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

1. The author is a Senior Research Analyst attached with the Research Department of the Bank of Papua New Guinea and available at edireye@bankpng.gov.pg. The author acknowledges Professor Peter Tillman and Mr David Finck of Justus Liebig University Giessen for providing technical assistance and reviews which improved the quality of this paper. The paper also benefited from comments gathered from the research seminar organised by SEACEN in Malaysia. The views expressed in the paper do not represent the stance of the Bank of Papua New Guinea, thus any error and omission remains the sole responsibility of the author.

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'

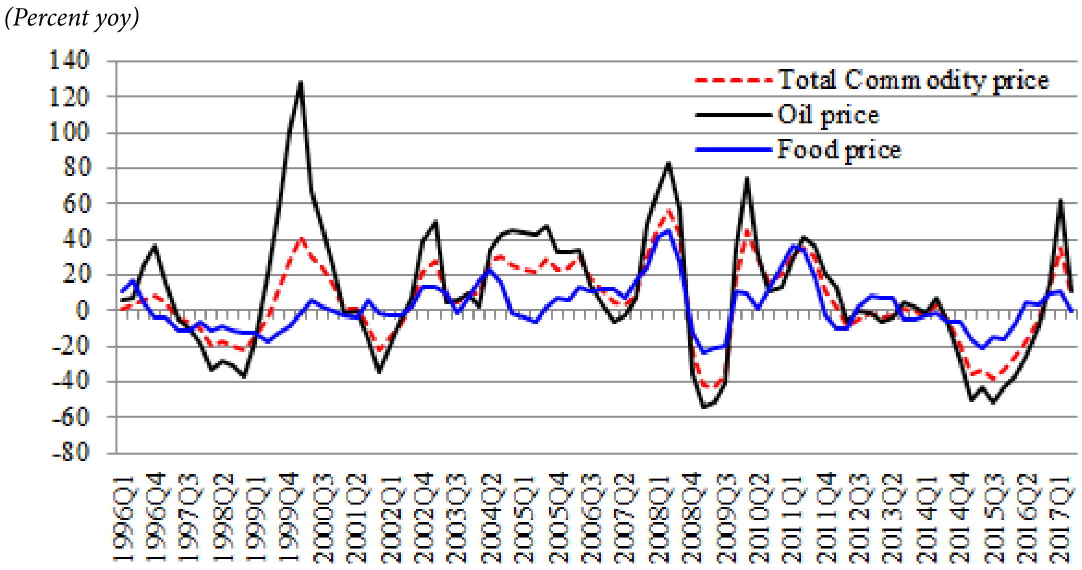
Source: NSO.

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

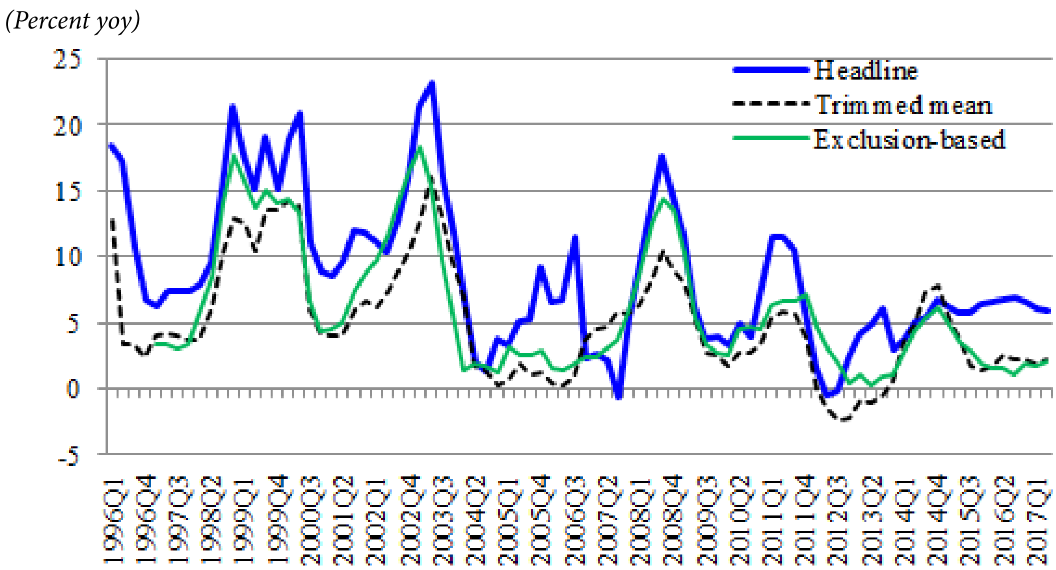
Overall inflation in PNG tends to positively correlate with developments in global commodity prices (Figures 1 & 2). The first-round effects of changes in food and oil prices on inflation are usually through import prices of domestic goods. This effect can happen directly on consumer prices or indirectly 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



