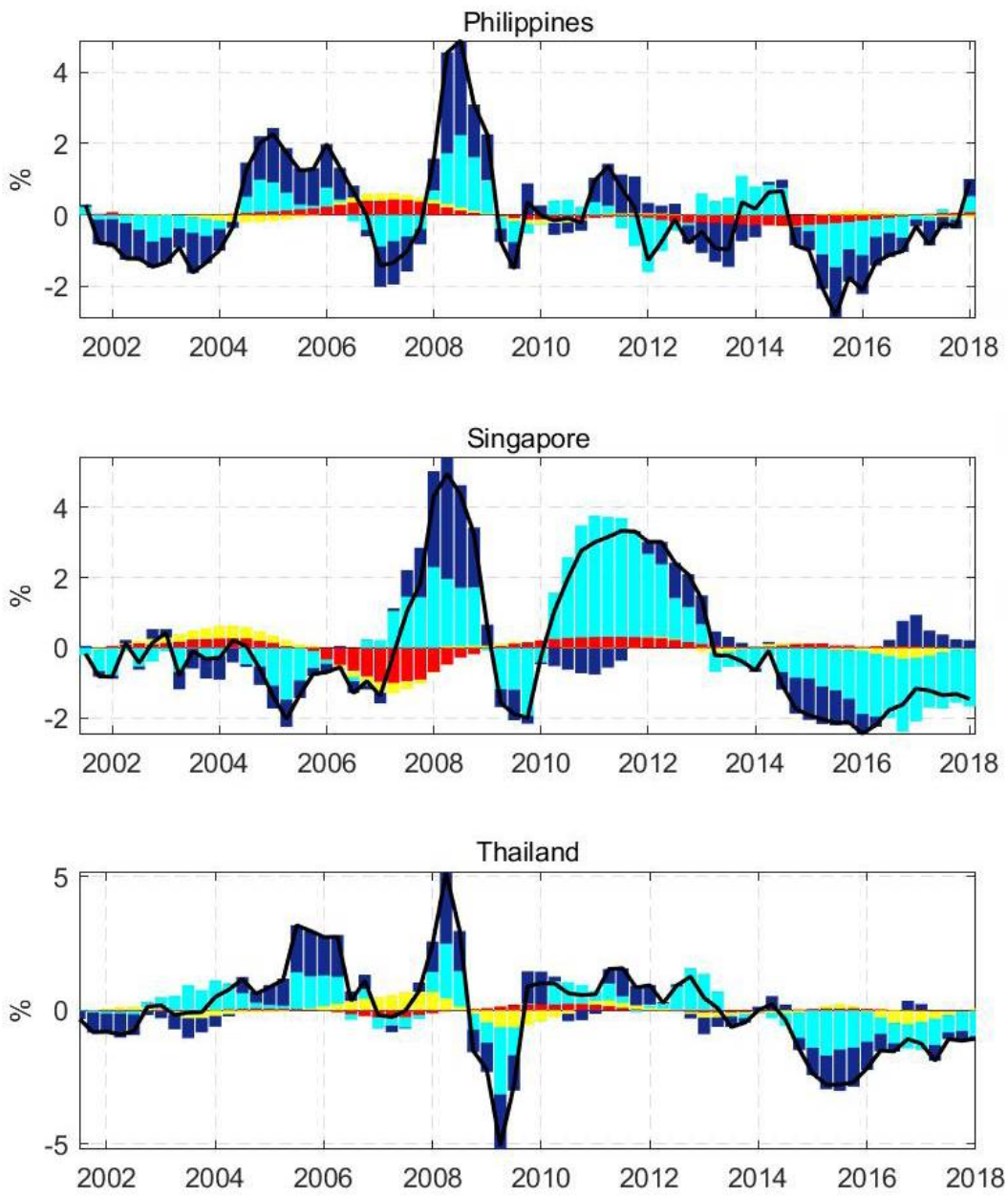
Notes: Median impulse response (red solid path) with 16th and 84th percentiles (red-shaded area). The sign restrictions are imposed on impact only. The identification of shocks relies on the Corsetti et al. (2014) identification.

Figure 13: Historical Contribution of Structural Shocks to Inflation for Indonesia, Korea and Malaysia



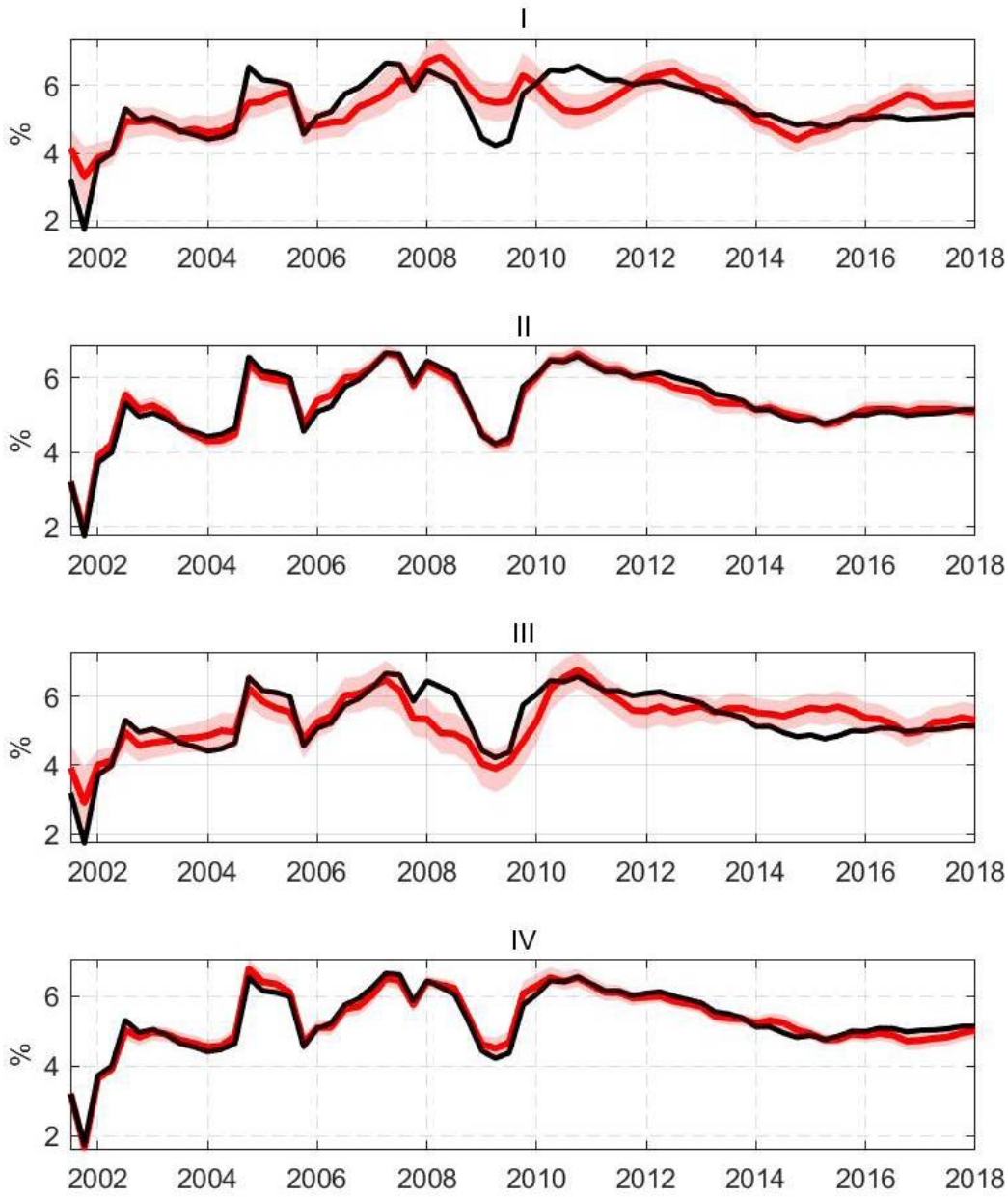
Notes: Median historical contribution of monetary policy shocks (red bars), exchange rate shocks (yellow bars), domestic shocks (teal bars) and global shocks (blue bars) to inflation for the Philippines, Singapore and Thailand. The black path corresponds to the sum of median contributions of all structural shocks. Results rely on identification strategy I.

Figure 14: Historical Contribution of Structural Shocks to Inflation for the Philippines, Singapore and Thailand



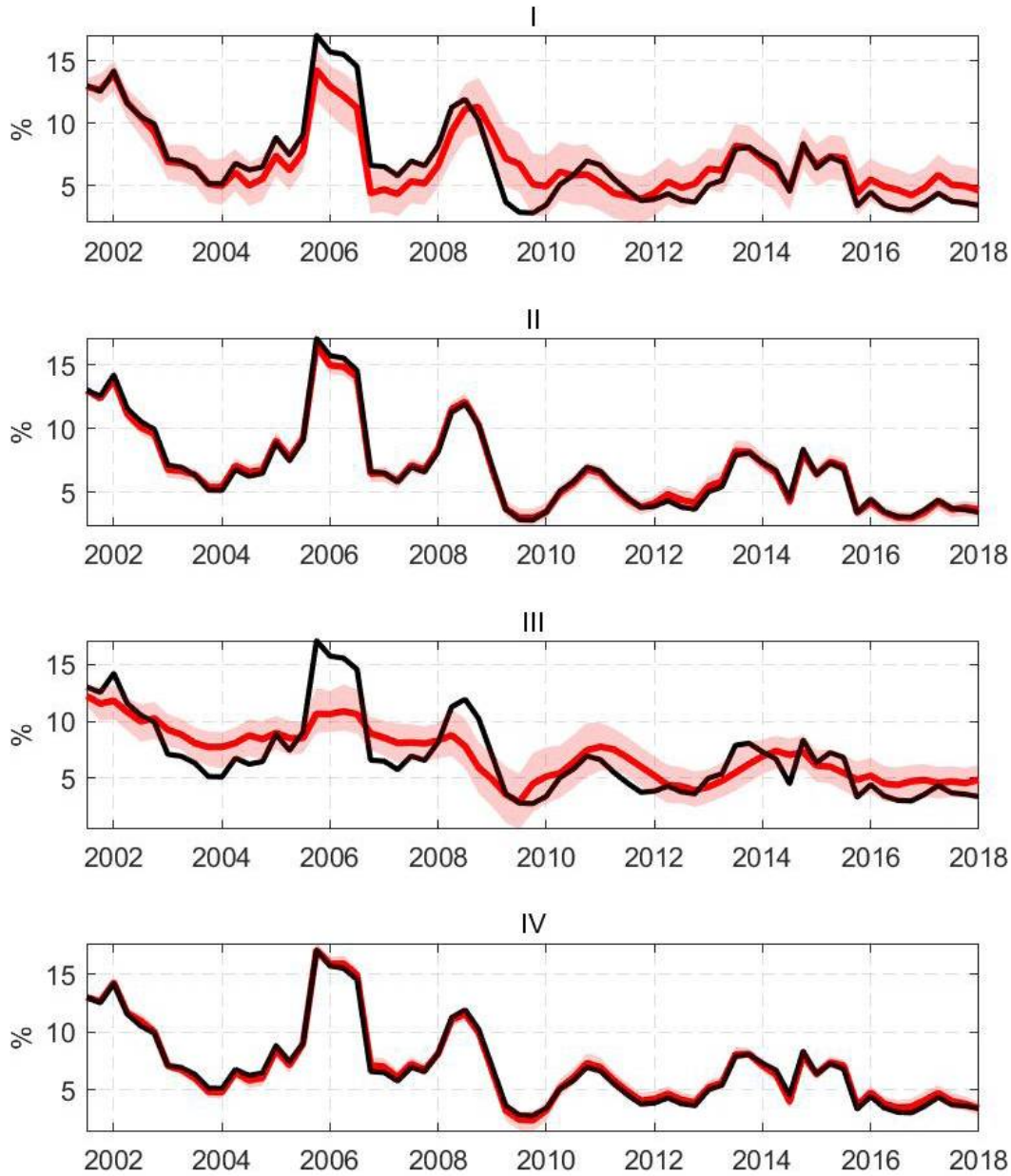
Notes: Median historical contribution of monetary policy shocks (red bars), exchange rate shocks (yellow bars), domestic shocks (teal bars) and global shocks (blue bars) to inflation for the Philippines, Singapore and Thailand. The black path corresponds to the sum of median contributions of all structural shocks. Results rely on identification strategy I.

Figure 15: Counterfactual Paths for GDP Growth with Suppressed Shocks – Indonesia



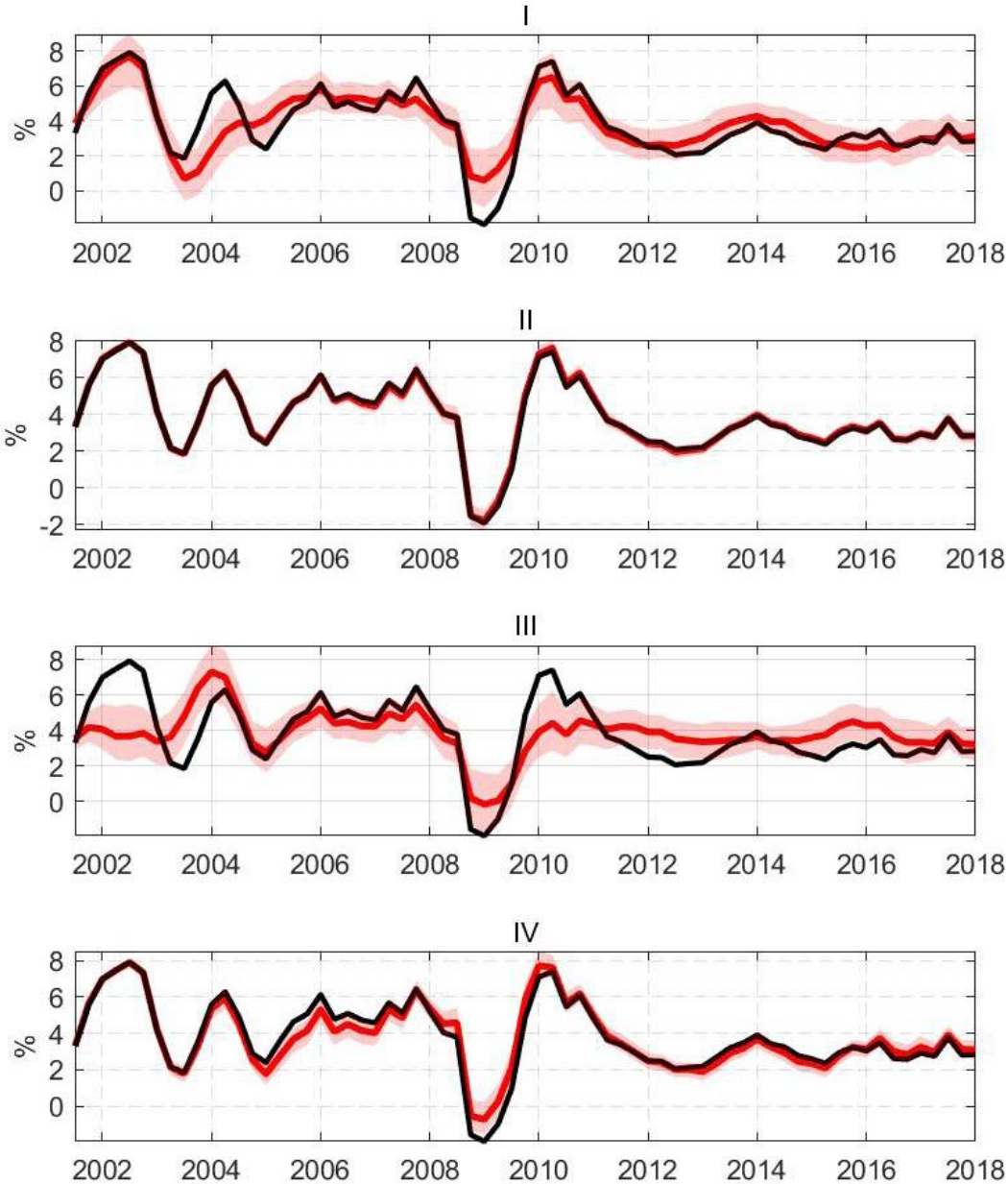
Notes: Median counterfactual paths (red solid path) with 16th and 84th percentiles (red-shaded area) for the growth rate of domestic real GDP (in %). In I, the counterfactual path corresponds to GDP growth where aggregate global shocks (oil supply shocks and global demand shocks) are suppressed, while the same is done in II with monetary policy shocks, in III with domestic shocks (domestic demand and domestic supply shocks) and in IV (exchange rate shocks). The identification of shocks relies on the Corsetti et al. (2014) identification.

Figure 16: Counterfactual Paths for Inflation with Suppressed Shocks – Indonesia



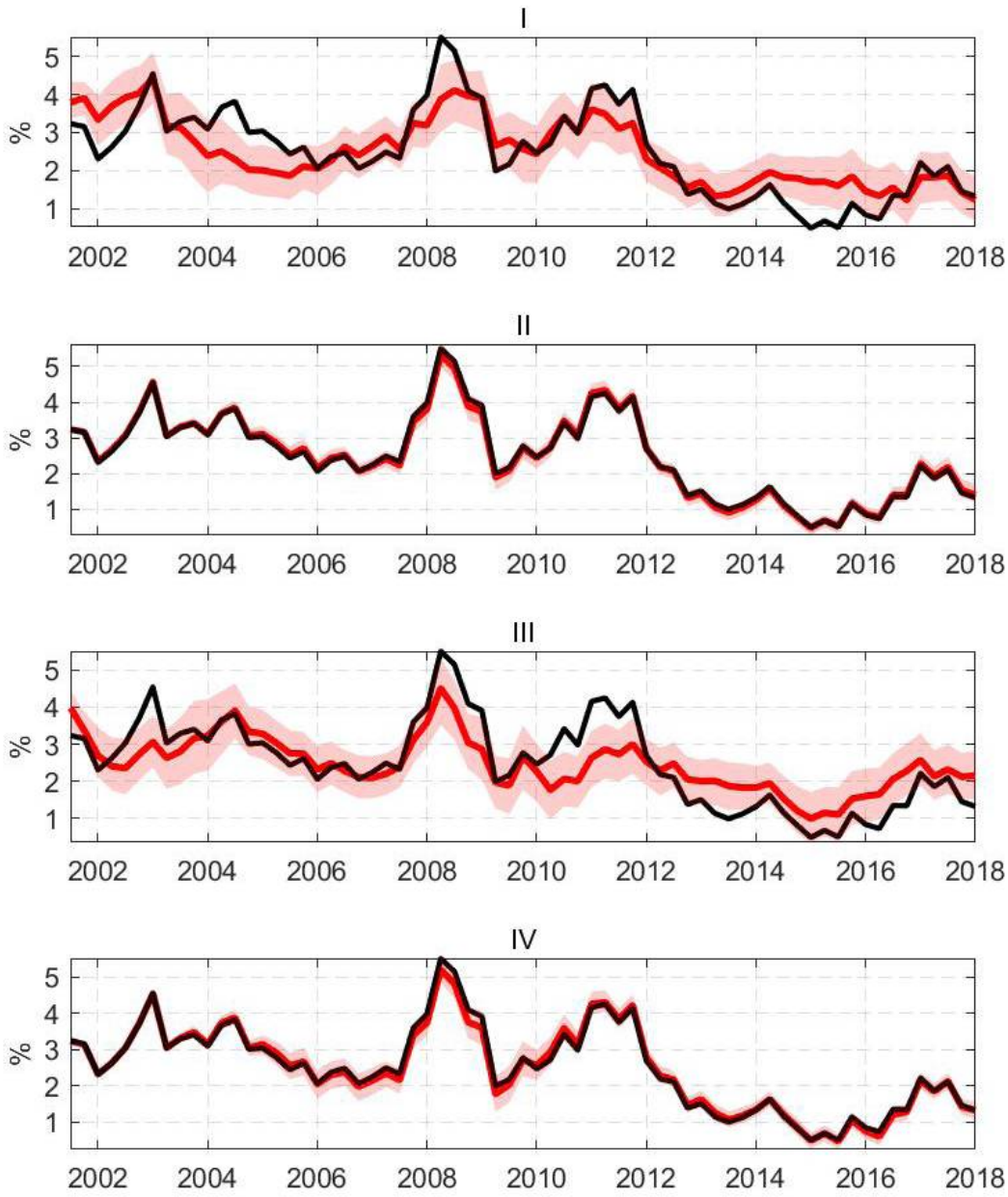
Notes: Median counterfactual paths (red solid path) with 16th and 84th percentiles (red-shaded area) for the growth rate of domestic real GDP (in %). In I, the counterfactual path corresponds to GDP growth where aggregate global shocks (oil supply shocks and global demand shocks) are suppressed, while the same is done in II with monetary policy shocks, in III with domestic shocks (domestic demand and domestic supply shocks) and in IV (exchange rate shocks). The identification of shocks relies on the Corsetti et al. (2014) identification.

Figure 17: Counterfactual Paths for GDP Growth with Suppressed Shocks – Korea



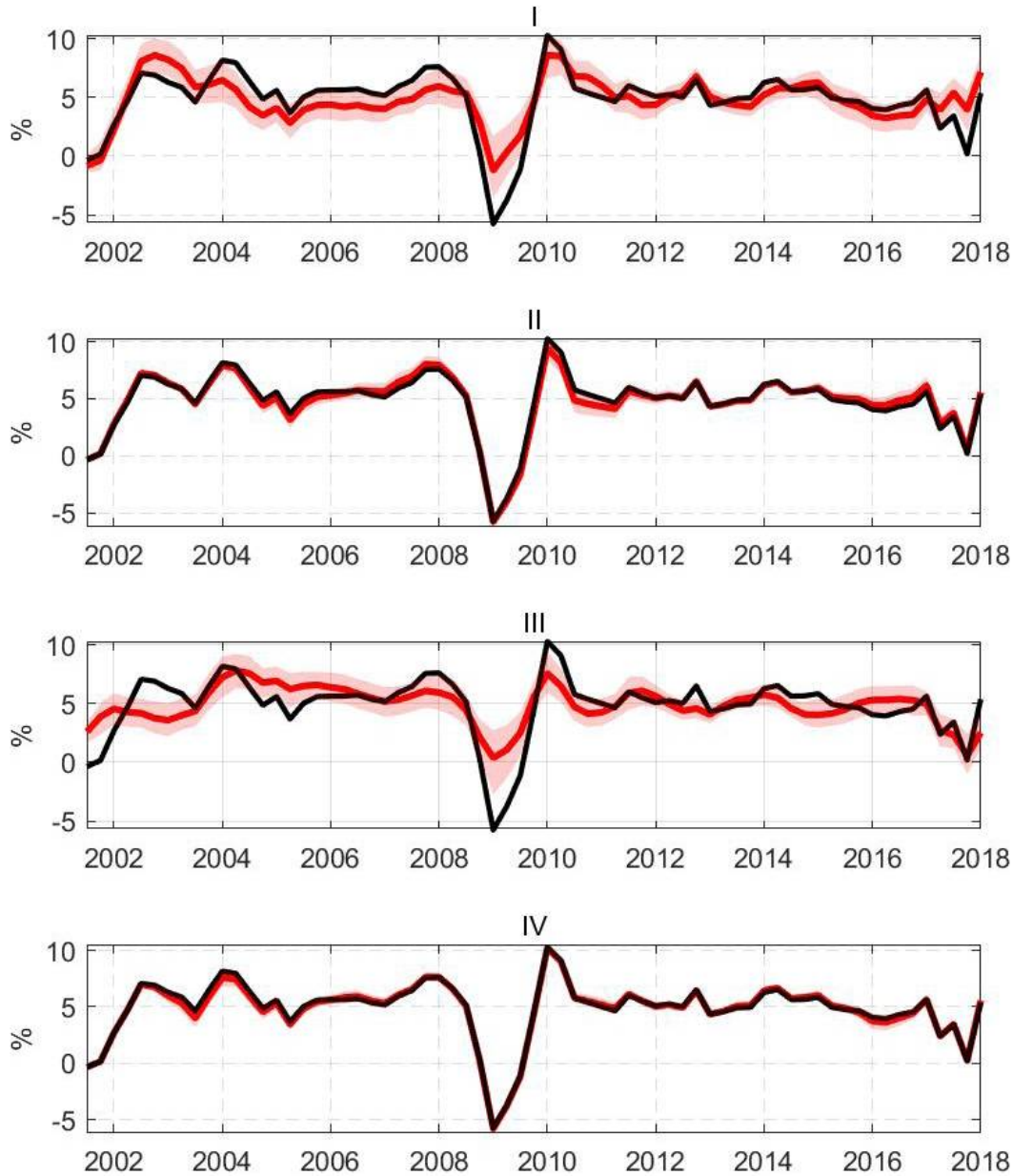
Notes: Median counterfactual paths (red solid path) with 16th and 84th percentiles (red-shaded area) for the growth rate of domestic real GDP (in %). In I, the counterfactual path corresponds to GDP growth where aggregate global shocks (oil supply shocks and global demand shocks) are suppressed, while the same is done in II with monetary policy shocks, in III with domestic shocks (domestic demand and domestic supply shocks) and in IV (exchange rate shocks). The identification of shocks relies on the Corsetti et al. (2014) identification.

Figure 18: Counterfactual Paths for Inflation with Suppressed Shocks – Korea



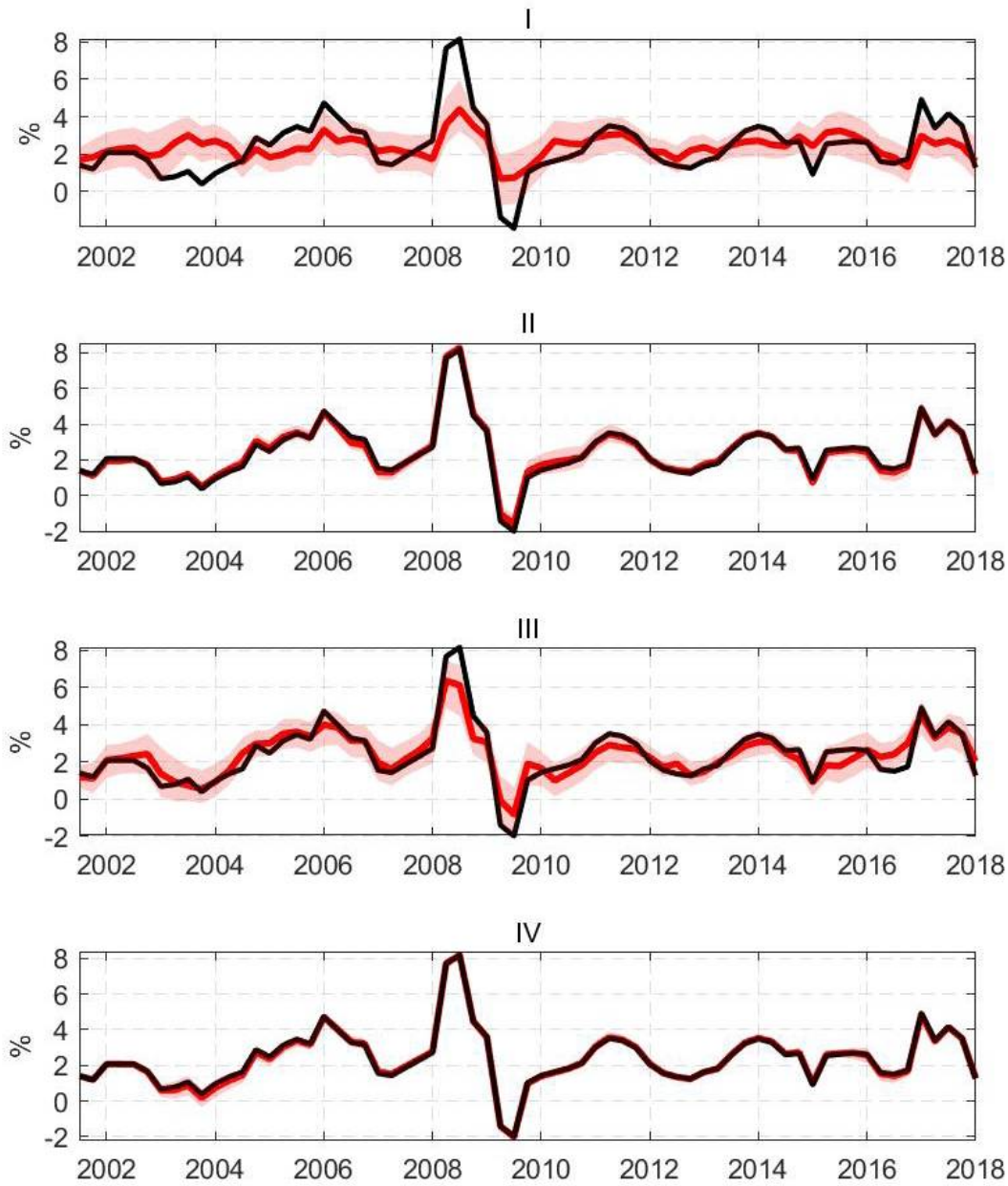
Notes: Median counterfactual paths (red solid path) with 16th and 84th percentiles (red-shaded area) for the growth rate of domestic real GDP (in %). In I, the counterfactual path corresponds to GDP growth where aggregate global shocks (oil supply shocks and global demand shocks) are suppressed, while the same is done in II with monetary policy shocks, in III with domestic shocks (domestic demand and domestic supply shocks) and in IV (exchange rate shocks). The identification of shocks relies on the Corsetti et al. (2014) identification.

Figure 19: Counterfactual Paths for GDP Growth with Suppressed Shocks – Malaysia



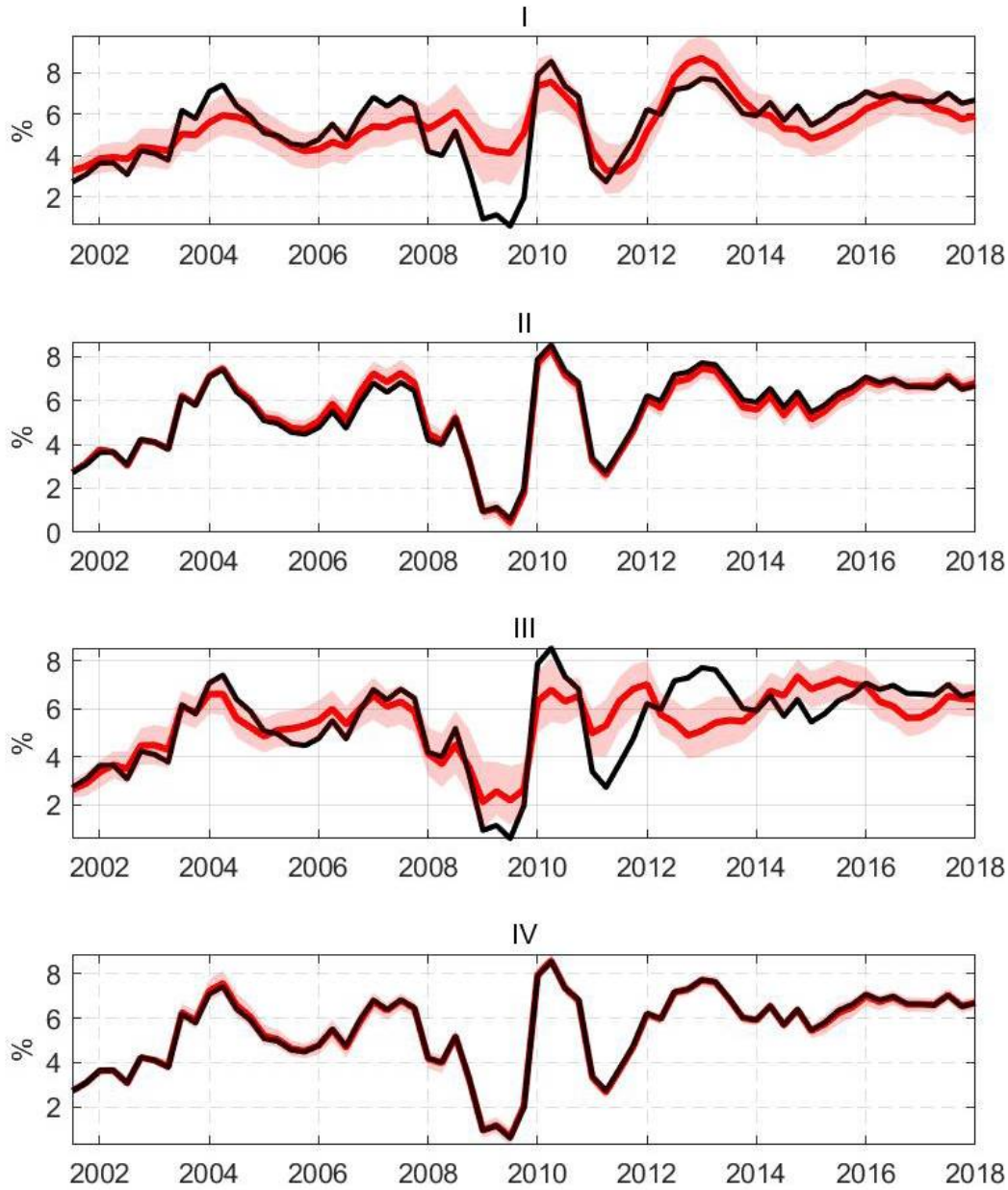
Notes: Median counterfactual paths (red solid path) with 16th and 84th percentiles (red-shaded area) for the growth rate of domestic real GDP (in %). In I, the counterfactual path corresponds to GDP growth where aggregate global shocks (oil supply shocks and global demand shocks) are suppressed, while the same is done in II with monetary policy shocks, in III with domestic shocks (domestic demand and domestic supply shocks) and in IV (exchange rate shocks). The identification of shocks relies on the Corsetti et al. (2014) identification.

Figure 20: Counterfactual Paths for Inflation with Suppressed Shocks – Malaysia



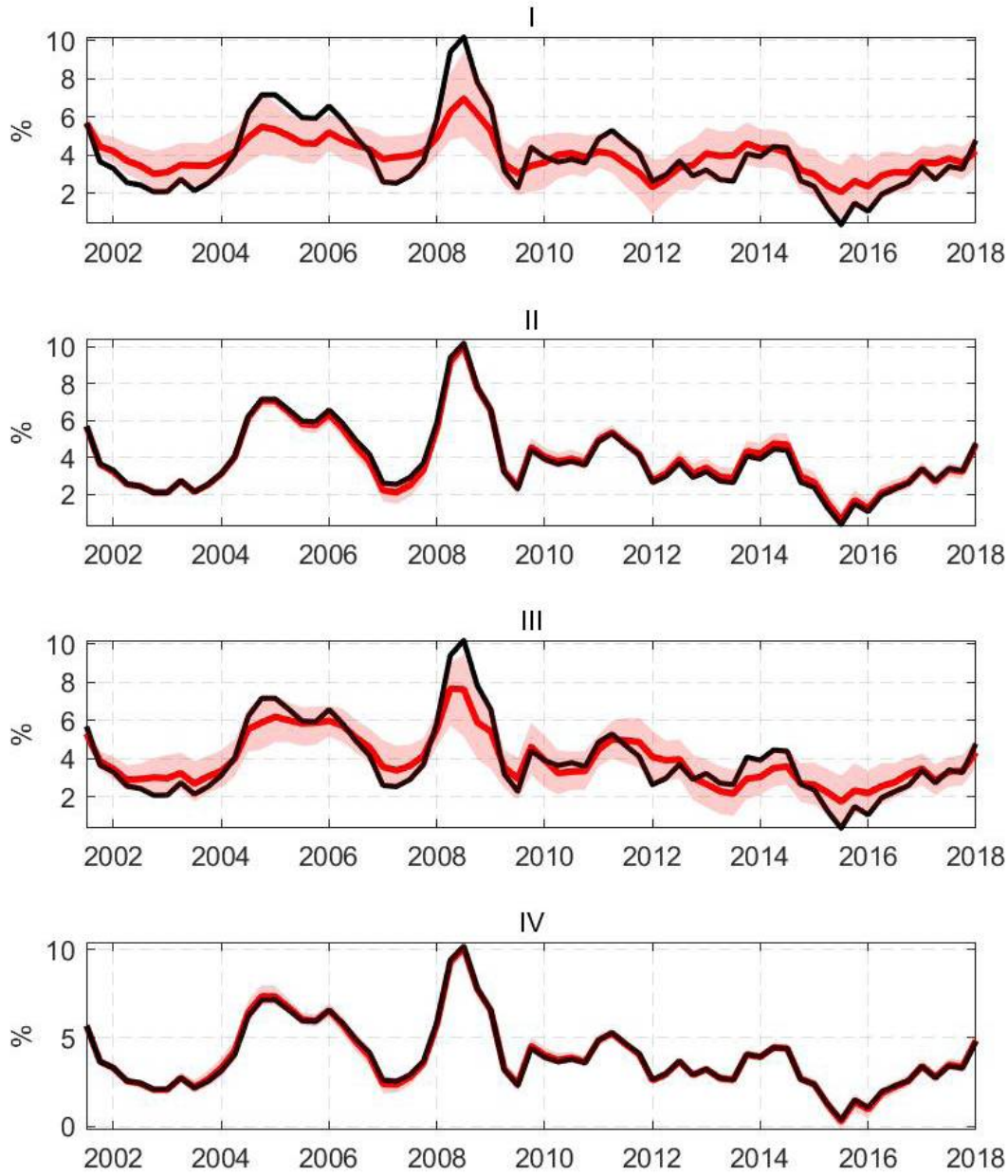
Notes: Median counterfactual paths (red solid path) with 16th and 84th percentiles (red-shaded area) for the growth rate of domestic real GDP (in %). In I, the counterfactual path corresponds to GDP growth where aggregate global shocks (oil supply shocks and global demand shocks) are suppressed, while the same is done in II with monetary policy shocks, in III with domestic shocks (domestic demand and domestic supply shocks) and in IV (exchange rate shocks). The identification of shocks relies on the Corsetti et al. (2014) identification.

Figure 21: Counterfactual Paths for GDP Growth with Suppressed Shocks – Philippines



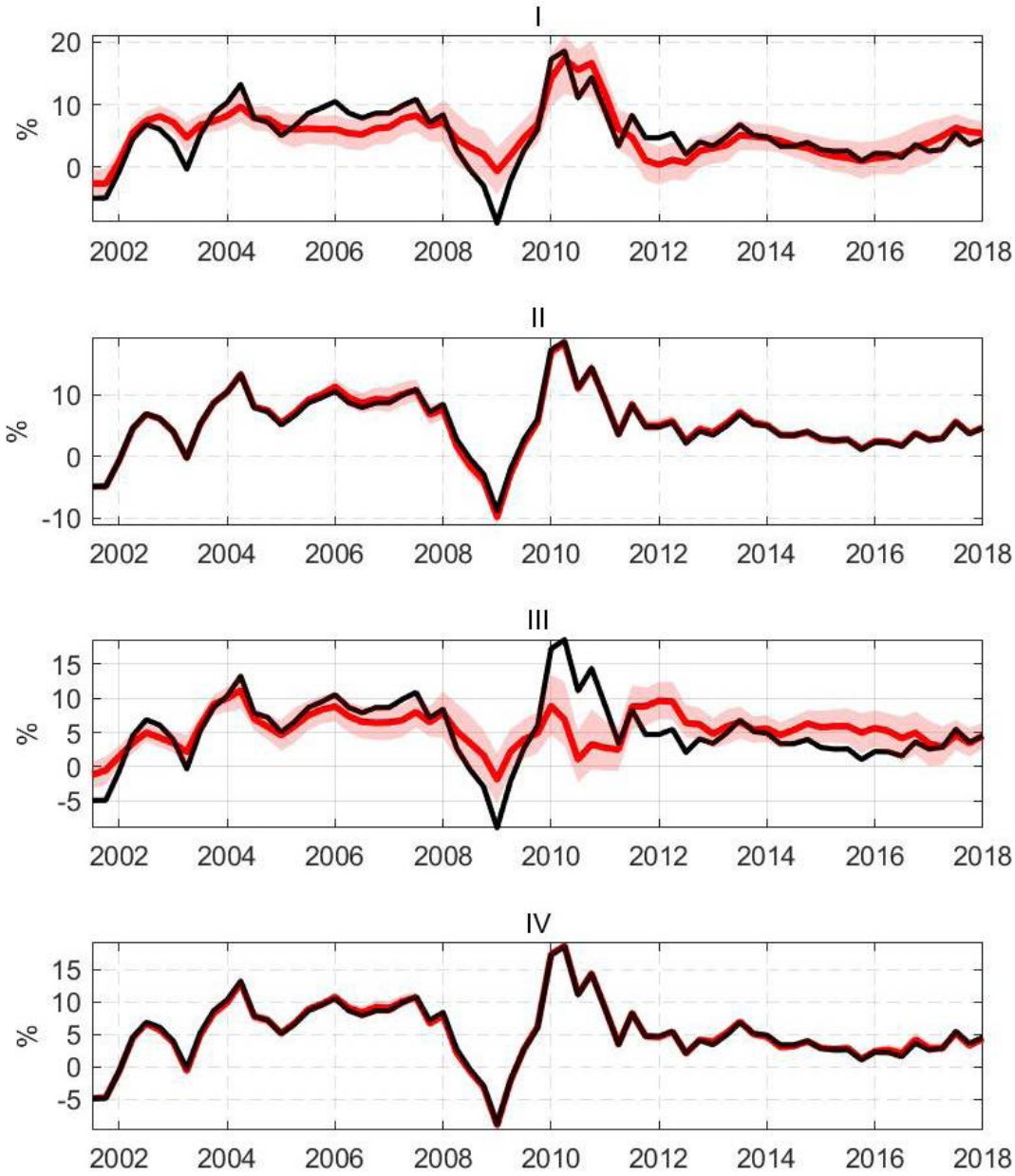
Notes: Median counterfactual paths (red solid path) with 16th and 84th percentiles (red-shaded area) for the growth rate of domestic real GDP (in %). In I, the counterfactual path corresponds to GDP growth where aggregate global shocks (oil supply shocks and global demand shocks) are suppressed, while the same is done in II with monetary policy shocks, in III with domestic shocks (domestic demand and domestic supply shocks) and in IV (exchange rate shocks). The identification of shocks relies on the Corsetti et al. (2014) identification.

Figure 22: Counterfactual Paths for Inflation with Suppressed Shocks – Philippines



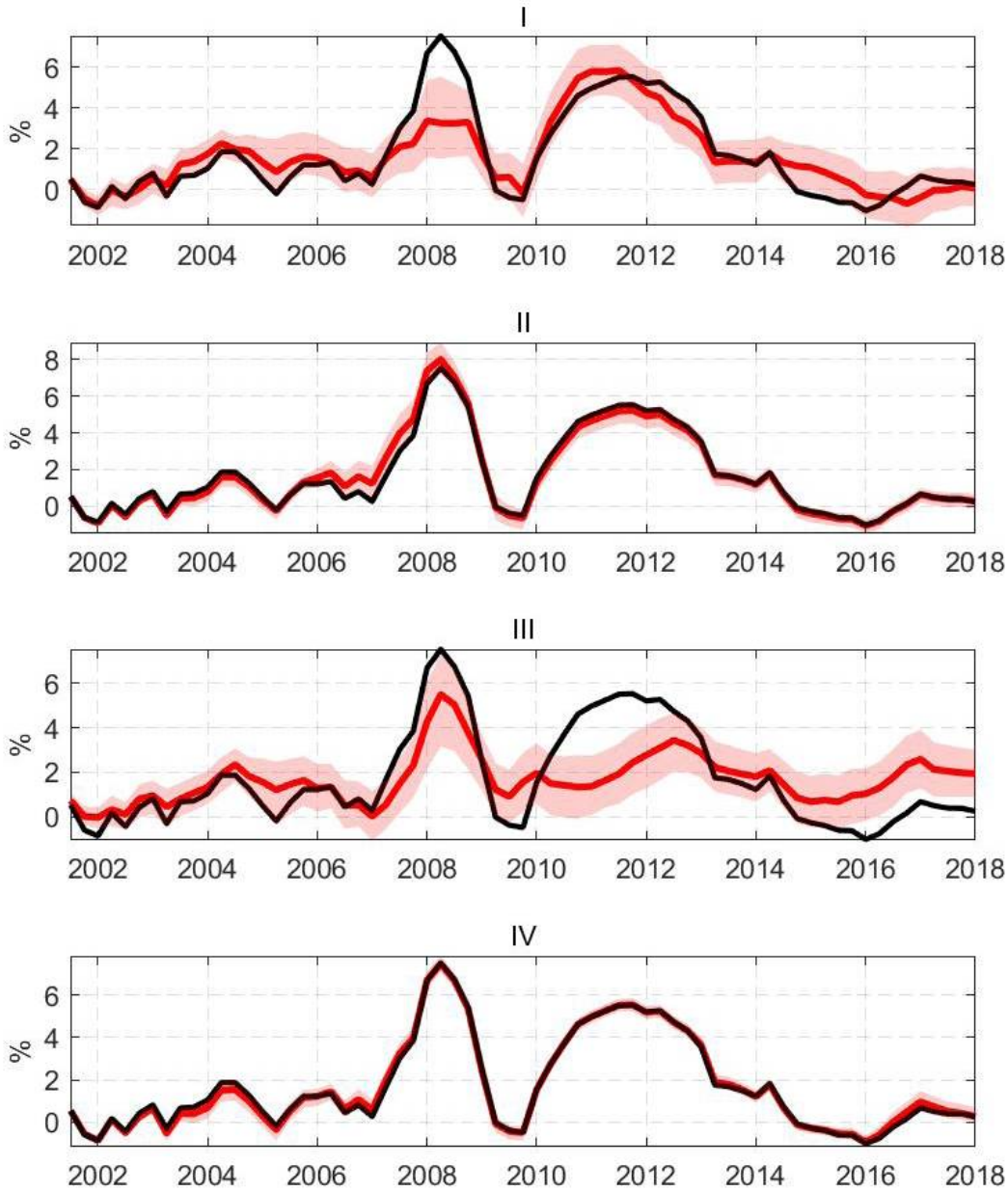
Notes: Median counterfactual paths (red solid path) with 16th and 84th percentiles (red-shaded area) for the growth rate of domestic real GDP (in %). In I, the counterfactual path corresponds to GDP growth where aggregate global shocks (oil supply shocks and global demand shocks) are suppressed, while the same is done in II with monetary policy shocks, in III with domestic shocks (domestic demand and domestic supply shocks) and in IV (exchange rate shocks). The identification of shocks relies on the Corsetti et al. (2014) identification.

Figure 23: Counterfactual Paths for GDP Growth with Suppressed Shocks – Singapore



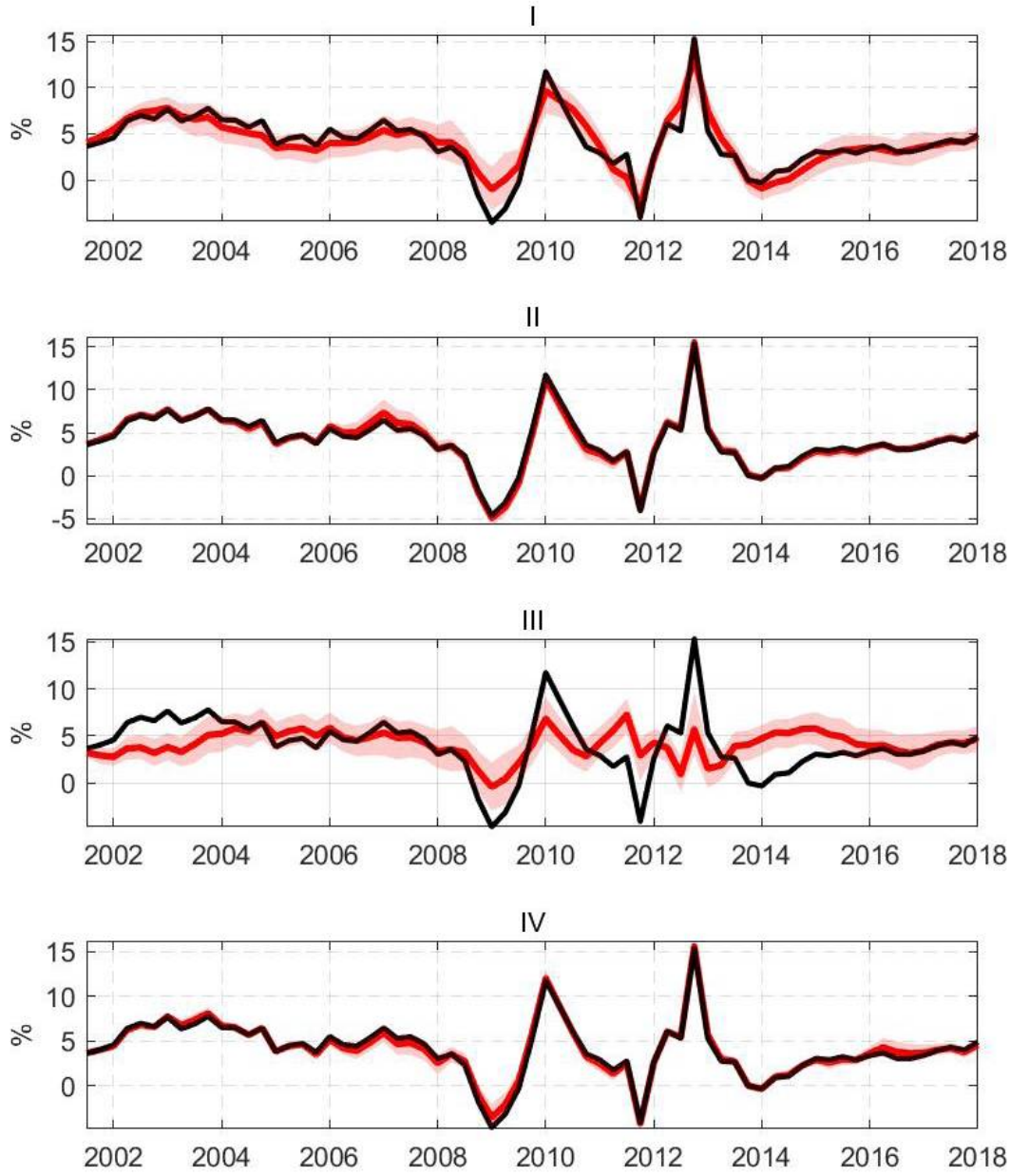
Notes: Median counterfactual paths (red solid path) with 16th and 84th percentiles (red-shaded area) for the growth rate of domestic real GDP (in %). In I, the counterfactual path corresponds to GDP growth where aggregate global shocks (oil supply shocks and global demand shocks) are suppressed, while the same is done in II with monetary policy shocks, in III with domestic shocks (domestic demand and domestic supply shocks) and in IV (exchange rate shocks). The identification of shocks relies on the Corsetti et al. (2014) identification.

Figure 24: Counterfactual Paths for Inflation with Suppressed Shocks – Singapore



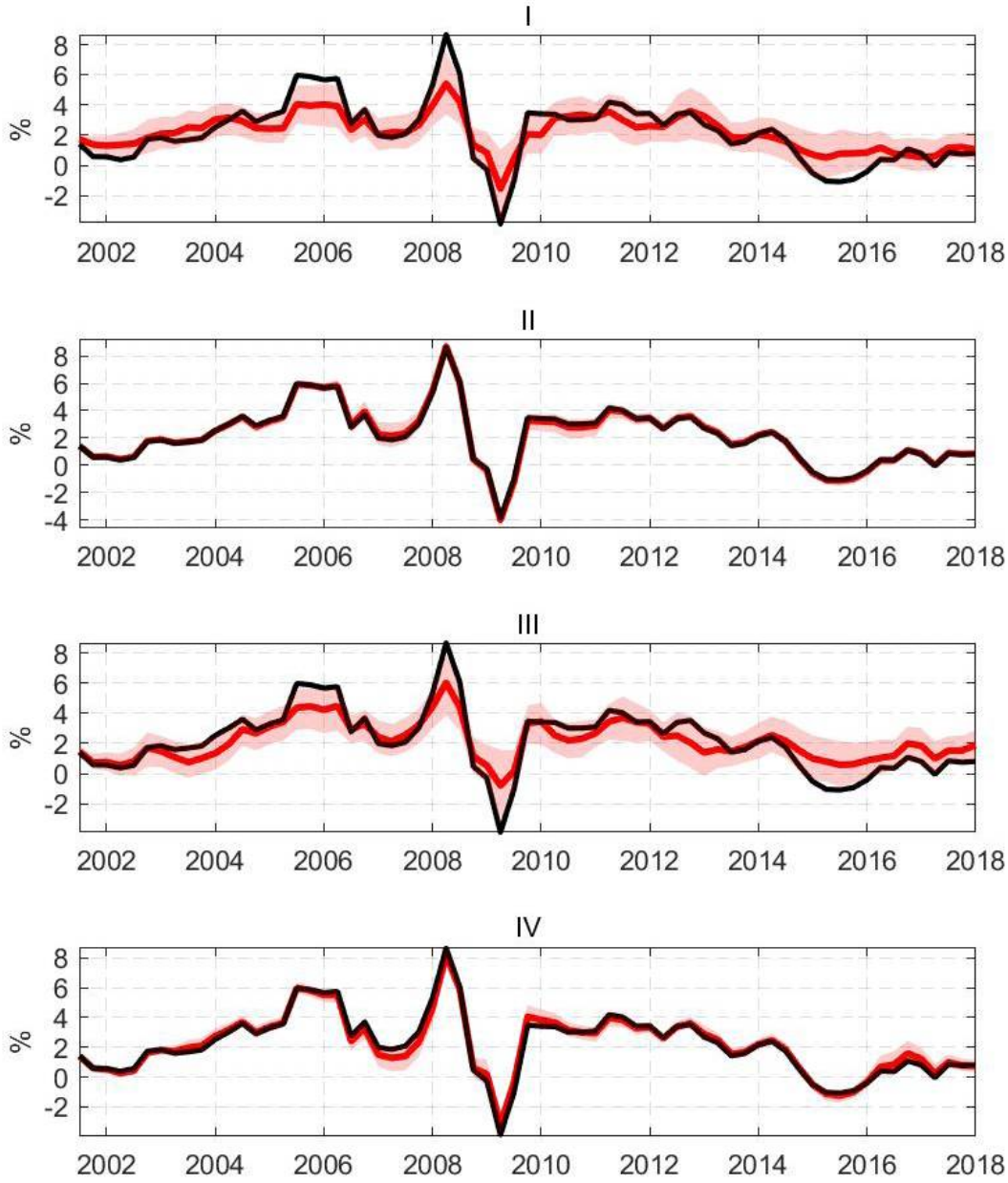
Notes: Median counterfactual paths (red solid path) with 16th and 84th percentiles (red-shaded area) for the growth rate of domestic real GDP (in %). In I, the counterfactual path corresponds to GDP growth where aggregate global shocks (oil supply shocks and global demand shocks) are suppressed, while the same is done in II with monetary policy shocks, in III with domestic shocks (domestic demand and domestic supply shocks) and in IV (exchange rate shocks). The identification of shocks relies on the Corsetti et al. (2014) identification.

Figure 25: Counterfactual Paths for GDP Growth with Suppressed Shocks – Thailand



Notes: Median counterfactual paths (red solid path) with 16th and 84th percentiles (red-shaded area) for the growth rate of domestic real GDP (in %). In I, the counterfactual path corresponds to GDP growth where aggregate global shocks (oil supply shocks and global demand shocks) are suppressed, while the same is done in II with monetary policy shocks, in III with domestic shocks (domestic demand and domestic supply shocks) and in IV (exchange rate shocks). The identification of shocks relies on the Corsetti et al. (2014) identification.

Figure 26: Counterfactual Paths for Inflation with Suppressed Shocks – Thailand



Notes: Median counterfactual paths (red solid path) with 16th and 84th percentiles (red-shaded area) for the growth rate of domestic real GDP (in %). In I, the counterfactual path corresponds to GDP growth where aggregate global shocks (oil supply shocks and global demand shocks) are suppressed, while the same is done in II with monetary policy shocks, in III with domestic shocks (domestic demand and domestic supply shocks) and in IV (exchange rate shocks). The identification of shocks relies on the Corsetti et al. (2014) identification.

Chapter 2

A VAR ANALYSIS OF EXCHANGE RATE PASS-THROUGH TO INFLATION IN BRUNEI DARUSSALAM[1]

By

Jason Lih Cheng Kok[2]

1. Introduction

Brunei Darussalam is a small and open economy reliant on trade and with a monetary policy based on the Currency Board Arrangement. These monetary policy arrangements pegging the Brunei dollar to the Singapore dollar have been in place since 1967, long before Brunei Darussalam officially gained independence in 1984. However, despite this long history, the effect of the exchange rate on inflationary developments in Brunei Darussalam remains a relatively understudied area. The IMF's Annual Report on Exchange Arrangements and Exchange Restrictions 2017 lists only ten member countries as having a currency board, with Brunei Darussalam placed in a unique position of being the only country in the world having a currency board pegged to the Singapore dollar (IMF, 2017). Adding to this, Singapore's monetary policy is based on an anchor to an undisclosed reference currency basket (IMF, 2017). Thus, Brunei Darussalam serves more as an outlier or corner case in the overall topic of exchange rate effects on domestic inflation with limited lessons to be drawn for other economies. Nevertheless, this is a key topic of interest for the national authorities in Brunei Darussalam.

Additional features that make Brunei Darussalam an interesting country case to examine the exchange rate pass-through are the involvement of the government in domestic goods and services markets through the provision of subsidies and price controls. In an earlier study, the author decomposed and categorised the Consumer Price Index (CPI) of Brunei Darussalam into sub-components, whereby the respective shares of subsidised and price-controlled goods and services within CPI are 13.16% and 18.76%, respectively (Kok, 2015).

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This paper adapts the methodology applied by Ito and Sato (2008) to estimate the exchange rate pass-through to inflation utilising a Vector Autoregression (VAR) methodology. Their original analysis had included Singapore, for which this paper serves as an interesting follow-up to examine a country pegged to the Singapore dollar. Some unique characteristics of Brunei Darussalam, such as government intervention in the pricing of goods and services via price controls and subsidies, necessitate adaptations to the methodology used by Ito and Sato (2008).

Abu Bakar and Ali (2016) found that movements in Singapore's monetary policy instrument, the Singapore Dollar Nominal Effective Exchange Rate (S$NEER), had no effect on Brunei Darussalam's CPI. It was suggested to be potentially due to an incomplete pass-through of the exchange rate to domestic prices due to the existence of price controls and other government policies in the country. This paper examines that proposition, offering support for the argument and a new perspective on the mechanism of exchange rate pass-through to domestic inflation in Brunei Darussalam.

The remainder of the paper is structured as follows; Section 2 is a literature review; Section 3 details the VAR model specification; Section 4 describes the data utilised; Section 5 analyses the results; and Section 6 offers some conclusions as well as suggests potential areas for future research.

2. Literature Review

The main methodology of this paper is based on Ito and Sato (2008). They used a VAR analysis to examine the exchange rate pass-through effects on domestic prices among the East Asian countries using the large exchange rate movements during the Asian financial crisis as a natural experiment. Five countries were investigated, namely Indonesia, Republic of Korea, Malaysia, Singapore and Thailand. The CPI response to the exchange rate shock was statistically significant for Indonesia, Republic of Korea and Thailand, whilst it was insignificant for Malaysia and Singapore. They also examined the effect of pass-through to import and producer prices which turned out to be larger than the pass-through to CPI and was statistically significant for all the countries examined, except Singapore.

A study by Jašová, Moessner and Takáts (2016) looked at whether the exchange rate pass-through changed after the global financial crisis whilst controlling for non-linearities in the exchange rate pass-through. They found that a 10% exchange rate appreciation in the emerging market economies pre-crisis led to an average decline of consumer prices of around 2% within the same year; whilst post-crisis consumer prices declined by around 0.8% from a similar exchange rate appreciation. They also found that a 1 percentage point decrease in inflation rate lowered the long-term average pass-through exchange rate movement by around 0.3-0.4 percentage points, which they attributed to the menu cost theory. The menu cost theory suggests that in an environment where inflation is higher, firms frequently adjust prices, and thus can pass on price changes due to exchange rate movements more easily.

Caselli and Roitman (2016) examined the exchange rate pass-through in the context of high depreciation episodes, the symmetry between periods of appreciation and depreciation, and the effect of adopting inflation targeting. They found that during depreciation episodes of 10% and above, the exchange rate pass-through effect was much larger and statistically more significant than during normal times. A 20% depreciation had an exchange rate pass-through of 44% after 6 months and 45% after 12 months, whilst a 10% depreciation had an exchange rate pass-through of 40% and 57%, respectively. Caselli and Roitman (2016) also found that during depreciation episodes the

exchange rate pass-through after 12 months was larger (about 38%) in comparison to appreciation episodes (less than 10%). The adoption of an inflation targeting regime was found to somewhat significantly reduce the exchange rate pass-through effect in comparison to non-inflation targeters (Caselli and Roitman, 2016).

A previous study was done on exchange rate pass-through in Brunei Darussalam by Abu Bakar and Ali (2016). They utilised a VAR which included CPI, nominal import growth, real import growth, the S$NEER as a reflection of monetary policy shock as well as exogenous variables (global oil prices, global food prices and world inflation) in the model to capture inflationary pressures from outside Brunei Darussalam. They found that a 1% appreciation of the S$NEER would result in nominal imports rising by 0.2% in the first three months but became statistically insignificant after five months. Additionally, there was no statistically significant effect on CPI. They concluded that there might be an incomplete exchange rate pass-through due to: (i) Administrative price controls; (ii) Importers adjusting profit margins rather than prices; (iii) Importers building up inventory rather than releasing them for sale to consumers; or (iv) Importers having a fixed contract for imported items which limited the sensitivity of imported goods' prices to exchange rate shocks.

In an earlier work (Kok, 2015), the author looked at a decomposition of Brunei Darussalam's CPI into four main sub-categories with respective weights as follows; (i) Subsidised Sector (18.76%); (ii) Price Controlled Sector (13.16%); (iii) Home Sector (41.09%); and (iv) Foreign Sector (26.99%). Notably, a large portion of goods and services (31.92%) under sub-categories (i) and (ii) were subject to government intervention in their pricing mechanism. The remaining sub-categories (iii) and (iv) indicated where production of such goods and services occurred, for which they were not subject to subsidies and price controls. The paper suggested that this involvement of government in pricing of goods and services led to an implicit inflation target for Brunei Darussalam, which for the period of January 2011 until April 2015, was roughly equivalent to 0.0% +/- 1.0%. A brief description of Brunei Darussalam's economy, monetary policy and history of price controls and subsidies is contained in Kok (2015), which is not repeated here for brevity.

3. Model

The baseline model used by Ito and Sato (2008) is shown below in Equation (1) where Δ represents the first difference operator, oil_t is the natural log of oil prices, gap_t is the output gap based on a Hodrick-Prescott (HP) filter of industrial production index, m_t is the natural log of base money for which the first differences are then multiplied by 100 to provide a percentage point interpretation, $neer_t$ is the nominal effective exchange rate expressed in an index form, and p_t is domestic prices which is specified as the CPI in an index form. In Ito and Sato (2008), this 5-variable VAR is then expanded to a 7-variable VAR with the addition of import price index and producer price index.

$$x_t = (\Delta oil_t, gap_t, \Delta m_t, \Delta neer_t, \Delta p_t)' \quad (1)$$

This paper adapts the model from Ito and Sato (2008), i.e. Equation (1), to be more suited for Brunei Darussalam's circumstances and data availability. An industrial production index is not published for Brunei Darussalam, thus the baseline model is adapted to Equation (2) below where gap_t^* is the output gap based on a HP filter of real Gross Domestic Product (GDP). This could be advantageous as it includes all goods and services produced by the economy rather than just industrial production.

$$x_t = (\Delta oil_t, gap_t^*, \Delta m_t, \Delta neer_t, \Delta p_t)' \quad (2)$$

Further adaptations of the model are also developed to account for some unique features of Brunei Darussalam. An alternative nominal effective exchange rate is developed, $neer_t^M$, whereby the weights utilised are based on shares of imports rather than total trade. This is to adjust for the fact that oil and gas exports have an outsized share of total trade of approximately 57.0% in 2016, for which exchange rate competitiveness is less of a concern (DEPD, 2016). An import weighted nominal effective exchange rate would also be better able to capture more relevant exchange rate changes that could pass through to domestic inflation. This model is shown in Equation (3).

$$x_t = (\Delta oil_t, gap_t^*, \Delta m_t, \Delta neer_t^M, \Delta p_t)' \quad (3)$$

An alternative specification of CPI represented in Equation (4) is also considered, utilising the categorisation of Foreign Sector developed in Kok (2015), and denoted here by p_t^F. However, since Brunei Darussalam does not have an import price index nor producer price index, hence these extensions in Ito and Sato (2008) are not considered in this paper.

$$x_t = (\Delta oil_t, gap_t^*, \Delta m_t, \Delta neer_t^M, \Delta p_t^F)' \quad (4)$$

The final adaptation of the baseline model is a change of the global inflationary variable from oil prices to a relative price index variable in line with Caselli and Roitman (2016), which takes the domestic price variable and divides it by the weighted averages of the price variables for trading partner countries. This adaptation is made because fuel is subsidised by the government of Brunei Darussalam which limits any direct and indirect effects on inflation (Kok, 2015). It is argued that the indirect effects through increasing the cost of transportation for imports via vehicles that cannot purchase the subsidised fuel would be better reflected by using a relative price index rather than using global oil prices. This variable is denoted by $p_t^{F^*,M}$ to denote it is comparing the foreign component of CPI not subject to price controls and subsidies as defined above divided by the weighted average CPI of partner trading countries which are weighted by import shares, i.e. the weighting is the same as for $neer_t^M$.

$$x_t = \left(\Delta p_t^{F^*,M}, gap_t^*, \Delta m_t, \Delta neer_t^M, \Delta p_t^F\right)' \quad (5)$$

The equations above are reduced-form VARs with endogenous variables ordered to identify structural shocks in similar ordering as in Ito and Sato (2008). The reduced-form residuals of the relative price index likely affect all variables in the system contemporaneously. It serves as an indicator of global inflationary conditions relative to Brunei Darussalam. Given the trade dependence of Brunei Darussalam's economy and oil prices being able to be reflected in foreign price indices, it is reasonable to expect there may be contemporaneous effect on domestic output, monetary base, exchange rates and inflation. The output gap should have contemporaneous impact on other variables except the relative price index.

The monetary base does not reflect monetary policy actions as Brunei Darussalam operates a currency board arrangement. In this reduced-form VAR, it serves to indicate monetary conditions in the country which may contemporaneously impact exchange rates. The nominal effective exchange rate is assumed to have a contemporaneous impact on inflation and responds to demand, supply and monetary shocks. Brunei Darussalam's currency board arrangement is reflected by maintaining

a fixed exchange rate against the Singapore dollar, which has a substantial weight in the basket of exchange rates. Finally, the inflation variable is ordered last based on the assumption that it is contemporaneously affected by all four other shocks.

Given that the monetary policy of Brunei Darussalam is exchange rate based, it may be reasonable to suggest ordering the effective exchange rate earlier in the VAR as it is can be thought of as an exogenous monetary policy shock from Singapore. It is not reasonable to order it before the relative price index as this monetary policy shock would not be able to influence the inflation rates of other countries. Ordering the exchange rate before the output gap and monetary base would suggest that domestic economic activities would not be able to contemporaneously influence the exchange rate. Singapore's relative economic size in comparison to Brunei Darussalam is not large enough that Brunei Darussalam's trade and cross-border financial activities would have no contemporaneous impact on the exchange rate. It can be argued that the contemporaneous impact is small but there is still an impact. Thus, the ordering of the nominal effective exchange rate is deemed to be appropriate to adequately identify structural shocks.

The VAR undertaken in this paper differs from typical open economy VARs due to the lack of an active monetary policy instrument. However, it is argued that a similar specification and ordering is still suitable. Analysis is undertaken in Section 5 for each of the Equations (2), (3), (4) and (5) to illustrate the change in the estimated effects from making these adaptations to the baseline model represented in Equation (1).

4. Data and Observations

Monthly data from January 2010 until March 2018 is used for the analysis in this paper, since this is the earliest period for which Brunei Darussalam has a consistent monthly CPI. Prior to this period, CPI was using a different base year for which a chain-linking exercise was not undertaken by the national authorities.

Global oil prices are represented by average monthly prices for West Texas Intermediate (WTI). To ensure consistency, daily exchange rate data, for which the end of day is defined in the context of Brunei Darussalam Time, was extracted from Bloomberg and used to calculate a monthly average price for each month. This specification of end of day is to make it clearer for any future replication studies on the precise data source considering the foreign exchange market operates on a 24-hour basis. The base money data is obtained from AMBD which defines it as monetary base comprising currency in circulation, liabilities to other depository corporations and liabilities to other sectors. GDP data is obtained from the Department of Economic Planning and Development (DEPD) and converted to an index with base period January 2010. The index value of GDP for the quarter is assumed to be constant for all three months in the quarter. This method of interpolation is chosen over other methods that perform smooth interpolation, such as linear or cubic interpolation, in order not to make arbitrary assumptions about the interpolation methodology that could best fit actual unobserved developments over the quarter.

The components of CPI that make up p_t^F are as described in Kok (2015), for which it is replicated in Table 1 below.

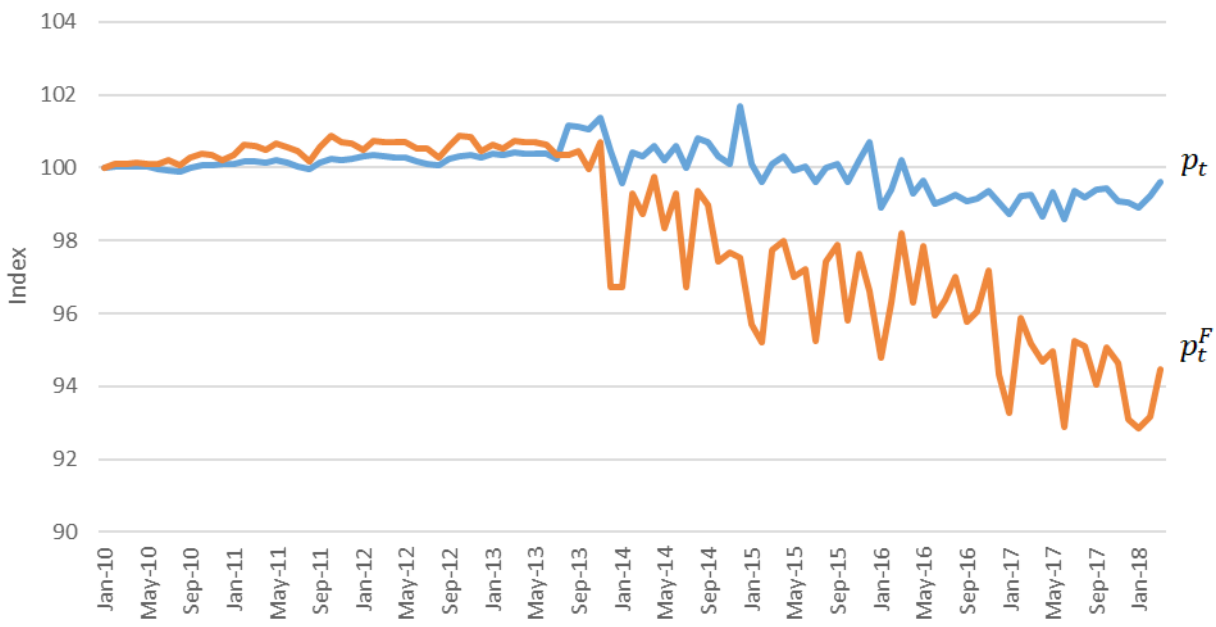
Table 1
Component Breakdown of p_t^F in CPI

Code in Monthly CPI Reports	Description	Weight in CPI (%)
01.1.4.1	Milk	1.09
01.1.4.2	Dairy Products	0.11
01.1.5.2	Margarine and Other Fats	0.07
01.1.8.2	Jam, Honey, Syrup	0.05
01.1.8.3	Chocolate and Confectionery	0.54
01.1.9	Food Products, not elsewhere classified	0.99
01.2.1	Coffee, Tea and Cocoa	0.76
01.2.2	Mineral Waters, Soft Drinks, Fruit and Vegetable Juices	1.64
02.1.1	Clothing Material	0.64
02.1.2	Garments	2.02
02.1.3	Other Articles of Clothing and Clothing Accessories	0.11
02.2	Footwear	0.70
04.1	Furniture and Furnishings, Carpets and Other Floor Coverings	1.52
04.2	Household Textiles	0.70
04.3	Household Appliances	1.98
04.4	Glassware, Tableware and Household Utensils	0.42
04.5	Tools and Equipment for House and Garden	0.41
04.6.1	Non-Durable Household Goods	1.32
06.1.2.1	Motor Cycles	0.10
06.1.3.1	Bicycles	0.05
06.2.1.1	Spare Parts and Accessories of Vehicles	2.62
07.2.1.1	Telephone and Telefax Equipment	1.07
08.1	Audio-Visual, Photographic and Information Processing Equipment	2.43
08.2.1.1	Games, Toys and Hobbies	0.62
08.2.2	Equipment for Sport, Camping and Open-Air Recreation	0.16
08.2.3.2	Other Garden Articles	0.14
08.2.4.1	Articles for Pets	0.52
08.4.1.1	Books	0.37
08.4.3.1	Stationery and Drawing Materials	0.55
11.1.2	Other Appliances Articles and Products for Personal Care	1.98
11.2.1	Jewellery, Clocks and Watches	0.71
11.2.2	Other Personal Effects	0.60
	TOTAL WEIGHT OF p_t^F IN CPI	**26.99**

Source: Kok (2015).

The components are then used to calculate an index for p_t^F based on the weighting in Table 1. It can be seen in Chart 1 where p_t^F is more volatile than p_t for the period under study, although both are on a downward trend. This largely reflects the role that price controls and subsidies have in stabilising the inflation of Brunei Darussalam. The period of global economic recovery following the global financial crisis coincided with a very stable period for inflation in Brunei Darussalam from 2010 to 2012.

Chart 1
Comparison of p_t and p_t^F (Jan 2010 = 100)



Source: Department of Economic Planning and Development, Prime Minister's Office, Brunei Darussalam; Author's own calculations.

The nominal effective exchange rates are calculated based on bilateral exchange rates obtained from Bloomberg and utilising time-varying weights similar to the Bank for International Settlements (BIS) effective exchange rate as elaborated in Klau and Fung (2006). Daily exchange rates, for which the end of day is defined in the context of Brunei Darussalam Time, were extracted from Bloomberg and used to calculate a monthly average exchange rate for each month for each currency. The weights are fixed for 3-year periods; 2010-2012 and 2013-2015. The weights for 2016 until March 2018 are based on the 2013-2015 weights, in line with the practice specified in Klau and Fung (2006). The nominal effective exchange rates utilised in this paper are then calculated using a geometric weighted average. The weighting for $neer_t$ and $neer_t^M$ by country is described in Table 2 below.

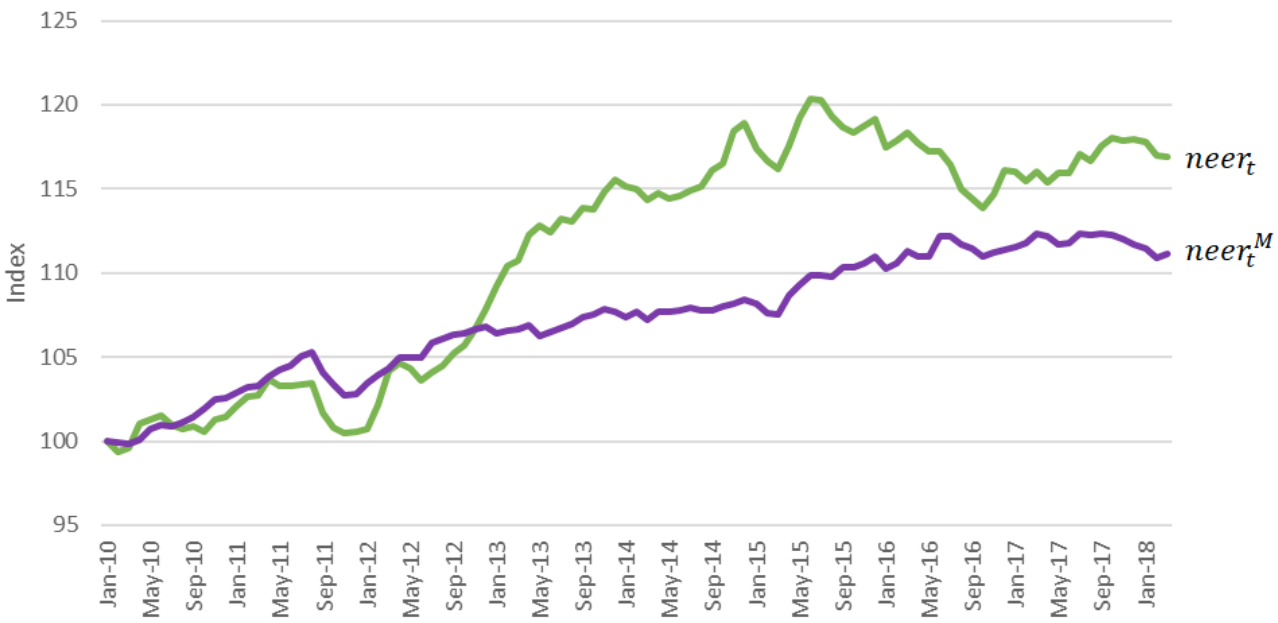
Table 2
Weights Utilised for $neer_t$ and $neer_t^M$

Country	Weights for $neer_t$ (%)		Weights for $neer_t^M$ (%)	
	2010-2012	2013-2015	2010-2012	2013-2015
Malaysia	5.9149	8.8322	20.9890	21.5920
Singapore	6.2428	7.5880	21.0348	18.1786
China	5.6133	3.9975	9.6046	11.1108
U.S.A.	2.2824	3.1844	9.2554	10.6942
Euro Area	1.4250	2.2791	6.0757	7.9964
Republic of Korea	14.2644	12.4428	7.4532	7.2584
Japan	35.8729	29.8479	7.8623	5.8796
Thailand	2.5212	5.5164	5.2234	4.5246
Indonesia	5.0503	3.9690	2.3140	3.3446
United Kingdom	0.7287	0.7496	2.9976	2.3915
Australia	7.5638	4.9934	1.5787	1.4408
India	6.0803	6.5367	0.9004	1.1606
Chinese Taipei	0.5060	3.1877	1.6393	0.9755
Hong Kong SAR	0.3292	0.3038	1.0450	0.9317
Vietnam	1.6637	1.9304	0.2618	0.5929
Canada	0.0783	0.7025	0.3126	0.4631
Switzerland	0.0618	0.1011	0.2817	0.3601
Philippines	0.2200	0.5316	0.2789	0.2915
New Zealand	3.4585	3.1460	0.3943	0.2723
United Arab Emirates	0.0463	0.0697	0.1776	0.2228
Denmark	0.0259	0.0352	0.1122	0.1283
Sweden	0.0238	0.0284	0.1083	0.1036
Brazil	0.0197	0.0108	0.0919	0.0416
Cambodia	0.0004	0.0069	0.0006	0.0268
Myanmar	0.0016	0.0049	0.0060	0.0176
Lao PDR	0.0003	0.0001	0.0006	0.0000
Norway	0.0045	0.0038	0.0000	0.0000

Source: Department of Economic Planning and Development, Prime Minister's Office, Brunei Darussalam; Author's own calculations.

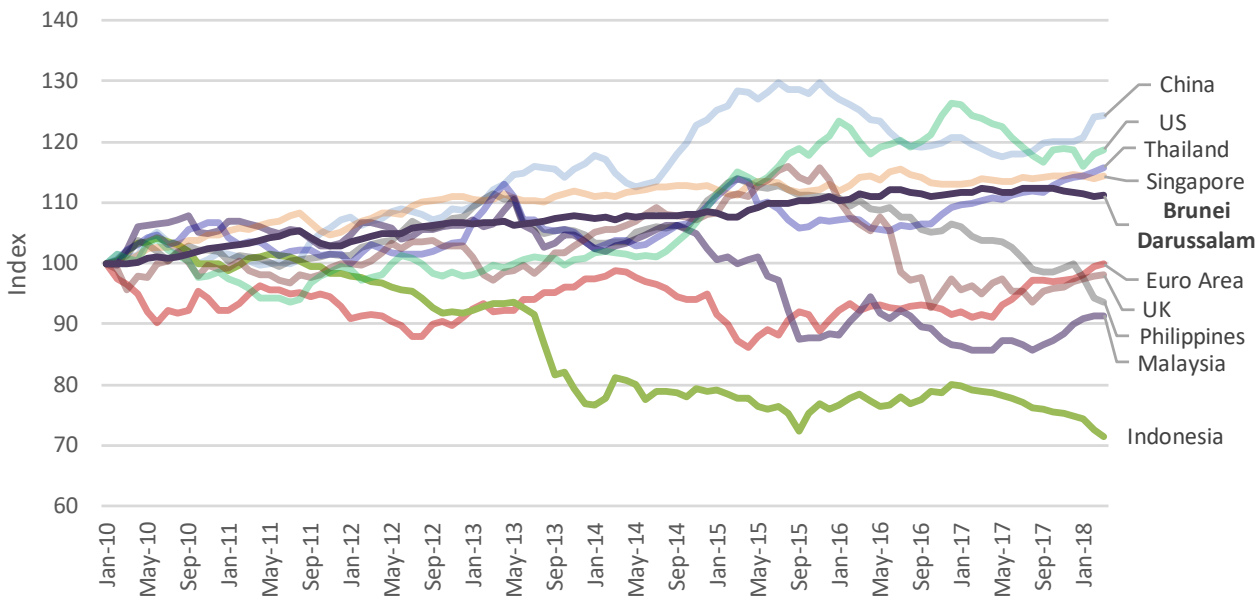
The most striking difference in the weighting comparing $neer_t$ to $neer_t^M$ is the reduction of weights for Japan and Korea (key export destinations for oil and gas exports of Brunei Darussalam) and the increase in weights for Malaysia and Singapore (key countries of import origin) when import shares are used as the basis for weighting. Notably, the increased share of Singapore results in a more stable nominal effective exchange rate due to the Brunei dollar being pegged to the Singapore dollar. Chart 2 below shows how the choice in weights influences the development of the nominal effective exchange rate which has been defined to be values above 100 indicating appreciation, where Brunei Darussalam's nominal effective exchange rate has been on an appreciating trend for the period of study. Furthermore, Chart 3 compares $neer_t^M$ with nominal effective exchange rates for selected countries which shows that Brunei Darussalam tends to have a relatively more stable nominal effective exchange rate, even in comparison to Singapore.

Chart 2
Comparison of $neer_t$ and $neer_t^M$ (Jan 2010 = 100)



Source: Department of Economic Planning and Development, Prime Minister's Office, Brunei Darussalam; Bloomberg; Author's own calculations.

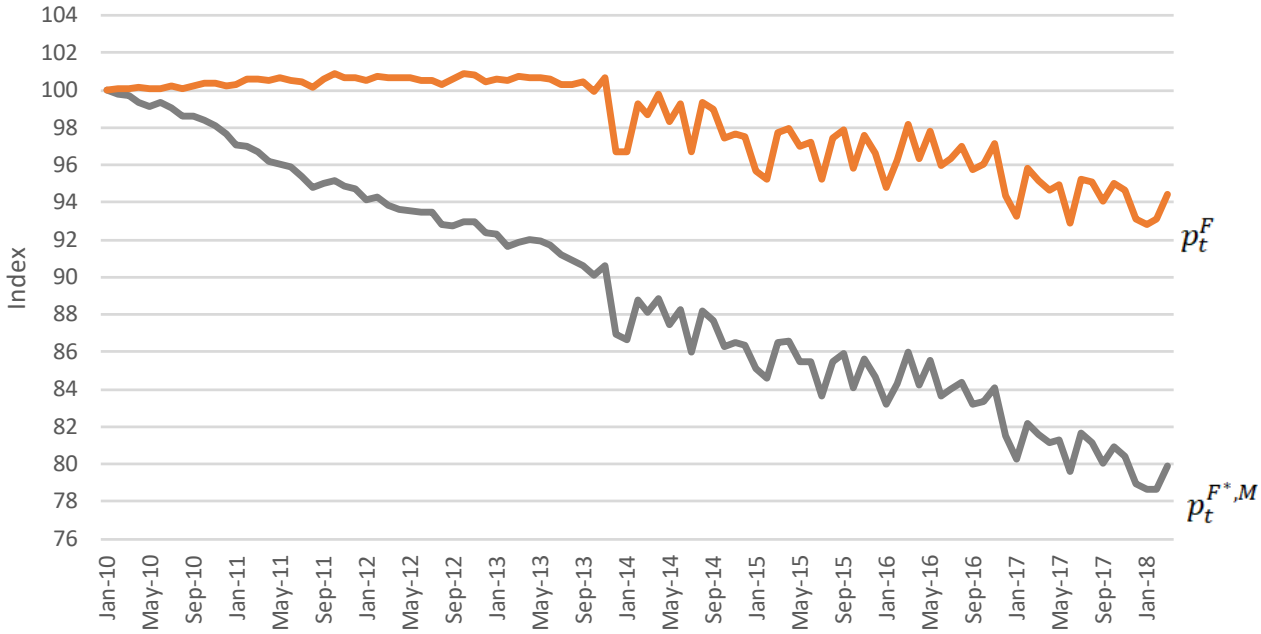
Chart 3
Comparison of $neer_t^M$ with Nominal Effective Exchange Rates of Selected Countries (Jan 2010 = 100)



Source: Bank for International Settlements; Department of Economic Planning and Development, Prime Minister's Office, Brunei Darussalam; Bloomberg; Author's own calculations.

The weights used for $neer_t^M$ are then used in the calculation of the relative price index $p_t^{F^*,M}$ for consistency of country weighting. Monthly CPI statistics for the countries are extracted from Bloomberg and re-scaled to the base period of January 2010. For Australia and New Zealand which release CPI on a quarterly basis, the index value for that quarter is assumed to be constant for all three months, i.e. Q1 index value of 103.4 is assumed to be the index value for January, February and March. Chart 4 below shows the evolution of $p_t^{F^*,M}$ in comparison with p_t^F where both indices have a downward trend over the sample period.

Chart 4
Comparison of $p_t^{F^*,M}$ and p_t^F (Jan 2010 = 100)



Source: Department of Economic Planning and Development, Prime Minister's Office, Brunei Darussalam; Bloomberg; Author's own calculations.

5. Analysis

Four VAR specifications were tested as represented by Equations (2), (3), (4) and (5) which have been recopied here for ease of reference.

$$x_t = (\Delta oil_t, gap_t^*, \Delta m_t, \Delta neer_t, \Delta p_t)' \quad (6)$$

$$x_t = (\Delta oil_t, gap_t^*, \Delta m_t, \Delta neer_t^M, \Delta p_t)' \quad (7)$$

$$x_t = (\Delta oil_t, gap_t^*, \Delta m_t, \Delta neer_t^M, \Delta p_t^F)' \quad (8)$$

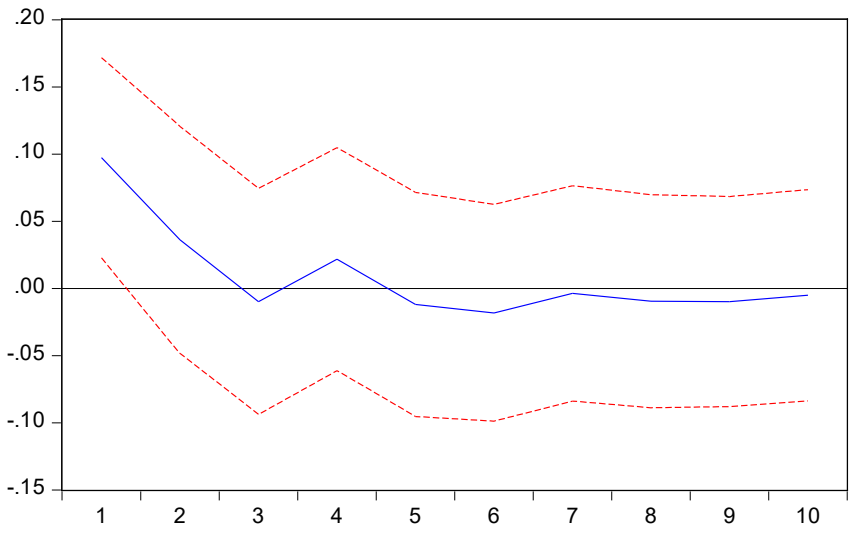
$$x_t = (\Delta p_t^{F^*,M}, gap_t^*, \Delta m_t, \Delta neer_t^M, \Delta p_t^F)' \quad (9)$$

The lag lengths are chosen based on the Schwarz information criterion: (2) 2 lags, (3) 2 lags, (4) 2 lags, (5) 1 lag. The VAR specifications are tested for unit roots and autocorrelation at these lag lengths and no issues are found.

The estimation output and cumulative impulse responses for the equations above are included in the appendices of this paper. This section mainly focuses on the accumulated impulse response for the exchange rate pass-through. Cumulative impulse responses are used to identify if there are any persistent effects over time from shocks.

In Equation (2), there is no statistically significant impact of inflation from exchange rates. An initial impact one month after the shock is estimated, but it is of the wrong sign, suggesting that an appreciation leads to an increase in inflation for one month before reversing itself in the second month. This is in line with the findings of Abu Bakar and Ali (2016) who could find no exchange rate pass-through for Brunei Darussalam, and Ito and Sato (2008) who also found no exchange rate pass-through for Singapore. Chart 5 below shows the accumulated impulse response.

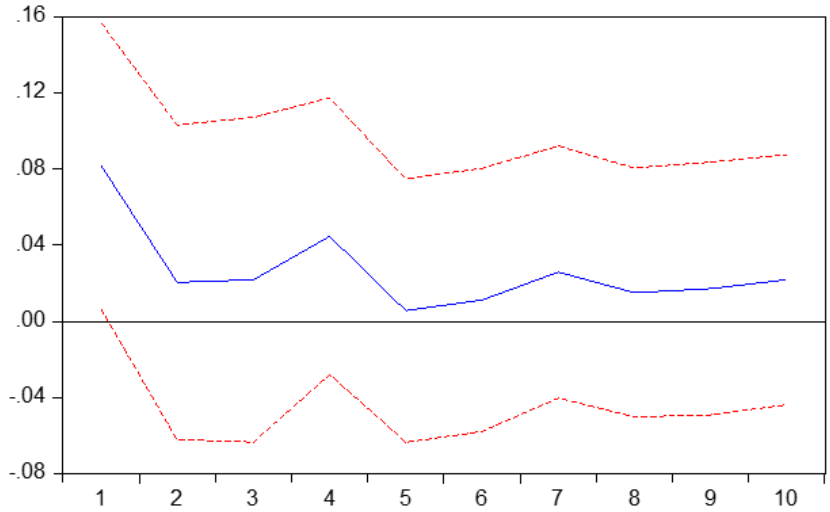
Chart 5
Accumulated Response of Inflation to a Nominal Effective Exchange Rate (Total Trade Weighted) Shock



Source: Author's own calculations.
Note: This is based on accumulated response of Δp_t to $\Delta neer_t$ Innovation using Cholesky (d.f. adjusted Factors +/- 2 S.E.

As we move to the specification that adjusts the nominal effective exchange rate to be based on import shares rather than total trade, we end up with Equation (3). Similar to the result for Equation (2), the estimated pass-through is not statistically significant, the impulse impact is of the wrong sign and reverses itself after two months. Chart 6 below shows the accumulated impulse response.

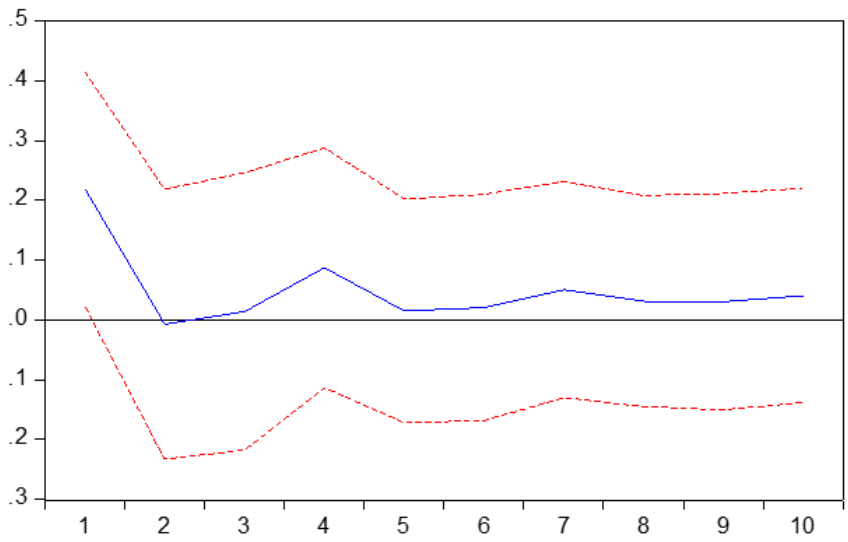
Chart 6
Accumulated Response of Inflation to a Nominal Effective Exchange Rate (Import Weighted) Shock



Source: Author's own calculations
Note: This is based on accumulated response of Δp_t to $\Delta neer_t^M$ Innovation using Cholesky (d.f. adjusted) Factors +/- 2 S.E.

We then reach Equation (4) after accounting for the stabilising effect of the government's intervention in the pricing of goods and services via price controls and subsidies by focusing on a sub-component of the CPI that is of foreign origin and not subject to these interventions. Again we are faced with the situation that the pass-through effect is not statistically significant, the impulse impact is of the wrong sign and reverses itself in the second month after the shock. The accumulated impulse response is shown in Chart 7 below.

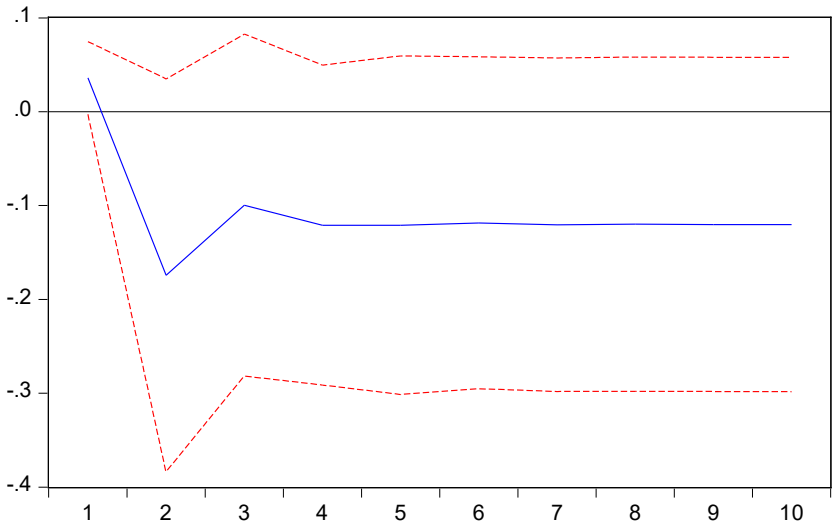
Chart 7
Accumulated Response of Foreign Component of Inflation to a Nominal Effective Exchange Rate (Import Weighted) Shock



Source: Author's own calculations
Note: This is based on accumulated response of Δp_t^F to $\Delta neer_t^M$ Innovation using Cholesky (d.f. adjusted) Factors +/- 2 S.E.

Further to this, recognising that global oil prices are an inappropriate control for global inflationary pressure given the presence and fixed price structure of fuel subsidies in Brunei Darussalam, we use a different control of a relative price index used in Caselli and Roitman (2016). This is the final VAR specification examined in this paper. Chart 8 shows the accumulated impulse response of Equation (5).

Chart 8
Accumulated Response of Foreign Component of Inflation to a Nominal Effective Exchange Rate (Import Weighted) Shock with Relative Price Index (Import Weighted) as Global Inflationary Variable



Source: Author's own calculations

Note: This is based on accumulated response of Δp_t^F to $\Delta neer_t^M$ Innovation using Cholesky (d.f. adjusted) Factors and $\Delta p_t^{F^*,M}$ instead of Δoil_t +/- 2 S.E.

The estimated coefficient is statistically significant. The initial impact of an appreciation in the nominal effective exchange rate is an increase in inflation which is then reversed to be deflationary in the second month. The impact stabilises in the fourth month at approximately -0.12 percentage points. The results are robust to alternative orderings of the endogenous variables as well as to different orderings of adjusting the specifications from Equation (2) to Equation (5). The alternative orderings examined are the two alternative orderings suggested in Ito and Sato (2008), an alternative ordering placing nominal effective exchange rate as the second endogenous variable, as well as an alternative ordering placing nominal effective exchange rate as the last endogenous variable.

The impact on monetary base from an exchange rate shock is negative, similar to the results found for Thailand and Malaysia by Ito and Sato (2008). There is no effect on the output gap from an exchange rate shock, similar to Ito and Sato's (2008) findings for Singapore. One interesting finding is that a monetary base shock has an estimated negative effect on the domestic price variable p_t^F. This may be due to the choice of the domestic price variable to be focused on imported goods and services. Increased demand could lead to declines in prices as for a country with a small population such as Brunei Darussalam, the economies of scale may still be increasing. This suggests that the importation costs attributable to individual units would be declining, hence potentially being deflationary with increased demand.

These results serve to highlight that there is an exchange rate pass-through effect on inflation in Brunei Darussalam after adjusting the VAR specification to account for government intervention in pricing of goods and services, and utilising a nominal effective exchange rate more reflective of imported inflationary pressures. This is in line with one of the arguments proposed by Abu Bakar and Ali (2006) for the lack of identified exchange rate pass-through, namely price controls affecting the pass-through.

The magnitude of the effect to the overall CPI is moderated by the weightage within the overall CPI. Thus, the overall impact to inflation from exchange rate pass-through is more muted. This is in line with Jašová, Moessner and Takáts (2016) as Brunei Darussalam typically experiences low inflation rates suggesting high menu costs. The results are also consistent with another argument proposed by Abu Bakar and Ali (2016) on importers adjusting profit margins rather than prices. Additionally, the results are in line with Caselli and Roitman (2016) who found lower magnitudes of exchange rate pass-through during periods of currency appreciation, which is experienced by Brunei Darussalam from 2010 until the present, as well as lower magnitude of pass-through for countries adopting inflation targeting, for which the government intervention in pricing in Brunei Darussalam is argued in Kok (2015) to be a form of implicit inflation targeting.

6. Conclusion

This paper adapted the methodology of Ito and Sato (2008) to examine the exchange rate pass-through to inflation in Brunei Darussalam. Adaptations to the methodology were made in order to account for the prevalence of price controls and subsidies in Brunei Darussalam as well as an import-weighted nominal effective exchange rate to better assess the pass-through effect to inflation. Overall, the results suggest a significant exchange rate pass-through in Brunei Darussalam albeit it is muted by government intervention in pricing, the nominal effective exchange rate tending to appreciate rather than depreciate in the period of study and the potential effects of an implicit inflation target from said government intervention in pricing. This is in line with the literature on this topic. The finding of a significant exchange rate pass-through supports the current use of the exchange rate as the main monetary policy instrument for Brunei Darussalam.

However, there are limitations to this study which may be suitable areas for further investigation. The effect of a monetary base shock on the domestic price variable p_t^F was interesting in that it was of the opposite sign in comparison to results from the existing literature. This result suggests that alternative monetary policy instruments in Brunei Darussalam, which rely on adjusting the monetary base, may not have the desired effect on inflation. This could be the result of increasing economies of scale from importing more items, thereby resulting in a reduction rather than increase in prices. Further research into the pricing mechanisms of importers in Brunei Darussalam may be needed to better understand this area and confirm this finding.

A fuller account of the transmission of exchange rate changes to inflation through the impact on import prices and producer prices is currently not possible due to data limitations. Given some of the unique characteristics of Brunei Darussalam's economy, the large share of economic activity from oil and gas as well as investment activities, it may be the case that a more consumer focused version of the import price index and producer price index would be necessary. The development

of such indices and a revisiting of this study may serve to improve the understanding of exchange rate pass-through in Brunei Darussalam. Alternative specifications of the output gap can also be investigated, perhaps more focused at household demand shocks which may impact demand-pull inflationary factors. An exercise to chain-link past data may also serve to give more insight into periods where exchange rates and inflation are more volatile. The period of study in this paper exhibited relatively stable exchange rates and inflation.

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Appendices

Variable	Data Source	Description
oil_t	Bloomberg	Natural log of oil prices. WTI daily prices are used and averaged for the month.
m_t	AMBD	Natural log of base money.
$neer_t$	Bloomberg; DEPD	Nominal effective exchange rates. Daily exchange rates are used and averaged for the month. Weights are based on total trade shares for a 3-year period which is updated for each new 3-year period.
p_t	DEPD	Domestic prices as represented by CPI.
gap_t^*	DEPD	Output gap based on HP filter of quarterly GDP.
$neer_t^M$	Bloomberg; DEPD	Nominal effective exchange rates. Daily exchange rates are used and averaged for the month. Weights are based on import shares for a 3-year period which is updated for each new 3-year period.
p_t^F	DEPD	Domestic prices as specified following categorisation of Foreign Sector developed in Kok (2015).
$p_t^{F^*,\ M}$	Bloomberg; DEPD	Relative price variable comparing a weighted average of CPI in foreign countries with p_t^F. Weights are based on import shares for a 3-year period which is updated for each new 3-year period.

Estimation Output for Equation (2): $x_t = (\Delta oil_t, gap_t^*, \Delta m_t, \Delta neer_t, \Delta p_t)'$

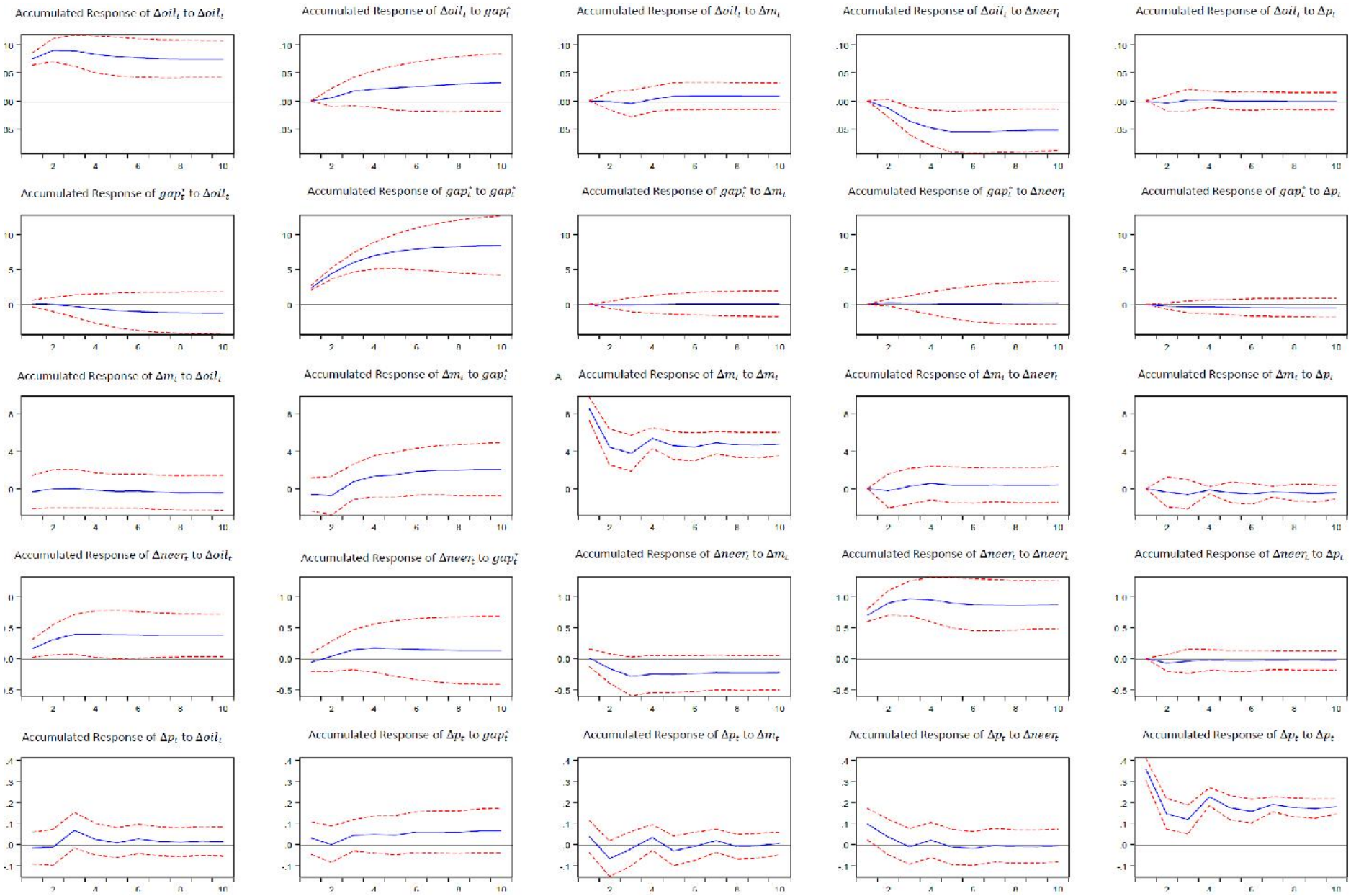
Vector Autoregression Estimates
Sample (adjusted): 2010M04 2018M03
Included observations: 96 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	Δoil_t	gap_t^*	Δm_t	$\Delta neer_t$	Δp_t
Δoil_{t-1}	0.241131	-4.435580	2.771091	1.050329	-0.109888
	(0.10785)	(3.42042)	(12.5290)	(1.03973)	(0.54425)
	[2.23573]	[-1.29679]	[0.22117]	[1.01020]	[-0.20191]
Δoil_{t-2}	0.032562	-0.157003	-2.891138	0.490049	1.157540
	(0.10488)	(3.32619)	(12.1838)	(1.01108)	(0.52926)
	[0.31046]	[-0.04720]	[-0.23729]	[0.48468]	[2.18709]
gap_{t-1}^*	0.002196	0.891021	-0.178233	0.046392	-0.007730
	(0.00338)	(0.10714)	(0.39246)	(0.03257)	(0.01705)
	[0.65004]	[8.31631]	[-0.45414]	[1.42444]	[-0.45342]
gap_{t-2}^*	0.001565	-0.140697	0.707850	-0.023368	0.020649
	(0.00344)	(0.10902)	(0.39934)	(0.03314)	(0.01735)
	[0.45528]	[-1.29055]	[1.77254]	[-0.70514]	[1.19032]
Δm_{t-1}	3.16E-05	-0.005607	-0.478615	-0.019627	-0.009598
	(0.00091)	(0.02893)	(0.10599)	(0.00880)	(0.00460)
	[0.03465]	[-0.19378]	[-4.51575]	[-2.23147]	[-2.08458]
Δm_{t-2}	-0.000938	0.005198	-0.319611	-0.020303	-0.004548
	(0.00093)	(0.02961)	(0.10845)	(0.00900)	(0.00471)
	[-1.00496]	[0.17557]	[-2.94720]	[-2.25603]	[-0.96540]
$\Delta neer_{t-1}$	-0.017079	0.436537	-0.208695	0.316894	-0.004877
	(0.01154)	(0.36602)	(1.34075)	(0.11126)	(0.05824)
	[-1.47982]	[1.19264]	[-0.15566]	[2.84816]	[-0.08373]
$\Delta neer_{t-2}$	-0.026405	-0.654695	0.902007	-0.014911	-0.057700
	(0.01182)	(0.37492)	(1.37334)	(0.11397)	(0.05966)
	[-2.23355]	[-1.74621]	[0.65680]	[-0.13084]	[-0.96719]
Δp_{t-1}	-0.010607	-0.747070	-1.009351	-0.196844	-0.593781
	(0.01931)	(0.61245)	(2.24339)	(0.18617)	(0.09745)
	[-0.54924]	[-1.21981]	[-0.44992]	[-1.05734]	[-6.09306]
Δp_{t-2}	0.009608	-0.032508	-1.932031	0.048142	-0.443164
	(0.01874)	(0.59445)	(2.17747)	(0.18070)	(0.09459)
	[0.51257]	[-0.05469]	[-0.88728]	[0.26642]	[-4.68519]
C	0.006369	0.087871	0.941320	0.143892	0.007322
	(0.00802)	(0.25426)	(0.93135)	(0.07729)	(0.04046)
	[0.79436]	[0.34559]	[1.01070]	[1.86174]	[0.18098]

R-squared	0.214377	0.608506	0.242673	0.227357	0.417995
Adj. R-squared	0.121950	0.562448	0.153575	0.136458	0.349524
Sum sq. resids	0.469476	472.1793	6335.485	43.62996	11.95505
S.E. equation	0.074319	2.356916	8.633372	0.716445	0.375030
F-statistic	2.319435	13.21171	2.723679	2.501197	6.104687
Log likelihood	119.1653	-212.6826	-337.3176	-98.36511	-36.22478
Akaike AIC	-2.253443	4.660054	7.256617	2.278440	0.983850
Schwarz SC	-1.959611	4.953886	7.550449	2.572271	1.277681
Mean dependent	-0.002693	0.087989	0.682457	0.180177	-0.004430
S.D. dependent	0.079312	3.563110	9.383963	0.770977	0.464997

Determinant resid covariance (dof adj.)	0.140701
Determinant resid covariance	0.076566
Log likelihood	-557.7495
Akaike information criterion	12.76561
Schwarz criterion	14.23477
Number of coefficients	55

Accumulated Response to Cholesky One S.D. (d.f. adjusted) Innovations ± 2 S.E.



Estimation Output for Equation (3): $x_t = (\Delta oil_t, gap_t^*, \Delta m_t, \Delta neer_t^M, \Delta p_t)'$

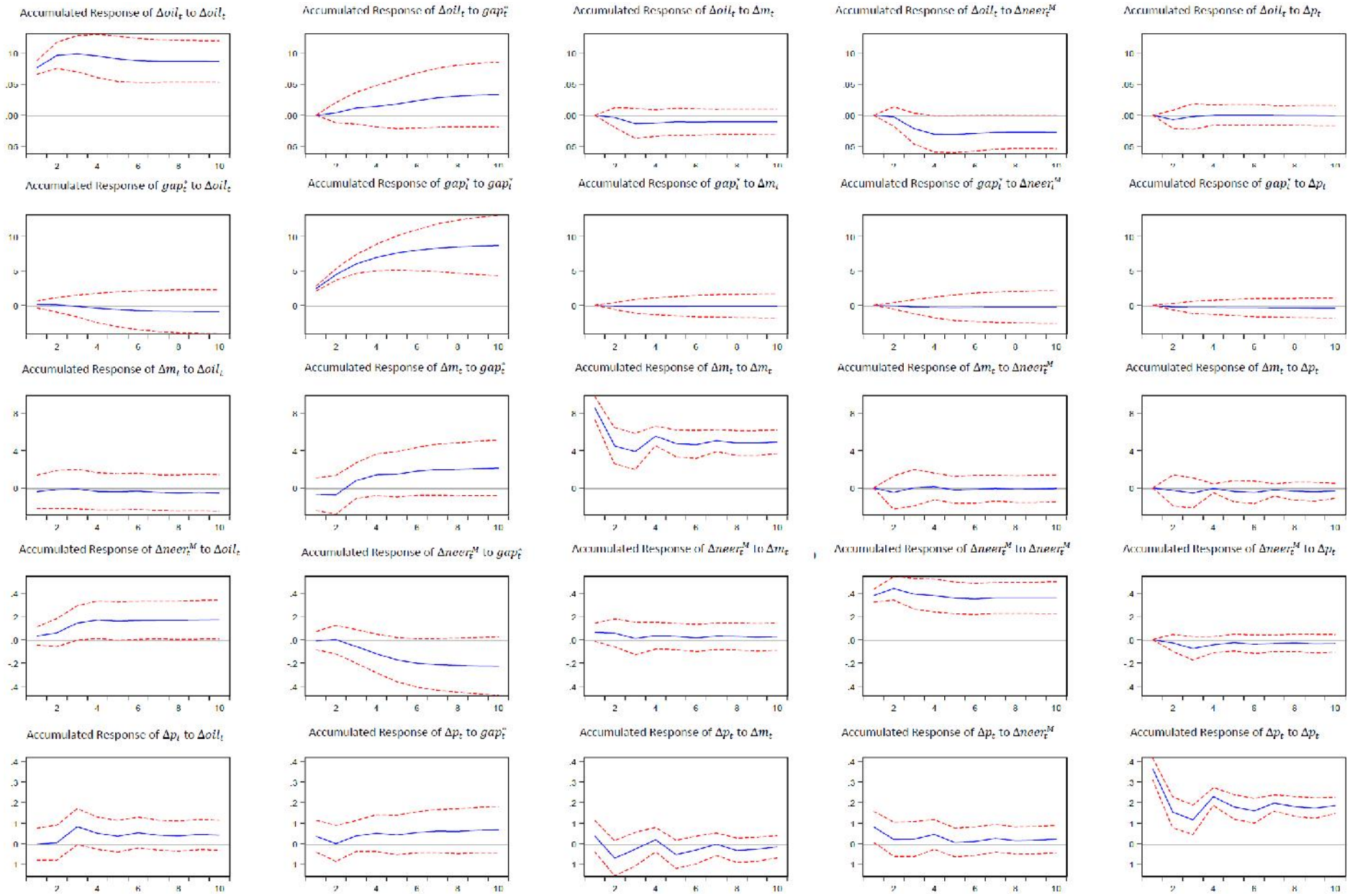
Vector Autoregression Estimates
Sample (adjusted): 2010M04 2018M03
Included observations: 96 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	Δoil_t	gap_t^*	Δm_t	$\Delta neer_t^M$	Δp_t
Δoil_{t-1}	0.258244	-2.334573	1.362708	0.268698	0.042103
	(0.10422)	(3.28610)	(11.8298)	(0.52512)	(0.51690)
	[2.47794]	[-0.71044]	[0.11519]	[0.51168]	[0.08145]
Δoil_{t-2}	-0.013090	-1.040726	-1.216578	1.061762	1.026356
	(0.10488)	(3.30705)	(11.9052)	(0.52847)	(0.52019)
	[-0.12480]	[-0.31470]	[-0.10219]	[2.00911]	[1.97302]
gap_{t-1}^*	0.001903	0.868459	-0.154851	0.005645	-0.008990
	(0.00343)	(0.10830)	(0.38987)	(0.01731)	(0.01704)
	[0.55416]	[8.01904]	[-0.39718]	[0.32621]	[-0.52774]
gap_{t-2}^*	-1.88E-06	-0.131235	0.691987	-0.031535	0.019352
	(0.00353)	(0.11121)	(0.40035)	(0.01777)	(0.01749)
	[-0.00053]	[-1.18006]	[1.72844]	[-1.77447]	[1.10626]
Δm_{t-1}	-0.000357	-0.008807	-0.464578	-0.001857	-0.009859
	(0.00094)	(0.02960)	(0.10654)	(0.00473)	(0.00466)
	[-0.38038]	[-0.29758]	[-4.36056]	[-0.39256]	[-2.11788]
Δm_{t-2}	-0.001026	-0.004751	-0.305906	-0.005327	-0.005092
	(0.00094)	(0.02963)	(0.10665)	(0.00473)	(0.00466)
	[-1.09159]	[-0.16035]	[-2.86821]	[-1.12516]	[-1.09257]
$\Delta neer_{t-1}^M$	-0.002438	-0.031673	-1.155664	0.184169	-0.036309
	(0.02131)	(0.67209)	(2.41947)	(0.10740)	(0.10572)
	[-0.11436]	[-0.04713]	[-0.47765]	[1.71478]	[-0.34345]
$\Delta neer_{t-2}^M$	-0.053605	-0.361324	1.204166	-0.138417	-0.001036
	(0.02110)	(0.66520)	(2.39468)	(0.10630)	(0.10463)
	[-2.54095]	[-0.54318]	[0.50285]	[-1.30214]	[-0.00990]
Δp_{t-1}	-0.019686	-0.576545	-0.746572	-0.077846	-0.583576
	(0.02010)	(0.63380)	(2.28163)	(0.10128)	(0.09970)
	[-0.97938]	[-0.90967]	[-0.32721]	[-0.76861]	[-5.85361]
Δp_{t-2}	0.007534	-0.108087	-1.657421	-0.153454	-0.453665
	(0.01939)	(0.61150)	(2.20138)	(0.09772)	(0.09619)
	[0.38848]	[-0.17676]	[-0.75290]	[-1.57036]	[-4.71642]
C	0.005037	0.103764	1.050451	0.114824	0.000399
	(0.00843)	(0.26577)	(0.95677)	(0.04247)	(0.04181)
	[0.59753]	[0.39043]	[1.09792]	[2.70360]	[0.00954]

R-squared	0.176759	0.594469	0.242294	0.191374	0.410845
Adj. R-squared	0.079907	0.546760	0.153152	0.096242	0.341533
Sum sq. resids	0.491956	489.1090	6338.652	12.49017	12.10192
S.E. equation	0.076077	2.398796	8.635530	0.383332	0.377327
F-statistic	1.825045	12.46020	2.718071	2.011661	5.927443
Log likelihood	116.9202	-214.3735	-337.3416	-38.32660	-36.81087
Akaike AIC	-2.206671	4.695281	7.257117	1.027638	0.996060
Schwarz SC	-1.912840	4.989113	7.550949	1.321469	1.289891
Mean dependent	-0.002693	0.087989	0.682457	0.117227	-0.004430
S.D. dependent	0.079312	3.563110	9.383963	0.403226	0.464997

Determinant resid covariance (dof adj.)	0.046223
Determinant resid covariance	0.025154
Log likelihood	-504.3183
Akaike information criterion	11.65246
Schwarz criterion	13.12162
Number of coefficients	55

Accumulated Response to Cholesky One S.D. (d.f. adjusted) Innovations ± 2 S.E.



Estimation Output for Equation (4): $x_t = (\Delta oil_t, gap_t^*, \Delta m_t, \Delta neer_t^M, \Delta p_t^F)'$

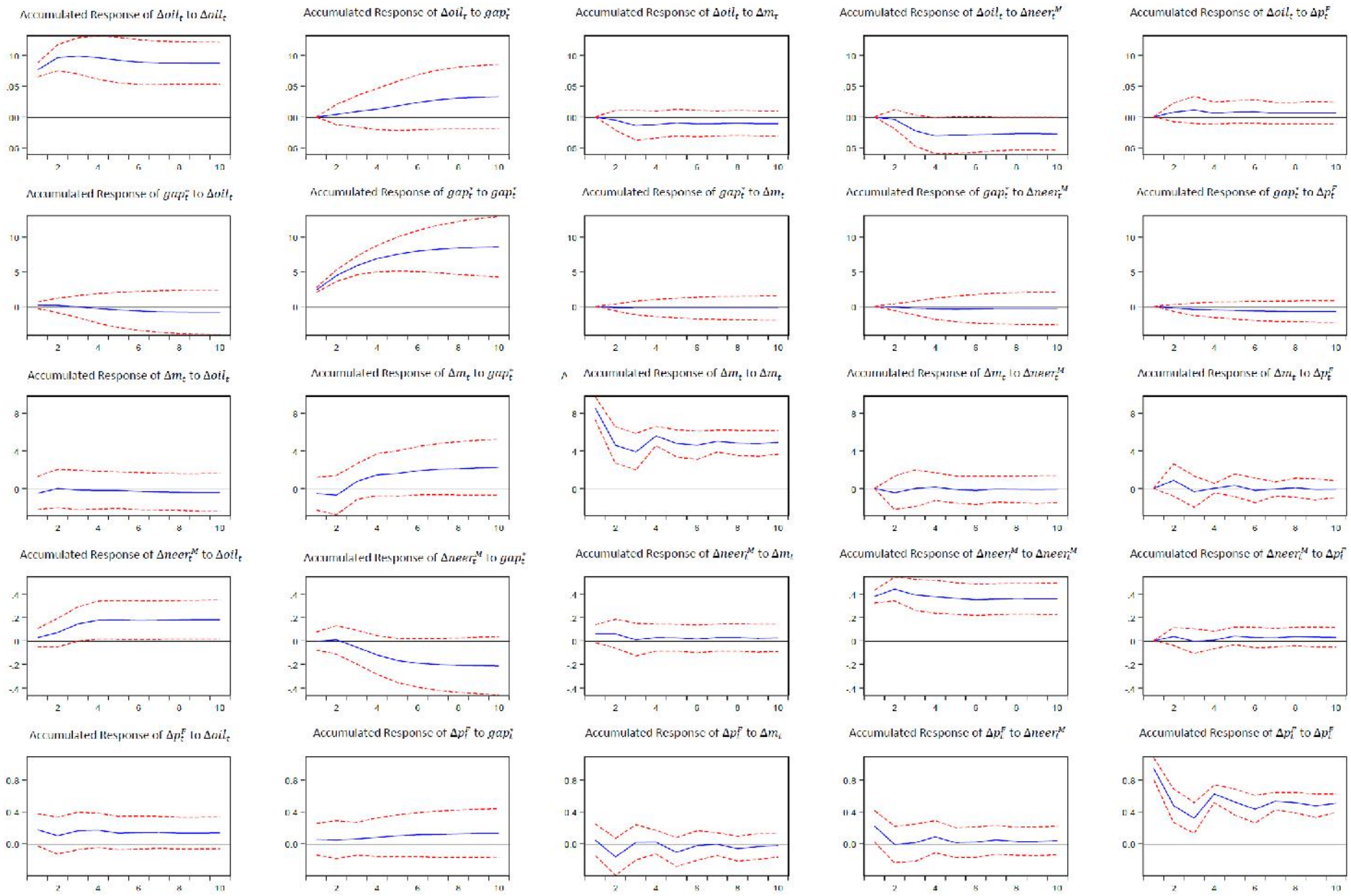
Vector Autoregression Estimates
Sample (adjusted): 2010M04 2018M03
Included observations: 96 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	Δoil_t	gap_t^*	Δm_t	$\Delta neer_t^M$	Δp_t^F
Δoil_{t-1}	0.238274	-2.013603	2.430324	0.373067	0.171837
	(0.10578)	(3.33062)	(11.8881)	(0.53156)	(1.37610)
	[2.25261]	[-0.60457]	[0.20443]	[0.70183]	[0.12487]
Δoil_{t-2}	-0.009648	-1.438686	-1.309411	1.024084	1.415781
	(0.10505)	(3.30778)	(11.8066)	(0.52791)	(1.36666)
	[-0.09184]	[-0.43494]	[-0.11090]	[1.93987]	[1.03594]
gap_{t-1}^*	0.001330	0.863858	-0.190562	0.003959	0.004002
	(0.00343)	(0.10799)	(0.38544)	(0.01723)	(0.04462)
	[0.38769]	[7.99966]	[-0.49440]	[0.22973]	[0.08970]
gap_{t-2}^*	0.000302	-0.126420	0.700874	-0.031770	0.009391
	(0.00352)	(0.11087)	(0.39574)	(0.01769)	(0.04581)
	[0.08590]	[-1.14025]	[1.77106]	[-1.79545]	[0.20501]
Δm_{t-1}	-0.000542	-0.012097	-0.452311	-0.001272	-0.019713
	(0.00095)	(0.02978)	(0.10629)	(0.00475)	(0.01230)
	[-0.57356]	[-0.40622]	[-4.25535]	[-0.26768]	[-1.60220]
Δm_{t-2}	-0.000611	-0.006894	-0.279048	-0.004336	0.002101
	(0.00095)	(0.02994)	(0.10685)	(0.00478)	(0.01237)
	[-0.64317]	[-0.23028]	[-2.61147]	[-0.90744]	[0.16985]
$\Delta neer_{t-1}^M$	-0.014421	-0.050522	-1.708754	0.149258	-0.311612
	(0.02142)	(0.67440)	(2.40718)	(0.10763)	(0.27864)
	[-0.67328]	[-0.07491]	[-0.70986]	[1.38673]	[-1.11833]
$\Delta neer_{t-2}^M$	-0.043989	-0.372920	1.750703	-0.118010	0.013170
	(0.02109)	(0.66409)	(2.37037)	(0.10599)	(0.27438)
	[-2.08569]	[-0.56155]	[0.73858]	[-1.11343]	[0.04800]
Δp_{t-1}^F	0.008224	-0.227657	0.933883	0.039561	-0.496390
	(0.00804)	(0.25314)	(0.90355)	(0.04040)	(0.10459)
	[1.02293]	[-0.89933]	[1.03358]	[0.97922]	[-4.74611]
Δp_{t-2}^F	0.007476	-0.079754	-0.389736	-0.030777	-0.381707
	(0.00787)	(0.24793)	(0.88495)	(0.03957)	(0.10244)
	[0.94948]	[-0.32168]	[-0.44040]	[-0.77780]	[-3.72627]
C	0.006394	0.093655	1.097540	0.118800	-0.076627
	(0.00851)	(0.26798)	(0.95653)	(0.04277)	(0.11072)
	[0.75131]	[0.34948]	[1.14742]	[2.77767]	[-0.69207]

R-squared	0.173928	0.594207	0.254638	0.192914	0.349709
Adj. R-squared	0.076743	0.546467	0.166948	0.097963	0.273204
Sum sq. resids	0.493647	489.4254	6235.390	12.46639	83.54783
S.E. equation	0.076208	2.399572	8.564901	0.382967	0.991421
F-statistic	1.789661	12.44665	2.903850	2.031717	4.571063
Log likelihood	116.7555	-214.4045	-336.5532	-38.23511	-129.5495
Akaike AIC	-2.203239	4.695928	7.240692	1.025731	2.928115
Schwarz SC	-1.909407	4.989759	7.534523	1.319563	3.221946
Mean dependent	-0.002693	0.087989	0.682457	0.117227	-0.058985
S.D. dependent	0.079312	3.563110	9.383963	0.403226	1.162925

Determinant resid covariance (dof adj.)	0.309026
Determinant resid covariance	0.168164
Log likelihood	-595.5154
Akaike information criterion	13.55240
Schwarz criterion	15.02156
Number of coefficients	55

Accumulated Response to Cholesky One S.D. (d.f. adjusted) Innovations ± 2 S.E.



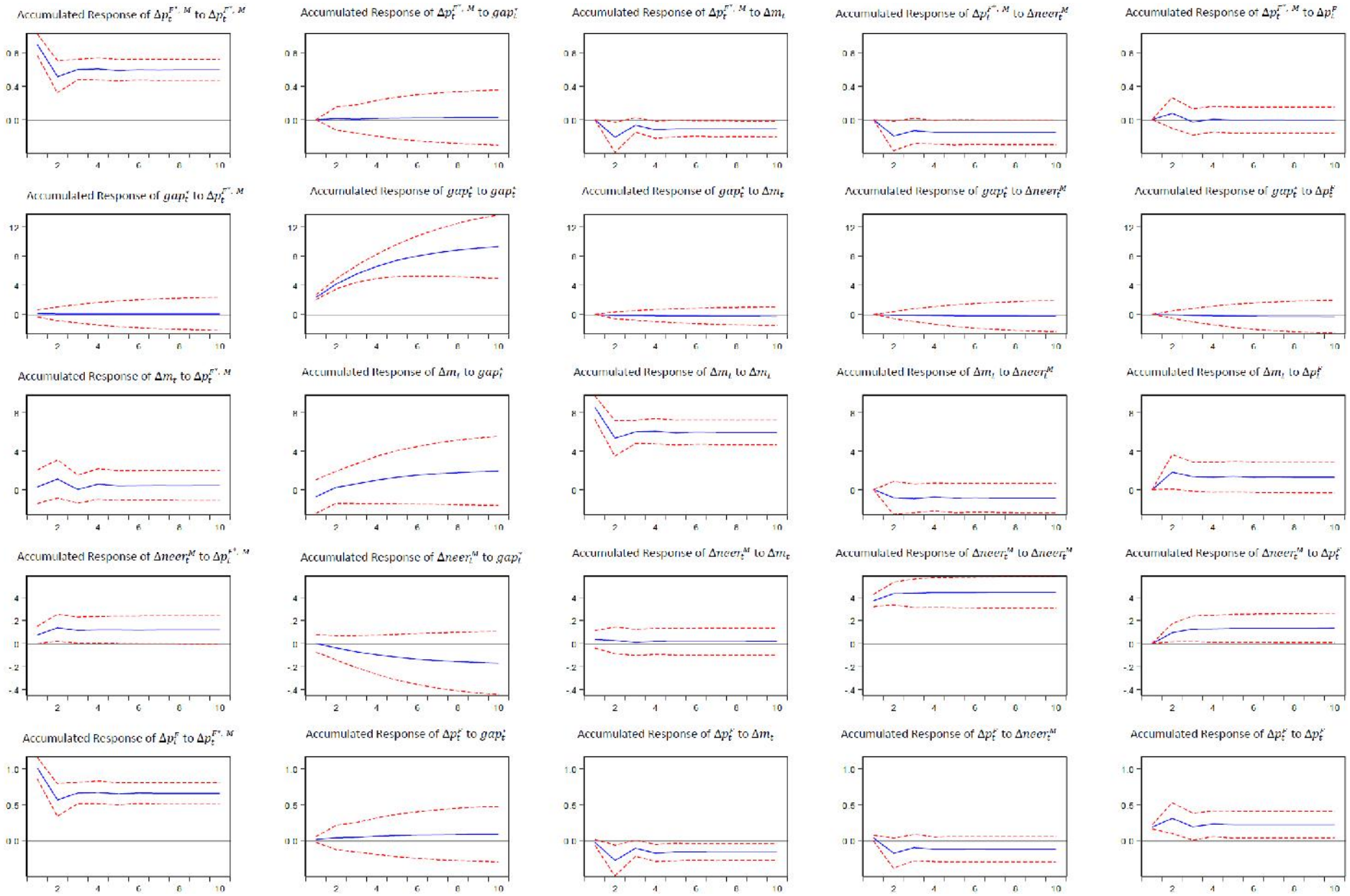
Estimation Output for Equation (5): $x_t = \left(\Delta p_t^{F^*,\,M}, gap_t^*, \Delta m_t, \Delta neer_t^M, \Delta p_t^F\right)'$

Vector Autoregression Estimates
Sample (adjusted): 2010M03 2018M03
Included observations: 97 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	$\Delta p_t^{F^*,\,M}$	gap_t^*	Δm_t	$\Delta neer_t^M$	Δp_t^F
$\Delta p_{t-1}^{F^*,\,M}$	-0.830061	0.025138	-9.657886	-0.499200	-1.146304
	(0.56137)	(1.47721)	(5.36779)	(0.23993)	(0.64095)
	[-1.47864]	[0.01702]	[-1.79923]	[-2.08063]	[-1.78845]
gap_{t-1}^*	-0.004800	0.763609	0.237847	-0.020220	-0.001226
	(0.02640)	(0.06947)	(0.25242)	(0.01128)	(0.03014)
	[-0.18184]	[10.9925]	[0.94226]	[-1.79217]	[-0.04068]
Δm_{t-1}	-0.021539	-0.013744	-0.334694	-9.78E-05	-0.025308
	(0.01011)	(0.02660)	(0.09666)	(0.00432)	(0.01154)
	[-2.13060]	[-0.51664]	[-3.46244]	[-0.02263]	[-2.19259]
$\Delta neer_{t-1}^M$	-0.563895	-0.189696	-3.189249	0.112841	-0.623119
	(0.23624)	(0.62164)	(2.25888)	(0.10097)	(0.26972)
	[-2.38700]	[-0.30515]	[-1.41187]	[1.11761]	[-2.31020]
Δp_{t-1}^F	0.409680	-0.150968	9.726117	0.501445	0.638349
	(0.49009)	(1.28965)	(4.68625)	(0.20946)	(0.55957)
	[0.83592]	[-0.11706]	[2.07546]	[2.39395]	[1.14079]
C	-0.284609	0.087608	-0.231464	0.028359	-0.182487
	(0.12748)	(0.33547)	(1.21901)	(0.05449)	(0.14556)
	[-2.23249]	[0.26115]	[-0.18988]	[0.52047]	[-1.25372]
R-squared	0.251629	0.582108	0.198997	0.134643	0.256367
Adj. R-squared	0.210510	0.559147	0.154986	0.087096	0.215508
Sum sq. resids	73.29108	507.5053	6701.101	13.38792	95.54331
S.E. equation	0.897439	2.361563	8.581286	0.383562	1.024659
F-statistic	6.119487	25.35191	4.521511	2.831793	6.274431
Log likelihood	-124.0438	-217.8947	-343.0499	-41.58967	-136.9032
Akaike AIC	2.681316	4.616385	7.196904	0.981230	2.946457
Schwarz SC	2.840577	4.775645	7.356165	1.140491	3.105718
Mean dependent	-0.205254	0.058055	0.676743	0.115595	-0.058309
S.D. dependent	1.010023	3.556744	9.335130	0.401443	1.156872

Determinant resid covariance (dof adj.)	1.629069
Determinant resid covariance	1.183826
Log likelihood	-696.3696
Akaike information criterion	14.97669
Schwarz criterion	15.77300
Number of coefficients	30

Accumulated Response to Cholesky One S.D. (d.f. adjusted) Innovations ± 2 S.E.



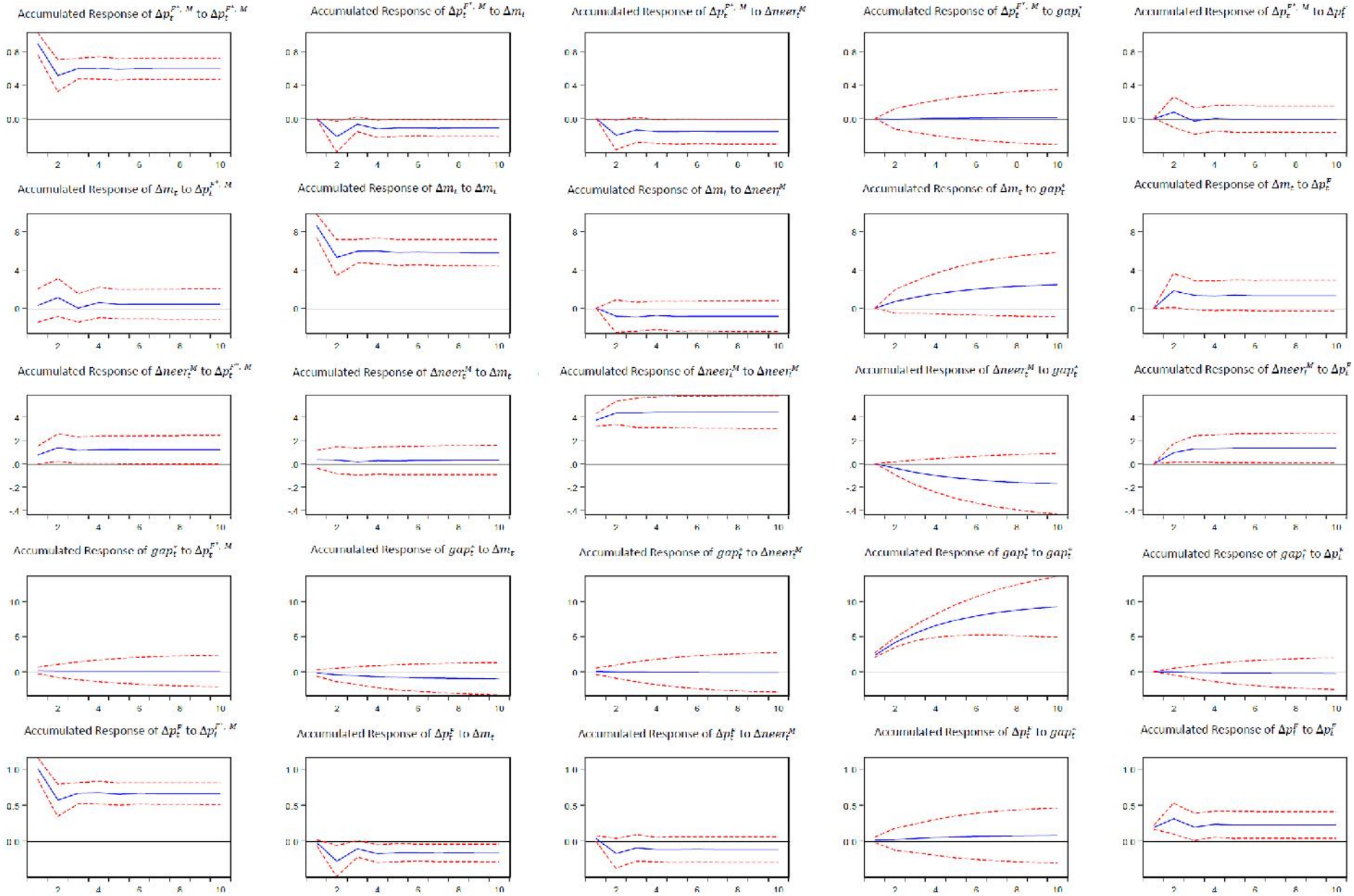
First Alternative Ordering for Equation (5): $x_t = \left(\Delta p_t^{F^*,\,M}, \Delta m_t, \Delta neer_t^M, gap_t^*, \Delta p_t^F\right)'$ as in Ito and Sato (2008)

Vector Autoregression Estimates
Sample (adjusted): 2010M03 2018M03
Included observations: 97 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	$\Delta p_t^{F^*,\,M}$	Δm_t	$\Delta neer_t^M$	gap_t^*	Δp_t^F
$\Delta p_{t-1}^{F^*,\,M}$	-0.830061	-9.657886	-0.499200	0.025138	-1.146304
	(0.56137)	(5.36779)	(0.23993)	(1.47721)	(0.64095)
	[-1.47864]	[-1.79923]	[-2.08063]	[0.01702]	[-1.78845]
Δm_{t-1}	-0.021539	-0.334694	-9.78E-05	-0.013744	-0.025308
	(0.01011)	(0.09666)	(0.00432)	(0.02660)	(0.01154)
	[-2.13060]	[-3.46244]	[-0.02263]	[-0.51664]	[-2.19259]
$\Delta neer_{t-1}^M$	-0.563895	-3.189249	0.112841	-0.189696	-0.623119
	(0.23624)	(2.25888)	(0.10097)	(0.62164)	(0.26972)
	[-2.38700]	[-1.41187]	[1.11761]	[-0.30515]	[-2.31020]
gap_{t-1}^*	-0.004800	0.237847	-0.020220	0.763609	-0.001226
	(0.02640)	(0.25242)	(0.01128)	(0.06947)	(0.03014)
	[-0.18184]	[0.94226]	[-1.79217]	[10.9925]	[-0.04068]
Δp_{t-1}^F	0.409680	9.726117	0.501445	-0.150968	0.638349
	(0.49009)	(4.68625)	(0.20946)	(1.28965)	(0.55957)
	[0.83592]	[2.07546]	[2.39395]	[-0.11706]	[1.14079]
C	-0.284609	-0.231464	0.028359	0.087608	-0.182487
	(0.12748)	(1.21901)	(0.05449)	(0.33547)	(0.14556)
	[-2.23249]	[-0.18988]	[0.52047]	[0.26115]	[-1.25372]
R-squared	0.251629	0.198997	0.134643	0.582108	0.256367
Adj. R-squared	0.210510	0.154986	0.087096	0.559147	0.215508
Sum sq. resids	73.29108	6701.101	13.38792	507.5053	95.54331
S.E. equation	0.897439	8.581286	0.383562	2.361563	1.024659
F-statistic	6.119487	4.521511	2.831793	25.35191	6.274431
Log likelihood	-124.0438	-343.0499	-41.58967	-217.8947	-136.9032
Akaike AIC	2.681316	7.196904	0.981230	4.616385	2.946457
Schwarz SC	2.840577	7.356165	1.140491	4.775645	3.105718
Mean dependent	-0.205254	0.676743	0.115595	0.058055	-0.058309
S.D. dependent	1.010023	9.335130	0.401443	3.556744	1.156872

Determinant resid covariance (dof adj.)	1.629069
Determinant resid covariance	1.183826
Log likelihood	-696.3696
Akaike information criterion	14.97669
Schwarz criterion	15.77300
Number of coefficients	30

Accumulated Response to Cholesky One S.D. (d.f. adjusted) Innovations ± 2 S.E.



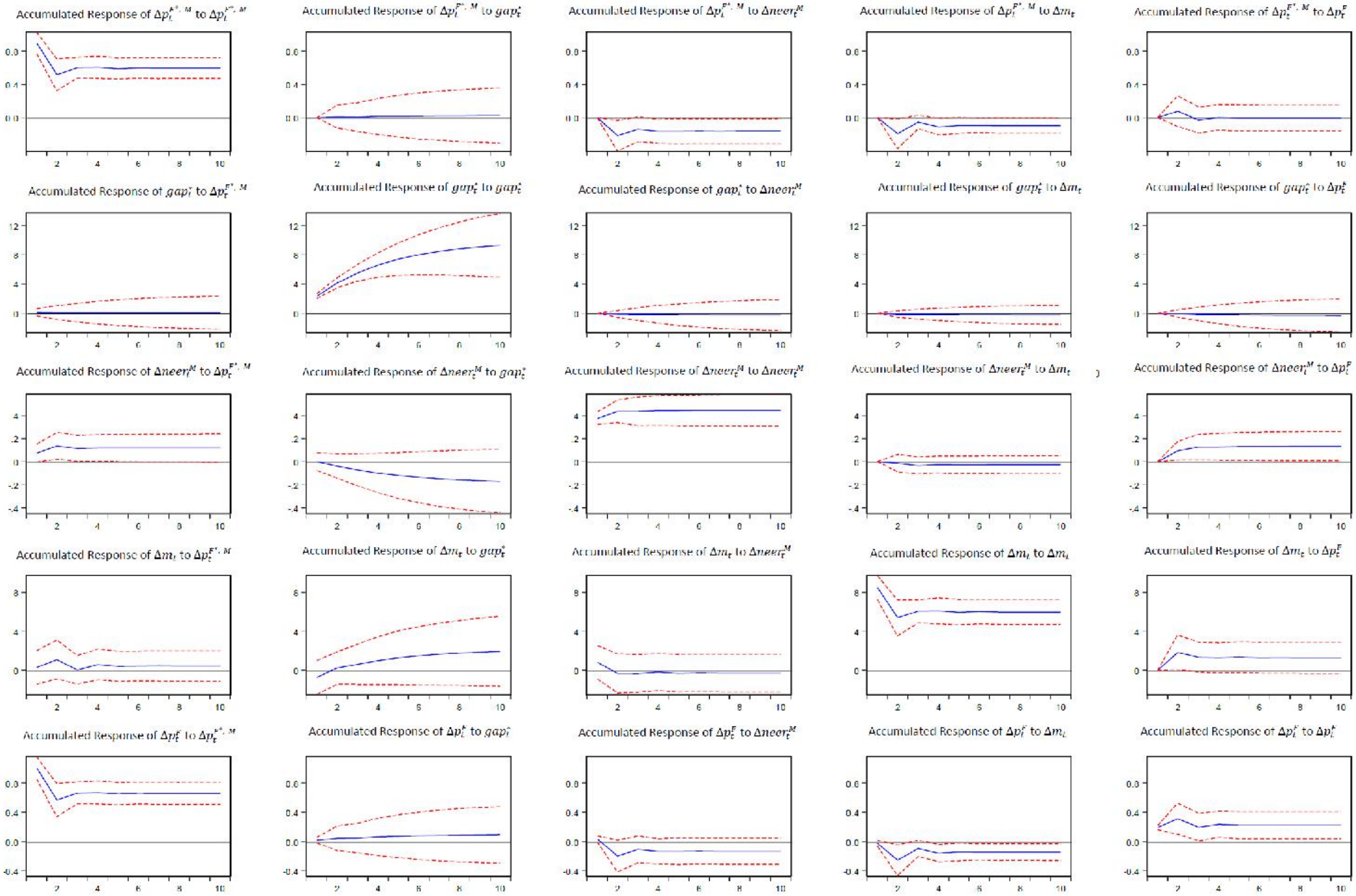
Second Alternative Ordering for Equation (5): $x_t = (\Delta p_t^{F^*,\,M}, gap_t^*, \Delta neer_t^M, \Delta m_t, \Delta p_t^F)'$ as in Ito and Sato (2008)

Vector Autoregression Estimates
Sample (adjusted): 2010M03 2018M03
Included observations: 97 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	$\Delta p_t^{F^*,\,M}$	gap_t^*	$\Delta neer_t^M$	Δm_t	Δp_t^F
$\Delta p_{t-1}^{F^*,\,M}$	-0.830061	0.025138	-0.499200	-9.657886	-1.146304
	(0.56137)	(1.47721)	(0.23993)	(5.36779)	(0.64095)
	[-1.47864]	[0.01702]	[-2.08063]	[-1.79923]	[-1.78845]
gap_{t-1}^*	-0.004800	0.763609	-0.020220	0.237847	-0.001226
	(0.02640)	(0.06947)	(0.01128)	(0.25242)	(0.03014)
	[-0.18184]	[10.9925]	[-1.79217]	[0.94226]	[-0.04068]
$\Delta neer_{t-1}^M$	-0.563895	-0.189696	0.112841	-3.189249	-0.623119
	(0.23624)	(0.62164)	(0.10097)	(2.25888)	(0.26972)
	[-2.38700]	[-0.30515]	[1.11761]	[-1.41187]	[-2.31020]
Δm_{t-1}	-0.021539	-0.013744	-9.78E-05	-0.334694	-0.025308
	(0.01011)	(0.02660)	(0.00432)	(0.09666)	(0.01154)
	[-2.13060]	[-0.51664]	[-0.02263]	[-3.46244]	[-2.19259]
Δp_{t-1}^F	0.409680	-0.150968	0.501445	9.726117	0.638349
	(0.49009)	(1.28965)	(0.20946)	(4.68625)	(0.55957)
	[0.83592]	[-0.11706]	[2.39395]	[2.07546]	[1.14079]
C	-0.284609	0.087608	0.028359	-0.231464	-0.182487
	(0.12748)	(0.33547)	(0.05449)	(1.21901)	(0.14556)
	[-2.23249]	[0.26115]	[0.52047]	[-0.18988]	[-1.25372]
R-squared	0.251629	0.582108	0.134643	0.198997	0.256367
Adj. R-squared	0.210510	0.559147	0.087096	0.154986	0.215508
Sum sq. resids	73.29108	507.5053	13.38792	6701.101	95.54331
S.E. equation	0.897439	2.361563	0.383562	8.581286	1.024659
F-statistic	6.119487	25.35191	2.831793	4.521511	6.274431
Log likelihood	-124.0438	-217.8947	-41.58967	-343.0499	-136.9032
Akaike AIC	2.681316	4.616385	0.981230	7.196904	2.946457
Schwarz SC	2.840577	4.775645	1.140491	7.356165	3.105718
Mean dependent	-0.205254	0.058055	0.115595	0.676743	-0.058309
S.D. dependent	1.010023	3.556744	0.401443	9.335130	1.156872

Determinant resid covariance (dof adj.)	1.629069
Determinant resid covariance	1.183826
Log likelihood	-696.3696
Akaike information criterion	14.97669
Schwarz criterion	15.77300
Number of coefficients	30

Accumulated Response to Cholesky One S.D. (d.f. adjusted) Innovations ± 2 S.E.



Third Alternative Ordering for Equation (5): $x_t = \left(\Delta p_t^{F^*,\,M}, \Delta neer_t^M, gap_t^*, \Delta m_t, \Delta p_t^F\right)'$

Vector Autoregression Estimates
Sample (adjusted): 2010M03 2018M03
Included observations: 97 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	$\Delta p_t^{F^*,\,M}$	$\Delta neer_t^M$	gap_t^*	Δm_t	Δp_t^F
$\Delta p_{t-1}^{F^*,\,M}$	-0.830061	-0.499200	0.025138	-9.657886	-1.146304
	(0.56137)	(0.23993)	(1.47721)	(5.36779)	(0.64095)
	[-1.47864]	[-2.08063]	[0.01702]	[-1.79923]	[-1.78845]
$\Delta neer_{t-1}^M$	-0.563895	0.112841	-0.189696	-3.189249	-0.623119
	(0.23624)	(0.10097)	(0.62164)	(2.25888)	(0.26972)
	[-2.38700]	[1.11761]	[-0.30515]	[-1.41187]	[-2.31020]
gap_{t-1}^*	-0.004800	-0.020220	0.763609	0.237847	-0.001226
	(0.02640)	(0.01128)	(0.06947)	(0.25242)	(0.03014)
	[-0.18184]	[-1.79217]	[10.9925]	[0.94226]	[-0.04068]
Δm_{t-1}	-0.021539	-9.78E-05	-0.013744	-0.334694	-0.025308
	(0.01011)	(0.00432)	(0.02660)	(0.09666)	(0.01154)
	[-2.13060]	[-0.02263]	[-0.51664]	[-3.46244]	[-2.19259]
Δp_{t-1}^F	0.409680	0.501445	-0.150968	9.726117	0.638349
	(0.49009)	(0.20946)	(1.28965)	(4.68625)	(0.55957)
	[0.83592]	[2.39395]	[-0.11706]	[2.07546]	[1.14079]
C	-0.284609	0.028359	0.087608	-0.231464	-0.182487
	(0.12748)	(0.05449)	(0.33547)	(1.21901)	(0.14556)
	[-2.23249]	[0.52047]	[0.26115]	[-0.18988]	[-1.25372]
R-squared	0.251629	0.134643	0.582108	0.198997	0.256367
Adj. R-squared	0.210510	0.087096	0.559147	0.154986	0.215508
Sum sq. resids	73.29108	13.38792	507.5053	6701.101	95.54331
S.E. equation	0.897439	0.383562	2.361563	8.581286	1.024659
F-statistic	6.119487	2.831793	25.35191	4.521511	6.274431
Log likelihood	-124.0438	-41.58967	-217.8947	-343.0499	-136.9032
Akaike AIC	2.681316	0.981230	4.616385	7.196904	2.946457
Schwarz SC	2.840577	1.140491	4.775645	7.356165	3.105718
Mean dependent	-0.205254	0.115595	0.058055	0.676743	-0.058309
S.D. dependent	1.010023	0.401443	3.556744	9.335130	1.156872

Determinant resid covariance (dof adj.)	1.629069
Determinant resid covariance	1.183826
Log likelihood	-696.3696
Akaike information criterion	14.97669
Schwarz criterion	15.77300
Number of coefficients	30

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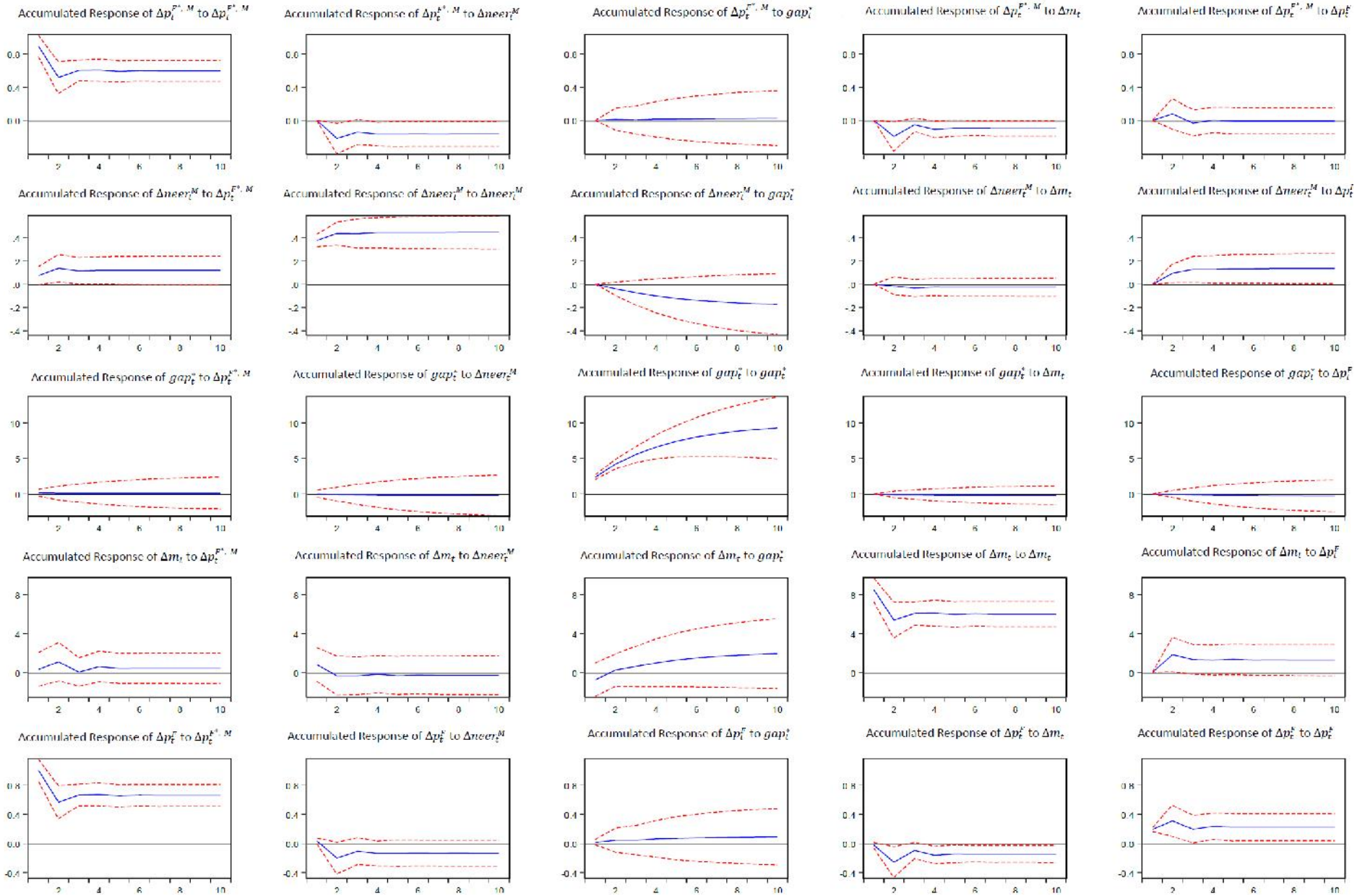

Fourth Alternative Ordering for Equation (5): $x_t = (\Delta p_t^{F^*,\,M}, gap_t^*, \Delta m_t, \Delta p_t^F, \Delta neer_t^M)'$

Vector Autoregression Estimates
Sample (adjusted): 2010M03 2018M03
Included observations: 97 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	$\Delta p_t^{F^*,\,M}$	gap_t^*	Δm_t	Δp_t^F	$\Delta neer_t^M$
$\Delta p_{t-1}^{F^*,\,M}$	-0.830061	0.025138	-9.657886	-1.146304	-0.499200
	(0.56137)	(1.47721)	(5.36779)	(0.64095)	(0.23993)
	[-1.47864]	[0.01702]	[-1.79923]	[-1.78845]	[-2.08063]
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	(0.02640)	(0.06947)	(0.25242)	(0.03014)	(0.01128)
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	(0.12748)	(0.33547)	(1.21901)	(0.14556)	(0.05449)
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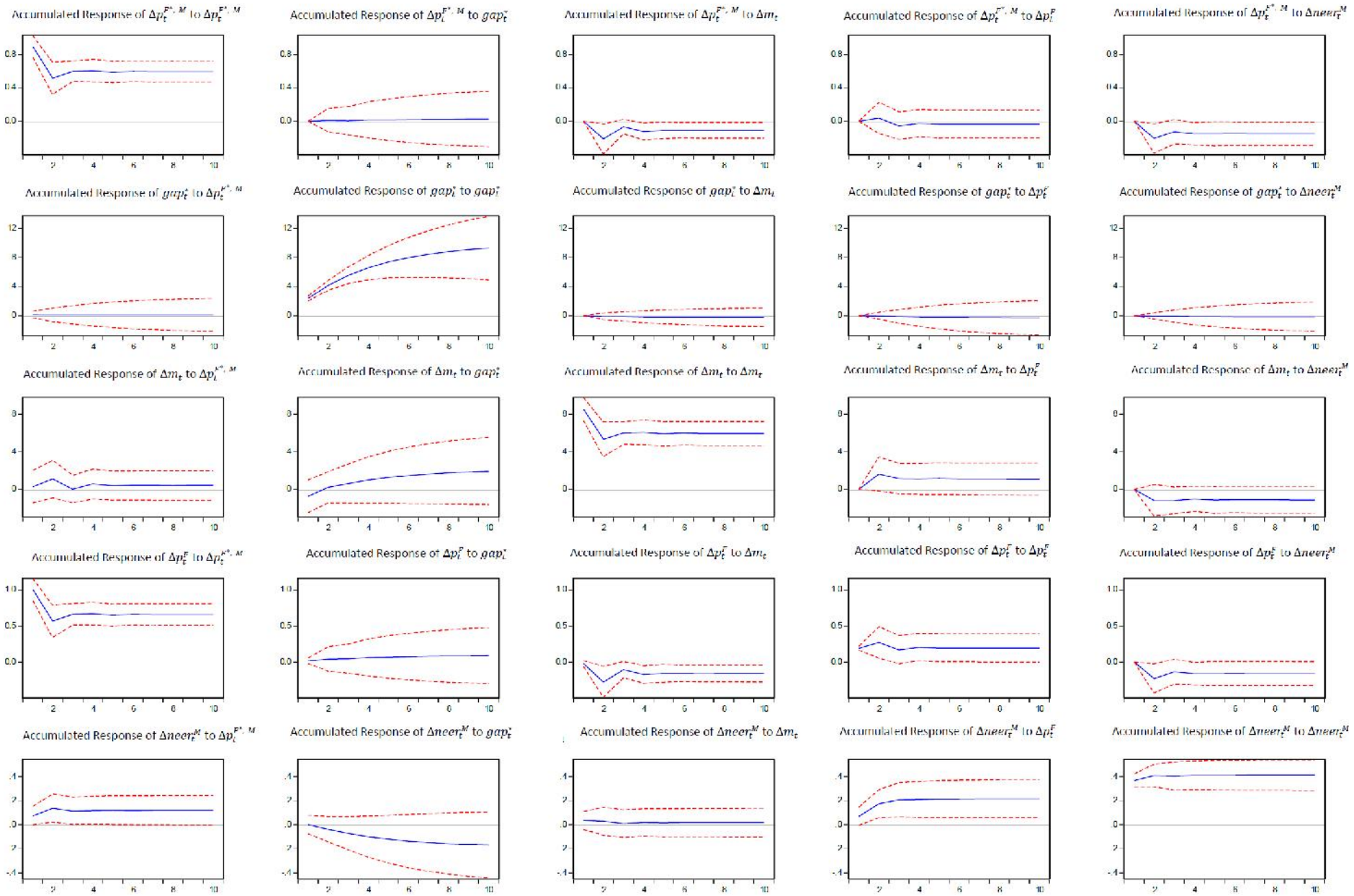

Chapter 3

THE IMPACT OF EXCHANGE RATE CHANGES ON CONSUMER PRICES: EVIDENCE FROM INDIA

By

Sujata Kundu[1]

1. Introduction

Inflation in emerging market economies, since the mid-2000s, has generally remained moderate and stable as compared with the late 1990s, irrespective of the fact that there exists considerable heterogeneity in inflation performance across the economies. While global factors, particularly the fall in crude oil prices, played a crucial part in achieving the benign inflation environment, a lot more was due to the softening in longer term inflation expectations (WEO, October 2018). However, crude oil prices are no longer moderate; and with monetary policy normalisation characterised by the rising interest rates in the advanced economies (AEs), specifically the United States, a host of emerging market economy (EME) currencies have suffered major depreciation against the US dollar (US$), particularly since the beginning of 2018. One of the leading EME currencies that witnessed a major fall in its exchange rate is the Indian rupee (INR)[2]; the others being the Turkish lira, Argentine peso and the Russian ruble. Some of the other developing countries such as Brazil, China, Vietnam, Colombia, Indonesia, Pakistan and South Africa, also struggled with pressures of currency depreciation to varying degrees. The events surfaced renewed concerns among policymakers as well as researchers in examining the nature and causes of such sharp depreciation. More importantly, central to the global transmission of inflation and economic cycles is the dynamics of exchange rate impact on domestic prices, which is popularly termed as exchange rate pass-through (ERPT) in the literature (Aron, et al. 2014).

In this context, one of the major areas of discussion among policymakers and researchers in the case of India, being an inflation targeting (IT) economy, has been to analyse the impact of the currency depreciation on inflation, or in other words the extent of ERPT on domestic inflation. Globally, crude oil prices have also been on the rise, which is an additional cause of discomfort as crude oil is one of the major constituents of India's import basket (India imports around 80% of its crude oil requirements). Therefore, the combination of both these events not only pose upside risks to the inflation path but could also have implications for the medium-term inflation target.

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1. The author is a Research Officer in the Prices and Monetary Research Division of the Department of Economic and Policy Research, Reserve Bank of India (RBI), Mumbai – 400 001. The paper is a part of the SEACEN Research Project on Price Setting Behaviour and Inflation Dynamics in SEACEN Member Economies and their Implications for Inflation. The author is extremely thankful to the Reserve Bank of India for nominating the author in the project. The author extends sincere thanks to Asish Thomas George, Director, RBI, for technical help in the paper, Soumasree Tewari, Research Officer, RBI, and Shobhit Goel, Manager, RBI, for their help in data related queries. The first draft of the paper was presented in the SEACEN seminar on 13 November, 2018. The author expresses sincere thanks to the Project leaders, Prof. Peter Tillman and David Finck, and to the other participants for their valuable comments and suggestions during the presentation. The author is extremely thankful to Binod B. Bhoi, Director, RBI, for his useful comments on the revised draft of the paper. The views expressed in this paper and errors, if any, may be attributed to the author only.
2. The INR depreciated by 14% in September 2018 over January 2018.

The ERPT is an empirical question (Patra, et al. 2018). Therefore, quite evidently, it has attracted the interests of policymakers, specifically the ones dealing with monetary policy making for quite some decades now. Moreover, with a majority of the EMEs adopting new monetary policy frameworks (specifically IT), the issue has depicted considerable evolution over time. EMEs have largely shifted from monetary policy frameworks with currency boards or pegged currencies in place. The new frameworks generally offer exchange rate flexibility and a new nominal anchor for monetary policy, which is inflation in most cases. Therefore, the dynamics of exchange rate movements could matter a lot for an IT monetary policy framework. In fact, the degree of ERPT is one of the key factors that could determine the effectiveness and performance of monetary policy. In addition, welfare effects working through the disposable incomes of the households as well as input costs/profit margins of firms, would have implications for their inflation expectations. Therefore, the extent of ERPT could pose crucial policy questions for the central bank in the sense that whether a central bank should respond to exchange rate changes even when its aim is to target inflation (Patra, et al. 2018). Moreover, together with other exogenous shocks to the economy, like an adverse crude oil price shock, exchange rate fluctuations can raise concerns of appropriate monetary policy decisions.

Against this backdrop, let us now set out the objective behind this paper and try to draw out some of the important questions that the study will attempt to address. As has been stated earlier, the INR has witnessed a phase of significant depreciation *vis-à-vis* the US$ during the current year, which has renewed interest in re-examining the extent of ERPT to domestic inflation. The paper begins with the question whether changes in exchange rate and inflation dynamics impact the extent of ERPT. The study uses the new all India consumer price index-combined (CPI-C) as the measure of domestic prices for the analysis. Using CPI-C becomes important because under the flexible inflation targeting (FIT) framework, all India headline inflation based on CPI-C is the nominal anchor for IT. While there exists a handful of studies in the Indian context that have looked at the issue of ERPT in some detail, this study will, at first, try to re-confirm the earlier estimates of ERPT to overall inflation.[3] Moreover, against the backdrop of the previous two decades characterised by major global events beginning with the dotcom bubble crash during 2000-02, followed by the global financial crisis during 2007-08 (which had a significant impact on global growth conditions), trailed by Quantitative Easing (QE) and subsequent taper tantrum; upturn and downturn of the global commodity price cycles, a major decline in domestic food inflation in India, and landmark institutional changes in the monetary policy framework in the domestic arena, the paper attempts to answer the question whether factors like global demand conditions, foreign costs, international commodity prices, domestic food price shocks, input cost conditions and trade scenario played any role in explaining inflation dynamics during this time. In addition, the paper inquires whether all through these years the extent of ERPT has varied over time. Considering that inflation during these years have gone through high and low phases characterised by considerable differences in inflation volatility, the paper attempts to model ERPT to inflation in a Markov-switching regression framework. In doing so, the paper answers the question whether ERPT has been different during high and low inflation phases. Although limited by the availability of data capturing the recent phase of currency depreciation in the Indian economy, the paper tries to assess whether the current phase of exchange rate fluctuation caused a major turning point or a regime-switch in inflation.

3. See Khundrakpam (2007) and Patra, et al. (2018).

Using a linear regression framework, the paper finds that the ERPT accumulated over the duration of four months is 0.09, *i.e.* around 10% of the changes in the exchange rate are cumulatively passed through to the changes in CPI-C, while over a duration of 12 months the cumulative pass-through is around 20%. The results also show that foreign costs, global demand conditions and food price shocks are statistically significant determinants explaining the changes in domestic consumer prices in India. The results of the linear regression model are further validated using a structural vector auto regression model. Further, using a regime-switching model the paper tries to analyse the time-varying nature of ERPT. In this regard, the paper finds that the lower inflation regime in India is also characterised by low volatility with the ERPT coefficient at 11%, which is much lower than the ERPT coefficient in the high inflation regime, which is around 20%. Additionally, the study finds that the one period lagged inflation and changes in food inflation shock are crucial determinants of inflation dynamics. Moreover, using rolling regression method, the study also finds that ERPT had been fairly high especially during 2007-08 to 2011-12, and has declined in the subsequent years.

The structure of the paper is as follows: Section 2 takes us through a brief review of the emergence and the gradual evolution of the literature on ERPT over the years. It also provides an overview of the earlier studies that came up with the ERPT estimates, specifically in the Indian context. Section 3 covers the stylised facts and puts forward the primary objective of the paper along with the questions that the paper attempts to answer. Section 4 presents the methodology and the modelling frameworks used in the paper. Section 5 provides the details of the data and the data sources used in the analysis. It also presents the results of the study. Finally, Section 6 concludes the paper with some implications for monetary policy.

2. Literature Review

The adoption of an IT monetary policy framework requires a careful analysis of the impact of exchange rate fluctuations on domestic consumer prices. Under an environment of complete ERPT, domestic currency depreciations can translate into an increase in domestic inflation *via* an increase in import prices. However, the ERPT is generally incomplete or partial as shown widely in the literature. Campa and Goldberg (2002), with a sample of 25 OECD countries, find that in the short run, import prices in local currencies reflect 60% of the exchange rate changes, while in the long run the extent goes up to 80%.

According to Dornbusch (1987) and Marston (1990), among others, the ERPT depends on the structure of competition in the industry, which is also depicted empirically by Knetter (1993) and Yang (1997). However, in another strand of the literature, Taylor (2000), in a seminal paper, shows that the degree of ERPT depends on the level of inflation. He argues that low ERPT in the advanced economies is the result of moderate inflation during the 1990s as compared with the high inflation episodes of the previous decades. In addition, he states that a commitment towards price stability should reduce the degree of ERPT. Therefore, the lower the extent of import price ERPT, the smaller is the impact on domestic inflation, thereby reducing the concerns of monetary policy adjustments in maintaining the inflation target. Devereux and Yetman (2002) shows that a higher mean inflation and a higher exchange rate volatility leads to more frequent price changes and a higher rate of pass-through.

Gagnon and Ihrig (2004) provides a validation of the Taylor hypothesis with a dataset of 20 industrialised economies between 1971 and 2003. The study reveals that ERPT into domestic inflation has declined in many of the countries since the 1980s. In addition, the study records widespread evidence of strong connection between estimated rates of pass-through and inflation variability.[4] Choudhri and Hakura (2006) re-visits the Taylor hypothesis and attempts to confirm its validity on a cross-section of 71 advanced and developing countries from 1979 to 2000. Their results show strong evidence of a positive and significant association between the average inflation rate and the exchange rate pass-through across the sample. In another study, Edwards (2006) estimates the ERPT for 7 IT economies (Australia, Brazil, Canada, Chile, Israel, Korea and Mexico) and finds evidence consistent with the Taylor hypothesis. The study reveals that the adoption of IT resulted in a decline in pass-through from exchange rate changes to inflation. Edwards (2006) also looks at some of the broader issues of importance like the upshots of IT on exchange rate volatility and the potential role of exchange rate changes on the monetary policy decisions/rule in IT countries. It reveals that IT as a monetary policy framework has not resulted in an increase in exchange rate volatility, whether real or nominal; and economies that have experienced phases of high and unstable inflation often tend to explicitly take into account developments in their nominal exchange rates while taking monetary policy decisions.

There is a general consensus in the available literature that IT as a monetary policy framework has helped to reduce ERPT not only in the AEs but also in the EMEs (Jasova, et al. 2016). In this regard, some of the recent literature like that of Baharumshah, et al. (2017) assess whether the adoption of an IT regime reduced the ERPT to inflation measured by the consumer price index (CPI) in the case of Mexico, and the results reveal that ERPT to CPI inflation is relatively higher (although incomplete) before IT, while lower (near but not zero) after the implementation of IT in early 2000. The study also states that changes in ERPT to inflation are closely associated with changes in monetary policy towards adoption of IT, possibly due to a boost in the credibility of the central bank after the adoption of an IT regime, a changing nature of the exchange rate movements, and a shift in the formation of inflation expectations as expectations tend to be better anchored under IT. Similar results are also obtained by another study done on a sample of 14 EMEs over the period 1994Q1-2015Q3 (López-Villavicencio and Mignon, 2017). WEO (October 2018) also states that inflation expectations when anchored better work towards lowering inflation persistence and limiting the degree of ERPT to domestic prices.

In another paper, Baharumshah, et al. (2017) with a sample of 6 Asian economies (Thailand, Indonesia, Japan, Philippines, China and South Korea) and using a Markov-switching model finds the prevalence of two regimes. During a regime with large and erratic variations in inflation, the extent of ERPT is higher in contrast to episodes of moderate inflation. Somewhat similar result is also shown by Goldfajn and Werlang (2000). According to this study, the initial level of inflation plays a key role in determining the degree of ERPT. Furthermore, the study also states that the cyclical component of output, the initial overvaluation of the real exchange rate and the degree of openness of the economy are the other major determinants of the extent of ERPT. Barhoumi (2006) also shows that countries that have witnessed high inflation experience higher long-run ERPT than countries that have lower inflation regimes. This study also points out that the extent of ERPT depends on the type of exchange rate framework that is in place (whether fixed or floating) and the trade barriers in the country.[5]

4. Also see Ihrig, et al. (2006); Brun-Aguerre, et al. (2012); and Shintani, et al. (2013).

5. Also see MacCarthy (2000).

A set of the literature also focuses on the asymmetric nature of ERPT, meaning the impact on prices is different during appreciations and depreciations. Delatte and López-Villavicencio (2012), using quarterly data from 1980Q1-2009Q3 for 4 major advanced economies (Japan, Germany, UK and US) provides evidence for exchange rate depreciations having a stronger impact on prices, suggesting weak competitive market structures. The study also indicates that such events could have crucial implications for the conduct of monetary policy.[6] In case of EMEs, Caselli and Roitman (2016) with a panel of 28 EMEs finds that the reaction of domestic prices to episodes of bigger depreciations is faster and more pronounced.

Turning to the Indian context, there are a handful of studies that look at the ERPT to domestic prices. A majority of the studies estimate the impact on inflation measured by the wholesale price index (WPI), which is often treated as a proxy for the producer price index (PPI) in the case of India in the absence of a PPI; there are a very few studies that have estimated the impact on CPI inflation. Table 1 summarises the results of these studies. Importantly, Khundrakpam (2007) studies the ERPT to domestic prices during the post-economic reforms period (specifically, 1991-2005) and finds no precise evidence of a decline in the ERPT to domestic prices. The study also finds signs of asymmetric behaviour in pass-through between phases of appreciation and depreciation and also between the magnitudes of exchange rate changes. Another study by Patra, et al. (2013) finds that ERPT to domestic inflation has declined in the post global financial crisis period as compared with the pre-crisis period (Table 1). One of the recent studies by Patra, et al. (2018), using a dynamic stochastic general equilibrium (DSGE) model calibrated for the Indian economy with open economy features, looks at non-linearities and time variations/time-varying effects in ERPT to consumer prices in India for the period April 2005 to March 2016 and finds ERPT to be asymmetric with pass-through from small depreciations to be the strongest. Moreover, the paper also states that ERPT to inflation has moderated in the recent years with an environment of low inflation and declining trade openness. With regards to imported inflation and policy transmission, the paper indicates that non-linear and time-varying ERPT could pose challenges for monetary policy.

6. Also see Kiliç (2016).

Table 1
Summary of Exchange Rate Pass-through Coefficients from Select Studies in the Indian Context[7]

Study	Time Period of Study	Price Index Used	Exchange Rate Pass-through Coefficient
Khundrakpam (2007)	August 1991 to March 2005	WPI	10% change in exchange rate increases final prices by 60 basis points (bps) in short-run and 90 bps in long-run.
Patra and Kapur (2010)	Q2:1996 to Q3:2009	WPI	10% appreciation (depreciation) of the INR *vis-à-vis* the US$ would lower (increase) inflation by 50 bps in the same quarter and by 150 bps after seven quarters.
Kapur (2012); Kapur and Behera (2012)	Q2:1996 to Q1:2011	WPI	10% appreciation (depreciation) of INR *vis-à-vis* the US$ decreases (increases) inflation by 60 bps in the same quarter, while the long-run ERPT is 120 bps.
Patra, et al. (2013)	Q2:1996 to Q1:2013	WPI	A 10% change in the exchange rate resulted in 1.5% change in prices prior to the global crisis and 1.0% change including post crisis period.
Ghosh and Rajan (2007)	Q1:1980 to Q4:2006	CPI	Exchange rate pass-through elasticity of the INR-US$ to CPI to be between 45% and 50% and quite stable over the period under consideration.
Bhattacharya, et al. (2008)	September 1997 to October 2007	CPI	1% increase in exchange rate causes increase in CPI by 0.10-0.11% in the short-run and 0.04-0.17% in the long-run.
Patra, et al. (2018)	April 2005 to March 2016	CPI-C	About 15% of exchange rate changes are cumulatively passed through to CPI inflation over a period of five months, with time varying parameter estimation increasing it to above 15% by 2013-14 and declining since then.

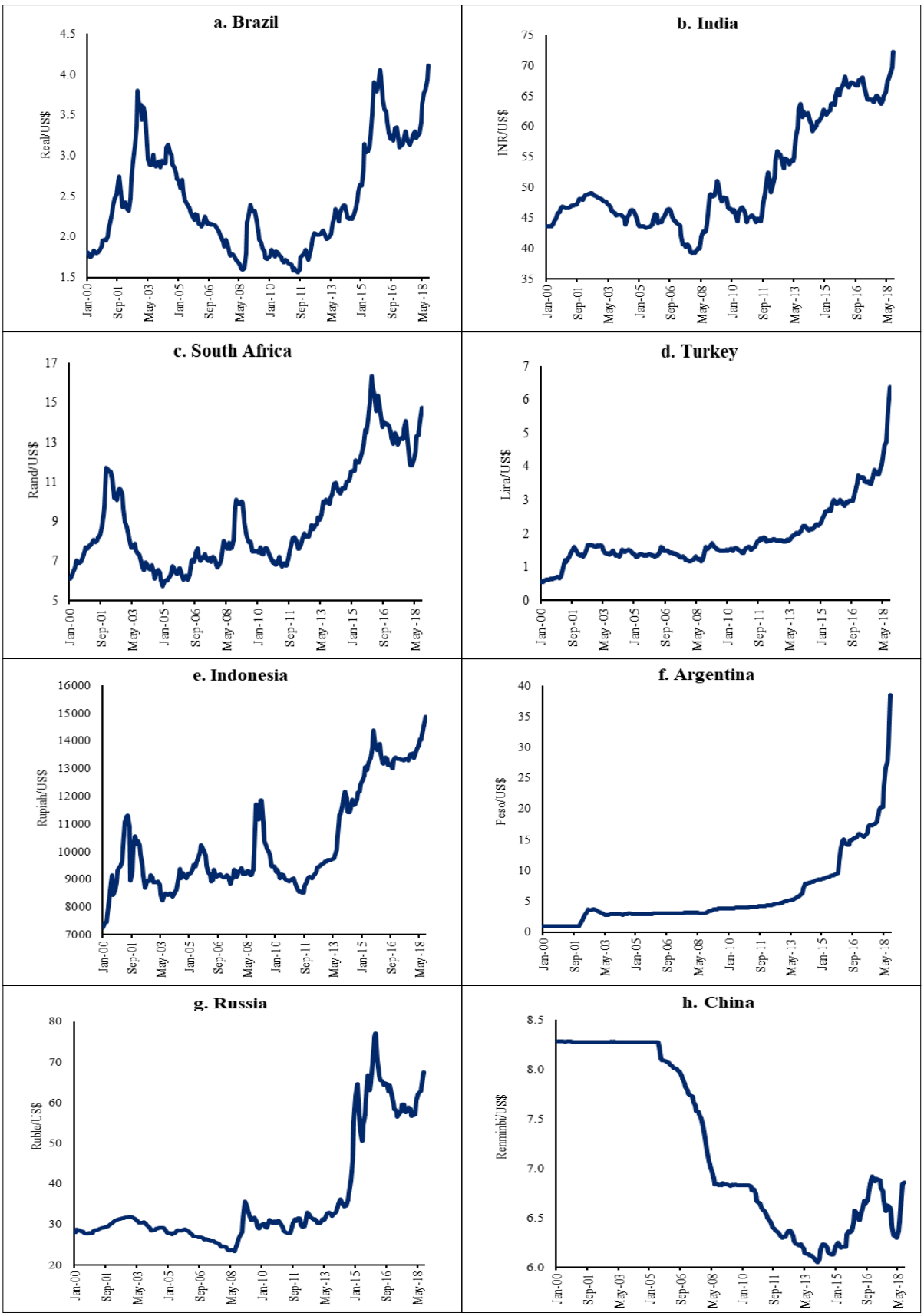
Source: Report of the Expert Committee to Revise and Strengthen the Monetary Policy Framework, Reserve Bank of India (RBI), 2014; and author's own findings.

3. Stylised Facts

Half-a-decade and more has passed since the 'taper tantrum'. In May 2013, Ben Bernanke, the former Chairman of the Federal Reserve, indicated the possibility of the Federal Reserve's plans to start rolling back the stimulus package of asset purchases, simply known as the programme of QE. Under QE, unprecedented actions were initiated by central banks and governments to restore normal functioning of the markets through various liquidity provision measures and to revive economic activity in the aftermath of the 2008 global financial crisis. Consequently, the announcement had an adverse impact on some of the leading emerging market economies – Brazil, India, South Africa, Turkey and Indonesia, later named as the 'Fragile Five'. These economies had witnessed significant currency depreciations and their financial markets were hit hard (Chart 1).

7. The studies based on CPI prior to 2018 have all used consumer price index - industrial workers (CPI-IW) as the measure of domestic inflation.

Chart 1
Exchange Rate Movements in Major EMEs



Source: CEIC database.

In order to address market volatility, these economies had used a range of policy measures including monetary, fiscal and macroprudential policies, capital flow management measures and interventions in the foreign exchange markets (Sahay, et al. 2014). The study also stated that EMEs like Brazil, India, Indonesia, Russia, South Africa and Turkey relied more on monetary policy to stabilise their economies. Countries that had begun their policy response as early as in May 2013 made faster progress in reducing their macroeconomic imbalances and showed more resilience (particularly, India and Indonesia in early 2014).

In the case of India, particularly, the Indian government and the RBI responded with measures to buffer up the foreign exchange reserves, restrict gold imports and tighten domestic liquidity in order to push up market interest rates in combination with monetary policy tightening. Along with the deterioration in the external accounts, a major drag on the economy during this time was inflation, which was already high and persistent in the post global financial crisis period. Following a drought in 2009 and global commodity price shock, inflation climbed up to double-digits and became generalised during this time, not to be reined by monetary policy tightening. It was at this juncture that the policymakers realised the need for a fundamental change in the monetary policy framework, which would restore the faith and credibility of the central bank. Subsequently, in January 2014, the RBI adopted a self-imposed target to bring down headline CPI inflation in a sequential manner – to 8% by end-2014, 6% by end-2015, and 5% by end-2016 – which was termed as the glide path for inflation (Patra, 2017).

Since then, the Indian economy has come a long way gaining a certain degree of macroeconomic stability, not only supported by domestic institutional developments but also with a considerable measure of good luck (the plunge in international commodity prices in 2014). The Indian economy recorded a modest improvement in terms of overall economic growth. From 6.4% growth in gross domestic product (GDP) during 2013-14 (the year of taper talks), GDP growth went up to 6.7% in 2017-18 with more than 7.0% growth during the years in between (Chart 2). Most importantly, the economy recorded remarkable achievements in the domestic inflation front. From average CPI headline inflation numbers of 10.0% in 2012-13 and 9.4% in 2013-14, the Indian economy witnessed a sharp deceleration in inflation to 5.8% in 2014-15.[8] In order to sustain the gains from disinflation, a flexible inflation targeting (FIT) monetary policy framework was formally adopted in May 2016, under which price stability has been mandated as the primary objective of monetary policy, while keeping in mind the objective of growth. Price stability has been defined in terms of a numerical inflation target (year-on-year change in the CPI-C series) set by the government at 4% with an upper tolerance level of 6% and a lower tolerance level of 2%. The disinflationary path endured all through the years, with inflation easing sequentially year after year to reach an average of 3.6% in 2017-18 (Chart 3).

8. Headline inflation is measured by the year-on-year changes in the all India CPI-C with base year 2012=100 released by the CSO. The back casted series is available from January 2011. Before the introduction and release of CPI-C by the CSO in February 2015, wholesale price index (WPI) was the only measure of prices available at a national level.

Chart 2
India's Real GDP Growth

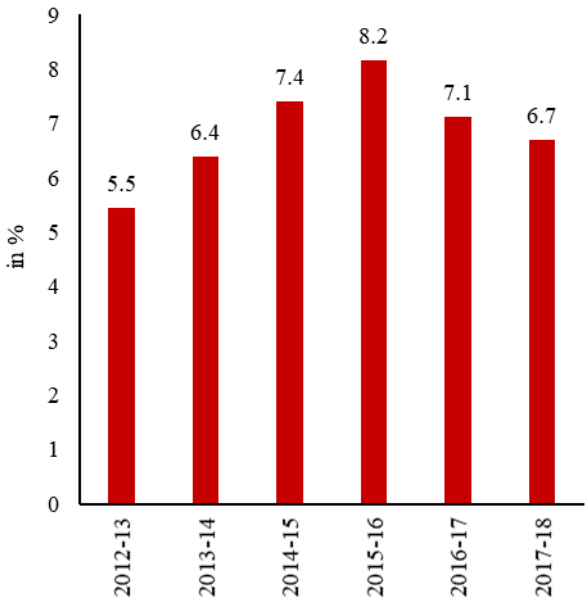
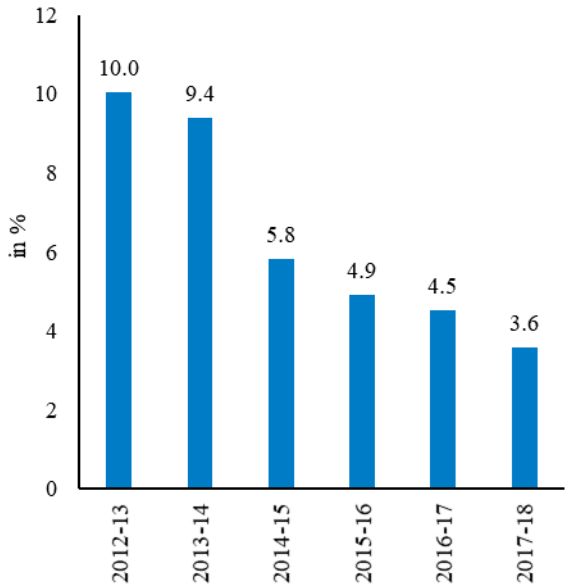


Chart 3
India's Inflation Scenario



Source: Central Statistics Office (CSO) under the Ministry of Statistics and Programme Implementation (MoSPI), Government of India (GoI); and author's own calculations.

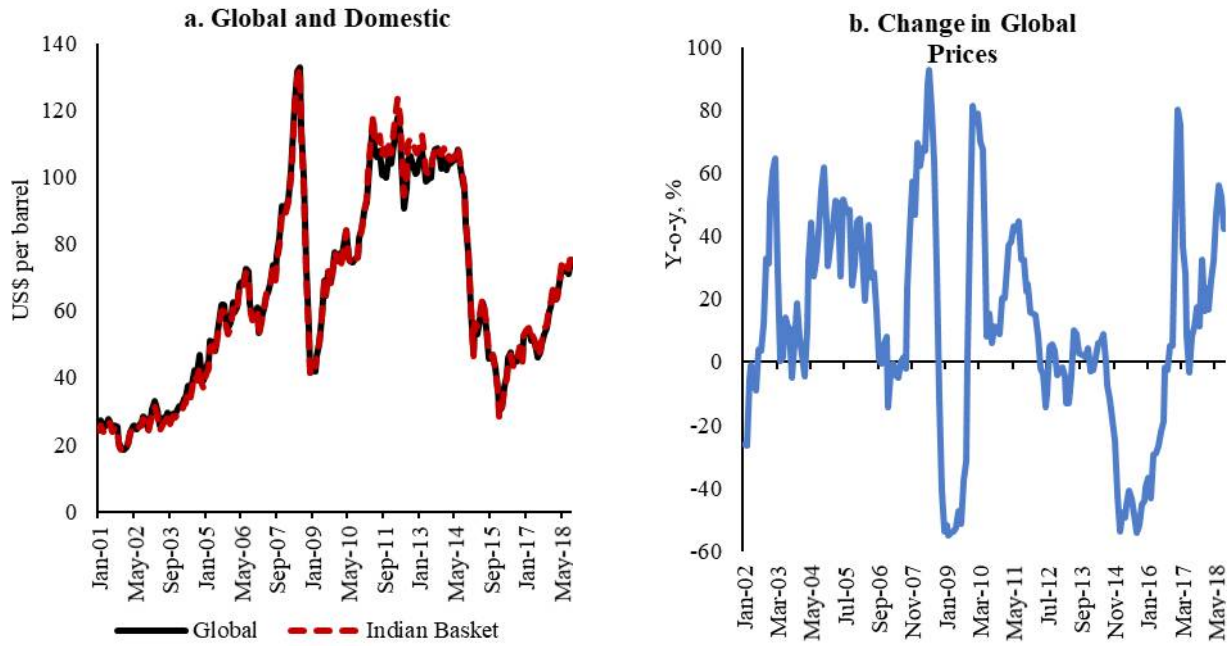
However, uncertain and volatile conditions reared up subsequently. While on the domestic front underlying growth impulses both in manufacturing and services sectors began deteriorating, inflation scenario was also beginning to get clouded by upside risks with the hardening of international prices of crude oil and metals. Globally, crude oil prices attained their recent trough in January 2016 (Chart 4a).[9] Since then, crude oil prices have generally been on a rising trend, with the price of the Indian basket crude oil clearly tracking the global oil price movements.[10] On an average, international oil prices have increased by 45% during April-October 2018-19, with the rate of increase in October 2018 at a high of 185% over its January 2016 level (Chart 4b). Despite comfortable food prices during 2018-19, which have continued to keep overall inflation at moderate levels, it seems that the disinflationary trend, which the economy has experienced during the past 5 years, could be disturbed during 2018-19 (Appendix Table 1).[11]

9. Globally, average crude oil price in January 2016 was US$ 29.78 per barrel.

10. The Indian basket of crude oil represents a derived basket comprising of Sour grade (Oman and Dubai average) and Sweet grade (Brent Dated) of crude oil processed in Indian refineries in the ratio of 74.77:25.23 during 2017-18.

11. Headline CPI inflation, on an average, has remained at 4.3% during April-September 2018.

Chart 4
Crude Oil Price Movements

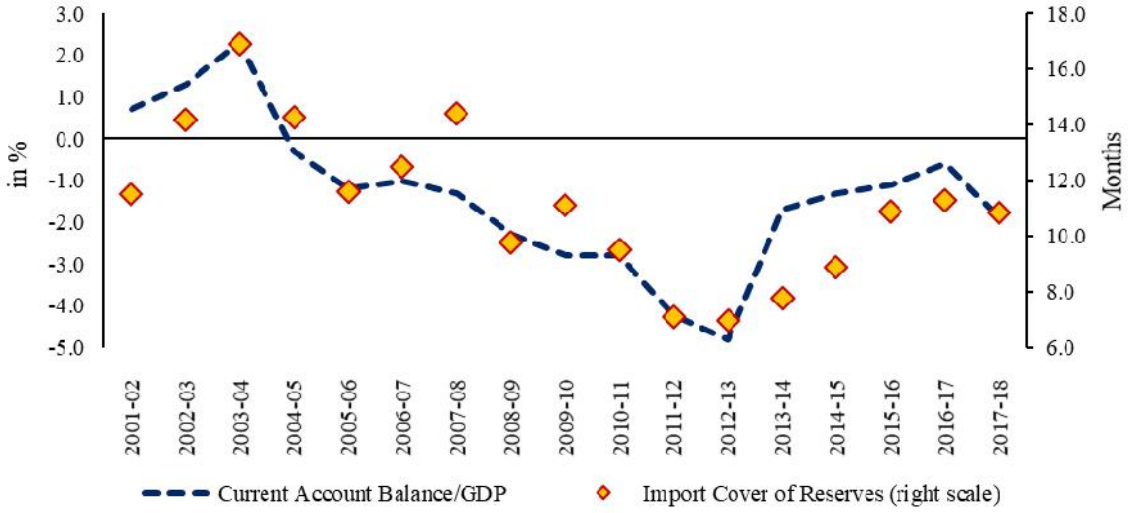


Source: World Bank Pink Sheet Database, Petroleum Planning and Analysis Cell, GoI; and author's own calculations.

Further, transitory impediments that came along with the implementation of the Goods and Services Tax (GST) in July 2017 also posed some disruptions in the economic activities. These events occurred in confluence with global geopolitical tensions and monetary tightening. Signals of uncertainty gained further momentum in 2018-19. The US Federal Reserve hiked the Federal Funds Rate thrice during 2018, which was virtually kept at 0% post the global financial crisis of 2008 in order to stimulate economic activity, with the first rate-hike done in December 2015. Consequently, the Indian economy witnessed a flight of foreign capital from the markets, thus, causing a dollar shortage and a depreciating INR *vis-à-vis* US$. Additionally, the European Central Bank (ECB) has also echoed its intention to rewind large-scale asset purchases under the QE programme. Along with these events, trade wars and imposition of tariffs between US and some of the EMEs, like Turkey and China, set forth heightened volatility across the global financial markets with a host of EME currencies facing intense pressures of depreciation at varying degrees (Chart 1).

As compared to the situation back in 2013, the Indian economy seems to be on a comfortable position though, in terms of external sector indicators. The current account deficit, as a percentage of GDP, is presently much lower as compared with 2012-13 and 2013-14 (Chart 5). Moreover, the import cover of reserves also seems to be benign at present.

Chart 5
External Sector Indicators



Source: Database on Indian Economy, RBI.

Nonetheless, a depreciating currency in conjunction with soaring global oil prices is something that is of major concern for the Indian economy in spite of a healthy macroeconomic environment. The INR has depreciated *vis-à-vis* US$ for 8 months in a row since February 2018 (Chart 6). In September 2018, the depreciation was to the extent of 14% over January 2018. Therefore, both the events together could pose major upside risks to domestic inflation. Despite the literature suggesting that with the adoption of IT the extent of ERPT has been declining across economies, the current phase of sharp depreciation of the INR has renewed concerns of the monetary policymakers as well as researchers about its impact on domestic inflation in India. Further, the stylised facts over the past 5-6 years clearly indicate that inflation has traversed through different phases (both high and low) accompanied by varied extents of exchange rate fluctuations. If we consider data that approximately cover the past two decades, we find two distinct phases of inflation – moderate and high – characterised by unavoidable and vivid exchange rate dynamics (Chart 7).

Chart 6
Exchange Rate (INR/US$)

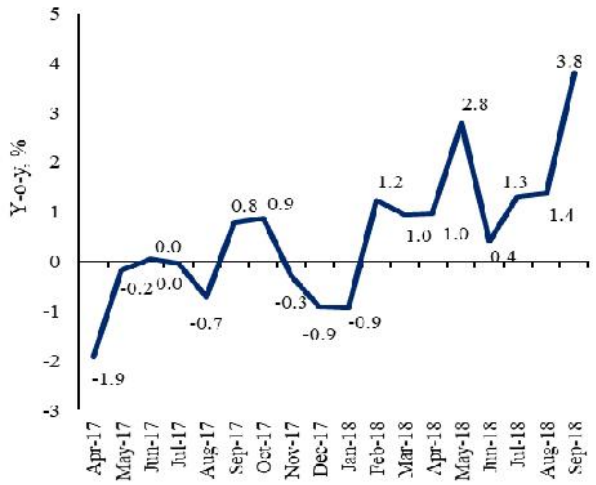
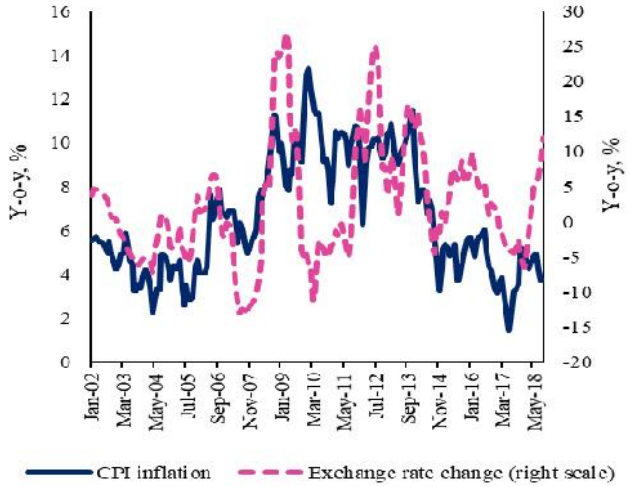


Chart 7
Movements in Inflation and Exchange Rate (INR/US$) in India



Source: Database on Indian Economy, RBI, MoSPI; and author's own calculations.

Therefore, in this regard, this paper attempts to re-examine the extent of ERPT on headline inflation during the previous two decades using CPI-C as the measure of domestic consumer prices. Using CPI-C becomes important not only because there is a dearth of literature on ERPT based on CPI-C (CPI-C being the new all India CPI series) but also because of the fact that under the FIT framework, headline inflation based on CPI-C is the nominal anchor for IT. In the backdrop of the previous two decades characterised by major global events like the global financial crisis during 2007-08, followed by QE and subsequent taper tantrum; upturn and downturn of the global commodity price cycles, a major decline in domestic food inflation (due to cyclical, irregular and various policy-related supply management measures by the government[12]) and changes in the monetary policy framework in India, the paper attempts to answer the question that whether factors like global demand conditions, foreign costs, domestic food price shocks, input price conditions and trade situation played any role in explaining inflation dynamics during this time. Further, the paper asks the question that whether the extent of ERPT has varied over time? In order to look at the time-varying nature of ERPT the study uses the rolling regression method with a recursive window of 3 years. Further, taking into account the fact that inflation during these years has gone through high and low phases characterised by considerable differences in inflation volatility, the paper then tries to model ERPT to inflation in a simplified regime-switching framework.[13]

4. Methodology and Framework of the Model

The transmission mechanism of the pass-through of exchange rate changes into domestic prices generally happens in two stages (Bhattacharya, et al. 2008). In the first stage, a depreciation of exchange rate increases prices of imported consumption and intermediate goods. (Not to forget, crude oil forms a major part of India's import basket. Around 80% of the domestic demand for petroleum products is met through the imports of petroleum and the petroleum oil lubricants products.) However, the effect is not limited to import prices only. In the second stage of pass-through, depreciation impacts prices of domestically produced goods through supply and demand channels. The rise in intermediate goods prices increases costs of production and hence, prices of domestically produced goods. On the other hand, because of the rise in import prices, demand shifts to domestically produced goods, leading to further increase in domestic prices. Therefore, the former effect is called the first-stage pass-through, while the latter is often referred to as the second-stage pass-through in the literature.[14] Simply stated, a unit change in exchange rate can cause import prices to change in the first-stage, which impacts producer prices and therefore, causes a trickle-down impact on consumer prices in the second-stage.

12. See Monetary Policy Report (April 2018, October 2018) and Annual Report, 2017-18, RBI.
13. In the backdrop of the taper tantrum of 2013, the literature has associated higher exchange rate volatility with higher ERPT and higher inflation variability (Cheikh and Rault 2015; Jasova et al. 2016). Moreover, some of the recent studies put forward strong evidences indicating that non-linear ERPT cannot be neglected and that factors like the phase of the economic cycle, changes in the monetary policy framework, pricing mechanisms, market structure and the composition of the import basket play a crucial role in determining the extent of ERPT to inflation. In this context, the recent study by Patra et al. (2018), mentioned earlier, with regard to the Indian case becomes noteworthy, more so because this was probably the first attempt to analyse the ERPT in India using the new CPI-C series. Not only that, using a time varying parameter-vector autoregression (TVP-VAR) model the paper documented the non-linear nature of ERPT and indicated its implications and significance in the conduct of monetary policy.
14. For example, in the case of India, since domestic petrol and diesel prices are deregulated, they are not only impacted by the changes in global crude oil prices, but also fluctuations in the exchange rate are easily transmitted to the domestic fuel prices. Consequently, a rise in prices of petrol and diesel, which are a part of the CPI basket, cause an increase in transport fares, which are again captured in the CPI.

As proposed by Campa and Goldberg (2005), a partial equilibrium approach for empirical estimation of the first-stage pass-through based on a micro-founded mark-up equation has developed to be one of the starting points in the literature on ERPT. More recently, there have been major efforts that have generalised and extended the standard model (Aron, et al. 2014). Following Aron, et al. (2014), the reduced form of the set of equations that determine the first-stage ERPT is generally written as follows:

$$p_t^m = a_0 + a_1 e_t + a_2 c_t^f + a_3 p_t^c + a_4 y_t^f + a_5 c_t^d + a_6 y_t^d + \varepsilon_t \qquad \dots (1)$$

where, p^m is the import price; e is the exchange rate (foreign currency per unit of domestic currency); c^f and c^d are the costs in the exporting country and the importing country, respectively; p^c refers to the international commodity prices which affect the marginal cost of the exporter; y^f and y^d represents demand conditions in the exporting and the importing country, respectively; ε is the error term; and *t* denotes time. Note that c^f and c^d feed into the mark-ups of the exporter's price in the exporting country and the producer's price in the importing country, respectively.[15]

In the stage-two of the ERPT, producer prices in the importing country can be expressed as the function of import prices. Further, the consumer prices in the importing country are a function of producer prices, which are in turn a function of import prices. Therefore, Equation 1 further reduces down to:

$$p_t^d = b_0 + b_1 e_t + b_2 c_t^f + b_3 p_t^c + b_4 y_t^f + b_5 c_t^d + b_6 y_t^d + \varepsilon_t \qquad \dots (2)$$

where, p^d is the domestic consumer price in the importing country, and b_1 is the coefficient denoting the ERPT.

Therefore, taking a cue from Patra, et al. (2018) and an earlier study by Khundrakpam (2007), this paper re-validates the extent of ERPT in the Indian context. The base model used for the analysis is as represented by Equation 2. The first stage of the analysis would be to portray the short-run dynamics of ERPT using lagged terms of the explanatory variables under the assumption of a gradual adjustment of domestic prices to fluctuations in exchange rate and other control variables. Further, as food price dynamics is a major driver of domestic inflation in India, an explanatory variable on food price shock is incorporated in the model.[16] Therefore, the benchmark model for the analysis becomes:[17]

$$\Delta p_t^d = b_0 + \sum_{i=0}^{n1} b_{1i} \Delta e_{t-i} + \sum_{i=0}^{n2} b_{2i} \Delta c_{t-i}^f + \sum_{i=0}^{n3} b_{3i} \Delta p_{t-i}^c + \sum_{i=0}^{n4} b_{4i} \Delta y_{t-i}^f + \sum_{i=0}^{n5} b_{5i} \Delta c_{t-i}^d$$
$$+ \sum_{i=0}^{n6} b_{6i} \Delta y_{t-i}^d + \sum_{i=0}^{n7} b_{7i} Foodpriceshock_{t-i} + \varepsilon_t \qquad \dots (3)$$

where, Δ represents the difference operator; n^i indicates the number of lags for each of the variables; and $\sum_{i=0}^{n1} b_{1i}$ is the ERPT coefficient.

15. See Aron, et al. (2014) and Patra, et al. (2018) for a detailed derivation of Equation (1).
16. The food group has a weight of 45.86% in the all India CPI-C.
17. Following Patra, et al. (2018), food price shock is defined as the excess of current food price inflation over headline inflation three months before. This represents the spillover of the excessive food price inflation to generalised inflation.

While the above-mentioned benchmark model is a useful way to study the extent of ERPT, some of the studies in the available literature have stated that there could be issues related to misspecification, as such a model does not take into account the possibility of long-run co-integrating relationships between the variables (Delatte and López-Villavicencio, 2012; Aron, et al. 2014).

The widely used approaches for checking the existence of long-run relationship between any two time series variables are Engle-Granger, Johansen and auto-regressive distributed lags (ARDL) model, provided the variables are non-stationary.[18] Therefore, in order to check for the existence of long-run relationships between the variables, first, unit root tests are carried out followed by the use of the three approaches. Having done that, the error correction term (ECM) obtained from the long-run relationship is incorporated in Equation 3 to avoid errors due to model misspecification. The lag of the ECM term is kept to be one higher than the maximum number of lags used for the exchange rate term. This is done to avoid any dynamic interaction of the exchange rate term with the ECM term. Therefore, Equation 3 augmented with the ECM term is as given below:

$$\Delta p_t^d = b_0 + \sum_{i=0}^{n1} b_{1i}\Delta e_{t-i} + \sum_{i=0}^{n2} b_{2i}\,\Delta c_{t-i}^{f}{}_{2} + \sum_{i=0}^{n3} b_{3i}\Delta p_{t-i}^{c} + \sum_{i=0}^{n4} b_{4i}\Delta y_{t-i}^{f} + \sum_{i=0}^{n5} b_{5i}\Delta c_{t-i}^{d} + \sum_{i=0}^{n6} b_{6i}\Delta y_{t-i}^{d} + \sum_{i=0}^{n7} b_{7i}\,Foodpriceshock_{t-i} + b_8 ECM_{t-n1-1} + \varepsilon_t \qquad \ldots(4)$$

So far, the specified models indicate ERPT in a linear framework, that is whether the fluctuations in the exchange rate (appreciation or depreciation) have any impact on domestic prices, and, if so, what is the extent of the impact. The models do not tell anything about whether there exists any asymmetric or non-linear impact of the ERPT. In order to find that out, following the earlier studies, we introduce a non-linear functional form in the benchmark models. In other words, we incorporate quadratic and cubic exchange rate terms in Equations 3 and 4. Therefore, the non-linear model is as follows:

$$\Delta p_t^d = b_0 + \sum_{i=0}^{n1} b_{1i}\Delta e_{t-i} + \sum_{i=0}^{n2} b_{2i}\,\Delta c_{t-i}^{f}{}_{2} + \sum_{i=0}^{n3} b_{3i}\Delta p_{t-i}^{c} + \sum_{i=0}^{n4} b_{4i}\Delta y_{t-i}^{f} + \sum_{i=0}^{n5} b_{5i}\Delta c_{t-i}^{d} + \sum_{i=0}^{n6} b_{6i}\Delta y_{t-i}^{d} + \sum_{i=0}^{n7} b_{7i}\,Foodpriceshock_{t-i} + b_8 ECM_{t-n1-1} + \sum_{i=0}^{n8} b_{9i}\Delta e^{2}{}_{t-i} + \sum_{i=0}^{n9} b_{10i}\Delta e^{3}{}_{t-i} + \varepsilon_t \qquad \ldots(5)$$

Therefore, the exchange rate coefficients represented by $\sum_{i=0}^{n8} b_{9i}$ and $\sum_{i=0}^{n9} b_{10i}$ in Equation 5 indicate the presence of non-linearity, in case they are statistically significant. The signs of these two coefficients will indicate whether or not non-linearity differs between appreciations and depreciations. Since the exchange rate is in the form of foreign currency per unit of domestic

18. The ARDL approach is considered to be superior if the variables are not integrated of the same order.

currency, an increase/decrease in the exchange rate implies appreciation/depreciation. Moreover, as inflation should increase with depreciation and decline with appreciation, the sign of the linear ERPT is expected to be negative. In case when the coefficient of the quadratic term is positive, it would amplify the linear term and make depreciations more inflationary, *i.e*. ERPT is higher in case of depreciation. However, if the coefficient of the cubic term is also positive, it would imply that ERPT associated with higher changes in the exchange rate is lower than with lower exchange rate changes (because there would be an offsetting impact of the coefficients on inflation).

In the literature, a second approach using some threshold value of exchange rate change is also used to study the non-linearity and asymmetric impact of the ERPT.[19] However, in this paper we do not go further in analysing the asymmetric impact of ERPT on domestic prices. Instead, we try to see whether ERPT has differed across time and across different phases of inflation characterised by regime-specific mean inflation and volatility. In order to study the time-varying nature of ERPT, we use the standard form of a two-state fixed transition probability Markov-switching regression model. The pioneering work using this framework was done by Hamilton (1989) and later discussed by Kim and Nelson (1999) (cited in, among others, Baharumshah, et al. 2017, and Marodin and Portugal, 2018). An interesting feature of this model is that it allows for the intercept term (which is indicative of the mean inflation) and the error variance to switch between regimes (implying a heteroscedastic error term).

The theoretical underpinning of the regime-switching models lies in the general behaviour of the various macroeconomic time series indicators. Over reasonable time span, macroeconomic variables tend to undergo changes, which may be in the form of a structural break that is generally due to a permanent change in the economy's structure or changes that are temporary in nature and are recurrent. Therefore, the behaviour of the time series can vary across different regimes. This is where constant parameter time series models fail to correctly model economic developments.[20] In the context of ERPT, some of the popular approaches used in the literature to analyse the time-varying nature of ERPT and regime-changes are by splitting the sample period or by using the method of rolling regression (Choudhri and Hakura, 2006; Gagnon & Ihrig, 2004; Reyes, 2007; and Sekine, 2006, among others). However, the demerit of such approaches is that in general they do not provide the specific time period of the change in the regime or the change in the exchange rate parameter. In contrast, in a Markov-switching regression model, the exact timing of the regime change can be identified, along with the transition probabilities between regimes. In case when the regimes are non-recurrent, the Markov-switching regression model can identify structural breaks in the series.

There are a handful of studies some of which have modeled exchange rate dynamics using the Markov-switching regression framework (Goutte and Zou, 2012; Mendy and Widodo, 2018); and there are some studies that have modeled ERPT to domestic prices using the same (Khemiri and Ali, 2012; Baharumshah, et al., 2017; Baharumshah and Soon, 2017; and Marodin and Portugal, 2018). In the Indian context, it would be interesting to see how the ERPT has evolved during different inflation regimes and what has been the duration of such regimes along with the transition probabilities between them. Further, in the context of the recent phase of currency depreciation, it would be interesting to see whether the framework indicates any turning point in the inflation dynamics due to such an event and whether the transition probability is significant (closer to 1).

19. See Pollard and Coughlin (2003); Khundrakpam (2007); and Patra, et al. (2018) for such an analysis.

20. See Piger (2007) for a detailed review of the regime-switching models.

The representation of such a model can be as follows:

Suppose that the probability of a variable S_t assuming some particular value j, depending only on the previous value S_{t-1}, is given by the following equation:

$$P\{s_t = i | s_{t-1} = j, s_{t-2} = k, \dots\} = P\{s_t = i | s_{t-1} = j\} = P_{ij} \qquad \dots (6)$$

The process represented by Equation 6 is described as a Markov chain with M-states where P_{ij} is the probability of the state i given state j. For the purpose of simplification, if we consider two regimes, then the probability of transition to the next regime relies only on the current regime. Thus, the regime changes are assumed to be the outcome of an unobserved, discrete, random variable, called the state variable, which is further assumed to follow a Markov process. In the current framework of the paper, we model inflation to follow two regimes (high and low), keeping in mind the historical trends of domestic inflation in India. Moreover, it is a commonly applied technique in the literature to model the dynamics of a macroeconomic variable into two regimes where switches between them are based on a probabilistic process (Piger, 2007; Khemiri and Ali, 2012).

5. Data and Results

5.1 Linear ERPT

In order to re-estimate the extent of linear ERPT on domestic consumer prices, the paper uses data covering the period from April 2004 to September 2018. The model estimation framework is as specified in Section 4 of the paper. The study uses domestic consumer prices p^d as measured by the CPI-C published by the CSO under the MoSPI, GoI. The exchange rate (e) is represented by the 36-country nominal effective exchange rate (NEER) series (based on trade-based weights) published by the RBI. The indicator of foreign price/cost conditions has been constructed as: c^f = NEER*CPI-C/REER, where REER is the RBI's 36-country real effective exchange rate (REER). Domestic demand y^d is proxied by the CSO's quarterly real GDP series.[21] In order to incorporate domestic costs (c^d) in to the model, both industrial input costs based on wholesale price index (WPI) which is published by the Office of the Economic Advisor, Ministry of Commerce and Industry, GoI, and Markit's manufacturing input cost indicator based on the purchasing managers' index (PMI) were used interchangeably.[22] In order to incorporate foreign demand conditions (y^f) in to our model, index of industrial production (IIP) of the OECD countries available from the OECD statistics has been used. International commodity prices (p^c) have been proxied by the global average crude oil prices available from the World Bank Pink Sheet database. As indicated earlier, the variable on food price shock has been constructed as the difference in food inflation at time period t over headline inflation three months before.

21. Using the Denton method on the seasonally adjusted index of industrial production (IIP) of the CSO (taking average IIP as the indicator), the quarterly real GDP series at market prices was converted to a monthly series. However, the variable when used in the regression models turned out to be statistically insignificant throughout and therefore, were dropped from the estimation. This is in contrast to the results obtained by Patra, et al. (2018). However, for similar results pertaining to this study, see Mihaljek and Klau (2008), and Baharumshah and Soon (2017).

22. However, none of these variables turned out to be statistically significant in the regression models and therefore, were dropped.

Variables were converted into their natural logarithms and were seasonally adjusted by the US Census Bureau X-13 ARIMA programme. The lag selection in the overall model has been done by re-running the model more than a time while testing for the statistical significance of the variables and at the same time checking through the Schwarz Criterion (SC), Akaike Information Criterion (AIC), and the Hannan-Quinn Criterion (HQC). However, the numbers across the three criteria showed very less variations. Two models were considered; one, where the summation of the exchange rate coefficients go up to the fourth lag and two, where the summation of the exchange rate coefficients go up to the twelfth lag (to denote a year). In case of the variables representing global demand conditions and foreign cost conditions, lag length beyond 1 were found to be statistically insignificant and hence, were not considered in the model estimation. All the variables, except food price shock, are stationary at first differences (Appendix Table 2).

Tables 2 and 3 given below present the estimate of ERPT based on the benchmark model (represented by Equations 3 and 4). The results show that foreign costs, global demand conditions and food price shock are statistically significant determinants explaining the changes in domestic consumer prices in India. The results also indicate that the ERPT accumulated over the duration of four months is 0.09 (same across all model specifications), *i.e*. about 10% of the changes in the exchange rate are cumulatively passed through to the changes in CPI-C, while over a duration of 12 months the cumulative pass-through is around 20%.

Table 2
Average ERPT Estimates – Specification 1
Dependent Variable D(log(CPI-C))

Variables	Benchmark (1)	Engle-Granger (2)	Johansen[23] (3)	ARDL[24] (4)
Constant	0.003*** (4.12)	0.003*** (3.91)	0.003*** (4.08)	0.0001 (0.13)
$\sum_{i=0}^{-4} e_i$	-0.09** (-2.42)	-0.09*** (-2.62)	-0.09** (-2.44)	-0.09** (-2.41)
$\sum_{i=0}^{-1} C_i^f$	0.67** (2.37)	0.67** (2.32)	0.69** (2.44)	0.72*** (2.66)
$\sum_{i=0}^{-1} iipoecd_i$	0.10 (1.39)	0.25*** (2.75)	0.18** (2.55)	0.16** (2.15)
Food shock[25]	0.0005*** (4.31)	0.0005*** (4.55)	0.0005*** (4.75)	0.0005*** (4.63)
ECM(-5)	-	-0.07*** (-4.23)	-0.06*** (-4.33)	-0.06*** (-4.39)
Adj. R^2	0.21	0.28	0.30	0.31
DW Statistic	1.68	1.84	1.91	1.96
F Statistic	12.49*** [0.000]	14.23*** [0.000]	15.04*** [0.000]	16.23*** [0.000]
Breusch Godfrey LM Test[26]	Prob [$chi^2(4)$]=0.02	Prob [$chi^2(5)$]=0.01	Prob [$chi^2(5)$]=0.00	Prob [$chi^2(5)$]=0.00
Breusch Pagan Godfrey Test[27]	Prob [$chi^2(4)$]=0.02	Prob [$chi^2(5)$]=0.06	Prob [$chi^2(5)$]=0.00	Prob [$chi^2(5)$]=0.00
No. of observations	169	169	168	169

Note: ***, **, and * indicate 1%, 5% and 10% levels of significance, respectively. Figures in ( ) indicate t-statistics and figures in [ ] indicate P-values.

23. Johansen Approach is preferable when all the variables are integrated of order 1, *i.e.* I(1).
24. ARDL approach gives better results when variables are of different orders like I(0) and I(1). ARDL approach indicates that CPI is determined by the other three variables in the long run.
25. Food shock was not included while checking for the long-run relationship.
26. Null Hypothesis: Absence of serial correlation.
27. Null Hypothesis: Absence of heteroscedasticity.

Table 3
Average ERPT Estimates – Specification 2
Dependent Variable D(log(CPI-C))

Variables	Benchmark (1)	Engle-Granger (2)	Johansen (3)	ARDL (4)
Constant	0.003*** (3.72)	0.004*** (3.74)	0.003*** (4.21)	0.0003 (0.25)
$\sum_{i=0}^{-12} e_i$	-0.20*** (-3.80)	-0.21*** (-4.09)	-0.18*** (-3.62)	-0.20*** (-3.73)
$\sum_{i=0}^{-1} C_i^f$	0.77*** (2.79)	0.72** (2.47)	0.69** (2.55)	0.77*** (2.96)
$\sum_{i=0}^{-1} iipoecd_i$	0.13* (1.69)	0.12* (1.67)	0.08 (1.17)	0.07 (-0.95)
Food shock	0.0005*** (4.33)	0.0005*** (4.78)	0.0005*** (5.18)	0.0005*** (5.09)
ECM(-13)	-	-0.06*** (-3.51)	-0.05*** (-3.26)	-0.05*** (-3.96)
Adj. R^2	0.25	0.32	0.31	0.33
DW Statistic	1.71	1.88	1.94	1.92
F Statistic	14.58*** [0.000]	15.89*** [0.000]	14.97*** [0.000]	16.59*** [0.000]
Breusch Godfrey LM Test	Prob [$chi^2(5)$]=0.02	Prob [$chi^2(5)$]=0.00	Prob [$chi^2(5)$]=0.00	Prob [$chi^2(5)$]=0.00
Breusch Pagan Godfrey Test	Prob [$chi^2(5)$]=0.00	Prob [$chi^2(5)$]=0.00	Prob [$chi^2(5)$]=0.00	Prob [$chi^2(7)$]=0.01
No. of observations	161	161	160	161

Note: ***, **, and * indicate 1%, 5% and 10% levels of significance, respectively. Figures in ( ) indicate t-statistics and figures in [ ] indicate P-values.

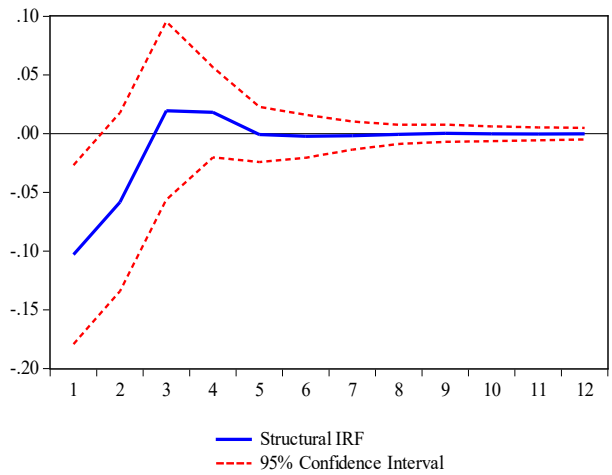
Co-integration tests using the three approaches, *viz.* Engle-Granger, Johansen and ARDL model were conducted in order to find out whether there exists any long-run relationship between the variables. Indeed, it was found that co-integrating relationships are present between CPI, global demand conditions and foreign costs (Appendix Table 3). Therefore, in order to avoid model misspecification errors, the benchmark model is augmented with the ECM terms obtained from the three alternative methods of co-integration. The results presented in Tables 2 and 3 show that the coefficients of the ECM term are statistically significant in all the specifications with the desired negative sign. Also, we do not find any evidence of a major improvement in the model specification as per the model robustness indicators, although there is a marginal improvement in the model fit (as indicated by the Adjusted R-Square values). Nonetheless, foreign costs, global demand conditions and food price shock continue to appear statistically significant determinants of changes in CPI and the ERPT coefficient witnesses a rise in the 12-month horizon.

A major drawback of the single equation linear ERPT estimates is that the model specification does not take into account the dynamic adjustment of prices and the exogeneity of the exchange rate fluctuations. Therefore, following Patra, et al. (2018), this study uses a simplified framework of a three-variable structural vector auto regression (SVAR) model to validate the linear estimates of ERPT. While in the linear regression models, domestic demand condition was not found to be statistically significant, which is not on the expected lines, in this framework, we consider it as the exogenous variable with the assumption that domestic output growth does not respond immediately to changes in exchange rate and consumer prices. In addition, it is also assumed that output growth and exchange rate movements impact prices contemporaneously. Therefore, based on these assumptions, the ordering of the variables in the SVAR model is: $\{\Delta y_d^t, \Delta e_t, \Delta p_d^t\}$ and the assumptions are applied to the structural identification of the model. The model was also augmented with a monetary policy variable, proxied by the weighted average call money rate (WACMR) with the assumption that domestic output growth and movements in exchange rate and consumer prices impact WACMR *via* the monetary policy decision, thereby representing the SVAR variables ordering as follows: $\{\Delta y_d^t, \Delta e_t, \Delta p_d^t, wacmr\}$. However, the results obtained from the 2 model specifications did not differ. Therefore, here we present the results from the second SVAR model.

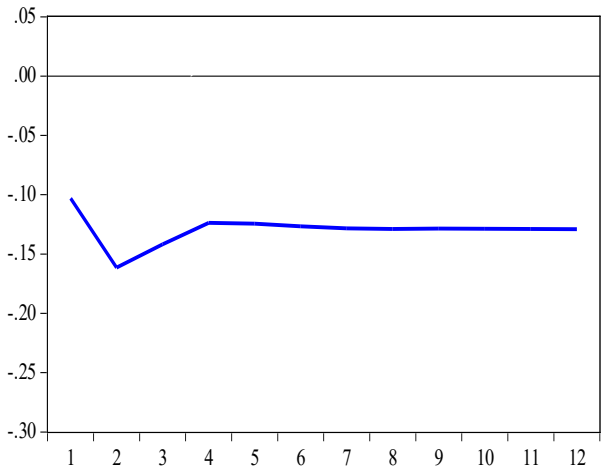
The results of the model are presented in Chart 8. The graphs indicate that the structural impulse response function of a ± 2 standard error shock in exchange rate is statistically significant during the first 3 months. The accumulated responses turn out to be around 16% during the first two months and then reduce to around 13% at the end of the 12 months horizon. The estimates are more or less in line with the linear ERPT estimates. In order to check the SVAR model robustness, the Lagrange Multiplier (LM) test for serial correlation was conducted and it turned out to be satisfactory (Appendix Table 4). Further, the inverse roots of the AR characteristic polynomial remained within the unit circle, thus, confirming the stability condition of the model (Appendix Chart 1).

Chart 8
Results of the SVAR Model – Impulse Response Functions of CPI-C from a ± 2 Standard Error Shock on Exchange Rate

Structural Impulse Response Function



Accumulated Impulse Response Function



5.2 Non-Linear and Asymmetric ERPT

In order to estimate the non-linearity in ERPT, quadratic and cubic exchange rate terms are introduced in the model as per the specification given in Equation 5. The results are presented in Tables 4 and 5 below. Only the coefficients associated with the quadratic terms are found to be statistically significant in all the models. Also, across models the coefficients of the quadratic term have a positive sign. Again, we do not find any major improvement in the robustness of the models. Since the coefficient of the quadratic term is positive, it implies that it would amplify the linear term and make depreciations more inflationary, *i.e.* ERPT is higher in case of depreciation. While the coefficients of the cubic terms are positive and much higher in magnitude across the four alternative model specifications, they do not turn out to be statistically significant. The accumulated ERPT over a duration of four months is around 8% and that for 12 months is around 17%, which is in line with the earlier linear model specifications.

Table 4
Non-Linear Estimates of Average ERPT – Specification 1
Dependent Variable D(log(CPI-C))

Variables	Benchmark (1)	Engle-Granger (2)	Johansen (3)	ARDL (4)
Constant	0.003*** (3.25)	0.003*** (3.24)	0.003*** (3.33)	0.000 (-0.09)
$\sum_{i=0}^{-4} e_i$	-0.07* (-1.76)	-0.08** (-2.04)	-0.08* (-1.88)	-0.08* (-1.87)
e^2	3.17** (2.52)	2.31* (1.76)	2.67** (2.17)	2.43** (2.06)
e^3	38.82 (1.19)	31.51 (0.95)	36.38 (1.14)	33.21 (1.09)
$\sum_{i=0}^{-1} C_i^f$	0.66** (2.33)	0.67** (2.30)	0.68** (2.41)	0.71*** (2.62)
$\sum_{i=0}^{-1} iipoecd_i$	0.12 (1.57)	0.25*** (2.69)	0.20*** (2.66)	0.18** (2.25)
Food shock	0.0005*** (4.27)	0.0004*** (4.53)	0.0005*** (4.75)	0.0005*** (4.62)
ECM(-5)	-	-0.06*** (-3.77)	-0.06*** (-4.05)	-0.05*** (-4.04)
Adj. R^2	0.23	0.29	0.30	0.32
DW Statistic	1.72	1.85	1.93	1.94
F Statistic	9.40*** [0.000]	10.63*** [0.000]	11.45*** [0.000]	12.17*** [0.000]
Breusch Godfrey LM Test	Prob [$chi^2(6)$]=0.00	Prob [$chi^2(7)$]=0.00	Prob [$chi^2(7)$]=0.00	Prob [$chi^2(7)$]=0.00
Breusch Pagan Godfrey Test	Prob [$chi^2(6)$]=0.00	Prob [$chi^2(7)$]=0.02	Prob [$chi^2(7)$]=0.00	Prob [$chi^2(7)$]=0.00
No. of observations	169	169	168	169

Note: ***, **, and * indicate 1%, 5% and 10% levels of significance, respectively. Figures in ( ) indicate t-statistics and figures in [ ] indicate P-values.

Table 5
Non-Linear Estimates of Average ERPT – Specification 2
Dependent Variable D(log(CPI-C))

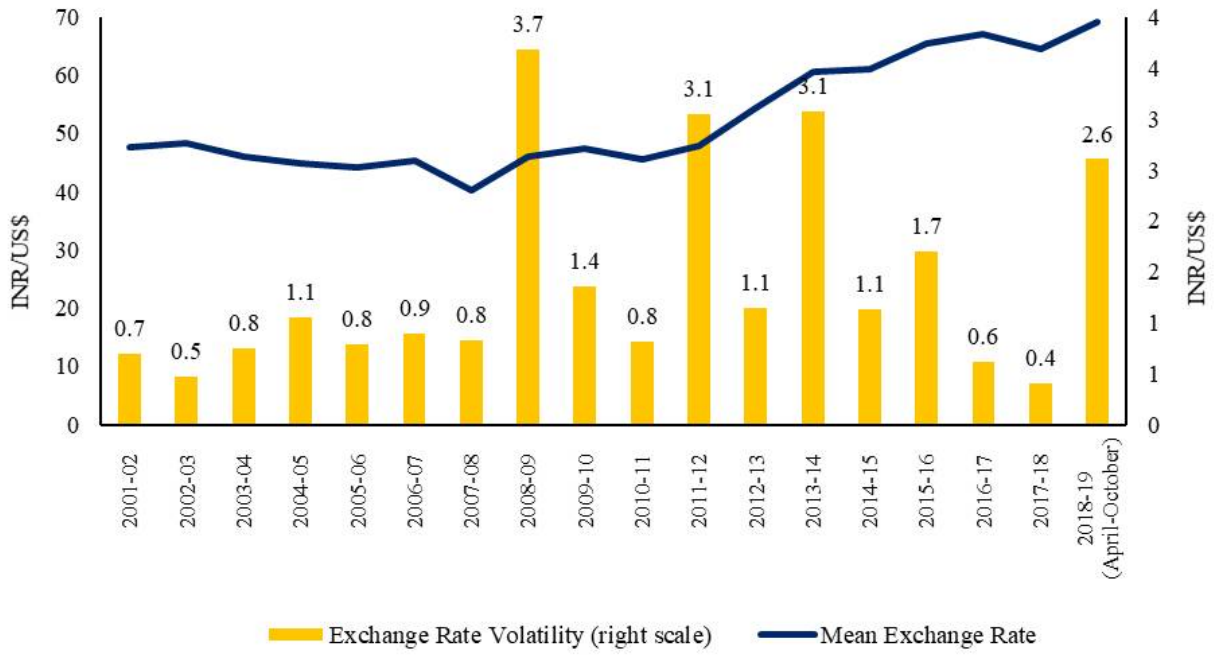
Variables	Benchmark (1)	Engle-Granger (2)	Johansen (3)	ARDL (4)
Constant	0.003*** (3.05)	0.003*** (3.10)	0.003*** (3.47)	0.00 (-0.07)
$\sum_{i=0}^{-12} e_i$	-0.17*** (-2.89)	-0.19*** (-3.24)	-0.16*** (-2.82)	-0.17*** (-3.00)
e^2	2.53** (2.18)	2.54** (2.16)	2.73** (2.32)	2.43** (2.15)
e^3	33.56 (1.17)	37.66 (1.31)	40.83 (1.39)	36.52 (1.31)
$\sum_{i=0}^{-1} C_i^f$	0.76*** (2.76)	0.71** (2.45)	0.68** (2.52)	0.76*** (2.95)
$\sum_{i=0}^{-1} iipoecd_i$	0.14* (1.73)	0.13* (1.75)	0.10 (1.28)	0.08 (1.06)
Food shock	0.0005*** (4.27)	0.0004*** (4.84)	0.0005*** (5.20)	0.0005*** (5.08)
ECM(-13)	-	-0.06*** (-3.48)	-0.05*** (-3.21)	-0.05*** (-3.87)
Adj. R^2	0.26	0.32	0.31	0.33
DW Statistic	1.71	1.88	1.95	1.92
F Statistic	10.34*** [0.000]	11.95*** [0.000]	11.42*** [0.000]	12.40*** [0.000]
Breusch Godfrey LM Test	Prob [$chi^2(6)$]=0.00	Prob [$chi^2(7)$]=0.00	Prob [$chi^2(7)$]=0.00	Prob [$chi^2(7)$]=0.00
Breusch Pagan Godfrey Test	Prob [$chi^2(6)$]=0.01	Prob [$chi^2(7)$]=0.01	Prob [$chi^2(7)$]=0.00	Prob [$chi^2(7)$]=0.02
No. of observations	161	161	160	161

Note: ***, **, and * indicate 1%, 5% and 10% levels of significance, respectively. Figures in ( ) indicate t-statistics and figures in [ ] indicate P-values.

5.3 Time-varying Nature of ERPT

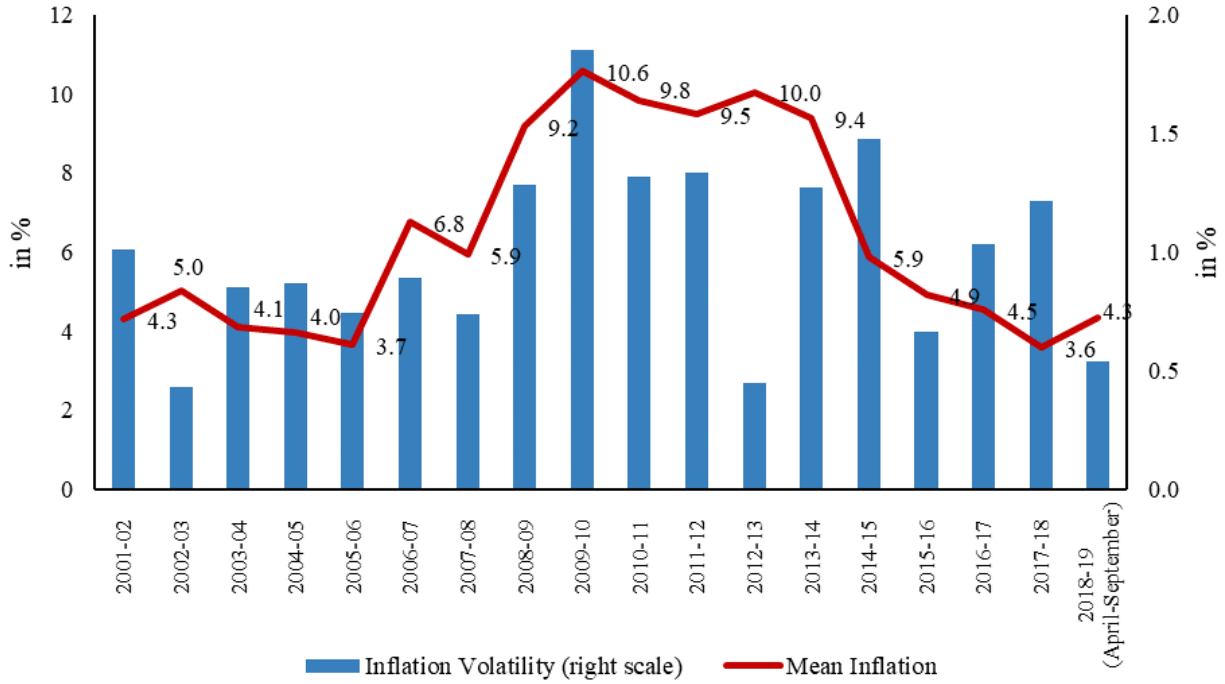
Data on the movements in exchange rate and inflation during the past 18 years show that both of these macroeconomic indicators have traversed through diverse phases (Charts 9 and 10). In case of inflation, we can clearly demarcate phases when inflation remained moderate and phases when it surged significantly. Further, patterns in inflation volatility also differed considerably across years. The literature provides ample evidence of higher exchange rate volatility associated with high ERPT and higher inflation volatility (Cheikh and Rault 2015; Jasova, et al. 2016). Therefore, in this context it becomes interesting to find out what has been the situation in the case of India.

Chart 9
Movements in Exchange Rate (INR/US$) and Exchange Rate Volatility



Note: Exchange rate volatility has been measured using standard deviation of exchange rate. Source: Database on Indian Economy, RBI, and author's own calculations.

Chart 10
Movements in Inflation and Inflation Volatility

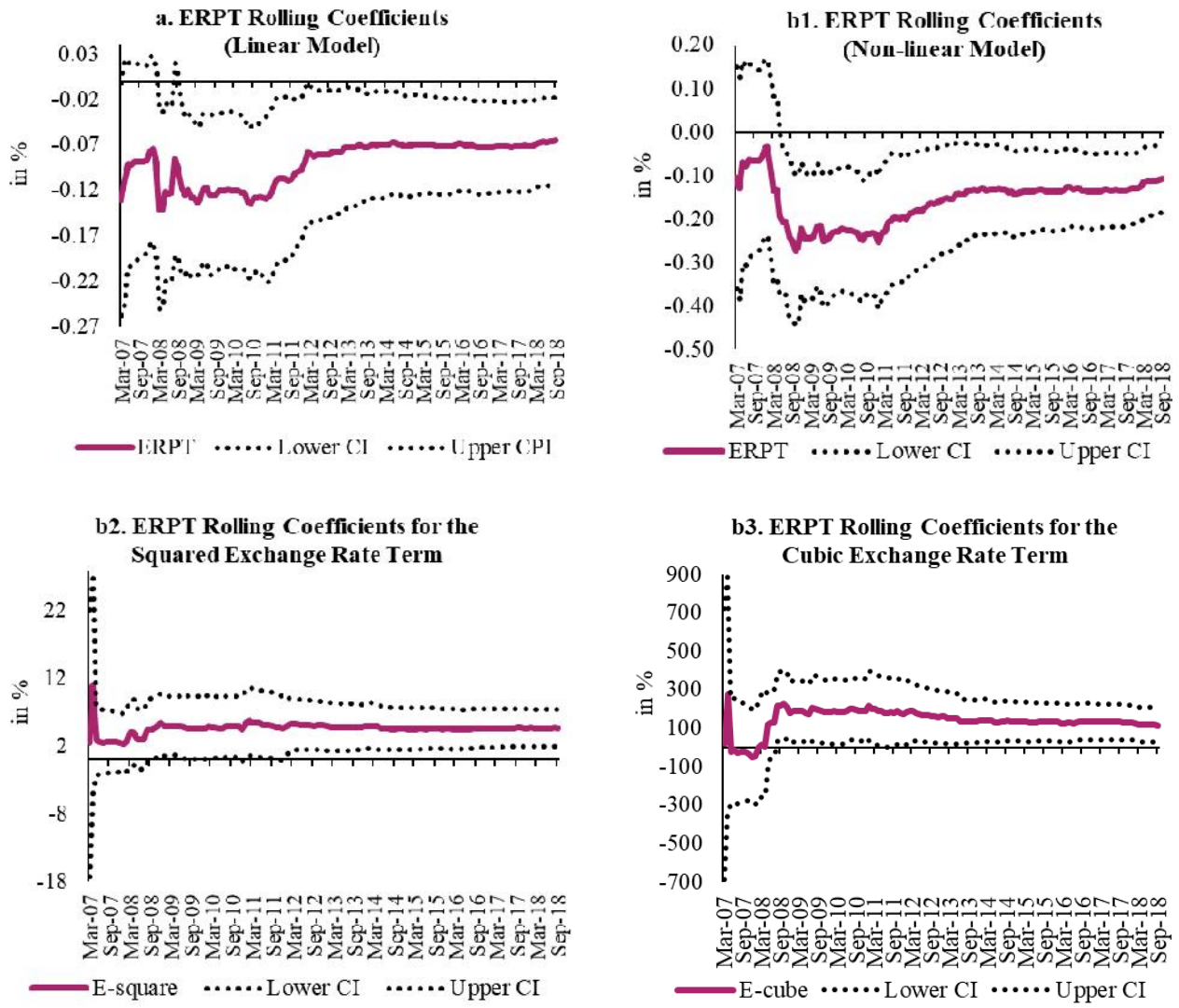


Note: Inflation volatility has been measured using standard deviation of monthly inflation. Source: MoSPI; and author's own calculations.

In order to see the time-varying nature of ERPT, we first employ the method of rolling regression using a recursive window of 36 months. We assume that this is a reasonably long duration to show up some diverse movements in inflation as well as the exchange rate, also because these variables are often affected by supply related shocks and geo-political events which are quite frequent in nature. The control variables remain the same as in the linear and non-linear ERPT presented earlier, while auto regressive terms of domestic prices with four lags are incorporated to take into account the intrinsic persistence of inflation (Patra, et al. 2013-14). The estimates of the ERPT from the rolling regression models are presented in Chart 11 below.[28]

28. Estimates of ERPT under this framework using different recursive windows and lags of CPI-C also produced similar trends.

Chart 11
Time-varying Nature of ERPT in a Rolling Regression Framework
Dependent Variable D(log(CPI-C))



Note: The black dotted lines indicate 95% confidence intervals. Chart (a) is the result obtained from the linear model of ERPT, while Charts b1, b2, and b3 are the results obtained from the non-linear model of ERPT.

The rolling coefficients of ERPT estimates indicate that over the years ERPT has declined from a maximum of around 13% (in case of the linear ERPT model), or 24% (in case of the non-linear ERPT model) in 2010-11 to around 7% (based on the linear ERPT model), or 13% (based on the non-linear ERPT model) in the more recent years (Chart 11; Table 6). The estimates also show that, as compared to the years of taper tantrum, ERPT of late has moderated marginally (as per the coefficients based on the non-linear ERPT model). Nonetheless, the results definitely indicate that during 2008-09 to 2012-13 the extent of ERPT was much higher possibly due to the global financial crisis and its aftermath. As indicated earlier, ERPT estimates based on rolling regression techniques do not exactly specify the time period of the change in the pass-through estimate, or how it differs between high and low inflation years, or whether a phase of major exchange rate fluctuation is a cause of worry from the point of view of inflation.

Table 6
Average ERPT Coefficients from the Rolling Regression Models

Year	Linear Model	Non-linear Model
2007-08	-0.09	-0.07
2008-09	-0.12	-0.23
2009-10	-0.12	-0.23
2010-11	-0.13	-0.24
2011-12	-0.10	-0.19
2012-13	-0.08	-0.16
2013-14	-0.07	-0.13
2014-15	-0.07	-0.14
2015-16	-0.07	-0.13
2016-17	-0.07	-0.13
2017-18	-0.07	-0.13
2018-19 (April-September)	-0.07	-0.11

Note: These results are derived from Chart 11.

Therefore, in order to model regime changes in inflation and the corresponding ERPT estimates, we use a standard two-state fixed transition probability Markov-switching regression model. We assume that during the past 20 years or so, inflation has majorly trodden through two distinct phases – high and low. In this framework while modeling for the ERPT, we control for food price shock, while other explanatory variables (foreign costs and global demand indicator) have been dropped as their coefficients turned out to be statistically insignificant. We consider exchange rate as the regime-switching regressor and allow for mean inflation (measured as the seasonally adjusted annualised rate of inflation (CPI-SAAR)) to vary across the regimes; while changes in food price shock and one period lagged inflation are incorporated as the non-switching regressors in the model. The reason behind using CPI-SAAR as the dependent variable is because in this framework the aim is to model inflation as against monthly changes in CPI-C. In addition, we allow for regime dependent error variances; thereby relaxing the assumption of homoscedastic error variance. In order to have a larger sample period beginning 2001 (so that the inflation and exchange rate dynamics are carefully integrated into the model), we consider INR/US$ (units of INR per one US$) exchange rate in this framework (in the earlier models we had a restricted time period beginning from April 2004 on account of the data limitations related to the various macroeconomic indicators). We first carry out the Brock, Dechert and Scheinkman (BDS) test for linear independence for inflation and the test results reject the null hypothesis of linear independence (Table 7).

Table 7
The BDS Test for Non-Linearity[29]

Dimension	BDS Statistic	Std. Error	z-Statistic	Normal Prob.	Bootstrap Prob.
2	0.032	0.006	5.45	0.0000	0.0000
3	0.050	0.009	5.33	0.0000	0.0000
4	0.052	0.011	4.64	0.0000	0.0000
5	0.051	0.012	4.38	0.0000	0.0000
6	0.048	0.011	4.29	0.0000	0.0008

Therefore, we now proceed with the Markov-switching regression model. The results of the model indicate that Regime 1 is the low inflation regime with a mean inflation much lower than in Regime 2, which is the high inflation regime and the coefficients are statistically significant (Table 8). Further, Regime 1 is characterised by low volatility with the ERPT coefficient at 11% which is much lower than the ERPT coefficient in Regime 2 (20%). Note that the pass-through coefficients are very much in line with the earlier estimates from the linear and non-linear model specifications; the difference being that in the previous case we were not able to separate out the impact during a high inflation regime *vis-à-vis* a low inflation regime. Additionally, if we look at the common parameters, then both changes in food inflation shock and the one period lagged inflation have turned out to be statistically significant. The coefficient associated with the lagged inflation is usually treated as the intrinsic persistence measure.

Table 8
Results of the Markov-switching Regression Model
Dependent Variable CPI-SAAR

Variable	Coefficient	Std. Error	Z -Statistic	Prob.
Regime 1				
D(INR-US$ exchange rate)	11.37	4.18	2.72	0.0065
C	0.99	0.13	7.51	0.0000
SIGMA	0.71	0.10	-3.37	0.0008
Regime 2				
D(INR-US$ exchange rate)	19.79	8.26	2.40	0.0166
C	1.47	0.26	5.58	0.0000
SIGMA	1.73	0.13	4.26	0.0000
Common				
D(Foodshock)	0.21	0.03	7.11	0.0000
CPI_SAAR(-1)	0.19	0.09	2.15	0.0316
Transition Matrix Parameters				
P11-C	2.74	0.67	4.10	0.0000
P21-C	-1.94	0.69	-2.82	0.0048
DW Statistic: 2.10; Log likelihood: -312.96; No. of observations: 211				

29. Null Hypothesis: series is linearly independent.

What is important to look at in such a modeling framework is the transition probabilities between regimes and their expected durations (Table 9).[30] The results indicate that the low inflation regime (Regime 1) has a longer expected duration of around 17 months and is therefore, more stable as compared with the high inflation regime (Regime 2). Also, the transition probability of a regime switch from 2 to 1 is much higher as compared to the transition probability of a regime switch from 1 to 2, which definitely is indicative of lesser risk in terms of inflation. The same is also indicated by the negative coefficient of the transition matrix parameter P21-C in Table 8. The negative sign implies that exchange rate changes have an important role to play in determining inflation dynamics and also the switch from the low inflation regime to the high inflation regime. Further, in order to check the robustness of the model the Wald test was carried out with the null hypothesis that the coefficients of ERPT in both the regimes are equal to zero. The results of the test indicate the rejection of the null hypothesis (Appendix Table 5). Further, a test for redundant variables in the model was carried out and the results indicated that changes in food price shock, which is used as a common non-switching regressor in the model, is not a redundant variable (Appendix Table 6).

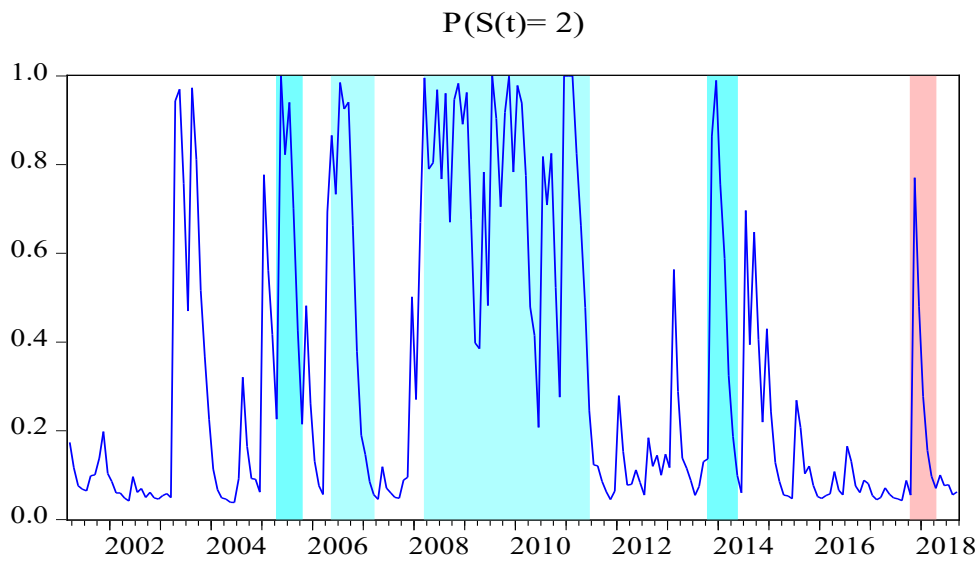
Table 9
Constant Transition Probabilities Matrix

	1	2
1	0.94	0.06
2	0.13	0.87
Constant Expected Durations		
	Regime 1	Regime 2
Months	16.5	8.0

Since Regime 2 is the high inflation state, we look at the Markov-switching filtered regime probabilities in case of Regime 2 (Chart 12) and we find that the model has been fairly able to identify the turning points in inflation during the past 17 years and their durations accompanied by exchange rate depreciations. The years shaded in light blue indicate the major turning points with transition probabilities very close to 1 or equal to 1. Therefore, in comparison to the past the recent sharp depreciation in exchange rate during 2018 (shaded in pink in Chart 12) has not been identified as a major turning point in inflation dynamics.

30. Transition probabilities are denoted by P(S(t)), where P represents probability; S represents state/regime; and t represents the particular regime (Regime 1/Regime 2).

Chart 12
Markov Switching Filtered Regime Probabilities



Also, the concentration of the regime probabilities around 1 or 0 (Charts 12 and 13) allows for the plausible identification of the high and low inflation regimes and therefore, confirm the usefulness of the model. Moreover, the smoothed regime probabilities plotted in Chart 13 for Regime 2 also indicate that the recent phase of currency depreciation has not been a major turning point, as seen in the past, like during the global financial crisis and the subsequent years (roughly around 2007-2011) and during the years of taper tantrum (2013-14). However, the filtered probability associated with Regime 2 for the current phase of depreciation is much higher as compared to the smoothed regime probability.[31] The smoothed probabilities indicate that inflation in the past 17 years has been mostly characterised by low/moderate inflation regime (Regime 1) and of course, for the very recent period, specifically since 2014, the model indicates a near absence of high inflation as was witnessed in the past. Chart 14 presents a picture of actual inflation outcomes juxtaposed on the smoothed probabilities of high inflation regime.

31. As stated in Calvet and Fisher (2008), filtered probabilities are useful in forecasting exercise, while smoothed probabilities generally provide an ex-post analysis of the data (Goutte and Zou, 2012).

Chart 13
Smoothed Regime Probabilities

Markov Switching Smoothed Regime Probabilities

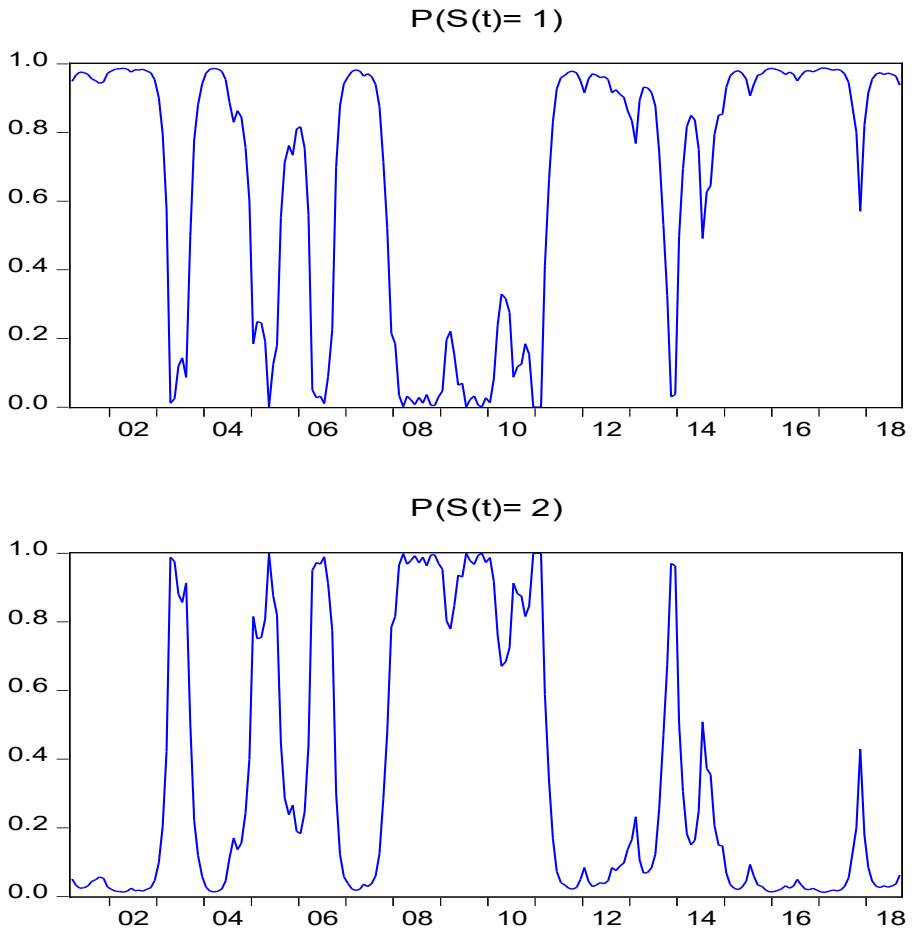
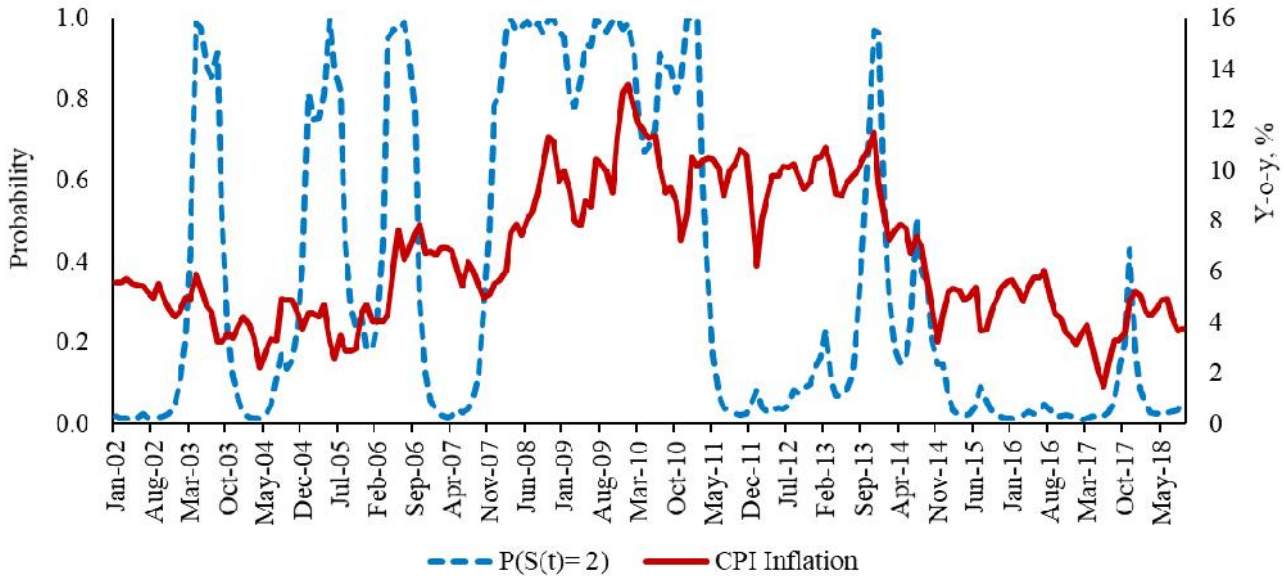


Chart 14
Smoothed Probabilities for High Inflation Regime *vis-a-vis* Actual Inflation



6. Conclusion

The paper presents the extent of ERPT to domestic prices in the context of India using the all India CPI-C series as the measure of domestic consumer prices. To the best of our knowledge, this would be the second paper after Patra, et al. (2018) studying the ERPT using CPI-C (CPI-C being the new all India consumer price index). The importance of ERPT to domestic prices arises from the fact that its degree matters for the efficient and smooth conduct of monetary policy. Importantly, in an inflation targeting monetary policy framework as the extent of ERPT is expected to decline, any sudden fluctuation in exchange rate can be a major cause of worry towards containing inflation within the target band.

The recent phase of currency depreciation in the EMEs, particularly from the beginning of 2018, has caused renewed concerns on the extent of ERPT to domestic prices. In this context, this paper re-visits the question that often bothers monetary policymakers and researchers whether changes in exchange rate and inflation dynamics has impacted the extent of ERPT. The paper finds that the ERPT accumulated over the duration of four months is around 10%, which implies that around 10% of the changes in the exchange rate are cumulatively passed through to the changes in CPI-C, while over a duration of 12 months the cumulative pass-through is 17-20%. Moreover, against the backdrop of the previous two decades characterised by major global events like the global financial crisis during 2007-08 (which had a significant impact on global growth conditions), followed by QE and subsequent taper tantrum; upturn and downturn of the global commodity price cycles, a major decline in domestic food inflation and institutional changes in the monetary policy framework in the domestic arena with the adoption of FIT, the paper shows that factors like global demand conditions, foreign costs and domestic food price shocks have played an important role in explaining the inflation dynamics.

Further, the paper also investigates the time-varying nature of ERPT. Using a Markov-switching regression framework, the paper answers the question whether ERPT has been different during high and low inflation phases. In this regard, the paper finds that the lower inflation regime in India is also characterised by low volatility with the ERPT coefficient at 11% which is much lower than the ERPT coefficient in the high inflation regime (20%). Additionally, the study finds that the one period lagged inflation and changes in food inflation shock are crucial determinants of inflation dynamics. Using transition probabilities, major turning points in inflation scenario were identified during the period of analysis (January 2001-September 2018). Further, using rolling regression methods the study shows that the average extent of ERPT had been significantly higher during 2008-09 to 2012-13, thereafter witnessing considerable moderation. However, the study has not explicitly associated/shown this moderation in ERPT to the implementation of FIT in India, which was formally adopted in 2016, which could be another interesting area of research.

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Appendix

Appendix Table 1
All India Consumer Price Index Combined and Annual Average Inflation

Major Components	Weights	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19 (April-September)
Food and beverages	45.86	11.2	11.9	6.5	5.1	4.4	2.2	1.8
Pan, tobacco and intoxicants	2.38	11.0	9.1	8.1	9.3	6.8	6.9	6.8
Clothing and footwear	6.53	12.2	9.3	7.3	5.8	5.0	4.7	4.9
Housing	10.07	9.5	7.0	5.9	4.9	5.2	6.5	7.8
Fuel and light	6.84	9.7	7.7	4.2	5.3	3.3	6.2	7.4
Miscellaneous	28.32	8.1	6.5	4.6	3.7	4.5	3.8	5.7
All Groups	100.00	10.0	9.4	5.8	4.9	4.5	3.6	4.2

Source: CSO, GoI; and author's own calculations.

Appendix Table 2
Results of the Unit Root Tests

Variables	Augmented Dickey Fuller Test Statistic		Phillips-Perron Test Statistic	
	Log X	Δ Log X	Log X	Δ Log X
CPI-Combined	-0.09	-11.26***	-0.0003	-11.24***
CPI-Miscellaneous				
CPI-Transport fuels				
NEER	-0.78	-10.15***	-0.72	-10.06***
Foreign costs	-2.59	-6.81***	-2.10	-10.90***
IIPOECD	-1.88	-5.25***	-1.31	-9.69***
Food shock	-4.29***	_	-5.07***	_
INR-US$ exchange rate	-0.05	-9.75***	0.22	-9.87***
CPI-SAAR	-11.23***	_	-11.21***	_
Domestic input costs (based on WPI)	-1.24	-10.15***	-1.29	-10.21***
Trade to GDP ratio	-1.26	-19.01***	-1.34	-19.01***
Global crude oil price	-1.81	-11.32***	-1.85	-11.40***

Note: ***, **, and * indicate 1%, 5% and 10% levels of significance, respectively. All series used in the analysis were seasonally adjusted using US Census Bureau X-13 method.

Appendix Table 3
Estimated Long-run Relationships

Variables	Engle-Granger	ARDL	Johansen
Constant	-1.89*** (-6.16)	-0.78 (-1.07)	1.24 (n.a.)
NEER	-0.43*** (-12.25)	-0.37*** (-4.51)	-0.39*** (6.65)
Foreign costs	1.68*** (50.82)	1.80*** (23.38)	1.74*** (-32.84)
IIPOECD	0.25*** (5.50)	-0.16 (-1.20)	0.005 (0.08)

Note: ***, **, and * indicate 1%, 5% and 10% levels of significance, respectively. All the series used in the analysis were in their logarithmic forms and seasonally adjusted using US Census Bureau X-13 method. Both Augmented Dickey-Fuller and Phillips-Perron tests showed the residual of the long-run estimate under Engle-Granger test to be stationary. The F-statistic for ARDL Bounds Test turned out to be 12.75, statistically significant at 1% level of significance, thus indicating the presence of long-run relationship between the variables. Using Johansen's method, both the trace and eigen value tests showed the presence of two co-integrating relationships.

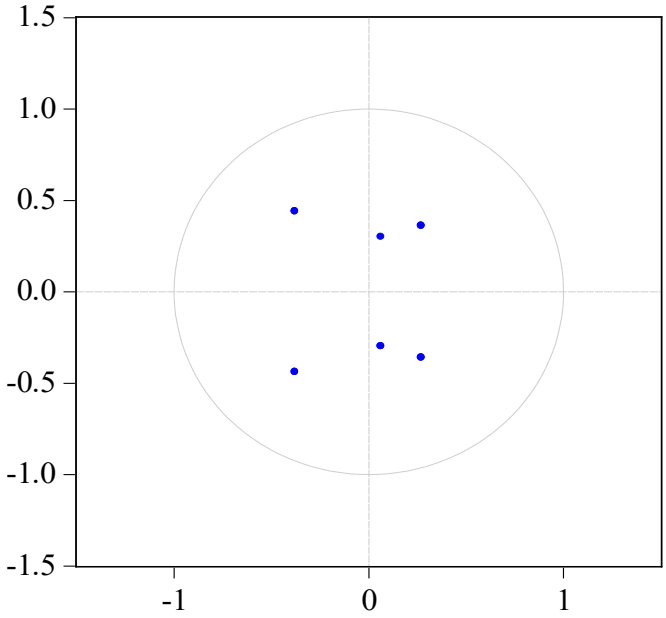
Appendix Table 4
VAR Residual Serial Correlation LM Test

	Null Hypothesis: No Serial Correlation at Lag h		Null Hypothesis: No Serial Correlation at Lags 1 to h	
Lag	**LRE* stat**	**Prob.**	**LRE* stat**	**Prob.**
1	11.93	0.22	11.93	0.22
2	10.05	0.35	17.85	0.47
3	9.84	0.36	25.89	0.52
4	12.21	0.20	32.64	0.63
5	6.03	0.74	44.99	0.47
6	14.65	0.10	56.26	0.39
7	7.31	0.60	69.64	0.26
8	7.66	0.57	80.41	0.23
9	5.52	0.79	87.39	0.29
10	7.69	0.57	92.52	0.41
11	19.07	0.02	107.62	0.26
12	14.44	0.11	120.19	0.20

Note: * indicates Edgeworth expansion corrected likelihood ratio statistic.

Appendix Chart 1
SVAR Stability Condition

Inverse Roots of AR Characteristic Polynomial



Appendix Table 5
Results of the Wald Test
(Null Hypothesis: Coefficient of INR-US$ exchange rate in Regime 1 = Coefficient of INR-US$ exchange rate in Regime 2 = 0)

Test Statistic	Value	Prob.
F-statistic (2, 201)	6.08	0.00
Chi-Square (2)	12.17	0.00

Appendix Table 6
Results of the Redundant Variables Test
(Null Hypothesis: Food shock is a Redundant Variable)

Test Statistic	Value	Prob.
Likelihood Ratio (1)	47.36	0.00

Chapter 4

THE DETERMINANTS OF INFLATION: THE CASE OF INDONESIA

By

Donni F. Anugrah, Bambang I. Ismaya and **Rakhmat Pratama**[1]

1. Introduction

The level and volatility of Indonesia's inflation rate have historically been higher compared with the trend in the emerging countries. Whereas other emerging markets had average inflation rates of between 1.55% (y-o-y) and 3.05% (y-o-y) during the period 2011 to 2017, Indonesia recorded an average annual inflation rate of 5.13% (y-o-y) over the same period. Indonesia's inflation characteristics apparently are different from other peer countries. Therefore, we propose to examine the factors influencing inflation in Indonesia, and also to study the differences in the determinants of headline, core and food price inflation.

Although Indonesia has higher inflation compared with its peer countries, the average headline inflation tends to decline over the past five years. The achievement of headline inflation in 2017 was recorded at 3.61% (y-o-y). The low realisation of headline inflation was driven by the stability of core inflation (2.95%) and food price inflation (0.71%). It is in line with the consistency of Bank Indonesia (BI)'s policies in maintaining exchange rate stability and directing inflation expectations. Also it was supported by managed inflation expectations, positive factors in demand and supply, moderate external pressures and strong policy coordination between BI and the government.

Since the adoption of an inflation targeting framework by BI in 2005, the central bank is predominantly focused on inflation. Under this framework, BI explicitly announces the government-set inflation target to the public and gears its monetary policy towards achievement of this target. For the inflation target to be attained, monetary policy is implemented with a forward-looking approach, meaning that any change in the monetary policy stance is undertaken after evaluating whether future developments in inflation are on track with the established inflation target.

Inflation is a persistent, ongoing rise across a broad spectrum of prices. An increase in prices for one or two goods alone cannot be described as inflation unless that increase spreads to (or leads to escalating prices for) other goods. The indicator commonly used to measure the level of inflation is the Consumer Price Index (CPI). Changes in the CPI over time are indicative of price movements for baskets of goods and services consumed by the public.

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In Indonesia, headline inflation or CPI inflation is disaggregated into core inflation, food price inflation and administered prices. The goods and services included in the core inflation group contribute around 60% of all commodities in the CPI basket. Core inflation is a component of inflation which tends to be persistent in the movement of inflation. Also, it is influenced by fundamental factors, such as interaction between demand-supply, external environment (exchange rate, international commodity prices, trade partner inflation), and inflation expectations of traders and consumers. Basically, it is a CPI inflation rate after excluding food commodities and goods the prices of which are determined by the government (administered prices). On the other hand, food price inflation is predominantly influenced by shocks in the foodstuff category, such as harvests, disruptions from natural events or movements in domestic food commodity prices and international food commodity prices. Even though food commodities only contribute 17.81% of commodities, they are key to inflation control because of the high volatility of their prices.

The policy discussions about inflation in Indonesia suggest that supply and demand imbalances, lack of infrastructure, climate change, and seasonal events are principal factors of inflation. Infrastructural development such as expansion of asphalt road network can improve distribution efficiency. Development of irrigation systems for the agricultural sector can increase food crop productivity. Rainfall has an impact on food production, because there are still many rice fields that do not have an irrigation system. Rice is the staple food of Indonesia's 260 million inhabitants. Climate change will affect rainfall that have a great influence in the production of food crops in Indonesia. Seasonal factors such as Ramadhan and Eid also have effects on headline and food price inflation. Meanwhile, school enrolment period has strong seasonal effect on core inflation. However, this research will focus on identifying the determinants driving each type of inflation group using real sector variables.

This research purposes to help us understand the determinants influencing inflation movement. Furthermore, the results of this study can offer inputs in recommending strategies for monitoring and controlling inflation. The rest of the paper is arranged as follows. In the next section, we review the literature on the determinants of inflation. Section 3 discusses the model, methodology, and data. We use the Error Correction Model (ECM) for headline and core inflation because it tends to be persistent and much influenced by economic fundamentals. Since food inflation is very volatile, it will be difficult to estimate with long-run and short-run ECM. Accordingly, we apply the Generalised Method of Moments (GMM) to analyse the factors influencing food inflation in Indonesia. The empirical results are presented in Section 4. Finally, Section 5 concludes and provides some policy recommendations.

2. Literature Review

There are several studies which aim to uncover the determinants of inflation. Lim & Sek (2018) found that money supply, national expenditure and GDP growth are the determinants imposing long-run impact on inflation in high inflation countries. In the short run, none of the variables is found to be significant as a determinant in high inflation countries. Mohanty and John (2015) attempt to identify the determinants of inflation in India in a multivariate econometric framework. They found that the determinants of domestic inflation are crude oil prices, output gap, fiscal policy and monetary policy. Rangasamy (2009) studied the persistence of inflation in South Africa and found that identifying the sources underlying inflationary pressure in the economy by using disaggregated components can show better results than from looking at the general level.

Another study by Dwyer & Leong (2001) determined whether there were structural changes in the components of inflation in Australia by using the Ordinary Least Squares (OLS) method. Some of the variables used in the analysis included nominal exchange rates, import retail prices, WTI oil prices, CPI, industrial wages, and output gap. This study found that several of the determinants of inflation in Australia experienced unusual or structural changes during the observation period.

Hutabarat (2005) analysed the characteristics of inflation in Indonesia and the factors that influence it. The study revealed evidence that inflation in Indonesia is very persistent due to the pattern of formation of inflation expectations dominated by past inflation (adaptive expectations). Meanwhile, estimates of the impact of global commodities (beef, gold, petroleum, CPO, soybean, corn, wheat flour, sugar and cotton) on general inflation in Indonesia was carried out by Utari, Ibrahim & Permata (2011) using the Autoregressive Distributed Lag (ARDL) method.

Fuel (notably, RON 88 – Premium) is a strategic commodity, the price of which is controlled by the government and adjusted at any time in response to the development of world prices. In view this commodity is a key factor of production for manufacturing, the price movement of this commodity will cause changes in production costs which will eventually be transmitted to the selling price. A study by Wimanda, Purwanto & Oktiyanto (2011) suggested that fuel price significantly affected core inflation which is persistent in Indonesia.

For the core inflation study, Wimanda, Purwanto & Oktiyanto (2011) applied a hybrid New Keynesian Phillips Curve using the ARDL Model. This study found that core inflation after the 1997/1998 economic crisis was affected by inflation in the previous period, consensus forecast, exchange rate, output gap, M1 growth, and exchange rate volatility.

For food price inflation, Durevall, Loening, & Ayalew Birru (2013) found that in the short run, food production affected food price inflation, causing large deviations from long-run price trends. In this study, food production has a negative correlation with food price inflation. Food import was also one factor having potential impact on food price inflation from the supply side. Kornher & Kalkuhl (2013), Joiya & Shahzad (2013), and Abdullah & Kalim (2009) found that imports affect food price inflation positively and significantly. In another study, Cashin, Mohaddes, & Raissi (2015) found that extreme weather, a result of climate change, such as El Nino, has significant impact on food price inflation.

Infrastructural development that is one of the government main programmes also have the potential to reduce the inflation rate. Extended asphalt road network can be expected to reduce transportation time for movement of goods and commodities and to reduce distribution cost. Prastowo, et al. (2008) found that infrastructure, such as roads, play an important role in commodity pricing, and therefore the government should devote greater attention to improving infrastructure facilities. Infrastructure also has the potential to reduce food price inflation through the production channel. One of the most important infrastructures in the agricultural sector is irrigation. Crops cultivated with proper irrigation system generally produce higher productivity yields. In Indonesia, irrigation is important because more than 50% of the rice fields depend on irrigation water to grow properly. It becomes an important issue because rice is the staple food of the Indonesian people and this commodity has a large weight in food price inflation calculation. The importance of agricultural infrastructure is also established by Fielding (2008). In this study it is suggested that improvements in agricultural productivity stimulated by government investment in rural

infrastructure, agricultural research and extension, irrigation, and appropriate price incentives contribute directly to economic growth, poverty alleviation, and price stability. We learn from several studies that the extension of agricultural credit could potentially impact food price inflation. For instance, a study by Joiya & Shahzad (2013) found that credit to the agricultural sector causes a reduction in food prices. In some other studies, oil price also is identified as one of the determinants of food price inflation. Irz, Niemi, & Liu (2013) found that oil price influencing energy cost plays a significant, but limited role in determining the equilibrium level of food prices in Finland. Beside various supply-side factors, the level of demand also has a big impact on food price. From the study by Khan & Schimmelpfennig (2006), besides credit to the private sector, money supply has a significant explanatory role for inflation. Higher monetary expansion caused by massive borrowing from the banking system to finance fiscal deficit has been the principal source in accelerating current inflation in Pakistan.

3. Model, Methodology and Data

In this section, we shall examine the determinants of headline, core, and food price inflation using two different approaches. In headline and core inflation, we use ECM and GMM for food price inflation.

3.1 Headline and Core Inflation

To identify the determinants of headline and core inflation, we use cointegration method with ECM which was introduced by Engle and Granger in 1987. The ECM method is chosen because of the nature of headline and core inflation which tend to be persistent (influenced by economic fundamentals). In the long-term model, price refers to demand for money. Where in the long run, price movement (inflation) is influenced by the amount of money in circulation. Based on the Quantity Theory of Money by Fisher, an increase in the money supply causes a decrease in the value of money because an increase in the money supply causes an increase in inflation. When inflation rises, both purchasing power and the value of money decline. Therefore it will be more expensive to buy the same amount of goods or services. In the short-term model, reference is to the Phillips Curve where inflation tends to be influenced by inflation expectations. The long-term equation for core inflation used is as follows:

$$P_t = c + \gamma D_t + \varepsilon_t \quad (1)$$

$$ECM_t = \varepsilon_t \quad (2)$$

$$ECM_t = P_t - c - \gamma D_t \quad (3)$$

where:

P_t : headline inflation or core inflation
c : constant
D_t : demand variable
γ : parameter of demand variable

The equation consisting of variables in the first difference form is estimated with the error correction term (ε) which has been obtained from the estimation of the first stage (as a correction factor if there is a deviation from its long-run equilibrium). This equation is known as the short-term equation, which can be written as follows:

$$\Delta P_t = \alpha_1 - \alpha_2 ECM_{t-1} + \alpha_3 \sum_{i=1}^{n} \Delta Z_{t-i} + \alpha_4 \sum_{i=1}^{n} \Delta P_{t-i} + \varepsilon_t \quad (4)$$

where:

P_t : headline inflation or core inflation
c : constant
P_{t-i} : inflation expectation
Z_{t-i} : control variable
$\alpha_1, \alpha_2, \alpha_3, \alpha_4$: parameter

In headline and core inflation, we use quarterly data from 2004 to 2017. We use various variables which are headline CPI, core CPI, gross domestic product, broad money, industrial production index, fuel price (Gasoline RON 88 – Premium), world gold price, exchange rate, length of asphalt road, rice production, beef production, seasonal events (Ramadhan), and education dummy. The data are collected from BI, Indonesia Central Bureau Statistic (BPS), Ministry of Agriculture, Bloomberg and CEIC. All data are in level and log form (see Table 1).

Table 1
Data of Headline and Core Inflation

Variable Name	Description	Frequency	Source
Headline CPI	Headline CPI	Monthly	BPS
Core CPI	Core CPI	Monthly	BPS
Y	Gross domestic product	Quarterly	BPS
M2	Broad money	Monthly	BI
IPI	Industrial production index	Monthly	CEIC
Fuel Price	Gasoline RON 88 – Premium Price	Monthly	BPS
Global Gold Price	World gold price	Monthly	Bloomberg,
Exchange Rate	Exchange rate	Monthly	BI
Asphalt Road	Length of asphalt road	Yearly	BPS
Rice Production	Rice production	Yearly	Ministry of Agriculture
Beef Production	Beef production	Yearly	Ministry of Agriculture
Ramadhan Dummy	Fasting season period		
Education Dummy	School enrolment period		

3.2 Food Price Inflation

We use the multivariate GMM framework to analyse the factor of food inflation in Indonesia. The GMM method is chosen because of the nature of food price inflation which more volatile than headline and core inflation. On this ground, we think the use of GMM method is more precise than ECM for estimating food price model. The basic model is as follows:

$$\pi_t = \omega\pi_{t-1} + \gamma\pi_{t+1} + \delta_i(\theta_i)_t + \varepsilon_t \quad (5)$$

where π_t is volatile food inflation as an independent variable, $\omega\pi_{t-1}$ is backward-looking inflation, $\delta\pi_{t+1}$ is forward-looking inflation, $\delta_i(\theta_i)_t$ is another explanatory variable, and ε_t is an error term. Since we do not have direct observations of backward- and forward-looking inflation expectations, we use the actual value of future inflation, as suggested by McCallum (1976). We use inflation t-1 as backward-looking inflation and inflation t+1 as foreward-looking inflation.To solve the endogenity problem, we use GMM. This method was previously used by Wimanda, et al. (2011). This approach also allow us to compare the elasticity between backward- and foreward-looking inflation. Beside backward- and forward-expectation in the food price inflation model, we also use food production, agricultural infrastructure (irrigation), narrow money (M1), fuel price (Gasoline RON 88 – Premium), agricultural credit, climate change, and food price inflation volatility. We also use seasonal events (Ramadhan) as a dummy variable to capture increased demand during 'Ramadhan' and 'Idul Fitri' day, the Moslem festival at the end of the fasting month. The data are collected from BI and BPS. We also use food production index from Food and Agriculture Organisation (FAO) as total food production proxy and Oceanic Niño Index (ONI) from National Oceanic and Atmospheric (NOAA) as climate change proxy.

Table 2
Data of Food Price Inflation

Variable Name	Description	Frequency	Source	Notes
Food Price	Food price inflation	Monthly	BPS	Using end of quarter data; % growth (y-o-y)
Food Production	Food production index	Yearly	FAO	Interpolated with quadratic-match-sum; % growth (y-o-y)
Irrigation	Number of irrigated land	Yearly	BPS	Interpolated with quadratic-match-average; % growth (y-o-y)
M1	Narrow money	Monthly	BI	Using end of quarter data; % growth (y-o-y)
Fuel Price	Gasoline RON 88 – Premium price	Monthly	BPS	Using average price in quarter priod. % growth (y-o-y)
Agricultural Credit	Credit of agricultural sector	Monthly	BI	Interpolated with quadratic-match-average; % growth (y-o-y)
Climate Change	Oceanic Niño Index (ONI)	Quarterly	NOAA	% growth (y-o-y)
Volatility	Volatility of food price inflation	Monthly	BPS, processed	Standard deviation of inflation.
Ramadhan	Fasting season period			

Most of the variables are used in the form of growth (% y-o-y) except for climate change which is used in a level form (see Table 2). Some of the data we used are annual data. To convert the frequency from yearly to quarterly, we interpolate the data by applying quadratic-match-average method and quadratic-match-sum. For stock data we use quadratic-match-sum and for flow data we use quadratic-match-average.

4. Empirical Result

4.1 Headline Inflation

For headline inflation, we conduct unit root test on the headline CPI dependent variable and M2Y independent variable. M2Y variable is a proxy for describing the proportion of public consumption, using the Broad Money (M2) divided by gross domestic product (Y). Thus, M2Y is the amount of money spent on per unit of GDP, or in other words a proxy of the demand side. The expansion of money supply if it is not balanced with an increase in the production of goods/ services, will cause inflation because the pressure from the demand side will be greater than the ability of the supply side to fulfill it.

Table 3
Long-run Headline Inflation

	Long Run
Constant	8.42 *
M2Y	0.70 *
Adjusted R-squared	0.97

*) significant at 5% confidence level
**) significant at 10% confidence level

Model 1

LR Headline Inflation = 8.42 + 0.70*M2Y + ε

In the long run, headline inflation is significantly affected by M2Y which is a proxy of demand (Table 3). Furthermore, we apply residual test by unit root test and find that it is stationary. It means that in the long term this model is robust. Therefore we have evidence that M2Y is strongly sigificant in influencing headline inflation in the long term. This finding strengthens the previous study of Su, et al. (2016) that money supply has positive impacts on inflation.

Table 4
Short-run Headline Inflation

		Short Run
Constant		0.01 *
Headline CPI	(t-1)	0.16
IPI		-0.14 **
Global Gold Price	(t-3)	0.02
Rice Production	(t-3)	-0.17
Beef Production	(t-3)	-0.11 *
Asphalt Road		-0.04
Ramadhan Dummy		0.01 **
ECM	(t-1)	-0.10 **
Adjusted R-squared		0.39

*) significant at 5% confidence level
**) significant at 10% confidence level

Model 2

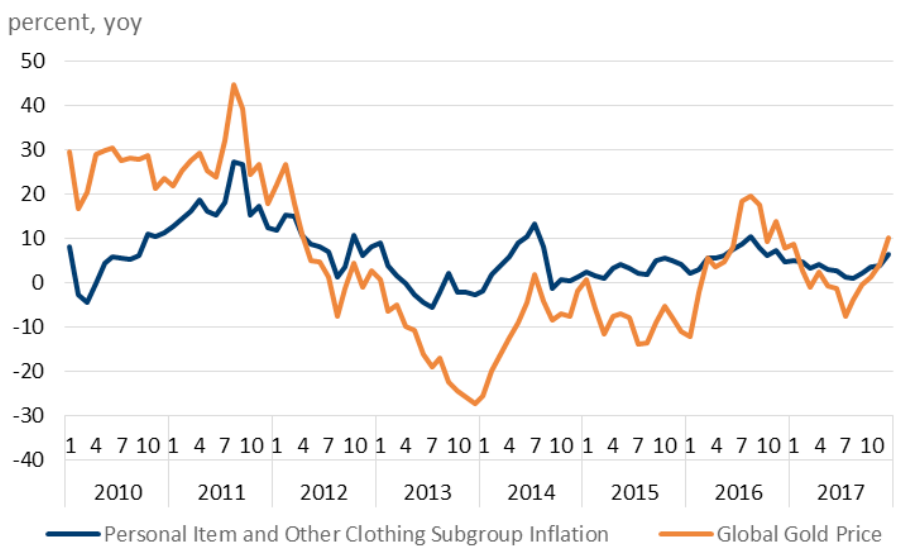
SR Headline Inflation = 0.01 + 0.16*Headline CPI (-1) – 0.14*IPI + 0.02*Global Gold Price (-3) – 0.17*Rice Production (-3) – 0.11*Beef Production (-3) – 0.04*Asphalt Road + 0.01*Ramadhan Dummy – 0.10*ECM(-1) + ε

In the short term, our model shows that headline inflation is significantly affected by Industrial Production Index (IPI), beef production, and seasonal events (Ramadhan). IPI has a negative and significant influence on headline inflation. Improved industrial performance as reflected by the IPI indicates that an increase in production from the manufacturing industry will cause the supply of goods on the market to increase. If demand is relatively constant, then an increase in supply of goods will help reduce headline inflation. This result was also found in Hutabarat (2005) study, where the persistence of inflation in Indonesia is inseparable from the influence of supply shocks, which is a condition where the level of supply is lower than the level of demand.

On the other hand, agricultural production was recorded to have a negative effect on headline inflation in the agricultural and livestock sector. In this model, the production variable is represented by rice production (coefficient: -0.17) and beef production (coefficient: -0.11). Rice production has greater impact to reduce headline inflation because rice is the staple food of Indonesians and this commodity has a large weight in food inflation calculation. Another variable that has relationship with headline inflation is seasonal events (notably Ramadhan). In Ramadhan, pressure from the demand side tends to increase, thus driving up headline inflation.

The variables that are not significant in the model although with the right sign and consistent with our hypothesis are backward-looking expectation, global gold price, rice production and asphalt road. This shows that public expectations are predominantly influenced by the realisation of headline inflation in the previous period.

Figure 1
Global Gold Price and Personal Item and Other Clothing Subgroup Inflation



Global gold prices also have a positive impact because gold has been known as a safe haven, which is used as a means of storing value and/or hedging against inflation. Investment in gold instruments is relatively safe because they are able to maintain purchasing power. In Indonesia, the weight of commodity gold jewelry is relatively large in the personal item and other clothing subgroup inflation (Figure 1). In this model, we also try to estimate the impact of infrastructural development on headline inflation. We find that infrastructure such as length of asphalt road has potential to reduce inflation even though it is not significant.

4.2 Core Inflation

For core inflation, we conduct unit root test on the core CPI dependent variable and M2Y independent variable. As mentioned above, this variable is as proxy for demand.

Table 5
Long-run Core Inflation

	Long Run
Constant	8.12 *
M2Y	0.65 *
Adjusted R-squared	0.99

*) significant at 5% confidence level
**) significant at 10% confidence level

Model 3

LR Core Inflation = 8.12 + 0.65*M2Y + ε

In the long run, core inflation is significantly affected by M2Y which is a proxy of demand. Furthermore, we apply residual test by unit root test and find that it is stationary. It means that in the long term this model is robust. Therefore, M2Y also is strongly sigificant in influencing core inflation in the long term.

Table 6
Short-run Core Inflation

		Short Run
Constant		0.00 *
Core CPI	(t-1)	0.37 *
IPI		-0.05 *
Fuel price		0.03 *
Global Gold Price		0.05 *
Exchange Rate		0.04 *
Asphalt Road		0.04
Education Dummy		0.01 *
ECM	(t-1)	-0.05 *
Adjusted R-squared		

*) significant at 5% confidence level
**) significant at 10% confidence level

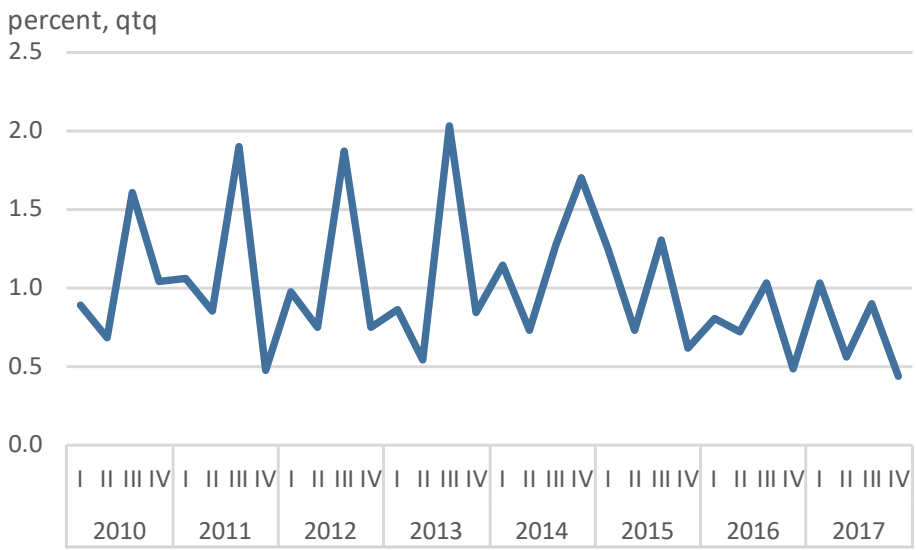
Model 4

SR Core Inflation = 0.00 + 0.37*Core CPI (-1) – 0.05*IPI + 0.03*Fuel Price + 0.05*Global Gold Price + 0.04*Exchange Rate + 0.04*Asphalt Road + 0.01*Education Dummy – 0.05*ECM(-1) + ε

In the short term, this model shows that core inflation is significantly affected by inflation expectations, IPI, fuel prices, global gold prices, exchange rates and education dummy for school enrolment period (Table 6). From this table, we can see that there are two independent variables in common with the determinants of headline inflation, namely IPI and global gold price. This result is in line with the initial statement that the commodity in the core inflation group contributes about 60% of commodities that used to calculate headline inflation.

From the global side, the depreciation of the exchange rate has a positive and significant effect in driving the increase in core inflation. The exchange rate depreciation will cause an increase in the price of imported raw materials so that it will have an impact on the increase in production costs which in turn will cause an increase in the price of goods. Fuel price (Gasoline RON 88 – Premium), which is set by government, play a very significant role in core inflation because it constitutes a relatively high volume of national consumption.

Figure 2
Movement of Quarterly Core Inflation



Another variable is the education dummy which shows a significant relationship with core inflation. School enrolment that happens in the third quarter of each year has positive and significant impact on core inflation. The new school-year period in Indonesia starts in July – August each year. Public expenditure in the education subsector has increased relatively because there are payments for education fees and educational support costs. This is seen in Figure 2 where the core inflation rate in the third quarter (shaded areas) tends to be higher than in the other quarters of the same year. Meanwhile, infrastructural development such as expansion of asphalt road network does not have a significant effect on core inflation.

4.3 Food Price Inflation

From the estimation there is econometric evidence that food price inflation in Indonesia is significantly determined by both types of expectations (backward-looking and forward-looking expectations), food production, infrastructure (irigation), food import, demand (M1), domestic fuel price, agricultural credit sector, climate change (El Nino), and volatility of food price inflation. The variables above are statistically significant. Only the seasonal event variable (Ramadhan) is not significant in the model although it is of the right sign and consistent with our hypotheis.

Table 7
Determinants of Food Price Inflation

Constant		1.62 *
Food price CPI	(t-1)	0.47 *
	(t+1)	0.37 *
Food Production		-0.27 *
Irrigation	(t-1)	-0.23 *
Agriculture Import	(t-2)	-0.02 *
Narrow Money	(t-3)	0.03 **
Fuel		0.05 *
Agricultural Credit	(t-1)	-0.09 *
Climate Change	(t-2)	0.21 **
Volatility of food price inflation	(t-1)	1.50 *
Ramadhan Dummy		0.30
Adjusted R-squared		0.55
Sum Square Resid		170.08
J-Statistic		9.27
prob (J-Statistic)		1.00

*) significant at 5% confidence level
**) significant at 10% confidence level

Model 5

Food Price Inflation = 1.62 + 0.47*Food Price CPI (–1) + 0.37*Food Price CPI (+1) – 0.27*Food Production – 0.23*Irrigation (-1) – 0.02*Agriculture Import (-2) + 0.03*Narrow Money (-3) + 0.05*Fuel – 0.09*Agricultural Credit (-1) + 0.21*Climate Change (-2) + 1.50*Volatility of Food Price Inflation (-1) + 0.30*Ramadhan Dummy + error

From the model we also find that backward-looking expectation is more critical (about 0.472) than forward-looking expectation (about 0.370). This fact shows that the central bank's ability to influence people's inflation expectations in the short term is limited. This fact confirms what Wimanda, et al. (2011) found in their study. In the study, the condition of backward-looking expectation is found to be more important and that makes central bank's job of maintaining inflation harder. This fact also showed that the combination of a commitment to low inflation and transparent

central bank policy is not enough to maintain public expectation concerning food price. In this situation central bank policy does not have enough traction to bring inflation quickly down to its target value. It sends a signal to the central bank to coordinate more closely with the government in fiscal policymaking, in view of the above finding that monetary policy does not have enough leverage to control food inflation.

Based on the model, we also can conclude that food price inflation in Indonesia is mostly driven by supply-side factors. As the empirical results indicate, most of the supply-side determinants are significant to food price, especially food production. For a country that relies on domestic production to fulfill its needs, such as Indonesia, maintaining high production capacity is a challenge. For there has been a mismatch between growing demand and actual production. As we know, agricultural production supply is not able to adjust immediately to changes in demand. Which is why adequate infrastructure, proper technology, and various supporting factors are necessary to facilitate higher production.

Another supply-side determinant is agriculture import. However, this factor is less effect to influence food price inflation. The level of transmission of international prices to domestic prices depends on a country's dependence on imports of food items and the inputs used in agricultural production. In the case of Indonesia, its dependency on food import is relatively low. It is because most of its food-demand could be fulfilled by domestic production, and with only a few commodities having a high dependency on imports (such as garlic and beef meat).

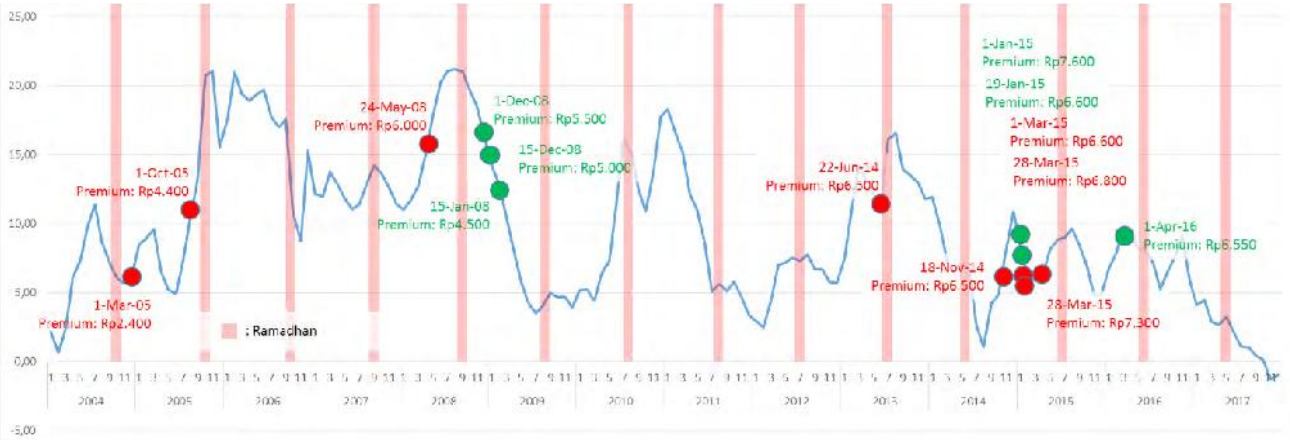
Based on the empirical results, we find that credit in the agricultural sector is significant to cause the reduction of food price. When the extension of credit to the agricultural sector is increased, small farmers are stimulated to adopt modern machinery, pesticides, tractors, and other productivity tools which will automatically enhance the productivity of farmers and control the food prices. Thus, more credit disbursed to agriculture sector causes the reduction of food price. Since credit to agricultural sector is essential in controlling food price, improved access to finance by agribusiness and local farms is vital. Credit institutions have to be strengthened by the government, and farmers require financial products to be tailored to their specific long-term financial and working capital needs.

A critical infrastructure for agriculture is irrigation. For an agricultural-based country like Indonesia, the improvement of infrastructure is critical in controlling inflation. In best food inflation models, the land area under irrigation as a proxy of irrigation showed significant correlation with food price, establishing irrigation statistically as a significant cause in the reduction of food price.

Irrigation becomes vital in inflation control because this is one of the primary factors in rice farming. Rice is the staple food of Indonesians; paddy cultivation employing irrigation covers 4.78 million ha or 58.4% of the total paddy fields (BPS, 2017). Another reason that makes irrigation a priority is climate change. In recent years, Indonesian agriculture has been plagued by the El Nino phenomenon which has resulted in hot weather, significant reduction in rainfall and droughts. Irrigation becomes crucial being the only one water source for agriculture. Considering that investment in the rural area is vital, the government must uphold the agricultural sector as one of the priorities for investment.

This study also shows that food price inflation is not only driven by supply side, but also by demand side. In food price inflation models, we can show that narrow money as a proxy of demand, is statistically significant to cause the rise in food price. It is consistent with the monetarist theory of inflation in that excess money supply drives inflation, but in this instance it does not affect food prices directly. It is possible that excess money supply affects the exchange rate, and thus inflation. This explains why in the model, this variable is significant in t-3 lag. It sends a signal to the central bank to be cognisant of the fact when formulating the monetary policy as it will affect the food price.

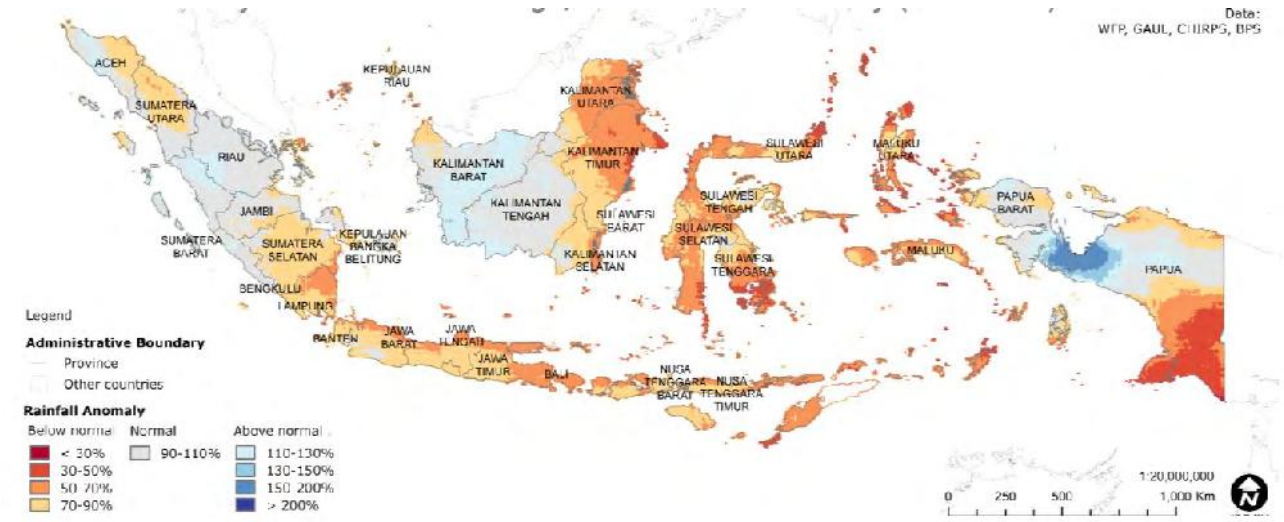
Figure 3
Event Analysis: Premium Price & Ramadan vs Food Inflation



Besides money supply, another factor that affects inflation from demand side is fuel price. Gasoline RON 88 – Premium is the cheapest and most consumed type of gasoline in Indonesia. If the price of Premium rises, it will drive inflation in every sector including food price. It is confirmed by the model that fuel price is statistically significant in causing food price rise. The price of Premium is set by the government and therefore do not float according to market conditions, and the subsequent deficit is required to be absorbed by the government's state budget. Since 2004, the price of Premium had been adjusted 14 times by the government, with the price increased 8 times (see Figure 3). From the chart we can see that each time fuel price goes up, it is followed by rising food inflation. Mostly, fuel price adjustments are transmitted to inflation through rising transportation costs.

Another factor that significantly affects food price inflation in Indonesia is climate change. Climate change becomes one of the factors affecting agricultural production, especially 3.4 million hectares of non-irrigated lands, which in the end will affect food prices. As we expected, El Niño as a proxy for climate change showed significant cause food price inflation. The latest Niño occurred in 2015-2016. It started to affect Indonesia in March 2015, reaching high El Niño levels by July before peaking in December 2015, and has remained stable in early 2016. ACAPS (2016) reported that the effects of El Niño in that period included reduced rainfall, especially in Central and South Kalimantan, southern Sumatera, Java, Sulawesi and Papua.

Figure 4
Rainfall Annomaly During El Nino 2015



Source: ACAPS (2016)

This reduced rainfall has reduced soil moisture content in many areas at the start of planting for 2016's first (primary) harvest season and delayed rice planting: about 25% of the national total had not been planted by the end of December 2015 predominantly in Java, Sulawesi, and eastern Indonesia. This development is not surprising when the model captured climate change (El Nino) as one of the significant determinants.

This study also confirms that idiosyncratic factors such as seasonal events (Ramadhan) also affect the food price. The last variable that significantly determined food price inflation in Indonesia is the volatility of food price inflation itself. This fact is established by the study of Hyeon & Chin (2012) that found a significant correlation between inflation and its volatility. In the inflation literature, there is a well-known proposition that a rise in inflation increases uncertainty about future inflation. This fact is one of reasons several central banks are using inflation-targeting as one of the strategic tools in controlling the volatility.

In another study by Ismaya and Anugrah (2018) a deeper analysis was made about food inflation. The researchers analyses the determinants of food inflation at the commodity group level, which are agricultural, livestock, and fishery commodities. From the study, they found that expectation (backward-looking and forward-looking expectations) is significant in affecting inflation in the above commodity groups but with different intensities. For agricultural commodities, backward-looking expectation is more critical than forward-looking expectations; for agriculture, livestock and fishery commodities, forward-looking expectations has more impact on inflation than backward-looking expectation. The study also found that production level and credit are significant in causing the reduction of food price in all commodity groups. Import also is significant in causing the reduction in food price but only with regard to livestock commodities.

5. Conclusion and Policy Recommendation

This study tries to evaluate the determinants of headline, core and food inflation in Indonesia. From the empirical results, we find that broad money over GDP (M2Y) as a representative variable of demand positively and significantly influences both head and core inflation in the long term. In the short term, headline inflation is significantly determined by IPI, beef production and seasonal events (Ramadhan). Meanwhile, some variables, such as backward-looking expectation, global gold price, rice production and asphalt road, are not significant even though their signs are correct. Core inflation is significantly affected by inflation expectations, IPI, fuel prices, global gold prices, exchange rates and school enrolment period in the short term.

In the model of volatile food inflation, we find that food price inflation is significantly determined by both backward-looking and forward-looking expectations. Both variables prove that expectation is an important factor of volatile food inflation. Interestingly, we also find that both climate change and seasonal event variables are significantly related to food price inflation. Those variables are cyclical factors which can influence the price of foodstuff. The other factors that are significantly linked to food price inflation are food production, irrigation, agricultural import, narrow money, fuel price, and credit to the agricultural sector.

Based on our findings, inflation is not only influenced by demand side, but also by supply side, such as food production, rice production, and irrigation. Therefore, we need to improve the supply-side factors. For example, we can improve agricultural productivity by applying appropriate technology and building agricultural infrastructure, especially water supply infrastructure (irrigation). Since the study shows that climate change has a significant effect on food supply and inflation, the government should formulate an appropriate mitigation plan to alleviate the adverse effects of climate change, especially on food inflation.

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Chapter 5

INFLATION PERSISTENCE IN MONGOLIA

By

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1. Introduction

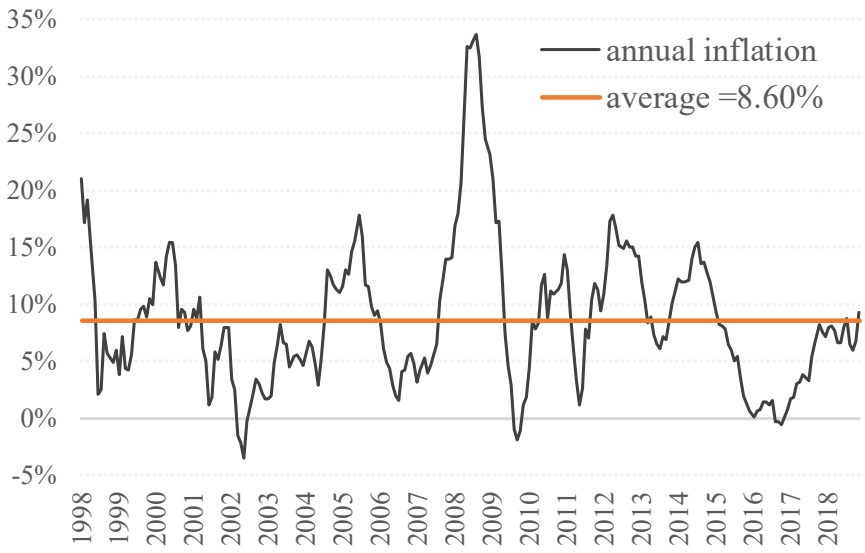
A degree of inflation persistence is one of the most important characteristics of the dynamics of inflation. It is related to how quickly inflation reverts to its initial level after a shock. When the persistence is high, the policy efficiency is low, thus it making it harder for the Central Bank to fight the inflation.

The purpose of this paper is to empirically analyze the degree of inflation persistence in Mongolia using the aggregate price index, group level price indices and individual commodity prices. We will study whether there are any changes in the persistence across different monetary policy regimes and across the CPI subcomponents. It is also informative to study the persistent properties of inflation in the disaggregate level to assess the true degree of persistence without the aggregation bias as the aggregation process itself could lead to spuriously high estimates of aggregate inflation. The research result would be useful information for parameter calibrations of DSGE (in process of development) and semi-structural models of Mongolia as well as other policy analysis.

It is hard to define an inflationary process in Mongolia because we had officially liberalized prices at the beginning of the 1990s and started to measure inflation in 1991.

Figure 1

Annual CPI Inflation of Mongolia



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Right after liberalization, we experienced a hyperinflation episode, and the average and deviation of inflation were very high. That is why we have decided to use data on consumer price indices and individual prices between 1998 and 2018. The annual growth rate of consumer prices in Mongolia is plotted in Figure 1. During this period, various shocks influenced the inflation rate and pushed it away from its long-run mean. Most frequent examples include oil and commodity price shocks, strong exchange rate movements, adverse weather conditions and animal loss, the cash changeover and fiscal measures such as VAT changes. Inflation is also strongly influenced by the cyclical position of the economy, with periods of weak economic activity usually associated with lower inflation, and vice versa. Despite these occurrences, inflation in Mongolia appeared to have been fluctuating around a mean of 8.6% over the past two decades, as can be seen in Figure 1.

Full sample periods cover several monetary policy regimes, which are often characterized by different values of average inflation. Accounting for changes in monetary policy regimes either by restricting the sample to cover the current policy regime or by allowing for statistically significant changes in the mean of inflation, most studies arrive at the conclusion that inflation (measured as quarter-on-quarter inflation) is only moderately persistent.

The Bank of Mongolia (BoM) had a monetary aggregate targeting framework from the beginning of the 1990s to 2006 with reserve money as the operating target and M2 as the intermediate target. In view of the difficulties in conducting monetary aggregate targeting due to the ongoing re-monetization process and the volatility of the money multiplier, the Bank of Mongolia started the shift from monetary targeting policy framework to the inflation targeting from 2007. However, the economy was hit by the global financial crisis in 2008 and 2009, as well as the public debt crisis in concert with fall in commodity prices in 2016. The problems were solved with the help of IMF programs with each lasting up to 3 years. During those periods, the Bank of Mongolia was required to focus on monetary aggregate targeting once again. Moreover, in 2013-15, the Bank of Mongolia injected a huge amount of money to finance quasi-fiscal spending focused on certain sectors to support economic growth and tackle the supply-driven inflation pressures. These short-term policies accompanied by the high volatile inflation makes it difficult to identify the changes in inflation persistence due to framework shifts. These frequent regime shifts make Mongolia an ideal candidate to study the effects of changes in the monetary policy framework on the persistence of inflation. Moreover, since some of these changes were exogenous (i.e., due to the debt crisis or the repercussions of the global financial crises), concerns about the endogenous nature of shifting inflation targeting regime might be limited.

In this paper, we explore inflation persistence in Mongolia using quarterly annual inflation, starting from the aggregate inflation, down to its micro-level exploration based upon changes in the prices of commodities in the CPI basket of Mongolia. We used the following two approaches in calculating the inflation persistence: (i) the first-order autocorrelation coefficient of the inflation series, and (ii) the sum of the autoregressive coefficients (SARCs) of the inflation process. The structural break test was used to define the structural breaks and the factor decomposition was done using principal component analysis to define the idiosyncratic persistence across sectoral inflation.

The expected outcome of this research is a degree of inflation persistence measured in the case of Mongolia, from the aggregate CPI inflation, group level, and individual prices in two samples in order to draw a conclusion on the degree of persistence, whether there is any difference among subcomponents, and individual products and if the persistence has changed over time.

2. Empirical Studies on Inflation Dynamics

Barnett et al. (2012) examined the inflation dynamics in Mongolia in several aspects using an AR model, a VAR model, and the Phillips curve between 2001-2011. They concluded that the key characteristics of inflation dynamics in Mongolia are that inflation is (i) highly seasonal; (ii) not very persistent; (iii) largely independent of international price movements; and, (iv) dominated by changes in food prices, explained by supply shocks. In terms of inflation persistence, the authors examined the persistence in aggregate CPI, food CPI, administered prices and the underlying CPI (all non-food and non-administered prices). They found that the underlying inflation ($AR(1)^U$=0.56) is more persistent than the headline inflation ($AR(1)^H$=0.30) using quarter-on-quarter inflation.

Bilguun et al. (2017) investigates the duration of consumer price spells and price change patterns for Mongolia by employing a micro-level price data of 2006-2016. Their main findings are:

- Prices have gotten more rigid: The average period of prices which remained unchanged, was 3.8 months in 2006-2010 and increased to 7.7 months in 2011-2016.
- The difference among sectors: The period that price does not change has prolonged in transport, hotel, and restaurants services, while the period has shortened for food and other goods.
- Imported goods' prices change (4.6 months) faster than the domestic goods' (9.3 months).
- The probability of price remaining the same for domestic firms and importers are $\theta_d = 0.89 \; and \;\; \theta_{im} = 0.78$.

Charemza and Makarova (2009) analyze inflation persistence by decomposing it into linear and nonlinear components for 119 countries. In case of Mongolia, annual inflation of 1993-2005 is used, and the authors found that, with its lag 3, bilinear lag 1 and considering the first effect of the eigenvalue, the total inflation persistence is 0.65, a linear persistence is 0.65 and a nonlinear persistence is 0.007. When the general effect of the eigenvalue is considered, the total inflation persistence is 0.80, a linear persistence is 0.72 and a nonlinear persistence is 0.09. With longer bilinear lags, the total inflation persistence dropped slightly to 0.78.

Tillmann (2012) studies inflation persistence in headline inflation and CPI subcomponents in two samples and finds that the inflation persistence falls after the adoption of inflation targeting and a large cross-sectional heterogeneity. Gerlach and Tillman (2012) study the inflation persistence in the Asia-Pacific region and find that persistence tends to decline adopting the inflation targeting regime, but the speed of decline varies across countries. Hanif et al. (2012) estimate the inflation persistence in Pakistan using monthly data from 1959 to 2011 and find that the estimate of overall inflation is low (0.16), but of core inflation is high (0.80), and the persistence in group levels is found to be relatively higher in most cases compared to the aggregate level. Altissimo et al. (2006) studies inflation persistence and price-setting behavior in the Euro Area and finds that industrial goods and particularly services, which require a larger share of labor input, have higher persistence and energy and unprocessed food have lower persistence. This suggests that persistence in wage developments can be a cause of price stickiness.

3. Measuring Inflation Persistence

We start from simple a first-order autoregressive model of inflation and check for the significance of a positive coefficient on the AR term in the inflation series. It is the standard method to measure inflation persistence in the literature. We also used the AR(1) model to check the stability of the estimated coefficient rolling the sample by 5-years window.

$$\pi_{i,t} = c + \rho \times \pi_{i,t-1} + \varepsilon_t$$

Here $\pi_{i,t}$ is the annual inflation rates $\pi_{i,t} = 100 \times \frac{P_{i,t} - P_{i,t-4}}{P_{i,t-4}}$, ρ is the inflation persistence coefficient, c is constant and ε_t is the error term.

Then we use the sum of autoregressive coefficients (SARCs) as a measure of inflation persistence as in O'Reilly & Whelan (2005), and Gerlach & Tillmann (2012). The SARCs approximates the long-run impulse response to a unit shock. It is estimated as below with the optimal lag length selected using Akaike information criterion:

$$\pi_{i,t} = c + \sum_{j=1}^{q} \rho_j \times \pi_{i,t-j} + \varepsilon_t$$

Both approaches have pros and cons. The sum of the autoregressive coefficients could cover more dynamics of persistence compared to the AR(1) approach, but estimates of ρ obtained from least squares suffer from a downward bias as the sum of the autoregressive coefficients approaches unity.

While measuring the persistence, we need to consider structural breaks in the mean of the inflation process. When there is a break in the mean, it can create an upward bias in the estimates of persistence. We tested structural breaks using Quandt-Andrews breakpoint test and it will be adjusted by a dummy variable in the regression equation if the break is found.

Finally, the factor decomposition was done using principal component analysis to define the idiosyncratic persistence across sectoral inflation.

4. Findings on Inflation Persistence of Mongolia

In this part, we examine the inflation persistence in Mongolia using quarterly time series data of annual inflation based on the consumer price index (CPI) released by the National Statistical Office of Mongolia. We investigate inflation persistence starting from the aggregate inflation, to various group level consumer price indices, and 245 individual prices. The CPI basket changed every 5 years: In 2001 (239 products), 2006 (287 products), 2011 (329 products), and 2016 (344 products). The share of food has declined as the number of products increased. All the inflation series used in this paper are seasonally-adjusted[4]. The following analysis was made:

- Aggregate CPI inflation persistence in samples of 1998-2018, 1998-2009, 2010-2018
- Persistence of 12 subcomponents of CPI inflation in 2003-2018, 2003-2009, 2010-2018: Food, Alcoholic beverages, Clothing footwear, Housing, Furnishing, Health, Transport, Communication, Recreation, Education, Restaurants, Other services,
- 5-years rolling window for inflation persistence in aggregate level and subcomponents,

4. AR(1) has been tested on seasonally unadjusted time series of CPI and its subcomponents as well. The seasonal differences were less than 0.1, therefore we used the seasonally adjusted series in the following analysis.

- Food prices, Admin prices vs Underlying prices (nonfood non-admin prices),
- Domestic prices vs Imported prices,
- 245 individual product prices in the CPI basket,
- The common factor for 12 CPI subcomponents.

The dummy variable of 2008 was included in the estimation representing the shock of the global financial crisis as the structural break test suggested a break in 2008 (in Table X.1 of Appendix). We found that aggregate inflation persistence is 0.67 with AR(1) and 0.74 with SARCs(5) with statistical significance in the period of 1998Q1-2018Q3 (Table 1).

Table 1
Inflation Persistence of Mongolia

		Inflation (year-on-year)			Inflation (quarter-on-quarter)		
	sample	AR(1)	SARCs	Lag order	AR(1)	SARCs	Lag order
Aggregate CPI inflation	1998-2018	**0.67*** ** [0.58; 0.77]	**0.74*** ** [0.65; 0.82]	-5	**0.15** [-0.02; 0.32]	**0.15** [-0.02; 0.32]	-1
	1998-2009	**0.63*** ** [0.50; 0.76]	**0.68*** ** [0.56; 0.80]		**0.06** [-0.16; 0.28]	**0.06** [-0.16; 0.28]	
	2010-2018	**0.81*** ** [0.65; 0.96]	**0.89*** ** [0.72; 1.06]		**0.34** ** [0.06; 0.61]	**0.34** ** [0.06; 0.61]	
Food inflation	2000-2018	**0.65*** ** [0.53; 0.77]	**0.67*** ** [0.52; 0.82]	-6	**-0.01** [-0.19; 0.17]	**-0.01** [-0.19; 0.17]	-1
	2000-2009	**0.61*** ** [0.43; 0.78]	**0.41** ** [0.14; 0.68]		**-0.07** [-0.31; 0.17]	**-0.07** [-0.31; 0.17]	
	2010-2018	**0.75*** ** [0.56; 0.93]	**0.87*** ** [0.66; 1.09]		**0.14** [-0.15; 0.43]	**0.14** [-0.15; 0.43]	
Oil inflation	2000-2018	**0.54*** ** [0.40; 0.67]	**0.58*** ** [0.43; 0.74]	-5	**0.13** [-0.07; 0.32]	**-0.11** [-0.38; 0.16]	-2
	2000-2009	**0.52*** ** [0.33; 0.71]	**0.46*** ** [0.19; 0.74]		**0.09** [-0.20; 0.37]	**-0.04** [-0.34; 0.25]	
	2010-2018	**0.58*** ** [0.34; 0.82]	**0.78*** ** [0.47; 1.09]		**0.16** [-0.14; 0.46]	**0.30** [-0.04; 0.64]	
Inflation exc. food, oil	2000-2018	**0.81*** ** [0.72; 0.90]	**0.81*** ** [0.71; 0.91]	-6	**0.23** ** [0.08; 0.38]	**0.23** ** [0.08; 0.38]	-1
	2000-2018	**0.75*** ** [0.62; 0.88]	**0.64*** ** [0.45; 0.82]		**0.12** [-0.08; 0.32]	**0.12** [-0.08; 0.32]	
	2010-2018	**0.88*** ** [0.75; 1.01]	**0.87*** ** [0.73; 1.01]		**0.42*** ** [0.17; 0.68]	**0.42*** ** [0.17; 0.68]	

*, **, *** indicate significance at 10%, 5% and 1%, respectively.

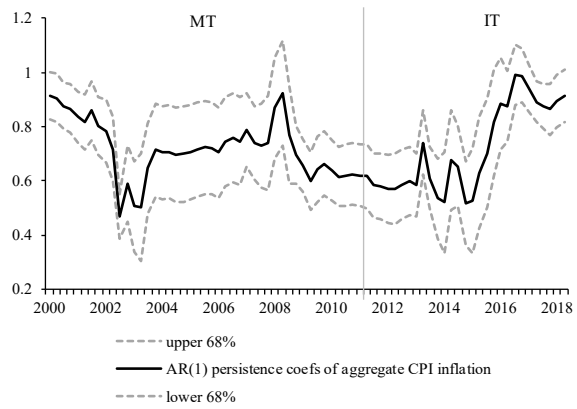
When measured by quarter-on-quarter inflation, the persistence is only significant for inflation excluding food and oil prices and it is much lower (0.23) than the estimate of year-on-year inflation (0.81). This is due to a strong seasonality in the economy. The prices fluctuated as the economic activities and production boosted in second and third quarters, and stagnated in the first and fourth quarters, in line with seasonal weather conditions. Food q-o-q inflation has no significant persistence. Most of the food staff are non-processed, such as meat, milk products, and vegetables, and their prices have strong seasonal volatility within the year. In other words, supply-driven factors are the main source of that seasonal volatility; and their second around effect is small enough to help quarter-on-quarter inflation persistent to be very small in Mongolia. Nevertheless, the estimate of q-o-q inflation is consistent with the finding of Barnett et al. (2012).

Then the analysis of annual inflation was done for two subsamples: 1998-2009, and 2010-2018. The sample length has been selected in line with the Bank of Mongolia's shift to an implicit inflation targeting framework. The aggregate inflation persistence (0.81-0.89) in 2010-2018 is higher than one (0.63-0.68) in 1998-2009. It suggests that the inflation persistence has increased since 2010 compared to before. There can be various reasons for high inflation persistence. Some of the reasons of inflation persistence reported in the literature on other countries include: A higher proportion of firms setting prices backward-looking, non-cooperation in monetary and fiscal policies, persistence in the cost-push inflation, discretionary monetary policy, and imperfect credibility of the central bank. We think that the shift in inflation targeting framework was only recent and not fully fledged. This "intermittent" policy framework was accompanied by other domestic factors including the huge amount of quasi-fiscal spending financed by the BoM between 2012-2016, the prolonged loose stance of fiscal policy during 2008-2018, and the wide spread cash hand out starting from 2010, thus limiting the room for inflation persistence to decline. And high persistence could also be due to external shocks hitting Mongolia and became more persistent in recent years as the economy's dependence on foreign trade increased.

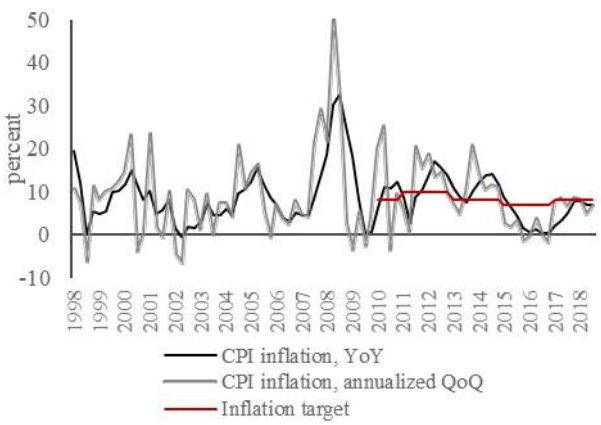
Then we measured the inflation persistence for volatile items such as food, oil separately from non-food, non-oil inflation. We can see that the food and oil inflations have lower persistence than the underlying (non-food, non-oil) inflation but the difference is not statistically significant (the values lie within the confidence bands in Table 1). To understand how the persistence dynamic changed over time, we did 5-years rolling window estimation of inflation persistence below.

Figure 2

Inflation persistence, 5-years roll over



CPI inflation, YoY vs annualized QoQ



Inflation persistence has been quite volatile over time mostly due to large volatilities in inflation and economic instability (Figure 2). Between 2008-2014, inflation persistence had a downward trend. Then it bounced back in 2016 due to the inflation stagnation and economic difficulty in Mongolia resulting from the public debt refinancing problem.

Table 2
Inflation Persistence of CPI Subcomponents and Groups, SARCs, 2003-2018

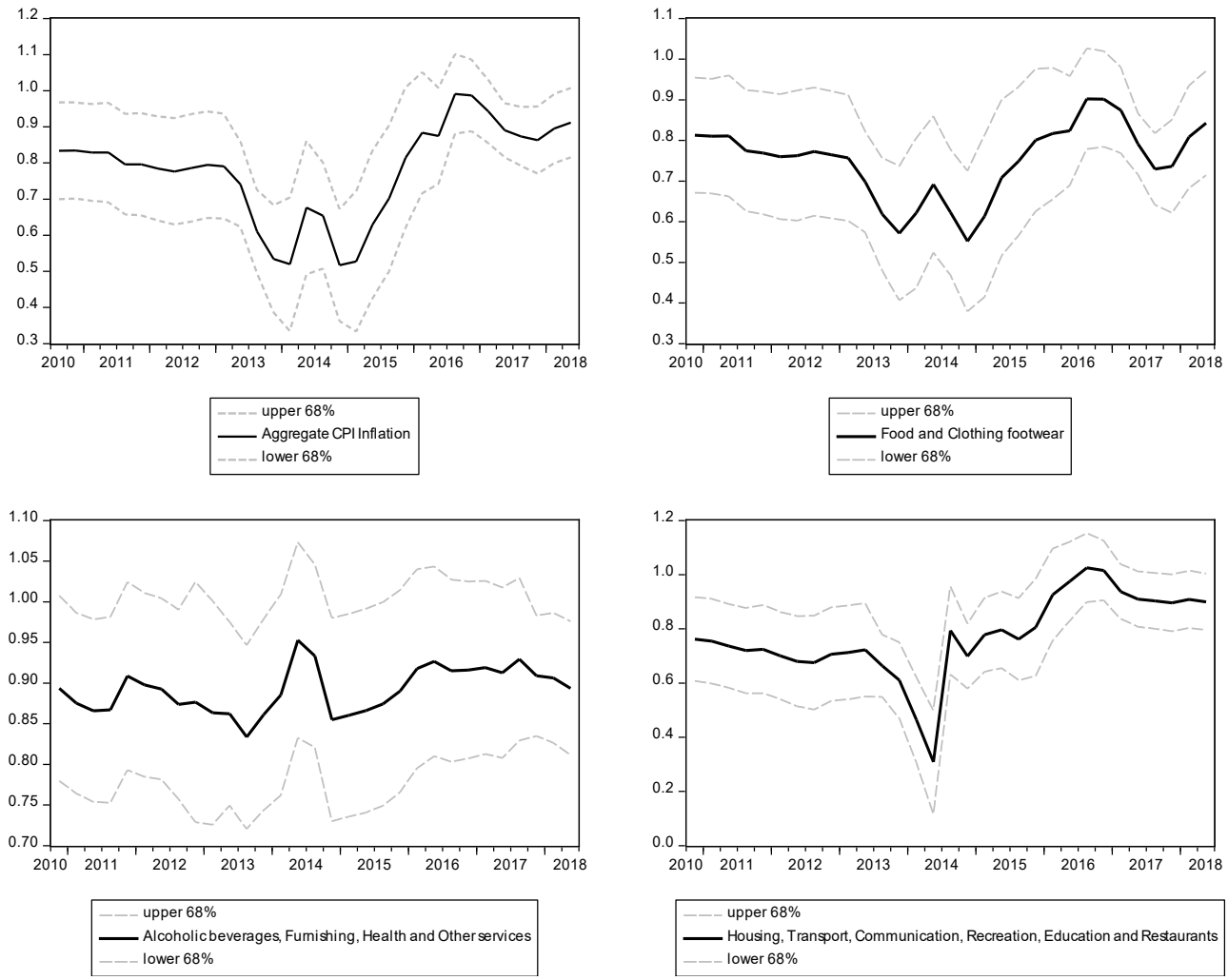
		2003-2018		2003-2008		2009-2018	
CPI components	weight	SARCs coef	confidence band 68%	SARCs coef	confidence band 68%	SARCs coef	confidence band 68%
Food	27%	**0.80**	[0.65,0.95]	**0.66**	[0.31,1]	**0.74**	[0.56,0.91]
Alcoholic beverages	6%	**0.77**	[0.67,0.87]	**0.78**	[0.56,0.99]	**0.73**	[0.58,0.87]
Clothing, footwear	13%	**0.92**	[0.82,1.02]	**1.16**	[0.21,2.11]	**0.94**	[0.81,1.06]
Housing	10%	**0.55**	[0.4,0.7]	**0.46**	[0.04,0.89]	**0.49**	[0.33,0.66]
Furnishing	4%	**0.84**	[0.76,0.91]	**0.91**	[0.78,1.04]	**0.79**	[0.68,0.9]
Health	3%	**0.83**	[0.73,0.94]	**0.92**	[0.71,1.14]	**0.79**	[0.67,0.9]
Transport	15%	**0.68**	[0.55,0.8]	**0.68**	[0.55,0.8]	**0.68**	[0.55,0.8]
Communication	5%	**0.74**	[0.62,0.86]	**0.73**	[0.5,0.96]	**0.73**	[0.56,0.91]
Recreation	3%	**0.50**	[0.28,0.72]	**0.42**	[-0.16,1]	**0.35**	[0.11,0.59]
Education	5%	**0.81**	[0.69,0.93]	**1.26**	[0.83,1.7]	**0.78**	[0.62,0.94]
Restaurants	4%	**0.82**	[0.71,0.94]			**0.79**	[0.68,0.9]
Other services	5%	**0.74**	[0.61,0.88]	**0.55**	[0.05,1.05]	**0.78**	[0.62,0.93]
Imported goods	40%					**0.78**	[0.68, 0.88]
Domestic goods	60%					**0.72**	[0.57, 0.87]
Common factor		**0.83**	[0.75, 0.91]	**0.88**	[0.56, 1.19]	**0.82**	[0.73 0.91]

Among the subgroups, the recreation, housing, and transportation sectors have the lowest persistence while clothing footwear, education, restaurants, and furnishing have the highest persistence (Table 2). In general, cross-sectional heterogeneity is not large for the entire sample except for 2 groups, recreation, and housing. 10 subgroups of CPI inflation show a persistence within the interval of 0.68-0.92. Housing group (including the electricity, water supply, monthly rental, and maintenance services) prices are mostly unchanged, but when it changes, the price doubles or triples, thus it is rather understood as a shock than a persistence. Imported goods have higher persistence (0.78) than the domestic goods and services (0.72) whereas Bilguun et al. found that $\theta_{imported} = 0.78, \theta_{domestic} = 0.89$. Clothing, footwear, and education groups have persistence higher than 1 in the sample of 2003-2008 due to persistent increase during the GFC[5]. The weighted average persistence of CPI groups is 0.76 for 2003-2018. Comparing two samples in Table 2, the persistence increased in food, housing, services sectors and decreased in other sectors. But the weighted average persistence of CPI groups is the same (0.73 for both 2003-2008 and 2009-2018).

5. The dummy variable of 2008 was not included in the group level estimations.

To illustrate the behavior of the persistence measure over time, we next estimate the model using a moving 5-year window shown in Figure 3. Similarly-patterned sectors have been combined in the same figure[6]. The food, clothing, and footwear groups' persistence have similar patterns to the aggregate inflation persistence dynamics. The inflation persistence of alcoholic beverages, furnishing, health, and other services groups remained stable since 2015. But inflation persistence of housing, transport, communication, education, recreation, and restaurants groups increased in 2013-2016 which is consistent with Bilguun et al. (2017) findings that these sectors have become more rigid in recent years. The persistence of food, clothing and services inflation increased since 2014 resulting in a higher persistence in aggregate inflation. This could be due to the fact that supply driven shock such as meat price shock was reduced after the Price Stabilization Program.

Figure 3
Inflation Persistence of CPI Subcomponents, 5-Year Rolling Window With 68% Confidence Band



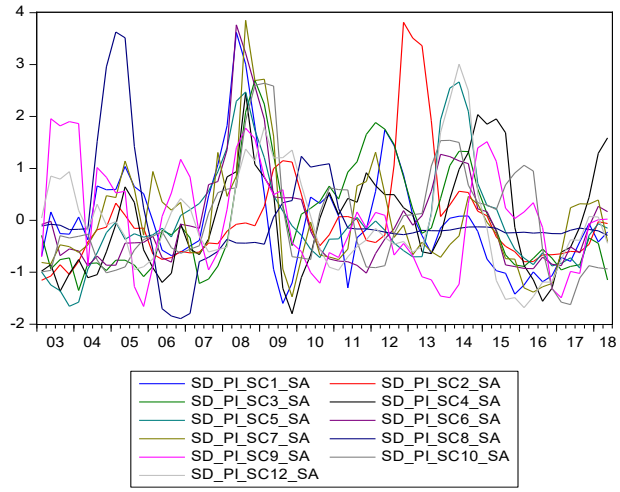
To see the role of common shocks for the evolution of persistence, we decomposed disaggregate inflation rates into a common and a sector-specific component. The common factor was estimated and found using the principal component analysis for 12 sectoral inflation rates (Figure 4). The

6. Persistence dynamics of 12 subgroups are provided in Appendix.

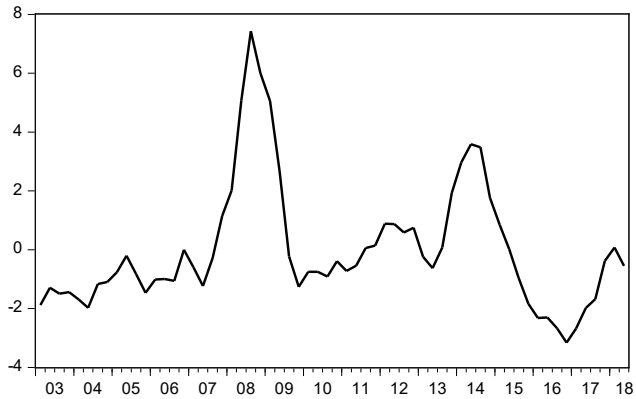
common factor is driven by aggregate shocks to the economy such as monetary policy shocks, aggregate demand, or aggregate technology shocks. Sector-specific technology or demand shocks could be responsible for the variation in the idiosyncratic components. The persistence of common factor was estimated using SARCs model with an optimal lag of 5 as 0.83 for 2003-2018 and remained the same in recent years (0.82 for 2009-2018) with statistical significance. In general, high persistence in the common factor is driving the aggregate level up. It suggests less persistent aggregate shocks are the key to a decline in the persistence of headline inflation.

Figure 4

Normalized Inflation Series For CPI 12 Subgroups

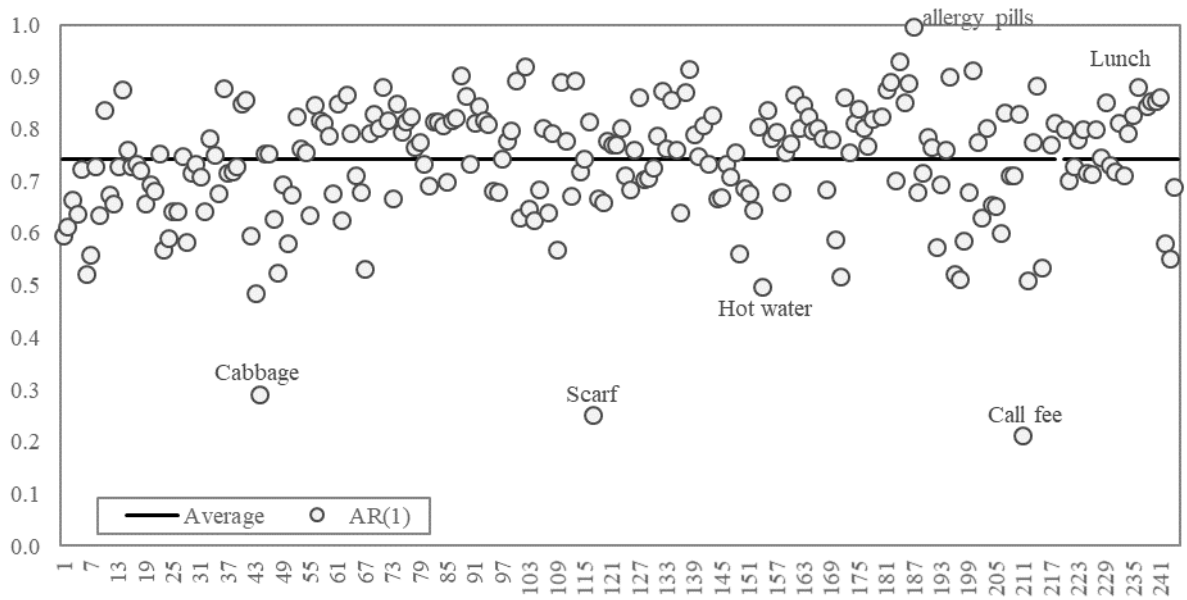


Common Factor across CPI Subcomponents



We were able to chain 245 products' time-series for the estimation in 2006-2018. These products represent 84.1% of the latest CPI basket.

Figure 5
AR(1) Persistence for Individual Price Inflation (2007-2018)



The inflation persistence of 245 individual prices, estimated by AR(1), mostly ranges between 0.6-0.9 with the average persistence of 0.74. The weighted average of persistence of 245 prices is 0.72, not so far from the simple average. The products with the lowest persistence are the cabbage (0.36), scarf (0.28), hot water (0.45) and call fee (0.21) while the product with the highest persistence was allergy pills (1.00), lunch (0.93), some clothing and services. The finding is consistent with Altissimo et al. (2006) that services and industrial goods tend to have higher persistence due to labor intensity. The low persistence of a call fee was due to a one-time 80% decline in the price in 2006. The micro-level averaging 0.72-0.74 is closer to the estimate of aggregate inflation persistence suggesting that there is no aggregation effect in Mongolian CPI. However, we are not able to tell for sure since disaggregated commodities are not representative of the whole CPI basket (only 84% of it).

5. Conclusion

In this paper, we estimated inflation persistence in Mongolia using quarterly time series of annual inflation based on the consumer price index (CPI), various group level consumer price indices, and 245 individual prices. We found that the degree of aggregate inflation persistence of annual inflation in Mongolia is 0.7 and the persistence has increased since 2010. We think that high persistence in aggregate CPI is due to backward-looking price-setting behavior of the firms, recent policy framework change and also due to both domestic and external factors, which have most likely affected inflation dynamics during the latter part of the full sample period. We propose a further investigation of a comprehensive survey at the micro-level to explore defined reasons for the increase in inflation persistence in Mongolia. The (core) inflation excluding food and oil prices has higher persistence than food and oil inflation. And inflation excluding food and oil prices is found to be only significant, but with very low persistence (the estimated result is 0.2) when measured by q-o-q inflation. At the group level, the persistence is high in services, clothing, footwear, and furnishing. It is low in housing, transport, and recreation. Cross-sectional heterogeneity is not large and it is strongly affected by a persistent common factor. Imported goods' inflation is more persistent than domestic goods. At the product level, the persistence is high for some of services, clothing, medicine, and processed foods. It is low for some vegetables, coke, fuels, utility bills etc. The micro-level averaging of persistence is closer to the estimate of aggregate inflation persistence.

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Appendix

Figure X.1 Inflation Persistence, 5-Year Rolling Window with 68% Confidence Bands

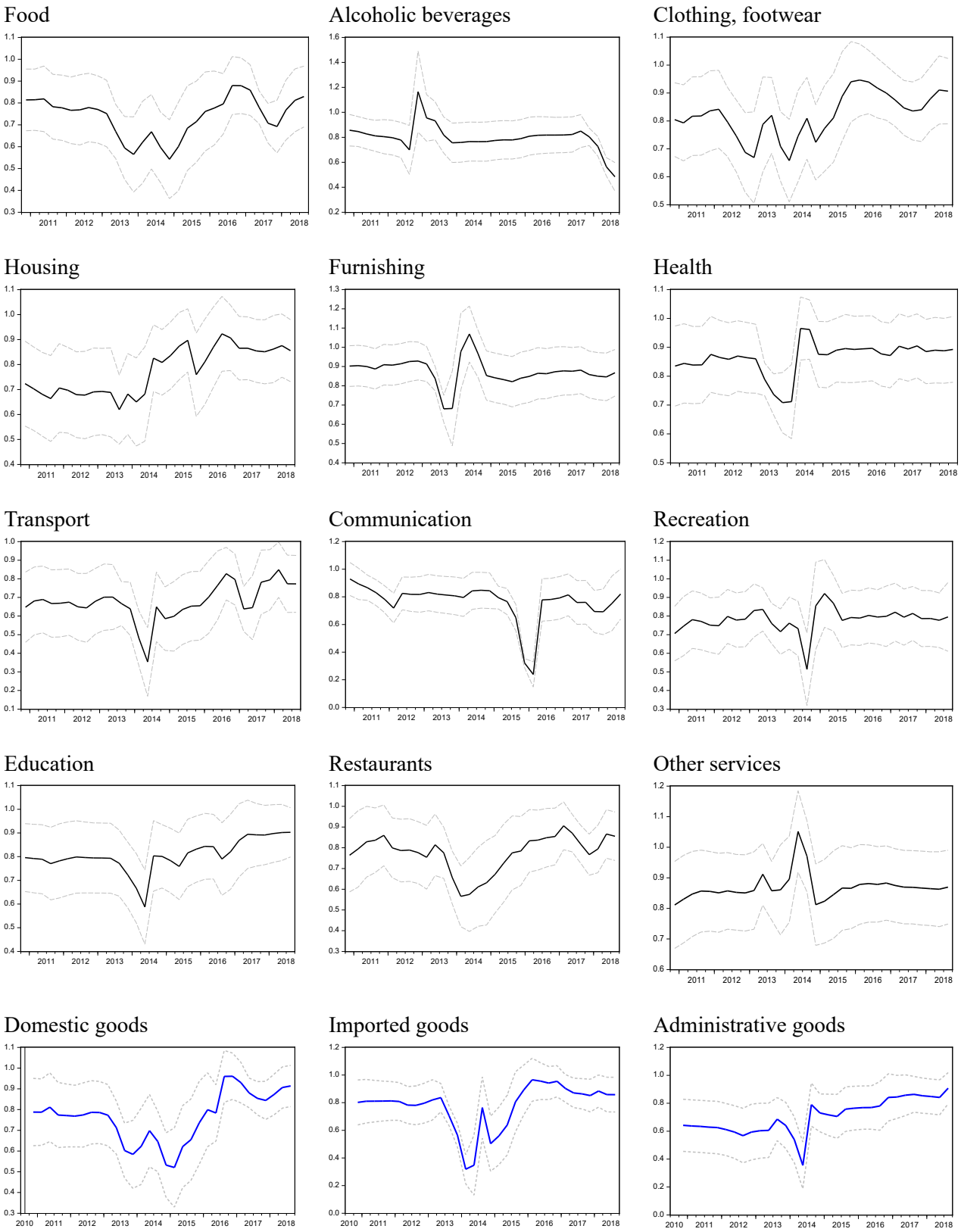


Figure X.2 Inflation Dynamics and Its Subcomponents

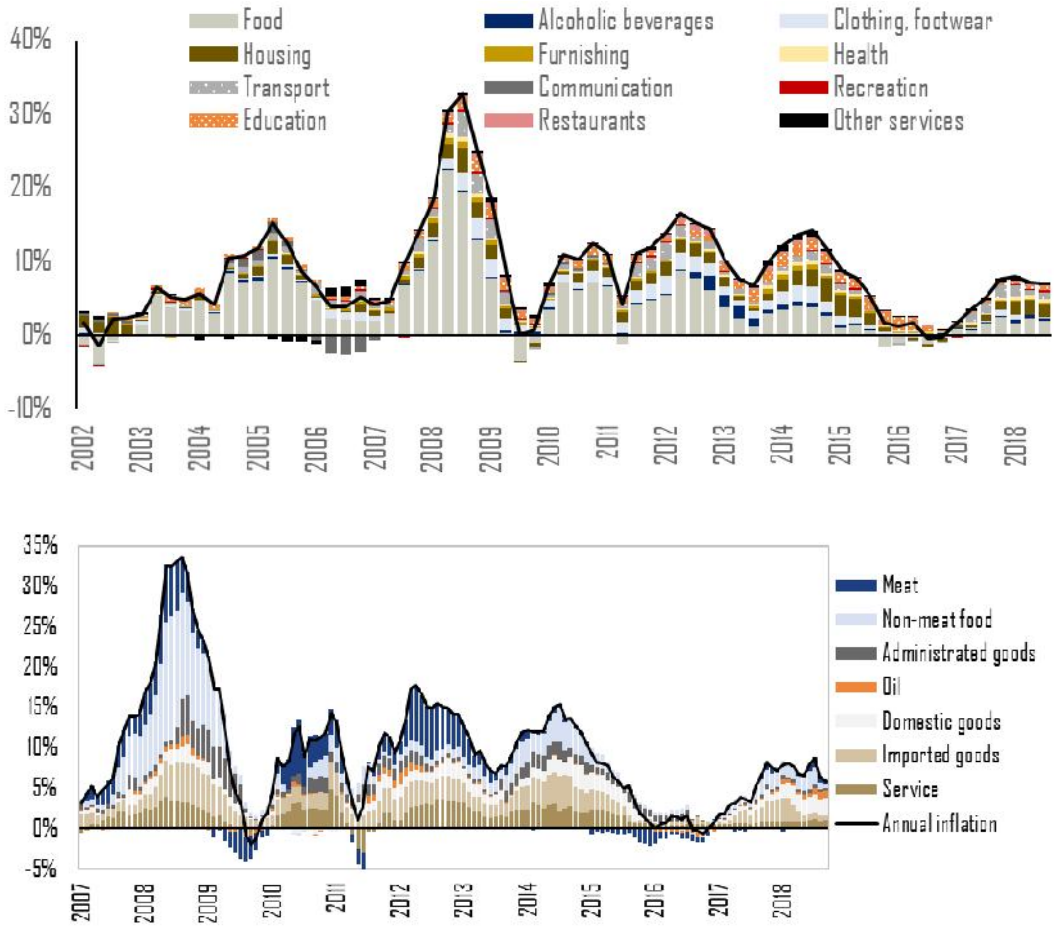


Table X.1 Quandt-Andrews Unknown Breakpoint Test

Aggregate CPI inflation, YoY

Quandt-Andrews unknown breakpoint test
Null Hypothesis: No breakpoints in 15% trimmed data
Varying regressors: All equation variables
Equation Sample: 1998Q1 2018Q3
Test Sample: 2001Q2 2015Q3
Number of breaks compared: 58

Statistic	Value	Prob.
Maximum LR F-statistic (2002Q2)	2.941028	0.4278
Maximum Wald F-statistic (2002Q2)	5.882056	0.4278
Exp LR F-statistic	0.849869	
Exp Wald F-statistic	1.919146	
Ave LR F-statistic	0.2491	
Ave Wald F-statistic	0.1964	

Note: probabilities calculated using Hansen's (1997) method

Aggregate CPI inflation, annualized QoQ

Quandt-Andrews unknown breakpoint test
Null Hypothesis: No breakpoints in 15% trimmed data
Varying regressors: All equation variables
Equation Sample: 1998Q1 2018Q3
Test Sample: 2001Q2 2015Q3
Number of breaks compared: 58

Statistic	Value	Prob.
Maximum LR F-statistic (2004Q4)	3.712166	0.2531
Maximum Wald F-statistic (2004Q4)	7.424332	0.2531
Exp LR F-statistic	1.155337	0.1287
Exp Wald F-statistic	2.623455	0.0921
Ave LR F-statistic	1.900132	0.0943
Ave Wald F-statistic	3.800263	0.0943

Note: probabilities calculated using Hansen's (1997) method

Chapter 6

MAIN DRIVERS OF INFLATION IN MYANMAR (1990-2017)

By

Hnin Htet Htet Win[1]

1. Introduction

1.1 Background

Inflation is one the most important macroeconomic indicators for economists and policy makers interested in the implication of monetary policy.

In Myanmar, the inflation rate has been fluctuating during the period 1990 to 2017 due to the changes in the economic system. There are two obvious economic changes in Myanmar. In 1990, the government changed the economic system from a planned economic system to a market oriented one. In 2012, as the new democratic government opened up the national economic system more and more, the inflation rate consequently became quite high for some time. Compared to the annual GDP growth rate, the annual inflation rate had been volatile during the period of study from 1990 to 2017. The annual inflation and GDP growth rate are shown in Figure (1.1).

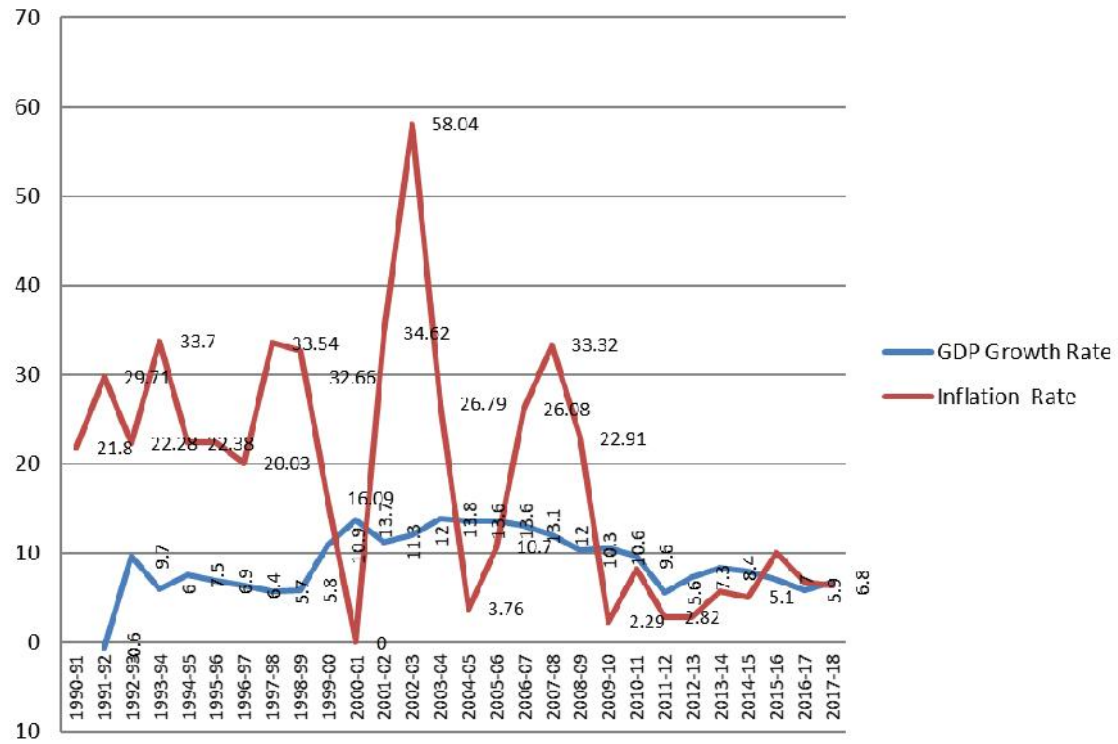
To understand the nature of inflation in Myanmar, we will consider both external and internal factors. Oil price is one of the important external factors which can affect the cost of production and import price in the domestic economy. The world's major oil production countries are located in the middle eastern region and the geographical instabilities that happened in that region caused the oil price shocks and consequently other oil importing countries suffered the impact of oil price increases.

The domestic factors which have a strong impact on inflation usually include money supply, budget deficit and GDP. Various empirical studies have analyzed the determinants of inflation by using both external and domestic factors in different countries and revealed several results.

By finding out the potential factors which are the root causes of high inflation, the policy makers can draw up the appropriate policy decisions more easily for better management of the economic condition. In this study, I will analyze the relationship between inflation and the oil price in Myanmar by considering other important domestic factors such as real GDP growth rate, unemployment rate, money supply and budget deficit.

1. Assistant Director, Research and Statistics Department, Central Bank of Myanmar.

Figure 1.1
Annual Inflation Rate and GDP Growth Rate in Myanmar (1990-2017)



1.2 Research Objective and Questions

The objective of this paper is to investigate the relationship between inflation and oil price and unemployment rate. We focus on the following research questions:

1. Does oil price matter for inflation in Myanmar?
2. What is the role of domestic factors in inflation in Myanmar?
3. Is the Philips Curve alive and well in Myanmar?

The Philips Curve is a hypothesis introduced by the William Phillips. The Phillips hypothesis proposes that there is negative trade-off relationship between inflation and unemployment rate. The assumption of Phillips is important in monetary policy implementation. One of the main responsibilities of a central bank is to maintain price stability with a low and stable inflation rate in an economy. Due to the inverse correlation between the inflation rate and unemployment rate, central banks can maintain a low inflation only by giving up the lower level of unemployment rate. Thus, central banks have a difficult condition in the implementation of monetary policies, having to juggle the combination of low inflation rate and high employment rate.

1.3 Research Methodology and Data

This paper uses changes in consumer price index as a proxy of inflation. We will use the growth rate of oil price to study the external effect on the domestic price. We also take into account other important variables such as real GDP growth, money supply and budget deficit. We include money supply to account for the role of monetary policy in determining the inflation of an economy. We also include real GDP to show the relationship between the economic growth and inflation in

Myanmar. Moreover, we include the budget deficit in the analysis to show the impact of government expenditure on price setting in Myanmar. This study covers the period 1990 to 2017 and applies the OLS regression model.

In Myanmar, money supply plays an important role for policy makers in implementing monetary policy rather than the management of interest rate policy. Policy makers usually try to increase or decrease liquidity in the economy with the aim to stimulate the economy and manage inflation.

This paper is organized in five sections: Section 2 reviews previous studies; Section 3 describes the data and methodology; Section 4 presents and discusses the empirical results. Finally, Section 5 summarizes and concludes the study.

2. Literature Review

This section summarizes selected literature review on the relationship between inflation and potential factors which cause inflation.

2.1 Theoretical Literature on Inflation

There are numerous theories on inflation. Among them, the two most popular theories are the demand-pull inflation and cost-push inflation. The demand-pull inflation comes from the increase in the demand side. The basic causes of demand-pull inflation include increase in money supply, increase in government purchase and so on. When there is an increase in demand side excess rather than the increase in the supply side, the country's overall price level will increase and thus this situation will lead to inflation.

Cost-push inflation happens due to an increase in the price level associated with a decreasing aggregate supply. For example, a rise in the cost of raw materials used in the production process will push the firms or producers to raise the price of their products to compensate for increased production costs. Ball (2007) stated that the main factors which may cause cost push inflation are as below:

- A rise in prices of non-labor inputs, such as oil prices;
- An increase in interest rates (increasing the cost of borrowing, which is also an input price);
- Increase in wages;
- An increase in indirect taxes, such as a value-added tax or import duties or the removal of subsidies; and
- An increase in the price of imported raw material due to changes in exchange rates, international commodity prices or external shocks.

The concept of the relationship between unemployment and inflation is another well-known theory to explain wage and inflation. Phillips (1958) found an inverse relationship between inflation and unemployment, which is also called the Phillips Curve. The empirical analysis of the Phillips Curve finds that there is a negative relationship between inflation and unemployment for the short-run. However, there are some studies which counter the concept of the Phillips Curve for the long-run. Friedman (1968) challenged the validity of the Phillips Curve and showed that the long-run Phillips Curve is vertical as the unemployment rate always returns to its natural rate in long-run.

2.2 Empirical Literature on Inflation

Several country studies, and cross-country studies have been carried out to investigate the impact of oil price on inflation. According to Blanchard and Gali (2007), the strong relationship between oil price and consumer inflation in the 1970s can be explained by two episodes, i.e. low growth, high unemployment and high inflation. However, after 1980, there are many empirical studies which find that there is a weak association between oil price and inflation. Evans and Fisher (2011) found no evidence of oil price pass-through effect on core inflation (inflation exclude food and energy prices). Hooker (2002) studied inflation for the sample year 1962-1980 and 1981 -2000. The results showed that oil price had a significance impact on inflation in the first sample period but not in the later sample period. Nogc et al. (2017) analyzed the effect of oil price on the economy of Vietnam for the period 2000-2005 and the results showed that there is a positive and strong relationship between oil price and inflation.

With regard to the association between inflation and unemployment rate, numerous studies found various evidences. Samuelson and Solow (1960) studied the Phillips Curve by using the data of US and the results supported the Phillips hypothesis that there is a negative relationship between unemployment and inflation. However, Islam et al. (2003) examined the Phillips hypothesis for the US from 1950 to 1999 and the results showed that there is a weak association between inflation rate and unemployment rate.

3. Data and Methodology

3.1 Data

We used annual data for the period of 1990 to 2017. To access the changes in the overall price level, we apply the percentage change of the consumer price index. Regarding the external impact on domestic price behavior, we employ the growth rate of global oil prices. In addition, we use the unemployment rate to study the concept of the Phillips Curve. We also control the other macroeconomic variables namely the money supply, real GDP growth, and the budget deficit, which are likely to affect inflation in Myanmar. Data on the world oil price is obtained from the macrotrends.net website, while the data on inflation is collected from the World Bank. Data on real GDP growth is collected from the Central Statistical Organization of Myanmar. For money supply and the budget deficit, we use data from the Central Bank of Myanmar and the Budget Department. Tables 3.1, 3.2 and 3.3 present a brief description of the definition, sources and descriptive statistics of the variables used in our empirical analysis.

3.2 Empirical Model

We estimate the following simple regression model for the inflation in Myanmar:

$$\mathrm{Inf}_t = \beta_0 + \beta_1 \Delta \mathrm{OP}_t + \beta_2 \mathrm{UE}_t + \beta_3 \Delta \mathrm{RGDP}_t + \beta_4 \Delta \mathrm{MS}_t + \beta_5 \mathrm{BD}_t + \varepsilon_t$$

where Inf_t is inflation rate of Myanmar at the time t, $\Delta \mathrm{OP}_t$ represents global oil price growth rate, UE_t is the Unemployment Rate, $\Delta \mathrm{RGDP}_t$ is real gross domestic product growth rate, $\Delta \mathrm{MP}_t$ is change in money supply and BD_t is the Budget Deficit (% of GDP) and ε_t is an error term.

For the estimation methodology, we apply the Ordinary Least Square regression model to examine the relationship between inflation, the oil price and the unemployment rate.

Table 3.1
Summary of the Variables and Data Sources

Variable	Description	Source
Inf	Inflation (% change in Consumer Price Index)	World Bank
Oil Price	WTI Oil Price Growth Rate	www.tradingeconomics.com
Unemployment Rate	Unemployment, total (% of total labor force)	World Bank's WDI
Real Gross Domestic Product	Real Gross Domestic Product	Myanmar's Statistical Organization
Money Supply	M2	Central Bank of Myanmar
Budget Deficit	% of GDP	Budget Department

Table 3.2
Descriptive Statistics and Correlation of the Variables (All Samples)

Variable	Obs	Mean	Std. Dev.	Min	Max
Inflation	29	18.065	13.969	-1.620	58.04
Global Oil Price	28	9.407	38.399	-53.517	112.191
Unemployment Rate	25	3.652	1.077	0.800	4.170
Real GDP Growth	28	8.692	3.572	-0.651	13.844
Money Supply Growth	27	29.333	9.298	11.280	47.350
Budget Deficit (% of GDP)	28	4.675	1.671	1.200	8.400

Table 3.3
Correlations

	Consumer Price Index	Global Oil Price Growth	Unemploy-ment Rate	Real GDP Growth Rate	Money Supply Growth	Budget Deficit
Inflation	1.000					
Global Oil Price Growth	-0.224	1.000				
Unemployment Rate	0.267	0.426	1.000			
Real GDP Growth Rate	0.133	0.290	0.372	1.000		
Money Supply Growth	-0.258	0.022	0.357	0.3442	1.000	
Budget Deficit	0.112	0.215	0.104	0.3848	0.505	1.000

4. Empirical Results and Discussion

To investigate the relationship between inflation, oil price and unemployment rate, this study uses the simple OLS regression model for the period 1990-2017. The results are presented in Table 4.1 and they generally indicate that oil price cannot stimulate the overall price in Myanmar. Moreover, the Philips Curve is not evident in Myanmar for the period of study. There is a strong positive relationship between the budget deficit and inflation. The results show that there is no significant relationship between real GDP growth rate and inflation but there is negative correlation between money supply and inflation in Myanmar.

Table 4.1
The Result of OLS Regression Estimation

Dependent Variable: Inflation	
	Inflation
Global Oil Price Growth	-0.038 (0.075)
Unemployment Rate	6.285* (3.042)
Real GDP Growth	-0.247 (1.087)
Money Supply Growth	-0.939* (0.366)
Budget Deficit (% of GDP)	3.568** (2.036)
_Cons	-1.841 (13.399)
Number of observations	28
Number of time periods	30
Robust standard errors are in parentheses	
***p<0.01, **p<0.05, *p<0.1	

5. Conclusion

This Section summarizes the results of empirical analysis. The following research questions were investigated to find out whether external and internal factors have impact on inflation and to develop policies to enhance price and economic sustainability through better financial management:

1. Does oil price matter for inflation in Myanmar?
2. What is the role of domestic factors in inflation in Myanmar?
3. Is Philips curve alive and well in Myanmar?

The analysis results indicate that the global oil price used as a proxy for the external factor has no significant impact on inflation in Myanmar. Among the domestic factors, the budget deficit is one of the main drivers of inflation. During the period of study, there are two political turning points in 2012 and 2015 in Myanmar. In 2012, the new Democratic Government took over political power and implemented some development plans by increasing government expenditure. The current government led by the National League of Democracy Party has also endeavored to implement development and infrastructure projects since becoming the newly elected government in 2015. Therefore, due to these efforts, the budget deficit might have caused inflation in Myanmar. This study finds that there is a negative relationship between money supply and inflation. In Myanmar, the interest rate is quite high and thus most people prefer to save their money in banks. However, banks are not able to lend out deposits due to the high borrowing costs. At the present time, the Central Bank of Myanmar is making deposit auctions frequently to manage the excess liquidity of private banks. Therefore, due to some weaknesses in the banking sector, there may be a negative correlation between money supply and inflation in Myanmar.

5.1 Limitation of the Study

This study analyzes the relationship between oil price, unemployment rate and inflation in Myanmar by using the annual data for the period 1990 to 2017. However, this study has some limitations.

1. This study focuses on the short period from 1990 to 2017 by using simple regression model. It may be better if the analysis is for a longer period and uses one of the time series model.

2. This study approach inflation by only using the consumer price. It might be better if both core inflation and headline inflation data are used to measure the price setting behavior.

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Chapter 7

DYNAMIC IMPACTS OF GLOBAL OIL AND FOOD PRICE SHOCKS ON INFLATION IN PAPUA NEW GUINEA

By
Eli Direye[1]

1. Introduction

Since the early 2000s, international commodity prices have generally increased due to strong global demand underpinned by rapid industrialisation and an increase in per capita income in emerging economies (Cecchetti & Moessner, 2008). Studies have found that large swings in global commodity prices have affected inflation considerably in most of the developing and emerging economies that are heavily dependent on imported energy and food (see, for example, Gelos & Ustyugova, 2012; Jongwanich & Park, 2011). While the central banks can accommodate the "first-round effects" of global crude oil and food price shocks, the development of the "second-round effects" is a matter of concern for monetary policy.

According to chapter 3 of the April 2018 edition of the International Monetary Fund (IMF) *World Economic Outlook*, inflation in the Asia-Pacific region in recent years has remained low. This finding is true for PNG since its overall inflation has subsided from over 15% in the late 1990s to around 5% in recent times (Figure 1). Nevertheless, inflation in PNG is largely driven by external factors (Aba & Vellodi, 2013), given the country's reliance on imports for most of the consumer and producer goods. With domestic food and transport expenditure groups having huge weights in the consumer basket, the first-round effects of upward swings in global oil and food prices on domestic inflation are expected to be strong. This development can have second-round effects if shocks in oil and food prices raise wage demand and core inflation (Portillo & Zanna, 2015).

Since both oil and food prices have second-round effects (Mija, et al., 2013), the relevance of their shocks on domestic inflation is an essential matter for monetary policy. It is in this context that this paper aims to examine the sensitivity of domestic inflation to global oil and food price shocks. The paper investigates the first-round and second-round effects of fluctuations in world crude oil and food prices on domestic inflation. In doing so, the paper anticipates that the findings of the research could also explain why inflation has been low in PNG in spite of the fact there were several hikes in international commodity prices recorded since 2000. It is expected that the findings

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may help the Bank of Papua New Guinea (BPNG) to understand the extent of inflationary pressures resulting from external shocks, so that appropriate policy actions can be taken to manage inflation during periods of high and volatile commodity prices.

The two econometric models that have been extensively used by earlier studies to examine the impact of world commodity price shocks on domestic inflation are the Autoregressive Distributed Lag (ADL) and Structural Vector Autoregressive (SVAR) estimation methods. Following Akcelik and Ogunc (2016) and, Jongwanich and Park (2011), the Vector Autoregressive (VAR) model is adopted by the author for the purpose of this research. The Cholesky decomposition of the covariance matrix developed by Sims (1980) is applied to identify the different shocks. The sensitivity analysis is conducted by way of assessing the pass-through impacts of world oil and food price shocks on domestic headline and core inflation. The pass-through coefficients overtime are calculated as a ratio of the cumulative impulse response of headline and underlying inflation after j months to world oil (food) price shocks (Jongwanich & Park, 2011). As in McCarthy (2000), the variance decomposition of forecast errors is utilised to examine the relative contributions of different shocks to fluctuations in headline and core inflation. To ratify the notion that the inclusion of the exchange rate and monetary supply dampens the effects of global oil and food price shocks on domestic inflation as Mija, et al. (2013) argue, the impacts of domestic fuel and food inflation on core inflation is also studied.

As expected, the study finds that fluctuations in global oil and food prices exhibit both first-round and second-round effects on domestic inflation in PNG. The magnitude of the impact on domestic inflation is proportional to the size of the weights of related domestic goods and services in the consumer basket. Sizeable impacts of these international price shocks on headline and core inflation are realised in the same year. The analysis of the impact of shocks in domestic food and fuel inflation is in line with the intuition that the exchange rate appreciation and monetary policy reaction have contained the effects of world oil and food price shocks on domestic inflation. Furthermore, the findings suggest that the indirect effect of an increase in domestic fuel prices through transport costs has considerable potential to spur second-round effects of positive shocks in global oil price. Apart from the external shocks, the findings have also revealed the significance of the domestic demand shock on the fluctuation of headline inflation.

Policy implications drawn from the empirical analysis suggest that exchange rate stability and active monetary policy are crucial for overall price stability in the economy amid large swings in international commodity prices. The paper encourages policymakers to be vigilant and closely monitor the inflationary impacts of global oil and food price shocks on domestic inflation and respond appropriately to threats of hikes in underlying inflation. Also, it is equally important to have cohesive monetary and fiscal policies to manage inflationary pressures arising from domestic demand. Overall, the underlying findings of the paper provide an impression that exchange rate stability, resistant monetary policy (especially during the times of large swings in commodity prices) and weak domestic demand in recent years have contributed to the low inflation environment in PNG.

The rest of the paper is arranged as follows: Section 2 presents the stylised facts, while Section 3 discusses the relevant literature. Section 4 describes the data and outlines the econometric procedure for implementing the VAR method. The empirical results are discussed in Section 5, and Section 6 concludes with a key summary of the findings. Finally, in Section 7, the references cited in this paper are provided.

2. Stylised Facts

This section provides an overview covering the inflation measures and qualitative assessment of the developments in the domestic inflation, exchange rate, monetary conditions and domestic demand condition of PNG in relation to major fluctuations in global commodity prices since the late 1990s. It is perceived that the insights drawn from the stylised facts will form prior expectations of the study.

2.1 Measures of Inflation

The three measures of inflation that the BPNG uses to observe price developments in the economy are the headline, exclusion-based and trimmed mean. The headline inflation measure is based on the total Consumer Price Index (CPI). The underlying inflation measure on the other hand, excludes all the items that are subject to seasonal volatility and price controls. The exclusion-based and trimmed mean are underlying or core inflation measures that the BPNG considers in its monetary policy decisions. In PNG, the National Statistical Office (NSO) is mandated to compile and disseminate information on the CPI. The CPI report is usually published on a quarterly basis. The BPNG first published the exclusion-based inflation measure in its Monetary Policy Statement in July 2001 and the trimmed mean inflation measure in July 2002 (Nindim, 2006). Unfortunately, there is no alternative inflation measure such as producer price, import price and retail price inflation in PNG (Sampson, Yabom & Marambini, 2006) that can provide a comprehensive overview on price developments at different stages of the distribution chain.

According to Nindim (2006), the exclusion-based measure is calculated by zero-weighting the subgroups that are highly volatile and those that are subject to excise duties and price control. The seasonal CPI items are: betel nut and mustard; and fruits and vegetables subgroups, while the items affected by changes in excise duties are alcoholic beverages and tobacco. The CPI subgroups that fall into the price regulated category are: rents; electricity; water; fares; fuels and lubricants, and other services; postal services; telephone services and other communication services; medical services; and education fee. The trimmed mean inflation measure excludes items with extreme price changes in each quarter. Once the distribution of price changes is arranged in ascending order, the extreme levels of the tail are trimmed off by eliminating 33% from the lower end and 27% from the higher end of the distribution. Hence, the subgroup items included in the trimmed mean measure differ every quarter depending on whether they are within the thresholds.

The prices for all consumer goods and services are collected from across the main towns and cities in the country. According to the new consumer basket, the total CPI comprises the 12 major expenditure groups reported in Table 1 below. These major components of CPI consist of 42 different subgroup items. The subgroup items for food and non-alcoholic beverages (Row 1) and transport (Row 6) are defined in Table 1.

Table 1
Components of Domestic CPI

Main Expenditure Group	Weight	Food & Non-alcoholic Drinks	Weight (34.9)	Transport	Weight (14.2)
1. Food & non-alcoholic drinks	34.9	Cereal	13.4	Vehicle purchase	4.3
2. Alcoholic drinks, tobacco & betel nut	7.9	Meat	6.9	Transport operations	1.3
3. Clothing & foot ware	5.5	Fish	2.8	Transport fares	6.1
4. Housing	11.2	Fruits & vegetables	5.08	Fuel & lubricants	1.9
5. Household equipment	4.5	Dairy, eggs & cheese	0.9	Other related service	0.7
6. Transport	14.2	Oil & fats	0.8		
7. *Communication*	4.5	Sugar & confectionary	1.5		
8. *Health*	2.7	Other food products	0.6		
9. *Recreation*	2.9	Non-alcoholic drinks	2.96		
10. *Education*	7.4				
11. *Restaurants & Hotels*	2.6				
12. Miscellaneous	1.7				

Note: * The household equipment includes furniture & furnishing & maintenance goods.
In May 2014, the NSO announced a revision of the CPI baskets and weights, and a new base year (base=2012Q2).
The expenditure groups in italics are new groups added to the consumer basket'

Source: NSO.

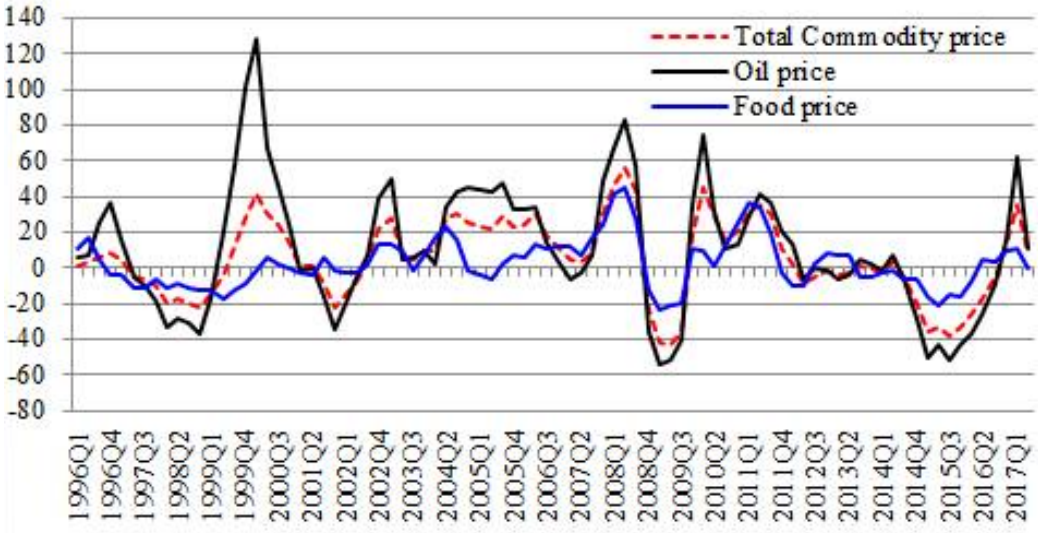
Dramatic changes in prices of items in the expenditure groups with large CPI weights have significant bearings on overall inflation. Therefore, large upward swings in global food and oil prices are expected to have strong first-round effects on headline inflation. When the food and non-alcoholic group is divided into its subgroups, we see that cereal, meat and, fruits and vegetables, which are mainly imported, have higher weights than other food and non-alcoholic beverage products. For the transport group, the domestic fuel and lubricants subgroup has very little weight, which implies that the direct impact of global oil price change would have a trivial impact on headline inflation. However, the oil price impact via the indirect channel through prices of related transport services is anticipated to be strong given higher share of the weights in the transport subgroup.

2.2 Commodity Price Development and Domestic Inflation

Overall inflation in PNG tends to positively correlate with developments in global commodity prices (Figures 1 & 2). The first-round effects of changes in food and oil prices on inflation are usually through import prices of domestic goods. This effect can happen directly on consumer prices or indirectly through production cost. The headline inflation rate ranged around 5 to 25% when commodity prices soared by over 20% between 1996 and 2017. In fact, inflation was over 15% only in 1998, 1999, 2002 and 2008. In 2001, 2009 and 2015 when commodity prices plummeted significantly by more than 20%, headline inflation dramatically fell to levels below 5%.

Figure 1
Global Commodity Price

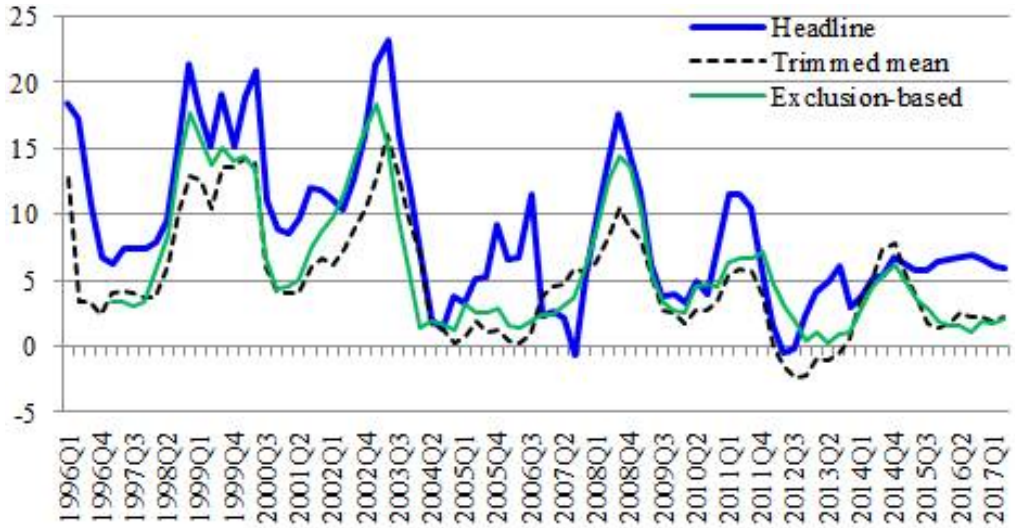
(Percent yoy)



Source: IMF Commodity price; Author's calculation

Figure 2
Domestic Headline and Core Inflation

(Percent yoy)

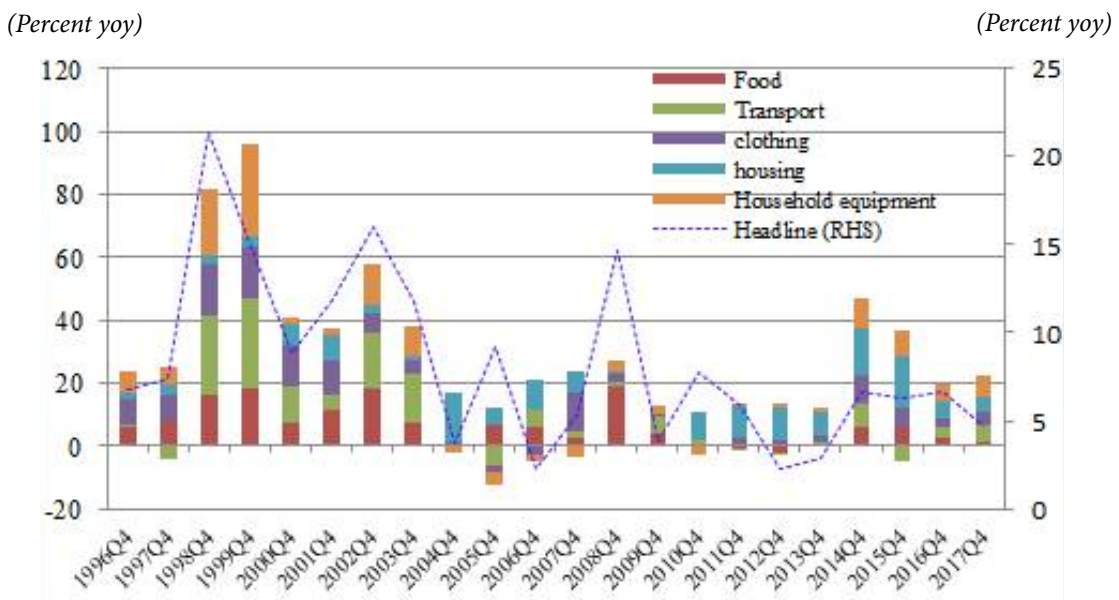


Source: BPNG; Author's calculation

The second-round effect, however, occurs when high headline inflation raises inflation expectation and demand for higher wages as firms and households seek to maintain the real value of profit and wages. Hence, the second-round effect can transform temporary commodity price shocks into more persistent inflationary pressures if not combated. The second-round effect can be observed through the development of core inflation. Figure 2 shows that during the periods of higher commodity prices the underlying or core inflation measures increased by over 10 percentage points. Throughout the period under review, core inflation has been lower than the headline inflation. While headline inflation has fluctuated between 5 and 10% after 2008, the underlying inflation measures trended below 5%. Overall trend indicates that inflation in PNG has subsided from over 15% in the late 1990s to around 5% in recent times, reflecting a low inflation environment.

An analysis on the components of CPI as depicted in Figure 3[2] shows that changes in the transport services and food prices have contributed largely to inflation in the late 1990s and early 2000s. Notably in 1998, 1999 and 2003, they increased by over 15%. It appears that in 2005 and 2008, surge in domestic food prices was mainly responsible for increases in the headline inflation. Between 2011 and 2012 when international food price increased, domestic food inflation subsided by an average of 1.2%. That could reflect households switching from imported food to locally grown produce (World Bank, 2011). We also notice that higher housing price contributed more to inflation in 2010, 2014 and 2015. That could reflect higher domestic demand driven by increased economic activities associated with the development of the Liquefied Natural Gas (LNG) project in the country (Aba & Vellodi, 2013). Even so, changes in domestic food and transport service prices remain as dominant contributors of overall inflation in PNG.

Figure 3
Major Contributors to Inflation



Note: Only the headline inflation is read from the right-hand-side (secondary axis)

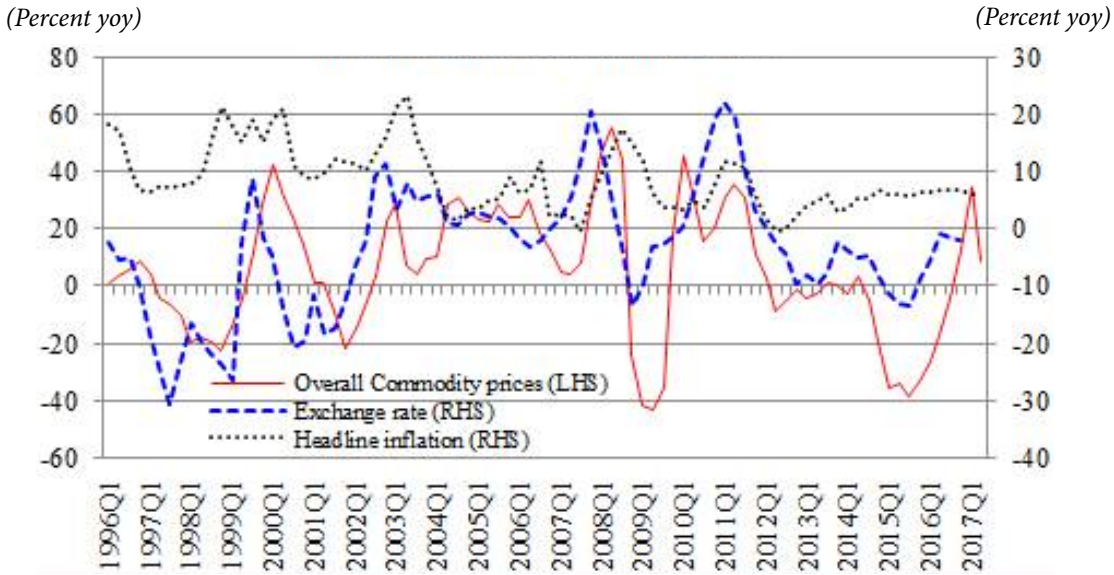
Source: BPNG; Author's calculation

2. The main components of CPI used here are in annual percentage change rather than as share of CPI. Therefore, summation of their percentage changes will not equal the overall growth rate of the headline inflation. The purpose is only to explain the changes in headline inflation in terms of the growth rates of its main components.

2.3 Exchange Rate Development

Kauzi and Sampson (2009) find that developments in commodity prices dictate the value of kina,[3] thus exposing the domestic economy to external shocks. As we can see from Figure 4, the exchange rate[4] fluctuates according to the development in international commodity prices. For example, in 2003, 2008 and 2010 when commodity prices surged by over 20%, the kina appreciated by 11.4, 20.6 and 19.4%, respectively. In contrast, the kina depreciated as commodity prices plummeted. In 2001, 2009 and 2015 for instance, the kina exchange rate depreciated by 13.2, 13.4 and 13.0%, respectively, as commodity prices fell by more than 20%. It is also noted that after the exchange rate was floated in 1994, the kina depreciated dramatically until 2000 when commodity prices rebounded. Development in the exchange rate has important implications for domestic inflation, given PNG's heavy dependence on imports for most of the producer and consumer goods.

Figure 4
Developments in Commodity Price Inflation, Headline Inflation and the Exchange Rate



Source: IMF; BPNG; Author's calculation

According to Sampson, Yabom and Marambini (2006), the exchange rate is a principal determinant of inflation in PNG. Their findings reveal that the effective exchange rate pass-through to underlying inflation is roughly 50-60% and completes after four to six quarters. As expected, Figure 4 shows that the development in inflation negatively correlates with movements in the exchange rate. It appears that between 2000 and 2012, inflation has broadly declined to levels below 10% as the exchange rate appreciated, albeit fluctuating at varying degrees. While the kina has depreciated in recent times, inflation picked up but less than the levels in the pre-2011 era. In

3. Kina is PNG's local currency.

4. The exchange rate here is adopted from Sampson, Yabom and Marambini (2006). They calculate this exchange rate as the weighted average of the nominal kina exchange rate against the US dollar, Australian dollar, Japanese yen, Singapore dollar and New Zealand dollar. The weights are from the imports purchased from each country. Simply it is a weighted exchange rate movement by currency of transaction.

2014 the BPNG imposed a trading margin to correct anomalies in the foreign exchange market which was alleged to accelerate rapid depreciation in the kina exchange rate. While this corrective policy measure is debated as leading to overvaluation of the real exchange rate harmful for the export sector (See for example; Fox & Schroder, 2016; Nakatani, 2017; Tumsok et al., 2017), it has slowed down the pace of depreciation. In the interim, it instils to a certain degree some stability in the exchange rate necessary to restrain some impacts of imported inflation.

2.4 Monetary Condition

Another important factor that can allow or deter the effects of external shocks on domestic inflation is monetary policy. Essentially, a reactive monetary policy during times of commodity price boom can alleviate the inflationary impact on domestic economy. Kauzi (2009) states that formulation of monetary policy in PNG addresses the subsequent or second- round effects on domestic inflation. The BPNG conducts the country's monetary policy based on the reserve money framework and sets immediate targets on monetary aggregates in order to achieve its mandated objective of price stability (BPNG, 2007). The BPNG mainly conducts monetary policy through open market operations by use of the Central Bank bills (CBBs). Other policy tools the BPNG uses includes the cash reserve requirement (CRR) and Repurchase Agreement. A summary of the monetary conditions is presented below in Table 2.

In theory, monetary operation should complement the policy stance. In PNG, issuance of CBBs and increase in the CRR reflect tightening stance of monetary policy. Therefore, when commodity prices were high especially in 2003, 2008 and 2011, the BPNG tightened monetary policy which involves raising the KFR and CRR. As a result, monetary aggregates in those periods declined. The decline in NFA since 2012 mainly attributes to BPNG's intervention in the foreign exchange market to stabilise the pace of depreciation in the exchange rate. That is, the BPNG supplied some of the foreign currencies earned from the past commodity price booms in exchange for kina to help clear backlog of import orders in the foreign exchange market. Figure 5 provides a glimpse of monetary reaction through the open market operation. Apparently, changes in the level of CBBs suggest restrictive monetary policy between 2004 and 2011. With low inflation environment in recent times, the BPNG has generally pursued accommodative monetary policy to support economic activity and growth.

Table 2
Monetary Conditions
(Unit in annual percentage change)

	Policy stance+	KFR*	CRR*	MS**	RM**	PSC**	NFA**
2003	Tightening	14.00	3.0	-4.3	-0.1	-4.1	14.1
2004	Easing	7.00	3.0	15.5	30.2	0.9	33.5
2005	Easing	6.00	3.0	28.9	7.4	23.7	35.3
2006	Neutral	6.00	3.0	34.1	21.7	28.3	58.7
2007	Neutral	8.00	3.0	26.0	61.8	34.3	52.5
2008	Tightening	8.00	3.0	13.5	-12.0	29.5	-12.6
2009	Easing	7.00	3.0	21.7	11.9	15.1	28.1
2010	Neutral	7.00	4.0	10.8	11.1	17.7	14.7
2011	Tightening	7.75	6.0	18.5	61.7	8.3	11.4
2012	Easing	6.75	8.0	8.7	17.6	12.2	-6.4
2013	Easing	6.25	9.0	9.6	0.5	17.5	-12.7
2014	Neutral	6.25	10.0	3.5	37.1	3.6	-17.4
2015	Neutral	6.25	10.0	4.9	-2.2	3.4	-13.8
2016	Neutral	6.25	10.0	12.4	24.4	7.2	-16.3
2017	Neutral	6.25	10.0	1.3	-16.6	-3.4	11.4

Note: Information provided is only to reflect monetary conditions following turnaround in international commodity prices since the early 2000s. It also commensurate the advent of central bank independence followed by inception of the KFR and CBB as the BPNG transits towards adopting market-based instruments.

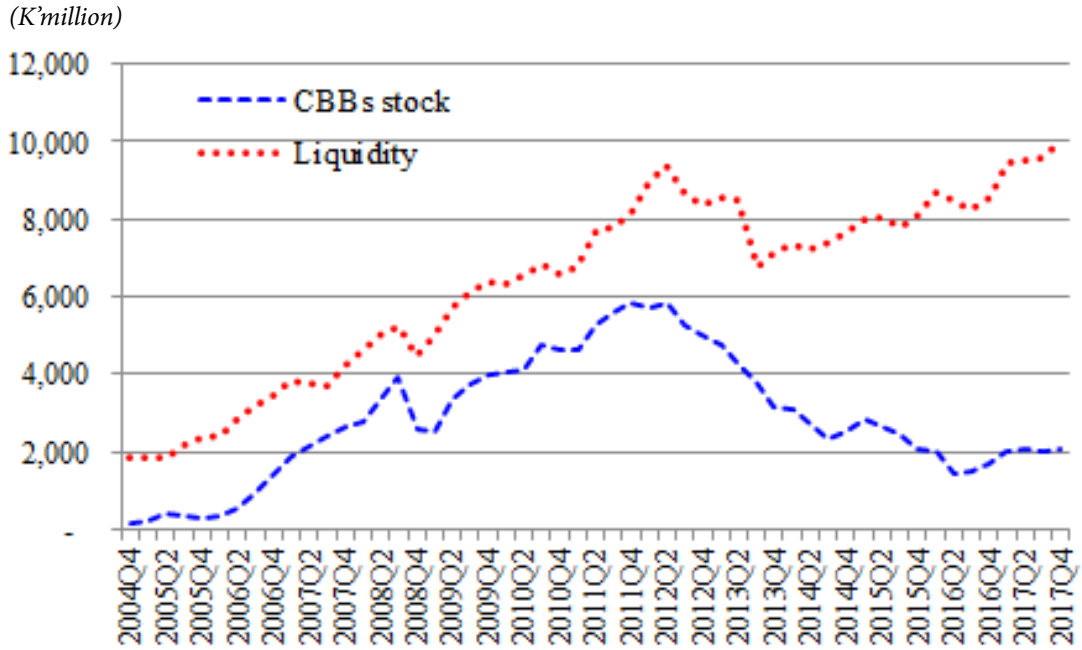
* Kina Facility rate (KFR) is a policy signalling rate. The KFR and CRR are adjusted monthly based on the assessment of macroeconomic condition by policymakers.

**Monetary aggregates namely, money supply (MS), reserve money (RM), private sector credit (PSC) and net foreign assets (NFA). Their values are in annual percentage change.

+Increase (decrease) in the KFR reflects tightening (easing) stance. If the KFR is held constant that denotes neutral stance such as the case between 2013 and 2017.

Source: BPNG

Figure 5
Central Bank Bill and Liquidity



Note: Liquidity refers to the total liquid assets of the banking system.

CBB stock is the outstanding balance of Central bank bills issued by the BPNG.

Source: BPNG; Author's calculation

We see in Figure 5 that, over the years, liquidity in the banking system has increased to almost K10 billion in 2017, which is reflective of increased export earnings attributed to past commodity price booms and capital expenditure associated with the construction of the LNG project and its spill-over activities. Additionally, excessive government spending after the completion of the LNG project also led to increase in the level of liquidity[5]. In spite of that, the overall inflation has remained low. This development contradicts the theory that higher liquidity through the credit channel should stimulate economic activity, thereby accelerate demand-pull inflation in the economy. According to Vellodi et al. (2012), liquidity in PNG is less inflationary as it does not fully translate into lending; instead it affects inflation passively through spill-over effects on the exchange rate. They allude that higher lending rates and lack of corporate demand for credits explain why liquidity is trapped in the banking system. That could possibly explain declines in private sector credit in recent years albeit monetary easing (see Table 2). The authors further argue that presence of excess liquidity has hampered the transmission mechanism of monetary policy, which supports David and Nants (2009) among others, who find that the interest rate channel of monetary policy transmission in PNG does not work. The development in private sector credit implicitly suggests decline in private investments, which is expected to negatively affect domestic demand.

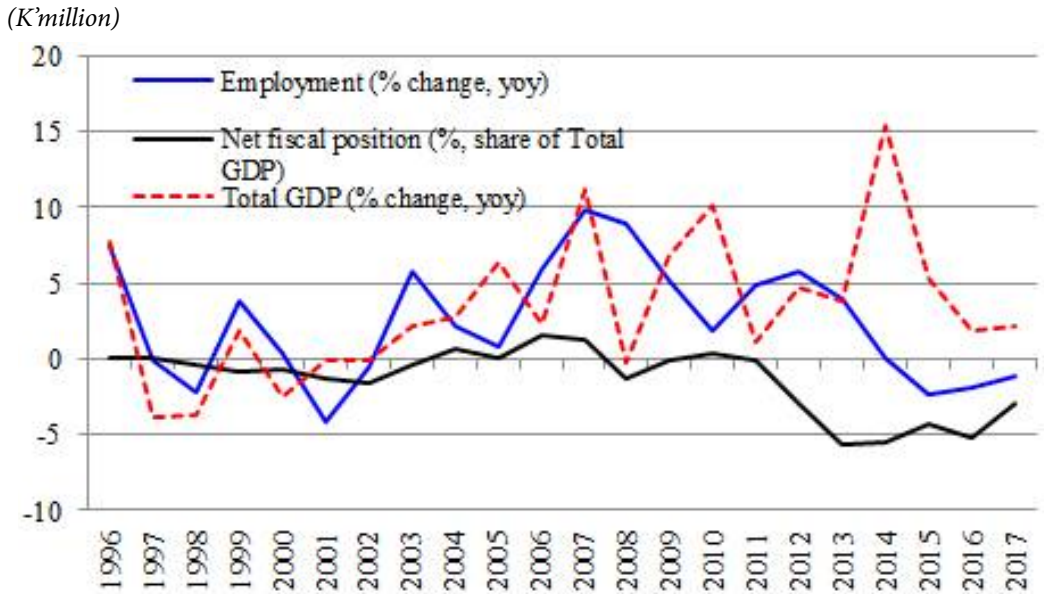
5. Government's use of external loans and funds drawdown from trust accounts held at the BPNG injected liquidity into the banking system.

2.5 Domestic Demand Condition

Aba and Vellodi (2013) find that while external factors still largely contribute to inflation in PNG, the demand-pull inflationary pressures appear to manifest prominently in recent times. Their findings show that domestic demand was strong in certain periods such as 2007 – 2009, which reflected the presence of counter-cyclical fiscal policy during the global financial crisis. Since there is no official data on output gap that measures domestic demand, the paper uses some implicit indicators[6] shown in Figure 6 to briefly explain the evolution of domestic demand in recent years. Note that the discussion that follows does not attempt to provide a thorough assessment of the structural changes in the economy.

Figure 6 indicates that when commodity prices were high in 2005, 2007 and 2010, PNG's economy expanded by 6.3, 11.1 and10.1%, respectively, while it contracted when commodity prices plunged, such as the case after 2010. This development indicates the significance of external demand on the aggregate demand in PNG. Following the completion of the LNG project construction in 2014, the economy contracted, reflecting a slowdown in activity as implied by dramatic decline in private sector employment[7]. We notice that at the same time, the government responded through successive expansionary fiscal policy to support growth. Nevertheless, overall economic growth remains below the levels achieved during the periods of higher commodity prices and construction of the LNG project. Therefore, the low economic growth in recent years suggests weak domestic demand, which possibly enhances disinflation in the economy.

Figure 6
Indicators of Domestic Demand



Source: BPNG; Author's calculation

6. It is assumed that changes in employment reflect the developments in private investments and consumption. The net fiscal position relates to public investments and consumption. Thus, it is taken that the overall developments in employment and net fiscal positions roughly represent the domestic demand conditions.

7. When the construction phase of the PNGLNG project ended, most of the labour and capital once utilised have not been immediately employed in other sectors of the economy. Emerson and Kraal (2014) highlight that following the completion of the LNG projects, unemployment in the petroleum industry and other associated industries rose due to redundancies.

3. Literature Review

This section is not intended to provide a thorough review of the literature that examines the impact of global oil and food price shocks on domestic inflation. Rather, it aims to broadly define the "first-round effect" and "second-round effect" of international oil and food price shocks; identify the methods widely used to study the impact of the commodity price shocks on inflation; and briefly highlight some key findings.

Large swings in international crude oil and food prices in recent times have affected inflation in oil and food import-dependent developing Asia nations (Jongwanich & Park, 2011). Fluctuations in crude oil and food prices are said to produce both the "first-round" and "second-round" effects on domestic inflation. The first-round effect captures the direct impact of global oil and food price shocks on domestic consumer prices, while the second-round effect involves the spill-overs from oil and food price shocks to demand for higher wage through collective bargaining and hike in the core inflation (Portillo & Zanna, 2015).

The two econometric models that have been extensively used by earlier studies to examine the impact of world commodity price shocks on domestic inflation are the ADL and SVAR estimation methods. For example, studies such as Gelos and Ustyugova (2012), and Gregorio, Landerretche and Neilson (2007) use the ADL model to estimate the Philips curve, while others like Mija, et al. (2013), Jongwanich and Park (2011), Khan and Ahmed (2011), and McCarthy (2000) apply the SVAR methods. Mija, et al. (2013) state that the magnitude of the transmission of the shocks to inflation, however, depends on the approach chosen to estimate it. That also includes the different country-specific structural and policy framework characteristics.

According to IMF (2008), the Philips curve estimation informs that the pass-through of international food prices to domestic consumer prices and core inflation is higher in emerging countries than advanced economies. That reflects higher share of food in the consumer basket in the emerging economies. For the oil price shock, the pass-through to core inflation through fuel price has declined for both emerging and advanced economies, but the size of the pass-through recorded for the former economies is lower than the latter. That outcome has been attributed to reduced energy intensity, widespread fuel subsidies and price controls in the emerging economies and high fuel taxes in advanced countries. Further, the report states that inflation expectation is well anchored in the advanced economies than in the emerging economies.

Gelos and Ustyugova (2012) employ a panel estimation of the Philips curve to analyse the monthly data for 2000 to 2011 for 31 advanced and 61 emerging and developing countries. They find that commodity price shocks have greater effects on inflation in the developing economies than in the advanced countries. Their findings reveal that economies with a large share of food in the CPI basket, high oil intensity and a high level of pre-existing inflation are susceptible to experience prolonged inflationary pressures from shocks in commodity prices.

Using quarterly data for 1996 to 2008, Jongwanich and Park (2011) study the pass-through of global oil and food prices to inflation in nine Asian countries using the VAR approach. Their findings suggest that the size of the pass-through has been limited in spite of the fact that the majority of the countries rely on imported oil and food. The authors explain that government policy relating to subsidies and price control in certain countries have hindered or delayed the pass-through of global oil and food price shocks to domestic prices.

Gregorio, Landerretche and Neilson (2007) estimate the Philips curve for 24 industrialised and 12 emerging economies to explain that the decrease in the pass-through of oil price shocks to domestic inflation is attributed to reduction in oil intensity and exchange rate pass-through. In addition, Jongwanich and Park (2011) state that the pass-through impact especially for oil price shock can dilute along the distribution chain reflecting the intensity of competition in the domestic market. Choi, et al. (2017) studying the impact of oil price shocks on inflation in 72 advanced and emerging economies for periods covering 1970 to 2015, find that improvement in monetary policy conduct has reduced the impact of oil price shocks over time. Further, their analysis on the monthly data for 2000 to 2015 asserts that the shares of the transport and energy subsidies are major factors explaining cross-country differences in effects of global oil price shocks.

Mija, et al. (2013) examine the impact of international oil and food price shocks on core inflation in Moldova by analysing the quarterly data for 2001 to 2004 through the VAR model. Their findings are consistent with the presence of a second-round effect resulting from both global oil and food price shocks. Further their analysis of domestic food and fuel price shocks on core inflation verifies the presence of second-round effects. According to Portillo and Zanna (2015), a common policy advice for central banks is to accommodate the first-round effects but respond to the second-round effects of commodity price shocks. IMF (2018) estimates the Philips curve and reports that weaker import prices including low commodity prices, have led to low inflation environment in Asia. But the IMF cautions the policymakers that if commodity prices and other factors reverse, central banks in Asia should be vigilant to accommodate the first-round effect and respond to the second-round effect.

That also depends on how fast the headline inflation reverts to core inflation or vice versa. Cecchetti and Moessner (2008) state that if headline inflation quickly reverts to core inflation, it means that inflationary impacts of global food and energy shocks are temporary. Conversely, a faster reversion of core inflation to headline inflation suggests that commodity price shocks could possibly produce second-round effect, which requires resistant monetary policy. Nindim (2006) finds that headline inflation reverts to the underlying inflation, but the latter does not revert to the former. While this may provide comfort for monetary policy in PNG, the researcher also finds that the underlying inflation reverts to average inflation. This implicitly signals the possibility of second-round effects that can arise from commodity price shocks, which partly motivates this study.

Hussain, et al. (2008) in an IMF country report for PNG examine the relationship between headline inflation and the nominal effective exchange rate, broad money, government expenditure and inflation in PNG's major trading partners. In a Vector Error Correction (VEC) model they use the quarterly data for 1995 to 2006. Their findings reveal that inflation is positively correlated with a lagged oil price. A 1% increase in oil prices is associated with a 0.05 and 0.06% increase in inflation. Kauzi (2009) estimates a VAR model using quarterly data for 1996 to 2005 finds a 2% increase in crude oil price causes 0.5% increase in inflation by the second quarter. In addition, Hussain, et al. (2008) report that a 1% appreciation in the nominal effective exchange rate causes inflation to decline by 0.59% and 0.87% in two separate models. That reaffirms the findings of Sampson, Yabom and Marambini (2006) that exchange rate is a chief determinant of inflation in PNG. Ofoi (2017) studies the transmission of monetary policy in PNG by use of SVAR finds that a positive shock in global oil prices causes the headline inflation to increase by around 0.3% by the 3rd quarter.

Aba and Vellodi (2013) estimate a Philips curve to study the impact of cost-push and demand-full inflationary impacts on inflation in PNG. Using quarterly data for 1996 to 2011, they adopt a basic ADL model to estimate the Philips curve. The authors find that determination of inflation in recent times has shifted towards domestic factors although effects from external factors still dominate. The long-run pass-through of the output gap to inflation is approximately between 30 to 60%. Further, historical decomposition of inflation shows that the output gap accounts for a greater portion of inflation in certain period such as 2007-2009, when domestic factors such as counter-cyclical expansionary fiscal policy was dominant. A pivotal difference between their analysis and this paper is that, they did not specify the global oil and food prices in their model. Instead, they claim that use of the exchange rate accounts for the effects of fluctuations in commodity prices. Apart from Aba and Vellodi (2013), there is no specific literature that explicitly studies the objective of this paper for PNG, which provides an additional impetus for this study.

4. Data and Methodology

This section describes the data and its statistical properties as well as the econometric approach used for the purpose of this study.

4.1 Data

The study uses data for the period covering 1996Q1 – 2017Q4 sourced online from the BPNG's Quarterly Economics Bulletin (QEB) publications, IMF commodity price, and World Bank country data for PNG. The statistical software, Eviews, version 10 is used to test the statistical properties of the data and perform the empirical analysis[8].

The quarterly international prices for food and oil are 3-month averages of monthly IMF commodity prices. The oil price index is a simple average of spot U.K. Brent, West Texas Intermediate, and Dubai Fateh. The global food price is an index consisting of the different food prices. The exchange rate[9], inflation measures and money supply are sourced from the BPNG's QEB publications. While there is no official output gap data for PNG, the author follows Aba and Vellodi (2012) to calculate it from the annual nominal non-mineral GDP series published by NSO. Firstly, the annual non-mineral GDP series is transformed into natural logarithm forms, then interpolated into quarterly series through the Chow Lin procedure with log of quarterly private employment index as an indicator. Secondly, the quarterly series for the log non-mineral GDP data is seasonally adjusted by X-11 method to reduce the effects of seasonal factor. Thirdly, the Hodrick-Prescott filter is applied to extract the cyclical component of the adjusted data series. Finally, the cyclical series is used as proxy for the output gap[10]. The headline, exclusion-based, and trimmed mean inflation are annual percentage changes of quarterly CPI indices usually computed and published by NSO and BPNG. Finally, money supply is the total stock of broad money supply reported by the BPNG in the QEB publications. All the variables are expressed in natural logarithm forms except inflation and the output gap.

8. Unit root tests and estimation of the econometric model chosen by the paper are carried out in the Eviews software.
9. The exchange rate is adopted from Sampson, Yabom and Marambini (2006). Refer to Footnote 4 for details. It is expressed as a unit of local currency per foreign currency (e.g. PGK/US$) so an increase (decrease) means appreciation (depreciation) in the value of the kina.
10. Total GDP is dropped as it does not generate robust results. Due to lack of appropriate data, the paper strictly follows Aba and Vellodi (2012) to derive the output gap.

Following standard practice of econometric modelling process, the variables are checked for stationarity using the Augmented Dickey-Fuller unit root test and Kwiatkowski-Philips-Schmidt-Shin (KPSS) stationary tests. The reason for choosing these tests is that they have a varying null hypothesis useful for comparing and verifying stationarity of the variables. The results of the unit root and stationarity tests are reported in Table 3 below. After the unit root and stationary tests, the variables in log forms are standardised to percentage change.

The results show that for the external variables, only the exchange rate is I(0) at the 5% level of significance. For the domestic variables, the output gap is I(0) at the 1% significance level, while headline inflation and exclusion-based core inflation are I(0) at the 5% level of significance, according to the ADF. The KPSS test finds the exchange rate, output gap, including all measures of inflation to be I(0). Both tests find that global oil and food prices, and money supply are I(1) variables. The KPSS test in particular finds that the inflation measures are I(0) with both constant and trend.

Table 3
Unit Root and Stationarity Test Results

Variable	Units+	*ADF*			*KPSS*			
		Level	1st Diff	Constant	Level	1st Diff	Constant	Trend
External								
Oil price	percent		-7.28***	yes		0.16*	yes	
Food price	percent		-7.15***	yes		0.16*	yes	
Exchange rate	percent	-3.02**		yes	0.46**		yes	
Domestic								
Output gap	percent	-4.18***		yes	0.05*		yes	
Government spending	percent		-10.50***	yes	0.09*		yes	yes
Money supply	percent		-7.11***	yes		0.13*	yes	
Inflation measures								
Headline	percent	-3.40**		yes	0.06*		yes	yes
Exclusion-base	percent	-3.2**		yes	0.05*		yes	yes
Trimmed mean	percent		-4.10***	yes	0.04*		yes	yes

Note: +The unit in percent for I(1) variables including the exchange rate is calculated as products of first difference of log value multiplied by 100.

The null hypothesis for ADF test states that variable has unit root, while for the KPSS test that variable is stationary. The asterisks ***, ** and * denote the significance levels of 1%, 5% and 10% respectively. For the ADF test, the asterisk represents the significance level at which the null hypothesis is rejected. In contrast for the KPSS, it reflects the level of significance whence we fail to reject the null hypothesis (t-test<asymptotic critical value).

Source: Eviews output; Author's calculation.

The empirical methodology selected for this study is the VAR model. The feature of the VAR approach is that all variables in the system are treated as endogenous, which eliminates the inherent problem of endogeneity prevalent in estimation of simultaneous equations. As in Duma (2008), the variables enter the VAR model according to the order of integration. That is, I(1) variables enter the VAR in first difference, while I(0) variables enter at levels in growth rates. Such approach can solve the problem of the so called "spurious regression". Because inflation is in percentage change, other variables in the system are standardised in the same unit as explained in Table 3. Accordingly, the variables this paper analyses are: percentage changes in global crude oil[11] (p_t^{oil}) and food (p_t^{food}) prices; output gap (y_t); percentage change in the exchange rate (e_t); inflation (π_t)[12]; and percentage change in money supply (m_t). Illustration of these time series variables and their basic statistical properties are presented in Appendix 8.1.

4.2 Methodology

The VAR procedure has proven to be a useful econometric tool for macroeconomic policy analysis (Lutkepohl, 2005) as it can trace the relationships between the dynamic effects of different shocks of the endogenous variables in the system. The setting of the VAR model especially the ordering of the variables broadly follows McCarthy (2000) and Akçelik and Öğünç (2016). Thus the array of variables in the baseline model is arranged in this order, p_t^{oil}, p_t^{food}, y_t, e_t, π_t, and m_t. The corresponding reduced-form VAR takes the subsequent generic form:

$$Y_t = \varphi + \rho(L,q)Y_{t-1} + U_t, \qquad (1)$$

where Y_t is a vector of all the endogenous variables, t = time; $\varphi = A^{-1}A_0$ denotes the vector of constants; $U_t = A^{-1}\varepsilon_t$ is a vector of reduced-form innovations; and $\rho(L,q)$ is the quarterly autoregressive lag polynomials that permits the coefficients of each quarter for the endogenous variables to depend on their past values. The vector of reduced-form residuals is denoted by $U_t \equiv \left(u_t^{oil}, u_t^{food}, u_t^{y}, u_t^{e}, u_t^{\pi}, u_t^{i}\right)$ follows a white noise process and has a non-singular covariance matrix Ω. Moreover, two dummy variables have been included to capture the effects of the inception of the value added tax (dum_vat) in 1999 and foreign exchange trading margin (dum_fx) in the 2nd quarter of 2014. The introduction of the VAT came into effect in September 1999, so 1999Q3 takes the value 1 to account for any one-off effect on domestic prices, while the rest of the periods have 0 values. For the exchange rate trading margin, the pre-2014Q2 periods take the value 0, while series after 20014Q1 have values equal 1. In the VAR regression, these dummies are restricted to only affect the domestic variables. As a robustness check, the data prior to 2014Q2 is truncated and the regressions are performed without the dummies[13].

11. Fuel (energy) price is not used here because in PNG we do not consume or export coal the price of which is included in the fuel price index. Therefore, it is relevant to use crude oil price, which directly affects the prices of refined petroleum products, such as petrol, diesel, kerosene and lubricants consumed in country. Henceforth, throughout the paper, crude oil is referred as just oil.
12. Inflation refers to both the headline and core inflation, which are used interchangeably in the baseline model. Additionally, government spending (g_t)g_t) is used interchangeably with the output gap to determine the relevance of domestic demand shock on headline inflation. However, the results drawn from the baseline models that have the output gap as proxy for domestic demand are discussed in this paper.
13. However, inclusion of these dummies produces bizarre results (especially on the impulse responses), which are not consistent with prior expectations, so are dropped in the VAR estimation.

The reduced-form VAR has little economic significance because its residuals are linear combinations of the underlying structural shocks. This requires imposition of certain structural restrictions to allow the model to recover the structural innovations from the reduced-form residuals. Thus, this paper uses a Cholesky decomposition approach introduced by Sims (1980) to identify the structural shocks. The baseline model (1) is basically a six-variable VAR system that can be estimated through Ordinary Least Squared process. The reduced-form residuals in accordance with recursive specification are as follows:

$$u_t^{oil} = \epsilon_t^{oil}, \tag{2}$$

$$u_t^{food} = \alpha_{21}\epsilon_t^{oil} + \epsilon_t^{food}, \tag{3}$$

$$u_t^{y} = \alpha_{31}\epsilon_t^{oil} + \alpha_{32}\epsilon_t^{food} + \epsilon_t^{y}, \tag{4}$$

$$u_t^{e} = \alpha_{41}\epsilon_t^{oil} + \alpha_{42}\epsilon_t^{food} + \alpha_{43}\epsilon_t^{y} + \epsilon_t^{e}, \tag{5}$$

$$u_t^{\pi} = \alpha_{51}\epsilon_t^{oil} + \alpha_{52}\epsilon_t^{food} + \alpha_{53}\epsilon_t^{y} + \alpha_{54}\epsilon_t^{e} + \epsilon_t^{\pi}, \tag{6}$$

$$u_t^{m} = \alpha_{61}\epsilon_t^{oil} + \alpha_{62}\epsilon_t^{food} + \alpha_{63}\epsilon_t^{y} + \alpha_{64}\epsilon_t^{e} + \alpha_{65}\epsilon_t^{\pi_t} + \epsilon_t^{m}, \tag{7}$$

where $u_t^{oil}, u_t^{food}, u_t^{y}, u_t^{e}, u_t^{\pi}$ and u_t^{m} are the reduced-form innovations for p_t^{oil}, p_t^{food}, y_t, e_t, and m_t, respectively. Correspondingly, their underlying structural shocks are denoted by $\epsilon_t^{oil}, \epsilon_t^{food}, \epsilon_t^{y}, \epsilon_t^{e}, \epsilon_t^{\pi}$, and ϵ_t^{m}. It is assumed that the shocks do not have serial correlation and also uncorrelated with each other within the same period. The coefficients $\alpha_{21} \ldots\ldots \alpha_{ij}$ explain the different contemporaneous relationships between the endogenous variables. For example, in Equation (6), the coefficients $\alpha_{51}, \alpha_{52}, \alpha_{53}$ and α_{54} represent the contemporaneous responses of inflation to one percent shocks in global oil prices, food prices, output gap, and exchange rate, respectively. The diagonal elements are unitary, implying that each of the endogenous variables is also affected by its own shock.

Since global oil and food prices are influenced by exogenous factors, they are ordered before other variables in the system. In this model set-up, the lag coefficients of domestic variables are restricted to zero so that they do not affect changes in global oil and food prices (i.e. Equations 2 & 3). The change in global oil and food prices capture international price shocks and the output gap is a proxy for domestic demand. These shocks are important as they account for cost-push and demand-pull inflationary pressures. The change in the exchange rate is affected by the supply and demand shocks through the balance of payment effects. Based on the findings of Sampson, Yabom and Marambini (2006), the exchange rate is ordered before inflation. The inflation Equation (6) is a function of developments in international commodity price shocks, domestic demand shock and exchange rate shock. Essentially, the use of money supply instead of interest rate as an indicator for monetary policy reaction embedded in Equation (7) is reflective of the reserve money framework that the BPNG uses. In addition, David and Nants (2009), and Ofoi (2017) find that transmission of monetary policy through the interest rate channel in PNG is very limited.

The transmission mechanism in the baseline model essentially explains that if there is a shock in international oil price, world food price will adjust immediately assuming that oil is an input in food production. Changes in these commodity prices will then affect domestic demand and their cascading effects through the balance of payment will determine the value of the kina exchange rate. Furthermore, the combined effects of changes in international commodity prices, domestic demand and exchange rate will then affect domestic inflation. Subsequently, the monetary policy reaction function explains that policy decision takes into account the inflationary impacts originating from cost-push and demand-pull inflation, and exchange rate development, including shock in domestic prices. Therefore, a reduction in money supply reflects a tightening of monetary policy if policymakers detect inflationary impacts of upward shocks in global oil and food prices manifest in domestic inflation.

In line with the interest of the study, the headline and core inflation reported in Figure 2 are used interchangeably in the baseline VAR model to determine the first-round and second-round effects of global oil and food price shocks on domestic inflation. The results of the impulse response function are used to inspect the direction and duration of the impact of international price shocks on output gap, exchange rate, inflation and money supply. This exercise is purposely to make sense of the stylised facts. Following Jongwanich and Park (2011), and Akcelik and Ogunc (2016), the cumulative pass-through coefficients over time are calculated as a ratio of cumulative impulse response of headline and core inflation after j quarters to world oil (food) price shocks[14].

For a VAR model to be stable, it requires the use of an optimal lag length. The decision on the appropriate number of lags is based on the results of different information criteria namely, Sequential Modified LR test (LR), Final Predictions error (FPE), Akaike information criterion (AIC), Schwarz information criteria (SC), and Hannan-Quinn information criterion (HQ). Table 5 reports the optimal lag selection results for 3 sets of VAR models containing the headline inflation, exclusion-based and trimmed mean inflation, respectively. According to the selection information criteria, lags one and two are chosen as optimal lag lengths for the VAR model and used interchangeably to determine which lag generates robust results. The lag two appears to perform well in all the models, so it is selected as the optimal lag length.

14. Formally, the ratio is denoted by $PT_{t,t+j}/E_{t,t+j}$ where $PT_{t,t+j}$ is the cumulative response in inflation & $E_{t,t+j}$ is the cumulative response between months t and $t+j$ to shocks in crude oil and food prices (Akcelik & Ogunc, 2016).

Table 5
VAR Lag Order Selection

Lag	LogL**	LR	FPE	AIC	SC	HQ
VAR (p_t^{oil}, p_t^{food}, y_t, e_t, $\pi_t^{headline}$, m_t)						
0	-1513.51	NA	3.21e+08	36.61	36.79	36.69
1	-1376.16	251.54	27998804	34.17	35.40*	34.66*
2	-1334.00	71.07	24472974*	34.02*	36.30	34.94
3	-1300.68	51.43*	26988263	34.09	37.41	35.43
4	-1264.98	49.89	29042288	34.10	38.47	35.85
VAR (p_t^{oil}, p_t^{food}, y_t, e_t, $\pi_t^{exclusion}$, m_t)						
0	-1492.33	NA	1.93e+08	36.10	36.28	36.17
1	-1335.74	286.76	10571802	33.20	34.42*	33.69*
2	-1285.85	84.15*	7665005*	32.86*	35.14	33.78
3	-1257.55	43.65	9545967	33.05	36.37	34.38
4	-1222.52	48.95	10441313	33.07	37.44	34.83
VAR (p_t^{oil}, p_t^{food}, y_t, e_t, $\pi_t^{trimmed}$, m_t)						
0	-1454.1	NA	2.87e+08	36.50	36.68	36.57
1	-1295.06	290.26	13281972	33.42	34.68*	33.92
2	-1231.20	106.96*	6717878*	32.73*	35.05	33.66*
3	-1203.16	42.77	8512871	32.93	36.32	34.29
4	-1173.13	41.29	10646254	33.08	37.54	34.87

Note: Data is in quarterly frequency so the maximum lag for the test is set at 4. The figures are rounded off to the nearest hundredth.

Source: Eviews output; Author's calculation

The diagnostic tests consisting of autocorrelation LM tests, the Normality test and White heteroskedasticity test are applied. As in Jongwanich and Park (2011), the residuals are also visually inspected to ensure absence of major outliers. Note that the residual diagnostic test results for the different VAR models containing each of the inflation measures cannot be provided in this paper due to space limitations.

5. Discussion of Results

This section discusses the dynamic responses or sensitivity of domestic inflation to shocks in global oil and food prices. The impulse response results are used to examine the direction and duration of international price shock on domestic inflation, while the pass-through effect calculates the magnitude of the cumulative impact over time. In line with Aba and Vellodi (2013), the impulse responses of headline inflation to output gap and government spending shocks are briefly discussed too. The contribution of different shocks to domestic inflation is explained by investigating the variance decomposition of the forecast errors. A discussion of the impacts of domestic fuel and food inflation on core inflation is also covered in this section in an attempt to ratify the notion that inclusion of the exchange rate and monetary supply dampens the effects of global oil and food price shocks on domestic inflation. Since the confidence bands cannot be computed directly in the Eviews for the cumulative pass-through coefficients, the cumulative impulse responses with ±2 standard deviation bands are reported instead in Appendix 8.3.

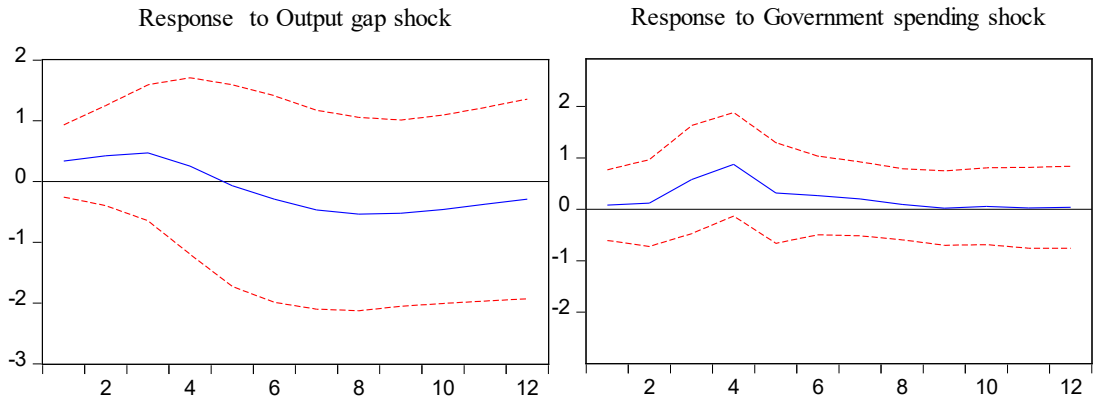
5.1 Impulse Responses

Figures 8 and 9 (Appendix 8.3) report the impulse responses of the exchange rate, domestic inflation and money supply to shocks in global oil and food prices. The results show that impact of shocks in global oil and food prices on headline inflation and core inflation are as expected. We find that the three measures of inflation increase within the first year suggesting that inflationary impacts arising from international price shocks is only temporary.

The exchange rate and money supply responses to shocks in global oil and food prices are also as expected. The exchange rate appreciates between the first and third quarters and depreciates thereafter before returning to its long-run trend. The kina appreciates because the rise in global prices for PNG's major export commodity such as oil, generates more inflow of foreign currencies, which exerts upward pressure on the exchange rate. The results on inflation and exchange rate developments emanating from oil price shock are consistent with the findings of Ofoi (2017) and Kauzi (2009). Another crucial finding is that the change in money supply as proxy for monetary policy reaction increases by the second quarter and declines thereafter then stabilises after the 4th quarter. The decline in money supply informs us that resistant monetary policy happens after the second half of the first year following upward shocks in world oil and food prices. This finding is true as Table 2 reports that BPNG in fact tightened monetary policy during the years when international commodity prices surged by over 20% (Figure 1). We next discuss the impulse response of headline inflation to shock in domestic demand explained by the output gap and government spending indicated in Figure 10[15].

15. Output gap and government spending are used interchangeably to generate their respective impulse response functions.

Figure 10
Impluse Responses of Headline Inflation to Domestic Demand Shock
[Response to Cholesky one S.D. (d.f. adjusted) Innovations ± S.E]



Note: The standard errors are generated through Monte Carlo simulation with 100 iteration levels. The red dotted lines denote the ±2 Standard deviations. The vertical axes are in percentage point and horizontal axes denote time horizon in quarters.

Source: Eviews output; Author's calculation.

Following the approach of Aba and Vellodi (2013), the paper studies the impact of output gap and government spending shocks on headline inflation to determine the significance of domestic demand. The empirical outcome suggests that inflationary impact of domestic demand prominently manifests within the first year. It intuitively suggests that the prominence of weak domestic demand in recent years partly explains the disinflation in the economy.

As far as the significance of the impulse response function is concerned, the confidence intervals generated by VAR suggest that the impulse response of the exchange rate is statistically significant. For rest of the variables, the impulse responses are not different from zero. Notwithstanding this setback, the direction and duration of the impact of global oil and food price shocks on domestic inflation in PNG is consistent with prior expectation.

5.2 Pass-through Impact on Headline Inflation

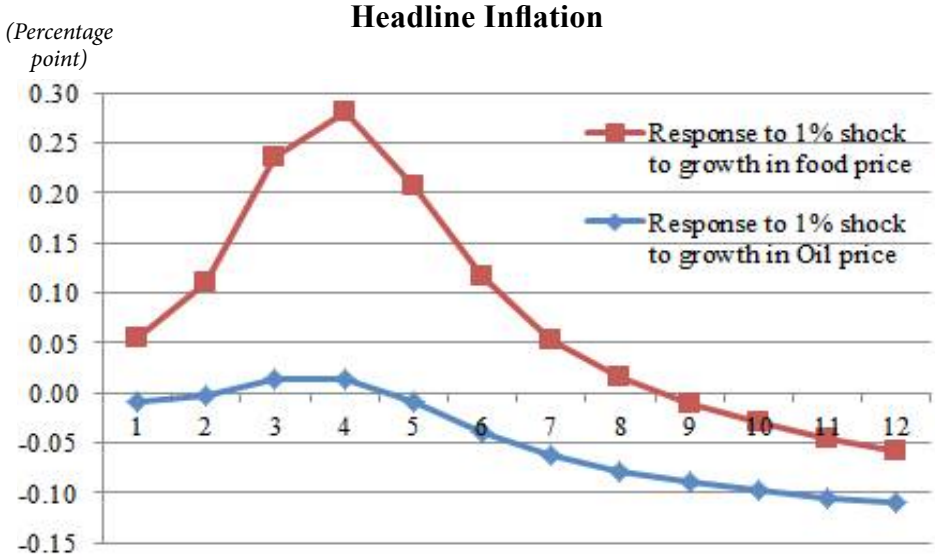
While we find that the direction and duration of the response in domestic inflation resulting from oil and food price shocks is as expected, it is equally important to understand the size of the cumulative impacts overtime[16]. Thus, the cumulative pass-through coefficient is interpreted as a percentage change in domestic inflation resulting from a 1% shock to growth in global oil or food prices.

As we can see in Figure 11, the immediate impact of 1% positive shock to growth in global oil and food price on headline inflation are -0.01 and 0.06 percentage points. A negative coefficient for growth in oil price shock on headline inflation could reflect the offsetting effect from appreciation in the exchange rate. The results show that the cumulative pass-through impacts of both commodity prices on headline inflation peak by the fourth quarter. It is encouraging that the pass-through coefficients are within the range of the levels calculated by Jongwanich and Park

16. Since the main focus of the paper is on the inflationary impacts of global oil and food price shocks, the cumulative coefficients for the pass-through effects of output gap shock on headline inflation are omitted.

(2011) for developing and emerging countries in Asia. The pass-through impact of the global food price shock is higher than that of the global oil price shock. This difference reflects the shares of relative domestic food and fuel prices in the CPI.

Figure 11
Cumulative Coefficients of Pass-through to Headline Inflation



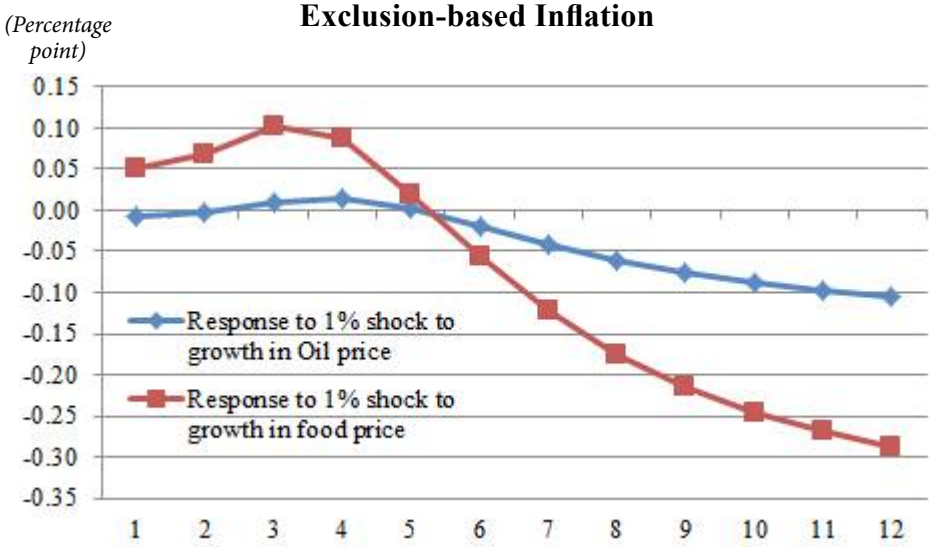
Source: Eviews output; Author's calculation

5.3 Pass-through Impact on Core Inflation

The pass-through impact of global food and oil price shocks on domestic core inflation are quite similar to those generated for headline inflation except that sizes of the impact vary (Figures 12 & 13). The highest cumulative coefficients for 1% shock in both the global oil and food prices on exclusion-based inflation are observed in the 4th quarter. Accordingly, the pass-through effect of food price shocks to exclusion-based inflation and trimmed mean are 0.10 and 0.13 percentage points, respectively. Likewise, for 1% shock to growth in oil prices, the exclusion-based and trimmed mean inflation increase by 0.02 and 0.10 percentage points.

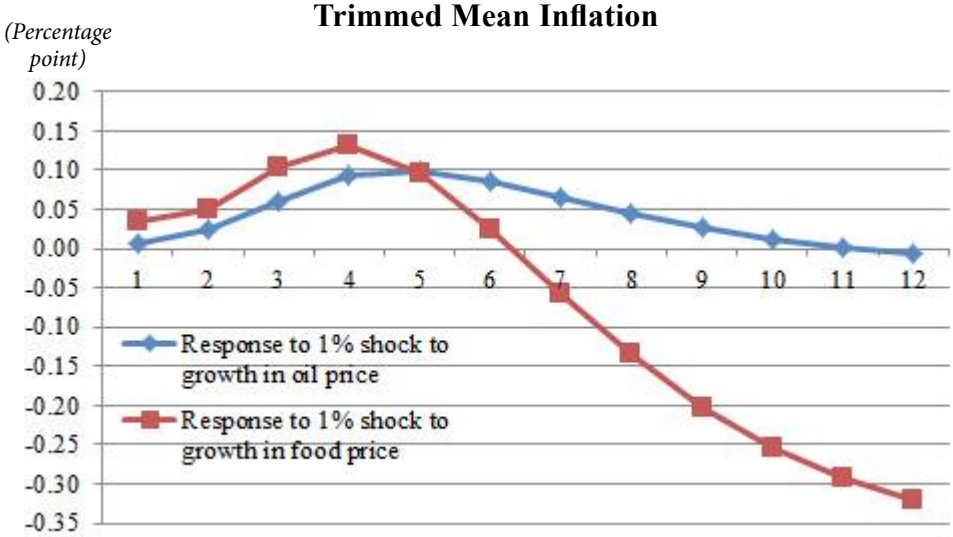
The analysis finds that the cumulative coefficients for the pass-through effect of global oil price shock to core inflation in the first year are higher than their impact on headline inflation. That could possibly suggest that the second-round effects of oil price shocks on domestic inflation might be larger than the first-round effects. For the food price shock, the average cumulative pass-through impact on the core inflation by the 4th quarter is about 0.12 percentage points, which is lower than its impact on the headline inflation. Overall, the analysis finds evidence of the second-round effects of inflation resulting from global oil and food price shocks.

Figure 12
Cumulative Coefficients of Pass-through to Exclusion-based Inflation



Source: Eviews output; Author's calculation

Figure 13
Cumulative Coefficients of Pass-through to Trimmed Mean Inflation



Source: Eviews output; Author's calculation

5.4 Variance Decomposition

While the impulse responses provide information valuable to understand the response of domestic inflation to shocks, they do not explain the relevance of these shocks in the domestic price fluctuations (McCarthy, 2000). If the global oil and food price shocks are small, they will have little influence on domestic inflation. Following McCarthy (2000), the variance decomposition of forecast errors is examined to access the contribution of shocks to fluctuations in domestic inflation. Table 6 presents the results for the variance decomposition of headline and core inflation.

Table 6
Variance Decomposition
(Cholesky d.f. adjusted factors)

Period	S.E.	p_t^{oil}	p_t^{food}	y_t	e_t	$\pi_t^{headline}$	m_t
Variance Decomposition of Headline Inflation							
1	2.73	0.29	1.30	1.03	0.17	97.21	0.00
		(1.56)	(2.84)	(3.14)	(1.54)	(5.05)	(0.00)
2	3.89	0.18	1.89	1.23	3.77	92.75	0.18
		(2.04)	(3.75)	(3.66)	(4.24)	(7.20)	(0.94)
3	4.52	0.64	3.18	1.34	9.86	83.63	1.36
		(3.60)	(5.43)	(3.95)	(6.50)	(9.11)	(2.31)
4	4.80	0.57	2.91	1.34	14.42	78.12	2.64
		(4.37)	(5.51)	(4.29)	(8.14)	(9.83)	(3.70)
Variance Decomposition of Core Inflation (Exclusion-based)							
		p_t^{oil}	p_t^{food}	y_t	e_t	$\pi_t^{exclusion}$	m_t
1	1.54	0.48	3.26	3.21	3.17	89.86	0.00
		(2.26)	(3.67)	(3.73)	(3.42)	(5.87)	(0.00)
2	2.58	0.19	1.65	2.25	13.97	81.91	0.02
		(2.44)	(2.97)	(3.63)	(6.68)	(7.41)	(0.60)
3	3.36	0.68	1.12	2.22	24.63	71.32	0.04
		(3.43)	(3.39)	(4.30)	(8.39)	(9.43)	(1.23)
4	3.84	0.56	0.96	2.59	31.34	64.31	0.24
		(3.88)	(4.19)	(5.20)	(9.85)	(10.71)	(2.06)
Variance Decomposition of Core Inflation (Trimmed Mean)							
		p_t^{oil}	p_t^{food}	y_t	e_t	$\pi_t^{trimmed}$	m_t
1	1.32	0.53	2.20	1.33	5.29	90.66	0.00
		(1.93)	(3.05)	(2.72)	(4.98)	(6.40)	(0.00)
2	2.59	2.42	0.86	2.24	21.05	73.42	8.38
		(4.13)	(1.79)	(3.94)	(8.64)	(9.69)	(0.45)
3	3.71	4.44	0.95	2.44	31.75	60.35	0.07
		(6.05)	(2.55)	(4.73)	(9.99)	(11.01)	(1.07)
4	4.46	4.28	0.72	2.59	38.92	53.10	0.38
		(6.59)	(3.17)	(5.37)	(10.85)	(11.35)	(2.24)

Note: All the values reported are rounded off to the nearest hundredth. The figures in brackets are standard deviations generated through Monte Carlo simulation of 100 iteration levels. Percentage of forecast error variance attributed to global oil and food price shocks in a year.

Source: Eviews output; Author's calculation.

The findings suggest that while much of the fluctuations of the headline and core inflation measures are explained by their own shocks, the exchange rate shock appears to be more pronounced than rest of the variables in the system. This result is consistent with the exchange rate discussion in Sub-section 2.3. The variance decomposition of the headline inflation additionally provides an interesting finding. We see that in the 4th quarter for example, the output gap explains about 1.3 percent of the variation in the fluctuations of the headline inflation, which is higher than the shock contributed by global oil. Similarly, the output gap contributes more to fluctuations in exclusion-based inflation than international oil and food prices. These findings support Aba and Vellodi (2013) who estimate a Philips curve for PNG and find that the inflationary impact from domestic sources becomes noticeable in recent times.

The global oil and food price shocks individually explain less the variations in the fluctuations of the headline and core inflation, which could imply that their effects may have diluted along the distribution chain. However, due to data limitations this assumption cannot be tested at the moment. But in terms of the total shock contributions, they still qualify as external drivers of domestic inflation. Overall, external factors contribute about 1.6 – 3.5%, 1.5 – 3.7% and 2.7 – 5% of the variations in the fluctuations of headline inflation, exclusion-based inflation and trimmed mean inflation, respectively, over the forecast time horizons.

5.5 Impact of Shocks in Domestic Food and Fuel Inflation

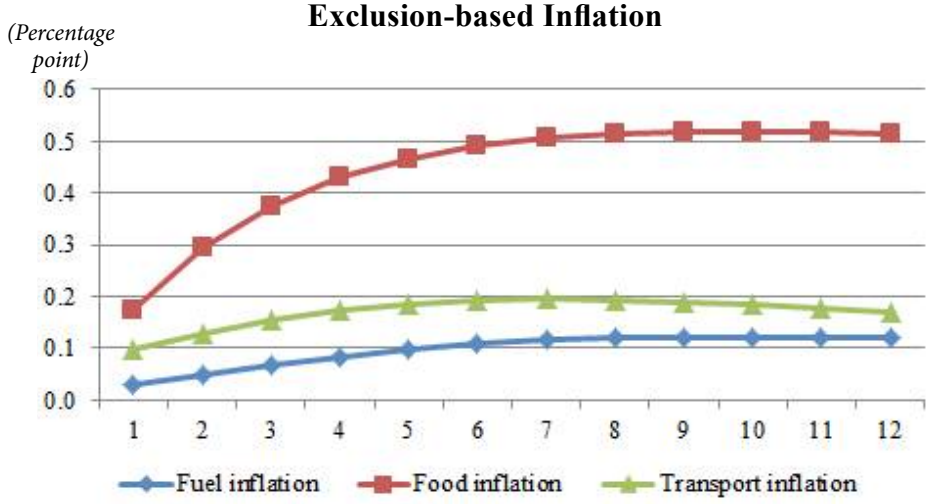
Mija, et al. (2013) argues that inclusion of the exchange rate and money supply in the baseline model limits the impact of world oil and food price shocks on domestic inflation. Note an alternative ordering of money supply in the baseline model has not altered the results very much. Therefore, this section focuses on testing the impact of domestic food and fuel inflation including transport inflation[17] on core inflation. The use of core inflation alone is purposely to verify the existence of the second-round effects that the preceding analysis establishes which concerns monetary policy.

A VAR model with a Cholesky decomposition of the covariance matrix is used to analyse the data. The model is similar to the baseline model (1) but contains only the domestic fuel inflation, transport inflation, food inflation, and core inflation. Similar type of approach is adopted by Mija, et al. (2013). Refer to Table 7 (Appendix 8.2) for description of the data and unit root and stationary test results. Only the dummy for VAT is included to capture the impact of a one-off increase in price induced by VAT introduced in 1999Q3. The arrangement of the variables in the VAR takes this order: fuel inflation, transport inflation, food inflation, and core inflation. Consequently, the cumulative pass-through coefficients are computed and presented below in Figures 15 and 16. The cumulative impulse response function is reported in Figure 17 (Appendix 8.3). The confidence interval band indicated by the ±2 standard deviation line suggest that all the cumulative impulse responses for all the variables are statistically different from zero for the first year (i.e. Q1 – Q4).

The cumulative pass-through coefficients shown in Figure 15 reveal that the impacts on exclusion-based inflation peak by the 9th quarter. The cumulative impact of 1% shock in fuel inflation, food inflation and transport inflation cause the exclusion-based inflation to increase by 0.12, 0.52 and 0.19 percentage points, respectively.

17. Transport inflation reflects the prices of fuel related items captured by the transport expenditure group in the CPI as shown in Table 1. The transport index analysed in this study excludes fuel inflation.

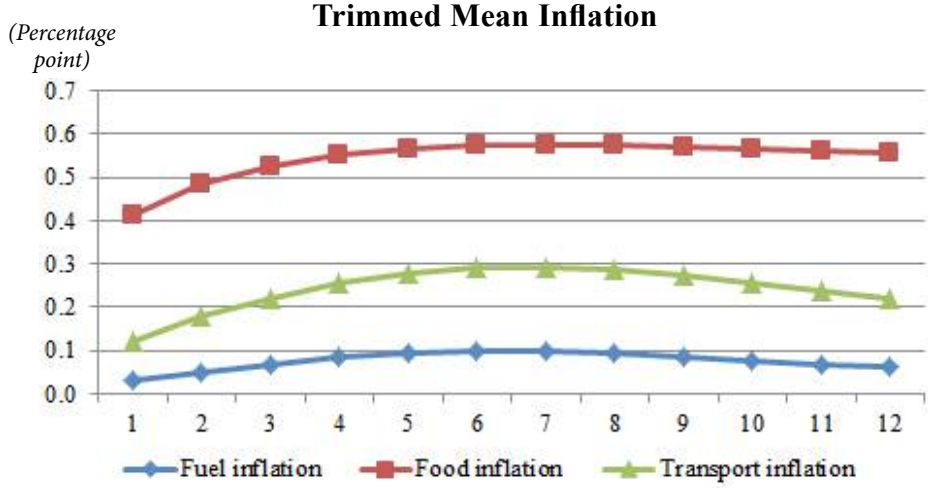
Figure 15
Cumulative Coefficients of Pass-through to Exclusion-based Inflation



Source: Eviews output; Author's calculation

Similar pattern is observed in the trimmed mean inflation but the impact of 1% shocks in fuel inflation, food inflation and transport inflation reach their highest levels of cumulative pass-through by quarter 7 (Figure 16). Accordingly, the cumulative pass-through at quarter 7 for fuel inflation, food inflation and transport inflation on trimmed mean inflation are 0.10, 0.57 and 0.29 percentage points, respectively. While food inflation has sizable impacts on core inflation, the impact of fuel inflation is low. One possible explanation could be that domestic fuel prices are regulated so the direct impact on inflation is minimal. A shock to transport inflation produces higher cumulative impacts on core inflation than fuel inflation. That could suggest that the indirect effect of increase in domestic fuel price through transport cost has a greater potential to trigger second-round effects of positive shock in global oil price.

Figure 16
Cumulative Coefficients of Pass-through to Trimmed Mean Inflation



Source: Eviews output; Author's calculation

6. Conclusion

This study finds that fluctuations in global oil and food price exhibit both the first-round and second-round effects on domestic inflation in PNG. The magnitude of the impacts of international food and oil price shocks on domestic inflation is proportional to the size of the weights of related domestic goods and services in the consumer basket. Sizeable impacts of these global price shocks on headline and core inflation are realised in the same year. The analysis of the impact of shocks in domestic food and fuel inflation points is consistent with the intuition that the exchange rate appreciation and monetary policy reaction have lowered the second-round effects of world oil and food price shocks on domestic inflation. Specifically, the cumulative impacts of global oil and food price shocks on core inflation are generally lower than those generated by shocks in domestic fuel and food inflation. Furthermore, the findings suggest that indirect effect of increase in domestic fuel price through transport cost has considerable potential to trigger second-round effects of positive shock in global oil price. The second-round effects resulting from domestic food and fuel inflation takes over a year to be more pronounced. Besides the external factors, it is also found that output gap shock notably contributes to variations in the fluctuation of headline inflation. Thus, if domestic demand is weak as highlighted earlier, that could also be responsible for disinflation in the economy.

Accordingly, policy implications drawn from the empirical analysis suggest that exchange rate stability and active monetary policy are crucial for overall price stability in the economy amid large swings in international commodity prices. This study supports the common policy adage stated by Portillo and Zanna (2015) that "…the central bank should accommodate first-round effects but respond to second-round effects" (p.3) because higher impacts of global oil and food price shocks on headline inflation in PNG materialises only in the first year. However, the relative impacts on core inflation peak towards the end of the medium term, which provides some comfort for monetary policy.

Going forward, policymakers are encouraged to be vigilant and to closely monitor the inflationary impacts of global oil and food price shocks on domestic inflation and respond appropriately to threats of hike in underlying inflation. This is not an explicit advice to focus on core inflation alone because an exorbitant surge in headline inflation can transform temporary impacts of the shocks in international oil and food prices into persistent inflationary pressures. Therefore, it is paramount to concurrently keep the headline inflation in check. The findings on the inflationary impact of output gap and government spending shocks underscore the essence of having cohesive monetary and fiscal policies to manage inflationary pressures arising from domestic demand.

To add more insights into understanding the global commodity price shocks on inflation in PNG, here are some highlights of the areas for future research. In order to draw a concrete conclusion that the inflationary impact of shock in commodity prices on domestic inflation is temporary, it is important to determine whether headline inflation reverts to core inflation or vice versa, as in Cecchetti and Moessner (2008). This paper shows evidence of second-round effects arising from global oil and food price shocks, which resurrects the interest in the findings of Nindim (2006) that both underlying inflation measures revert to average inflation rather than the headline inflation. With accumulation of new data, there is a need to reinvestigate this topic. The paper recommends the use of other methods of ratifying the current findings. Moreover, it would be interesting also to study the factors affecting the pass-through effects, as in Gelos and Ustyugova (2012) among others. Nonetheless, the principal findings of this paper provide an impression that exchange rate stability, reactive monetary policy (especially during the times of large swings in commodity prices) and weak domestic demand in recent years have contributed to a low inflation environment in PNG since the late 1990s.

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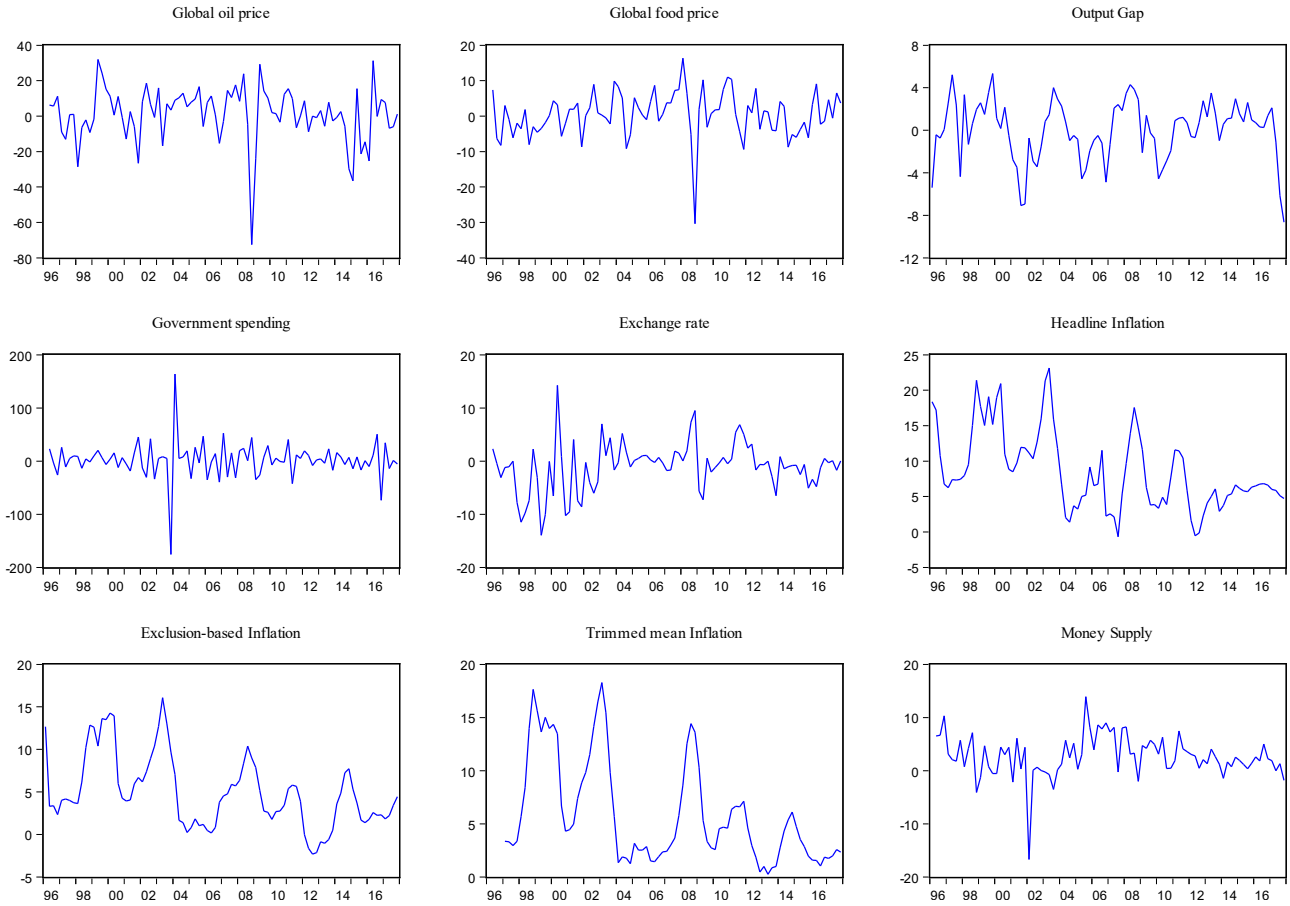
Appendix

8.1. A.

Figure 7
Visualisation of the Data
(Units in percent)



8.1. B.

Table 4
Basic Statistics of the Data
(Units in percent)

Statistics	p_t^{oil}	p_t^{food}	y_t	g_t	m_t	e_t	$\pi_t^{headline}$	$\pi_t^{exclusion}$	$\pi_t^{trimmed}$
Mean	0.9	0.5	-0.1	2.2	2.6	-1.1	8.3	4.9	5.9
Median	1.3	0.8	-0.7	4.8	2.3	-0.4	6.7	4.0	4.3
Maximum	32.0	16.3	5.0	163	13.9	14.2	23.1	16.1	18.3
Minimum	-75.6	-30.4	-5.0	-175.6	-16.7	-13.9	-0.7	-2.3	0.2
Std.Dev	15.8	6.3	2.3	3.7	3.8	4.7	5.4	4.2	4.9
Skewness	-1.4	-1.2	0.4	-0.5	-1.1	-0.1	0.8	0.7	1.0
Kurtosis	7.6	8.7	2.7	14.8	9.8	4.2	3.1	2.9	2.8
Observations	84	84	84	84	84	84	84	84	84

Source: Eviews output; Author's calculations.

8.2.

Table 7
Domestic Food, Fuel and Transport Inflation
(1996Q1 – 2017Q4)

Variable	Unit	ADF	KPSS	Description
Fuel inflation	Percent	-4.75*** I(0)	0.05* I(0)	Average of quarterly prices for diesel, petrol & kerosene in kina expressed in annual growth rates. These are at the pump retail prices collected by NSO within Port Moresby city only.
Transport inflation	Percent	-5.32*** I(0)	0.06* I(0)	Annual percentage change in CPI of the transport expenditure group sourced from BPNG research database. This is a proxy for prices of fuel related services.
Food inflation	Percent	-6.74*** I(1)	0.06* I(0)	Annual percentage change in CPI of the food expenditure group sourced from BPNG research database. In the absence of consumer prices, it is taken as proxy for domestic food prices.

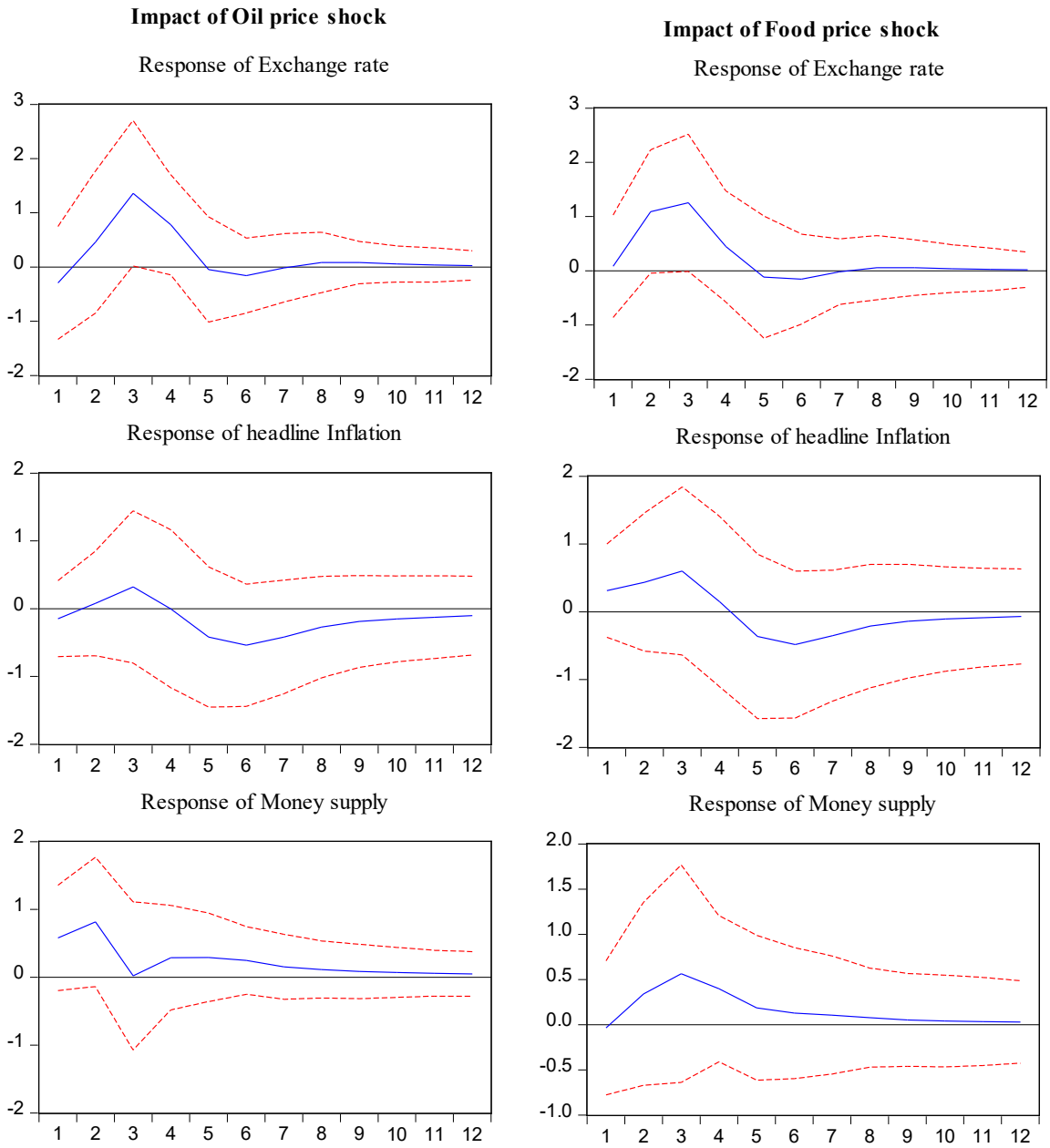
Note: The transport and food inflation are proxy for domestic food and transport services related prices due to absence of these data. The asterisks *** and * denote the 1% and 10% significance level of the tests at which, the null hypothesis is rejected for ADF and fails to reject for KPSS. Both tests find that all the variables are basically I(0) or stationary at levels. Thus they enter the VAR in levels following the same reasoning applied on the baseline model where variables are as per the order of integration.

Source: BPNG; Author's calculation.

8.3. Impulse Responses of Domestic Inflation to Global Oil and Food Price Shocks

Appendix 8.3 consists of Figures 8, 9, 14 and 16. The results of the various impulse response functions for headline and core inflation to 1% shock to growth in global oil and food prices are provided in Figures 8 and 9. The corresponding cumulative impulse responses are shown in Figure 14. The results for cumulative impulse responses for core inflation to shocks in domestic fuel inflation, transport inflation and food inflation are illustrated in Figure 17. As a recap, the cumulative impulse responses are reported primarily to show the ±2 standard deviations lines as the confidence band for each cumulative pass-through coefficients reported above in Figures 11, 12, 13, 15 and 16 could not be calculated in the econometrics software package the study uses.

Figure 8
Impluse Responses of Headline Inflation and Selected Variables to Shocks in Global Oil and Food Prices
[Response to Cholesky one S.D. (d.f. adjusted) Innovations ± S.E]

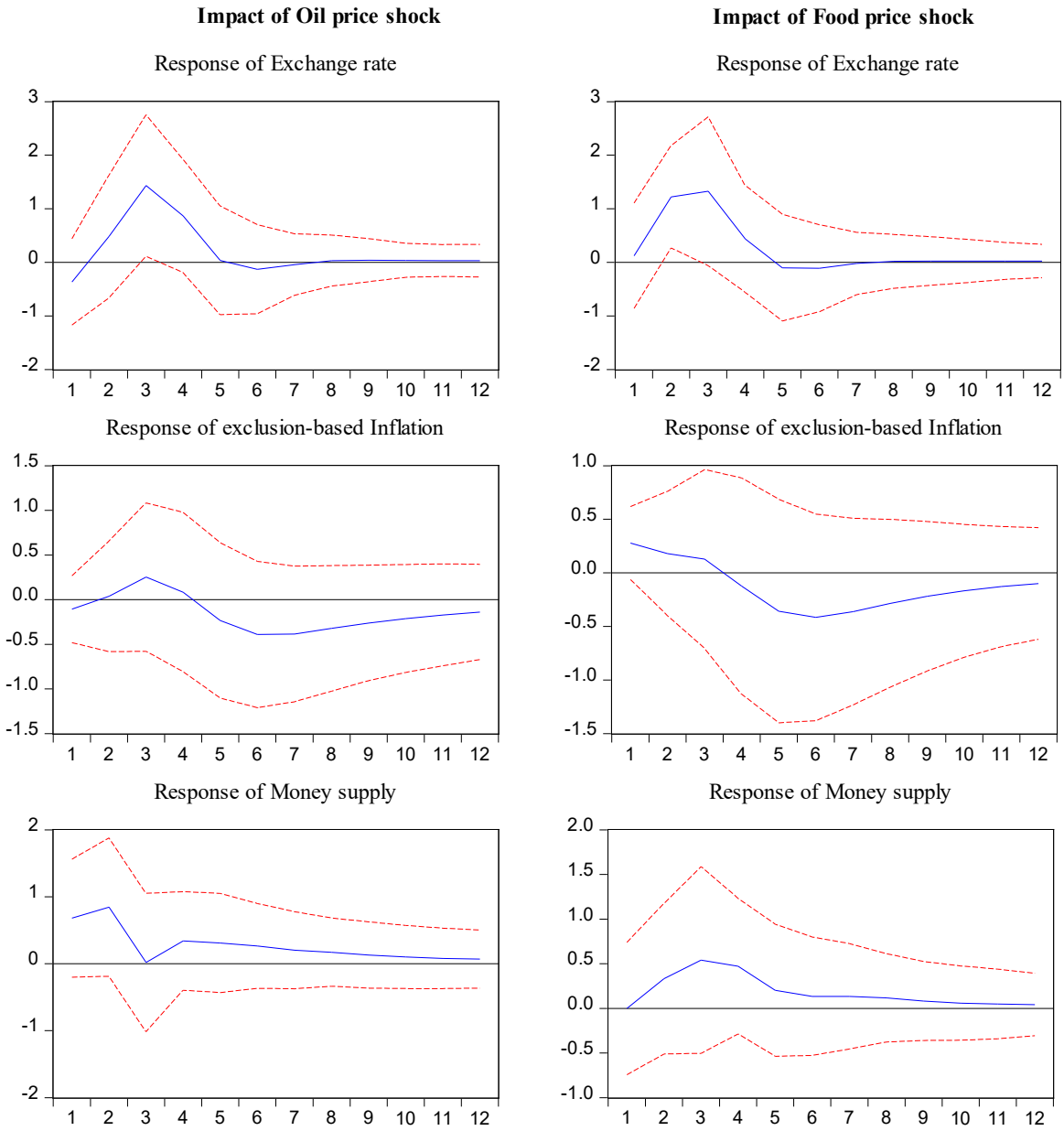


Note: The standard errors are generated through Monte Carlo simulation with 100 iteration levels. The red lines denote the ±2 Standard deviations. Per the object of the paper, impulse response of domestic demand is excluded.

Source: Eviews output; Author's calculation.

Figure 9
Impluse Responses of Core Inflation and Selected Variables Shock in Global Oil and Food Prices
[Response to Cholesky one S.D. (d.f. adjusted) Innovations ± S.E]

Impact on Exclusion-based Inflation

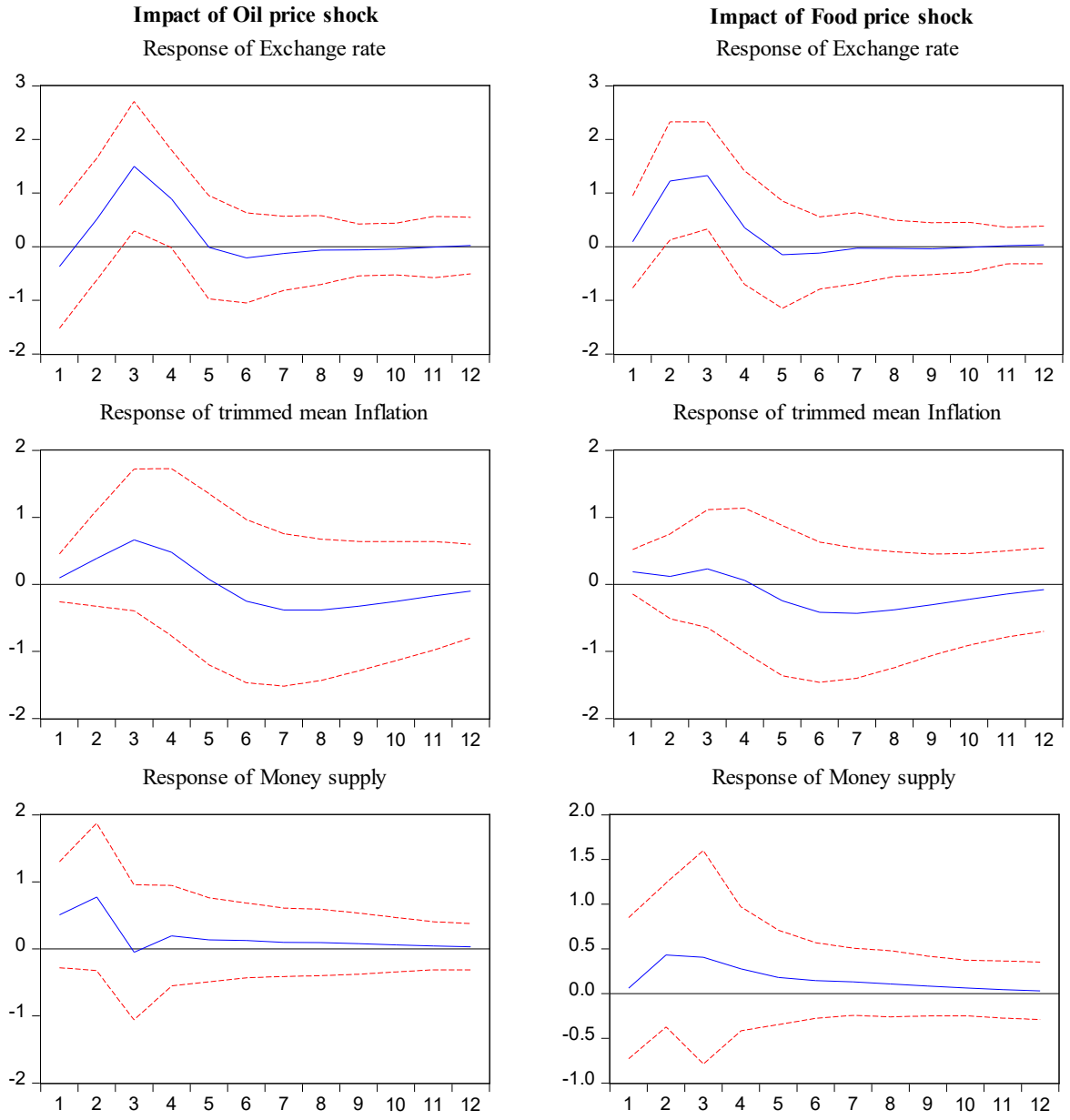


Note: The standard errors are generated through Monte Carlo simulation with 100 iteration levels. The red lines denote the ±2 Standard deviations.

Source: Eviews output; Author's calculation.

(End)

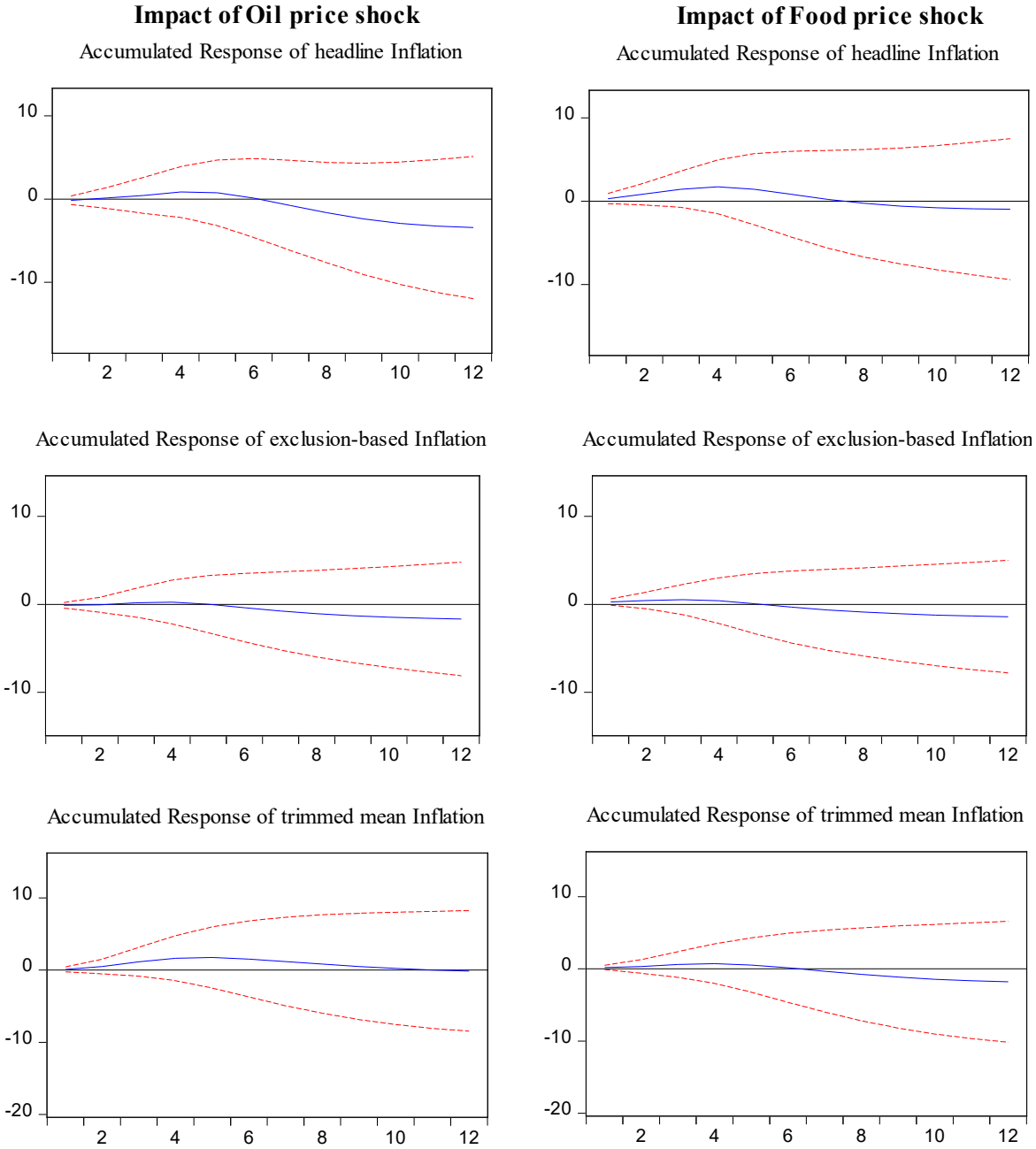
Impact of Trimmed Mean Inflation



Note: The standard errors are generated through Monte Carlo simulation with 100 iteration levels. The red lines denote the ±2 Standard deviations.

Source: Eviews output; Author's calculation.

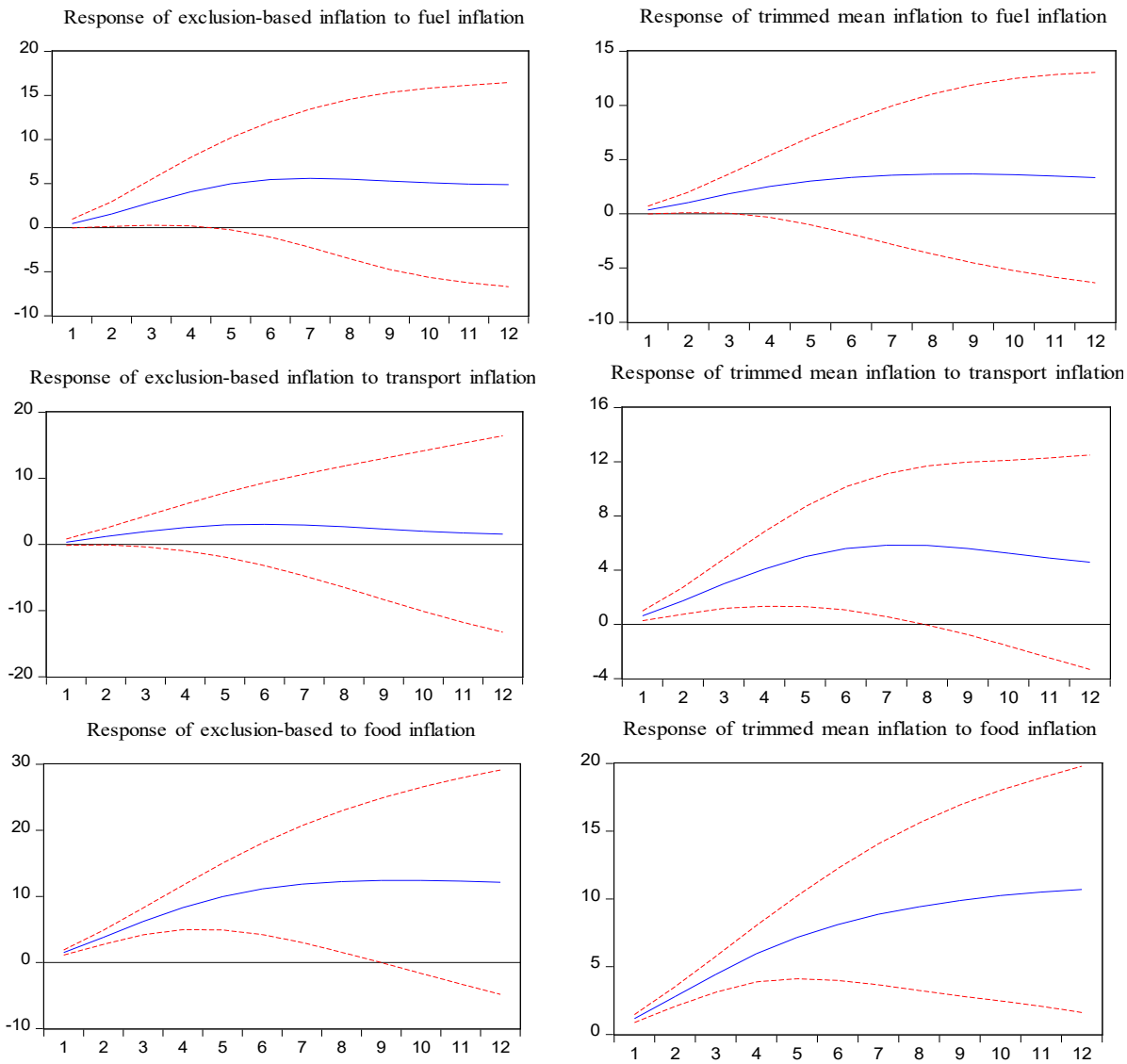
Figure 14
Cummulative Impluse Responses of Domestic Inflation to Shocks in Global Oil and Food Prices
[Response to Cholesky one S.D. (d.f. adjusted) Innovations ± S.E]



Note: The first row of the panel is the cumulative impulse responses for headline inflation while the next two rows are for the core inflation. The standard errors are generated through Monte Carlo simulation with 100 iteration levels. The red dotted lines denote the ±2 Standard deviations.

Source: Eviews output; Author's calculation.

Figure 17
Cummulative Impluse Responses of Core Inflation to Shocks in Domestic Fuel, Transport and Food Inflation
[Response to Cholesky one S.D. (d.f. adjusted) Innovations ± S.E]



The standard errors are generated through Monte Carlo simulation with 100 iteration levels. The red lines denote the ±2 Standard deviations.

Source: Eviews output; Author's calculation.

Chapter 8

THE FLATTENING OF THE PHILLIPS CURVE IN THE PHILIPPINES: THE ROLE OF THE GLOBAL OUTPUT GAP[1]

By

Jan Christopher G. Ocampo[2] and **Vanessa T. Español**[3]

1. Introduction

In forecasting inflation, policymakers rely on a suite of models, including the Phillips curve in an attempt to capture as accurately as possible the relationship between variables driving the inflation process and inflation itself. Because of the inherent uncertainty involved in inflation forecasting, the ability to come up with a reliable inflation forecast is crucial as it gives policymakers a better handle in deciding the appropriate stance of monetary policy and thus contribute to macroeconomic stability, especially during periods of unanticipated shocks. There has been a number of criticisms since the Phillips curve framework of linking nominal and real activity was introduced six decades ago. The most prominent one is that fluctuations in economic activity no longer generate the same inflationary pressures in the short run, compared to in the past. This phenomenon of the flattening of the Phillips curve, first observed in advanced economies (Roberts, 2006; Beaudry and Doyle, 2000; Iakova, 2007), and more recently in emerging economies (Dany-Knedlik and Garcia, 2018; Szrafranek, 2017) have been attributed to several factors, including credible monetary policy and globalization forces (Borio and Filardo, 2007).

The flattening of the Phillips curve has important policy implications. Mishkin (2007) notes that on the one hand, an economy facing overheating problems will no longer necessarily experience a corresponding large increase in inflation. On the other hand, a decline in the sensitivity of inflation to excess demand conditions also means that it would now be costlier, i.e., it would take a larger reduction in output, to bring inflation back to the desired target.

As is the practice in any inflation-targeting (IT) central bank, the Bangko Sentral ng Pilipinas' (BSP's) main consideration in setting the monetary policy stance is largely based on domestic considerations. Thus, if global factors were seen to become increasingly important in influencing the domestic inflation process, this could have important policy implications. The objective of this study is to examine whether globalization now plays a significant role in the domestic inflation process and how this might impact the conduct of monetary policy in the Philippines. There have been earlier studies using the Phillips curve framework in explaining the inflation dynamics for the Philippines. However, these studies have a few limitations, including the choice of variables which might not more fully capture the role of globalization (e.g., exchange rate and import price inflation) and the use of lags of inflation as a measure of inflation expectations which might not

1. The views expressed in this study are solely the responsibility of the authors and do not necessarily represent those of the BSP.
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more accurately depict the forward-looking behavior of agents. The main contribution of the study is to extend the standard reduced-form Phillips curve model through the use of a trade-weighted global output gap (in addition to the nominal exchange rate and import price inflation) to proxy for the impact of globalization on the domestic inflation process, with the sample period divided into two sub-sample periods, namely the pre-IT era (1990Q1-2001Q4) and IT period (2002-2018Q2).

There are several channels by which globalization could affect the domestic inflation-output tradeoff in the short run, including via increased trade integration of international goods, labor, and capital or financial markets (Razin and Binyamini, 2007). This paper focuses only on the international trade in goods channel. In addition, to reflect the forward-looking behavior of agents since the BSP formally adopted an inflation targeting (IT) framework in 2002, this study employs survey-based measure of inflation expectations. Empirical evidence (Lyziak, 2013; Ang et al., 2007) indicates its superior performance over using expectations derived from models or those implied from financial instruments in explaining the behavior of inflation.

The rest of the paper is organized as follows. Section 2 provides a discussion on the merits of the Phillips curve as a framework for modelling inflation, as well as related studies on Phillips curve for the Philippines, and implications of increasing roles of inflation expectations and globalization in the conduct of monetary policy. Section 3 presents evidence of a flattening of the Phillips curve in the Philippines using different measures of inflation, while section 4 outlines the empirical strategy involved in determining the factors behind the flattening phenomenon, including by using domestic and global variables. Section 5 reports estimation results and analysis arising from the estimation procedure, and finally section 6 provides policy implications.

2. Related Studies

2.1 Phillips Curve Framework of Modeling Inflation

Six decades have already passed since the Phillips curve was first introduced as a framework for modeling inflation, and yet no universal framework has emerged. Instead, several variants of the model have arisen, reflecting the need to modify the perceived shortcomings of earlier versions. For example, the specification of a simple reduced-form Phillips curve has inflation as a function of past inflation, a measure of economic slack, and other control variables such as supply shocks. However, this specification does not have a variable which explicitly accounts for the forward-looking behavior of agents in the economy (although the lagged inflation is sometimes used as a proxy). Meanwhile, a new Keynesian Phillips curve (NKPC), which is purely forward-looking has inflation being dependent on expected future inflation and a measure of excess demand conditions. A significant criticism of the NKPC, however, is its failure to capture the observed inertial component of inflation. To address this, a hybrid NKPC is introduced which incorporates the role of backward and forward-looking components of inflation, as well as the role of external factors. Thus, for an open emerging economy, a hybrid NKPC could take the following specification:

$$\pi_t = \alpha_0 + \alpha_i(L)\pi_t + \beta_d y_t^d + \beta_f y_t^f + \gamma neer_t + \delta\pi_t^{imp} + \mu\pi_{t+1|t}^e + \varepsilon_t$$

where π_t denotes inflation; $\pi_{t+1|t}^e$ is expected inflation; y_t^d is domestic output gap; y_t^f is foreign output gap; $neer_t$ is nominal effective exchange rate; π_t^{imp} is import price inflation, $\alpha(L)$ is a lag operator; and ε_t is the error term.

2.2 Phillips Curve Studies for the Philippines

An examination of earlier studies on the behavior of inflation in the Philippines using the Phillips curve yields mixed results. Dany-Knedlik and Garcia (2018), using quarterly data from 1995-2016 and a hybrid New Keynesian Phillips curve with time-varying parameters assess the changes in the contribution of long-term expectations, economic slack, oil price inflation, and non-oil import price inflation on inflation dynamics across the ASEAN-5 economies (e.g., Indonesia, Malaysia, the Philippines, Singapore, and Thailand). The study reports a greater role of forward-looking behavior in explaining headline inflation for the Philippines. The study also finds a significant steepening of the Phillips curve, and explains this increased sensitivity of domestic inflation to excess demand conditions to the reduced fluctuations in the output gap since the global financial crisis. At the same time, the study indicates a limited impact of oil price inflation to headline inflation, which is rather counterintuitive given that the Philippines is largely an oil-importing economy, importing nearly 100% of its total oil requirements abroad.

Meanwhile, Cacnio (2013), using quarterly data from 1988-2009 and also a hybrid New Keynesian Phillips curve finds evidence of a flattening of the Phillips curve and attributes this to the adoption of inflation targeting and increased trade openness. Her results are robust even with the introduction of globalization factors (e.g., exchange rate and the price of imported goods relative to wages), in contrast to the results of Dua (2006) which show the opposite. Nevertheless, a significant limitation of Cacnio's (2013) study pertains to the measure of inflation expectations used, which is proxied instead by lagged inflation. Empirical evidence (Ang et al., 2007; Lyziak, 2013) indicates that the use of survey-based measures of inflation expectations has a relatively superior performance over expectations derived from models or those implied from financial instruments in explaining the behavior of inflation. Meanwhile, Bagsic (2004) and Dumlao (2005) present evidence of a short-run trade-off between inflation and unemployment.

2.3 Increasing Role of Inflation Expectations in Monetary Policy Formulation

Since the Bangko Sentral ng Pilipinas transitioned to an inflation targeting framework in 2002, Guinigundo (2016) reports a growing role for inflation expectations in explaining the inflation dynamics in the Philippines, as the public have now become more forward-looking in their decision-making process. The ability of a central bank to anchor the public's inflation expectations around the inflation target becomes especially critical amid an environment characterized by elevated inflation and a greater degree of uncertainty. With a lower probability of inflation expectations becoming disanchored, or there being less deviation of inflation expectations from the inflation target, this implies that during unanticipated shocks, monetary policy need not react aggressively to bring the economy back to normal.

Thus, Calabria (2016) notes that the increasing role of behavioral economics now offers additional support to the use of a Phillips curve framework for analyzing inflation dynamics. As an example, he observes the presence of asymmetry between how individuals weigh potential losses and potential gains – that is, people generally tend to assign a greater weight on potential losses than potential gains. In a monetary policy setting, this kind of loss aversion may result in biased policymaking in the sense that policymakers may be compelled to adhere to inflation targets known by the public even when deviations may sometimes be acceptable or even optimal, as in the case of supply-side shocks wherein central banks, in principle, allow initial price increases to "pass through", and only react when second-round effects emerge that could threaten the inflation

objective. However, this kind of loss aversion has not translated in biased policymaking in the case of the BSP, as in line with international best practices and economic theory, it has allowed inflation to deviate slightly from the target when price movements are deemed to be emanating mainly from supply-side shocks, such as the rising cost of crude oil and elevated commodity prices in the global market, which are best addressed via non-monetary government measures.

In the case of monetary policy decision-making, however, what is crucial is that when faced with a potential breach to the inflation target, policymakers may need to respond more aggressively to prevent inflation expectations from becoming dislodged.

2.4 Impact of Global Factors on Domestic Inflation

From the point of view of policymakers, one of the most important implications of globalization is that it could complicate the conduct and effectiveness of monetary policy by dampening the role of or relative importance of domestic variables in the inflation process. As an example, Helbling et al.. (2006) observe that, in the mid-2000s, even against a backdrop of rising global commodity prices, a broad-based growth, and a generally accommodative monetary policy stance in major advanced economies, there has been an observed downtrend and relative stability in inflation across countries, leading some analysts to posit the argument that global factors have now become much more important than domestic factors in explaining the evolution of inflation. A situation of increasing dependence of domestic inflation on global conditions could potentially result in an undermining of a central bank's ability to control the behavior of domestic inflation, by compelling it to give up part of its independence in the conduct of monetary policy in favor of tracking other national policies (Calza, 2008).

Several channels have been put forward to explain how globalization could influence the variables driving the domestic inflation process. These include increasing trade integration of international goods, labor, and capital or financial markets (Razin and Binyamini, 2007). This paper focuses only on the international trade in goods channel. Greater trade integration with the rest of the world suggests that increases in domestic demand could be addressed via a rise in imports, instead of merely relying on domestic production (Kuttner and Robinson, 2010). An important implication of this is that increases in domestic economic slack will now have a smaller impact on domestic marginal costs, and consequently, produce limited inflationary pressures. At the same time, greater world demand for local products could generate a corresponding larger impact on the price-setting behavior of domestic firms, by raising their flexibility to adjust prices when demand rises, thereby leading to a steepening of the Phillips curve (Ball, 2006). However, Iakova (2007) notes that greater external competitive pressures could also diminish the pricing authority of local businesses, limiting their ability to adjust prices when demand rises, thus contributing to the decline in the sensitivity of inflation to domestic slack, or a flattening of the Phillips curve.

Meanwhile, other studies point to the limited role of global factors. Calza (2008) provides evidence that foreign output gaps do not feature significantly in the euro area's inflation dynamics and concludes that while external factors certainly merit closer monitoring, reacting to those factors do not appear to be warranted. Likewise, Roberts (2006) reports that shifts in monetary policy are almost entirely responsible for modifying the relationship between inflation and unemployment since the early 1980s. Aside from showing that there is now a reduced sensitivity of the change in inflation to the unemployment rate, he also finds that a significant part of the reduction in the volatility of the output gap can be explained by changes in monetary policy.

Nevertheless, while conceding that monetary policy does, to a great extent, explain the observed downtrend in inflation, Borio and Filardo (2007) provide evidence that inclusion of a proxy for global excess demand conditions, aside from other measures of external factors that could influence the domestic inflation process such as import and oil prices, resulted in a significant improvement in the ability of inflation models including the Phillips curve to predict inflation. In addition, they find the role of globalization factors as having grown over time and appeared to have contributed to the declining sensitivity of inflation to domestic economic slack.

3. Data

The coverage of the study is divided into two sub-sample periods, namely the pre-IT era (1990Q1-2001Q4) and IT period (2002Q1-2018Q2). Figure 1 provides a description of the variables.

Figure 1
Description of Data

π_t	Year-on-year headline, core, Gross Domestic Product (GDP) deflator, Personal Consumption Expenditure(PCE) deflator
y_t^d	Domestic output gap
y_t^f	Foreign/global output gap
$neer_t$	Year-on-year change in nominal effective exchange rate (NEER)
π_t^{imp}	Import price inflation
$\pi_{t+1\|t}^f$	Private sector one-year inflation expectations (from the Consensus Economics Survey); BSP one-year ahead inflation forecasts

3.1 Headline Inflation and Domestic Output Gap

Figure 2 plots the evolution of the different measures of inflation (e.g., headline, core, GDP deflator, and PCE deflator) for the Philippines over the full sample period. Relative to the pre-IT period (pre-2002), headline inflation during the IT era (2002-present) has been generally low and stable. The BSP was able to achieve its inflation targets for six consecutive years from 2009-2014 and in 2017. At the same time, economic growth has been robust, with GDP growing annually by above 6 percent since 2012.

Figure 2
Inflation Measures

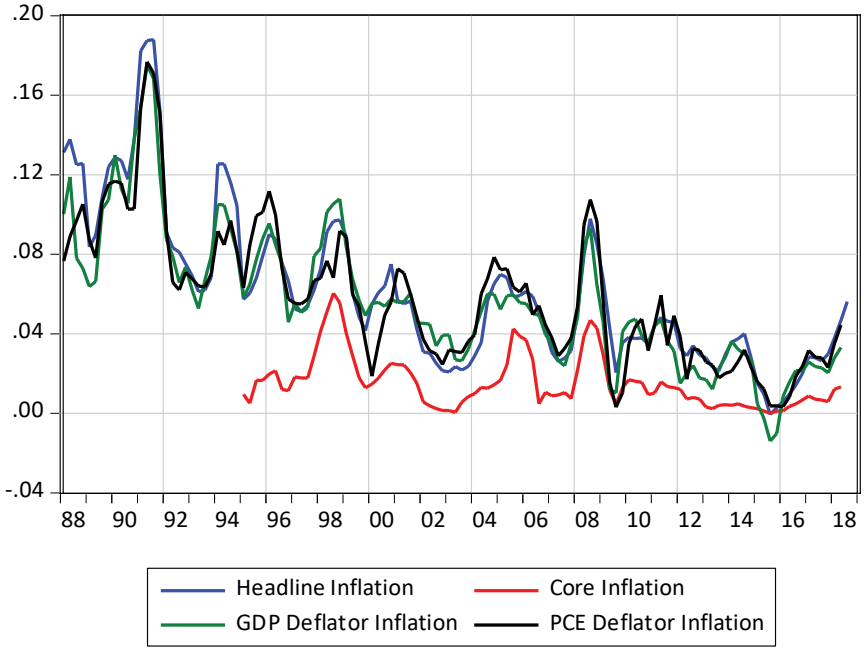
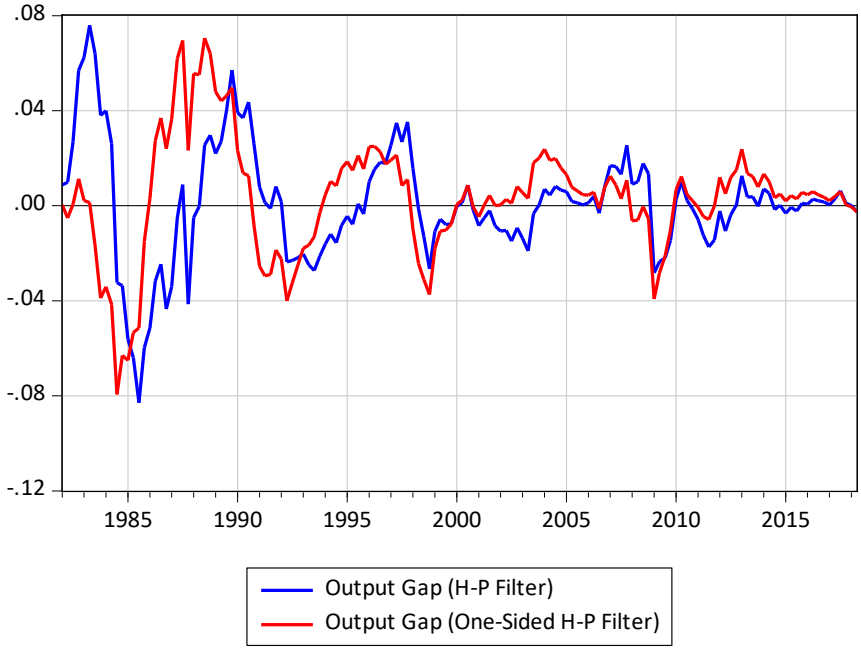


Figure 3 illustrates how the domestic output gap has behaved over the last three decades. With the exception of crisis periods, most notably the 1997 Asian Financial Crisis and the 2008 Global Financial Crisis, domestic output gap has remained fairly constant at near zero.

Figure 3
Domestic Output Gap



A regression of the different measures of inflation against the domestic output gap is presented in Figures 4 to 7. A graphical examination of said figures show that there appears to be a flattening of the Phillips curve during the IT period (2002Q1-2018Q2) compared to the pre-IT period (1990Q1-2001Q4). This flattening phenomenon holds regardless of the measure of inflation used (e.g., headline, core, GDP deflator, or the PCE deflator). Figure 8 indicates the evolution of the output gap coefficients over a 30-quarter rolling window using the different measures of inflation.

Figure 4
Headline Inflation and the Output Gap

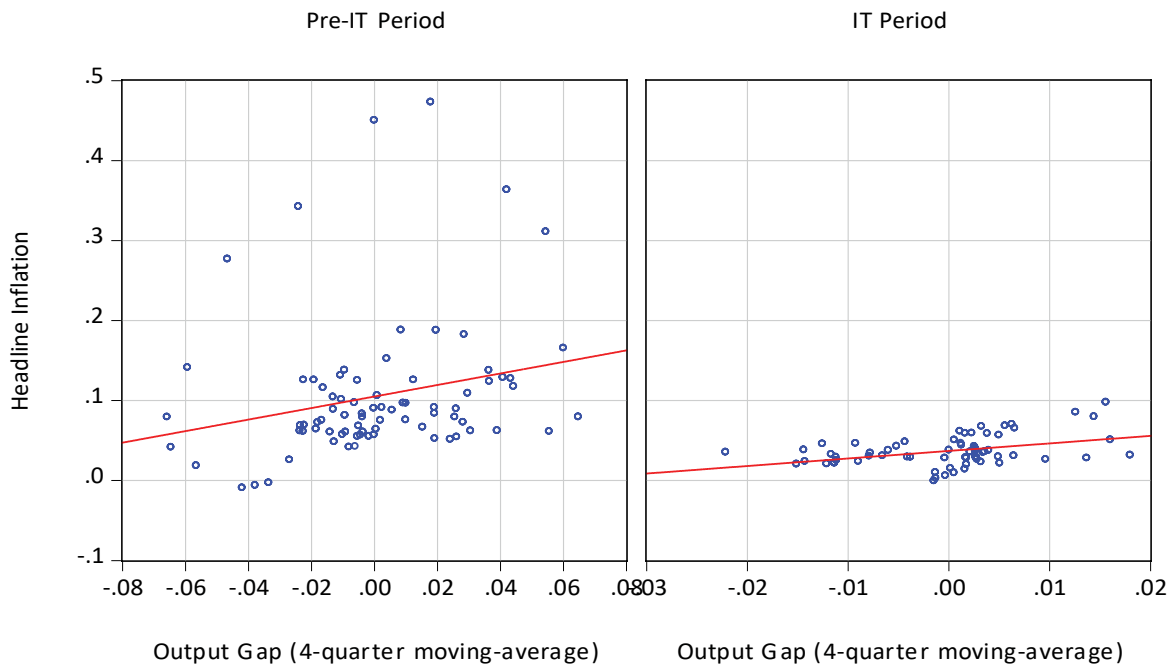


Figure 5
Core Inflation and the Output Gap

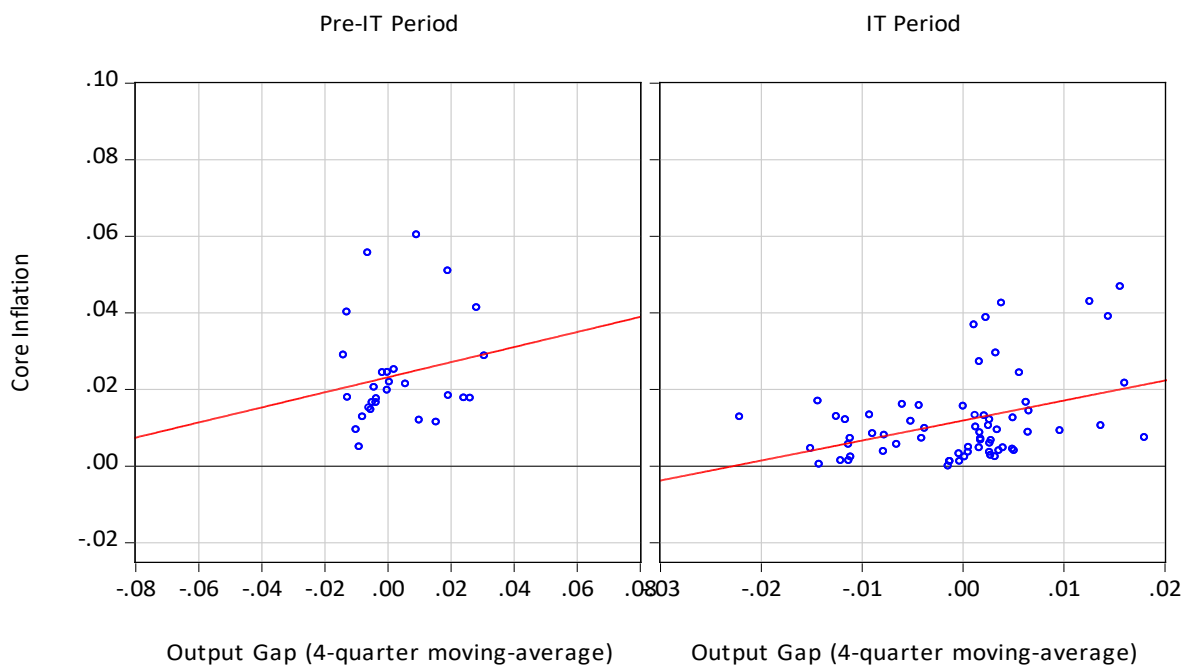


Figure 6
GDP Deflator Inflation and the Output Gap

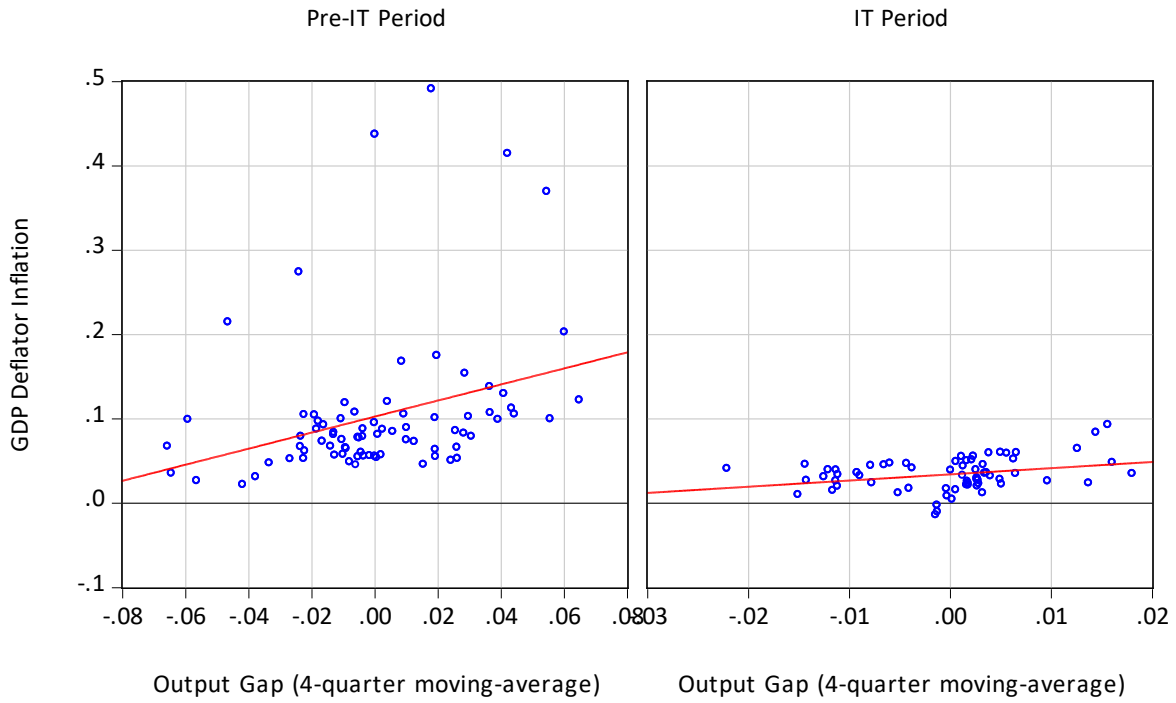


Figure 7
PCE Deflator Inflation and the Output Gap

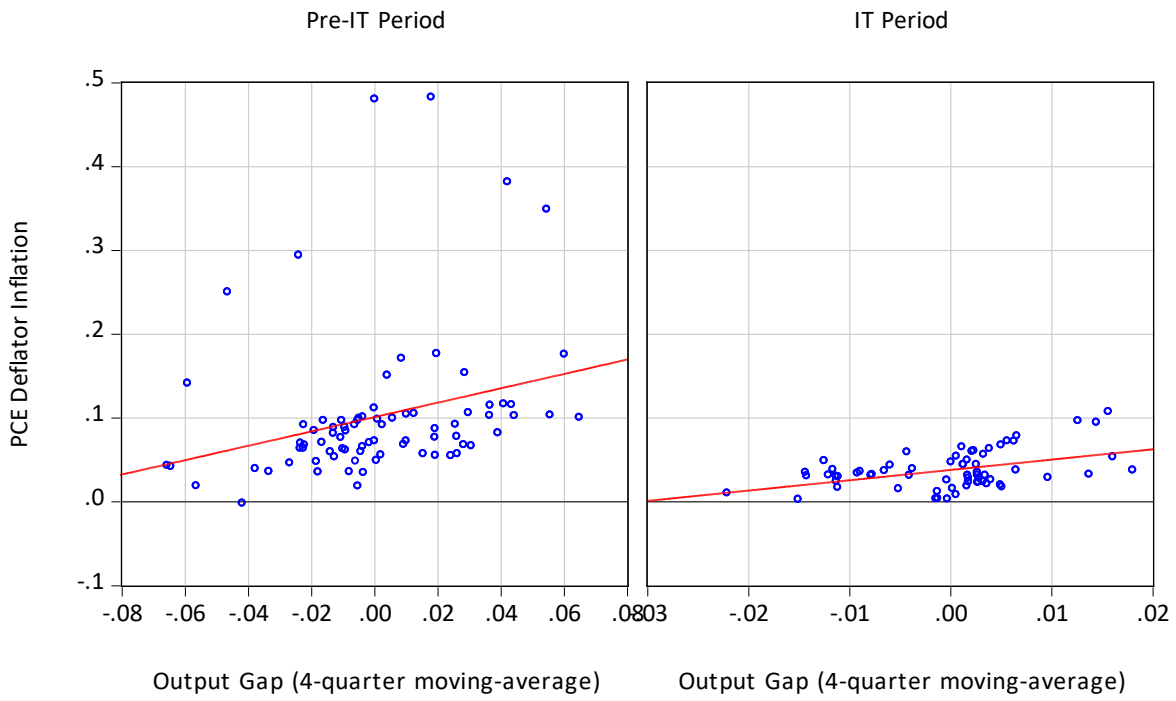
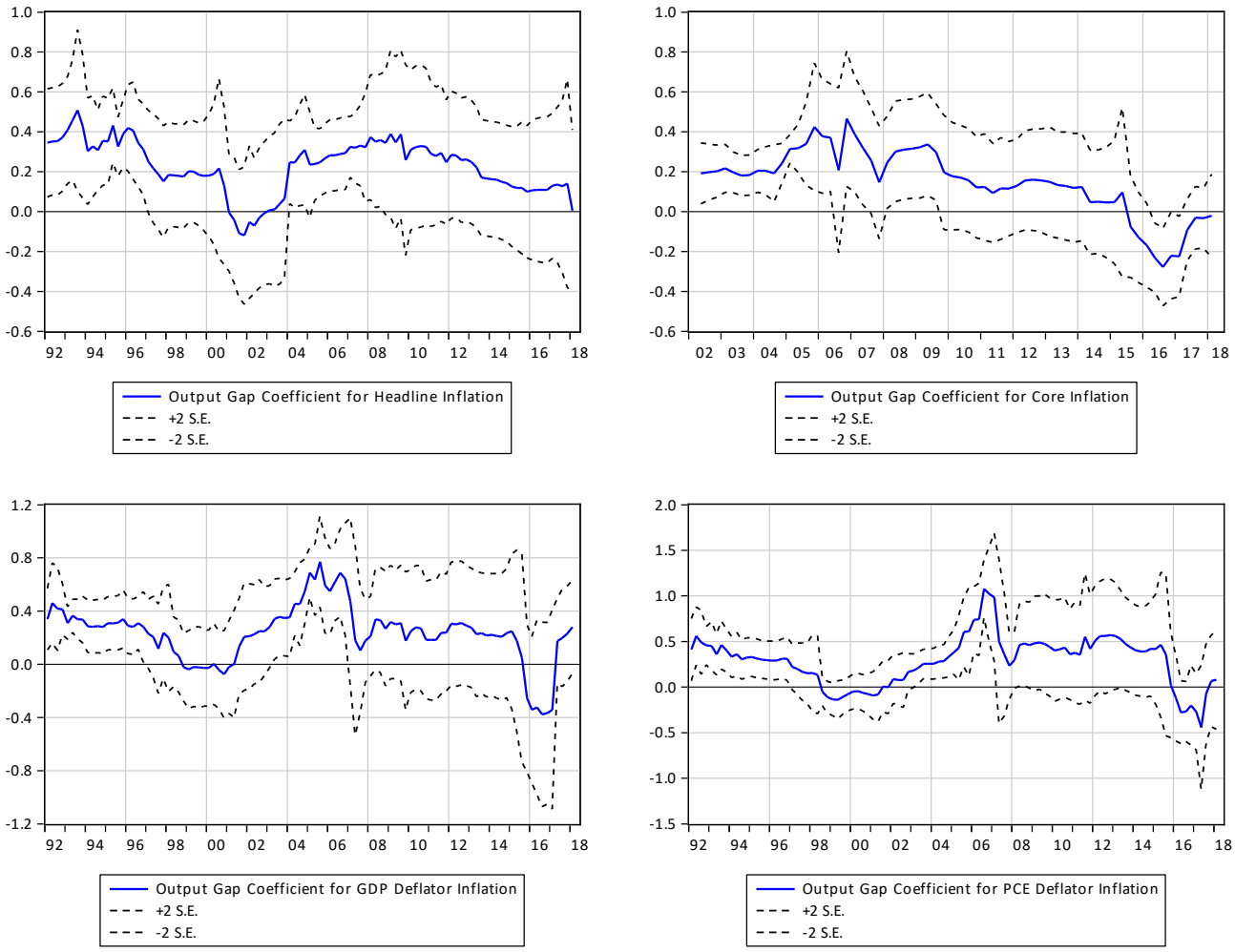


Figure 8
Output Gap Coefficient (30-Quarter Rolling Window)



3.2 Globalization Impact

3.2.1 Trade Channel

Increased openness of goods market is considered as one of the channels by which globalization can affect the variables driving the domestic inflation process. The role of trade in the Philippine has been increasing in significance, with total trade (imports plus exports) as a percentage of GDP, averaging less than 100.0 percent from 1990-2009 to more than 130.0 percent in 2018Q2 (Figure 9). In particular, the share of exports to GDP has risen from less than 50.0 percent from 1990-2009 to 60.0 percent in 2018 Q2 (Figure 10), while imports as a percentage of GDP has also picked up from less than 50.0 percent from 1990-2009 to more than 70.0 percent in 2018Q2 (Figure 11).

Figure 9
Trade-to-GDP Ratio

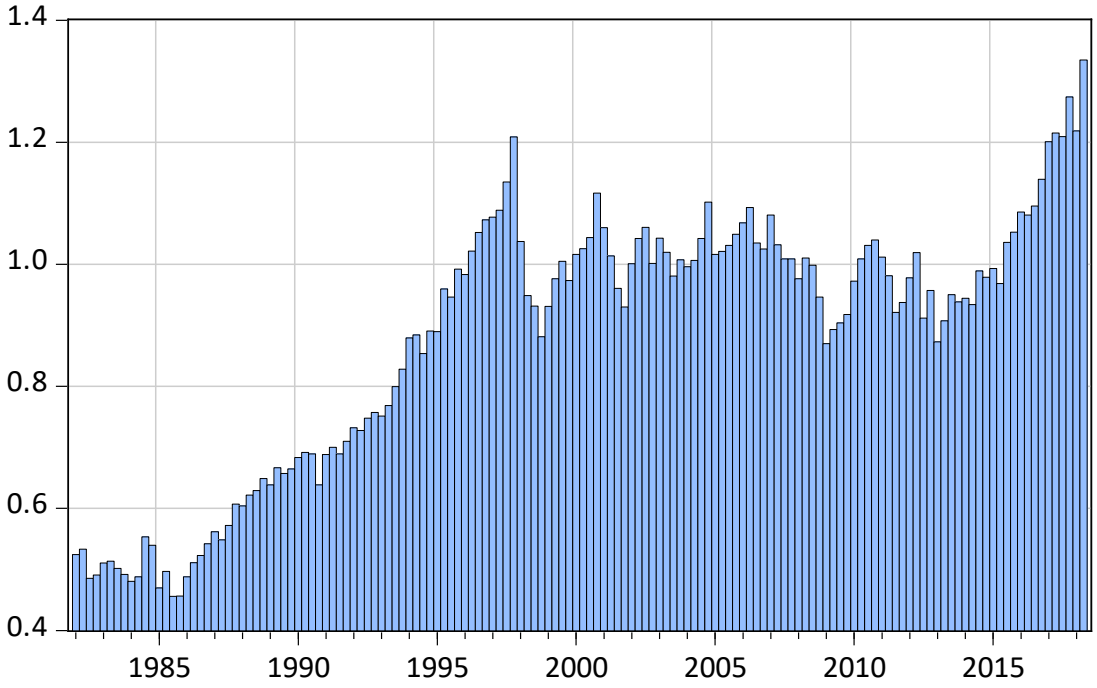


Figure 10
Exports-to-GDP Ratio

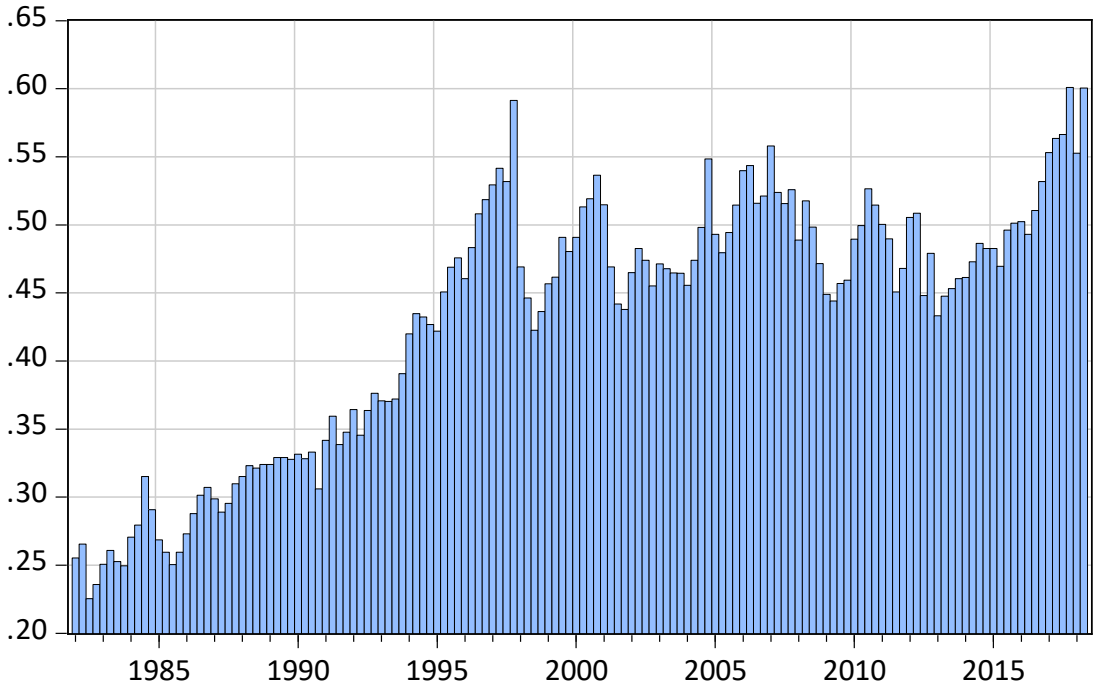
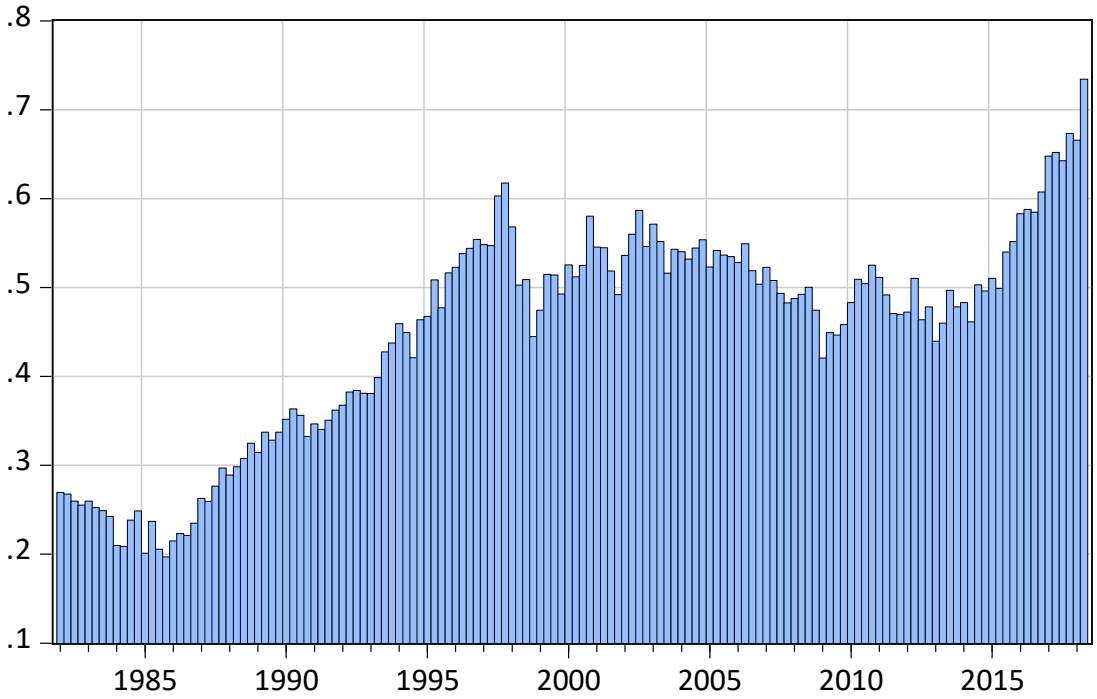


Figure 11
Imports-to-GDP Ratio

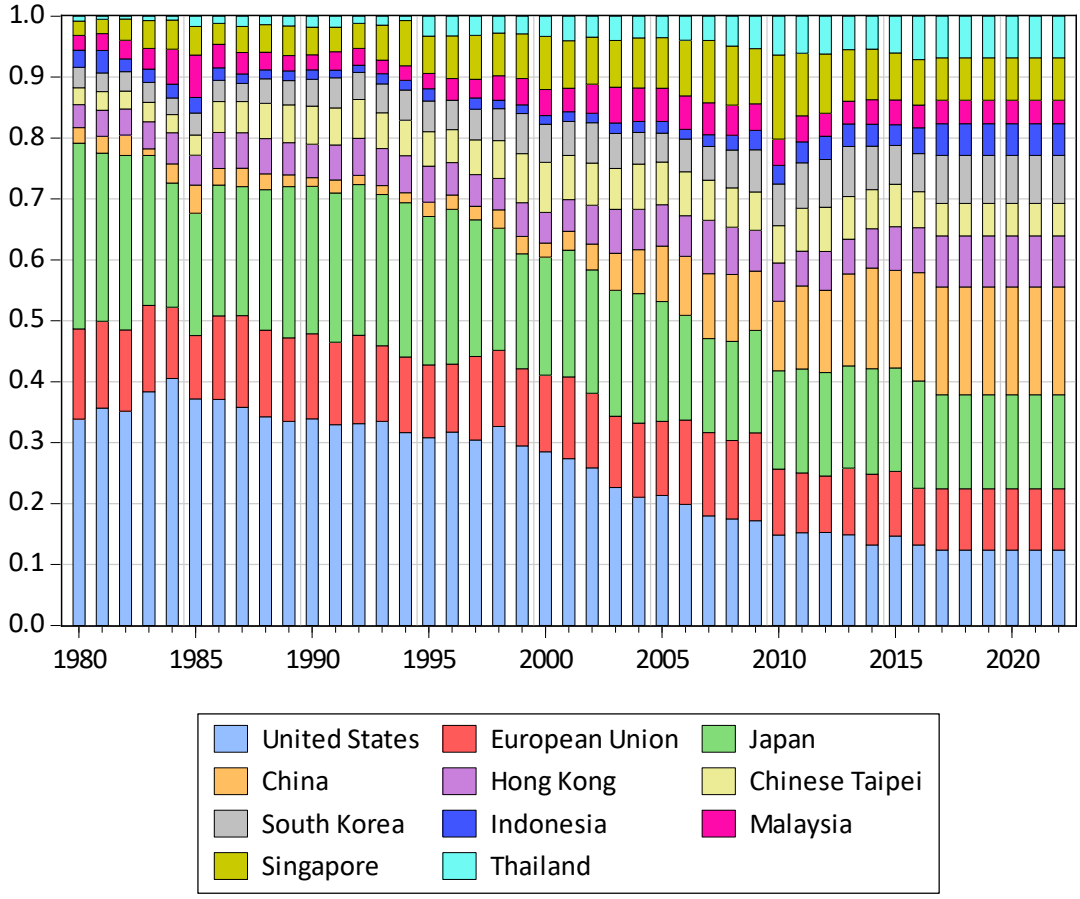


On a related note, as the share of traded goods and services to GDP increases, a given exchange rate movement could have a larger pass-through on domestic prices via the imported component of the consumer price index, as well as on exporters' competitiveness, average mark-ups, and pricing behavior. However, since the adoption of the inflation targeting framework in 2002, there has been a substantial decline in the responsiveness of inflation to movements in the exchange rate, attributed largely to the increasing monetary policy credibility of the BSP and the conduct of a flexible exchange rate regime (BSP, 2015; Mihaljek and Klau, 2008).

3.2.2 Global Output Gap

A corollary of the hypothesis that increased trade integration with the rest of the world influences the domestic inflation process is that the global excess demand conditions have now become an important driver of domestic inflation. Since the 1980s, the composition of trade weights for the Philippines' main trading partners has had notable changes (Figure 12). For instance, the United States, Japan, and the European Union used to be the country's top trading partners at around 60.0 percent from 1990-2009, but the shares have since gone down to 40.0 percent in 2010-2018. At present, while the United States continues to be a major trade partner of the Philippines, trade with Asian countries, particularly China, has risen in significance.

Figure 12
Trade Weights



As a proxy for the global output gap, a trade (exports and imports)-weighted world GDP index is constructed using the Philippines' primary trading partners (e.g., China, European Union, Hong Kong, Indonesia, Japan, Malaysia, South Korea, Singapore, Chinese Taipei, Thailand, and the United States), as follows:

$$w_{t,j} = \frac{x_{t,j+M_{t,j}}}{\Sigma_t(x_t + M_t)}$$

In constructing a trade-weighted world GDP index, the bottom-up approach (which is done by summing up the weighted output gaps of trading partners, $y_t^f = \Sigma_j w_{j,t} y_t^j$) and top-down method (by filtering the aggregate weighted GDPs of trading partners) were considered. Figure 14 illustrates that the top-down and bottom-up approaches in calculating the global output gap yields fairly similar estimates. Hence, this top-down approach will be used henceforth to avoid estimating the output of each trading partner.

Figure 13
Trade-weighted World GDP Growth

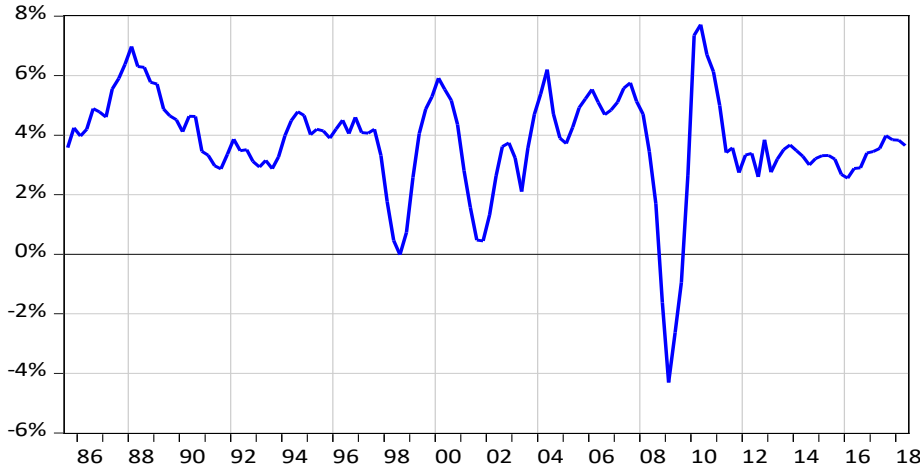
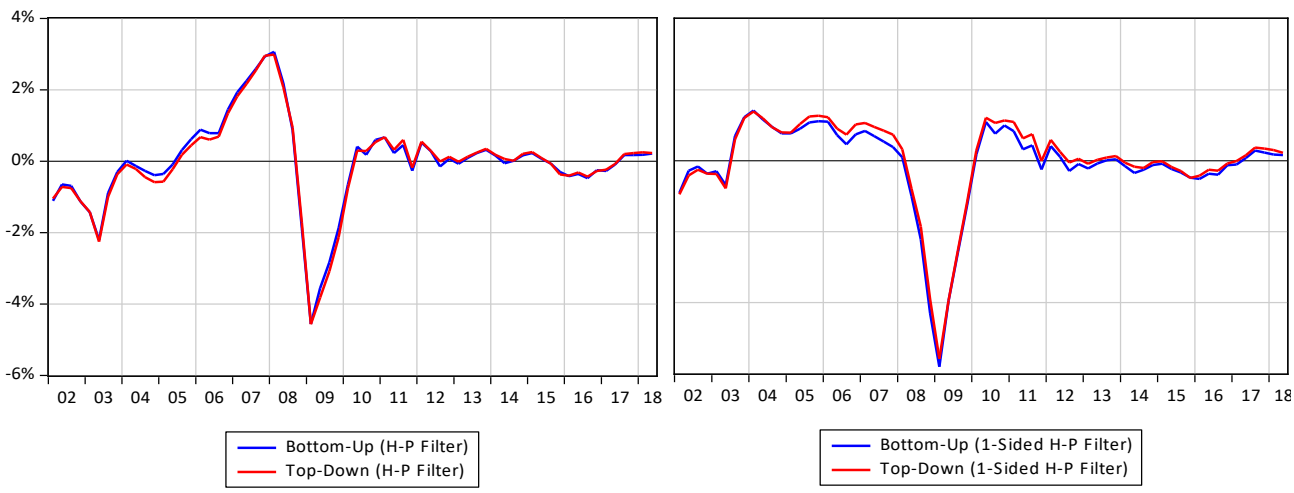
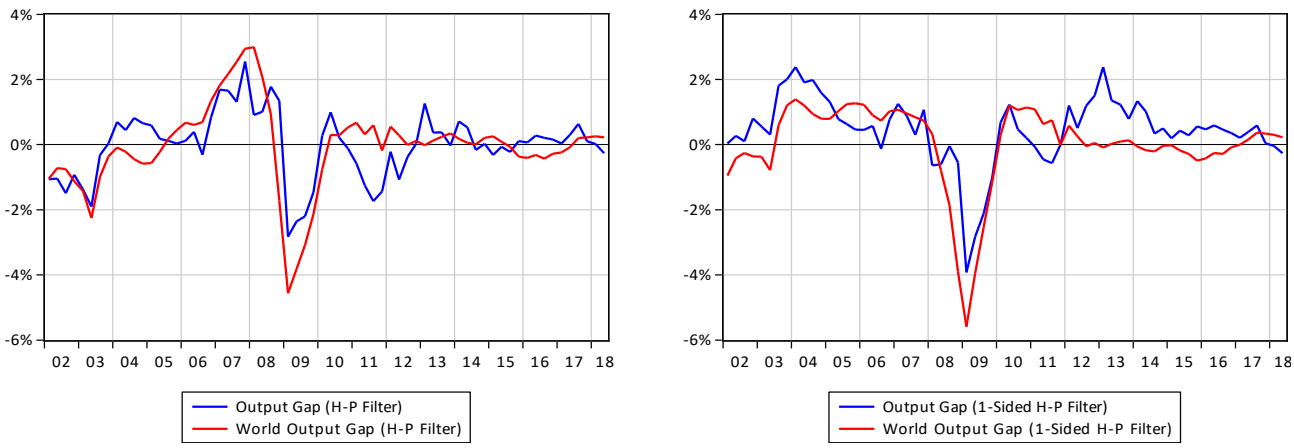


Figure 14
Trade-weighted Foreign Output Gap



A comparison of domestic and global output gaps, estimated using both the HP filter and one-sided HP filter (Figures 15) indicates that they move closely together.

Figure 15
Domestic and Global Output Gap



4. Methodology

Six versions of the Phillips Curve model are estimated using the generalized method of moments as follows:

$$\pi_t = \alpha_0 + \alpha_i(L)\pi_t + \beta_d y_t^d + \varepsilon_t \quad (0)$$

$$\pi_t = \alpha_0 + \alpha_i(L)\pi_t + \beta_d y_t^d + \beta_d y_t^f + \varepsilon_t \quad (1)$$

$$\pi_t = \alpha_0 + \alpha_i(L)\pi_t + \beta_d y_{t-1}^d + \beta_f y_{t-1}^f + \varepsilon_t \quad (2)$$

$$\pi_t = \alpha_0 + \alpha_i(L)\pi_t + \beta_d y_t^d + \beta_f y_t^f + \gamma neer_t + \varepsilon_t \quad (3)$$

$$\pi_t = \alpha_0 + \alpha_i(L)\pi_t + \beta_d y_t^d + \beta_f y_t^f + \gamma neer_t + \delta\pi_t^{imp} + \varepsilon_t \quad (4)$$

$$\pi_t = \alpha_0 + \alpha_i(L)\pi_t + \beta_d y_t^d + \beta_f y_t^f + \gamma neer_t + \delta\pi_t^{imp} + \mu\pi_{t+1|t}^e + \varepsilon_t \quad (5)$$

where π_t refers to the measure of inflation used (e.g., headline, core, GDP deflator, and PCE deflator inflation); y_t^d is domestic output gap; y_t^f is foreign output gap; $neer_t$ is nominal effective exchange rate; π_t^{imp} is import price inflation; $\mu\pi_{t+1|t}^e$ is one-year ahead inflation expectations (from the BSP and Consensus Economics survey); and ε_t is an error term.

5. Estimation Results and Analyses

This section shows the estimation results for each equation using headline inflation as the endogenous variable.

For equation 0, the coefficient for domestic output gap for both filtering methods yield results that are not statistically different from zero in the pre-IT period. Meanwhile, the coefficients were found to be positive and significant for the IT period, which suggests that the Phillips curve for the Philippines has become steeper. However, this result could be explained by omitted variables bias as can be seen in the succeeding regression estimation results.

The inclusion of the global output gap in equation 1 results in lower coefficients for domestic output gap, albeit statistically insignificant, in the IT period. On the other hand, the coefficients for global output gap, which were statistically insignificant in the pre-IT period, has turned positive and statistically significant in the IT period (Figure 17). The estimates for equation 2 confirms the results of equation 1, which indicates the specification is not sensitive to the contemporaneous or lagged values of domestic and global output gaps (Figure 18).

Including the growth in the NEER in equation 3 as an added measure of global factors continues to show that the global output gap remains a positive and significant determinant of domestic headline inflation especially for the IT period (Figure 19). Extending the specification further by adding imported price inflation in equation 4 continues to yield a positive and significant coefficient estimate for the global output gap using the 1-sided H-P filter (Figure 20).

Finally, incorporating two measures of inflation expectations in equation 5, which are the year-ahead inflation forecast survey of private sector economists and the BSP's year-ahead inflation forecast, again shows that global output remains a significant determinant of domestic headline inflation. Meanwhile, the positive and significant values for the coefficients of inflation expectations illustrate the importance the expectations channel in influencing inflation dynamics. Hence, monetary policy actions have a scope in affecting inflation movements by guiding the public's inflation expectations.

In addition to headline inflation, robustness checks were conducted for equations 1 to 6 by using other measures of inflation such as core, GDP deflator, and personal consumption expenditure deflator.

Figure 16
Estimation Results for Equation 0:
$$(\pi_t = \alpha_0 + \alpha_i(L)\pi_t + \beta_d y_t^d + \varepsilon_t \pi_t = \alpha_0 + \alpha_i(L)\pi_t + \beta_d y_t^d + \varepsilon_t)$$

Output Gap Measurement:	H-P Filter		One-Sided H-P Filter	
Sample Period:	1990-2001	2002-2018	1990-2001	2002-2018
Constant	0.02	0.01	0.02	0.00
	(0.00)***	(0.00)***	(0.00)***	(0.00)*
Inflation(-1)	1.19	1.35	1.21	1.39
	(0.10)***	(0.08)***	(0.09)***	(0.09)***
Inflation(-2)	-0.39	-0.51	-0.40	-0.52
	(0.09)***	(0.07)***	(0.09)***	(0.10)***
Domestic Output Gap	0.03	0.20	-0.05	0.19
	(0.09)	(0.11)*	(0.09)	(0.10)*
R-squared:	0.81	0.86	0.81	0.85
J-statistic	4.34	3.24	4.64	4.18
Prob(J-statistic)	0.50	0.66	0.46	0.52

Standard errors in parenthesis; Significance at * 10% level, ** 5% level, *** 1% level

Figure 17
Estimation Results for Equation 1:

$$(\pi_t = \alpha_0 + \alpha_i(L)\pi_t + \beta_d y_t^d + \beta_d y_t^f + \varepsilon_t \pi_t = \alpha_0 + \alpha_i(L)\pi_t + \beta_d y_t^d + \beta_d y_t^f + \varepsilon_t)$$

Output Gap Measurement:	H-P Filter		One-Sided H-P Filter	
Sample Period:	1990-2001	2002-2018	1990-2001	2002-2018
Constant	0.02	0.01	0.02	0.01
	(0.00)***	(0.00)***	(0.00)***	(0.00)***
Inflation(-1)	1.18	1.42	1.21	1.44
	(0.08)***	(0.08)***	(0.08)***	(0.07)***
Inflation(-2)	-0.40	-0.57	-0.42	-0.59
	(0.08)***	(0.08)***	(0.08)***	(0.08)***
Domestic Output Gap	0.16	0.08	0.09	-0.07
	(0.09)	(0.13)	(0.09)	(0.10)
Global Output Gap	-0.32	0.16	-0.33	0.23
	(0.19)	(0.08)*	(0.20)	(0.06)**
R-squared:	0.81	0.87	0.81	0.87
J-statistic	6.46	6.55	6.86	4.09
Prob(J-statistic)	0.60	0.59	0.55	0.85

Standard errors in parenthesis; Significance at * 10% level, ** 5% level, *** 1% level

Figure 18
Estimation Results for Equation 2:

$$(\pi_t = \alpha_0 + \alpha_i(L)\pi_t + \beta_d y^d_{t-1} + \beta_f y^f_{t-1} + \varepsilon_t \pi_t = \alpha_0 + \alpha_i(L)\pi_t + \beta_d y^d_{t-1} + \beta_f y^f_{t-1} + \varepsilon_t)$$

Output Gap Measurement:	H-P Filter		One-Sided H-P Filter	
Sample Period:	1990-2001	2002-2018	1990-2001	2002-2018
Constant	0.02	0.01	0.02	0.01
	(0.01)***	(0.00)***	(0.00)***	(0.00)***
Inflation(-1)	1.16	1.43	1.18	1.41
	(0.09)***	(0.07)***	(0.08)***	(0.08)***
Inflation(-2)	-0.41	-0.61	-0.42	-0.57
	(0.08)***	(0.06)***	(0.08)***	(0.08)***
Domestic Output Gap(-1)	0.19	-0.04	0.16	-0.11
	(0.08)**	(0.07)	(0.07)**	(0.07)
Global Output Gap(-1)	-0.41	0.17	-0.46	0.24
	(0.23)*	(0.07)**	(0.22)**	(0.05)***
R-squared:	0.82	0.87	0.82	0.87
J-statistic	6.93	7.85	6.84	5.05
Prob(J-statistic)	0.54	0.45	0.55	0.75

Standard errors in parenthesis; Significance at * 10% level, ** 5% level, *** 1% level

Figure 19
Estimation Results for Equation 3:
$$(\pi_t = \alpha_0 + \alpha_i(L)\pi_t + \beta_d y_t^d + \beta_f y_t^f + \gamma neer_t + \varepsilon_t)$$

Output Gap Measurement:	H-P Filter		One-Sided H-P Filter	
Sample Period:	1990-2001	2002-2018	1990-2001	2002-2018
Constant	0.02	0.00	0.00	0.01
	(0.01)*	(0.00)***	(0.01)	(0.00)***
Inflation(-1)	0.94	1.26	0.97	1.46
	(0.14)***	(0.09)***	(0.15)***	(0.12)***
Inflation(-2)	-0.29	-0.36	-0.18	-0.62
	(0.12)*	(0.10)***	(0.12)	(0.14)***
Domestic Output Gap	-0.01	0.02	0.10	-0.13
	(0.07)	(0.13)	(0.07)	(0.10)
Global Output Gap	-0.04	0.40	0.25	0.24
	(0.18)	(0.09)***	(0.12)*	(0.06)***
%Change in NEER	-0.06	-0.05	-0.10	0.00
	(0.02)**	(0.02)***	(0.02)***	(0.02)
R-squared:	0.61	0.87	0.60	0.87
J-statistic	6.10	10.48	6.15	7.71
Prob(J-statistic)	0.87	0.49	0.86	0.74

Standard errors in parenthesis; Significance at * 10% level, ** 5% level, *** 1% level

Figure 20
Estimation Results for Equation 4:

$$(\pi_t = \alpha_0 + \alpha_i(L)\pi_t + \beta_d y_t^d + \beta_f y_t^f + \gamma neer_t + \delta\pi_t^{imp} + \varepsilon_t)$$

Output Gap Measurement:	H-P Filter		One-Sided H-P Filter	
Sample Period:	1990-2001	2002-2018	1990-2001	2002-2018
Constant	0.03	0.00	0.02	0.01
	(0.01)***	(0.00)***	(0.00)***	(0.00)***
Inflation(-1)	0.75	1.08	0.81	1.47
	(0.09)***	(0.12)***	(0.06)***	(0.11)***
Inflation(-2)	-0.26	-0.17	-0.26	-0.64
	(0.06)***	(0.12)	(0.06)***	(0.12)***
Domestic Output Gap	-0.29	0.25	-0.18	-0.21
	(0.06)***	(0.16)	(0.08)**	(0.09)**
Global Output Gap	0.07	0.23	0.23	0.21
	(0.12)	(0.14)	(0.06)***	(0.06)***
%Change in NEER	0.02	-0.04	0.01	0.01
	(0.01)**	(0.02)***	(0.02)	(0.01)
Import Price Inflation	0.10	0.07	0.08	0.03
	(0.01)***	(0.03)**	(0.01)***	(0.02)
R-squared:	0.67	0.88	0.66	0.88
J-statistic	7.64	10.14	7.60	8.04
Prob(J-statistic)	0.91	0.75	0.91	0.89

Standard errors in parenthesis; Significance at * 10% level, ** 5% level, *** 1% level

Figure 21
Estimation Results for Equation 5

$$(\pi_t = \alpha_0 + \alpha_i(L)\pi_t + \beta_d y_t^d + \beta_f y_t^f + \gamma neer_t + \delta\pi_t^{imp} + \mu\pi_{t+1|t}^e + \varepsilon_t)$$

Output Gap Measurement:	H-P Filter		One-Sided H-P Filter	
Sample Period:	2002-2018	2002-2018	2002-2018	2002-2018
Constant	0.00	-0.01	0.00	-0.01
	(0.00)	(0.00)***	(0.00)	(0.00)***
Inflation Expectations (Survey)	0.34		0.53	
	(0.12)***		(0.10)***	
Inflation Expectation (CB Forecasts)		0.76		0.72
		(0.09)***		(0.08)***
Inflation(-1)	0.98	0.84	1.02	1.05
	(0.12)***	(0.08)***	(0.10)***	(0.07)***
Inflation(-2)	-0.27	-0.20	-0.52	-0.48
	(0.10)***	(0.06)***	(0.08)***	(0.08)***
Domestic Output Gap	0.14	0.01	-0.10	-0.40
	(0.12)	(0.07)	(0.09)	(0.10)***
Global Output Gap	0.11	0.16	-0.33	0.23
	(0.10)	(0.05)***	(0.09)***	(0.08)***
%Change in NEER	-0.02	-0.02	0.06	0.01
	(0.01)	(0.01)**	(0.01)***	(0.01)
Import Price Inflation	0.09	0.07	0.17	0.03
	(0.03)***	(0.01)***	(0.02)***	(0.02)
R-squared:	0.92	0.94	0.92	0.94
J-statistic	11.13	12.25	10.17	10.53
Prob(J-statistic)	0.85	0.78	0.90	0.88

Standard errors in parenthesis; Significance at * 10% level, ** 5% level, *** 1% level

Figure 22
Summary of Global Output Gap Coefficients for Headline Inflation

Output Gap Measurement:	H-P Filter		One-Sided H-P Filter	
Sample Period:	1990-2001	2002-2018	1990-2001	2002-2018
Eq. 0	-0.32	0.16	-0.33	0.23
	(0.19)	(0.08)	(0.20)	(0.06)**
Eq. 1	-0.41	0.17	-0.46	0.24
	(0.23)*	(0.07)**	(0.22)**	(0.05)***
Eq. 2	-0.04	0.4	0.25	0.24
	(0.18)	(0.09)***	(0.12)*	(0.06)***
Eq. 3	0.07	0.23	0.23	0.21
	(0.12)	(0.14)	(0.06)***	(0.06)***
Eq. 4		0.11		-0.33
		(0.10)		(0.09)***
Eq. 5		0.16		0.23
		(0.05)***		(0.08)***

Standard errors in parenthesis; Significance at * 10% level, ** 5% level, *** 1% level

Figure 23
Summary of Global Output Gap Coefficients for Core Inflation

Output Gap Measurement:	H-P Filter		One-Sided H-P Filter	
Sample Period:	1990-2001	2002-2018	1990-2001	2002-2018
Eq. 0	-0.15	0.14	-0.17	0.17
	(0.12)	(0.06)*	(0.09)	(0.05)**
Eq. 1	-0.08	0.14	-0.13	0.16
	(0.08)	(0.06)*	(0.16)	(0.04)**
Eq. 2	-0.06	0.17	0.02	0.14
	(0.06)	(0.05)**	(0.06)	(0.05)**
Eq. 3	-0.01	0.13	0.05	0.14
	(0.02)	(0.07)	(0.03)	(0.06)*
Eq. 4		0.02		-0.07
		(0.05)		(0.06)
Eq. 5		0.03		0.07
		(0.06)		(0.05)

Standard errors in parenthesis; Significance at * 10% level, ** 5% level, *** 1% level

Figure 24
Summary of Global Output Gap Coefficients for GDP Deflator Inflation

Output Gap Measurement:	H-P Filter		One-Sided H-P Filter	
Sample Period:	1990-2001	2002-2018	1990-2001	2002-2018
Eq. 0	-0.39	0.21	-0.49	0.29
	(0.23)	(0.12)	(0.32)	(0.09)**
Eq. 1	-0.45	0.08	-0.63	0.27
	(0.19)*	(0.15)	(0.25)*	(0.08)**
Eq. 2	-0.01	0.23	0.08	0.28
	(0.15)	(0.13)	(0.11)	(0.09)**
Eq. 3	0.02	0.14	0.1	0.31
	(0.08)	(0.18)	(0.06)	(0.11)**
Eq. 4		0.22		0.07
		(0.11)*		(0.09)
Eq. 5		0.21		0.67
		(0.16)		(0.12)**

Standard errors in parenthesis; Significance at * 10% level, ** 5% level, *** 1% level

Figure 25
Summary of Global Output Gap Coefficients for PCE Deflator Inflation

Output Gap Measurement:	H-P Filter		One-Sided H-P Filter	
Sample Period:	1990-2001	2002-2018	1990-2001	2002-2018
Eq. 0	-0.23	0.43	-0.33	0.52
	(0.24)	(0.14)**	(0.35)	(0.12)**
Eq. 1	-0.2	0.4	-0.42	0.47
	(0.19)	(0.14)**	(0.27)	(0.09)**
Eq. 2	0.05	0.75	-0.02	0.54
	(0.17)	(0.14)**	(0.19)	(0.10)**
Eq. 3	0.21	0.39	0.13	0.44
	(0.14)	(0.24)	(0.16)	(0.13)**
Eq. 4		0.03		-0.07
		(0.21)		(0.16)
Eq. 5		0.16		0.39
		(0.19)		(0.15)*

Standard errors in parenthesis; Significance at * 10% level, ** 5% level, *** 1% level

6. Conclusion/Policy Implications

This study presents a comprehensive assessment of the determinants of inflation in the Philippines, by accounting for the impact of global factors, in addition to domestic variables, as well as inflation expectations. This study also analyzes how the roles of the various drivers of inflation in the Philippines have evolved over time with the sample periods divided into the pre-IT era (1990Q1-2001Q4) and IT period (2002Q1-2018Q2).

The main findings of the study are the following. First, there have been changes in the contribution of the different drivers of inflation, with the domestic output gap now playing a less significant role, hence a flattening of the Phillips curve, during the IT period. Second, offsetting the diminished role of the domestic output gap is the growing role of global factors, as proxied by global output gap. This particular finding is consistent with the assumption in the literature that global developments have now become an important factor in influencing the short-run trade-off between domestic inflation and output. Adding other external variables such as the exchange rate and import price inflation does not diminish the explanatory of the global output gap. An important implication of this finding for monetary policy is whether the BSP would now consider incorporating the global output gap in its suite of inflation models, as this study has shown its significance and growing role in explaining the domestic inflation process.

Nevertheless, while the role of global factors has grown in significance over time, this study also highlights the relevance of domestic factors such as the role of the credibility of monetary policy (via the inflation expectations channel) in explaining the domestic inflation process. This finding is particularly relevant as the central bank's ability to anchor inflation expectations is critical especially during periods marked by elevated inflation levels, unanticipated shocks, or greater degree of uncertainty. With a lower chance of inflation expectations becoming disanchored, monetary policy need not react aggressively during such times, in order to bring inflation back to the desired target. At the same time, there is also a need to preserve the credibility of the BSP such that in times wherein actual inflation has breached the inflation target, an explanation of what caused the breach and the measures needed to bring the inflation back to target, need to be carefully communicated to the public.

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Chapter 9

INFLATION PERSISTENCE: EVIDENCE FROM CPI SUBCATEGORIES - THE SRI LANKAN EXPERIENCE[1]

By

Lasitha R C Pathberiya[2] and W S Navin Perera[3]

1. Introduction

Central banks are constantly faced with the challenge of ensuring price stability in their respective economies. Recent developments in the world economy indicate that while most advanced economies have been successful in maintaining inflation at their target levels, some appear to have been faced with the challenge of driving inflation up towards the desired levels.[4] With respect to emerging market and developing economies, a notable moderation in inflation has been observed over the past decade and a half, although inflation remains well above levels seen in advanced economies (IMF, 2018).

It is conceivable that moderation in inflation in many advanced economies and a few emerging markets and developing economies was due to the adoption of inflation targeting as their monetary policy framework. This is reflected in two ways; firstly, through the gradual stabilisation of inflation at the desired levels, and secondly, the waning of the degree of inflation persistence following the adoption of inflation targeting (Gerlach and Tillmann, 2012). In other words, the degree of inflation persistence is relatively high for non-inflation targeting economies or ones that have multiple objectives, as the price stability objective attracts less attention (Bratsiotis et al., 2015). For such economies, it is extremely important to have a gauge of the magnitude of inflation persistence. Higher the persistence of inflation, longer it would take policymakers to bring back inflation to desired levels following an idiosyncratic shock.

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4. There is a continuing debate as to whether inflation being maintained at low and targeted/desired levels is due to good luck or good policy. However, the consensus is that policy has had a significant influence on this trend.

Sri Lanka, which has had historically high levels of inflation in the past (averaging 11.9% during 1978-2008 and 13.7% during 2004-2008), has observed close to a decade of single digit inflation, in spite of it being a non-inflation targeting economy. Such discipline in inflation was largely a result of the continued dialogue between the Central Bank of Sri Lanka and its key stakeholders about their commitment towards maintaining inflation at single digits, making it known that the Central Bank of Sri Lanka is implicitly targeting inflation, while being in a broadly monetary targeting-based policy framework. Nonetheless, Sri Lanka, at times, has found it challenging to maintain inflation within single digits owing to factors such as rising global energy prices, rupee depreciation, rising food prices on account of supply disruptions resulting from adverse weather conditions and loose fiscal policy, *inter alia*. Most notably, past inflation, or inflation persistence has also been a significant factor in the determination of current period's inflation as well as inflation expectations, and Harischandra (2010) highlights that the degree of inflation persistence in Sri Lanka fell gradually from a high of around 0.90 (with 1 being fully persistent and 0 implying no persistence), on average, during late 1970s through early 1990s to around 0.60, on average, in the 2000s. As Sri Lanka envisions to transition to flexible inflation targeting as its monetary policy framework by 2020, it would be interesting to examine the degree of inflation persistence, particularly in the past decade, and careful scrutiny of inflation persistence in the subcategories of CPI to see the presence of sectoral heterogeneity would be of great importance for policy formulation purposes.

Therefore, in this paper, we examine 15-years of monthly data on inflation and its subcomponents in Sri Lanka to assess the degree of persistence in inflation using an autoregressive process. The contribution of this paper to the available literature is twofold. Firstly, research on examining the degree of inflation persistence in multiple CPI subcomponents and its heterogeneity using Sri Lankan data has not been carried out before. Further, this paper would provide insights on the evolving dynamics of persistence in core inflation, and its implications on monetary policy. Secondly, the Department of Census and Statistics – Sri Lanka follows a regular base change policy and there is no study which analyses inflation persistence using data under the new inflation series (CCPI, Base 2013=100).

The rest of the paper is structured as follows: Section 2 provides a brief review of the relevant literature, followed by Section 3, which details the methodology followed by us to analyse inflation persistence in Sri Lanka and the heterogeneity in inflation persistence in CPI subcomponents. Section 4 presents the results of the study and an interpretation, followed by the concluding section, which summarises the key findings and highlights implications for policy.

2. Literature Review

While there is a large amount of literature on inflation persistence at aggregate and subcomponent levels, we have meticulously chosen a few which were crucial in motivating our understanding on how to conduct a similar study for Sri Lanka. Among these articles, the study by Pivetta and Reis (2007) investigate the persistence of inflation in the US using three approaches, namely the largest autoregressive root (LAR), the sum of autoregressive roots and half-life, defined as the number of periods where inflation stays above half its initial value following a shock (i.e. 0.5 following a unit shock). They find inflation to be highly persistent in the US during the sample period of 1965 to 2001 and no evidence of a change in the degree of inflation persistence over this period, although highlighting that there is some intercept shift in the inflation process in the early 1990s.

Along the same lines, Clark (2006) examine consumer price inflation in the US using data from 1959 to 2002. He finds that inflation persistence (measured as the sum of the autoregressive coefficients) at the disaggregate level is constantly below that at the aggregate level, although a notable fraction of the disaggregate series remains highly persistent. However, the degree of inflation persistence is much lower, both at the aggregate and disaggregate level, when the series is restricted to 1984-2002 and after allowing for a break in the data in early 1990s. Most importantly, the degree of inflation persistence at the disaggregate level is almost similar to that of the aggregate level after accounting for a mean break. Most importantly, failing to account for structural breaks in the inflation series could produce high estimates on the magnitude of persistence, which would largely be flawed and spurious. (Perron, 1990) (Levin and Piger, 2004).

Investigating aggregate and sectoral inflation dynamics in the Euro area, Altissimo et al. (2006) find evidence of high inflation persistence among countries in the region in addition to sectoral heterogeneity in inflation persistence. They also find inflation persistence to be smaller at disaggregated levels (i.e. subcomponents of inflation and at country level), when compared to the aggregated level (i.e. at country level and euro area, respectively).

The study by Gerlach and Tillmann (2012) extends the literature on inflation persistence to the Asia Pacific region, where they compare the change in the degree of inflation persistence in selected countries in the region following the adoption of inflation targeting with those who followed other monetary policy regimes. They find that the persistence of inflation in inflation targeting economies declined noticeably with the adoption of inflation targeting, while that of non-inflation targeting economies continued to remain high, and on certain instances increased, in the period after the Asian Financial Crisis.

Another study by Tillmann (2012) examines how the adoption of inflation targeting changed the dynamics of inflation persistence in Korea. This study, which uses disaggregated quarterly data presents three main findings; firstly, the degree of persistence in aggregate inflation and most of the subcategories decline following the adoption of inflation targeting. Secondly, he finds evidence of varying degrees of inflation persistence in disaggregate level data, indicating sectoral heterogeneity. Lastly, he also finds evidence that inflation persistence at the aggregate level was higher than the combined disaggregated levels during the early part of the sample, which however, changes displaying a “reverse aggregation effect” in the latter part of the sample.

Using quarterly data from 1960 to 2009, Harischandra (2010) examines the degree of inflation persistence in Sri Lanka by employing an array of modelling and estimation techniques, and finds evidence of high inflation persistence during the 1970s and 1980s as inflation dynamics during this era are primarily driven by shocks to its trend component. However, a gradual moderation in persistence is observed thereafter towards the end of the sample period as inflation is driven mainly by shocks to its transitory component. He also finds evidence of a notable easing of variance in both inflation and real GDP growth in the latter years, indicating that inflation persistence is time varying.

Harischandra (2009) uses the degree of inflation persistence as a criterion to examine inflation performance across different exchange rate regimes in Sri Lanka using quarterly data from 1960 to 2005. He uses three types of measures of inflation persistence for this analysis, where in Type 1, which uses autocorrelation properties, he finds evidence of an increase in inflation persistence in the flexible exchange rate regime when compared to the fixed exchange rate regime. Inflation persistence, measured by the lag between a change in monetary policy and its peak effect on

inflation, referred to as Type 2, yields similar results as in Type 1. In type 3, inflation persistence is measured by impulse responses following shocks to monetary aggregates, and this indicates that effects of such shock tend to last longer in a flexible exchange rate regime, while inflation response to an innovation in short term interest rates provides weak evidence on inflation persistence.

Sivarajasingham and Applanaidu (2015) find strong evidence of persistence in food inflation in Sri Lanka highlighting that focusing on a measure such as core inflation, which excludes food prices, for policymaking purposes might be inappropriate as food prices have long term memory, hence not transitory, thereby ultimately leading to higher inflation expectations. This study confirms the findings by Ratnasiri (2009), which highlights that the price of rice is the most important determinant of inflation in Sri Lanka, both in the short run and the long run, indicating the high degree of persistence in rice (price) inflation.

3. Methodology

Following large amount of literature, we deploy the univariate measure of persistence in inflation, to gauge inflation persistence. Accordingly, inflation persistence is calculated as the sum of autoregressive coefficients in a univariate process of AR(q) in inflation rate (π_t) as follows (see Tillmann, 2012):

$$\pi_t = c + \sum_{k=1}^{q} \beta_k \pi_{t-k} + \varepsilon_t \tag{1}$$

where c denotes the intercept term, ε_t is a serially correlated shock. This equation can be rewritten as follows:

$$\pi_t = c + \rho\pi_{t-1} + \sum_{k=1}^{q-1} \gamma_k \Delta\pi_{t-k} + \varepsilon_t \tag{2}$$

where $\rho = \sum_{k=1}^{q} \beta_k$ and $\Delta\pi_t = \pi_t - \pi_{t-1}$

For ρ=1, the inflation process contains a unit root while ρ >1 is an explosive process, meaning the monetary authority has only a little or no control over inflation. If the absolute value of ρ is lower than the unit, the monetary authority has some control over inflation. The appropriate lag length of the autoregressive process is chosen based on Akaike Information Criteria (AIC), subject to maximum lag length of 8 months in the empirical analysis conducted in this study.

Since least squares estimates of ρ suffer from a downward bias as sum autoregressive coefficients approaches unity, median unbiased estimator of Hansen (1999) and the grid bootstrap approach is used to construct confidence intervals.[5]

Further, we deploy rolling-window regressions to CPI and main subcomponents to examine the behaviour of inflation over time.

5. We are grateful to Peter Tillmann for sharing his RATS code of Tillmann (2012) to construct median unbiased estimator and related confidence intervals. The bootstrap calculations are based on 999 draws and 101 grid points over a range spanned by the sample estimate of persistence surrounded by four OLS standard errors.

3.1 Data

We use monthly data on year-on-year headline inflation measured by the percentage change in the Colombo Consumer Price Index (CPI) and its 12 subcategories[6] from January 2004 to September 2018, published by the Department of Census and Statistics – Sri Lanka. Core inflation, which excludes volatile food, energy and transport is also taken into account in this study. We have advertently chosen the above sample period primarily because this study focuses on analysing inflation persistence using subcategorical data and CPI data prior to 2003 contain fewer and broader subcategories thereby limiting its use for analysis in the current study. Further, over the selected sample period, CPI data has been rebased three times, i.e., CPI data under three base years, namely 2002, 2006/07 and 2013, have been used and a combined (single) series has been generated by splicing (or retropolating) the CPI data, where past CPI data has been regenerated to be expressed in terms of the 2013 series.

Although the Central Bank of Sri Lanka conducted its monetary policy under a monetary targeting framework since the early 1980s, the notion of bringing inflation to single digits and managing it sustainably at mid-single digit levels became a greater priority for the Central Bank of Sri Lanka since 2007/08 and was therefore known to have been implicitly targeting inflation.[7] As a result, a taming of inflation was observed since early 2009, averaging around 5% during this period. The low levels of inflation, post-2009, has created a conducive environment for policymakers to successfully transition towards adopting a flexible inflation targeting framework by 2020. Therefore, in order to capture this development, we segment the full sample to two, the first being a pre-2008 sample that spans from January 2004 to end 2008, while the next, a post-2009 sample spanning from January 2009 to September 2018 with a view of investigating any change in the dynamics of inflation persistence.[8]

Descriptive statistics, including the weights of each subcategory in the CPI are shown in Table 1. The subcategory of Housing (31.98%) accounts for the largest share of the overall CPI basket, followed by the Food subcategory (28.24%). It is clearly visible that movements in overall headline inflation mimics the movements in food inflation (See Figure 1). Table 1, which shows the mean and variance of inflation for the pre-2008 and post-2009 periods reveal that both the level

6. The exact subcategories are: Food and Non-Alcoholic Beverages (food), Alcoholic beverages, Tobacco and Narcotics (alcohol), Clothing and Footwear (clothing), Housing, Water, Electricity and Fuel (housing), Furnishing, Household equipment & Routine household maintenance (furniture), Health (health), Transport (transport), Communication (communication), Recreation and Culture (recreation), Education (education), Restaurant and Hotels (restaurants), Miscellaneous goods and services (miscellaneous). In CPI (Base: 2006/07=100), Alcoholic beverages, Tobacco and Narcotics division was not included and Restaurants and Hotels division was included under the food group.

7. In 2007, the Central Bank commenced announcing key monetary and financial sector policies for the medium term through a policy document known as the "Road Map" which was produced annually thereafter. This approach enhanced the dialogue between the Central Bank and its stakeholders, thereby increasing transparency and clarity of future policy actions and objectives.

8. The unit root with break test on overall CPI returned June 2008 as the break date, while the Quandt-Andrews Breakpoint test returned February 2010 as the break date. However, considering the developments in inflation over the years and changes in the policy approach of the Central Bank of Sri Lanka during 2007/2008, we decided to choose December 2008 as the structural break date. Moreover, visual inspection of the CPI movements would also support our choice of the break date. These results are not presented to preserve space, but can be made available upon request.

of inflation and the variance in most subcategories of CPI are lower in the post-2009 subsample. In terms of subcategories, the Transport subcategory exhibits the highest average rate of inflation, followed by Food, then Housing in the pre-2008 period, while the subcategory of Alcohol exhibited the highest average rate of inflation in the post-2009 period, followed by Health and Clothing. Likewise, volatility of inflation in certain subcategories were reportedly higher compared to aggregate inflation, particularly in the subcategories of Health, Communication, Food and Transport during the pre-2008 period and in subcategories of Transport, Health and Alcohol in the post-2009 period. Volatility among those subcategories were largely as a result of the volatility in oil prices and certain government policy decisions, such as changes in the tax structure as well as incentives in several occasions, in the form of subsidies or rebates, which directly impacted those prices.[9] Inflation in the Communication subcategory remained largely stable except for a few hikes and drops in certain months. Nevertheless, core inflation remained in single digits in both subsamples and was noticeably less volatile when compared to that of most other subcategories.

9. Collection of prices of certain categories/services such as health, education and communication is performed at less frequent intervals.

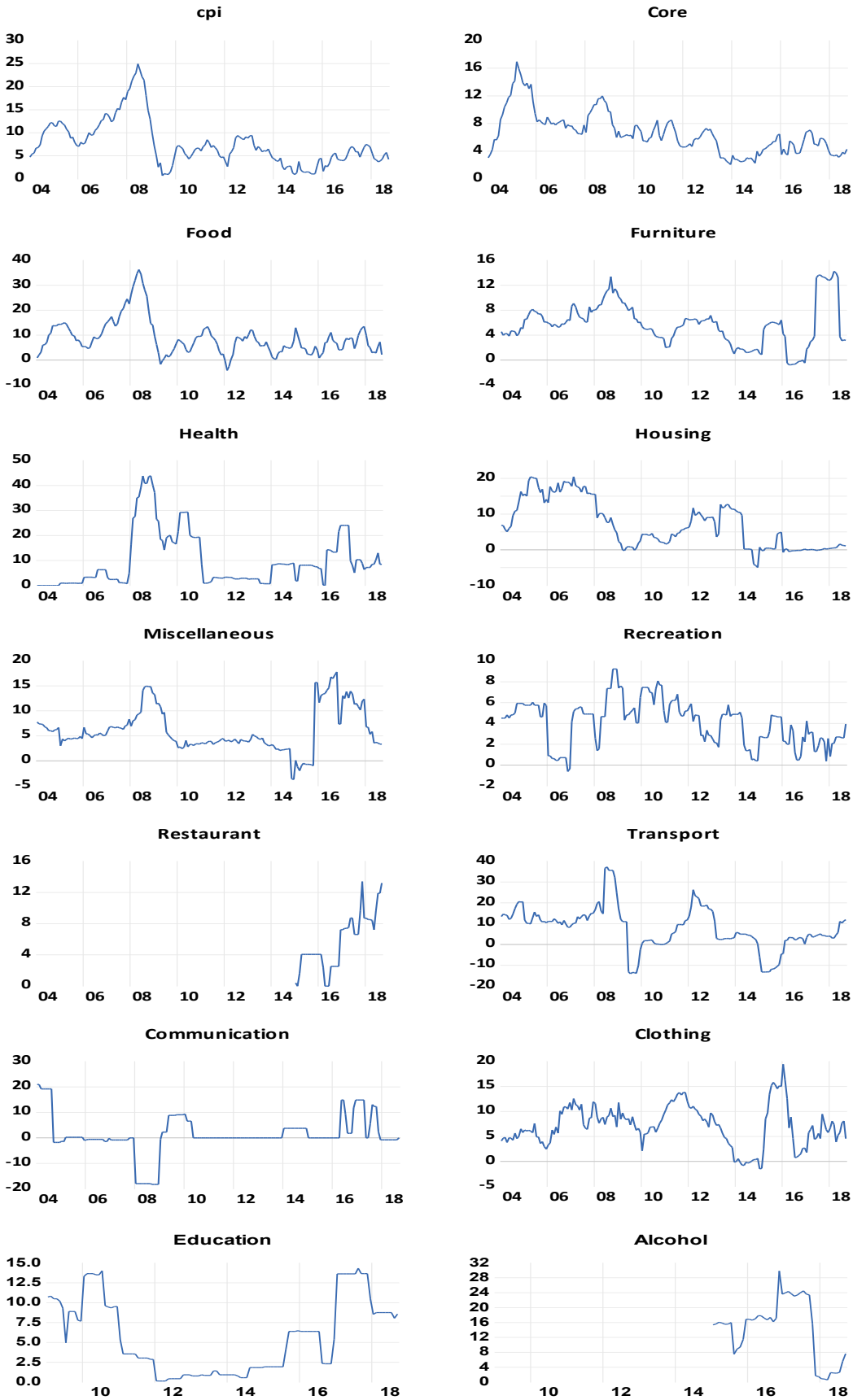
Table 1
Descriptive Statistics - Inflation

CPI Category	Weight	Mean		Variance	
		Pre-2008 2004:01 - 2008:12	Post-2009 2009:01 - 2018:09	Pre-2008 2004:01 - 2008:12	Post-2009 2009:01 - 2018:09
Food	28.2%	14.7	6.0	74.1	13.3
Alcohol	1.0%	*NA*	14.4	*NA*	65.9
Clothing	2.3%	7.3	7.1	7.4	20.9
Housing	32.0%	14.0	3.3	22.7	17.9
Furniture	2.5%	7.0	5.1	4.7	13.9
Health	4.4%	8.7	10.2	207.5	70.6
Transport	10.6%	15.7	3.6	56.1	77.1
Communication	3.3%	-1.4	2.8	117.3	21.2
Recreation	1.3%	4.4	3.9	5.8	4.0
Education	5.9%	5.4	5.7	2.6	22.0
Restaurants	5.1%	*NA*	5.7	*NA*	12.9
Miscellaneous	3.3%	6.9	5.7	8.4	23.6
Aggregate	**100.0%**	**12.7**	**5.0**	**24.5**	**5.3**
Core		9.5	5.2	8.9	2.8

Source: Department of Census and Statistics; Authors' calculations.

Notes: The data are taken from the Department of Census and Statistics. The exact subcategories are: Food and Non-alcoholic beverages (food), Alcoholic beverages, Tobacco and Narcotics (alcohol), Clothing and Footwear (clothing), Housing, Water, Electricity and Fuel (housing), Furnishing, Household Equipment & Routine Household Maintenance (furniture), Health (health), Transport (transport), Communication (communication), Recreation and Culture (recreation), Education (education), Restaurant and Hotels (restaurants), Miscellaneous goods and services (miscellaneous). In CPI (Base: 2006/07=100), Alcoholic beverages, Tobacco and Narcotics division was not included and Restaurants and Hotels division was included under the food group.; Aggregate refers to overall headline inflation.

Figure 1
Inflation Rate Across CPI Subcategories



Source: Department of Census and Statistics; Authors' calculations.

4. Results

As the focus of this study is to analyse the presence of persistence in inflation and its magnitude, and the heterogeneity of inflation persistence across CPI subcategories, understanding the data temporal properties would be appropriate before conducting the autoregressive analysis. We perform the Augmented Dickey Fuller (ADF) test to identify the nature of stationarity of the data.

Table 2, which presents the results of the unit root tests, indicates that the subcategories of Housing, Furniture, Education and Miscellaneous goods and services are non-stationary at levels, therefore integrated of order 1 (or I(1)), while the rest of the subcategories of CPI inflation were stationary at levels or I(0) in the full sample (Column 3). Unit root tests were also performed on the pre-2008 and post-2009 periods as this study focuses on analysing the dynamics of inflation persistence across these two subsamples. Results of the unit root tests revealed that all subcategories of CPI inflation were non-stationary at levels (i.e. I(1)) in the pre-2008 period (Column 1), while most subcategories, excluding Clothing, Education and Miscellaneous goods and services, were stationary at levels (i.e. I(0)) in the post-2009 period (Column 2). This indicates that inflation during the pre-2008 era followed an explosive process thereby suggesting that inflation was highly persistent during this period. However, a majority of the subcategories of CPI inflation being stationary at levels during the post-2009 period suggest that the time series is well-behaved, implying that the magnitude of persistence is lower when compared to the pre-2008 era.

Table 2
Results of the Augmented Dickey-Fuller (Unit Root) Tests

CPI Category	Pre-2008 2004:01 - 2008:12		Post-2009 2009:01 - 2018:09		Full Sample 2004:01 - 2018:09	
	(1)		(2)		(3)	
	p-value	Order of Integration	p-value	Order of Integration	p-value	Order of Integration
Food	0.0050*	I(1)	0.0001*	I(0)	0.0387*	I(0)
Clothing	0.0000*	I(1)	0.0000*	I(1)	0.0471*	I(0)
Housing	0.0000*	I(1)	0.0641**	I(0)	0.0000*	I(1)
Furniture	0.0000*	I(1)	0.0671**	I(0)	0.0000*	I(1)
Health	0.0005*	I(1)	0.0070*	I(0)	0.0736**	I(0)
Transport	0.0000*	I(1)	0.0431*	I(0)	0.0270*	I(0)
Communication	0.0000*	I(1)	0.0002*	I(0)	0.0013*	I(0)
Recreation	0.0000*	I(1)	0.0118*	I(0)	0.0136*	I(0)
Education	0.0000*	I(1)	0.0000*	I(1)	0.0000*	I(1)
Miscellaneous	0.0000*	I(1)	0.0001*	I(1)	0.0000*	I(1)
Core	0.0262*	I(1)	0.0250*	I(0)	0.0025*	I(0)

Source: Authors' calculations.

Note: MacKinnon (1996) one-sided p-values.

*,** suggest that the null hypothesis is rejected at 5% and 10%, respectively.

Although the ADF test results provide some insight into the drop in persistence during the post-2009 period, it fails to measure the exact magnitude of persistence during the two subsamples. To serve this purpose, we adopt the methodology followed by Gerlach & Tillmann (2012) and others which involves an autoregressive analysis, where persistence is measured as the sum of autoregressive coefficients in a univariate process of inflation and use Hansen (1999) mean unbiased estimates.

Table 3 presents the findings following the forming of univariate autoregressive models for overall headline inflation, core inflation, inflation of CPI subcategories as well as mean weighted inflation. The estimates of ρ in Column 3, which is based on the entire sample period, indicate the presence of very high persistence across all measures of inflation, including the subcategories. Persistence in overall headline inflation is estimated to be 0.97, while core inflation persistence also remains at a high of 0.96. The Housing subcategory, which accounts for the highest weight in the CPI basket, exhibits the case of a unit root, while Food inflation also appears to be highly persistent with a ρ estimate of 0.95. All other subcategories of CPI display high levels of inflation persistence as well. Meanwhile, the mean weighted inflation persistence also remains high at 0.96 although remaining marginally lower than the persistence of overall headline inflation.

Limiting the analysis to the full sample is bound to mask the true underlying forces of persistence considering the change in inflation dynamics over time. Therefore, the analysis is extended by measuring persistence under the two subsamples – pre-2008 and post-2009, findings of which are presented in Columns 1 and 2, respectively, in Table 3.

Overall headline inflation recorded a persistence estimate of 0.94,[10] while core inflation also remains at a high of 0.92. The subcategories of Housing, Furniture, Health, Recreation and Miscellaneous goods and services are unit root processes portraying characteristics of an explosive process, while the subcategories of Food, Transport, Communication and Clothing remain near unit root processes. Most strikingly, mean weighted inflation persistence in the pre-2008 subsample remains elevated at 0.97.

10. The difference in the estimates of overall inflation persistence between this study and Harishchandra (2010) could be due to the differences in the sample period of the studies as well as the frequency of data.

Table 3
Inflation Persistence Across CPI Categories

CPI Category	Pre-2008 2004:01 - 2008:12			Post-2009 2009:01 - 2018:09			Full Sample 2004:01 - 2018:09		
		(1)			(2)			(3)	
	Lag order	Sum of AR coefficients	Confidence Band	Lag order	Sum of AR coefficients	Confidence Band	Lag order	Sum of AR coefficients	Confidence Band
Food	2	0.98	(0.92, 1.02)	8	0.69	(0.63, 0.81)	2	0.95	(0.92, 1.00)
Clothing	3	0.90	(0.76, 1.05)	1	0.95	(0.88, 1.02)	6	0.87	(0.81, 0.94)
Housing	1	1.01	(0.85, 1.07)	1	0.95	(0.88, 1.02)	1	1.00	(0.95, 1.02)
Furniture	1	1.02	(0.88, 1.07)	2	0.92	(0.86, 1.01)	6	0.89	(0.84, 0.95)
Health	2	1.02	(0.99, 1.05)	2	0.89	(0.83, 0.95)	2	0.96	(0.92, 1.01)
Transport	1	0.97	(0.85, 1.06)	2	0.92	(0.87, 0.99)	2	0.95	(0.90, 1.01)
Commu-nication	1	0.93	(0.85, 1.04)	2	0.68	(0.59, 0.77)	2	0.84	(0.78, 0.91)
Recreation	1	1.02	(0.86, 1.08)	1	0.87	(0.79, 0.95)	1	0.90	(0.83, 0.97)
Education	5	0.60	(0.38, 0.83)	2	0.97	(0.92, 1.02)	2	0.96	(0.91, 1.01)
Miscella-neous	2	1.07	(1.02, 1.12)	3	0.94	(0.86, 1.03)	3	0.95	(0.89, 1.02)
Mean (weighted)		0.97			0.86			0.96	
Total	**4**	**0.94**	**(0.89, 1.00)**	**3**	**0.85**	**(0.79, 0.92)**	**4**	**0.97**	**(0.94, 1.00)**
Core	3	0.92	(0.84, 1.02)	1	0.90	(0.83, 0.97)	3	0.96	(0.93, 1.01)

Source: Authors' calculations
Note: This table presents the mean unbiased estimator of the sum of autoregressive coefficients and the bootstrapped 90% confidence band based on 101 grid points and 999 replications. The lag order is chosen according to the Akaike Information Criteria (AIC)

However, comparing the findings of the pre-2008 subsample with those of post-2009 produces some interesting results. Except for the subcategories of Clothing and Education, persistence across all other measures and subcategories of inflation appear to have eased somewhat. We observe a decline in the persistence of overall headline inflation to 0.85 in the post-2009 subsample when compared to 0.94 in the pre-2008 period, although it remains much higher than most other economies in the region (see Gerlach and Tillmann, 2012).[11] However, core inflation persistence dropped measly in the post-2009 period to 0.90 as opposed to 0.92 in the pre-2008 period. Although one could interpret this to be a poor development, one should be aware that the period of the post-2009 subsample is quite large, and therefore one could obtain better insights as to how persistence has evolved over by observing rolling regression coefficients, which are discussed later in this paper.

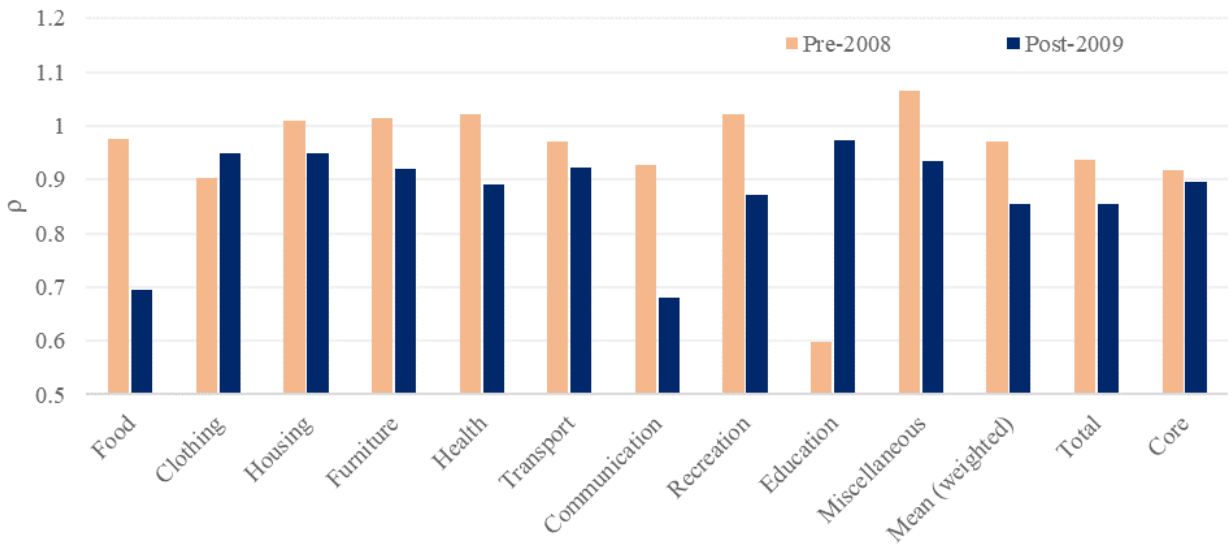
11. The sample period (1985-2010) for which Gerlach and Tillmann (2012) conducted the persistence analysis is different to the sample in this study, hence not directly comparable.

Another notable finding is that the degree of inflation persistence in the Food subcategory of CPI has dropped to 0.69 in the post-2009 period implying that there is faster return in food prices towards equilibrium following an idiosyncratic shock.[12] From a policymaker's perspective, this is a favourable development as agents appear to believe that any shocks to food inflation are comparatively transitory, which eases the policymaker's task in monetary policy formulation as expectations of inflation appear to be relatively anchored, particularly when compared to the estimate of food inflation persistence in the pre-2008 period.

Similarly, we also observe that inflation persistence in the Housing, Furniture, Health, Recreation and Miscellaneous goods and services subcategories of CPI have declined in the post-2009 period and no longer follow a unit root process. However, the near unit root estimates of ρ indicate that there is still a very high level of persistence in inflation in those subcategories.

Since we do not observe a substantial difference between overall inflation persistence and mean weighted inflation persistence of subcategories in any sample, we find no evidence for aggregation or reverse aggregation effects in the sample period considered.

Figure 2
Inflation Persistence Across CPI Categories



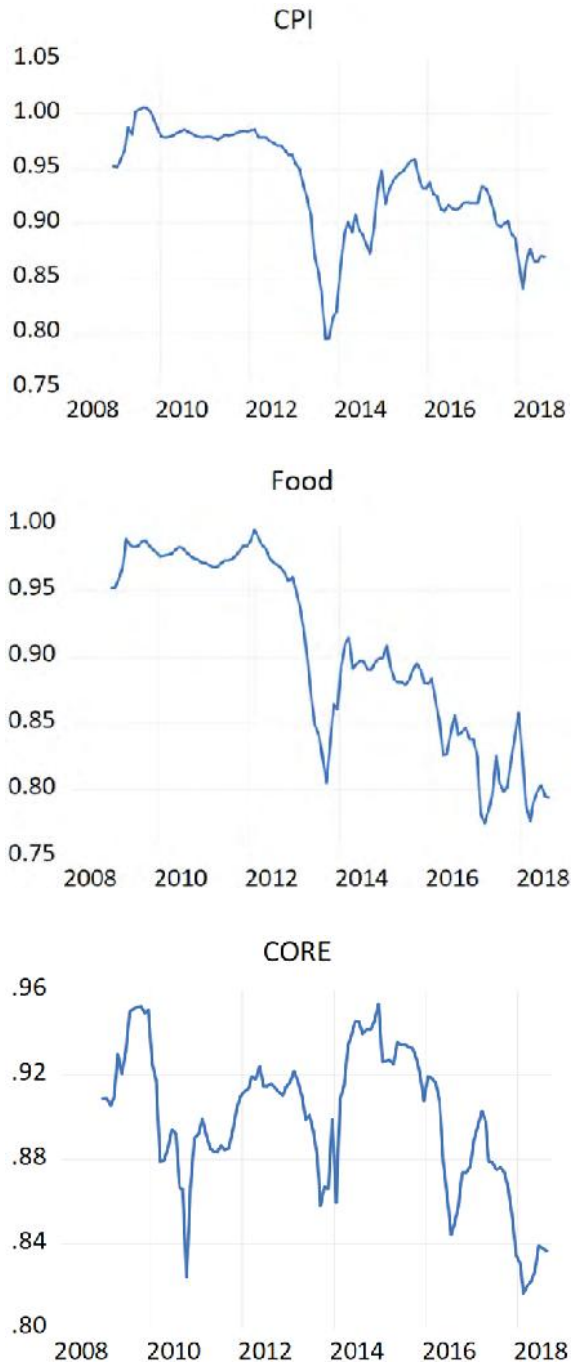
Source: Authors' calculations.

Figure 2 shows the heterogeneity in inflation persistence across subcategories in both samples. This has implications on monetary policy. Heterogeneity in price stickiness across subcategories implies a sluggish response of aggregate prices to a monetary policy shock compared to a case where price stickiness is alike across subcategories (see Altissimo et al. (2009) and references therein).

12. It was examined whether the drop in domestic food inflation over time was driven by the world food inflation. For this purpose, to compute world food inflation persistence, monthly data on the FAO food price index was used. However, as evidenced in domestic food inflation, no evidence of a notable drop in persistence of world food inflation was observed in the post-2009 subsample when compared to pre-2008.

Next, we estimate 5-year rolling-window regressions to examine the behaviour of inflation over time in major components of CPI, results of which are shown in Figure 3.[13]

Figure 3
Rolling Regression (Inflation Persistence - 5 Year Rolling Window)



Source: Authors' calculations.

13. Rolling window regressions are estimated using least square estimates.

Both CPI and core inflation exhibit declining trends in inflation persistence over time, as observed in the inflation persistence in two samples. However, notably, although a significant decline in core inflation was not observed in the post-2009 period when compared to pre-2008 in the previous analysis, the rolling regression uncovers a declining trend in core inflation persistence since mid of the post-2009 sample.

5. Conclusion

In this study, we examine 15-years of monthly data on inflation and its subcomponents in Sri Lanka to assess the degree of persistence in inflation using an autoregressive process. We do not find significant evidence to establish an aggregation or reverse aggregation effect as observed in some other countries. We consider two subsamples; pre-2008 (January 2004 – December 2008) and post-2009 (January 2009 – September 2018) for the analysis. We observe that inflation persistence is lower in the post-2009 period compared to pre-2008, primarily driven by food inflation. Further, inflation persistence is lower in most subcategories in the post-2009 period compared to pre-2008. Persistence in core inflation follows a declining trend in the latter part of the post-2009 sample. Substantial cross-sectional heterogeneity is also observed in both subsamples.

These findings have implications on monetary policymaking in Sri Lanka. The decline in persistence in overall inflation as well as inflation persistence in subcategories including core inflation imply that the policymakers have been able to anchor inflation expectations relatively well in recent times. However, inflation persistence in Sri Lanka appears to be still high compared to peers. With the introduction of flexible inflation targeting in Sri Lanka, as experienced in some other countries, it is expected to observe a further decline in inflation persistence in time to come.

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Chapter 10

OIL PRICE SHOCKS, INFLATION EXPECTATIONS AND MONETARY POLICY: EVIDENCE FROM CHINESE TAIPEI

By

Wan-Jung Hsu[1]

1. Introduction

For most central banks, maintaining an environment of stable inflation is their key mission. In the formation of inflation, inflation expectations play an essential role. In theory, inflation expectations can influence firms' wage-price settings and consumers' spending and saving decisions. In the new Keynesian models, for example, firms adjust prices in response to expected inflation. In reduced form, the new Keynesian Phillips Curve implies that inflation responds approximately one-for-one to shocks to inflation expectations. Therefore, for a central bank to control inflation, the ability to anchor inflation expectations is important, and many studies used this measure to assess the effectiveness of a country's monetary policy.

Since headline inflation is an aggregate of multiple sectoral prices, it is subject to many temporary shocks (noises). For a central bank, the ultimate goal is to keep underlying inflation, which is trend inflation, at a desired level. Overreactions in monetary policy to temporary shocks to inflation may result in unwarranted fluctuations in economy. Following Bryan and Cecchetti (1994), trend inflation can be thought of as a long-term level that headline inflation will converge to when temporary shocks die out. In this regard, to control trend inflation, anchoring long-term inflation expectations is more relevant than short-term inflation expectations. Yellen (2015) suggested that the stability of trend inflation appeared linked to a change in the behaviour of long-term inflation expectations. Better anchored long-term inflation expectations may reflect an improvement in the conduct of monetary policy.

Many studies examined the anchoring ability of long-term inflation expectations to measure the effectiveness of monetary policy. Bomdirm and Rudebusch (2000); Beechey and Wright (2009); Gurkaynak et al. (2010a); Beechey et al. (2011); and Buono and Formai (2018) assessed the degree of anchoring in developed countries by examining how long-term inflation expectations respond to actual inflation, short-term inflation expectations, and macroeconomic news. For emerging countries, Mehrotra and Yetman (2014) examined long-term inflation expectations of ten Asian countries from 1995 to 2012, among which four of them adopted inflation targeting around the year 2000. They found that while countries experienced a decline in long-term inflation expectations after adopting inflation targeting, long-term inflation expectations in the non-inflation targetters had also fallen and became more tightly anchored since 2000. They also found the degree of anchoring of long-term inflation expectations appeared to be similar for both inflation and non-inflation targeting countries. Filardo and Genberg (2010) examined the dynamics of inflation rates

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and inflation expectations of 12 countries in Asia and the Pacific from 1990 to 2009 and found a common trend of lower and more stable inflation. They also suggested that formal inflation targeting was not the only monetary policy framework capable of delivering price stability. The IMF (2018) found inflation in emerging and developing countries since the mid-2000s has, on average, been low and stable. It suggested changes in longer-term inflation expectations were the main determinant of inflation and it also found that the bulk of improvements in anchoring long-term inflation expectations took place in the 2000s. Based on the findings in the aforementioned studies, inflation targeting should not be the only way to stabilise inflation. Monetary policy that emphasises the importance of inflation stability and communicates with the public with clear and credible procedures should also be able to anchor inflation expectations and lead to a low inflation environment.[2] While the Central Bank of Chinese Taipei (CBCT) does not adopt inflation targeting, stabilising domestic inflation is within its mandates. Hence, it is interesting to examine the degree of long-term inflation expectations anchoring by using data from Chinese Taipei. Particularly, the author would like to investigate whether there is any change in the behaviour of long-term inflation expectations given the common trend of improved inflation performance since the 2000s in Asia found in other studies.[3]

As suggested in the literature, one way to measure the degree of anchoring of long-term inflation expectations is to see how sensitive the expectations are to macroeconomic news (shocks). If the public is clear about the (explicit or implicit) inflation goal of the central bank and believes the central bank would commit to its goal, long-term inflation expectations should not be sensitive to temporary shocks which impact the economy, while short-term inflation expectations may be revised to its persistent nature. Among macroeconomic shocks, global oil prices played a salient role in the literature. A large number of studies suggested that inflation expectations were sensitive to oil price shocks (Harris et al., 2009; Coibon and Gorodnichenko, 2015). Conceptually, to analyse the effects of oil price shocks on actual inflation, most studies divide the impacts into two parts. One is first-round effects, occurring largely through increased energy cost feeding directly into higher input costs. The other is second-round effects, where oil price shocks feed into inflation indirectly through inflation expectations (Blinder and Rudd, 2012). Choi et al. (2017) examined the impacts of global oil prices in 72 advanced and developing countries from 1970 to 2015. They found that factors, such as the inflation targeting regime and the central bank governance index, influenced the degree of oil price pass-through into domestic inflation most significantly. They suggested that the improved conduct of monetary policy over time can result in the reduced impact of oil price shocks. As Choi et al. (2017) mentioned in their study, one important channel through which that monetary policy influences inflation is anchoring inflation expectations. By increasing the credibility of monetary policy, temporary shocks, such as oil price socks, will not lead to a significant change in inflation expectations. However, as they did not explicitly examine the behaviour of inflation expectations, it is still unclear through which channels monetary policy reduced the impacts of oil price shocks.

2. Walsh (2009) suggested a similar point.

3. For example, Mehrotra and Yetman (2014) and IMF (2018) Figure 3.3.

This paper is aimed to fill this gap. First, is to test whether there is any structural change in the behaviour of long-run inflation expectations in Chinese Taipei as what was found in many other countries. Then the sensitivity of inflation expectations to various shocks is examined, and the resulting difference between the sensitivity before and after the structural change is observed. Most importantly, this study examines how the change in the behaviour of long-term inflation expectations influences the pass-through of oil price shocks and whether it implies any change in the conduct of monetary policy.

To analyse the degree of anchoring of long-term inflation expectations and its role in transmitting oil price shocks, a structural vector autoregressive (SVAR) model is used to explore dynamic relationships among inflation expectations, other relevant macroeconomic variables, and global oil prices. The benefit of using SVAR is that a counter-factual analysis can be carried out by shutting down the response of long-term inflation expectation to oil price shocks. By comparing the counter-factual and actual impulse responses, the role of long-term inflation expectations in propagating oil price shocks into inflation can be assessed. As pointed out in Wong (2015), an observation that inflation expectations and inflation co-moving in the same direction after oil price shocks could not support a mechanism through which inflation expectations transmits the oil price shocks into inflation. Using a counter-factual analysis is suitable to disentangle this transmission mechanism.

The rest of the paper is organised as follows. Section 2 discusses the relevant literature and how this study contributes to them. Section 3 presents the data and the SVAR model used in this study. Here, the diagrams of various measures of inflation and inflation expectations are also examined, and the possibility of a structural change in the behaviour of long-term inflation expectations is tested. Section 4 presents the relevant impulse responses and forecast error variance decompositions to examine the degree of anchoring of long-term inflation expectations. Section 5 provides a counter-factual analysis to assess the role of long-term inflation expectations in transmitting oil price shocks. In this section, whether the results of the two sub-samples in the counter-factual analysis imply any change in the conduct of monetary policy is also explored. Section 6 investigates the robustness of these results to alternative SVAR settings. Section 7 concludes the findings of the study.

2. Literature Review

This paper fits in the literature concerning the assessment of the degree of anchoring of inflation expectations and of how the monetary policy framework contributes to it. The literature proposing different approaches in analysing this topic can be separated into two groups in general. Many studies apply event-study or single regression type of analysis, where the left-hand side of the regression is the long-run inflation expectations and the right-hand side is macro-news. However, ignoring the dynamics of long-term inflation expectations and their interdependence with other macroeconomic variables may mislead the conclusion. Thus, a structural vector autoregressive (SVAR) model including inflation expectations and other relevant macroeconomic variables could be an alternative way to complement the above approach.

Davis (2014), Chang (2014) and Wong (2015) are the studies most relevant to this paper. Davis (2014) used survey data across 36 developed and developing countries from 1990 to 2011 in a SVAR setting to examine whether the adoption of inflation targeting had helped to anchor inflation expectations. He showed that there was a major change in the behaviour of short-term (12-month ahead) inflation expectations between the pre-2000 period and the post-2000 period for countries adopting inflation targeting around the year 2000, but there was no similar change for countries not adopting inflation targeting. He explained that by adopting inflation targeting, a central bank can enhance its transparency, credibility, and communication with the public and therefore can better anchor inflation expectations. However, the author did not include long-term inflation expectations in his analysis. As mentioned in the introduction, to assess the extent of inflation expectations anchoring, long-term inflation expectations which are closely related to the target of central banks, should be more relevant than short-term inflation expectations. His study did not discuss the role of inflation expectations in transmitting oil price shocks, either. Chang (2014) used data for Chinese Taipei from Consensus Forecasts to examine the dynamics of short-term (12-month ahead) inflation expectations with other macroeconomic variables in a SVAR setting. Unlike Davis (2014), the sample period covered in this study is from Jan. 2003 to May 2013. However, without covering the period before the early 2000s, it may be difficult to detect significant changes in the behaviour of inflation expectations, given that most studies found the changes in inflation expectations anchoring occurred around the year 2000. Moreover, this paper focuses on understanding the interactions among all the variables included in the model and does not emphasise the extent of inflation expectations anchoring. Wong (2015) only included three variables (i.e. oil prices, inflation expectation (long-run or short-run), and headline inflation) in his SVAR setting to analyse the behaviour of inflation expectations. As argued in Banbura, Giannone and Reichlin (2010), a large number of variables should be included in a VAR model because including too few variables risks omitting important variables and may lead to a problematic analysis. In addition to the differences in SVAR setting and the sample period covered, another contribution of this paper is the empirical investigation of the behaviour of monetary policy in affecting the role of inflation expectations in transmitting oil price shocks. Unlike Wong (2015) who was unable to provide evidences about monetary policy reactions explicitly from the model, the inclusion of policy rate (and other policy-related variables) in the SVAR setting provides more information about monetary policy.

3. Data and Model Specification

3.1 Inflation, Inflation Expectations and Global Oil Prices

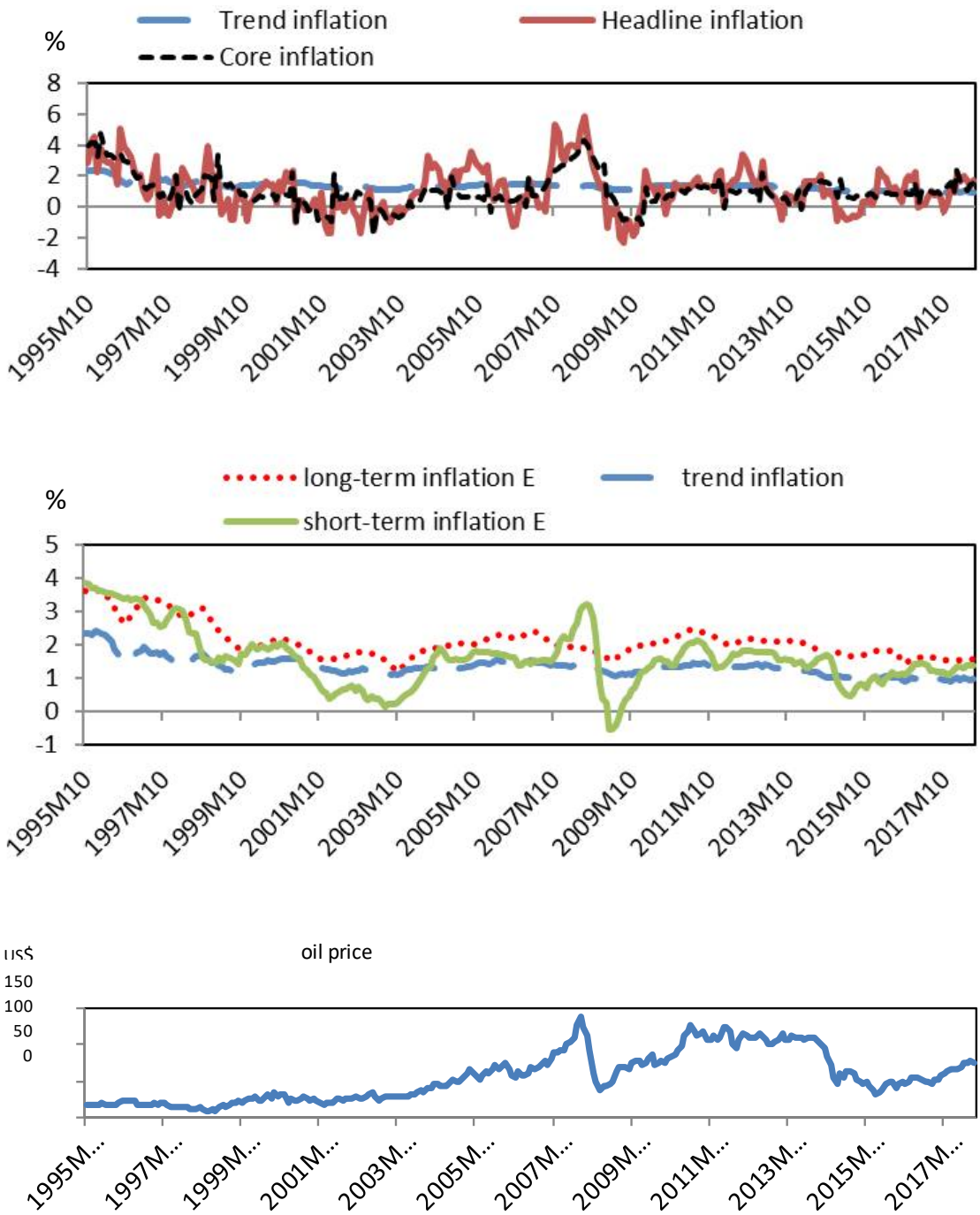
Figure 1 provides an overview of the historical diagrams of various inflation rates, inflation expectations, and global oil prices (Brent oil) from Oct.1995 to Jul. 2018. The inflation expectations data used in this study are from the Consensus Forecasts since it is the only available source that provides long-term inflation expectations for Chinese Taipei. The upper panel presents the dynamics of headline inflation,[4] core inflation (excluding fresh vegetables, fruit, and energy prices), and trend inflation.[5] The middle panel shows the dynamics of long-term (10-year ahead) and short-term (1-

4. Defined as year-on-year changes of non-seasonal adjusted monthly consumer price index (CPI).

5. Estimated by the method from Chan, Clark, and Koop (2018). Rather than just equaling the trend inflation with the long-term inflation expectations, their model allowed for the estimation of the link between trend inflation and the long-run forecast, which is helpful in fitting and forecasting inflation. The estimation model is provided in Appendix 1. Please see Chan, Clark, and Koop (2018) for details.

year ahead) inflation expectations. The lower panel shows historical Brent oil prices per barrel in US dollars. While headline inflation was very volatile as expected, core inflation also showed great fluctuations. Trend inflation was smoother and was about 2.3% in 1995, later declining to 1.5% around 2000 and then moving between 1% and 1.5% hereafter. In general, the long-term inflation expectation co-moved well with trend inflation, whereas the short-term inflation expectation deviations more.

Figure 1
Inflation, Inflation Expectations, and Oil Prices



As stated in the introduction, many studies found the dynamics of inflation and long-term inflation expectation in the Asia-Pacific region to have declined, and this change was not subject to central banks adopting inflation targeting. In general, trend inflation in Chinese Taipei also showed a downward trend from 1995 to the early 2000s and stayed stable thereafter. It is therefore reasonable to suspect that the behaviour of long-run inflation expectations in Chinese Taipei had changed around the early 2000s. Unlike some studies which simply divided samples into two parts based on the periods before and after the year 2000, this study conducts a structural break test as a preliminary examination on long-term inflation expectations. The purpose of conducting a structural break test is to decide sub-samples for the following analysis, and it does not imply that a dramatic change is expected in the behaviour of long-term inflation expectations at certain points.[6]

To examine the possibility of a structural change in the long-term inflation expectation without specifying a possible structural change in certain statistical characteristic, a linear regression model is first estimated to explain the behaviour of long-term inflation expectation and an OLS-based CUSUM structural break test[7] is applied on it. Based on Clark and Davig (2011) and Sousa and Yetman (2016), seven variables, including trend inflation, actual inflation (headline inflation), short-term inflation expectation, change in oil price, change in output[8], change in nominal effective exchange rate (NEER), and one period lag of long-term inflation expectation, are chosen as regressors in the regression. Using OLS-based CUSUM structural break test, the null hypothesis of no structure break is rejected significantly and the estimated structural change point is Oct. 2003. Figure 2 shows the OLS-based CUSUM test with 0.05 confidence level. To better understand the possible source of this structure change, using the model from Chan, Clark, and Koop (2018)[9] to estimate the dynamic properties of trend inflation, which is closely linked to the long-term inflation rate, may give us some hints. Based on the estimated trend inflation and the parameter, λ_n, which controls the value of stochastic volatility of trend inflation[10] (Figure 3), it is obvious that both the

6. Unlike some economies in the Asia-Pacific region, which adopted inflation targeting around the year 2000, the Central Bank of Chinese Taipei does not change its official monetary policy framework. It is therefore unlikely to have a dramatic change in the behaviour of long-term inflation expectations. Meanwhile, as it is stated in Yallen (2015), even if central banks change their monetary policy frameworks or announce an inflation target, inflation expectations would be affected only after the central bank has had sufficient time to demonstrate its sustained commitment—a process that might take years, based on the U.S. experience.

7. The CUSUM-type tests are used to assess the stability of coefficients (β) in a multiple linear regression model of the form y = Xβ+ε. Inference is based on cumulative sums, or cusums, of residual resulting from recursive regressions. Values of the sequence outside an expected range suggest structural change in the model over time.

8. Throughout this study, the author uses the detrended coincident indicator to represent output. Following Clark and Davig (2011) who use the Chicago Fed National Activity Index (CFNAI) because of its broad coverage, strong contemporaneous correlation to real output and reduced data revision issues, the author uses the detrended coincident indicator, which closely co-moves with the business cycle of Chinese Taipei to measure border coverage of output. The detrended coincident index is a weighted average indicator that is composed of seven time-series variables, including the industrial production index, electric power consumption, the index of producer's shipment for manufacturing, sales of trade and food services, non-agricultural employment, customs-cleared exports, and imports of machineries and electrical equipments.

9. Appendix 1 provides the model specified in Chan, Clark, and Koop (2018). Please see Chan, Clark, and Koop (2018) for details.

10 $\lambda_{n,t}$ controls the magnitude of stochastic volatility of trend inflation. The bigger the $\lambda_{n,t}$ is, the larger the stochastic volatility of trend inflation.

level and the volatility of trend inflation were on a downtrend from 1995 to 2003 and stayed more stable hereafter. Thus, given the close link between long-term inflation expectations and trend inflation, it was likely that the mean and volatility of long-term inflation expectations moved to a lower and more stable regime after 2003 as well.

Figure 2
OLS-based CUSUM test

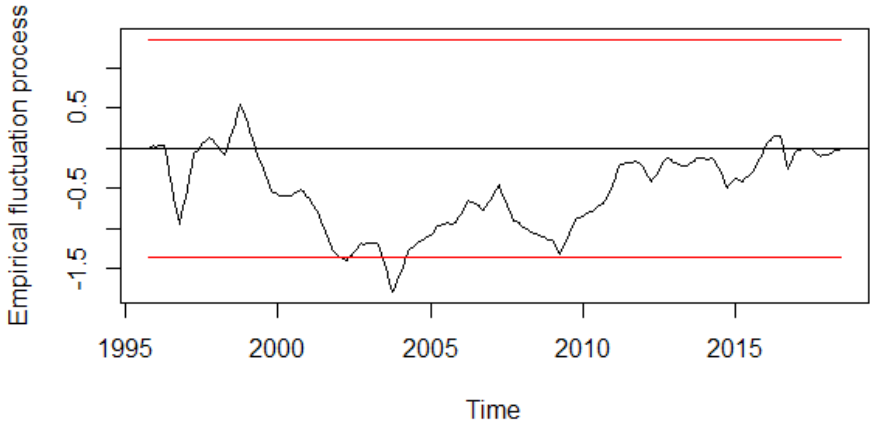
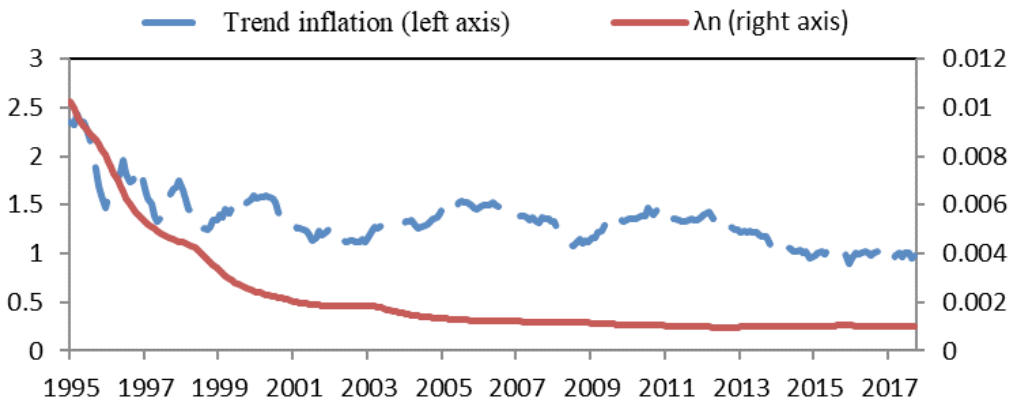
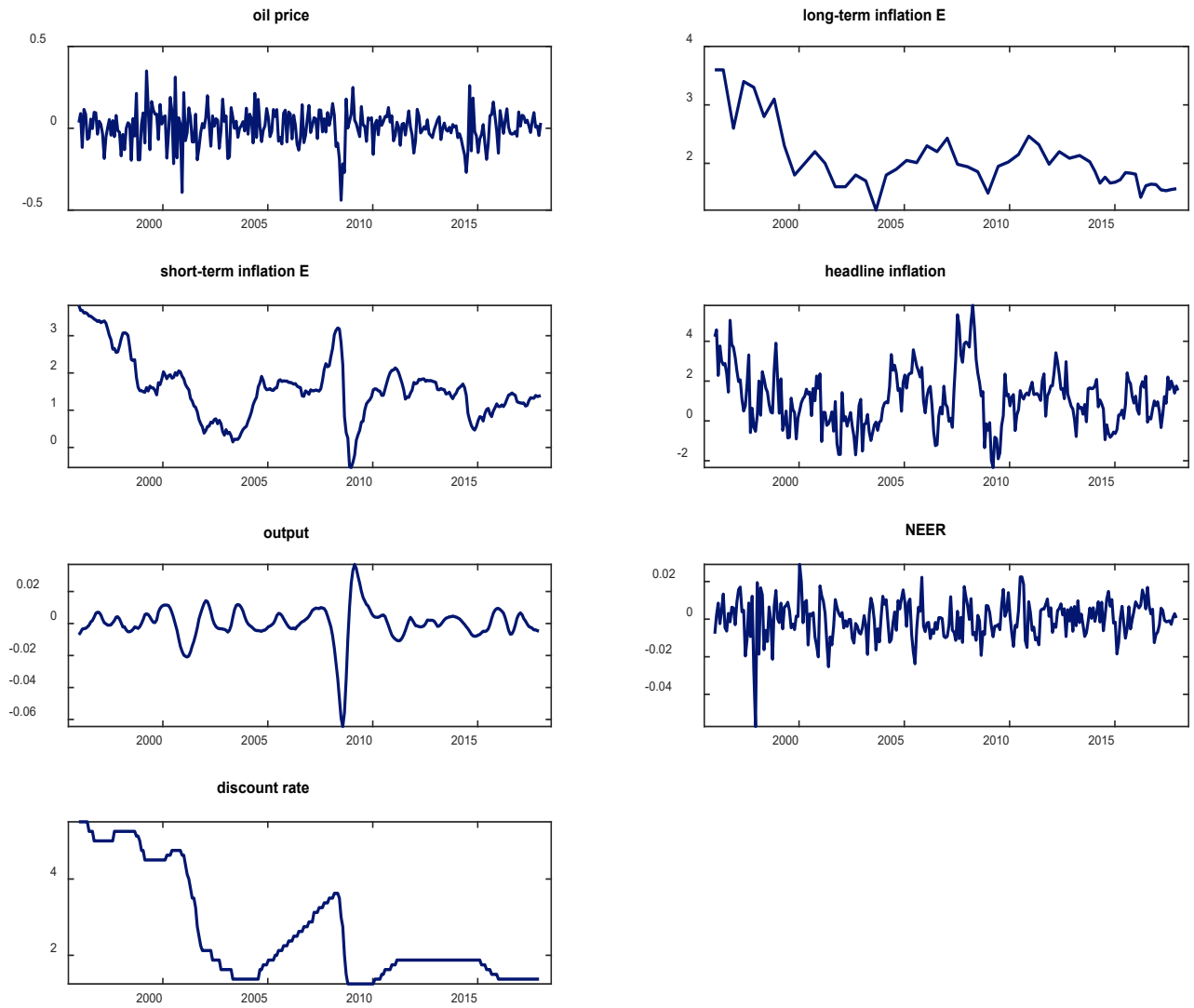


Figure 3
Trend Inflation



Then, the same set of variables is used and the discount rate as the policy rate is included to estimate an SVAR model to describe the dynamic relationships between inflation expectations and other macroeconomic variables. The whole sample observations are monthly data from Oct. 1995 to Jul. 2018, and the sample before and after Oct. 2003 is used to decide the sub-samples. The data sources and data handling are presented in Appendix Table A1. Unit root test for each variable is provided in Appendix Table A2 to ensure stationarity of the SVAR system. Figure 4 gives an overview of the dynamics of all the data.

Figure 4
Data in the SVAR Model



Given that global oil prices should be predetermined and the setting in Clark and Davig (2011)[11] are followed, short-run recursive restrictions are used to identify structural shocks and order variables in the SVAR model with the constant suppressed as follows:

$$A_0 y_t = \sum_{i=1}^{p} A_i y_{t-i} + \varepsilon_t, \mathrm{Var}(\varepsilon_t) = I_7 \quad (1)$$

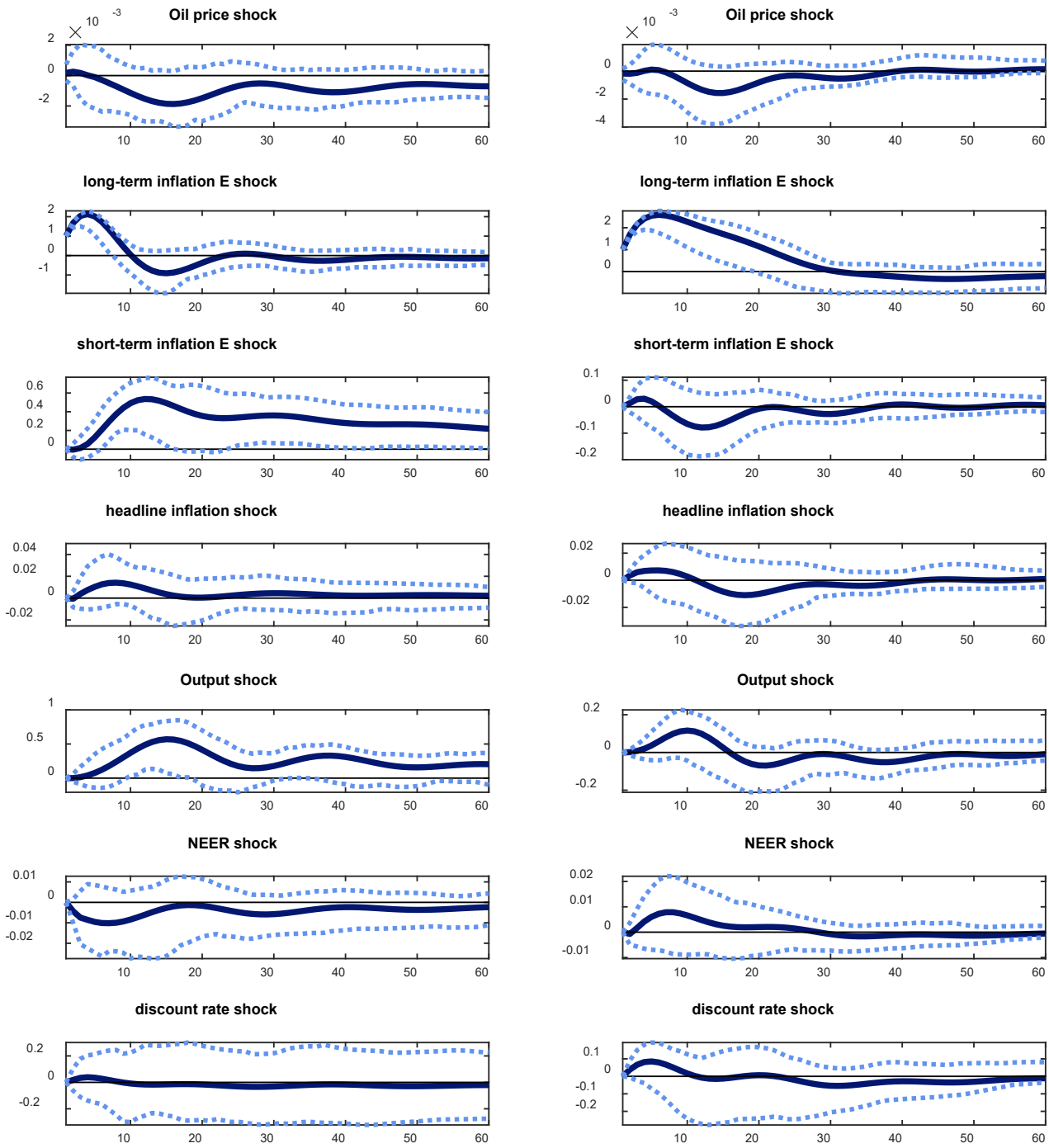
where $y_t = [P_t, \pi_{t,l}^e, \pi_{t,s}^e, \pi_t, a_t, EX_t, R_t]'$ consists of the difference in natural log of oil price (P_t), long-term inflation expectations[12] ($\pi_{t,l}^e$), short-term inflation expectations ($\pi_{t,s}^e$), the headline CPI inflation rate (π_t), the difference in natural log of output[13] (a_t), the difference in natural log of NEER (EX_t), and the discount rate (R_t). Using BIC inflation criteria to choose the number of lag terms, the model is estimated with 2 lags for both sub-samples.

4. Impulse Responses

To examine the degree of anchoring of long-term inflation expectations, the estimates of a set of impulse responses of long-term inflation expectations to all the structural shocks in the model over the two sub-samples are presented. If the public is clear about the central bank's goal (explicit or implicit), and believes the central bank intends to fulfill it, long-term inflation expectations should be well-anchored and should not be sensitive to temporary economic shocks. Further, the persistence of responses is also related to how clear or confident the public is concerning the central bank's objectives. As suggested in Moreno and Villar (2010), if the public is clear about the goal of the central bank, they would find it easier to disentangle whether a given shock (for example, a surprise outcome of actual inflation) reflects a shift in the inflation target or just a transitory disturbance. Therefore, a transitory shock should not have persistent impacts on inflation expectations if the monetary policy framework is transparent and credible, and long-term inflation expectations are well-anchored. The impulse responses trace out the average effect of a hypothetical one-time structural shock. Here, the responses to 1% of various structural shocks for 60 periods with 90% confidence intervals are calculated. Figure 5 presents the results. The left panel is the impulse responses estimated with the first sub-sample (from Oct. 1995 to Oct. 2003), whereas the right panel is the responses estimated with the second sub-sample (from Nov. 2003 to Jul. 2018).

11. As it was explained in Clark and Davig (2011), the official release of monthly inflation data is delayed for one month, which means survey respondents do not have current inflation data within the month they are submitting their forecasts. Long-term expectations are ordered before short-term expectations since a respondent usually will also revise his short-term forecast when revising his long-term forecast, but not vice versa. This argument is supported by the fact that long-term forecasts are less frequently revised compared to short-term forecasts in Consensus Forecasts. The discount rate is ordered last since the central bank is likely to adjust the rate in response to movements in observable data.
12. Throughout this study, 10-year ahead inflation expectation and 1-year ahead inflation expectation from Consensus Forecasts are used to represent long-term and short-term inflation expectations.
13. Based on the same argument as Note 4, the detrended Coincident indicator to represent output is used.

Figure 5
Impulse Responses of Long-term Inflation Expectations to Various Structural Shocks



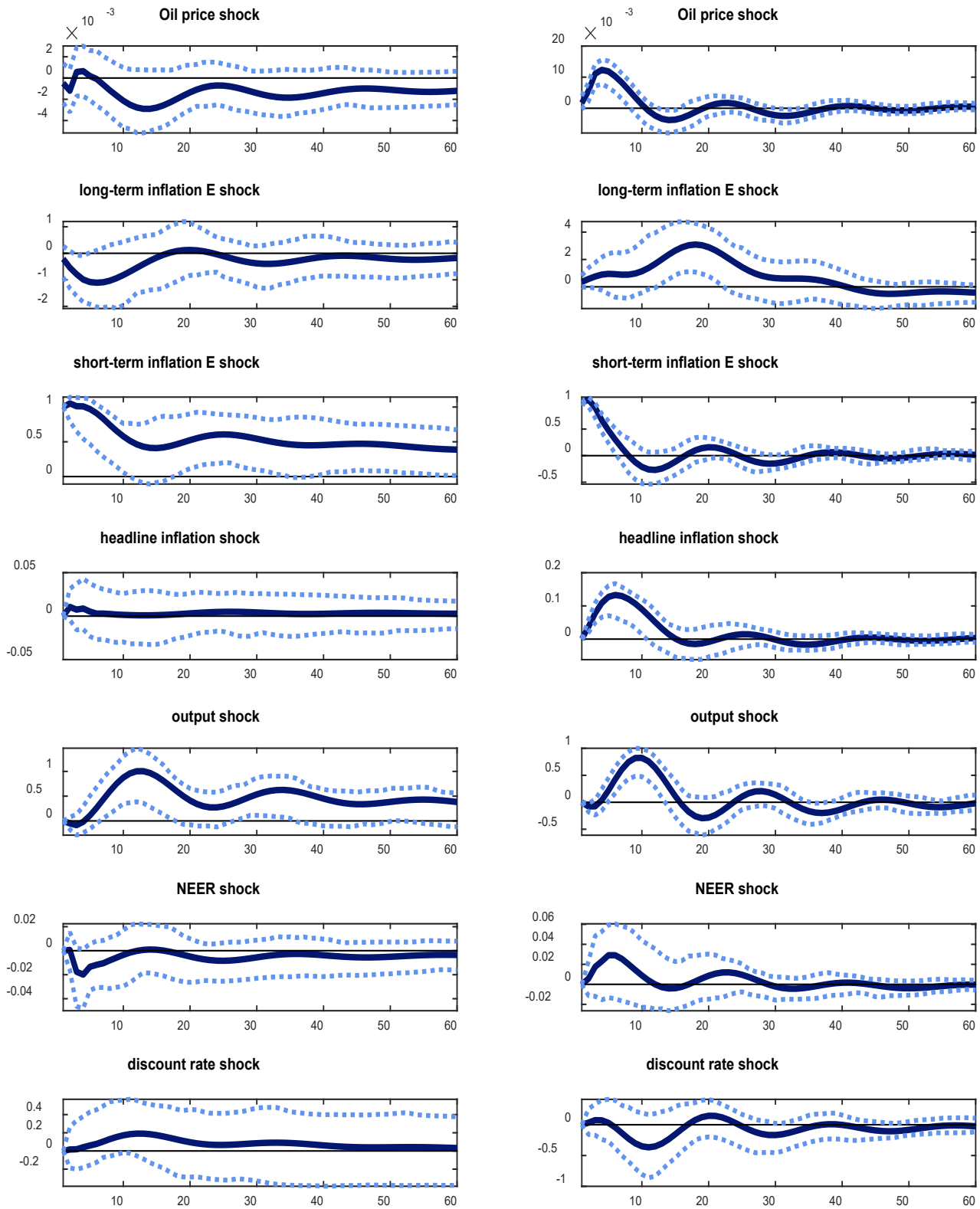
The solid black lines represent the responses of long-term inflation expectations to 1% of various structural shocks for 60 periods with a 90% confidence interval (the dotted blue lines) constructed using bootstraps.

In the first sub-sample, the responses of long-term inflation expectations to short-term inflation expectations shocks are significant and very persistent compared to those in the second sub-sample. This means that variations in short-term inflation expectations can spill over to long-term inflation expectations and cause persistent changes in the long-term inflation expectations in the first sub-sample, which is an important source of de-anchoring (Jochmann et al., 2010). However, this spillover effect becomes smaller and insignificant in the second sub-sample. For oil price shocks and headline inflation shocks, the responses become smaller in magnitude in the second sub-sample, though being insignificant in both sub-samples. Long-term inflation expectations are also significantly sensitive to the output shocks. The impacts are very persistent. Since long-term inflation expectations can be interpreted as the perceived inflation target of the central bank (Yellen 2015), this result may indicate that the public thinks the central bank would like to partially accommodate any surprise from output and thus adjust its target. However, in the second sub-sample, impacts from output shocks become insignificant and less persistent, which can be another evidence of better anchored long-term inflation expectations. Other than short-term inflation expectations shocks and output shocks, long-term inflation expectations are also sensitive to their own shocks, which can be seen as to how the public adjusts their expectations about the central bank's inflation target on the impacts of target shocks.

On the other hand, though short-term inflation expectations are intrinsically more sensitive to temporary economic disturbances, the persistence of their responses should also be related to how clear the public is about the objective of the central bank. Figure 6 presents the impulse responses of short-term inflation expectations, where the left panel is the estimates of the first sub-sample, and the right panel is the estimates of the second sub-sample. In the first sub-sample, the responses of short-term inflation expectations are only persistent to oil price shocks, output shocks, and shocks from short-term inflation expectations. Impacts from oil price shocks are not significant.

In the second sub-sample, the responses of short-term inflation expectations to all the shocks, except long-term inflation expectations shocks, become less persistent, but more significant at the initial stage. The impacts of long-term inflation expectations shocks may reflect that the public's short-term inflation expectations are more likely to be affected by the news about central bank's target but with a one-year delay. The above impulse response results show that long-term inflation expectations become less sensitive to macro-news and more sensitive to changes in perceived inflation targets. For short-term inflation expectations, though they are more sensitive to macro-news as expected, most of the impacts become less persistent in the second sub-sample. These results support a more credible monetary policy and better anchored long-term inflation expectations.

Figure 6
Impulse Responses of Short-term Inflation Expectations to Various Shocks



The black solid lines represent the responses of short-term inflation expectations to 1% of various structural shocks for 60 periods with a 90% confidence interval (the dotted blue lines) constructed using bootstraps.

4.1 Variance Decomposition

The forecast error variance decompositions that measure the extent of seven structural shocks explaining the variability of long-term inflation expectations on average are also examined. Table 1 presents the results, where the upper panel shows the results from the first sub-sample, and the lower panel displays the results from the second sub-sample.

Comparing the two sub-samples, the major differences are in the extent of long-term inflation expectation shocks, short-term inflation expectation shocks, and output shocks to explain the variation of long-term inflation expectations. In the first sub-sample, more than 60% of the variation in long-term inflation expectations is driven by their own shocks until the first year, but the share declined over time and is reduced to about 30% after three years. In contrast, short-term inflation expectation shocks explain 20% of the variation until one year and then the share increases to about 35% after three years. Output shocks explain 25% of total variation after three years. However, in the second sub-sample, more than 90% of the variation is driven by shocks from long-term inflation expectation shocks, and the influences are very stable over time. All the other structural shocks contribute to trivial portions of total variation. This result also shows that long-term inflation expectations are better anchored in the latter sub-sample period. The significant share made up by output shocks in the first sub-sample is consistent with the results from Figure 5, where output shocks have significant and persistent impacts on long-term inflation expectations. Davis (2014) provided a model with a similar idea to explain the high volatility of long-term inflation expectations in the U.S in the early 1980s, when the public was unsure about the central bank's commitment to its target. The higher volatility territory in trend inflation of Chinese Taipei in the first sub-sample (Figure 3) is consistent with the argument made by Davis (2014).

Table 1
Variance Decomposition of Long-term Inflation Expectation (%)

First Sub-sample							
Horizon	Oil Price	Long-term Inflation E	Short-term Inflation E	Headline Inflation	Output	NEER	Discount Rate
12	1.39	63.17	21.44	1.64	10.72	1.57	0.07
24	3.68	40.22	29.75	0.94	24.42	0.94	0.06
36	3.64	34.24	35.77	0.9	24.29	1.06	0.1
60	4.01	28.55	39.28	0.81	26.18	1.02	0.14
Second Sub-sample							
Horizon	Oil Price	Long-term Inflation E	Short-term Inflation E	Headline Inflation	Output	NEER	Discount Rate
12	0.61	95.46	0.6	0.38	2.19	0.47	0.29
24	1.99	93.23	0.81	1.02	2.35	0.39	0.21
36	2.18	92.53	0.88	1.13	2.52	0.4	0.35
60	2.14	92.19	0.87	1.13	2.8	0.42	0.44

5. Oil Price Shocks and Monetary Policy

5.1 Counter-factual Analysis of Oil Price Shocks

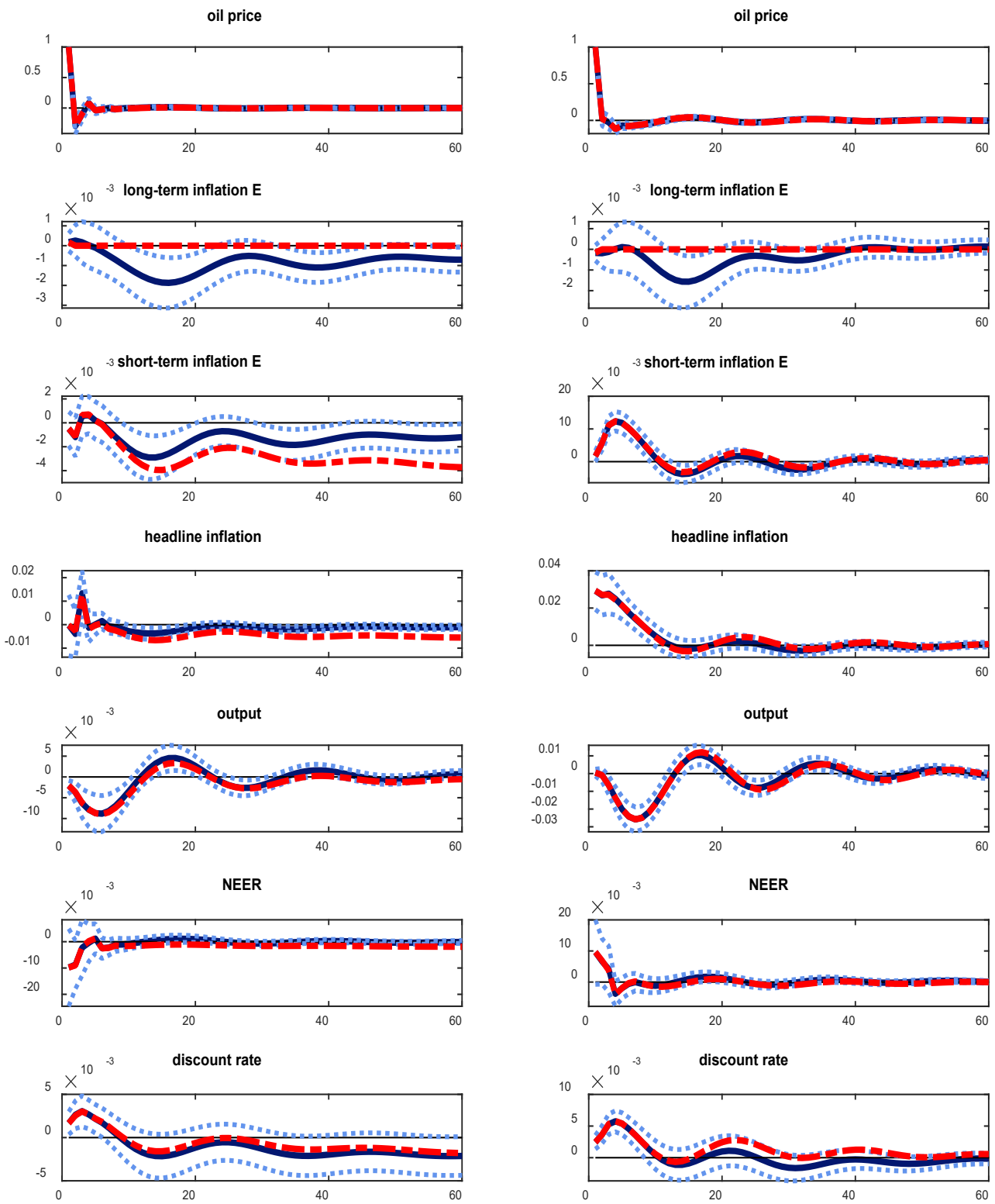
In Section 4, evidence from the impulse responses and forecast error variance decompositions supports the idea that the ability to anchor long-term inflation expectations has improved. As mentioned in the introduction, one channel through which oil price shocks pass through into inflation is influencing inflation expectations. Therefore, it will be interesting to investigate how changes in the behaviour of long-term inflation expectations affect the impacts of oil price shocks on headline inflation. To disentangle this mechanism, a counter-factual analysis is conducted by shutting down the response of long-term inflation expectations to 1% of oil price shocks and the consequent responses of short-term inflation expectations and headline inflation are examined. Following Wong (2015) and Kilian and Lewis (2011), to constrain the response of long-term inflation expectations, a sequence of long-term inflation expectation shocks just large enough to mute out the responses of long-term inflation expectations to oil price shocks is generated. The details describing the procedures of this counter-factual experiment are provided in Appendix 2.

Figure 7 represents the counter-factual results from SVAR models. The left panel is the counter-factual analysis for the first sub-sample, whereas the right panel is for the second sub-sample. The dashed red lines represent the counter-factual impulse responses caused by the shutdown of the responses of long-term inflation expectations to 1% of oil price shocks, whereas the solid black lines represent the actual impulse responses. The dotted blue lines are one standard error bands. In the first sub-sample, examining the degree of the passing-through of oil price shocks into headline inflation by shutting down the channel of long-term inflation expectations (i.e. the response of long-term inflation expectations to 1% of oil price shocks is zero), it is found that short-term inflation expectations fall from about -0.002% to about -0.003% three years after the oil price shocks. However, the decline in the responses of short-term inflation expectations is more related to the counter-factual responses of the discount rate and output, which increases mildly and decreases marginally, respectively, in response to the counter-factual response of long-term inflation expectations. Consequently, the responses of headline inflation change from -0.002% to -0.005%. It shows that a significant second-round effect of oil price shocks driven by short-term inflation expectations[14] is mitigated indirectly by the shutdown of the responses of long-term inflation expectations.

Turning to the second sub-sample, it is notable that under the actual impulse responses, compared to that in the first sub-sample, the response of long-term inflation expectations is smaller and not significant. Shutting down the response of long-term inflation expectations does not lead to any significant changes in the responses of other variables. Overall, there is no significant difference between the counter-factual and actual impulse responses both in short-term inflation expectations and in headline inflation. This result suggests a weaker role of long-term inflation expectations in affecting the responses of short-term inflation expectations and thus the responses of headline inflation to oil price shocks. After all, long-term inflation expectations are less sensitive to oil price shocks in the second sub-sample under the actual impulse responses.

14. The more significant second-round effect with the short-term inflation expectation, but not with long-term inflation expectation, is consistent with the evidence that shorter term inflation expectations are more important in determining headline inflation (Fuher 2011; Fuher et. al. 2012; Chang 2014; Wong 2015).

Figure 7
Actual and Counter-factual Impulse Responses to 1% of Oil Price Shocks



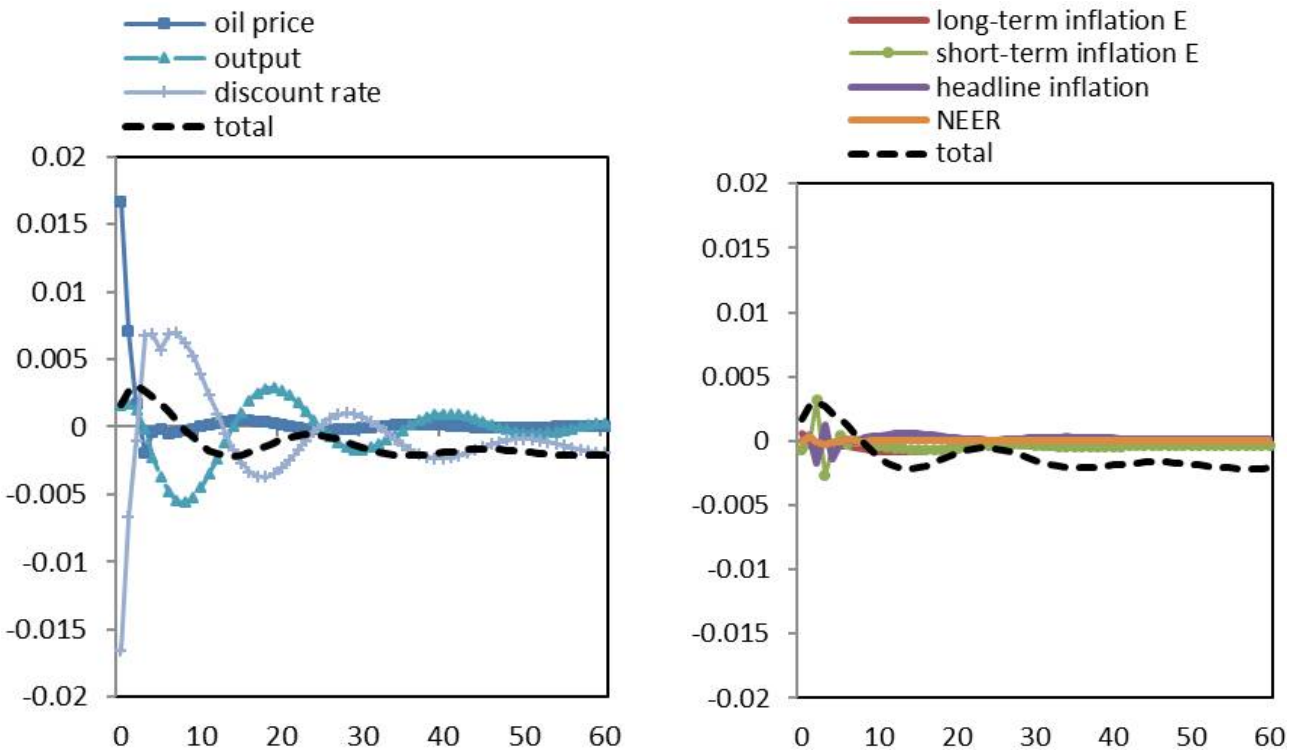
The solid black lines represent the actual impulse responses to 1% of oil price shocks. The dotted blue lines are the one standard error band of the actual impulse responses. The dashed red lines are the counter-factual impulse responses.

5.2 The Stances of Monetary Policy

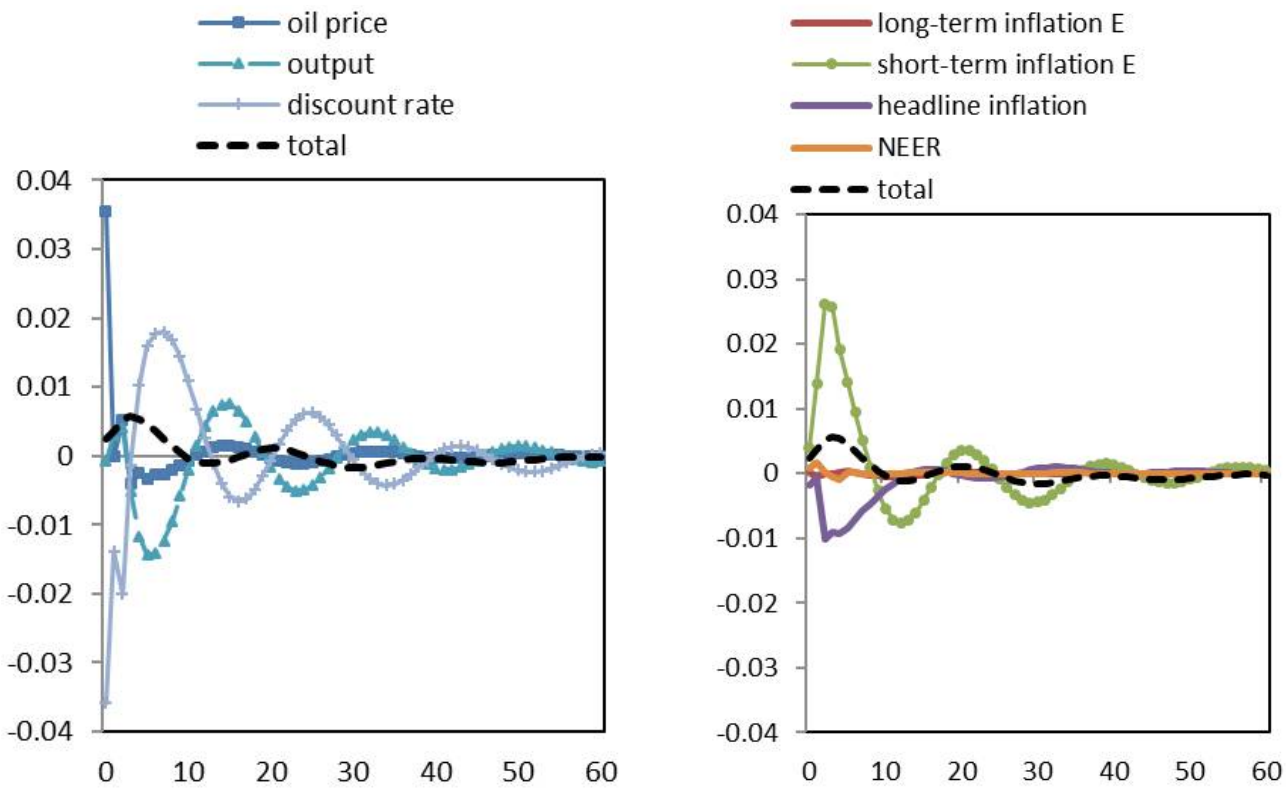
The breakdown of transmission from inflation expectations to headline inflation was also found in the post-1990 sample period in Wong (2015). He provided two possible explanations. One was through the price and wage setting channel. When the economy was in a very low and stable inflation environment, it was costly to change prices (Ball, Mankiw, and Romer, 1998; Akerlof, Dickens, and Perry, 2000), which might have caused the influence of inflation expectations on actual price inflation to become less pronounced. Figure 3 demonstrates that trend inflation in Chinese Taipei after 2003 became lower and more stable. This could represent a low inflation environment where the role of inflation expectations in transmitting shocks to actual prices became insignificant. Another possible interpretation provided by Wong (2015) was related to the role of monetary policy. As he suggested, if monetary policy placed more weight on targeting inflation, inflation expectations would be better anchored. In the related literatures, a number of papers showed that the effect of transitory oil price shocks had diminished over time and went on to argue that one of the reasons for this change was the improved monetary policy (e.g., Blanchard and Gali, 2007; Leduc, Sill and Stark, 2007; Mehra and Herrington, 2008; Blanchard and Riggi, 2009; Evans and Fisher, 2011).

To investigate the role of monetary policy in the impacts of oil price shocks, the impulse responses of the discount rate to oil price shocks are decomposed to understand the percentage contributions of seven structural shocks in the SAVR.[15] Figure 8 illustrates the results, where the upper and lower panels present the results of the first and second sub-samples, respectively. To improve the readability, the contributions of seven structural shocks are divided into two charts (left and right charts). In each chart, the dashed black line represents total impulse responses of the discount rate.

Figure 8
Decomposition of the Response of the Discount Rate to 1% of Oil Price Shocks



15. Detailed procedures are provided in Appendix 3.

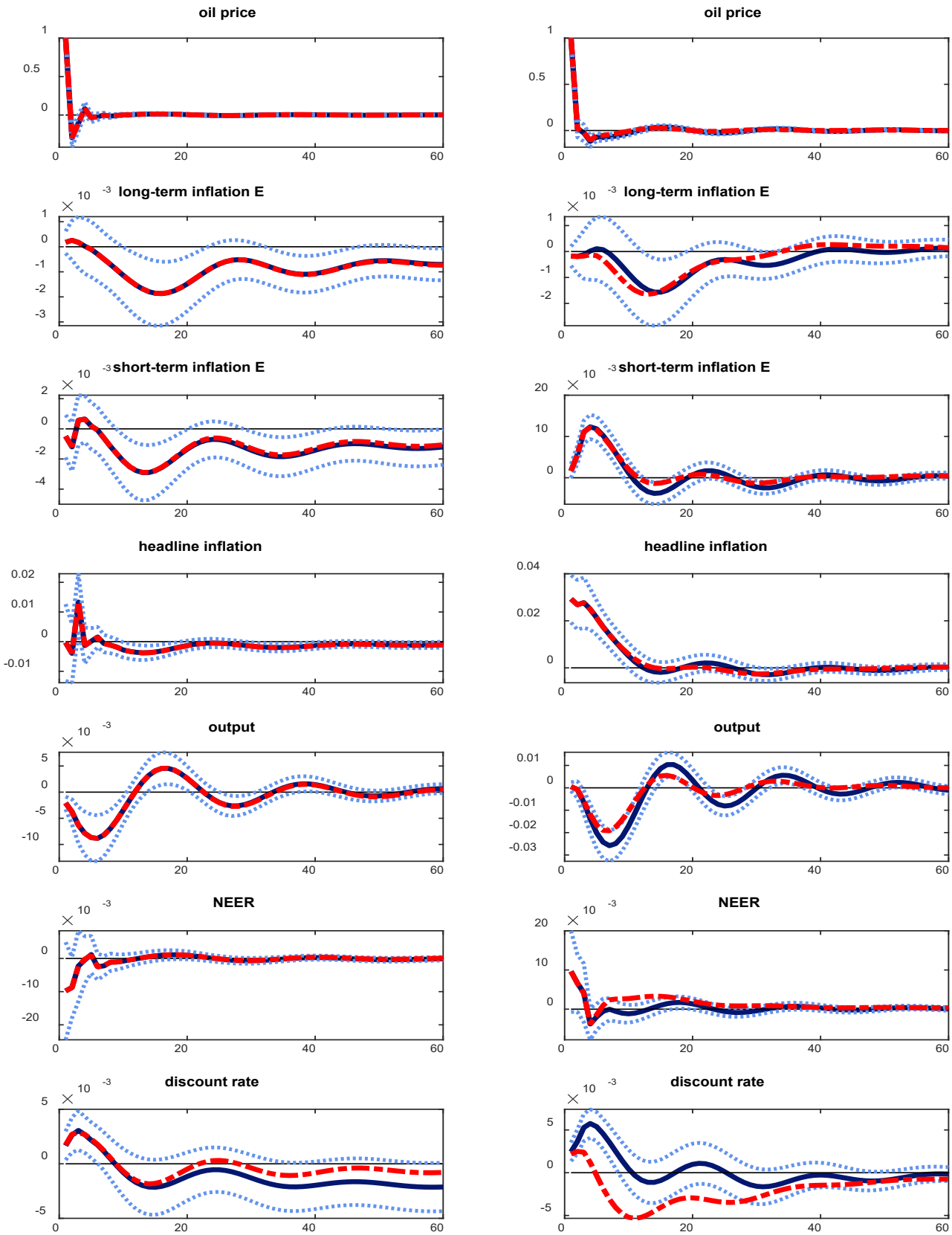


In both sub-samples, the discount is raised substantially for the first 3 months in response to the oil price shocks, whereas it is lowered for the first 12 months in response to the declines in output triggered by oil price shocks. However, in the first sub-sample, the discount rate nearly only responds to output dynamics and the discount rate's own lags. Its direct responses to oil prices almost vanished after the first 3 months, and it hardly reacts to headline inflation, long-term and short-term inflation expectations, and NEER at all horizons. In the second sub-sample, while most of the responses of the discount rate are on account of output dynamics and the discount rate's own lags, its direct responses to oil prices last around 2 years with small magnitude. More importantly, unlike that in the first sub-sample, the discount rate responds more to the dynamics of short-term inflation expectations and headline inflation in the second sub-sample. A larger portion of the discount rate's responses is accounted for by short-term inflation expectation dynamics with expected sign. This finding supports the idea that monetary policy becomes more aggressive in the battle against inflation and is also more forward-looking than before.

Regarding the role of short-term inflation expectations in monetary policy found above,[16] an interesting question is how different it would be if monetary policy does not respond directly to short-term inflation expectation dynamics. To answer this question, another counter-factual analysis is conducted by shutting down the direct responses of the discount rate to short-term inflation expectation dynamics triggered by oil price shocks. Figure 9 presents the results, where the left and right panels represent the estimates in the first and the second sub-samples, respectively.

16. The contribution of headline inflation is much smaller and less persistent than that of short-term inflation expectations in the decomposition of the discount rate's responses, so it is not considered here.

Figure 9
Actual and Counter-factual Impulse Responses to 1% of Oil Price Shock



The solid black lines represent the actual impulse responses to 1% of oil price shocks. The dotted blue lines are the one standard error band of the actual impulse responses. The dashed red lines are the counter-factual impulse responses.

In the first sub-sample, within the first year after oil price shocks, even though shot-term inflation expectations drop significantly, there is almost no difference between the actual and counter-factual responses of the discount rate. The responses of the discount rate start to decrease to a lesser extent[17] after the first year, and the gap between the counter-factual and actual impulse responses expands gradually and becomes stable three years after the shocks. However, the change in the responses of the discount rate, though not significant, has nearly no impact on the responses of other variables. In the second sub-sample, given substantial increases in short-term inflation expectations[18] in response to oil price shocks, under the counter-factual analysis, the response of the discount rate decreases significantly compared to the actual analysis within the first year. The decrease in the responses of the discount rate causes the responses of output to decline to a lesser extent (though probably not significant). For other variables, changes in their impulse responses are marginal. While the results from this counter-factual analysis do not show much difference in the responses of other variables under the alternative monetary policy, the more significant and timely changes (with expected sign) in the responses of the discount rate do support a more aggressive monetary policy stance in fighting inflation in the second sub-sample. This also supports the explanation that the improved conduct of monetary policy contributes to better anchored long-term inflation expectations in the second sub-sample found in Section 4.[19]

Another way to examine the stance of monetary policy is to see, on average, what factors drive the dynamics of the discount rate. Table 2 presents the variance decomposition of the discount rate under the two sub-samples. In the first sub-sample, most of the variations of the discount rate are driven by output shocks and the discount rate's own shocks. Inflation related variables contribute to trivial portions of total variation. On the other hand, in the second sub-sample, inflation related variables, especially long-term inflation expectations, explain a larger portion of the discount rate variations. The contribution of the discount rate's own shocks decreases remarkably, which can also support the improvements of monetary policy. As suggested by Clark and Davig (2011), a monetary policy that responds more systematically to macroeconomic developments and is less reflective of idiosyncratic changes in the discount rate can better anchor long-term inflation rates[20] since it can provide a better understood mapping between observable macroeconomic data and the discount rate, a factor that could help the public form long-term inflation expectations.

17. In the actual analysis, short-term inflation expectations decrease in response to oil price shocks. Shutting down their direct impacts on the discount rate causes the discount rate to decrease to a lesser degree in the counter-factual analysis.

18. Given the counter-factual analysis in Figure 5, the increase in short-term inflation expectations is directly triggered by oil price shocks and has not much to do with long-term inflation expectations.

19. If the public anticipates the central bank to respond aggressively to inflationary shocks, they may assume the effects of these shocks will dissipate sooner and set prices accordingly. As a result, inflation expectations will be less responsive to transitory shocks (Davig and Doh, 2014).

20. As explained by Clark and Davig (2011), a more systematic monetary policy could provide a better understood mapping between observable macroeconomic data and the discount rate, a factor that could help the public form long-term inflation expectations.

Table 2
Variance Decomposition of the Discount Rate (%)

The First Sub-sample							
Horizon	Oil Price	Long-term Inflation E	Short-term Inflation E	Headline Inflation	Output	NEER	Discount Rate
12	3.07	2.26	1.96	0.7	30.19	0.27	61.55
24	2.4	1.21	4.86	0.54	42.93	0.41	47.66
36	2.21	0.93	10.89	0.38	45.21	0.28	40.1
60	2.58	0.73	20.1	0.24	47.05	0.2	29.1
The Second Sub-sample							
Horizon	Oil Price	Long-term Inflation E	Short-term Inflation E	Headline Inflation	Output	NEER	Discount Rate
12	9.63	16.23	4.03	1.29	38.9	1.8	28.12
24	4.18	54.73	1.84	0.73	20.31	1.48	16.74
36	3.31	63.39	1.49	0.71	16.9	1.31	12.89
60	3.11	66.26	1.39	0.8	15.36	1.27	11.81

6. Robustness Test

To investigate the robustness of these results, the sensitivity of these results to two alternative short-term recursive identification schemes is first tested. One is interchanging the order between inflation expectations and headline inflation, which means instead of ordering inflation expectations before headline inflation, the headline inflation is ordered before inflation expectations.[21] The other ordering scheme is that since most studies considered the currency market as the most efficient market, any changes in economy should be reflected in the currency market immediately. In this regard, alternatively the NEER is ordered as the last variable in the SVAR ordering. The fourth and fifth SVAR settings examined are related to the variable representing the CBCT's monetary policy instrument. In fact, the official monetary policy intermediate target is M2 growth; however, Chen and Wu (2010) argued that it was more likely that the CBCT had switched to use the discount rate as the policy rate to achieve its final targets[22] since 1998. Similarly, many studies focused on estimating an interest rate reaction function of monetary policy in Chinese Taipei by using (interbank) overnight rate as the policy rate. Therefore, the M2 growth rate and the overnight rate are used, respectively, to replace the discount rate as the policy rate of CBC. Table 3 explains the differences among alternative SVAR settings, whereas the resulting figures and tables for alternative

21. The order between long-term inflation expectation and short-term inflation expectation should not be altered.
22. The final goals (mandates) of the CBCT are maintaining price stability, promoting financial system soundness, and fostering economic growth.

SVAR settings are presented in the appendix.[23] Overall, the results under four alternative SVAR settings are very similar, which proves the robustness of the current results.

Table 3
Alternatives SVAR Settings

Model	Differences in SVAR setting
SVAR 1	The main SVAR setting of current study
SVAR 2	Interchange the order of inflation expectations and headline inflation
SVAR 3	Order the NEER as the last variable in the SVAR
SVAR 4	Replace the policy rate (the discount rate in SVAR 1) with the M2 growth rate[24]
SVAR 5	Replace the policy rate (the discount rate in SVAR 1) with the overnight rate

7. Conclusion

Though the monetary policy framework of the CBCT is not inflation targeting, long-term inflation expectations of Chinese Taipei have also been within the downtrend commonly seen across emerging and developing economies, especially in Asia, since the late 1990s. By examining the sensitivity of long-term inflation expectations to various macro-news in an SVAR framework, it is found that the degree of anchoring of long-term inflation expectations has improved since the early 2000s. Particularly, for global oil price shocks, while there are significant second-round effects indirectly affected by long-term inflation expectations before the early 2000s, the counter-factual analysis shows that better-anchored long-term inflation expectations, found after the early 2000s, have little to do with the actual inflation outcome in the latter sub-sample. This phenomenon is consistent with Wong's (2015) explanation of a lower inflation and improved monetary policy environment, which is supported by the finding of this study through exploring the role of monetary policy.

In line with the theory and the empirical literature, the more aggressive policy stance of the CBCT in fighting inflation and the more systematic responses of its monetary policy to macroeconomic developments can contribute to better-anchored long-term inflation expectations. As implied from the theory and suggested by the IMF (2018), well-anchored inflation expectations can significantly improve economic resilience to external shocks, such as global oil price shocks or currency depreciation shocks, which are particularly challenging for emerging economies. Therefore, improving the extent of inflation expectations anchoring by increasing the credibility and transparency of monetary policy is helpful for central banks not only to stabilise inflation, but also to focus on smoothing output. Given that Chinese Taipei is a small open economy and relying on imported oil and commodities, improving the extent of inflation expectations anchoring is essential for the CBCT.

23. Figures A1.1.1-2, A1.2.1-2, A1.3.1-2, and A1.4.1-2 provide the impulse responses of long-term inflation expectations and short-term inflation expectations under SVAR 2, SVAR 3, SVAR 4, and SVAR 5 settings, respectively. Figures A2.1, A2.2, A2.3, and A2.4 present the counter-factual impulse responses to 1% of oil price shocks by the shutdown of the response of long-term inflation expectations under SVAR 2, SVAR 3, SVAR 4, and SVAR 5 setting, respectively.

24. Since M2 growth can only possible be the CBCT's policy rate till late 1990s, the author only estimated SVAR 4 in the first sub-sample and compared it to that of SVAR 1 in the first sub-sample.

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Appendix 1

Chan, Clark, and Koop (2018) developed a bivariate model of inflation and a survey-based long-run forecast of inflation that allows for the estimation of the link between trend inflation and the long-run forecast. The following is the baseline model (M1) presented in their paper:

$$\pi_t - \pi_t^* = b_t(\pi_{t-1} - \pi_{t-1}^*) + v_t, \quad \text{(A1)}$$

$$z_t = d_{0t} + d_{1t}\pi_t^* + \varepsilon_{z,t} + \varphi\varepsilon_{z,t-1}, \quad \varepsilon_{z,t} \sim N(0, \sigma_z^2) \quad \text{(A2)}$$

$$\pi_t^* = \pi_{t-1}^* + n_t, \quad \text{(A3)}$$

$$b_t = b_{t-1} + \varepsilon_{b,t}, \quad \text{(A4)}$$

$$d_{it} - \mu_{di} = \rho_{di}(d_{i,t-1} - \mu_{di}) + \varepsilon_{di,t}, \varepsilon_{b,t} \sim N(0, \sigma_{di}^2), \mathrm{i} = 0,1, \quad \text{(A5)}$$

$$v_t = \lambda_{v,t}^{0.5}\varepsilon_{v,t}, \varepsilon_{v,t} \sim N(0,1), \quad \text{(A6)}$$

$$n_t = \lambda_{n,t}^{0.5}\varepsilon_{n,t}, \varepsilon_{n,t} \sim N(0,1), \quad \text{(A7)}$$

$$\log(\lambda_{i,t}) = \log(\lambda_{i,t-1}) + v_{i,t}, v_{i,t} \sim N(0, \emptyset_i), i = v, n, \quad \text{(A8)}$$

where π_t is the headline inflation rate, π_t^* is trend inflation, and z_t is survey-based long-run inflation expectations. The stochastic volatility is controlled by the Equations (A6) and (A7) for inflation gap and trend inflation, respectively.

Appendix 2

Following Wong (2015), to construct a counter-factual analysis by shutting down the responses of long-term inflation expectations, Equation (1) is first defined in companion form,

$$A_0 y_t = \sum_{i=1}^{p} A_i y_{t-i} + \varepsilon_t,$$

$$y_t = \sum_{i=1}^{p} A_0^{-1} A_i y_{t-i} + A_0^{-1}\varepsilon_t\,,$$

$$X_t = \Lambda X_{t-1} + v_t\,,$$

where,

$$X_t = \begin{pmatrix} y_t \\ y_{t-1} \\ \vdots \\ y_{t-p+1} \end{pmatrix}, \Lambda = \begin{pmatrix} A_0^{-1}A_1 & \cdots & A_0^{-1}A_p \\ \vdots & \ddots & \vdots \\ 0 & \cdots & 0 \end{pmatrix}, v_t = \begin{pmatrix} A_0^{-1}\varepsilon_t \\ 0 \\ \vdots \\ 0 \end{pmatrix}. \qquad \text{(A9)}$$

Let $\mathrm{EE}(v_t' v_t) = \Omega$. I define $\tilde{A}_0^{-1} = chol(\Omega)$ and e_j as a selector row vector with 1 as the *j*th element and 0 elsewhere. The impulse response function of variable j to 1% of oil price shocks at horizon *k*, Ψ_j^k, is:

$$\Psi_j^k = e_j \Lambda^k \zeta,$$

where,

$$\zeta = \tilde{A}_0^{-1} e_1' \zeta = \tilde{A}_0^{-1} e_1'. \qquad \text{(A10)}$$

To construct a sequence of long-term inflation expectation structural shocks, $\hat{\varepsilon}_k^{\pi_l^e}$, to offset the responses of long-term inflation expectations to 1% of oil price shocks for *k* periods means to solve a sequence of shocks so that $\Psi_2^k = 0, k \in N$. It requires:

$$e_2\zeta + e_2 \widetilde{A_0}^{-1} e_2' \hat{\varepsilon}_0^{\pi_l^e} = 0.$$

It means $\hat{\varepsilon}_0^{\pi_l^e} = -\frac{e_2\zeta}{e_2 \widetilde{A_0}^{-1} e_2'}$. The rest of the sequence can be calculated recursively through:

$$\hat{\varepsilon}_0^{\pi_l^e} = \frac{-\Psi_2^k - \sum_{n=0}^{k-1} e_2 \Lambda^n \tilde{A}_0^{-1} e_2' \hat{\varepsilon}_n^{\pi^e}}{e_2 \tilde{A}_0^{-1} e_2'}, k \in \mathrm{N}\,.$$

The counter-factual impulse response function for all variables to 1% of oil price shocks with long-term inflation expectations held fixed, $\hat{\Psi}_j^k$, can be computed as:

$$\hat{\Psi}_j^k = \Psi_j^k + \sum_{n=0}^{k-1} e_j \Lambda^n \tilde{A}_0^{-1} e_2' \hat{\varepsilon}_n^{\pi^e}, j = \{1,2,\ldots,7\}.$$

Appendix 3

To decompose the impulse responses of the discount rate to the dynamics triggered by oil price shocks, Equation (1) is first rearranged in the following form,

$$A_0 y_t = \sum_{i=1}^{p} A_i y_{t-i} + \varepsilon_t,$$

$$y_t = C y_t + A_1 y_{t-1} + \cdots + A_p y_{t-p} + \varepsilon_t,$$

where C is a F×F dimensional lower triangular matrix with zeros on the diagonal, and F denotes the number of structure variables in the system.
Define

$$\mathrm{B} \equiv [\mathrm{C}\ A_1\ \ldots A_p].$$

The contribution of variable *i* to the response of the discount rate at horizon *k* to 1% of oil price shocks is given by:

$$d_{discount\ rate,i,k} = \sum_{m=0}^{\min(p,k)} B_{7,mF+i}\theta_{i,1,k-m}, \qquad k = 0,1,\ldots;\mathrm{i} = 1,\ldots,\mathrm{F},$$

where $\theta_{i,1,k-m}$ refers to the (i,2) element of the F×F impulse response coefficient matrix at horizon *k-m*, denoted by Θ_{k-m}, as defined by Lutkepohl (2005).

Table A1
Data Source and Data Handling

Name	Explanation	Source	Data Handling
Oil prices	Brent oil price in US$	Datastream	1
Long-term inflation E	average of 10-year ahead expectations of consumer price index (CPI) inflation rate survey	Datastream (provided by Consensus Forecasts)	3
Short-term inflation E	mean of the 1-year ahead expectation of CPI inflation rate survey	Datastream (provided by Consensus Forecasts)	2
Headline inflation	year-on-year monthly CPI inflation rate	DGBAS, Executive Yuan	0
Core inflation	year-on-year monthly core inflation index rate (excluding fresh vegetable, fruit, and energy prices)	DGBAS, Executive Yuan	0
Output	detrended Coincident indicator	DGBAS, Executive Yuan	1
NEER	nominal effective exchange rate (broad index, year 2010=100)	BIS	1
Discount rate	key policy rate	CBC	0
M2	monetary aggregate (operating target)	CBC	1
Overnight rate	interbank overnight rate	CBC	0

To be continued…

Table A1
Data Source and Data Handling

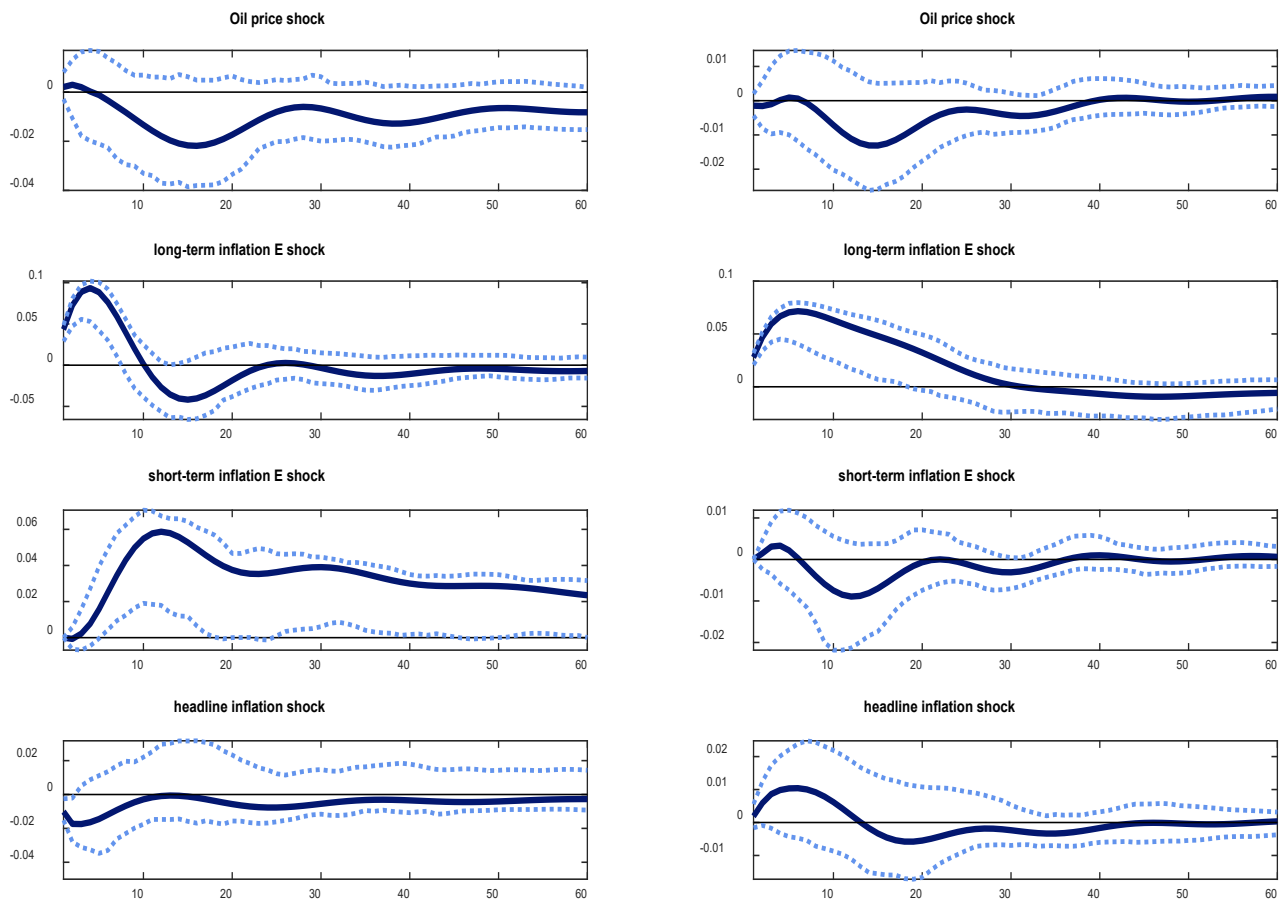
Data Handling Index	Explanation
0	No change
1	First difference of natural log
2	Following Davis (2014), a simple weighted extrapolation to combine the inflation expectations over two calendar years into one measure of 1-year ahead inflation expectations is used.
3	$\pi^e_{t,l} = \frac{1}{10}\sum_{i=1}^{10} \pi^e_{t+i}$, where π^e_{t+i} is the expectation of year $t+i$ inflation rate The data is available in semi-annual frequency before 2014 and becomes quarterly frequency hereafter. Linear extrapolation is used to transfer the data as monthly frequency.

Table A2
Unit Root Test

Variable	ADF Test Statistics
Oil price	-16.87***
Long-term inflation E	-2.79***
Short-term inflation E	-2.21**
Headline inflation	-4.4***
Output	-3.02***
NEER	-13.47***
Discount rate	-3.84***
M2	-8***
Overnight rate	-2.53**

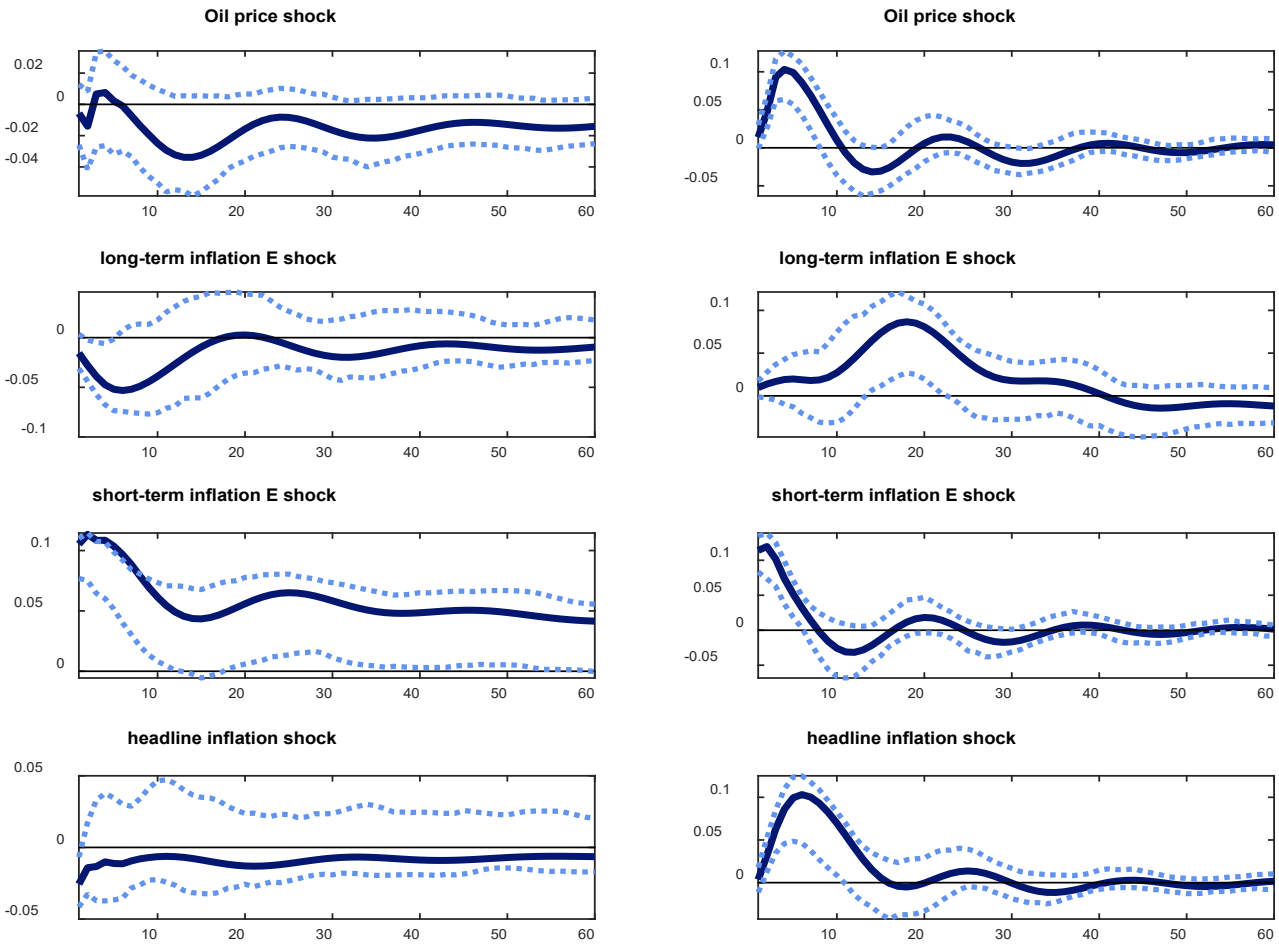
"*", "**", and "***" denote p-value<0.1, p-value<0.05, and p-value<0.01, respectively.

Figure A1.1.1
Impulse Responses of Long-term Inflation Expectations to Various Structure Shocks under SVAR 2 Setting



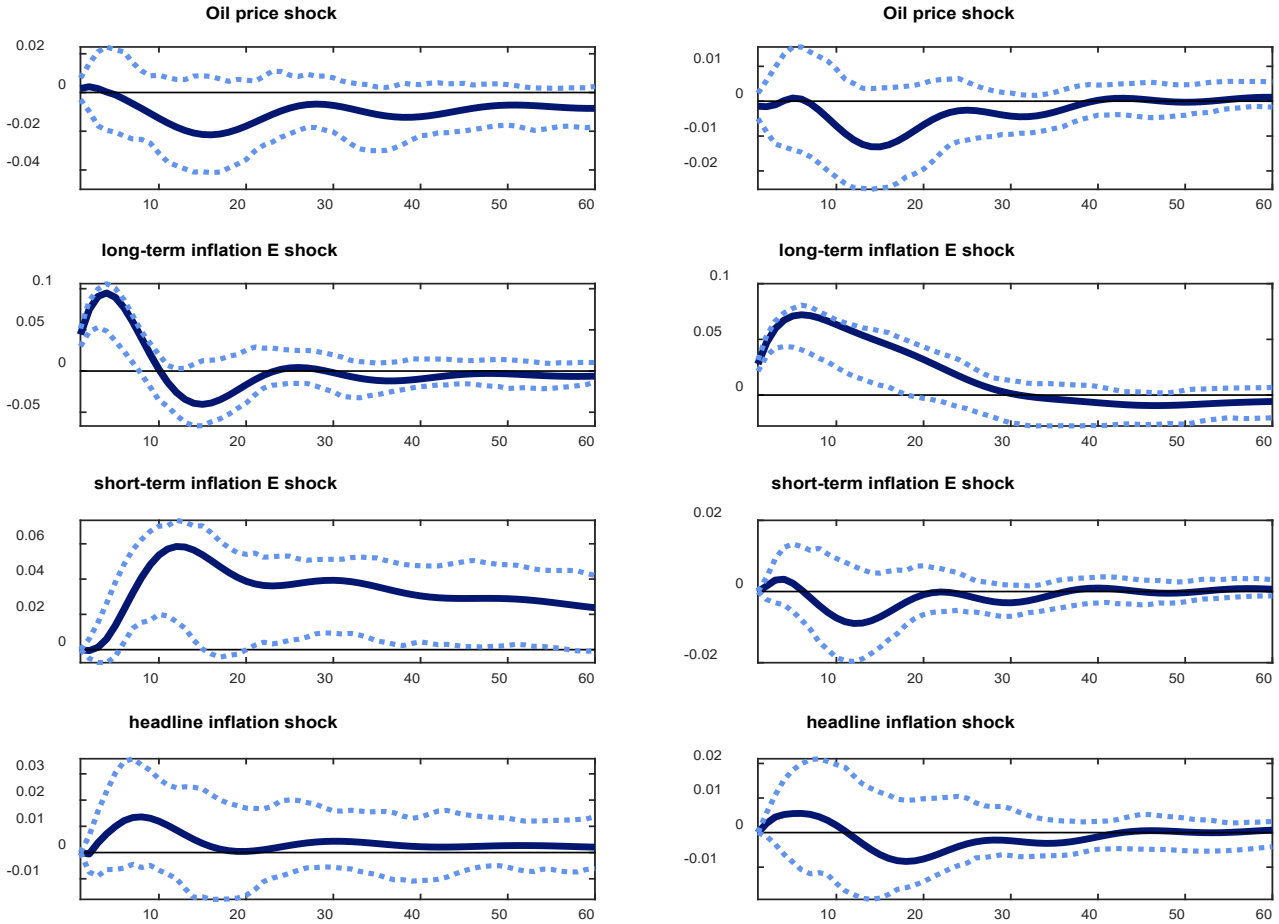
The left and right panels represent the results for the first and the second sub-samples, respectively.

Figure A1.1.2
Impulse Responses of Short-term Inflation Expectations to Various Structural Shocks under SVAR 2 Setting



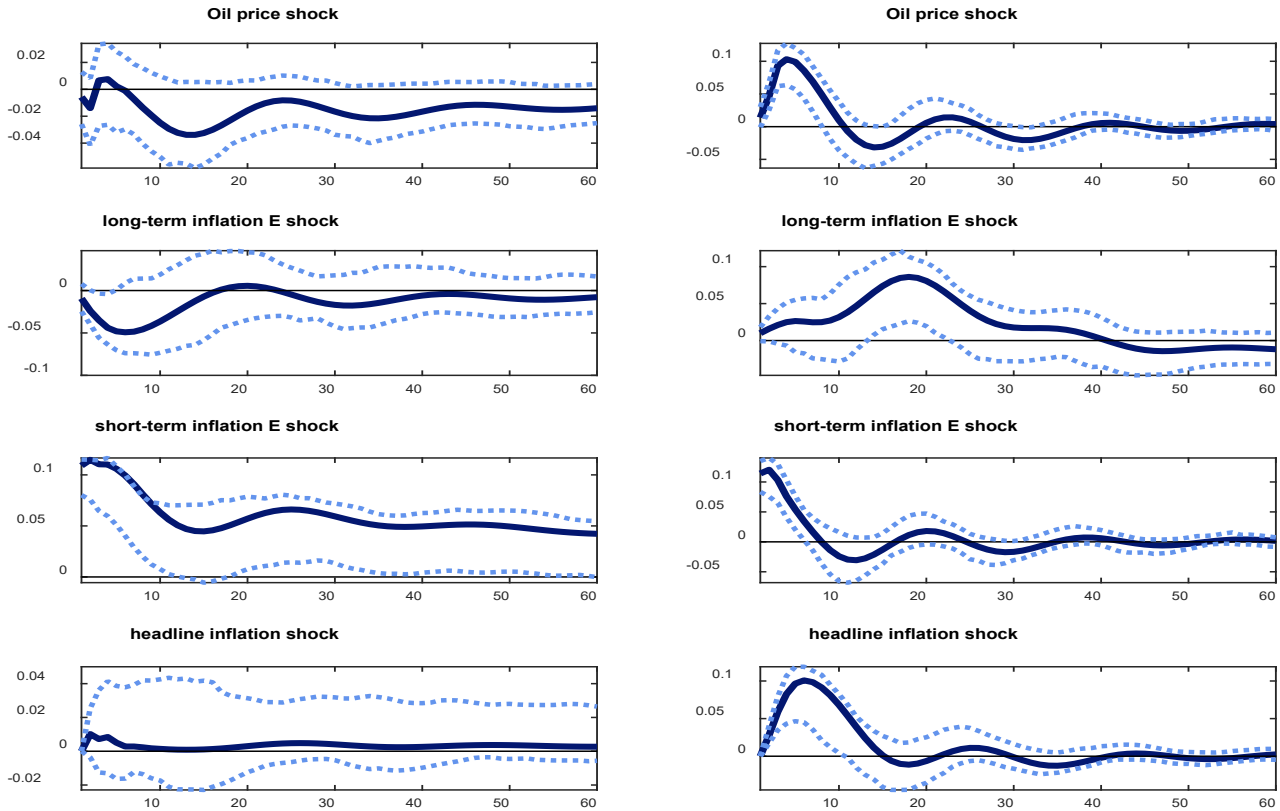
The left and right panels represent the results for the first and the second sub-samples, respectively.

Figure A1.2.1
Impulse Responses of Long-term Inflation Expectations to Various Structural Shocks under SVAR 3 Setting



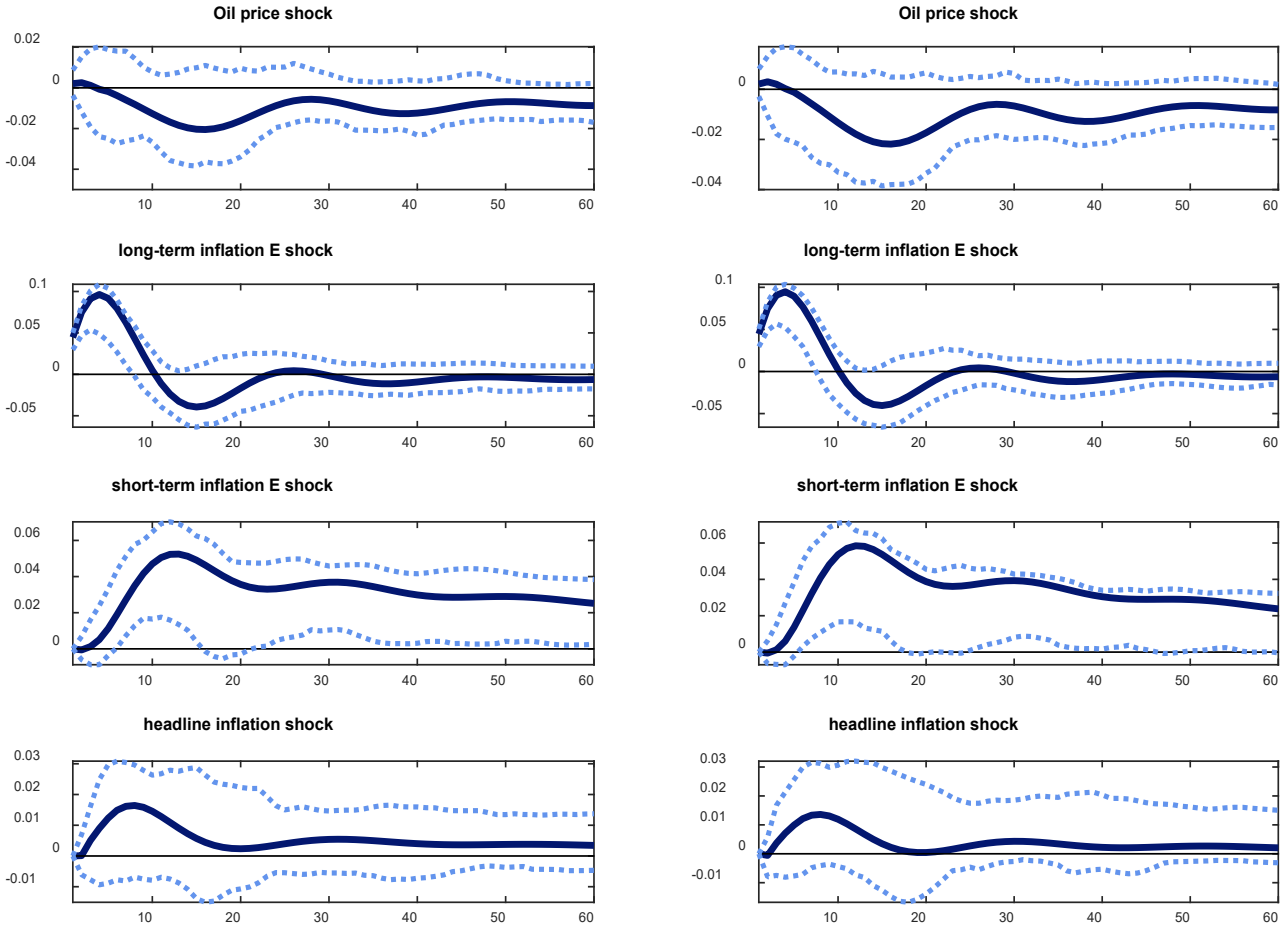
The left and right panels represent the results for the first and the second sub-samples, respectively.

Figure A1.2.2
Impulse Responses of Short-term Inflation Expectations to Various Structural Shocks under SVAR 3 Setting



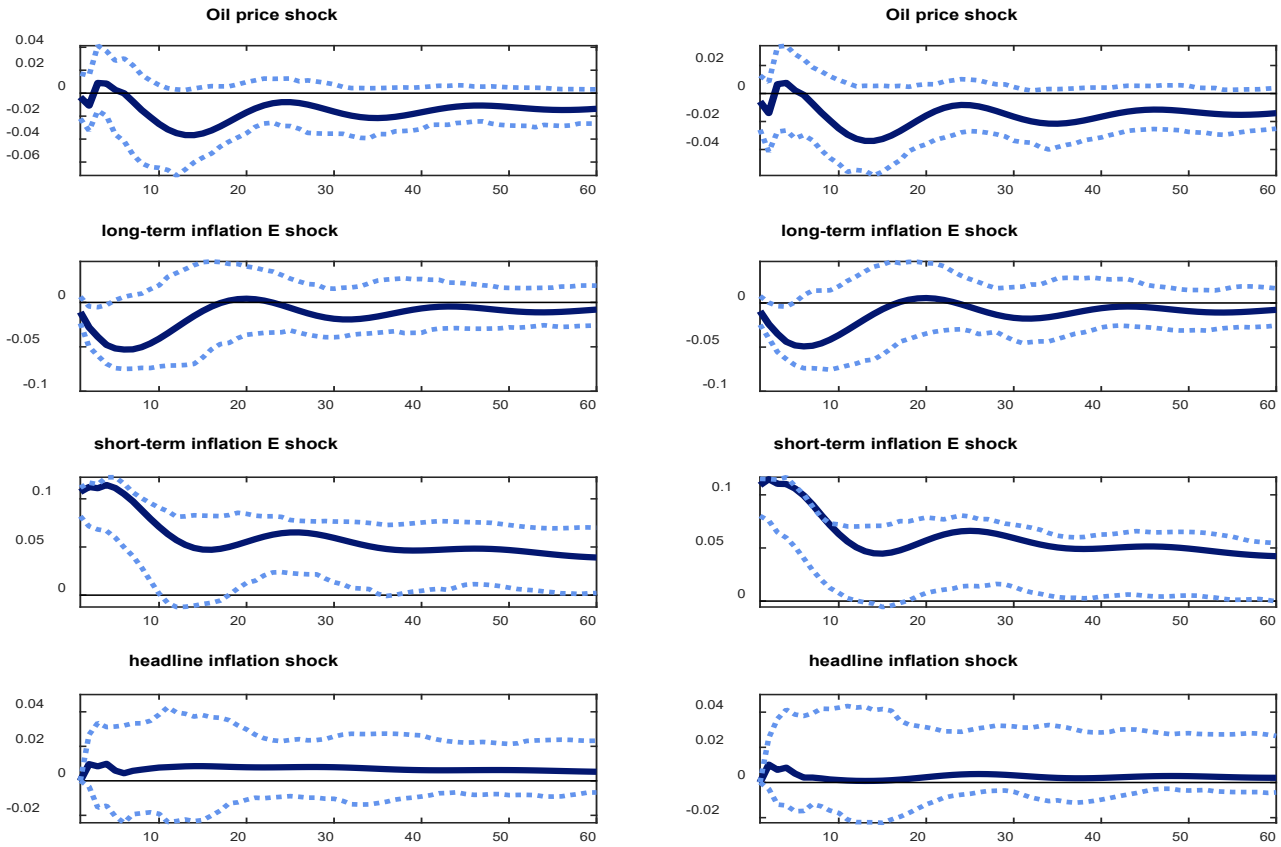
The left and right panels represent the results for the first and the second sub-samples, respectively.

Figure A1.3.1
Impulse Responses of Long-term Inflation Expectations to Various Structural Shocks in the First Sub-sample under SVAR 4 and SVAR 1 Settings



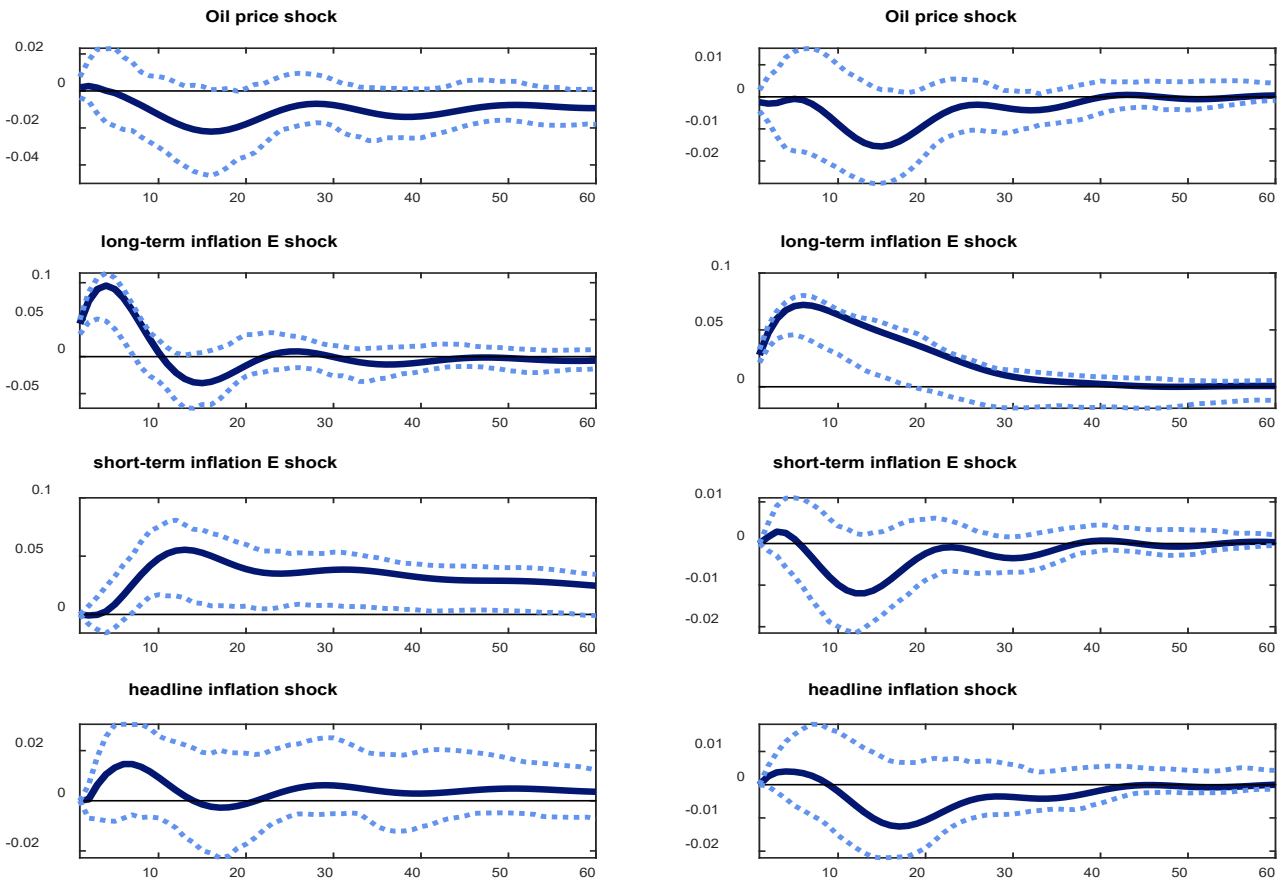
The left and right panels represent the results for the SVAR 4 and SVAR 1 settings, respectively.

Figure A1.3.2
Impulse Responses of Short-term Inflation Expectations to Various Structural Shocks in the First Sub-sample under SVAR 4 and SVAR 1 Settings



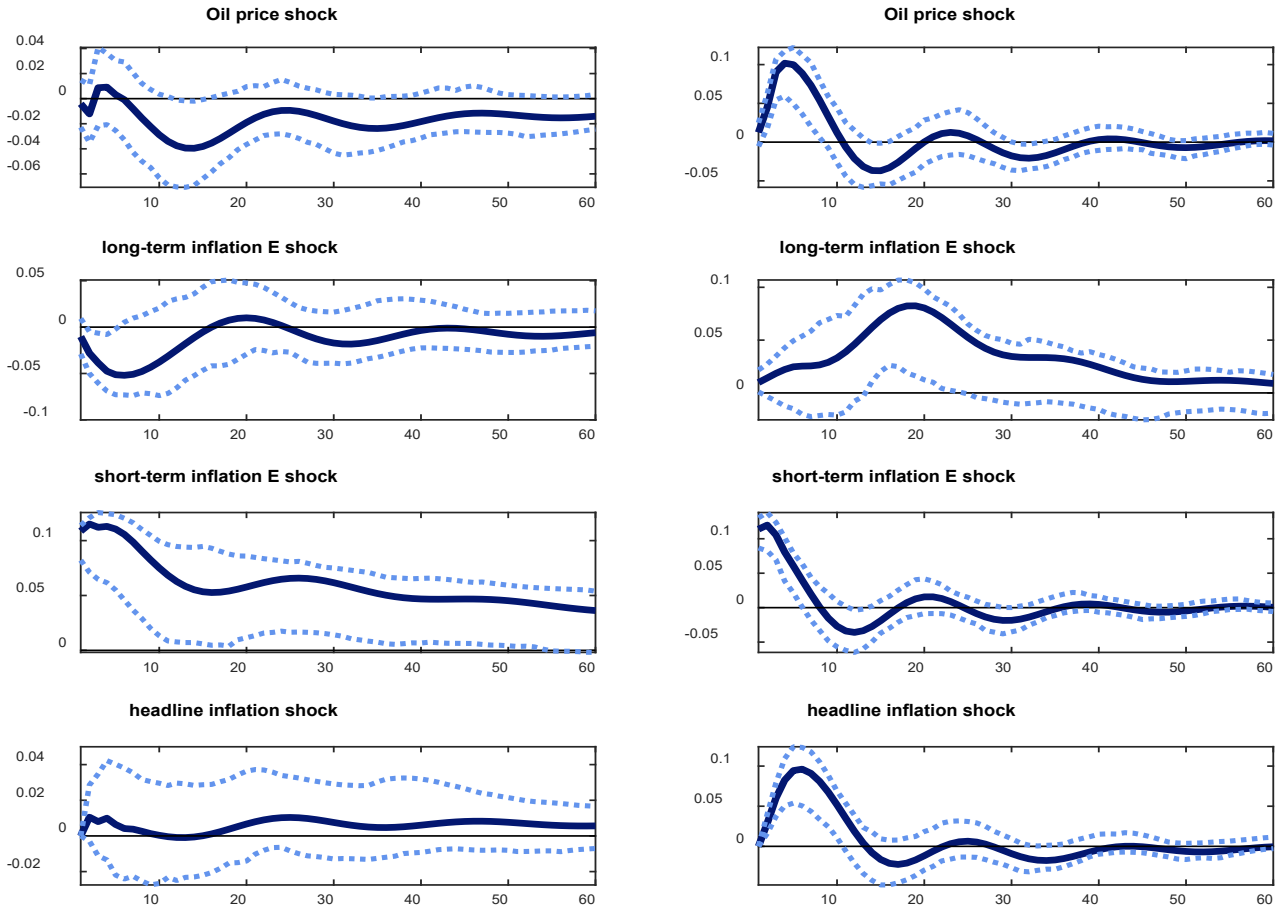
The left and right panels represent the results for the SVAR 4 and SVAR 1 settings, respectively.

Figure A1.4.1
Impulse Responses of Long-term Inflation Expectations to Various Structural Shocks under SVAR 5 Setting



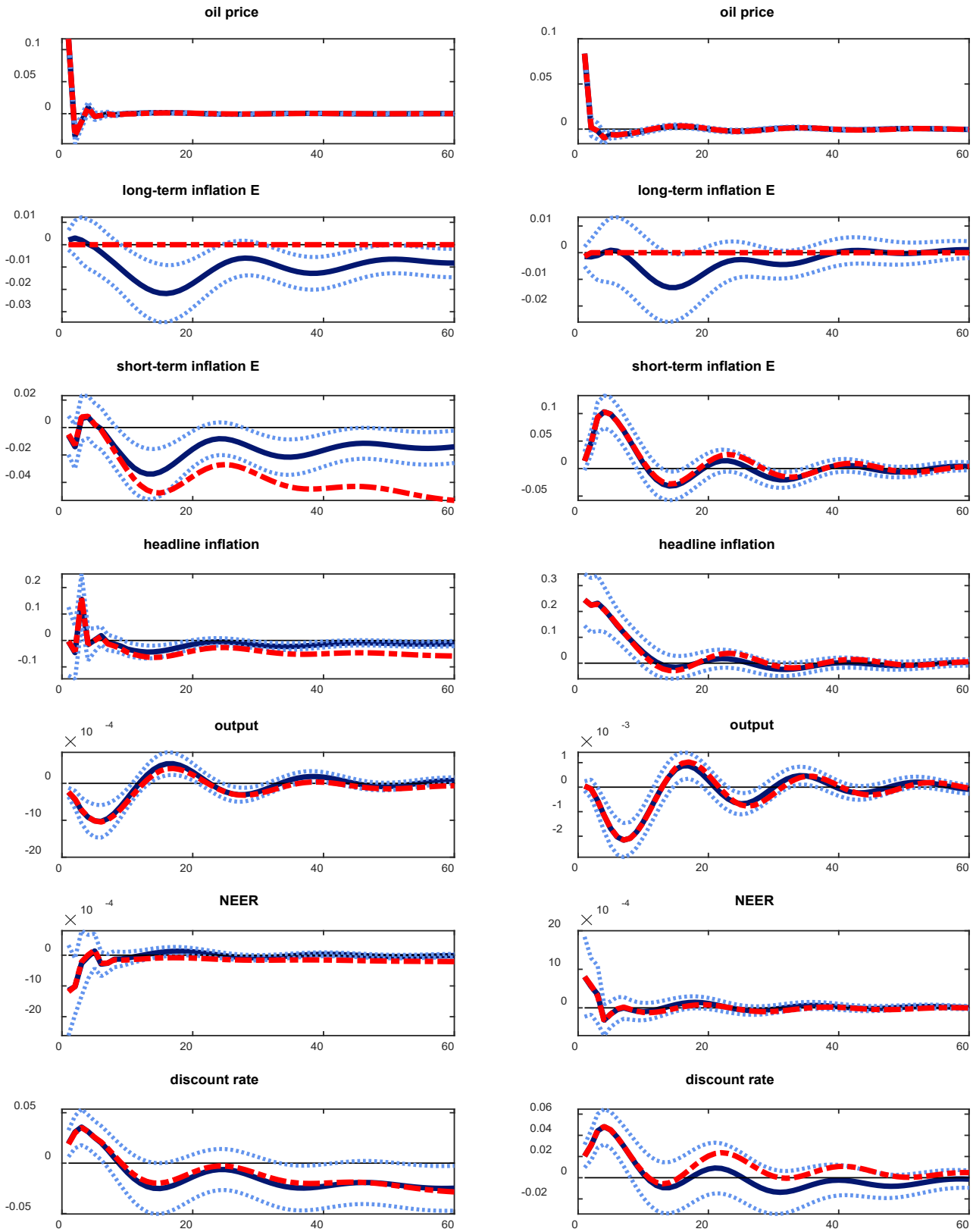
The left and right panels represent the results for the first and the second sub-samples, respectively.

Figure A1.2.1
Impulse Responses of Short-term Inflation Expectations to Various Structural Shocks under SVAR 5 Setting



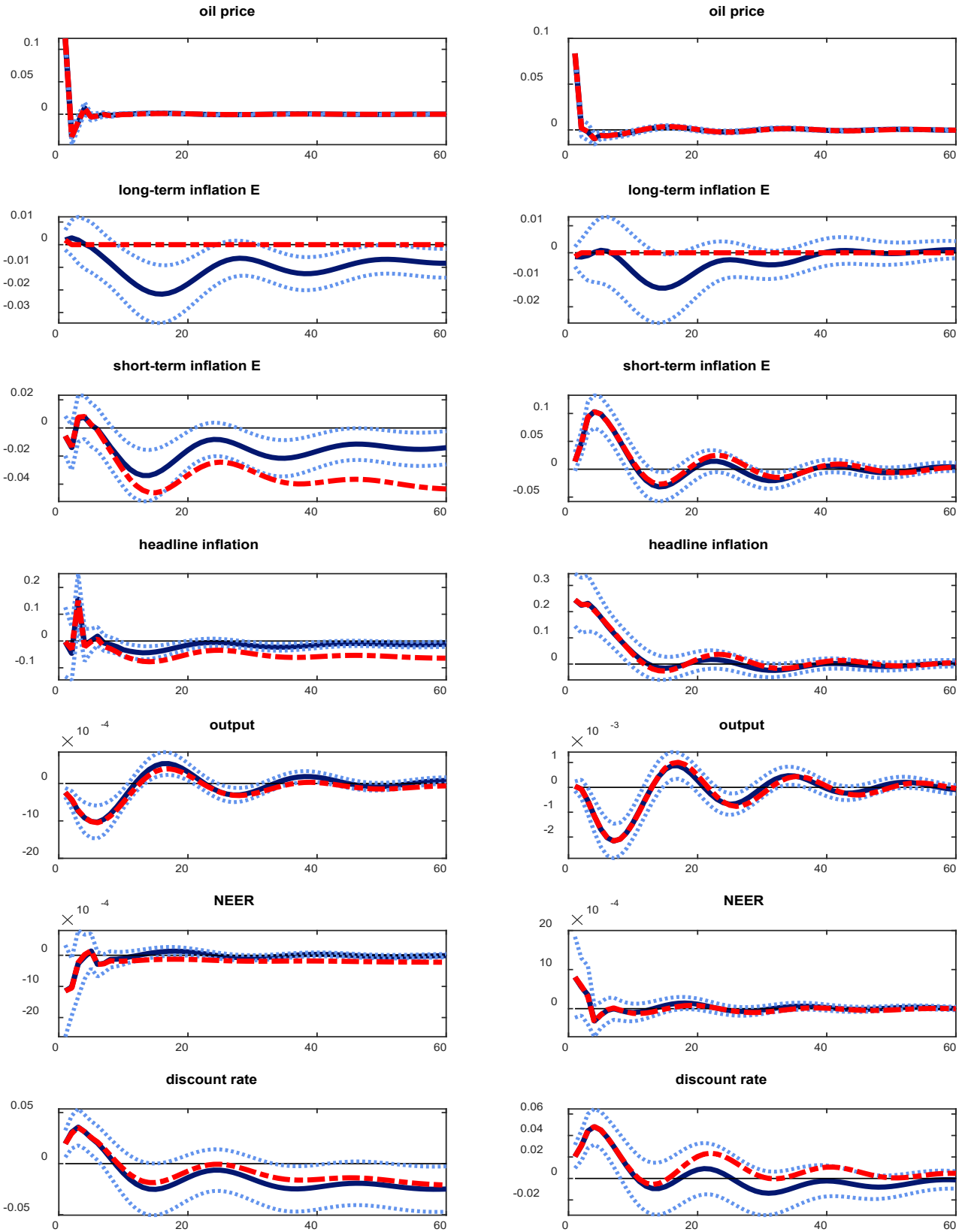
The left and right panels represent the results for the first and the second sub-samples, respectively.

Figure A2.1
The Counter-factual Impulse Responses to 1% of Oil Price Shocks under SVAR 2 Setting



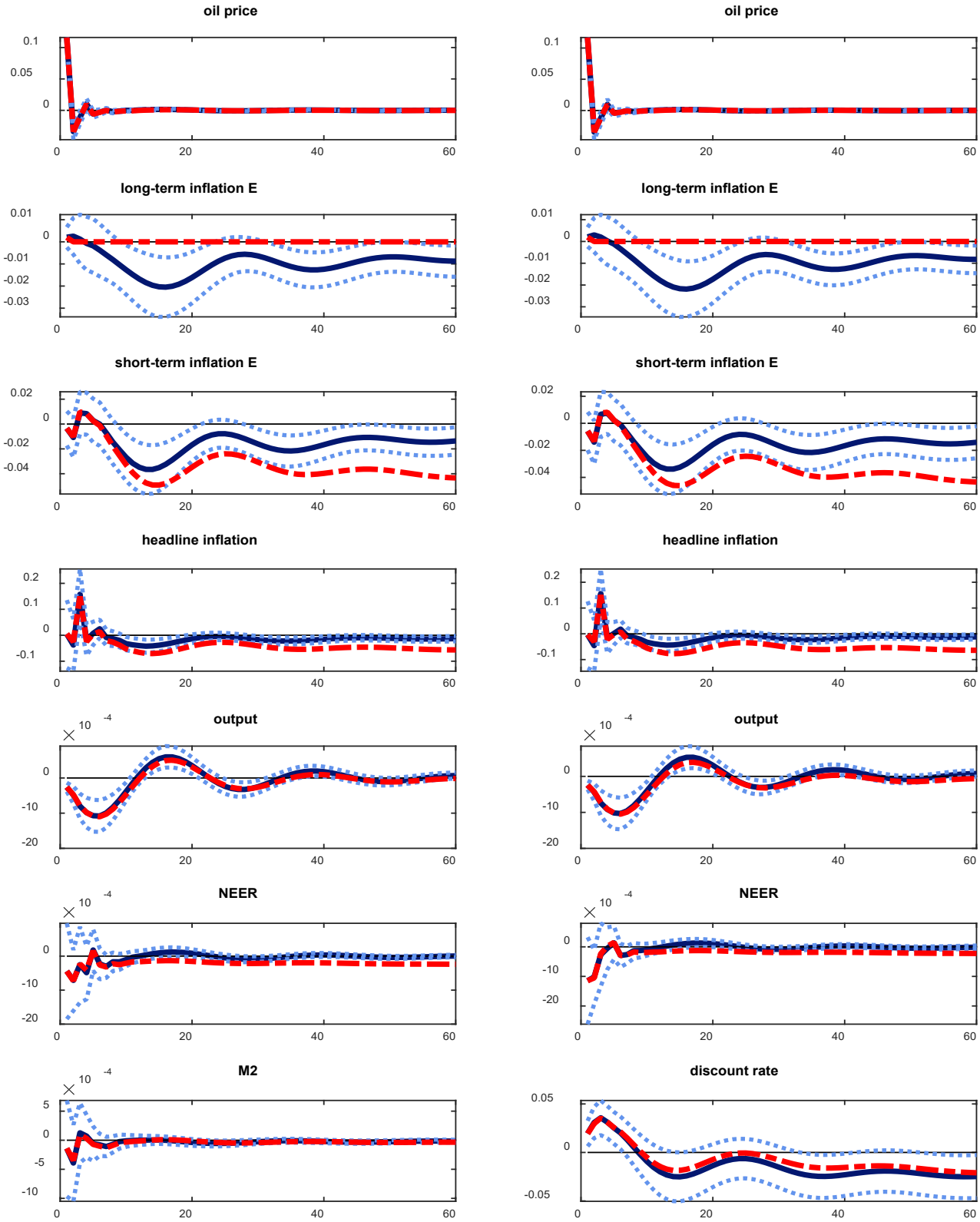
The counter-factual impulse responses are conducted by the shutdown of the responses of long-term inflation expectations. The left and right panels represent the results for the first and the second sub-samples, respectively.

Figure A2.2
The Counter-factual Impulse Responses to 1% of Oil Price Shocks under SVAR 3 Setting



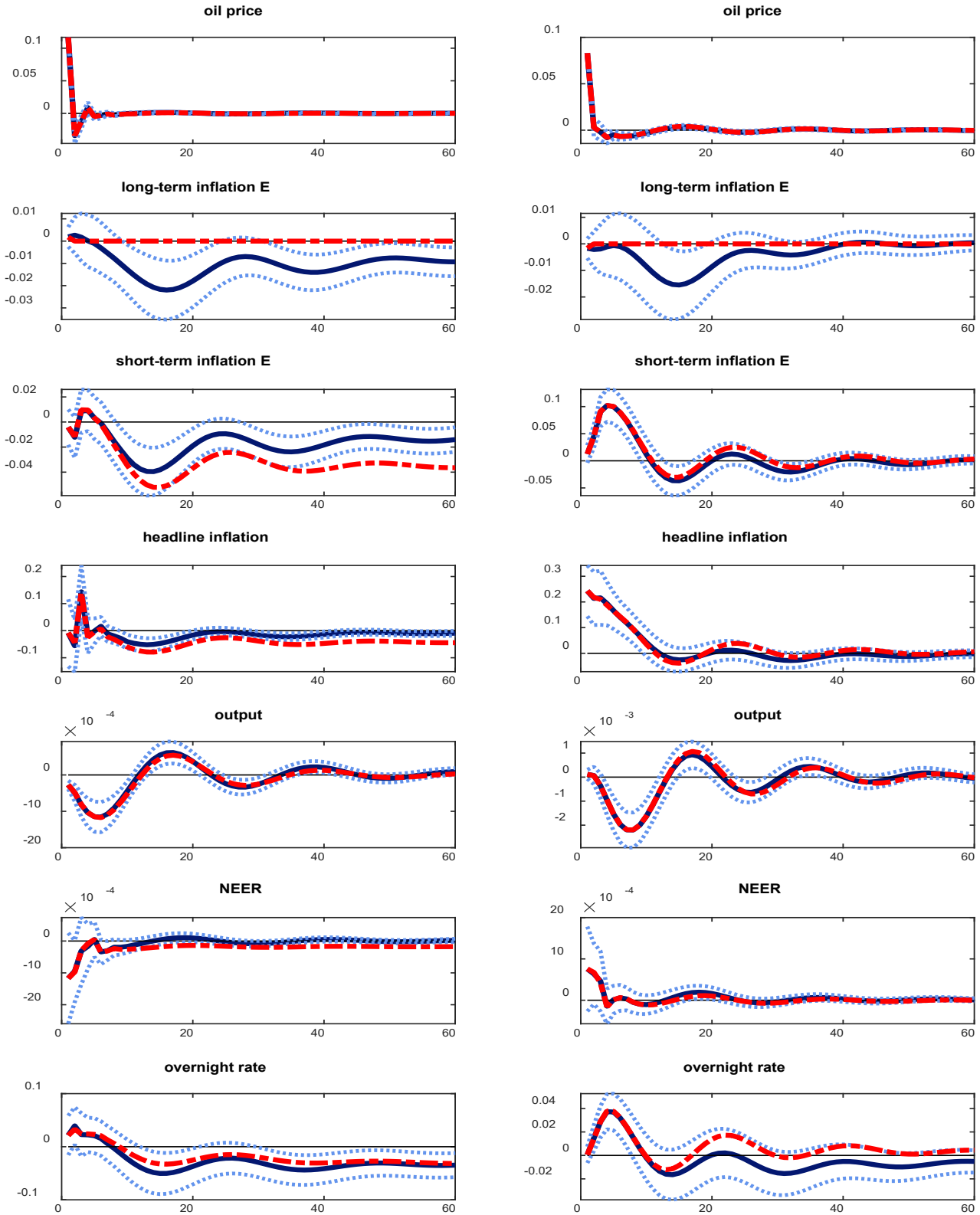
The counter-factual impulse responses are conducted by the shutdown of the responses of long-term inflation expectations. The left and right panels represent the results for the first and the second sub-samples, respectively.

Figure A2.3
The Counter-factual Impulse Responses to 1% of Oil Price Shock in the First Sub-sample under SVAR 4 and SVAR 1 Settings



The counter-factual impulse responses are conducted by the shutdown of the responses of long-term inflation expectations. The left and right panels represent the results for the SVAR 4 and SVAR 1 settings, respectively.

Figure A2.4
The Counter-factual Impulse Responses to 1% Oil Price Shocks in the First Sub-sample under SVAR 5 Settings



The counter-factual impulse responses are conducted by the shutdown of the responses of long-term inflation expectations. The left and right panels represent the results for the first and the second sub-samples, respectively.

Chapter 11

THE ROLE OF GLOBAL FOOD AND OIL PRICES ON THAILAND'S INFLATION AND MONETARY POLICY

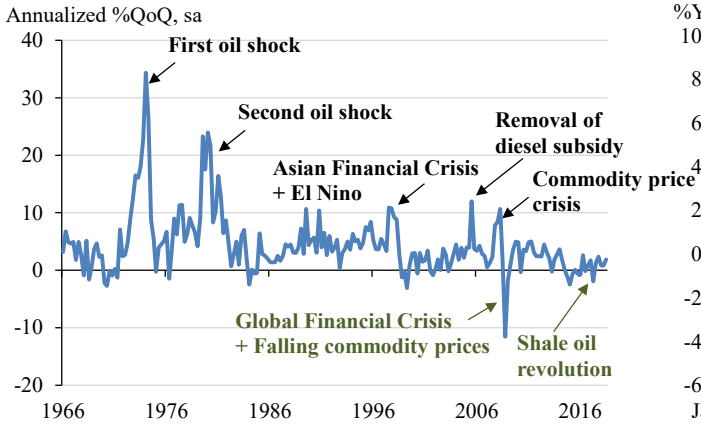
By

Nuwat Nookhwun and Warinthip Worasak[1;2]

1. Introduction

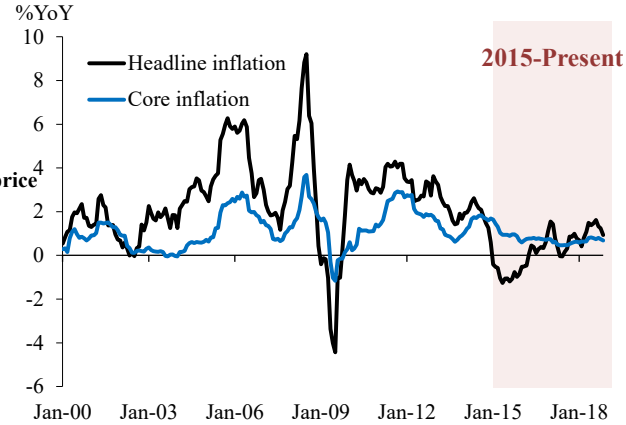
Commodity price dynamics have been important sources of macroeconomic fluctuations for over decades. In retrospect, two oil crises emerged during 1970s and triggered global economic stagflation, characterised by high inflation and unemployment rates. Although commodity prices were less volatile since then, they were once again on a constantly rising trend during 2000s. Both global oil and food prices peaked in 2008, causing high inflation worldwide amidst global economic downturn. The situation has, however, reversed over the past decade, with both commodity prices in the down-cycle. Global inflation has, thus, declined and stood at a low level, posing concern over monetary policy normalisation. Thailand's inflation is without exception. Commodity price developments have played a crucial role in Thailand's inflation dynamics. Figure 1 depicts quarter-on-quarter changes in the consumer price index, where many extreme inflation movements are found to be associated with periods of high volatility in commodity prices. In response to recent declines in global oil prices, headline inflation fell sharply at the end of 2014 and has been low since then (Figure 2). Thai fresh food inflation over the past 4-5 years is also lower than its historical average, raising doubts over the extent such a decline is induced by falling global food prices.

Figure 1
Thailand's Headline Inflation (1966-2561Q3)



Source: IMF

Figure 2
Thailand's Headline and Core Inflation



Source: Ministry of Commerce and calculated by BoT

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2. The authors would like thank project managers, Peter Tillmann and David Finck, participants at the SEACEN Research Seminar on "Price Setting Behaviour and Inflation Dynamics in SEACEN Member Economies and their Implications for Inflation," and Surach Tanboon for their helpful comments.

Since price stability is the overriding objective of monetary policy, inflation volatility triggered by commodity price changes has posed challenges to policymakers. In particular, to the extent that such changes have persistent effects on inflation and hence have a second-round impact on inflation expectations, monetary policy may have to respond to anchor inflation expectations and avoid any wage-price spiral that once occurred in 1970s. The Bank of Thailand (BoT), therefore, constantly monitors developments and dynamics of commodity prices, among various macroeconomic indicators, in order to cater appropriate policy decisions. This paper aims to benefit monetary policymaking by studying the roles of global food and oil prices in driving Thailand's inflation. The authors focus on three main research questions: First, what is the impact of changes in global food and oil prices on Thailand's inflation? Second, do those changes matter for underlying (trend) inflation pressure? Last, what are their implications on monetary policy?

The analysis on the impact of commodity prices on domestic inflation has garnered more attention after the global commodity crisis during late 2000s. Most researches were conducted in a multi-country setting including a large number of advanced and emerging economies. Furceri et al. (2015), for example, studied the effects of global food prices and found that, for advanced countries, 10-percentage-point increases in global food inflation raised domestic inflation by 0.5 percentage points. However, they reported that the impact could be much larger for emerging economies, partly owing to the higher food share in the CPI basket and less-anchored inflation expectations. Meanwhile, Choi et al. (2017) found that domestic inflation rose by 0.4% following 1% increases in global oil prices. The authors also documented that positive oil price shocks had a larger effect on inflation than negative ones. Such an impact asymmetry is another area to be explored in this study of Thailand.

A few articles hypothesised that structural characteristics of each country mattered for the magnitude of the impact. Choi et al. (2017) found that the share of transport in the CPI basket and energy subsidies could help explain cross-country variations in the effects of oil price shocks. Meanwhile, Gelos and Ustyugova (2012) explicitly studied the factors influencing dispersion in inflation responses to commodity price shocks. They found that food shares in the CPI basket, fuel intensities, and pre-existing inflation levels were behind such dispersion. This has, therefore, raised a question of where Thailand stands in terms of the commodity price pass-through. Most studies including Blanchard and Gali (2007), nevertheless, documented the decline in the pass-through over time, due in part to a better conduct of monetary policy.

To the knowledge of the authors, Jongwanich and Park (2011) is the only paper that focuses exclusively on the role of global oil and food price shocks on inflation in the case of "developing Asia". They, however, concluded that the magnitude of the pass-through is small, citing a role played by subsidies and price controls in alleviating the impact.[3] In the case of Thailand alone, Manopimoke and Direkudomsak (2015) examined how the process of globalisation has altered Thai inflation dynamics since 1990s. They found that, since 2001, Thai inflation has become increasingly dependent on the global factors, particularly world oil prices. Furthermore, the recent paper by Limjaroenrat et al. (2018) showed that food and energy prices combined could explain approximately 70 percent of relative price changes at business cycle frequencies.

3. The pass-through estimated in this paper is indeed comparable to that from Jongwanich and Park (2011). However, the authors view that they are economically important, given high volatility of global commodity prices.

To shed light on the three research questions outlined above, the authors rely on two approaches. First, they adopt the local projection method following Jorda (2005) to quantify the sensitivity of Thailand's headline and core inflation to global oil and food price changes. The method was previously employed by Choi et al. (2017) and Furceri et al. (2015) to study the role of commodity prices in a panel comprising a large number of countries. As in the literature, the authors are also interested in whether the impact is asymmetric and non-linear, and whether the pass-through has changed over time. Their findings suggest that both oil and food price changes have statistically significant and economically important, though short-lived, effects on headline inflation. Food price changes, in particular, seem to have a larger and more long-lasting impact, perhaps due to a high share of food in the CPI basket. However, core inflation is barely affected, suggesting limited second-round effects on inflation expectations and labour wages. With regard to impact asymmetry and non-linearity, they find that negative changes tend to have a larger impact on headline inflation than positive changes. The result underscores the importance of government measures as well as firms' price-setting behaviour in a high-competition environment. Large changes, meanwhile, are found to have bigger consequences on inflation than small changes, highlighting the existence of adjustment costs. Additionally, compared to the past, the impact of both commodity price changes is smaller and less persistent. This may be partly attributed to greater commitment of monetary policy towards price stability.

Second, the authors follow the trend-cycle approach of Forbes et al. (2017), by disentangling trend and cyclical components from headline inflation, and then examining whether changes in global food and oil price matter to any of them. To extent that these movements affect trend inflation, there will be important implications on monetary policy. In order to extract trend inflation, they rely on a Multivariate Unobserved Component Stochastic Volatility model following Stock and Watson (2016) and Manopimoke and Limjaroenrat (2017). They find that oil and food price growth are a significant driver of both permanent and transient components of Thailand's headline inflation. In other words, their changes may affect trend inflation or have persistent effects on actual inflation. Their changes are also found to explain larger variation in inflation, compared to other standard macroeconomic variables. A puzzle arises, since the earlier finding from the local projection method points out that changes in commodity prices do have merely short-lived effects on Thailand's inflation. The authors explain this discrepancy by arguing that changes in commodity inflation may themselves persist, thus inducing a persistent impact on inflation. Trend growth of commodity prices is indeed time-varying and can be shown to coincide well with Thailand's trend inflation. As stated above, this finding poses important challenges to monetary policymakers. This is not limited to interest rate decisions that may need to take into account potential long-lasting effects from commodity price developments, but to the setting of the inflation target.

The rest of the paper is organised as follows. Second 2 estimates the local projections in order to quantify the sensitivity of inflation to commodity price changes. The roles of fiscal and monetary policy in alleviating the pass-through are also discussed. The trend-cycle approach is adopted in Section 3 to examine whether commodity prices can persistently affect trend inflation. It is shown how the result can be useful in understanding Thailand's low inflation dynamics. Section 4 reports policy implications, while section five concludes.

2. The Effects of Global Oil and Food Prices on Thailand's Inflation: A Local Projection Approach

2.1 Model Specification

In this section, the authors attempt to quantify the impact of changes in global oil and food prices on Thailand's inflation, relying on a local projection approach. Like a vector autoregression (VAR) model, the method allows them to trace the dynamic effects of shocks on variables of interest. Nevertheless, as argued by Jorda (2005), it is more robust to model misspecification and accommodates experimentation with non-linear specifications, which are impractical in a multivariate context. To perform local projections, the following specification is estimated:

$$\pi_{t+k} = \alpha^k + \sum_{j=1}^{l} \gamma_j^k \pi_{t-j} + \beta_k \pi_t^c + \sum_{j=1}^{k} \theta_j^k \pi_{t+j}^c + \delta_k y_{t+k} + \varepsilon_t^k, c \in \{oil, food\}. \qquad (1)$$

π_t denotes the percentage change in Thailand's headline consumer price index (CPI), while π_t^c is the percentage change in global oil or food prices[4]. For global oil prices, the authors rely on Dubai crude oil prices, since Thailand, or more generally the South East Asian countries, mainly imports crude oil from the Middle East. Dubai prices, hence, serve as a price benchmark for oil from such region. Meanwhile, a food price index compiled by the World Bank is used as a proxy for global food prices. The index covers prices of a wide variety of food commodities, such as vegetable oils, meals, grains, etc. The authors, alternatively, employ a food price index from Food and Agricultural Organisation of the United Nations (FAO) for a robustness check. To capture the persistence of inflation, lagged values of the dependent variable are included, where $l = 4$ is set. Furthermore, as in Choi et al (2017) and Teulings and Zubanov (2010), the forward leads of commodity price changes are also included in the specification to correct the bias in impulse responses inherent in the local projection method. The only controlled variable present in the equation is the output gap. This is to capture the role of domestic economic conditions in determining inflation dynamics.

The coefficient of interest is β_k, which measures the impact of changes in global oil or food prices on Thailand's inflation for each future period k. To obtain dynamic responses of inflation to each commodity price change, the authors plot estimated β_k from $k = 0$ (the date of the commodity price change) to the end of the forecast horizon. Here, $k = 6$ *is set.* 95% confidence bands for the impulse responses are computed using the Newey-West standard errors associated with the estimated coefficients. The estimation sample is from January 2000 to September 2018 (monthly frequency). The chosen sample corresponds to periods under the Inflation Targeting regime, which commenced in May 2000 and potentially caused shifts in structural parameters, especially those related to inflation dynamics.

2.2 Baseline Results

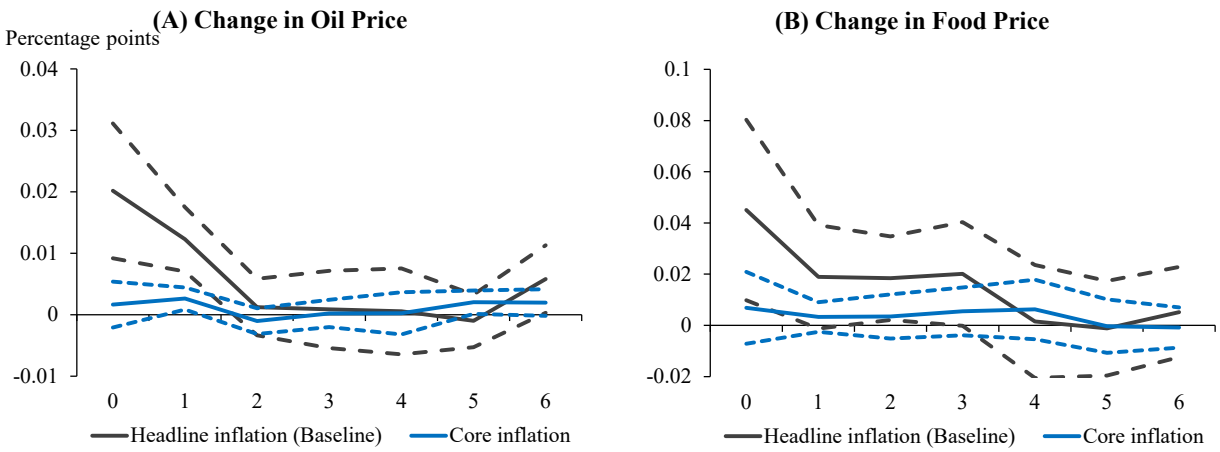
Figure 3 shows the baseline results obtained from estimating Equation (1) above. The results suggest that both global oil and food price changes have significant, but short-lived, effects on Thailand's headline inflation (black lines). For changes in oil prices, the responses of inflation are relatively instantaneous, as the impact dissipates after one month. In particular, they find that a one-percentage-point increase in Dubai oil price growth causes Thai inflation to rise by approximately 0.03 percentage point after one month. Meanwhile, the effects of a food price change appear to

4. See sources and definitions of all variables in the Appendix

be larger and last slightly longer. The estimates, in particular, are statistically significant for one quarter after a change in food prices occurs. Overall, rises in global food inflation of 1.0 percentage point will result in 0.10-percentage-point increases in headline inflation.

The larger impact from global food price movements on Thailand's inflation may reflect a huge share of food products within the CPI basket. Based on Thailand's household socio-economic survey in 2015, food products, including fresh food, processed food, non-alcoholic beverages and seasonings and condiments, account for 36% of the basket. Gasoline, on the contrary, accounts for only 7-8%. In addition, domestic retail gasoline prices are subject to several taxes and contributions to oil funds, which should help mitigate somewhat the effects of global oil price changes. Meanwhile, certain price adjustment costs encountered by domestic food producers may give rise to a more persistent impact of global food price changes. The government, moreover, allows retail oil prices to adjust promptly to any changes in ex-refinery prices.

Figure 3
The Impact of Oil and Food Price Changes on Headline and Core Inflation



Note: the figure shows the impact of 1 percentage-point change in global oil and food inflation on domestic headline inflation (black lines) and core inflation (blue lines). The dashed lines indicate 95-percent confidence bands. t=0 denotes the month in which commodity price changes occur.

To examine whether the estimated impact is economically important, standardised beta coefficients ($\beta_k \times \frac{stdev(\pi_t^c)}{stdev(\pi_t)}$) are considered. The authors compute such coefficients for 6-month cumulative responses of inflation to each commodity price change. The results suggest that a one-standard-deviation change in both commodity prices causes headline inflation to alter by approximately 0.80 standard deviations, which are considered large. It can, therefore, be concluded that changes in both global oil and food prices are economically-important determinants of Thailand's inflation. The finding is, indeed, not surprising given the high volatility of commodity prices.

The next area of interest is studying whether changes in commodity prices affect Thailand's core inflation, defined as an inflation rate for the CPI basket that excludes fresh food and energy goods. Since innovations in commodity prices likely have direct effects on prices of the two excluded components, examining their impact on core inflation enables the authors to trace any indirect effects on inflation, as well as second-round effects on public's inflation expectations and labor wages. In doing so, the dependent variable in Equation (1) is replaced with π_{t+k}^{core}, representing the

percentage change in Thailand's core CPI. The results can be found in Figure 3, which shows that only global oil price changes have a significant impact on core inflation (blue lines). The impact, nevertheless, is much smaller than that on headline inflation and occurs with a one-month lag. Meanwhile, a global food price change does not have any significant effects on core inflation. The results, hence, imply limited spillovers to prices of core goods and services. Also, they suggest that the observed impact of commodity price changes on headline inflation is mainly attributed to their direct effects on non-core (i.e. fresh food and energy) components.

2.3 Impact Asymmetry and Non-linearity

The estimation so far assumes a linear response of Thai inflation to commodity price changes. Price adjustments, however, are likely to be asymmetric and non-linear. Firms, for example, may adjust their product prices more readily when facing large and/or positive changes in the production costs. In this sub-section, the authors therefore explore whether there exist any asymmetry and non-linearity with respect to inflation responses to global oil and food price changes. They begin by examining whether positive and negative changes have heterogeneous effects on headline inflation. To do so, the explanatory variable π_t^c in Equation (1) is replaced with $\pi_t^{c,pos}$ and $\pi_t^{c,neg}$, defined as:

$$\pi_t^{c,pos} = \begin{cases} \pi_t^c \ if \ \pi_t^c > 0 \\ 0 \ otherwise \end{cases} \text{ and } \pi_t^{c,neg} = \begin{cases} \pi_t^c \ if \ \pi_t^c < 0 \\ 0 \ otherwise \end{cases}$$

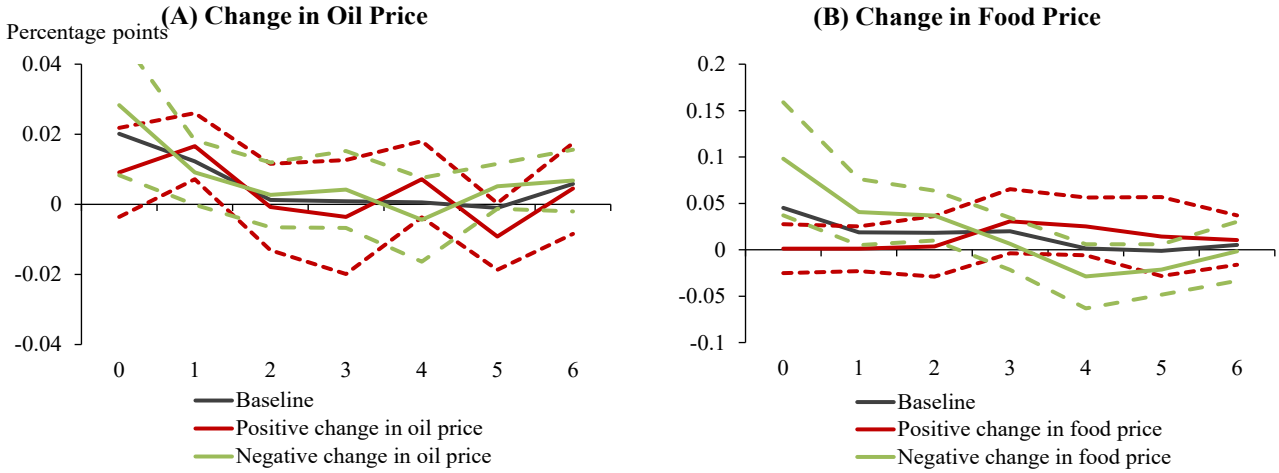
and the following specification is then obtained:

$$\pi_{t+k} = \alpha^k + \sum_{j=1}^{l} \gamma_j^k \pi_{t-j} + \beta_k^{pos} \pi_t^{c,pos} + \beta_k^{neg} \pi_t^{c,neg} + \sum_{j=1}^{k} \theta_j^k \pi_{t+j}^c + \delta_k y_{t+k} + \varepsilon_t^k, \quad c \in \{oil, food\}. \tag{2}$$

The estimated coefficients β_k^{pos} and β_k^{neg} show the effects of positive and negative changes, respectively.

The results, shown in Figure 4, illustrate that negative global oil and food price changes tend to have a disproportionately larger impact on Thailand's headline inflation, particularly for food price changes. In the face of negative changes in global food prices, headline inflation declines by as large as 0.18 percentage point after one quarter, whereas there is a small, delayed and insignificant impact from positive changes. For global oil price changes, there are also slightly larger, and more immediate, effects from decreasing, compared to increasing, oil prices. But, the cumulative pass-through after one month for both positive and negative changes is relatively similar. These results may seem in the first place to contradict intuition, since firms should be more eager to raise, than to lower, prices in response to changing production costs so as to pass the burden to consumers. Meanwhile, when the production costs fall, firms may have incentive to retain product prices to reap greater profits. Nevertheless, since markets for oil and fresh food are highly-competitive, firms may instead become more reluctant to increase prices in order to avoid losing their market share, explaining smaller inflation responses to positive changes in commodity prices. In addition, with an aim of mitigating higher costs of living, the government may take action to reduce the impact from rising prices. The roles of the government will be discussed further in Sub-section 2.6.

Figure 4
The Impact of Oil and Food Price Changes on Headline Inflation: Positive vs. Negative Changes



Note: the figure shows the impact of 1 percentage-point change in global oil and food inflation on domestic headline inflation. The red and green lines present the responses to positive and negative changes, respectively. The dashed lines indicate 95-percent confidence bands. t=0 denotes the month in which commodity price changes occur.

Apart from the impact asymmetry, the effects of commodity price changes may also be non-linear. As firms could face a menu cost while re-optimising their product prices, large changes in commodity prices should have bigger consequences on inflation than small ones. This hypothesis is examined by replacing the explanatory variable π_t^c in Equation (1) with $\pi_t^{c,large}$ and $\pi_t^{c,small}$, defined as:

$$\pi_t^{c,large} = \begin{cases} \pi_t^c \ if \ |\pi_t^c| > stdev(\pi_t^c) \\ 0 \ otherwise \end{cases} \text{ and } \pi_t^{c,small} = \begin{cases} \pi_t^c \ if \ |\pi_t^c| < stdev(\pi_t^c) \\ 0 \ otherwise \end{cases}$$

and the following specification is then obtained:

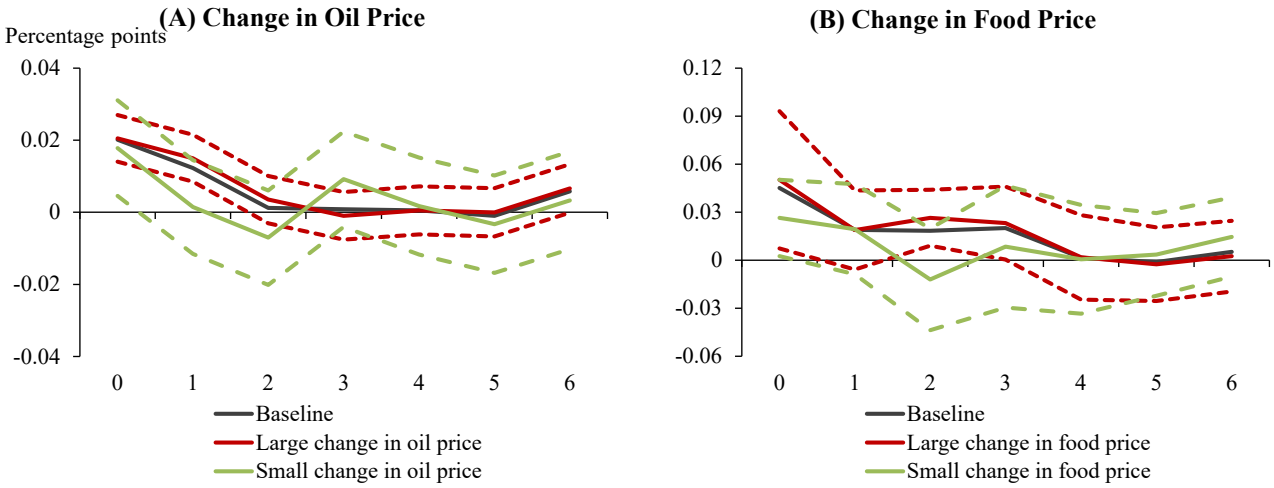
$$\pi_{t+k} = \alpha^k + \sum_{j=1}^{l} \gamma_j^k \pi_{t-j} + \beta_k^{large} \pi_t^{c,large} + \beta_k^{small} \pi_t^{c,small} + \sum_{j=1}^{k} \theta_j^k \pi_{t+j}^c + \delta_k y_{t+k} + \varepsilon_t^k, c \in \{oil, food\}. \quad (3)$$

The estimated coefficients β_k^{large} and β_k^{small} show the effects of large and small commodity price changes, respectively.

Figure 5 shows that inflation responses to commodity price changes clearly feature non-linearity. The impulse responses based on large changes, indeed, resemble the baseline results. Nevertheless, for both global food and oil price changes, the responses to small price movements are statistically significant only in the period of the shock. The estimated pass-through also reduces to 0.04 and 0.02, respectively. The findings, therefore, confirm the existence of menu costs. If small changes occur, firms likely choose to adjust their margins, rather than product prices, and absorb gains and losses by themselves[5].

5. This paper also examines whether there is heterogeneity in the responses to large positive and large negative commodity price changes. The results are shown in Figure 18 in the Appendix. For changes in both oil and food prices, the effects of large negative (positive) changes are similar to the responses to negative (positive) changes shown in Figure 4.

Figure 5
The Impact of Oil and Food Price Changes on Headline Inflation: Large vs. Small Changes



Note: the figure shows the impact of 1 percentage-point change in global oil and food inflation on domestic headline inflation. The red and green lines present the responses to large and small changes, respectively. The dashed lines indicate 95-percent confidence bands. t=0 denotes the month in which commodity price changes occur. Large (small) changes are defined as changes in oil and food prices larger (smaller) than one standard deviation from their mean.

Last, it is hypothesised that the effects of commodity price changes may be conditional upon the prevailing level of commodity prices (p_t^c). Such hypothesis is examined by replacing the explanatory variable π_t^c in Equation (1) with $\pi_t^{c,high}$ and $\pi_t^{c,low}$, defined as:

$$\pi_t^{c,high} = \begin{cases} \pi_t^c \ if \ p_t^c > avg(p_t^c) \\ 0 \ otherwise \end{cases} \text{ and } \pi_t^{c,low} = \begin{cases} \pi_t^c \ if \ p_t^c < avg(p_t^c) \\ 0 \ otherwise \end{cases},$$

and the following specification is then obtained:

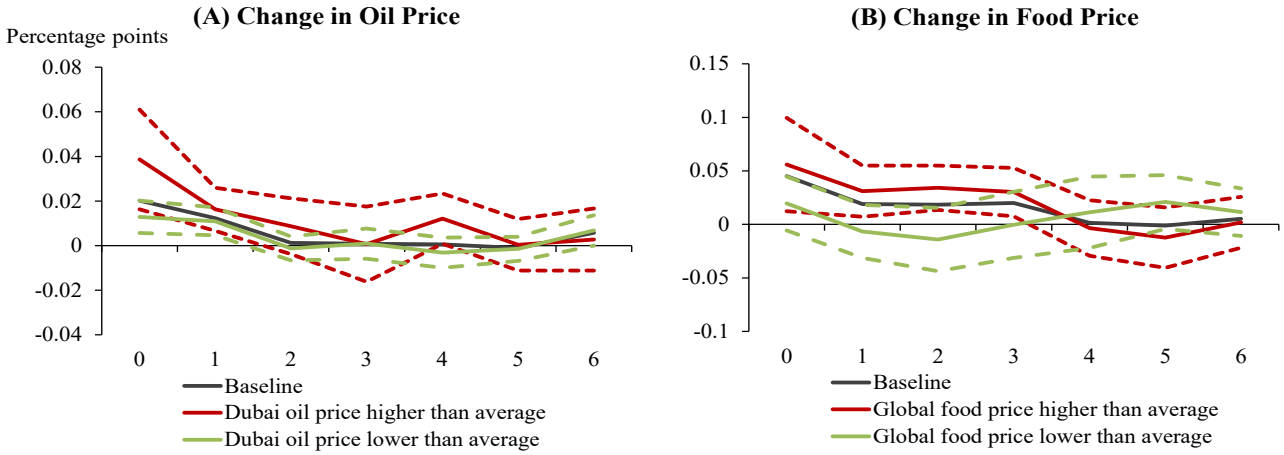
$$\pi_{t+k} = \alpha^k + \sum_{j=1}^{l} \gamma_j^k \pi_{t-j} + \beta_k^{high} \pi_t^{c,high} + \beta_k^{low} \pi_t^{c,low} + \sum_{j=1}^{k} \theta_j^k \pi_{t+j}^c + \delta_k y_{t+k} + \varepsilon_t^k, c \in \{oil, food\} \quad . (4)$$

The estimated coefficients β_k^{high} and β_k^{low} show the effects of commodity price changes when the prevailing level of commodity prices is high and low, respectively. As shown above, commodity prices are considered high (low) when they are above (below) their mean. The finding is shown in Figure 6, where we find that, when Dubai oil prices are at a high level, inflation responses to oil price changes are significantly larger. Their estimated cumulative impact after one month is as high as 0.05, much larger than the baseline results. Impulse responses in the event of low Dubai oil prices are, on the other hand, slightly below the baseline estimates. The explanation for such a finding is that, when global oil prices increase, the content of ex-refinery prices within retail gasoline prices becomes larger, rendering the latter more sensitive to innovations in global oil prices[6]. Likewise, the inflation responses to global food price changes are larger than the baseline

6. The structure of domestic retail gasoline prices includes the ex-refinery prices, excise taxes, municipality taxes, contributions to oil funds and energy conservation promotion funds, marketing margin and VAT.

estimates when global food prices prevail at a high level. In contrast, when they are low, the responses of Thai inflation are found to be insignificant. These results are useful in understanding Thailand's on-going inflation movements. Given that both commodity prices are currently at the down-cycle, any of their changes will not have much influence on Thai headline inflation, thereby explaining the current subdued inflationary pressure.

Figure 6
The Impact of Oil and Food Price Changes on Headline Inflation, Conditional on the Level of Corresponding Commodity Prices



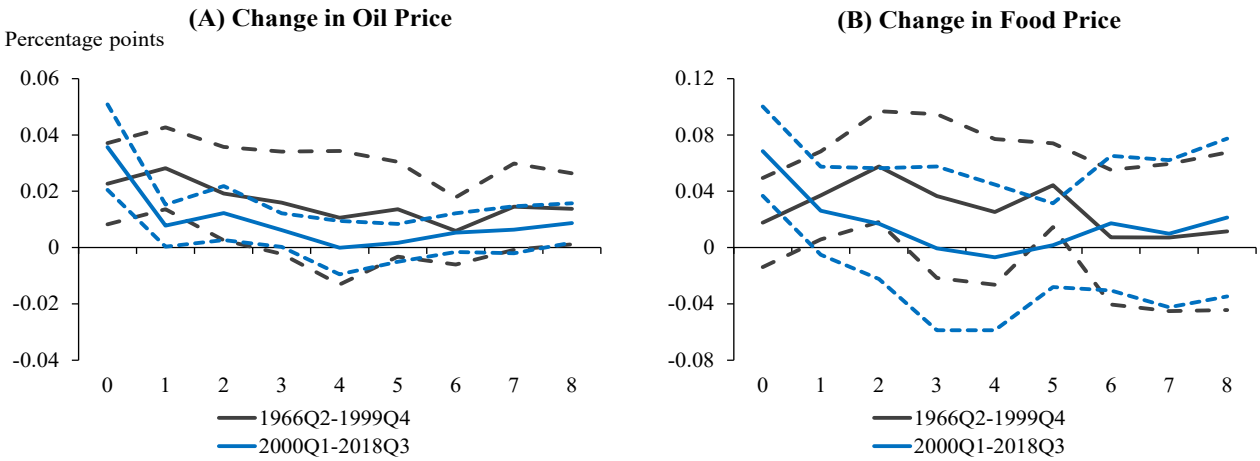
Note: the figure shows the impact of 1 percentage-point change in global oil and food inflation on domestic headline inflation when the corresponding commodity prices are higher (red lines) and lower (green lines) than their average. The dashed lines indicate 95 percent confidence bands. t=0 denotes the month in which commodity price changes occur.

2.4 How Has the Pass-through Changed Over Time?

Another question of interest is whether the pass-through of commodity price changes to Thailand's inflation has declined over time, as widely-documented in the literature. The authors strive to answer the question by estimating Equation (1) for both pre-2000 (from 1966 to 1999) and post-2000 periods. The pre-2000 sample should cover the two oil crises that brought about heightened oil prices and, hence, high global inflation. Given limited data availability, the quarterly data is used for both samples. The impulse responses are reported for $k = 0$ to $k = 8$.

Figure 7 compares the impulse responses between the two periods. In the face of global oil price changes, the inflation responses are found to be larger and more persistent for pre-2000 samples. The cumulative impact of oil price changes after eight quarters is approximately 0.14, much larger than the post-2000 estimate. Responses of Thai inflation to global food price changes, meanwhile, are also found to be statistically significant and more persistent, despite some delay, for pre-2000 samples. The results, therefore, are supportive of the notion of more persistent inflation prior to 1990s, the periods when monetary policy does put much emphasis on price stability. For Thailand, the adoption of an Inflation Targeting regime, which makes explicit the central bank's inflation target, may help explain a more muted response to oil and food price shocks after 2000.

Figure 7
The Impact of Oil and Food Price Changes on Headline Inflation: 1966Q2-1999Q4 vs. 2000Q1-2018Q3



Note: the figure shows the impact of 1 percentage-point change in global oil and food inflation on domestic headline inflation. The black and blue lines present the responses estimated from the sample 1966Q2-1999Q4 and 2000Q1-2018Q3, respectively. The dashed lines indicate 95-percent confidence bands. t=0 denotes the quarter in which commodity price changes occur.

The impact asymmetry and non-linearity are also examined for the responses of core inflation. The results are shown in Figures 19 and 20 in the Appendix. The authors find that only positive changes in global oil prices have statistically significant effects on core inflation at 5% significant level. Meanwhile, for global food price changes, although the authors do not find any significant effects on core inflation in our baseline linear estimates, their negative changes are found to have a significant impact. However, the pass-through from both commodity prices remains low. Now, turning to the results with respect to the impact non-linearity, like with the baseline estimates, the authors do not find any material effects of global food price changes on core inflation for either small and large changes. Meanwhile, only large changes on Dubai oil prices significantly affect core inflation with a one-period lag, though the magnitude of the effects is small. All in all, the impact of commodity prices on core inflation is, once again, found to be limited.

2.5 Robustness Checks

In this Sub-section, a few checks are performed to ensure that the baseline results are robust. First, since both global oil and food prices are found to be an important driver of Thailand's inflation, the authors are aware of the possibility that they are highly collinear, thus causing an endogeneity problem on the parameter estimates. As a result, to address the issue, they are incorporated into the equation simultaneously. The following specification is thus estimated:

$$\pi_{t+k} = \alpha^k + \sum_{j=1}^{l} \gamma_j^k \pi_{t-j} + \beta_k^{oil} \pi_t^{oil} + \sum_{j=1}^{k} \theta_j^{k,oil} \pi_{t+j}^{oil} + \beta_k^{food} \pi_t^{food} + \sum_{j=1}^{k} \theta_j^{k,food} \pi_{t+j}^{food} + \delta_k y_{t+k} + \varepsilon_t^k. \quad (5)$$

As shown in Figure 21 in the Appendix, it is that, after controlling for global food price developments, the impact of global oil price changes to Thai inflation does not alter, thus confirming that the baseline results are robust. However, the inflation responses to global food price changes are clearly smaller than the baseline estimates. In particular, the responses remain statistically significant, but only in the period of the shock, while the cumulative effects after one quarter are reduced to 0.05. The baseline estimate, therefore, needs to be viewed with caution.

Second, the potential outliers in the estimation are taken care of, by excluding observations with headline inflation or commodity price changes greater than two standard deviations from their corresponding average. As in the previous robustness check, the responses of Thai inflation to global food price changes alter from the baseline estimates (Figure 22). Again, such changes do not have any lagged effects on headline inflation, while the magnitude of the impact also declines. Changes in global oil prices, meanwhile, significantly affect Thai inflation both contemporaneously and with a one-period lag. The magnitude of the impact, nonetheless, falls to some extent. Last, the authors attempt an alternative measure of a global food price index, which is obtained from FAO. The results shown in Figure 23 suggest that the baseline estimates are fairly robust. In particular, the estimated coefficients are close to those from the baseline regression. The fact that the lagged responses to food price changes appear insignificant is merely driven by the estimated standard errors that become slightly larger.

2.6 Policies to Alleviate the Impact of Commodity Prices

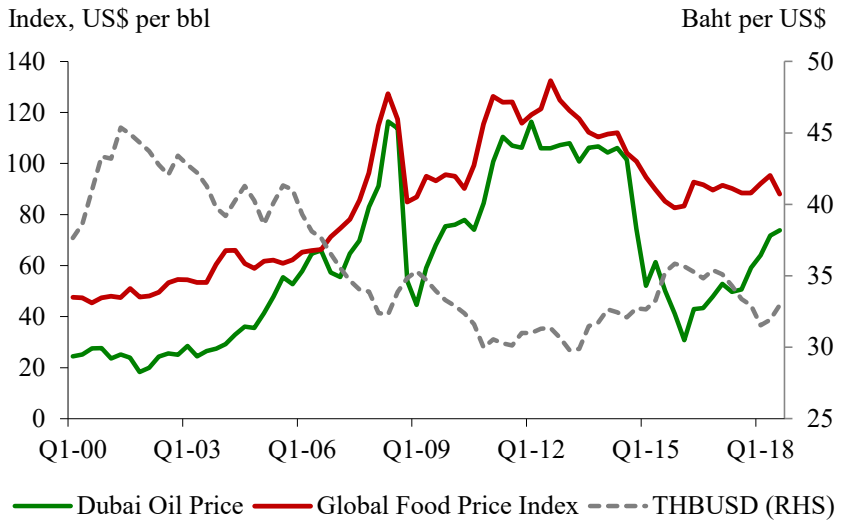
The findings above suggest that both global oil and food prices significantly affect and explain a substantial variation of Thailand's headline inflation. Thai inflation, therefore, tends to exhibit excessive volatility particularly in the short run, which in turn matters for households' costs of living and, in some occasions, price stability. In this Sub-section, the role of government policies, both monetary and fiscal, in alleviating the impact of commodity price changes, is discussed. Without these policies in place, the inflation rates could be even more volatile and complicate decisions of both households and firms.

The first in line is monetary policy, given its mandate in achieving monetary stability and sustainable economic growth. After the adoption of an Inflation Targeting regime in May 2000, the BoT has placed price stability as an overriding objective of monetary policy. Since then, Thailand's inflation rates have substantially declined and shown lower volatility, while public's inflation expectations are well-anchored. Except in the recent periods, inflation has been most of the time within the central bank's announced target. Monetary policy stands ready to offset any shocks that cause inflation to persistently deviate from target, including those triggered by commodity price developments. Such circumstances have made Thailand's inflation less persistent than in the past (Figure 7). Furthermore, changes in commodity prices are found to have limited consequences on core inflation, reflecting the low second-round effects on inflation expectations (Figure 3). All these observations underscore the merits of having price stability and hence well-anchored inflation expectations.

The behaviour of exchange rates could be another factor that helps cushion the impact of global oil and food price changes on Thailand's inflation. Advocates of the flexible exchange rate regime have underlined the role of exchange rates as an absorber to external shocks (Friedman, 1953). That is, when a commodity price increases, an exchange rate tends to appreciate, which

should help lower costs of importing commodities and thus reduce inflationary pressure. For Thailand, the BoT abandoned a fixed exchange rate and adopted a managed-float regime in 1997. The subsequent switch towards an Inflation Targeting framework, which entails monetary policy independence, accommodates such exchange rate flexibility. Under such a regime, the BoT intervenes in the foreign exchange market only when exchange rate movements are excessively volatile. The value of the baht, hence, is mostly determined by the market mechanism. Therefore, exchange rates may play a potential role in lessening the impact of external shocks for the Thai economy. Figure 8 graphs the movements of Thai baht against US$ along with global food and oil prices. It can be seen that exchange rates potentially act as a shock absorber. That is, whenever oil and food prices rise, the baht tends to appreciate against US$. The cointegration analysis (results are available upon request) suggests that 1% increases in commodity prices are coincided with a 0.2% baht appreciation. Regardless of what induce the cointegration between commodity prices and an exchange rate, such a relationship implies that, without such strengthening, Thailand's headline inflation may rise to an even larger extent than suggested by the baseline estimate.

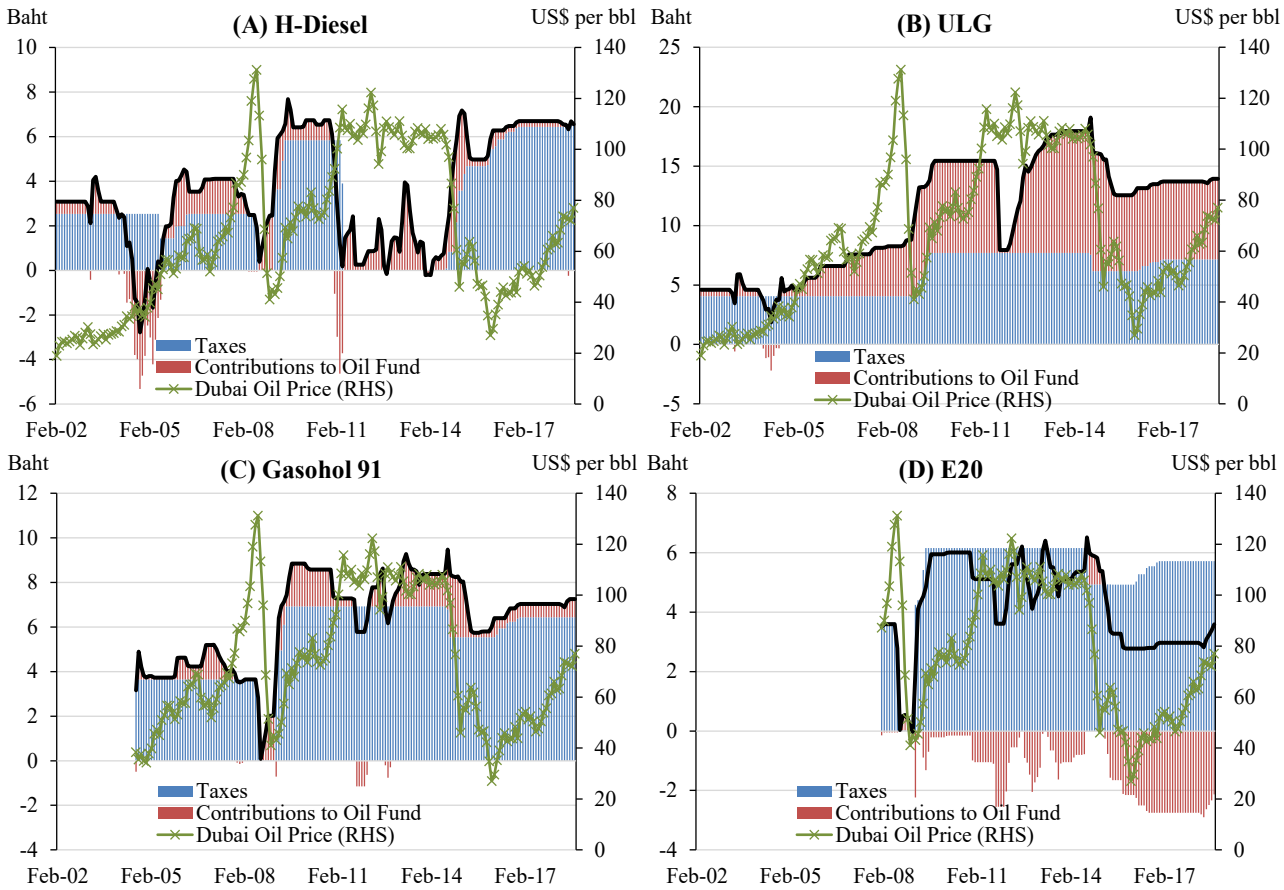
Figure 8
Global Commodity Prices and the Baht Exchange Rate



Source: World Bank, Bloomberg, Energy Policy and Planning Office and BoT

Apart from monetary policy and exchange rates, the government also plays an important role in countering shocks to commodity prices, especially those to crude oil prices. Considering the structure of domestic retail gasoline prices, it contains excise taxes and contributions to oil funds, which serve as the degree of freedom that the government can exploit in stabilising retail prices. In some occasions, normally when Dubai oil prices climb up to a certain level, contributions to oil funds even become negative, implying that the government is subsidising retail prices. Figure 9 shows developments of taxes and oil fund contributions for selected types of petroleum: H-diesel, ULG, Gasohol 91 and E20, all of which have a high share of consumption in Thailand. The Figure clearly illustrates the role of taxes and oil fund contributions in cushioning the impact of rising oil prices during 2008, when daily Dubai oil prices reached US$145 per barrel. Except for ULG, both taxes and contributions were cut immensely for other petroleum. It is also observed that both were raised significantly after global oil prices had fallen at the end of the same year.

Figure 9
Taxes and Contributions to Oil Fund For Selected Petroleum



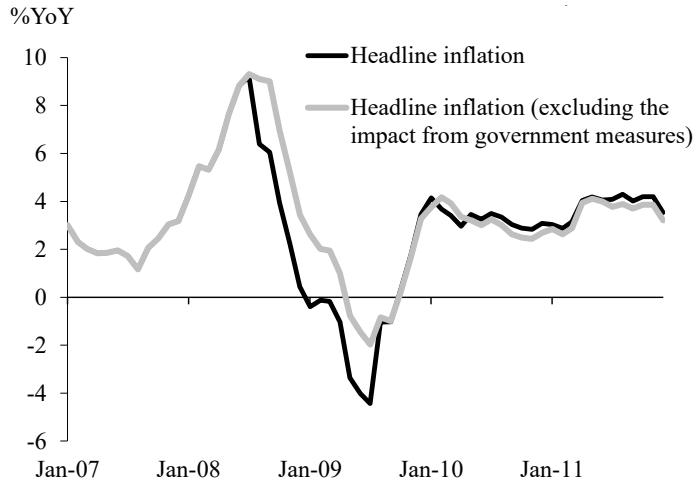
Note: H-Diesel denotes high speed diesel. ULG is Unleaded premium gasoline. while E20 is Gasoline with Ethanol 20% by volume.
Source: Energy Policy and Planning Office, and Bloomberg

Nevertheless, in other periods, there seems to be a mixed relationship between taxes and oil fund contributions, and Dubai oil prices. For H-diesel, their correlation is clearly negative. That is, taxes and contributions tend to fall as global oil prices increase. Retail diesel prices are, thus, stabilised. During 2011-2014, for example, when Dubai oil prices were higher than US$100 per barrel, all the taxes were lifted. Diesel prices were, indeed, held fixed in certain periods. This is achieved by daily adjustments of oil fund contributions. Over the recent periods (October 2018), as Dubai oil prices are approaching US$80 per barrel, the government stepped in to stabilise diesel prices by cutting oil fund contributions and eventually introducing subsidies. A diesel price ceiling of 30 baht per liter was announced at that time. Such active government intervention towards diesel prices is not surprising, as diesel is mostly used by low-income households and industries. On the contrary, global oil prices tend to move positively with taxes and contributions imposed on ULG, Gasohol 91 and E20. This might be explained by a tendency of the government to nullify any changes in taxes and oil fund contributions collected from diesel usage. Net effects of such government intervention on retail gasoline prices are left for further researches.

The episode of 2008 highlighted the role of government measures in stabilising shocks to global oil and food prices. Over the periods leading up to 2008, both commodity prices were on a rising trend, driven by a wide range of factors. Commodity prices then peaked during the midst of 2008, causing inflation to rise and the central bank to hike policy interest rates globally. Households, therefore, encountered economic hardship in terms of heightened costs of living. Consequently, the

Thai government introduced several measures to alleviate such rising living costs, which comprised cutting oil excise tax rates aforementioned, preventing a rise in household LPG prices, subsidising electricity and water fees, and free fares for third-class trains and buses. Figure 10 shows the extent these measures helped in softening Thailand's headline inflation. In particular, headline inflation is purged of any impact from government policies. It can be seen that, without those policies, inflation could be higher by around two to three percentage points from mid-2008 to mid-2009. Although inflation was on the decline over such periods, those measures were critical in mitigating the high level of living costs.

Figure 10
Headline Inflation (Excluding the Impact from Government Measures)



Note: An inflation measure that excludes the impact from government measures is one of the underlying inflation indicators constructed and monitored by the Bank of Thailand.
Source: Ministry of Commerce and BoT

3. Effects of Global Oil and Food Prices on Thailand's Inflation: Trend-Cycle Approach

In this section, the authors follow Forbes et al (2017) by disentangling trend and cyclical components from headline inflation measures, and then exploring the relative importance of global versus domestic factors in explaining the extracted trend and cycles. The approach allows them to confirm whether innovations in global oil and food prices can have persistent effects on Thailand's inflation. To the extent that commodity price developments matter for trend inflation, monetary policy may need to take care of them. The earlier finding based on the local projections suggest that global oil and food price changes only have short-lived, despite economically important, effects on headline inflation. However, this may be owing to the dominance of short-term volatility in headline inflation that masks any persistent effects from developments in commodity prices. The trend-cycle approach amounts to estimating separately and directly the impact of commodity prices on the trend and transient components of inflation, and hence should be more appropriate in detecting any persistent impact.

3.1 Extracting Trend Inflation

In order to extract trend inflation, the authors rely on the multivariate unobserved component stochastic volatility (MUCSV) model with outlier adjustments a la Stock and Watson (2016)[7]. This model has been employed by Manopimoke and Limjaroenrat (2017) in estimating trend inflation for Thailand. Therefore, the trend estimates from the latter paper are used for this exercise.

In brief, the model assumes that trend inflation is made up from the weighted average of sectoral trend inflation. Inflation of each sector i ($\pi_{i,t}$), meanwhile, is expressed as the sum of a permanent (τ_t) and transitory (ε_t) component. The permanent or trend component follows a random walk process, while the transitory component is serially uncorrelated. The innovations to both components $(\mu_{\tau,t}, \mu_{\varepsilon,t})$ have variances that evolve over time according to independent stochastic volatility processes. The innovation to the temporary component can also have heavy tails (s_t). The model specification is as follow:

$$\pi_{i,t} = \alpha_{i,\tau,t}\tau_{c,t} + \alpha_{i,\varepsilon,t}\varepsilon_{c,t} + \tau_{i,t} + \varepsilon_{i,t} \tag{6}$$

$$\tau_{c,t} = \tau_{c,t-1} + \sigma_{\Delta\tau,c,t} * \mu_{\tau,c,t} \tag{7}$$

$$\varepsilon_{c,t} = \sigma_{\varepsilon,c,t} * s_{c,t} * \mu_{\varepsilon,c,t} \tag{8}$$

$$\tau_{i,t} = \tau_{i,t-1} + \sigma_{\Delta\tau,i,t} * \mu_{\tau,i,t} \tag{9}$$

$$\varepsilon_{i,t} = \sigma_{\varepsilon,i,t} * s_{i,t} * \mu_{\varepsilon,i,t} \tag{10}$$

$$\alpha_{i,\tau,t} = \alpha_{i,\tau,t-1} + \rho_{i,\tau}\varphi_{i,\tau,t} \text{ and } \alpha_{i,\varepsilon,t} = \alpha_{i,\varepsilon,t-1} + \rho_{i,\varepsilon}\varphi_{i,\varepsilon,t} \tag{11}$$

$$\Delta\ln(\sigma^2_{\Delta\tau,c,t}) = \gamma_{\Delta\tau,c} * \vartheta_{\Delta\tau,c,t},\ \Delta\ln(\sigma^2_{\varepsilon,c,t}) = \gamma_{\varepsilon,c} * \vartheta_{\varepsilon,c,t},\ \Delta\ln(\sigma^2_{\Delta\tau,i,t}) = \gamma_{\Delta\tau,i} * \vartheta_{\Delta\tau,i,t},$$
$$\Delta\ln(\sigma^2_{\varepsilon,i,t}) = \gamma_{\varepsilon,i} * \vartheta_{\varepsilon,i,t} \tag{12}$$

where the variance-covariance matrix $(\mu_{\varepsilon,c}, \mu_{\tau,c}, \mu_{\varepsilon,i}, \mu_{\tau,i}, \varphi_{\varepsilon,i}, \varphi_{\tau,i}, \vartheta_{\varepsilon,c}, \vartheta_{\Delta\tau,c}, \vartheta_{\varepsilon,i}, \vartheta_{\Delta\tau,i})$ is iid (independent and identically distributed) standard normal.

The model assumes a common latent factor in both the trend and transitory components of inflation. Let the subscripts c denote the common latent factor and i denote the sector. Equation (6) represents sector i inflation as the sum of a common factor for trend inflation, $\tau_{c,t}$, a common transient component, $\varepsilon_{c,t}$, and sector-specific trends and transient components, $\tau_{i,t}$ and $\varepsilon_{i,t}$, and where the factor loadings are time-varying and evolve according to a random walk (11). Equations (7)-(10) allow for stochastic volatility in innovations to both the common and sector-specific components, where the stochastic volatility evolves according to the logarithmic random walk (12). The transitory innovation is modeled as a mixture of normal and allows for outliers through the independent random variables $s_{c,t}$ and $s_{i,t}$ in (8) and (10), respectively. $s_t = 1$ with probability (1- p), and $s_t \sim U[2,10]$ with probability p. The model is estimated using Bayesian methods. The authors follow Stock and Watson (2016) in setting the priors. Please refer to their paper for details.

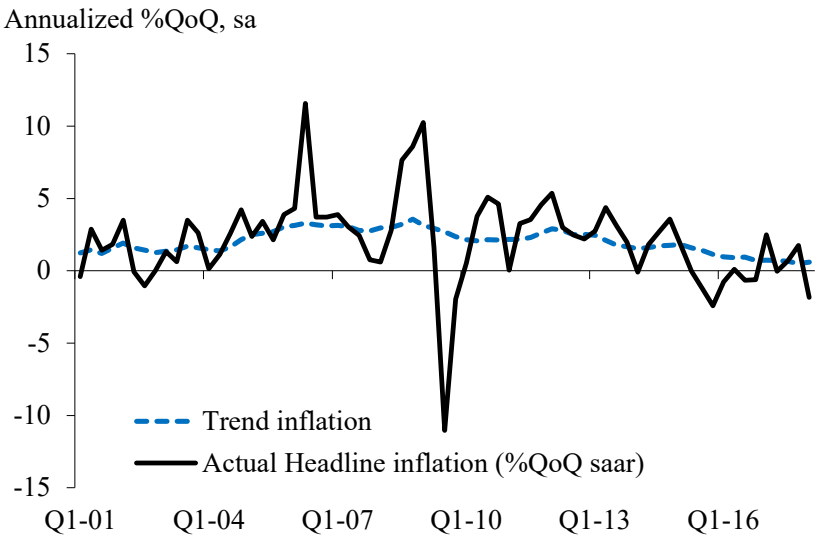
7. The 2016 paper is an extension of Stock and Watson (2007), which extract trend inflation in a univariate setting, i.e. directly from aggregate headline inflation.

The sectoral trend inflation is the sum of the contribution of the common latent factor to that sector and the sectoral trend ($\alpha_{i,\tau,t}\tau_{c,t} + \tau_{i,t}$). To obtain aggregate trend inflation, the sum of the sectoral trend, weighted by the share w_{it} of sector i in the CPI basket is computed:

$$\text{Aggregate trend} = \tau_t = \tau_t \sum_{i=1}^{n} w_{it}(\alpha_{i,\tau,t}\tau_{c,t} + \tau_{i,t}), \quad (13)$$

where n denotes the number of sectors. Based on Manopimoke and Limjaroenrat (2017), headline inflation is disaggregated into 10 major sectors: (1) raw food; (2) prepared food, non-alcoholic beverages, seasonings and condiments; (3) apparel and footwear; (4) housing and furnishing (excluding gases and electricity); (5) medical and personal care; (6) transportation and communication (excluding fuel); (7) recreation and education; (8) tobacco and alcoholic beverages; (9) gases and electricity; and (10) fuel. Given dispersion in trend inflation across sectors, extracting trend inflation in a multivariate setting is believed to entail more accurate trend inflation compared that from a univariate setting.

Figure 11
Estimated Trend Inflation and Actual Inflation



Source: Ministry of Commerce and estimated by authors

Figure 11 shows the extracted trend inflation along with actual headline inflation. By construction, headline inflation fluctuates around its trend, with some extreme movements, e.g. in the fourth quarter of 2008 (negative commodity price shocks). The trend is slow-moving, always positive and, for most of the time, stays close to the BoT's inflation target. The authors can also observe that, from 2004 to 2013, trend inflation stood at a high level relative to other periods. Since 2014, it has been on a declining trajectory, consistent with the worldwide low inflation phenomenon. The latest figure of trend inflation is as low as 1%, falling from the pre-crisis average of 2.5%.

3.2 What (Other Than the Trend) Explains Inflation Dynamics?

The authors, first, explore what variables other than the slowing-moving trend may help improve our understanding of inflation dynamics. In particular, of interest is the role of global oil and food prices in driving the cyclical component of inflation. Based on the earlier finding that both commodity prices do have economically important and short-lived effects on Thailand's headline inflation, they expect to find a strong and statistically significant impact in this exercise. Hence, the following equation is estimated:

$$\pi_t = \alpha + \beta\tau_t + \gamma X_t + \varepsilon_t \quad (14)$$

where X_t is a variable that can help explain the cyclical movements of inflation around its trend, including growth of global food and oil prices. According to theories, a set of variables that potentially drive inflation cycles also comprises percentage changes in the baht-US$ exchange rate, average labour earning growth, the output gap, the unemployment gap, short-term and medium-term inflation expectations. The output gap and the unemployment gap are a deviation of real GDP and unemployment rates from their corresponding HP-filtered trend, respectively. With respect to inflation expectations, short-term (1-year) inflation expectations are obtained from Consensus Economics, while medium-term expectations (5-year) are extracted from government bond yields using a macro-finance term structure model. Each variable in the set is included in equation (14) one at the time. The equation is estimated using the quarterly data from 2002 to 2017, given data availability. Since the inflation data of the fourth quarter of 2008 could be an outlier, the estimation results for both with and without a dummy variable for such period are presented.

Table 1
Explaining Inflation: the Trend and Other Variables

	Without 2008Q4 Dummy			With 2008Q4 Dummy		
	Coeff on Trend	Coeff on Interested Variable	R^2	Coeff on Trend	Coeff on Interested Variable	R^2
Oil price growth	1.27 (0.00)	0.12 (0.006)	0.50	1.65 (0.00)	0.07 (0.00)	0.66
Food price growth	1.17 (0.01)	0.23 (0.013)	0.44	1.66 (0.00)	0.11 (0.04)	0.61
% changes in the Baht exchange rate	1.47 (0.01)	-0.14 (0.53)	0.17	1.90 (0.00)	0.01 (0.95)	0.56
Average labor earning growth	1.37 (0.03)	0.20 (0.29)	0.18	1.86 (0.00)	0.06 (0.61)	0.57
Output gap	1.24 (0.03)	0.69 (0.04)	0.30	1.74 (0.00)	0.36 (0.08)	0.59
Unemployment gap	1.51 (0.00)	-5.08 (0.11)	0.23	1.89 (0.00)	-2.73 (0.24)	0.58
1-year consensus forecast	1.37 (0.01)	3.13 (0.05)	0.34	1.82 (0.00)	1.39 (0.17)	0.60
5-year inflation expectations	1.49 (0.00)	12.44 (0.00)	0.52	1.78 (0.00)	7.70 (0.00)	0.67

Note: The coefficients are estimated using the data from 2002Q1 to 2017Q4, except for 1-year consensus forecast regression, whose sample starts from 2004Q1. P-value is shown in parentheses.

The results are shown in Table 1, reporting coefficients on trend inflation, coefficients on each of the extra explanatory variables and the corresponding p-values (in parentheses) and adjusted R-squared for each specification. First, it is found that the coefficient on trend inflation is positive and highly significant. However, as in Forbes et al. (2017), the coefficient is always larger than one, which results from the fact that the constant term in the regression tends to be negative. Without constant, such coefficient would be close to one by construction. Concerning coefficients on other variables, both oil and food price growth are found to be positive and statistically significant, even after 2008Q4 dummy variable is added into the equation. The R-squared for all specifications with global food and oil prices is also large and higher than most of other standard macroeconomic variables, implying significant contributions of commodity prices on the movements of headline inflation around its trend. As in the results found in Section 2, growth of global food prices has a higher pass-through than that of oil prices. Among the rest of the variables, only 5-year inflation expectations and the output gap significantly influence inflation cycles in both regression (i.e. with and without a dummy variable) at 1% and 10% level of significance, respectively. However, whether inflation expectations cause actual inflation remains a puzzle, since the estimate may be subject to a reverse-causality problem. Meanwhile, the coefficient on 1-year inflation expectations is significant in the specification without a dummy variable; however, with it, the coefficient becomes statistically insignificant. Last, the authors did not find any significant effects from changes in the baht exchange rate, the unemployment gap and average labour earning growth on Thailand's headline inflation cycles.

The above findings highlight the importance of both global oil and food price dynamics in driving inflation around its trend. This is consistent with the results found earlier from the local projection approach, where commodity price developments explain substantial short-term fluctuations of headline inflation. Many other standard macroeconomic variables, which are mainly domestic factors, however are not behind the cyclical movements of Thailand's inflation.

3.3 What Explains Trend Inflation?

Next, the drivers of trend inflation are investigated. The analysis here will entail important policy implications, since monetary policy should take into account, or respond to, shocks that have persistent effects on inflation over the medium term (i.e. ones that matter for trend inflation). As mentioned above, this is also to confirm whether commodity price shocks do have merely a transient impact on Thai inflation. Therefore, the following specification is estimated:

$$\Delta\tau_t = \alpha + \sum_{j=0}^{L} \gamma_j X_{t-j} + e_t \qquad (15)$$

Since many of the explanatory variables of interest may affect trend inflation with a lag, the authors sometimes include lags of each of those variables. L is the number of lags of each variable (either 0 or 4). Table 2 shows the estimation results, reporting the coefficient estimates for each of the explanatory variables as well as the corresponding p-value and adjusted R-squared. Whenever lagged variables are included, the sum of the coefficient estimates and the p-value from a Chi-squared test of their joint significance are reported.

The results suggest that oil price growth, food price growth, 5-year inflation expectations and the output gap again are variables that significantly affect trend inflation for both specifications (i.e. with and without their corresponding lagged values). The fact that the output gap affects trend inflation implies that the extracted trend inflation, to some extent, captures medium-frequency movements of inflation, making it possible to be explained by economic cycles. Despite the fact

that the coefficient on the output gap and 5-year expectations is much larger than that on oil and food price growth, the latter are found to explain a larger variation of changes in trend inflation (see the adjusted R-squared). This may be owing to the low variation of the output gap and inflation expectations. The results, once again, highlight the dominant role of global commodity prices in driving Thailand's inflation. For the rest of the variables, the authors we did not find any significant effects from the unemployment gap and 1-year inflation expectations. Furthermore, they found that trend inflation is also significantly influenced by labour earning growth and changes in the baht-US$ exchange rate. The latter result with regard to exchange rates is in line with the finding in Forbes et al. (2017) in the case of UK.

Table 2
Explaining Trend Inflation

	No lag		4 lags	
	Coeff	R^2	Sum of Coeff	R^2
Oil price growth	0.005 (0.009)	0.10	0.013 (0.00)	0.28
Food price growth	0.01 (0.007)	0.11	0.019 (0.00)	0.25
% changes in the Baht exchange rate	-0.01 (0.24)	-0.00	-0.06 (0.014)	0.11
Average labor earning growth	0.02 (0.01)	0.04	0.002 (0.95)	0.08
Output gap	0.05 (0.04)	0.15	0.07 (0.00)	0.15
Unemployment gap	-0.22 (0.46)	0.01	-0.24 (0.46)	-0.01
1-Year consensus forecast	0.09 (0.104)	0.02	0.12 (0.63)	0.11
5-Year inflation expectations	0.36 (0.03)	0.05	1.48 (0.00)	0.23

Note: The coefficients are estimated using the data from 2002Q1 to 2017Q4, except for 1-Year consensus forecast regression, whose sample starts from 2004Q1. P-value is shown in parentheses. For specification with lagged variables, we report the sum of coefficients on both contemporaneous and lagged variables, while the statistical inference is based on Chi-squared test.

3.4 Some Explanation

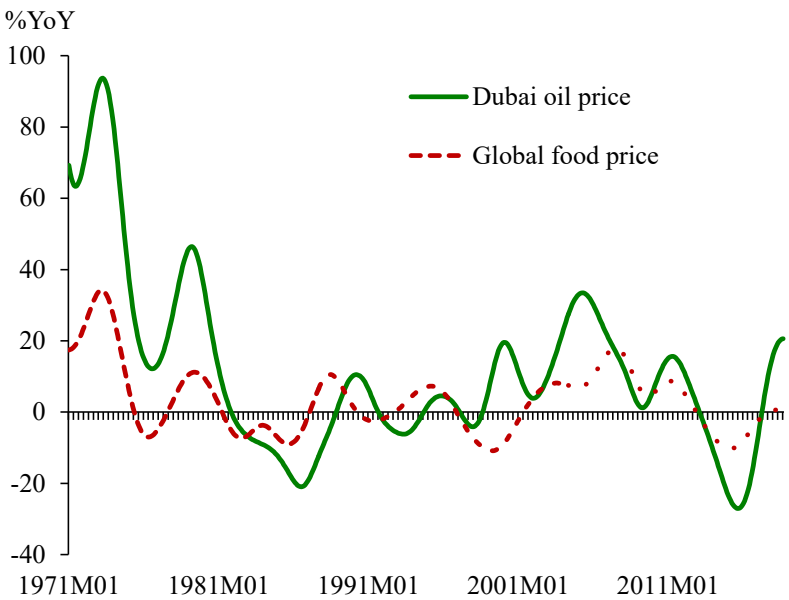
The finding from the previous sub-section suggests that commodity price changes are important drivers of both permanent and transient variations, and hence can have persistent effects on Thailand's inflation. This result has important implications on monetary policy decision-makings. As argued in Cecchetti and Moessner (2008), in deciding how to react to price increases/decreases, policymakers need to know whether certain shocks have temporary or persistent effects on inflation. If it is the former, then commodity price changes are less likely to affect headline inflation over the medium-term horizon relevant for monetary policy, and the price changes can

safely be ignored. If, however, it is the latter, then they are more likely to affect inflation over the horizons relevant to policymakers. Without proper monetary policy responses, inflation may persistently deviate from the target, which will in turn impair an ability of monetary policy in anchoring inflation expectations.

Nevertheless, the result may appear to contradict the earlier finding from the local projection exercise that commodity price changes merely have a short-lived impact on headline inflation and, therefore, should not matter for trend inflation dynamics. This paper argues that the fact that such changes significantly affect trend inflation is possibly due to the persistence of global food and oil inflation dynamics themselves, which in turn results in the persistent responses of Thailand's inflation to their initial changes.

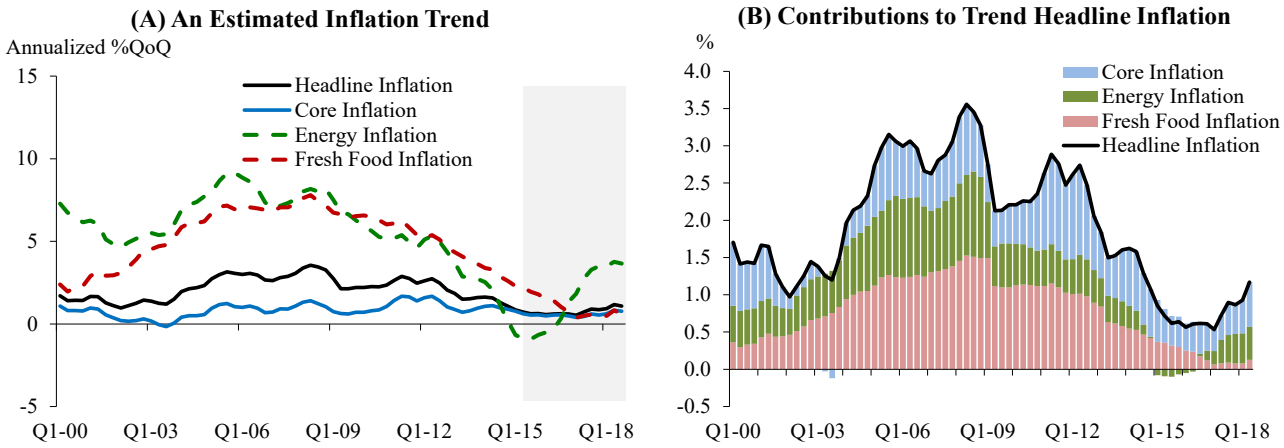
Evidence of commodity inflation persistence can, primarily, be found in the dynamics of global oil and food inflation trend. The trend is obtained by computing growth rates of HP-filtered trend of both commodity prices. From Figure 12, it can be clearly noticed that their trend growth rates are time-varying and exhibit a non-mean-reversion property, thus signaling some degree of inflation persistence. Global food inflation trend has risen consistently since 2001, and stabilised at around 9% during 2002 and 2011. The trend declined since then, and the latest figure is as low as 1%. Like food prices, global oil inflation trend were relatively high before 2012, but then began to fall and recorded a large negative value. The trend only rebounded during mid-2015. There is, consequently, a possibility that such changes in trend growth of global commodity prices directly translate into changes in domestic trend inflation. Figure 13 shows Thailand's trend inflation along with the trend of each inflation component, i.e. energy, fresh food and core inflation, all of which are estimated by the MUCSV model aforementioned. Developments of Thailand's fresh food and energy inflation trend are found to coincide well with the trend growth of commodity prices, i.e. high in 2000s and low in 2010s. Trend headline inflation responds to changes in energy and fresh food inflation trend, accordingly.

Figure 12
The Trend Growth Rate of Global Commodity Price



Note: A trend is computed using the Hodrick-Prescott (HP) filter
Source: World Bank, Bloomberg and estimated by authors

Figure 13
An Estimated Trend of Headline Inflation and Its Components



Note: Trend inflation is estimated by a Multivariate Unobserved Component Stochastic-Volatility (MUCSV) Model with Outlier Adjustment a la Stock and Watson (2016).
Source: Ministry of Commerce and estimated by authors

To confirm that the persistence of commodity price inflation, as reflected by changes in commodity inflation trend, matters for changes in trend headline inflation, the following specification is estimated:

$$\Delta\tau_t = \alpha + \gamma\Delta\tau_t^c + e_t \qquad (16)$$

where τ_t^c is the trend growth rate of commodity prices. The results are shown in Table 3 below, which suggest that changes in the trend growth rate of both global oil and food prices significantly affect changes in trend inflation, despite small R-squared. The hypothesis that the observed persistent effects of commodity price changes on Thailand's inflation are explained by the persistence of commodity price inflation itself is, thus, not rejected.

Table 3
Explaining Trend Inflation Using Commodity Price Growth Trend

	Coeff	R^2
Oil price growth trend	0.22 (0.04)	0.04
Food price growth trend	0.44 (0.054)	0.07

Note: The coefficients are estimated using the data from 2002Q1 to 2017Q4.
P-value is shown in parentheses.

3.5 Structural Changes in Global Oil and Food Markets, and Thailand's Current Low Inflation

The recent finding on the significant effects of commodity price growth on trend inflation is useful in understanding Thailand's current low inflation. Thai Headline inflation declined immensely since the end of 2014, and stood at a low level since then. Core inflation has, also, been lower than its historical average, partially driven by a stagnant economy. The trend inflation estimates have clearly confirmed that Thailand's inflation over the long run is likely to be lower than in the past, or that it may exhibit a sluggish return to the central bank's target.

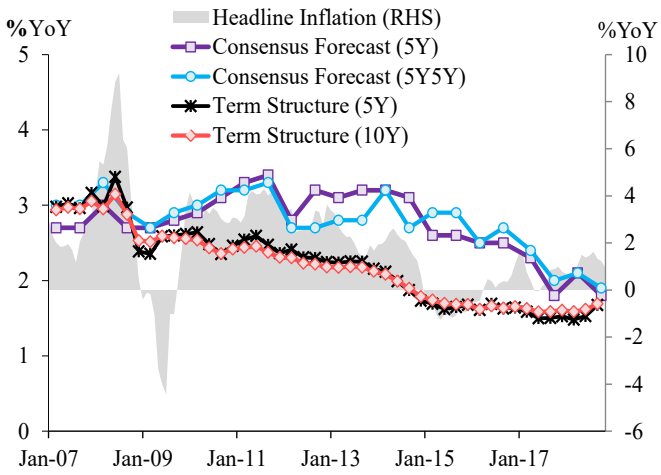
So, what explains such low trend inflation? Economists have proposed a number of factors that potentially contribute to low inflation dynamics including, for instance, globalisation, an expansion of e-commerce and the move towards an aging society. The results of this study, additionally, suggest that falling trend growth of commodity prices could also be the other main culprit that triggers a decline in Thailand's fresh food, energy and, hence, headline inflation trend. Over the past 4-5 years, global commodity markets have witnessed major structural shifts that have evidently altered commodity price and global inflation dynamics. Before the 2008 global financial crisis, the rise of emerging market economies, especially China and India, led to high demand for commodities. The insufficient supply and the financialisation of commodity markets were also among other factors contributing to price surge and explaining consistent growth of commodity prices during 2000s. However, the global financial crisis and the ensuing sluggish economic recovery have softened demand for commodities. On the supply side, technological advancements in oil extraction and production, namely the shale oil revolution, have substantially lowered costs of oil production. Such advancements have contributed to lower global crude oil prices since the end of 2014. Global oil supply has also become more price-elastic; that is, the supply becomes more responsive to shocks, leaving oil prices intact. At the same time, food production also has benefitted from improved technology as well as fewer supply disruptions, particularly from disasters. The poor demand and benign supply conditions together explain why food prices are now still in the down-cycle. These structural shifts in the global commodity markets have been an inevitable force that drive global and Thailand's inflation down over the past few years.

The low actual and trend inflation in Thailand have led to several policy implications. First, as headline inflation has missed the BoT's officially announced target for three consecutive years, this may threaten monetary policy credibility, namely an ability of the policy to achieve inflation target. In this light, the BoT constantly monitors the public's medium-term inflation expectations (5 to 10 years ahead) to judge whether inflation expectations remain well-anchored, which in turn signals whether monetary policy remains credible. Both survey-based and market-based inflation expectations, depicted in Figure 14, are monitored by the central bank's staff. The Figure shows that medium-term inflation expectations have declined since the episode of falling commodity prices commenced. Market-based expectations extracted from the term-structure model were faster to react as they fell considerably to around 1.6-1.7% in 2015. Survey-based expectations from Consensus Economics only declined much at the end of 2017.

Declining inflation expectations have left the BoT with a challenge in assessing whether there are risks of inflation expectation de-anchoring and whether they reflect a shift in the long-term mean (or steady state) of the inflation process (Ciccarelli and Osbat, 2017)[8]. The New Keynesian theory has highlighted the possibility that, if left uncontrolled, falling inflation expectations could contribute to further deflationary pressure. Actual inflation may, hence, fall even further, threatening the BoT's commitment in maintaining price stability. Worse, the public's inflation expectations could become more backward-looking, thereby adding more persistence to inflation dynamics.

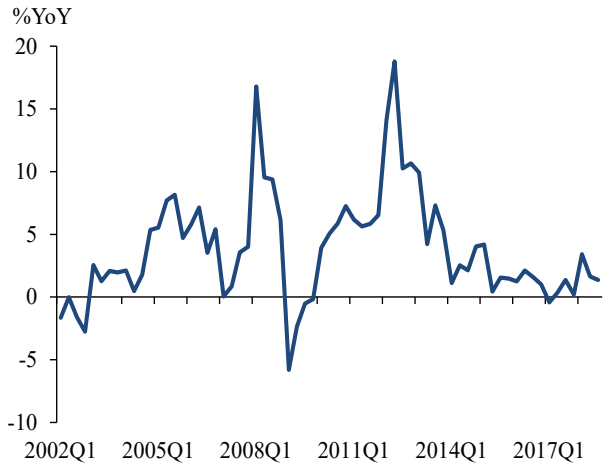
The low inflation phenomenon also has a bearing on wage growth dynamics. As firms form expectations regarding future inflation developments in their wage-setting decisions, both low actual and expected inflation can result in subdued wage growth. Figure 15 plots non-agricultural average labour earnings growth, which, like inflation, has been at a low level since 2014. Although slow wage growth may be mainly due to structural changes in the labour markets, historically low inflation in Thailand cannot be disregarded as one of the major causes. The danger is that, if labour earnings growth remains low, inflationary pressure that arises from labour costs will also be small and may not be sufficient to bring inflation back towards the target. The so-called wage-price spiral could, hence, occur.

Figure 14
Medium-term Public's Inflation Expectations



Note: "Term Structure" inflation expectations are extracted from a semi-structural macro-finance term structure model. See Apaitan (2015) for more information. 5Y5Y denotes 6-10 years.
Source: Ministry of Commerce, Consensus Economics and BoT

Figure 15
Non-agricultural Average Labor Earnings Growth



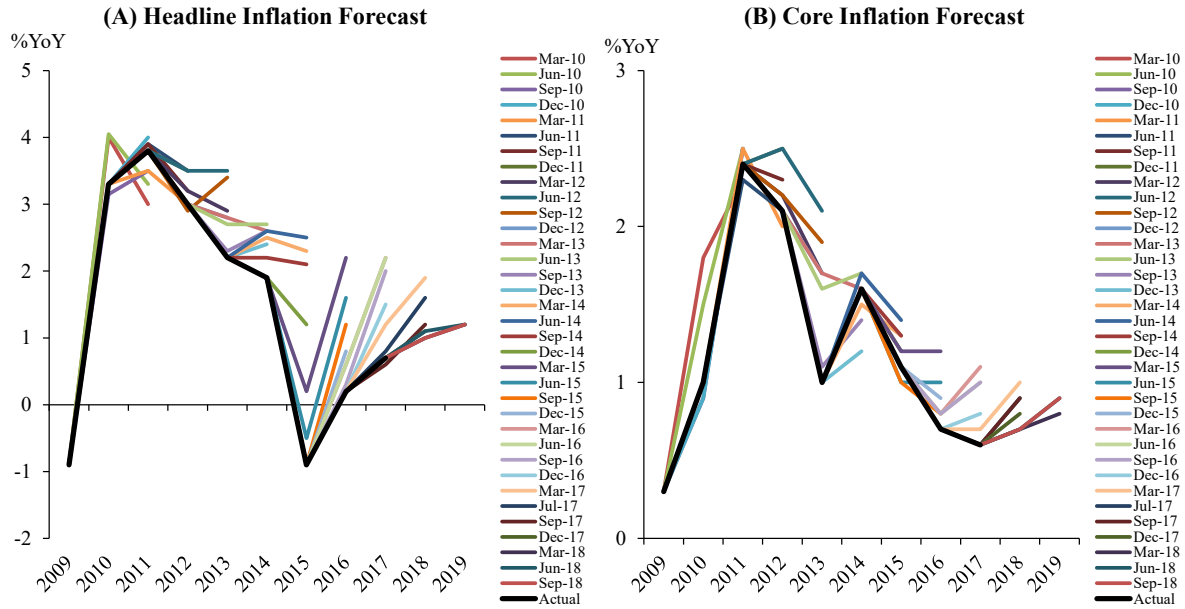
Source: National Statistical Office, and calculated by BoT

Despite an on-going economic recovery, the subdued inflationary pressure has contributed to low inflation out-turns. The BoT has, therefore, consistently adjusted downward its forecasts of headline and core inflation, as shown in Figure 16. In 2015, the BoT's macroeconomic model still forecasted headline inflation to converge back to 2%. The latest forecast, however, shows that headline inflation may average at around 1% in the next 1-2 years. For core inflation, its forecasts

8. Conceptually, shifts in the mean inflation rate expected in the long run indicate impaired trust in the central bank's commitment to achieve and maintain price stability. In fact, they imply a de-anchoring of public perceptions of the central bank's inflation target from the officially announced target.

have also been gradually adjusted downward since 2014. These projections, despite being short-term, have underscored the possibility that developments of global oil and food prices may have an impact on the country's inflation dynamics over the long run, and hence on monetary policy.

Figure 16
Bank of Thailand's 2-Year-Ahead Forecast of Headline and Core Inflation



Note: Each line in the figure shows inflation forecasts shown in each Monetary Policy Report from 2010 onwards. The black lines depict actual inflation.
Source: Ministry of Commerce and BoT

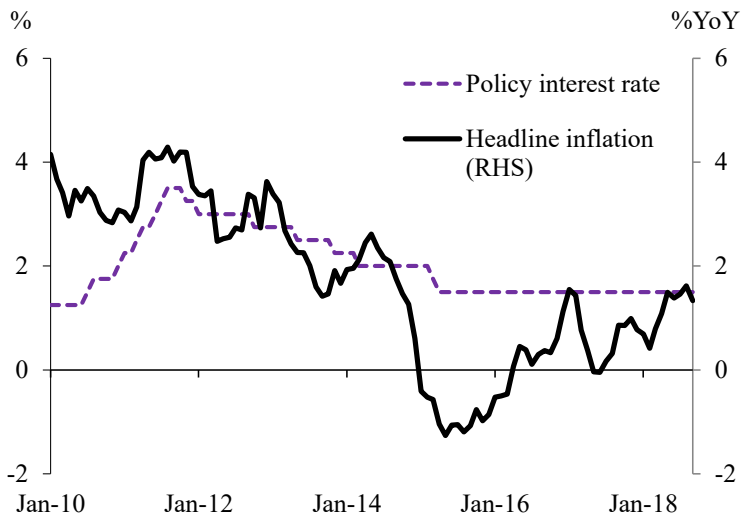
4. Implications on Monetary Policy

Recognising that growth of global oil and food prices can have both short-term and long-term consequences on Thailand's inflation, the next subject for discussion is the implications on monetary policy. First, the implications on monetary policy deliberations at each Monetary Policy Committee (MPC)'s meeting are explained. Then, the implications on the setting of inflation target are discussed.

4.1 Implications on Monetary Policy Deliberations

Generally, the central bank can safely ignore changes in global oil and food prices given that inflation volatilities induced by commodity price developments are usually short-term in nature. However, on certain occasions, those changes can be persistent, and hence lead to changes in the dynamics of trend inflation. Like in the recent episode, there can be long, or even sustained, deviations of actual inflation away from target that are driven in part by commodity price changes.

Figure 17
Thailand's Inflation and Policy Interest Rate



Note: The Bank of Thailand currently uses a 1-day bilateral repurchase rate as the monetary policy interest rate.
Source: Ministry of Commerce and BoT

Nevertheless, given the inefficiency in addressing supply shocks, monetary policy is having a hard time in preserving price stability. Policy reactions to offset supply shocks will also induce trade-offs in terms of worsened growth and financial stability, which are another key mandates of the central bank. The BoT, therefore, faces a challenging task in striking the right balance between maintaining price stability, growth stability and financial stability. In the present context, against the background of Thailand's low inflation, the MPC has decided to keep its policy rate at a low level of 1.5% since 2015, in spite of the fact that the economy has continued recovering (Figure 17). However, a low-for-long interest rate is not without costs. The MPC has acknowledged the possibility that low interest rates may lead to the search-for-yield behaviour and heightened risks to financial stability. Keeping rates too low for extended periods may render monetary policy itself a source of financial imbalances and economic overheating. Nevertheless, raising the policy rate too early and too much could pose risks to an inflation recovery. That is, if the MPC puts too much emphasis on economic growth and financial stability objectives, it may take more time for inflation to revert back to target. Inflation could become more persistent, thus requiring a longer monetary policy normalisation process.

4.2 Implications on Setting of an Inflation Target

4.2.1 Should the Central Bank Use Core or Headline Inflation as a Target?

The main results of this study suggest that headline inflation, notably the non-core component, is to a non-negligible extent driven by external factors, especially commodity price dynamics. Headline inflation has, therefore, been volatile and may not be perfectly controlled by monetary policy. The BoT, consequently, faces an important question of whether headline inflation should serve as a target measure for Thailand. Or, core inflation, which is quite insulated from global oil and food price shocks, should instead be targeted.

Thailand is indeed the last country to abandon core inflation as an inflation target. After adopting the Inflation Targeting framework, the BoT introduced core inflation of 0-3.5% as an inflation target. The rationale for targeting core inflation is that such inflation measure is less volatile, less subject to supply-side innovations and can be influenced by monetary policy. The "core" inflation targeting framework has proven to be successful in terms of macroeconomic achievement.[9] Nevertheless, in 2015, the BoT switched to "headline" inflation targeting, citing an ease of public communication and in anchoring public's inflation expectations, given that headline inflation reflects better the households' costs of living.

Though headline inflation is proven to be volatile and largely driven by external shocks, the BoT believes that it remains an appropriate target for Thailand. The fact that headline inflation reflects the overall costs of living and hence is easily-understood by the public remains a key reason. Core inflation, on the other hand, is not a widely-known concept, and could create confusion to the public when they make price-setting or wage-setting decisions.

Another important reason to support headline inflation as a target measure is based on the authors' trend inflation estimates for the CPI components. From Figure 13, huge and persistent dispersion in core and non-core inflation trend, particularly before 2015, are observed. Thailand's core inflation tended to be biased downward. This implies that core inflation is far from being a good underlying inflation indicator and so is not an appropriate anchor for the public's inflation expectation formation. In particular, the "core" inflation target could be "too high" or "too low" to reflect the economy's true costs of living. In the current context where fresh food and energy inflation trend are relatively low, the core inflation target could be higher than the overall living costs. This may have adverse consequences on resource allocations and macroeconomic stability. Take, for example, the effects on interest rate pricing. A too high core inflation target could lead to "too high" ex-ante nominal interest rates and hence underinvestment. The high ex-post real interest rates also contribute to unnecessary wealth redistributions from borrowers to savers. On the other hand, a too low core inflation target implies "too low" nominal interest rates and under-saving. Furthermore, headline inflation out-turns that persistently deviate from the "core" inflation target could derail the credibility of such "core" inflation target in serving as an anchor for public's inflation expectations. Nevertheless, employing headline inflation as a target brings about challenges to monetary policy deliberations as described in Section 4.1 above.

4.2.2 What Should Be an Appropriate Level of the Inflation Target?

Given the prominent role of external factors in driving trend inflation, another challenge to monetary policymakers is how to determine the target level of inflation. Structural changes in global oil and food price dynamics can induce changes in trend inflation, and so may influence a long-term equilibrium of inflation and affect an ability of monetary policy in controlling inflation back towards the target. For Thailand, structural changes in the commodity markets have resulted in low inflation dynamics and posed a concern over the appropriateness of the current target level at 2.5+/-1.5%. In particular, the current target may be too high to achieve, affecting policy credibility. Furthermore, it may call for large, prolonged monetary expansion to bring inflation towards target. This may foster economic overheating and financial instability. Nevertheless, the MPC is also aware of potential long-term costs from lowering the inflation target. One of these is

9. See Grenville and Ito (2010). The core inflation target was revised once in 2010 to the target range to 0.5-3%, with the aim of strengthening the commitment towards price stability and avoiding the potential for deflation risks.

a reduction in neutral nominal interest rates, which means the lower monetary policy space. There may also be increasing risks of deflation. Furthermore, monetary policy commitment towards the pre-announced target can be derailed. Any adjustments made to the inflation target must, therefore, be carefully reviewed.

However, it is argued that a too rigid inflation target that does not take into account changing inflation dynamics, particularly those induced by commodity price developments, implies that prolonged deviations of inflation away from target may frequently occur, like in the present context. As argued earlier, monetary policy actions to offset commodity price shocks so as to preserve price stability may, nonetheless, weaken the attainment of other policy objectives. To accommodate the maintenance of multiple objectives, the BoT has indeed gradually moved towards enhancing the flexibility of monetary policy framework. In 2015, as the BoT switched from core to headline inflation targeting, the point target with a tolerance band is adopted. While the point target raises the ability of the central bank in anchoring inflation expectations, the tolerance band helps preserve the bank's flexibility in pursuing other policy objectives, at least in the short run. The band also helps accommodate large short-term inflation volatility that usually results from supply shocks. It, thus, ensures that the inflation target is not strictly-defined such that it derails economic growth and financial stability. Then, in 2016, the target horizon was extended to medium term in line with international practices. The move allows policymakers to ignore temporary effects of shocks, particularly shocks to global oil and food prices, on inflation and focus on those that have a persistent impact and matter for inflation expectations and trend inflation.

Whether the moves are adequate in the circumstance that commodity price shocks may affect trend inflation remains an important question. It is argued that potential shifts in commodity price dynamics support the case for even greater flexibility in the monetary policy framework, notably the inflation target, since such shifts may cause inflation to persistently deviate from the target, making the latter difficult to attain and hence constraining monetary policy decisions. Two plausible solutions are presented here. First, the inflation target should be allowed to adjust more promptly to external or non-core developments. This should allow the target to be a credible anchor for long-term inflation dynamics. In addition, it helps avoid excessive monetary policy expansion or tightening that could threaten other policy objectives. However, it entails some costs since the inflation target may change too often, which in turn results in higher uncertainty regarding future inflation. The public may also doubt the commitment of the central bank in pursuing a price stability objective. The other solution is to adopt the range, instead of point, target. The range target, in the authors' reckoning, means that the central bank is satisfied whenever actual inflation falls within the band. There is, hence, no committed or explicit mid-point that the central bank has to achieve over the medium run. Both arguments give the central bank more flexibility in deliberating policies. Nevertheless, without the explicit mid-point, an ability of the target to serve as an anchor for inflation expectations could be derailed. Furthermore, according the New Keynesian theory, this may result in price dispersion which worsens resource allocations and welfare. Last, monetary policy decisions will also become harder to predict, which may weaken the effectiveness of monetary policy.

5. Conclusion

This paper relies on two approaches to examine the roles of global oil and food prices on Thailand's inflation. First, the local projection method is adopted to quantify the sensitivity of Thailand's headline and core inflation to commodity price changes, and then the trend-cycle approach following Forbes et al. (2017) is used to examine whether changes in commodity prices matter for trend inflation. The results from the local projections suggest that global oil and food price changes have significant and economically important, but short-lived, effects on Thailand's headline inflation. However, the pass-through is found to be smaller and less persistent than in the past, while core inflation is barely affected. The impact asymmetry and non-linearity are also evident. In particular, large negative changes in commodity prices tend to have a disproportionately bigger impact on inflation. Nevertheless, the trend-cycle analysis suggests that changes in commodity prices can impact trend inflation. This, it is argued, could be owing to the fact that those changes themselves can be persistent. This latter finding is useful in understanding the current low inflation dynamics in Thailand, since trend growth rates of commodity prices have decreased over the recent years and potentially dragged down Thai inflation.

Three challenges to monetary policymaking are discussed, one related to interest rate decisions and the others to the setting of the inflation target. First, as commodity price developments may have long-lasting effects on inflation, policymakers face a crucial task in distinguishing between transient and permanent effects of the price changes so as to form appropriate policy decisions. The fact that they may matter for trend inflation complicates monetary policy decisions that need to strike the right balance between maintaining several objectives. The economy could face large trade-offs in terms of output fluctuations if the central bank responds to commodity price changes. However, if monetary policy is irresponsive, the anchoring of inflation expectations may be adversely affected. Second, as headline inflation, to a large extent, is driven by external shocks, there exists a question of whether it should serve as a target measure for Thailand. In this regard, it is argued that core inflation, an alternative target, is not a good underlying inflation measure, while being inferior to headline inflation in terms of public communication. Last, an appropriate level of inflation target is another issue facing monetary policymakers, since changes in commodity prices can influence trend inflation. This paper concludes by arguing that, although the BoT has moved towards greater flexibility in the monetary policy framework, which should accommodate a deviation of inflation from target, even greater flexibility of the framework may be needed.

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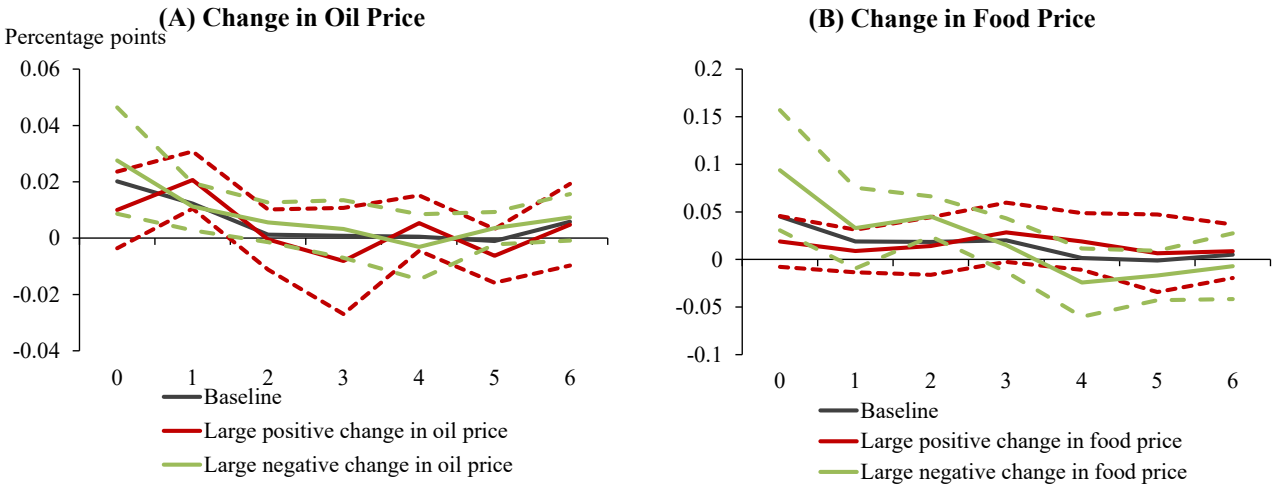
Appendix

Table 4
Sources and Definitions of Variables

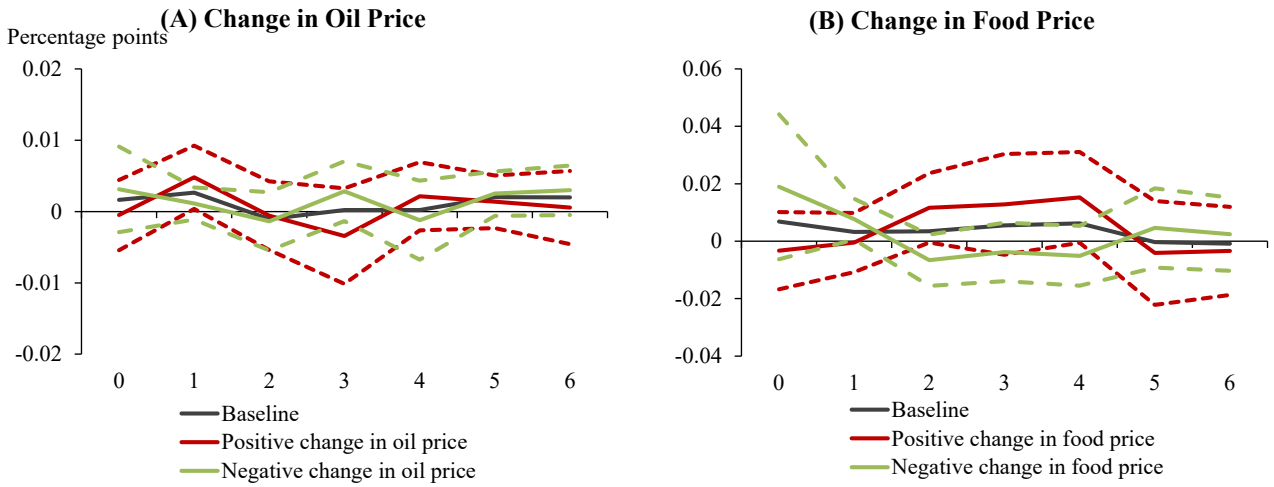
Definitions	Sources	Note
Consumer Price Index	Ministry of Commerce /IMF	The CPI data prior to 2000 from the IMF database (2010=100) is used.
Global oil price	Bloomberg/World Bank	Dubai crude oil price (Unit: US$ per barrel)
Global food price	World Bank	Global food price index based on nominal US$ (2010=100)
Output gap	NESDB	Output gap is defined as the deviation of real GDP from the potential output. Real GDP is seasonally adjusted. The quarterly real GDP is interpolated to obtain monthly data using quadratic interpolation. The potential output is extracted by Hodrick–Prescott filter.
Unemployment gap	NSO/BoT	Unemployment gap is the deviation of an unemployment rate from the natural rate of unemployment. An unemployment rate (U3) is seasonally adjusted, while the natural rate of unemployment is extracted by Hodrick–Prescott filter.
Baht-US$ exchange rate	BoT	Monthly average of a daily exchange rate
Average labour earning	Labor force survey (NSO)	Average of nonagricultural Thai labours' salaries and overtime payments
Short-term Inflation Expectation	Consensus Economics	1-year ahead inflation expectations by professional economic forecasters
Long-term Inflation Expectation	BoT	5-years ahead inflation expectations extracted from government bond yields using macro-finance term structure model. See Apaitan (2015)

Figure 18
The Impact of Oil and Food Price Changes on Headline Inflation: Large Positive vs. Large Negative Changes



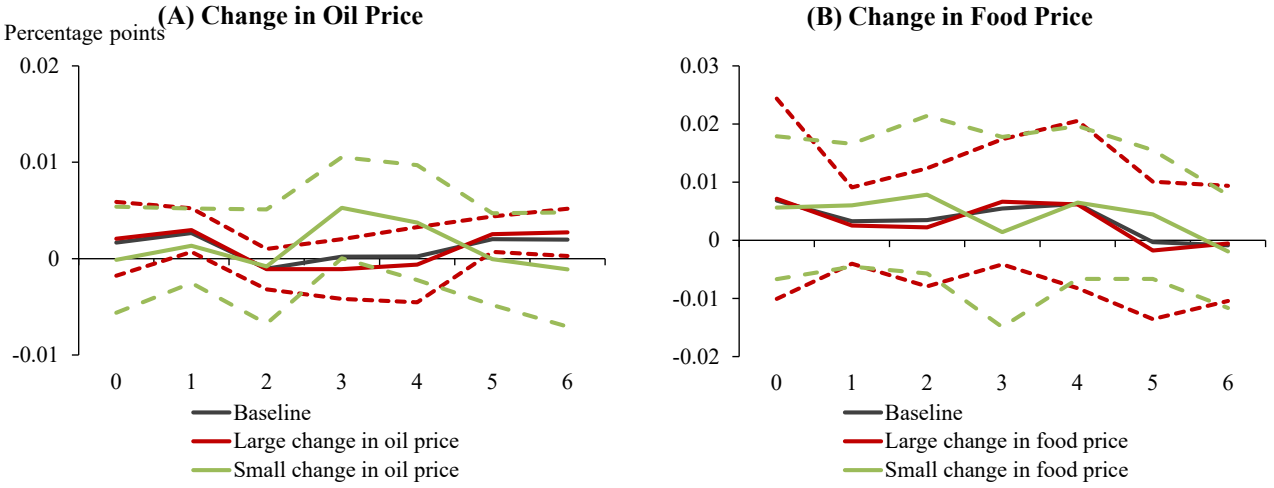
Note: the figure shows the impact of 1 percentage-point change in large global oil and food inflation on domestic headline inflation. The red and green lines present the responses to large positive and large negative changes, respectively. The dashed lines indicate 95-percent confidence bands. t=0 denotes the month in which commodity price changes occur. Large changes are defined as changes in oil and food prices larger than one standard deviation from their mean.

Figure 19
The Impact of Oil and Food Price Changes on Core Inflation: Positive vs. Negative Changes



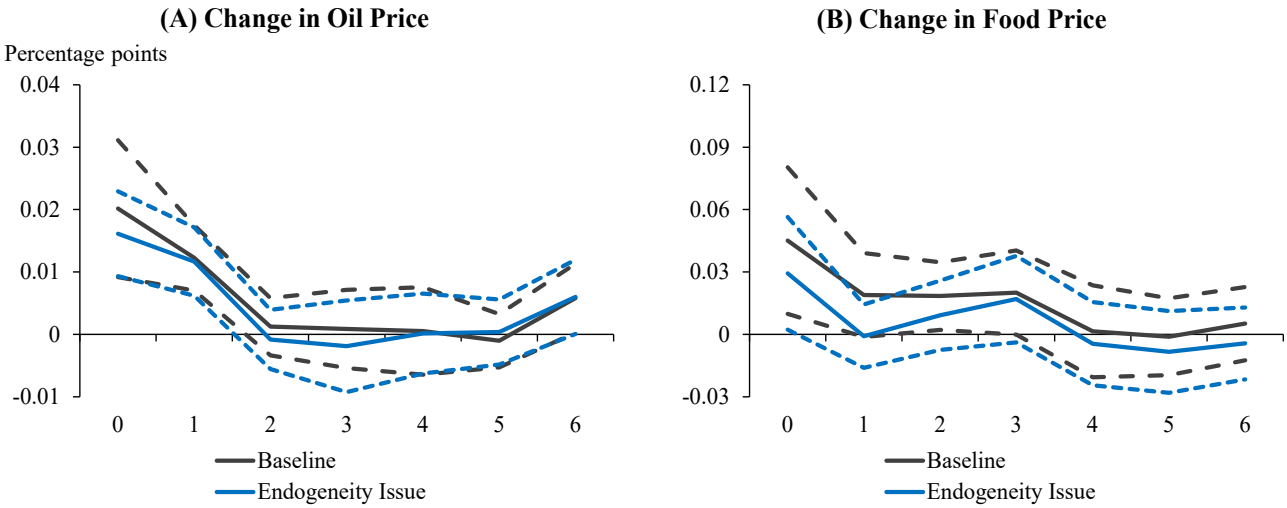
Note: the figure shows the impact of 1 percentage point change in global oil and food inflation on domestic core inflation. The red and green lines present the responses to positive and negative shocks, respectively. The solid line is the impulse response function (IRF), while the dashed lines indicate 95 percent confidence bands. t=0 denotes the quarter of the shock. Also juxtaposed in the figure is the baseline IRF as shown in figure 1.

Figure 20
The Impact of Oil and Food Price Changes on Core Inflation: Large vs. Small Changes



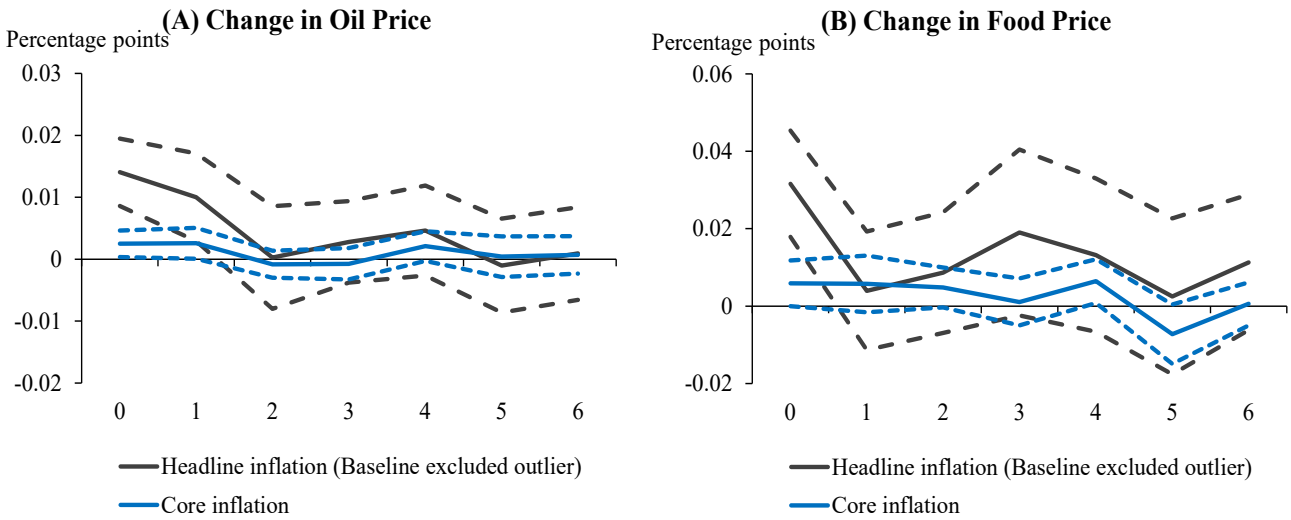
Note: the figure shows the impact of 1 percentage-point change in global oil and food inflation on domestic core inflation. The red and green lines present the responses to large and small changes, respectively. The dashed lines indicate 95 percent confidence bands. t=0 denotes the month commodity price changes occur. Large (small) changes are defined as changes in oil and food prices larger (smaller) than one standard deviation from their mean.

Figure 21
The Impact of Oil and Food Price Changes on Headline Inflation: Endogeneity Issue



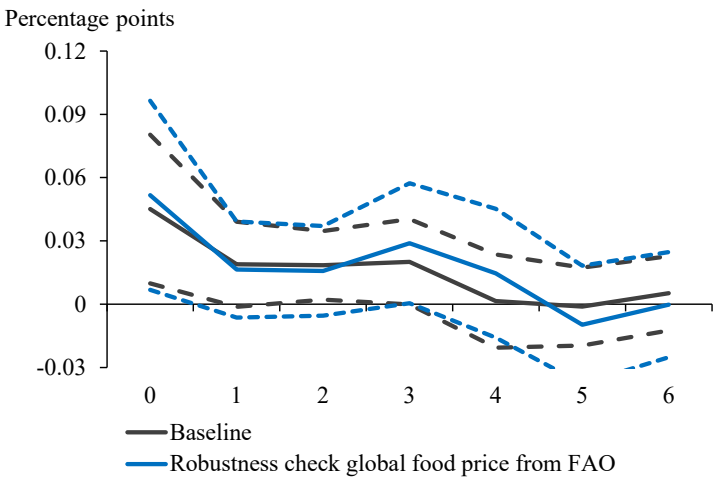
Note: the figure shows the impact of 1 percentage-point change in global oil and food inflation on domestic headline inflation. The black lines present the baseline responses, whereas the blue lines are from estimating the model that includes both oil and food price changes simultaneously. The dashed lines indicate 95 percent confidence bands. t=0 denotes the month in which commodity price changes occur.

Figure 22
The Impact of Oil and Food Price Changes on Headline Inflation: Outlier Exclusion



Note: the figure shows the impact of 1 percentage-point change in global oil and food inflation on domestic headline inflation. The black lines present the baseline responses, whereas the blue lines are from the estimation that excludes extreme observations. The dashed lines indicate 95 percent confidence bands. t=0 denotes the month commodity price changes occur.

Figure 23
The Impact of Food Price Changes on Headline Inflation: FAO Food Price Index



Note: the figure shows the impact of 1 percentage-point change in global food inflation on domestic headline inflation. The black lines present the baseline responses, whereas the blue lines are from the estimation that relies on food price index from FAO. The dashed lines indicate 95-percent confidence bands. t=0 denotes the month in which commodity price changes occur.

Chapter 12

PASS-THROUGH OF EXCHANGE RATE TO DOMESTIC PRICES: AN EMPIRICAL STUDY FOR VIETNAM

By

Dang Thi Quynh Anh[1], **Pham Duc Anh**[2], and **Le Thi Phuong Hoa**[3]

1. Introduction

In today's open trade and investment environment, apart from the traditional interest rate channels, the pass-through of exchange rate movements on inflation has recently been the focus of attention of the central banks in emerging market economies. As indicated in numerous studies, due to the close link with interest rate fluctuations in the economy, the exchange rate is deemed among the key monetary transmission mechanisms in these economies. Unlike the alternative transmission mechanisms (i.e., interest rate, asset prices and domestic credit), variations in the exchange rate could exert either an instant direct impact via the composition of the consumption bundle, or an indirect contractionary impact via the traditional expansionary competitiveness, financial cost of capital and balance sheet destabilization effects, on domestic price indices (Carranza et al., 2009). Such procedures are referred to as 'exchange rate pass-through' (ERPT).

The magnitude of ERPT to domestic prices could be determined by the percentage change in local-currency import prices derived from a one percent change in an exchange rate between the exporting and importing nations (Goldberg and Knetter, 1996). As ERPT takes the value of 1, this pass-through effect is considered complete, implying the existence of the law of one price and purchasing power parity (PPP) theory. Having reviewed early studies, it is clear that the degree of ERPT may vary significantly across nations, thus, correctly determining how exchange rate changes affect domestic prices is deemed an undeniable duty of the emerging-market central banks to serve the objectives of bringing down inflation and trade deficits.

In theory, exchange rate variations could affect domestic prices through two main channels, directly or indirectly. The direct channel reflects the impact of exchange rates on domestic inflation through import prices. Specifically, in case of a domestic currency depreciation, the prices of domestic goods and imported inputs become more expensive, resulting in a rise in the consumer prices. Meanwhile, through the indirect channel, following the depreciation of the local currency, the prices of exported goods become more competitive, boosting foreign demand for domestically produced goods. Increased demand for labor, wages and aggregate demand would, in turn, lead to higher price levels. However, this effect only exists in the long term due to the stickiness of the prices. Besides, as proven empirically, higher degrees of dollarization of the economy may possibly amplify this indirect transmission effect (Carranza et al., 2009). For instance, in some Latin American and Asian economies, despite not being traded internationally, luxury goods, such

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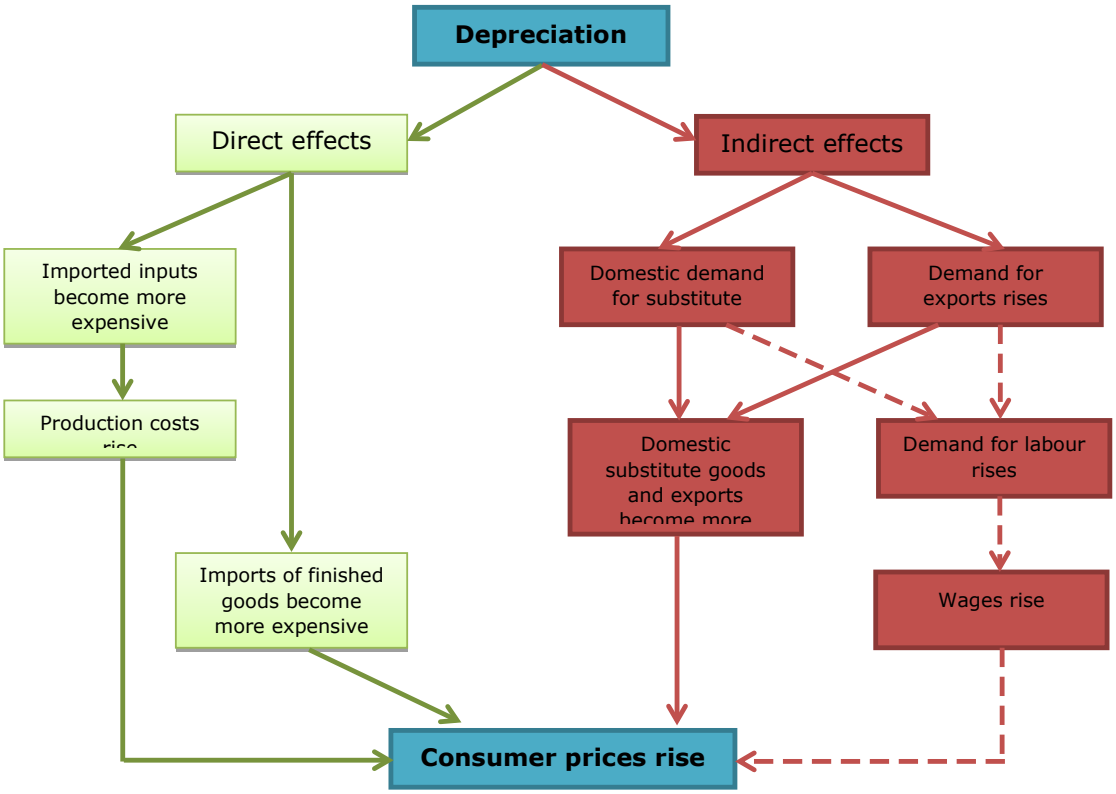
as real estate and automobiles, are customarily quoted in USD (Berg and Borensztein, 2001). Specifically, the depreciation of the home currency could lead to a rise in the local-currency prices of these items, thus increasing the money supply. As a result, domestic inflation occurs.

Figure 1
Pass-through from a Depreciation of the Domestic Currency to Consumer Prices



Source: Laflèche (1997).

Since the 1980s, there has been an extensive literature on the relationship between the exchange rate regimes and the evolution of domestic prices in developed and developing economies. These works primarily concentrate on two dimensions: the pass-through of exchange rate movements to import prices, and the ERPT to a chain of domestic prices, namely, import, producer and consumer prices.

(i) In the first direction, most existing studies (e.g. Barhoumi, 2005; Menon, 1995) confirm the existence of the ERPT into import prices, yet with varying degrees across economies. For instance, using data on 71 advanced and developing economies over the period between 1979 and 2000, Goldfajn and Werlang (2000) find that in general, developed economies tend to experience a lower pass-through than developing ones, however, both groups of countries are witnessing a sharp decline in recent trends.

(ii) Researches under the second direction are primarily based on McCarthy's (2007) approach. The merit of this methodology is that, by developing three separate equations employing import, producer and consumer prices as dependent variables together with a set of explanatory variables incorporating oil supply shocks, demand shocks (represented by the output gap) and exchange rate shocks, it is possible to justify the effect of exchange rate shocks on domestic

price indices simultaneously in a vector autoregressive (VAR) model. Based on panel dataset covering 9 advanced economies, McCarthy (2007) shows that there exists a gradual pass-through of exchange rate shocks to multiple domestic prices, where timings and magnitudes of response, ranked in descending order, are import, producer and consumer prices. In an effort to judge the inflationary effects of the exchange rate changes in differing economies, Rowland (2004), Ca'Zorzi et al. (2007), Ito and Sato (2008), Sek and Kapsalyamova (2008) have found consistent results of how the exchange rate shocks transmit, yet with distinct degrees and speed rates.

In light of present evidence, primary sources for the difference in the magnitude and timing of ERPT between advanced and emerging market economies, or even between emerging market economies might be derived from either macro or micro environment. At the macro level, the degree of ERPT is closely associated with the inflation environment (Taylor, 2000; Choudhri and Hakura, 2006; Ca'Zorzi et al., 2007; Devereux and Yetman, 2010) and monetary policy environment (Clarida et al., 1998; Taylor, 2000; Mihaljek and Klau, 2001; Gagnon and Ihrig, 2004). Micro environment sources, meanwhile, encompass price-setting and price-adjustment strategies of the enterprises, size and structure of the industry, market segmentation, origin of tradable goods, costs of transportation and distribution, non-tariff barriers to trade, the influence of multinational enterprises, the economies of scale and the price elasticity of import demand (Dornbusch, 1985; Krugman, 1986; Menon, 1995; Yang, 1997; Campa and Goldberg, 2005; Shioji, 2012).

Besides studies on monetary transmission mechanisms, research findings related to the pass-through of exchange rate have explicitly endorsed advanced economies' central banks in sustaining an annual inflation rate of approximately 2% over the past two decades. On top of that, it has also contributed to the improvement in the monetary policy effectiveness within transitional economies, bringing down inflation from the double digits during the early stage of the economic reforms to the range of 3 - 5% in the recent years. Meanwhile, although the ERPT has received considerable attention of policymakers and academics, in contrast to the current trend of research in other emerging market economies, the number of research works on this issue in Vietnam seems rather limited. Accordingly, a majority of studies concentrate on exploring either the determinants of exchange rates movements or the choice of exchange rate policy (Nguyen and Nguyen, 2009; Nguyen et al., 2010). Most recently, the relationship between exchange rate variations and consumer prices has been regarded in in-depth studies on inflation and monetary policy (e.g.; Nguyen and Nguyen, 2010; Pham, 2015). However, the absence of in-depth and practical analysis of the ERPT mechanisms and the employment of the bilateral exchange rate against USD to represent the ERPT effect (which remains almost fixed over certain long periods of time) for estimation might be the major drawbacks to these existing works.

Alternatively, until the present time, the conduct of monetary policy in Vietnam has been moving towards inflation targeting and floating exchange rate regime. This requires a proper understanding of the ERPT into domestic inflation to support the exchange rate management and stabilization (Pham, 2015). Through a number of transmission channels, exchange rate variations could exert an influence on the import and consumer price indices. Adjustments in the exchange rates may as well alter the inflation expectations, thus redirecting the current inflation of the economy. For these reasons, exchange rate policy has long been rated as one among the most effective tools by the SBV in the fulfilment of its inflation targets. Aside from that, in-depth studies of the ERPT would also be helpful for the SBV in determining the scale and timing of the exchange rate adjustments, thereby promoting the objectives of inflation control and macroeconomic stabilization.

As regards methodology, the estimation of the ERPT is primarily based on single equation or system-based approach, including linear ordinary least squares (OLS), vector error correction model (VECM) and VAR. Typical cases for linear approaches might include Ihrig et al. (2006) and Campa and Goldberg (2005). Some studies, such as Beiner and Bijsterbosch (2011), Dahl and Lo (2005), might also apply VECM to determine the degree of ERPT. Finally, the most popular approach, VAR model, has been employed in an enormous number of scholarly works. As pointed out by Faruquee (2006), the use of VAR approach to judge the ERPT effects has several advantages compared to single-equation methods emphasizing on future exchange rate shocks. By examining the ERPT to a set of prices along the pricing chain, the VAR analysis characterizes not only absolute but relative pass-through in upstream and downstream prices. On the other hand, following the VAR procedure, Cholesky variance decomposition could be carried out to identify specific structural shocks affecting the whole system. With this identification scheme, one can map the empirical results into a well-defined shock in an economic model of incomplete pass-through.

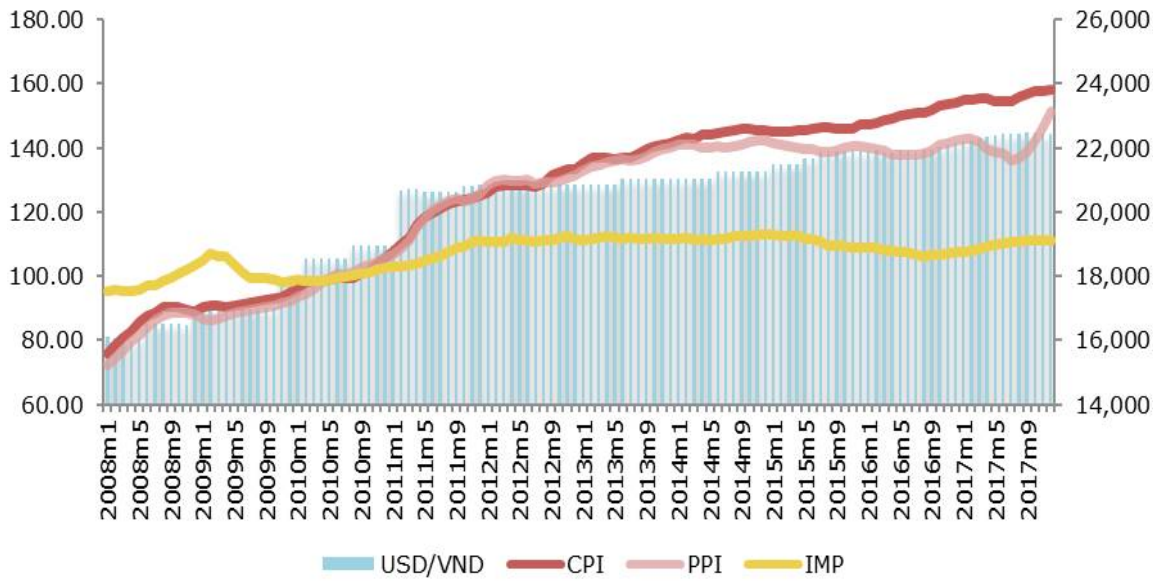
Therefore, derived from the review of existing literature, a VAR approach (in the reduced form) is applied to evaluate the pass-through effects of exchange rate fluctuations on each price variable as well as a set of prices along the pricing chain (consisting of import prices, producer prices and consumer prices). Besides, based on comparison of the ERPT effects on each price variables, we attempt to figure out the underlying reasons behind such differences among them. It is worth noticing that, the bilateral exchange rate vis-à-vis USD, other than nominal effective exchange rate (which is quite common in the current literature on the ERPT), is utilised in our empirical models for the particular case of Vietnam, since nearly 85% of the trade value of Vietnamese enterprises are quoted in USD - according to the Vietnam Customs' statistics over the 2008-2017 period.

2. Pass-through in Vietnam

It is clear from Figure 2 that the pass-through effects of exchange rate changes to both consumer and producer prices remain positive and significant. However, in each period of time, the relationship between this transmission channel and the inflation target needs in-depth analysis under specific circumstances and conditions.

Prior to the 2007-2008 global financial crisis, Vietnam's economy experienced a period of impressive economic growth under stable macroeconomic conditions with below two-digit inflation, exchange rates grew below 2% per year, trade deficits below 5 billion USD. Nevertheless, this stability has not been maintained since the beginning of 2008. Trade deficits started to exceed 10 billion USD, causing the current account deficit to GDP ratio in excess of 9%. Simultaneously, the forex market revealed its inability to absorb the excessive amount of foreign currency inflows into the economy, in which exchange rate stress became a big concern as it showed the external value of the VND had been distorted in the markets. The exchange rate quoted at commercial banks used to have a difference of over 2,000 VND per USD compared to the exchange rate on the free market. The VND depreciated nominally against the USD, yet its real exchange rate continued to rise against most of the trading partner currencies due to high inflation.

Figure 2
Vietnam's Price Indices and Nominal Exchange Rate Vis-À-Vis USD



Notes: Left axis (index, 2010=100): consumer (CPI), import (IMP) and producer (PPI) prices. Right axis: USD/VND exchange rate.
Sources: Vietnam's General Statistics Office (GSO), SBV and IMF International Financial Statistics (IFS) (2018).

Together with SBV's difficulties in achieving the final objectives of the monetary policy, the economy has seen a highly volatile exchange rate and a galloping inflation since 2008. On the other hand, this trend also has a significant impact on the stability and growth of the economy as Vietnam had to import up to 70% of input materials for production of exported and consumer goods. Basically, during the period from 2008 to 2013, inflation and exchange rates in Vietnam varied considerably and did not follow any rule.

Table 1
Vietnam's Macroeconomic and Monetary Indicators (annual percentage change)

Year	GDP	CPI	M2	Domestic credit	USD/VND
2008	6.31	19.9	20.31	25.43	5.36
2009	5.32	6.5	29	37.53	5.68
2010	6.78	11.8	33.3	31.2	5.52
2011	5.9	18.1	12.4	14.4	10.01
2012	5.03	6.81	17	5.5	0.03
2013	5.42	6.04	18.5	12.51	0.98
2014	5.89	1.84	15.65	14.16	1.00
2015	6.68	0.63	16.23	17.26	3.03
2016	6.21	4.74	18.38	18.25	1.23
2017	6.81	3.54	14.5	18.17	1.20

Sources: Authors' calculations based on data from GSO, SBV and IFS (2018).

Theoretically, when the exchange rate is maintained stable, enterprises operating in the import and export sector will reduce exchange rate risk from which the foreign currency loans fluctuations will not become a burden for all sectors in the economy. In 2011, the Government issued Resolution No. 11/NQ-CP with the aim of stabilizing the macro economy, reducing the trade deficits and curbing inflation through synchronously coordinated macro policies such as tightening fiscal and monetary, capital priorities for manufacturing and exports, etc. Yet in reality, CPI inflation in 2011 reached an all-time high of 18.6%. In early 2012, SBV signaled that the VND/USD exchange rate would not fluctuate more than 3% in the whole year. Immediately, commercial banks sold USD to the SBV for VND as at that time, VND interest rates was higher than the USD interest rate. Subsequently, the SBV directed commercial banks to reduce VND deposit rates, commercial banks had to borrow VND on the interbank market to avoid exchange rate risk at the end of the year as demand for foreign currency increased. At the end of 2012, the exchange rate was stable.

From 2014 until present, as the money supply has been increasingly tightened, inflation and exchange rates remained relatively stable, contributing significantly to macroeconomic stability and economic growth. In order to fulfill the task of inflation controlling assigned by the government, in the period until 2020, the SBV is expected to make changes to exchange rate policy in the direction that the exchange rate must be really flexible and the announced interbank exchange rate must closely follow the market spot rate.

An increase in the exchange rate would, to a certain extent, affect the interest rate and inflation, thus putting pressure on the general interest rate in the market. The greater the difference in interest rates in VND and USD, the more favorable for the VND. If the exchange rate increases sharply, depositors would tend to withdraw VND and convert to USD bank deposits. Therefore, commercial banks need to consider raising interest rates in VND to retain customers. Once the input interest rates rise, the output interest rates also increase accordingly. This could affect the production investment sector when having loans. Nevertheless, in recent years, the SBV has repeatedly affirmed that the USD/VND exchange rate will fluctuate no more than 2% per year, regardless of the “room” so far is no longer available and the SBV is willing to sell foreign currency to intervene the market if necessary. With SBV’s commitment to stabilize exchange rates, the trade deficits in the past few years have not significantly affected the market interest rates.

In a nutshell, the exchange rate variations explicitly correlate with the inflation in Vietnam, to a greater of lesser degree depending on each stage of the economic development. The maintenance of the less volatile nominal exchange rate is deemed a great effort of the SBV to stabilize the currency market, VND value and support production activities. However, Vietnam’s inflation in recent years seems to be still high and unstable. Facing this situation, SBV’s exchange rate policy has been adjusted to be more flexible. As a result, the belief in VND of local and foreign invested enterprises has been strengthened, and simultaneously, exchange rate stabilization also effectively supports sectors in the medium and long-term business planning.

3. Methodology and Data

3.1 Econometric Model

A reduced-form VAR (RVAR) approach is adopted to analyze the pass-through effects of exchange rate variations on the domestic prices for the case of Vietnam. To begin with, the general RVAR specification is written as follows.

$$Y_t = c + \sum_{i=1}^{p} \theta_i Y_{t-i} + \varepsilon_t \qquad (1)$$

where: Y_t is the vector of endogenous variables, θ_i denotes the coefficient matrices, ε_t is the composite of contemporaneous structural disturbances and c is the intercept.

Following the recent exposition in McCarthy (2000), we construct the baseline five-variable RVAR including the exchange rate (EX), the domestic price (P) and other three macroeconomic variables, viz. world commodity price (WCP) as the supply shocks, the output gap (YGAP) as the demand shocks and the broad money (M2) as the monetary policy shocks – in which, exchange rate and domestic price variables are the main focus of attention.

Structural shocks in the RVAR model could be identified by setting out endogenous variables in the most appropriate order and applying Cholesky decomposition for a variance-covariance matrix of the reduced-form residuals (εt). The following order of variables in the RVAR model is selected: (i) the world commodity price is ordered first since it could influence all other variables contemporaneously, yet unlikely to be influenced by any other shocks (Ca'Zorzi et al., 2007; Ito and Sato, 2008); (ii) the output gap is placed second since it is likely to be affected by the variations in the world commodity price while output gap (demand) shocks could have contemporaneous impact on the other variables (except world commodity prices); (iii) placed third in the ordering would be the monetary variable since in the case of Vietnam, monetary policy has a noticeable impact on the exchange rate through State Bank's adjustments to the average interbank exchange rate and trading bands, meanwhile, monetary policy might also be affected by changes in demand or supply; (iv) the exchange rate is placed fourth, indicating that it might respond contemporaneously to changes in supply, demand and monetary policy, yet unable to respond to the price variations; (v) the domestic price is placed last for the purpose of gauging how this variable reacts to the supply, demand as well as monetary policy shocks. Accordingly, the Y_t vector of five endogenous variables takes the following form:

$$Y_t = \{WCP_t, YGAP_t, M2_t, EX_t, P_t\} \qquad (2)$$

Instead of applying the original version of McCarthy's (2000) model as a whole, we tend to make the following adjustments:

First, instead of employing oil prices as in previous studies, in this paper, we use the world commodity price (WCP) extracted from the IMF to represent supply shocks since this indicator better reflects the price changes of major commodities in the international market (including oil prices).

Second, apart from consumer price (CPI), this study also considers the other two alternatives, viz. import (IMP) and producer (PPI) prices. Accordingly, each price indicator is in turn incorporated in a five-variable RVAR model and placed at the bottom so that the ERPT to domestic prices could be judged, and simultaneously the degree and timing of the pass-through effects could be compared among the three prices. Import prices are expected to have quicker and larger response to the exchange rate shock than the others, since non-tradable components such as distribution costs, rents and profits appear higher in producer prices than import prices, and even higher in consumer prices than producer prices.

Third, in order to perceive the contagion of the exchange rate shock spreading to the consumer prices over time, the study also analyses the pass-through effects on a set of prices along a pricing series, from the import, producer to the consumer price level. Accordingly, the five-variable RVAR model is developed into seven-variable, with Y_t vector restructured as follows.

$$Y_t = \{WCP_t, YGAP_t, M2_t, EX_t, IMP_t, PPI_t, CPI_t\} \quad (3)$$

3.2 Data

To estimate the pass-through effects of exchange rate variations on prices, we utilise monthly data covering a span of ten years from 2008M1 to 2017M12, with a total of 120 observations. These data are collected from IMF International Financial Statistics (IFS) and General Statistics Office of Vietnam (GSO). All the data, except the output gap, are seasonally adjusted and in the logarithmic form. Details about each series are set out as follows:

World Commodity Price (WCP): represents the supply shock to the economy. This variable is proved empirically to have a direct impact on the import prices, and thus the consumer prices. Data on WCP is recorded from IFS and normalised to have a monthly mean of the base year 2010 equal to 100.

Output Gap (YGAP): by definition, is the difference between actual output and the maximum potential output of an economy. An excess of actual output over potential output implies that the economy is growing over its long-run capacity or, in other words, over its full employment capacity – hence, the output gap is often seen as an indicator of excess demand in the economy. In reality, a well-established method of measuring the output gap is taking the residuals from a regression of the log of industrial production indices on a constant plus linear and quadratic trend, which is best known as the Hodrick – Prescott (HP) filtering method. In this paper, the output gap is generated by applying the HP filter to the natural log of the industrial production index with monthly smoothing parameter set at 14,400. Data for the industrial production index (average 2010 = 100) is taken from the GSO and CEIC Global Database.

Money Supply (M2): a proxy for the monetary policy shock. In Vietnam, since the interest rates are sometimes not a truly effective instrument, the SBV tends to make use of the broad money (M2) as a key intermediate target in support of monetary policy implementation. Data on the broad money of Vietnam is collected from the IFS.

Exchange Rate (EX): the nominal exchange rate of VND vis-à-vis USD is selected as a proxy for the exchange rate and collected from the IFS database. The underlying reasons for our choice is that, according to the Vietnam Customs' statistics, over the period from 2008-2017, approximately 80 to 85% of the total export and import value of Vietnamese enterprises are in USD. Alternatively, the bilateral USD/VND exchange rate is also kept under severe control and management by the SBV on a daily basis. Hence, investigation into the ERPT effects with the use of the nominal USD/VND exchange rate to price changes seems highly consistent with the reality in Vietnam.

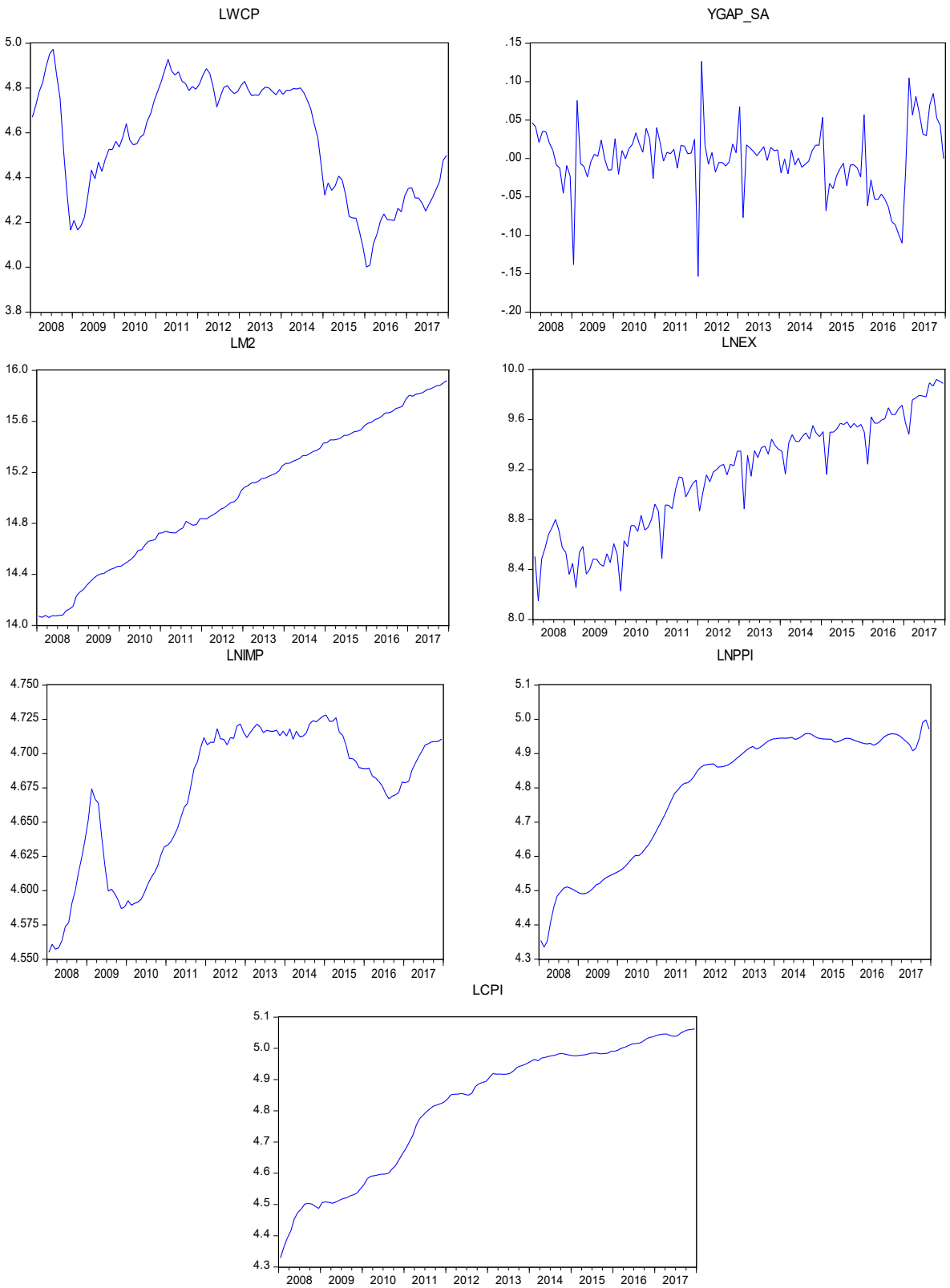
Price variables (P), *including import price index (IMP), producer price index (PPI) and consumer price index (CPI):* Monthly series of all price candidates are recorded from the GSO, IFS and CEIC Global Database and rebased so that the base period 2010's monthly mean is equal to 100.

Table 2
Description of Variables in the Model

Variables	Notation	Definition and Measurement	Source
World commodity price	WCP	World commodity price index (2010 = 100)	IFS
Output gap	YGAP	Difference between the economy's actual output and potential output, where HP filter is applied to the natural log of the industrial production index.	GSO – CEIC
Money supply	M2	Broad money	IFS
Exchange rate	EX	Nominal exchange rate of USD vis-à-vis VND. An increase in the exchange rate is linked to the depreciation of VND.	IFS
Import price	IMP	Import price index (2010 = 100)	GSO - CEIC
Producer price	PPI	Producer price index (2010 = 100)	GSO - CEIC
Consumer price	CPI	Consumer price index (2010 = 100)	IFS

Innovations of the data during ten-year research period is presented in Figure 3. It is noticeable that M2 and CPI witnessed a sustained rise while WCP, IMP and EX plunged to their record lows in 2008, primarily due to the global financial upheaval.

Figure 3
Innovations of Data in Log Form, 2008-2017



Source: Authors' calculations.

3.3 Testing for Stationarity

Assessment of the time series properties of variables is conducted with the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests. Unit root test results (exhibited in Table 3) indicate that all the series, other than YGAP, are non-stationary in levels, yet their first differences appear stationary at the 1% significance level, or in other words, all variables are integrated of order one [I(1)]. Therefore, variables in first differences (except YGAP) are incorporated in the VAR estimation. Such transformations are in line with the current literature (e.g. Ito and Sato, 2008) for Asian economies. Besides, to cope with seasonal patterns which are typically present in the monthly series, Census-X12 procedure is applied as suggested by Nguyen and Nguyen (2010).

Table 3
Results of the Unit Root Tests

Variable	Level		First difference		Conclusion
	t statistic (ADF Test)	t statistic (PP Test)	t statistic (ADF Test)	t statistic (PP Test)	
WCP	-2.189	-1.845	-6.228***	-6.266***	I(1)
YGAP	-5.061***	-9.061***			I(0)
M2	-0.742	-0.714	-10.289***	-10.295***	I(1)
EX	-0.243	-1.072	-11.796***	-26.064***	I(1)
IMP	0.185	-0.239	-10.737***	-20.199***	I(1)
PPI	-2.813	-2.731	-4.485***	-4.908***	I(1)
CPI	-2.047	-3.283**	-5.380***	-5.233***	I(1)

Note: ***,** indicate significance at 1% and 5%, respectively.
Source: Authors' calculations.

4. Results and Discussion

The lag order of the five-variable RVAR models is selected based on the Likelihood Ratio (LR) test with reference to the Akaike and Schwarz Information Criteria (AIC and SIC). From the RVAR estimation results, exchange rate shocks are identified based on Cholesky decompositions under the recursive assumption. Accordingly, evaluation of the ERPT to price indices could be carried out in five steps as follows: (1) estimating the RVAR models with any lag; (2) selecting the optimal lag-lengths; (3) re-estimating the RVAR models with the selected optimal lag-lengths; (4) conducting the diagnosis and stability tests on the estimated results; and (5) quantifying the exchange rate shocks (in terms of degree and timing) to the price indices.

4.1 ERPT to the Price Indices

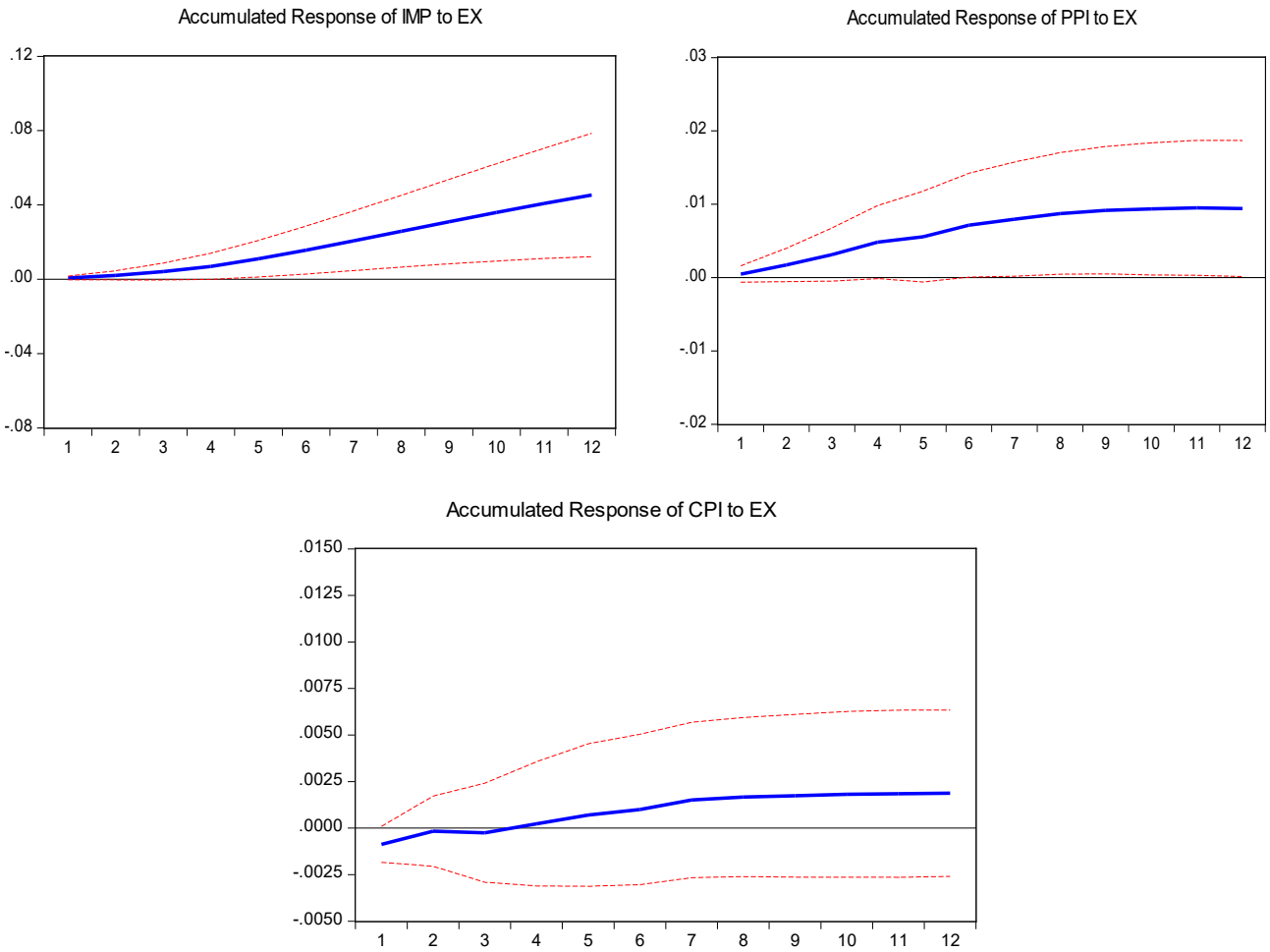
First, we estimate the five-variable RVAR models [where the Y_t vector is specified as in Eq.(2)] with every different price variables (P), namely, import prices (IMP), producer prices (PPI) and consumer prices (CPI) and simultaneously, measure the response of each price indice to the

exchange rate shocks. According to Ito and Sato (2008), the ERPT magnitude could be calculated by normalizing the exchange rate shocks to shocks of a 1% change in the exchange rate. A 1% shock is determined by dividing the cumulative response of the price change to the exchange rate shock after i month (indicated as $P_{t,t+i}$) by the corresponding impulse response of the exchange rate change (indicated as $E_{t,t+i}$). Specifically:

$$PT_{t,t+i} = \frac{P_{t,t+i}}{E_{t,t+i}}$$

Estimated results from Figure 4 show that price indices have a reaction to exchange rate shock yet at varying magnitudes. Import prices began to rise when there was an exchange rate shock from the first month. Specifically, in response to a 1% increase in the exchange rate, import prices rise 0.002% after one month and reached the highest level of 0.1374% after 7 months. This finding reveals that the pass-through effects of the exchange rate changes to import prices do exist in Vietnam, as a 1% change in the exchange rate would be transferred to import prices in VND with an increase of roughly 0.135% after 9 months.

Figure 4
Responses of Price Indices to the Exchange Rate Shocks



Source: Authors' calculations.

The response of producer prices response seems weaker than that of import prices when there was a 1% increase in the exchange rate. Producer prices began to increase from the second month and reached the highest level, increasing 0.09% after 6 months. Thus, the exchange rate shocks have spread to the producer prices through the import prices. However, as there remain other inputs used for production and unaffected by the exchange rate, the reaction of the producer prices appears weaker than the import prices. In addition, similar to import prices, in the long run, the new balance of producer prices would be set after the third quarter, at an increase of 0.074% compared to the period before exhibiting the exchange rate shocks.

Consumer prices have a weaker reaction than producer prices when there emerges an exchange rate shock. CPI started rising after four months of the exchange rate shock. When the exchange rate increased by 1%, CPI recorded the highest increase of 0.06% after 7 months and a new balance of 0.054% after 9 months. Thus, it can be seen in Vietnam that exchange rate shocks have an impact on the consumer prices, yet with a negligible degree.

Table 4
Responses of Price Indices to a 1% Exchange Rate Shock (%)

	IMP	PPI	CPI
After 1 month	0.02	0.04	0.006
After 6 months	0.07	0.09	0.045
Highest level	0.137	0.095	0.060
New balance level after 9 months	0.135	0.074	0.054

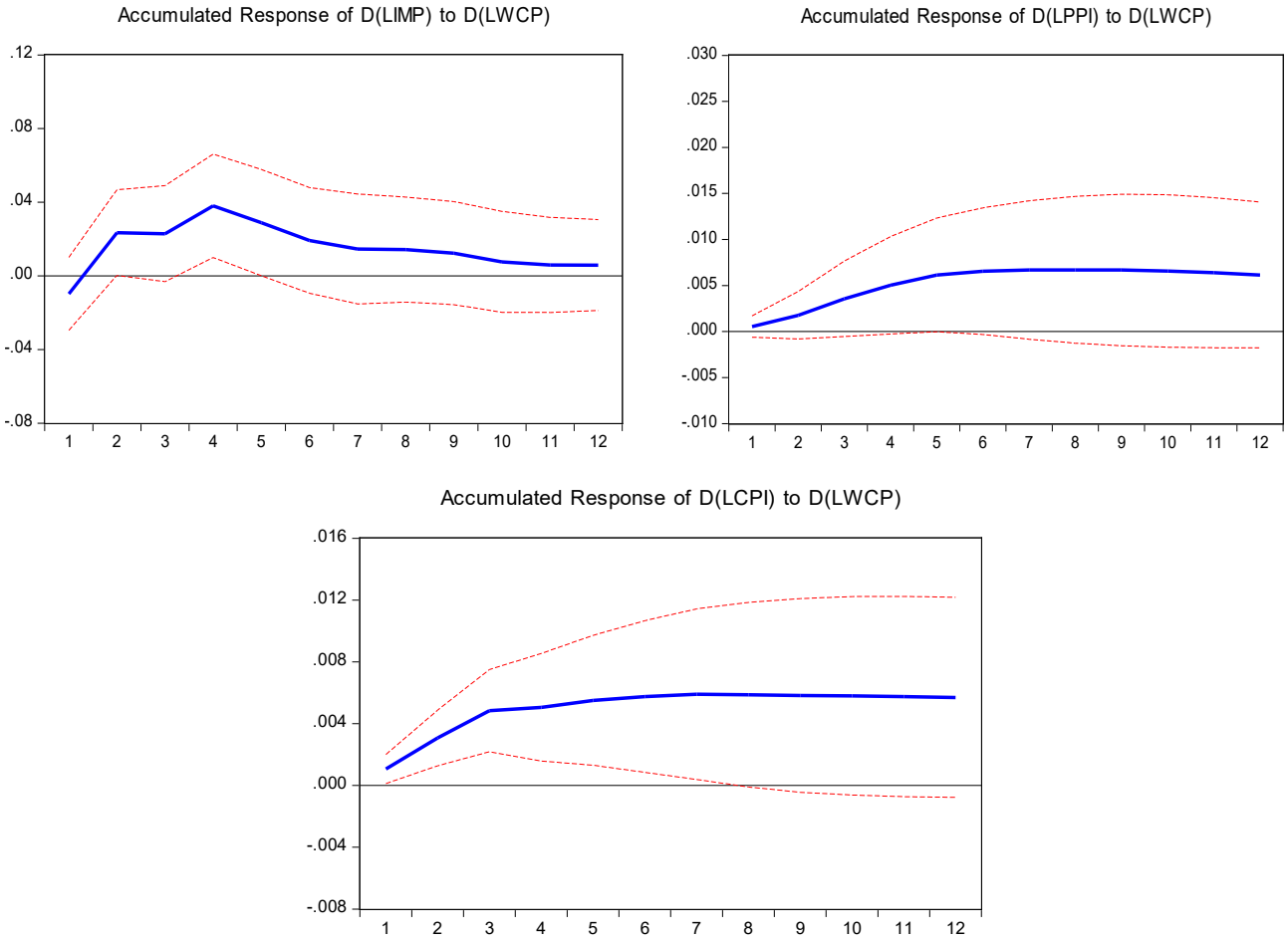
Source: Authors' calculations.

To sum up, the reaction of price indices to a 1% exchange rate shock in Vietnam shows some distinguishing characteristics as follows: (1) ERPT to import prices reached a relatively high level after a period of 9 months; (2) the reaction magnitudes of the price indices decline along the pricing chain: import prices show the largest response, followed by producer prices and consumer prices; (3) the evolution of price indices seems identical in the direction: rapidly increasing during the early months of the shock - mirroring the price stickiness (since import contracts are usually concluded from 3 to 6 months before the actual delivery date), then falling gradually to a new equilibrium. This proves that importers of final consumer goods or capital goods might possibly relocate the sources of imports, searching and switching to cheaper items.

Impact of Supply Shocks on Price Indices

Analysis of impulse response functions (Figure 5) shows that all the three prices responded in the same direction with the shock of rising world commodity prices. Accordingly, import prices began to increase sharply from the second month when there was a world commodity price shock and reached the highest cumulative increase of 3.8% after 4 months. Later on, however, the growth rate slowed down and returned to the initial balance level after one year. Meanwhile, producer prices and consumer prices started rising with the world commodity price from the second month and reached a new balance of 0.5% after 6 months.

Figure 5
Responses of Price Indices to the World Commodity Price Shocks

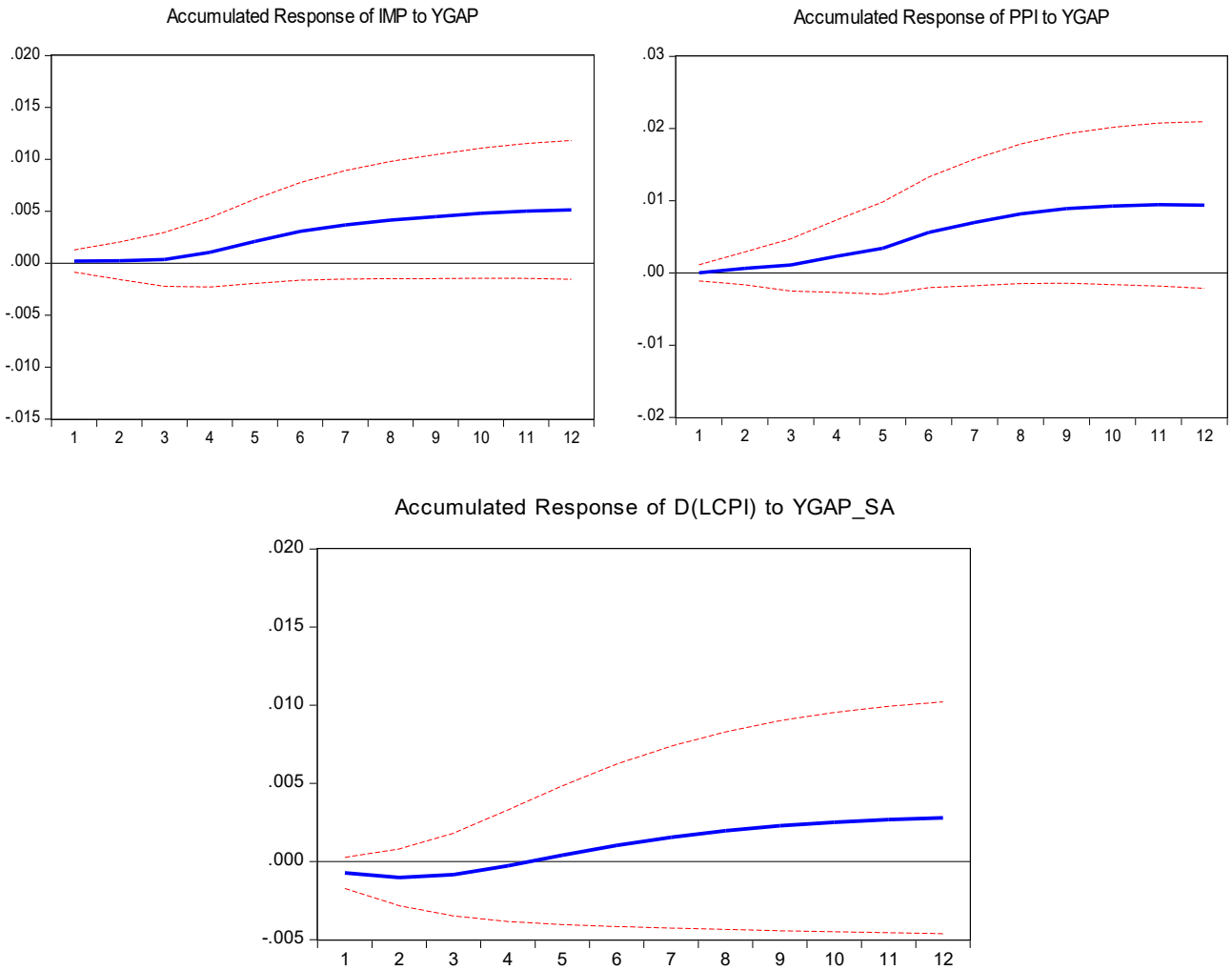


Source: Authors' calculations.

Impact of Demand Shocks on the Price Indices

Figure 6 illustrates the reaction of price indices due to a one-standard-deviation shock of the output gap. Import prices began to increase from the fourth month of the output gap shock and reached the highest increase of 0.5% after 9 months, while producer prices began to increase from the third month of the shock and reached a new balance of 0.9% after 8 months. It is worth noting that consumer prices reacted far more slowly to demand shocks, specifically, CPI started rising from the sixth month and reached a new balance of approximately 0.3% after 12 months.

Figure 6
Responses of Price Indices to the Output Gap Shocks



Source: Authors' calculations.

It can be concluded that the demand shock is among the key reasons for price inflation, especially producer prices and consumer prices, although the magnitude of the pass-through may not be large.

LM and Pormanteau testing results on the above models show that the residuals of RVAR models are free from serial correlation. The stability of the RVAR models is also guaranteed since inverse roots of AR characteristic polynomials have absolute values less than one. In a nutshell, the estimated results are statistically reliable.

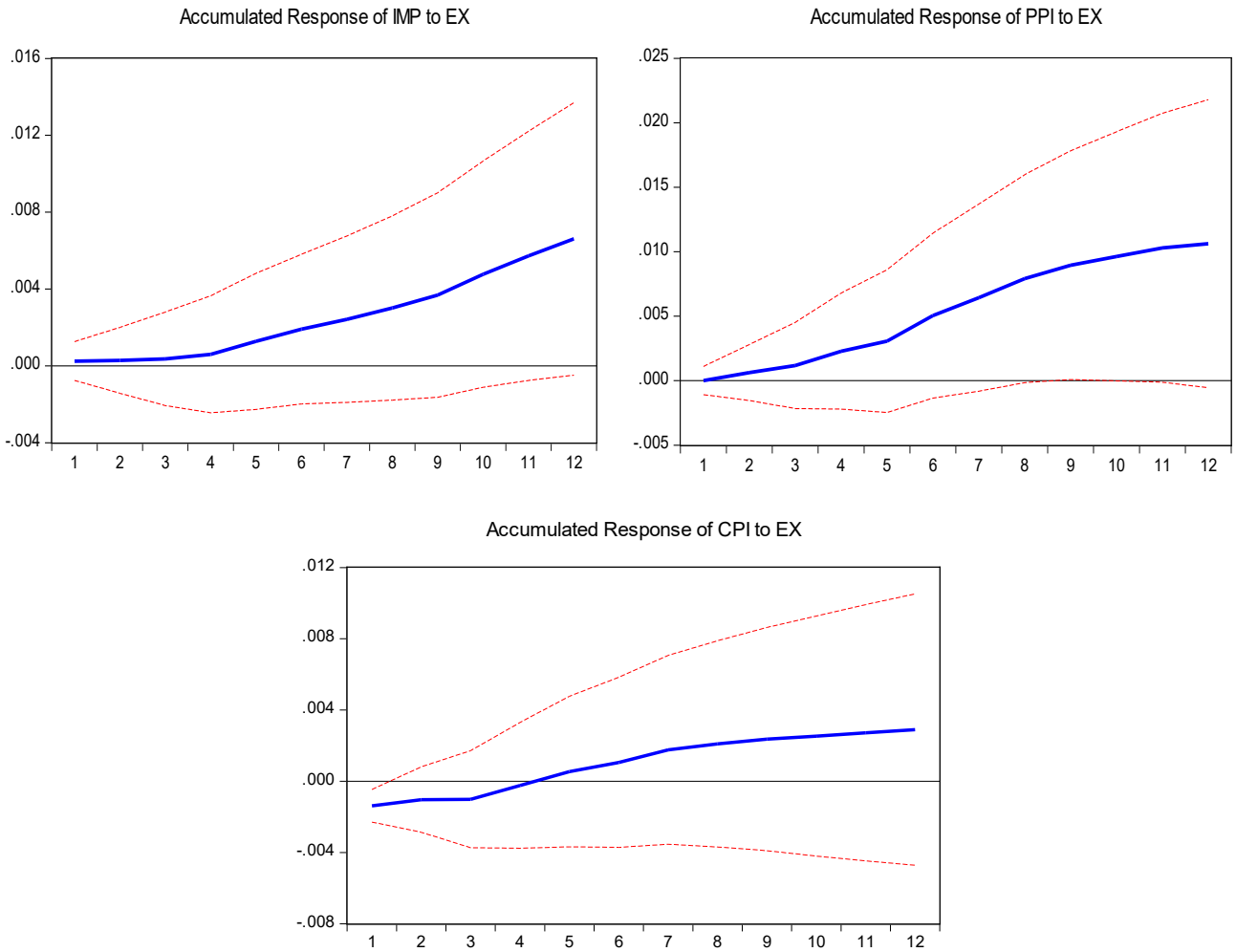
4.2 ERPT to Price Series

Seven-variable RVAR model [where the Y_t vector is specified as in Eq. (3)] is employed to assess the impact of 1% exchange rate shocks on the price series. As indicated in the diagnostic test results (see Appendices): (i) the residuals of RVAR model are normally distributed, (ii) serial correlation does not exist, and (iii) the model achieves general stability. Therefore, the reliability of the seven-variable RVAR could be guaranteed.

Estimation results for the seven-variable RVAR show that: (i) import prices reacted strongly to the exchange rate shock with an increase of 0.13% from the third month and then 0.66% after 12 months; (ii) producer prices began to rise sharply from the third month and reached a new balance of 1.03% after a whole year; (iii) Consumer prices saw a slower reaction than import prices and producer prices, specifically, CPI started accelerating from the fourth month and reached a balance of 0.27% after 9 months compared to the level before the exchange rate shock.

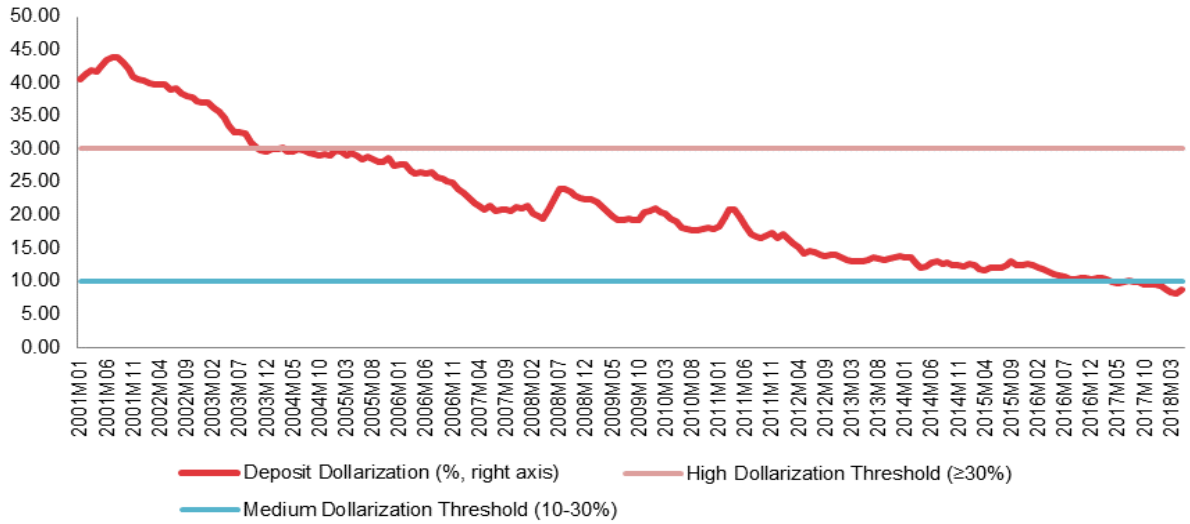
As suggested in the analysis of the impulse responses (Figure 7), the magnitude of pass-through to domestic prices in Vietnam seems not so large, because Taylor (2000) argues that relieving the dollarization of an economy might possibly lead to a reduction in the magnitude of pass-through. According to the IMF's criteria, a nation with a ratio of foreign currency deposits to M2 in excess of 30% is classified as highly dollarized. As observed in Figure 8, the dollarization degree of the Vietnamese economy has dropped sharply, from nearly 45% in 2001 to less than 10% in 2018. Unquestionably, this would help minimize the impact of the exchange rate, and thus reducing the degree of pass-through to price inflation.

Figure 7
Responses of Price Series (Import Prices → Producer Prices → Consumer Prices) to the Exchange Rate Shocks



Source: Authors' calculations.

Figure 8:
The Dynamics of Dollarization in Vietnam, 2001-2018



Source: IMF International Financial Statistics.

In reality, to prevent the exchange rate risk, import and export enterprises have implemented various ways such as parallel buying and selling foreign currencies, reserving foreign currency in advance, buying and selling derivative contracts. These actions appear rather effective in helping enterprises unaffected by the exchange rate volatility in the short run, as well as staying out of the exchange rate risk in the long run. As a result, the magnitude of the pass-through to price indices would be lowered regardless of the sustained increase in the exchange rate.

4.3 Variance Decomposition

Table 5
Variance Decomposition of IMP, PPI and CPI

Period	YGAP	M2	EX	PRICE
Variance Decomposition of IMP				
1	0.288	1.087	0.909	97.717
3	1.952	2.911	1.150	93.986
6	3.341	10.267	1.672	84.720
9	4.335	18.720	3.585	73.360
12	4.355	19.627	4.177	71.841
Variance Decomposition of PPI				
1	0.259	4.904	2.633	92.204
3	0.500	2.882	9.258	87.360
6	26.147	2.605	9.795	61.454
9	36.014	2.305	8.282	53.399
12	33.415	3.346	8.327	54.912
Variance Decomposition of CPI				
1	6.666	0.136	0.318	92.880
3	4.786	1.803	2.821	90.591
6	9.247	1.832	2.812	86.109
9	10.959	3.236	2.911	82.893
12	10.896	3.816	2.884	82.404

Source: Authors' calculations.

Although the reaction measurements indicate the exchange rate shocks have an impact on price indices in the economy, such results seem not fully reflect the role of the exchange rate on price changes during the research period. Therefore, the study continues to conduct variance decomposition of price variables for 12 months' time to clarify the cause of the variables for the price evolution. Using the five-variable RVAR model with the Y_t vectors as in Eq.(2) for each price variable in turn, we find that the exchange rate is not a key determinant of the price volatility. As revealed in Table 5, the exchange rate could explain about 4% of the import price movements, nearly 9% of producer price movements and approximately 3% of consumer price movements after 6 months. This implies that the impact of the exchange rate shock on prices in Vietnam is rather modest, similar to the results of the pass-through effects as per Section 5.2. This may bring some policy implications which could boost exports while not having much influence on the domestic inflation.

5. Conclusions and Policy Recommendations

5.1 Conclusions

In this paper, the pass-through mechanisms of the exchange rate changes to a price series, from import prices, producer prices to consumer prices in Vietnam over the ten-year period of 2008-2017 were brought to light. Our findings highlight that the exchange rate shocks have a positive impact on price variations in Vietnam. Import prices have by far the largest response to the exchange rate shocks, followed by producer prices and consumer prices. In addition, the contagion effects of exchange rates during every stage of development were realized from the estimated results of the ERPT to the pricing chain under RVAR model.

In fact, the magnitude of pass-through of an exchange rate shock to consumer prices seems rather small. As indicated in the analysis of variance decomposition, the exchange rates have played a minor part in explaining the fluctuation of CPI. Hence, on condition that the aggregate demand and monetary policy were under control, devaluation of domestic currency might not necessarily cause inflation.

5.2 Policy Implications

Based on the key findings as stated, several far-reaching policy implications for the SBV could be drawn out:

First, the SBV may consider devaluation of VND to promote exports in the current situation. Aside from that, a more flexible exchange rate regime with broadened bands might also be necessary to assist the SBV in having a more flexible and timely responses to external shocks, while mitigating risks due to the impact of exchange rate volatility on inflation.

Second, the SBV should continue to implement strict measures to control and fight against dollarization, and step by step abolish foreign currency transactions within the territory of Vietnam. It is because a highly dollarized economy becomes more exposed to the exchange rate risks, otherwise, currency devaluation would also affect debt assets and liabilities in the local currency. By and large, such problems could lead to inefficiency in the conduct of monetary policy.

Finally, in pursuit of the inflation targeting policy framework in the long run, it is essential that the SBV recognizes exchange rates as a policy tool rather than an operational target. Accordingly, rather than recurrent intervention to stabilize the exchange rates, exchange rate management needs directing towards the attainment of the targeted inflation. Nevertheless, at times, direct interventions seem still necessary, particularly when the exchange rate fluctuations are forecasted to have adverse effects on the inflation targets.

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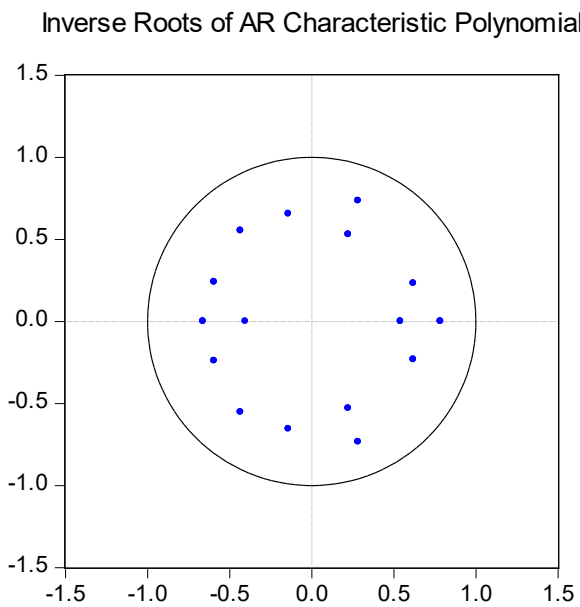
Appendices

Appendix A:
Unit Root Tests

Figure A1
Five-variable RVAR Model (WCP, YGAP, M2, EX, IMP/PPI)



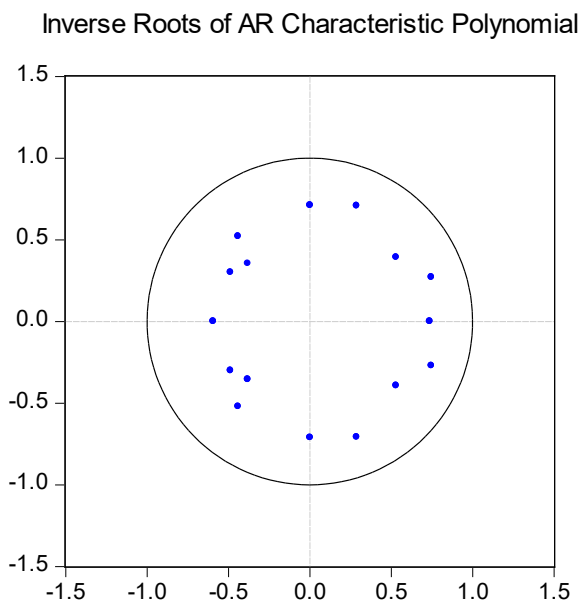
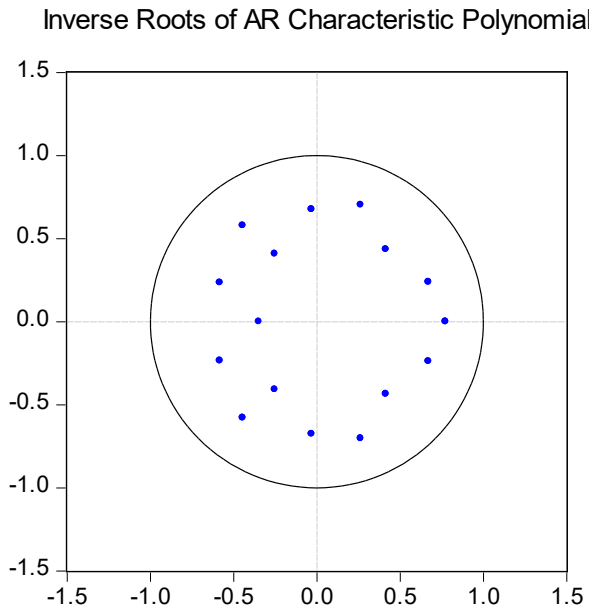
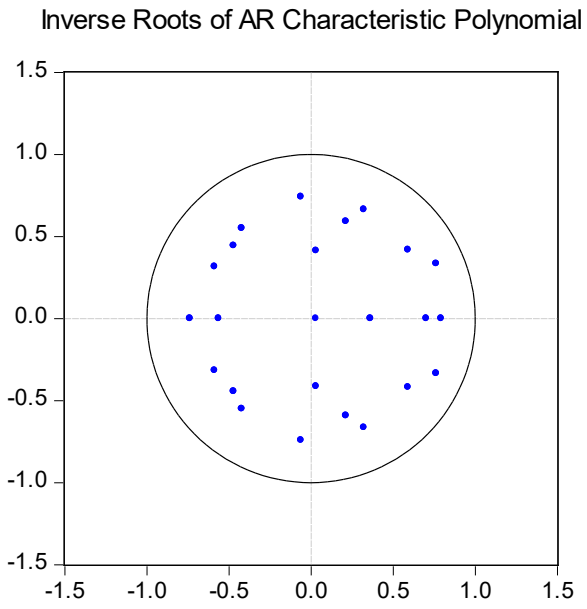


Figure A2
Five-variable RVAR (WCP, YGAP, M2, EX, CPI)
vs. Seven-variable RVAR (WCP, YGAP, M2, EX, IMP, PPI, CPI)





Appendix B:
Lag-length Selection for Var Models

VAR Lag Order Selection Criteria

Endogenous variables: YGAP D(LNM2) D(LNEX) D(LNIMP)

Exogenous variables: C D(LNWCP)

Sample: 2008M01 2017M12

Included observations: 107

Lag	LogL	LR	FPE	AIC	SC	HQ
0	907.1205	NA	5.91e-13	-16.80599	-16.60615	-16.72498
1	983.1169	143.4699	1.93e-13	-17.92742	-17.32791*	-17.68438*
2	1003.432	36.83251	1.78e-13	-18.00807	-17.00888	-17.60301
3	1017.836	25.03880	1.84e-13	-17.97824	-16.57938	-17.41116
4	1031.017	21.928303*	1.95e-13*	-17.92556*	-16.12702	-17.19645
5	1047.880	26.79160	1.94e-13	-17.94169	-15.74347	-17.05056
6	1068.899	31.82211	1.80e-13	-18.03549	-15.43760	-16.98234
7	1080.002	15.98081	2.01e-13	-17.94397	-14.94640	-16.72879
8	1095.568	21.23944	2.09e-13	-17.93585	-14.53861	-16.55866
9	1135.555	51.57201	1.39e-13	-18.38421	-14.58729	-16.84499
10	1152.144	20.15490	1.44e-13	-18.39522	-14.19863	-16.69397
11	1183.505	35.7571	1.15e-13	-18.68233	-14.08607	-16.81907
12	1202.234	19.95478	1.18e-13	-18.73335	-13.73741	-16.70806

* indicates lag order selected by the criterion

VAR Lag Order Selection Criteria

Endogenous variables: YGAP D(LNM2) D(LNEX) D(LNPPI)

Exogenous variables: C LNWCP

Sample: 2008M01 2017M12

Included observations: 107

Lag	LogL	LR	FPE	AIC	SC	HQ
0	873.6919	NA	1.10e-12	-16.18116	-15.98132	-16.10015
1	975.9954	193.1338	2.20e-13	-17.79431	-17.19479*	-17.55127*
2	994.3217	33.22713	2.11e-13	-17.83779	-16.83860	-17.43273
3	1007.110	22.23076	2.25e-13	-17.77776	-16.37890	-17.21068
4	1023.619	27.46370*	2.24e-13*	-17.78728*	-15.98874	-17.05818
5	1045.971	35.51128	2.01e-13	-17.90599	-15.70778	-17.01487
6	1065.302	29.26863	1.92e-13	-17.96827	-15.37038	-16.91512
7	1087.410	31.81833	1.75e-13	-18.08243	-15.08486	-16.86726
8	1095.680	11.28495	2.09e-13	-17.93795	-14.54071	-16.56076
9	1120.024	31.39627	1.85e-13	-18.09391	-14.29699	-16.55469
10	1136.904	20.50835	1.92e-13	-18.11035	-13.91376	-16.40911
11	1164.079	30.98506	1.65e-13	-18.31924	-13.72297	-16.45597
12	1182.822	19.96847	1.69e-13	-18.37050	-13.37456	-16.34521

* indicates lag order selected by the criterion

VAR Lag Order Selection Criteria

Endogenous variables: YGAP D(LNM2) D(LNEX) D(LNCPI)

Exogenous variables: C WCP

Sample: 2008M01 2017M12

Included observations: 107

Lag	LogL	LR	FPE	AIC	SC	HQ
0	914.2522	NA	5.17e-13	-16.93929	-16.73946	-16.85828
1	1006.507	174.1625	1.24e-13	-18.36461	-17.76510*	-18.12158*
2	1024.277	32.21941	1.21e-13	-18.39770	-17.39851	-17.99265
3	1034.908	18.47985	1.34e-13	-18.29735	-16.89848	-17.73027
4	1051.421	27.46962*	1.33e-13*	-18.30693*	-16.50839	-17.57782
5	1067.446	25.46027	1.35e-13	-18.30740	-16.10918	-17.41627
6	1090.505	34.91281	1.20e-13	-18.43935	-15.84146	-17.38620
7	1102.375	17.08322	1.33e-13	-18.36215	-15.36458	-17.14697
8	1107.789	7.387026	1.66e-13	-18.16427	-14.76703	-16.78708
9	1136.036	36.43108	1.37e-13	-18.39319	-14.59628	-16.85398
10	1146.979	13.29512	1.59e-13	-18.29867	-14.10208	-16.59743
11	1179.560	37.14820	1.24e-13	-18.60859	-14.01232	-16.74533
12	1198.606	20.29293	1.26e-13	-18.66554	-13.66960	-16.64025

* indicates lag order selected by the criterion

VAR Lag Order Selection Criteria

Endogenous variables: YGAP D(LNM2) D(LNEX) D(LNIMP) D(LNPPI) D(LNCPI)

Exogenous variables: C LNWCP

Sample: 2008M01 2017M12

Included observations: 107

Lag	LogL	LR	FPE	AIC	SC	HQ
0	1681.967	NA	1.12e-21	-31.21433	-30.91458	-31.09282
1	1819.794	255.0452	1.67e-22	-33.11765	-31.91862*	-32.63158*
2	1852.239	56.39836	1.80e-22	-33.05119	-30.95289	-32.20057
3	1876.350	39.20962	2.29e-22	-32.82898	-29.83141	-31.61380
4	1903.112	40.51801*	2.81e-22*	-32.65630*	-28.75947	-31.07658
5	1952.827	69.69390	2.29e-22	-32.91266	-28.11655	-30.96838
6	1997.518	57.63911	2.11e-22	-33.07511	-27.37973	-30.76628
7	2040.147	50.19860	2.10e-22	-33.19901	-26.60437	-30.52563
8	2073.433	35.46310	2.59e-22	-33.14828	-25.65436	-30.11034
9	2139.939	63.39816	1.83e-22	-33.71848	-25.32530	-30.31600
10	2189.453	41.64758	1.91e-22	-33.97109	-24.67863	-30.20405
11	2267.606	56.97113	1.29e-22	-34.75899	-24.56726	-30.62740
12	2352.160	52.15523*	8.83e-23	-35.66655	-24.57556	-31.17041

* indicates lag order selected by the criterion