Source: IMF Commodity price; Author's calculation

Figure 2
Domestic Headline and Core Inflation

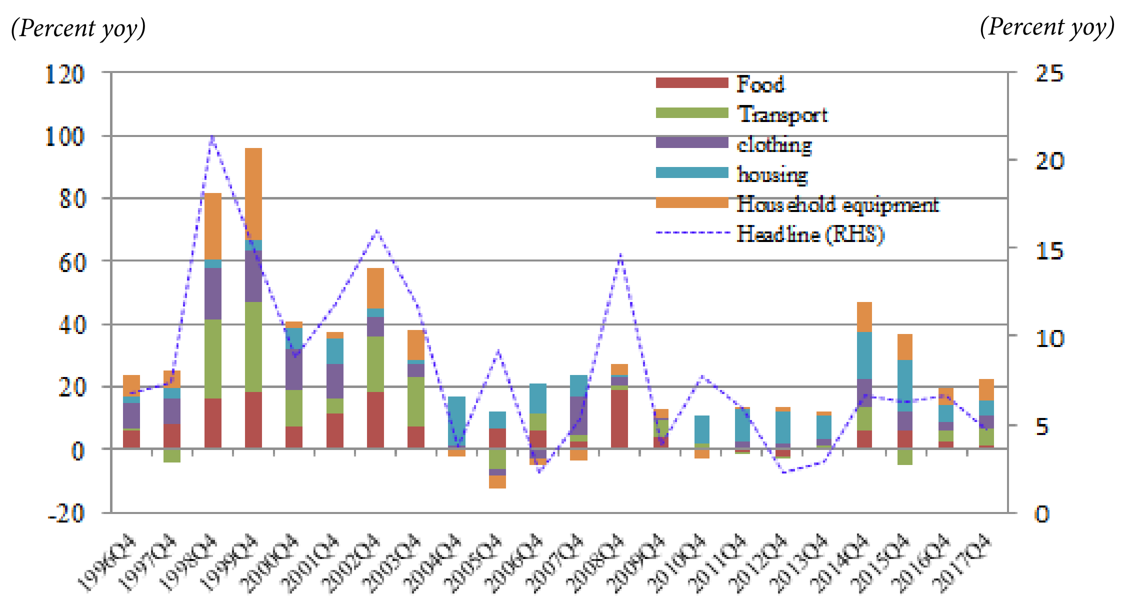


Source: BPNG; Author's calculation

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)

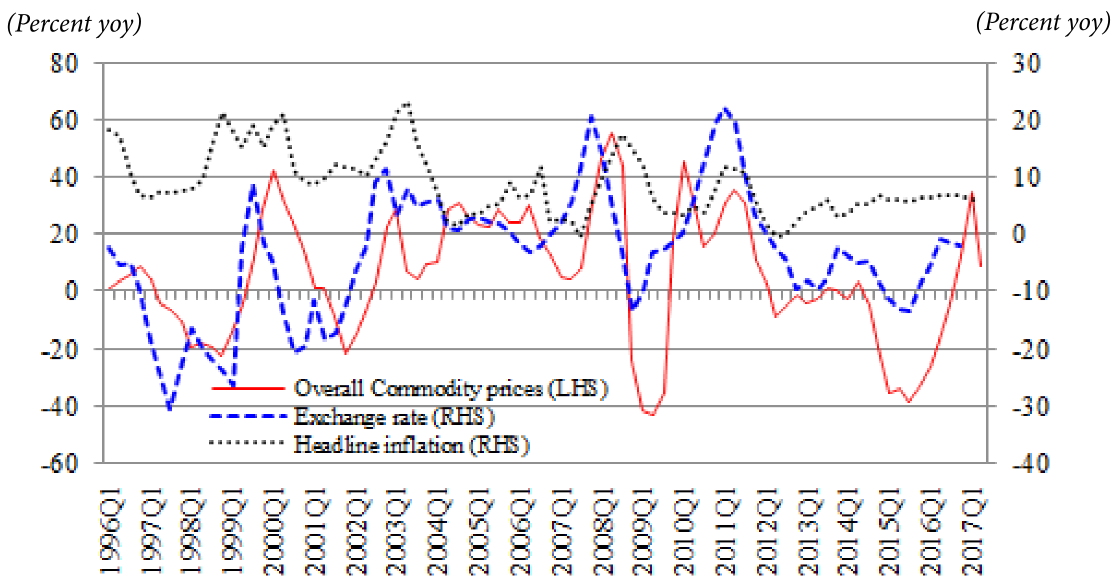
Source: BPNG; Author's calculation

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.

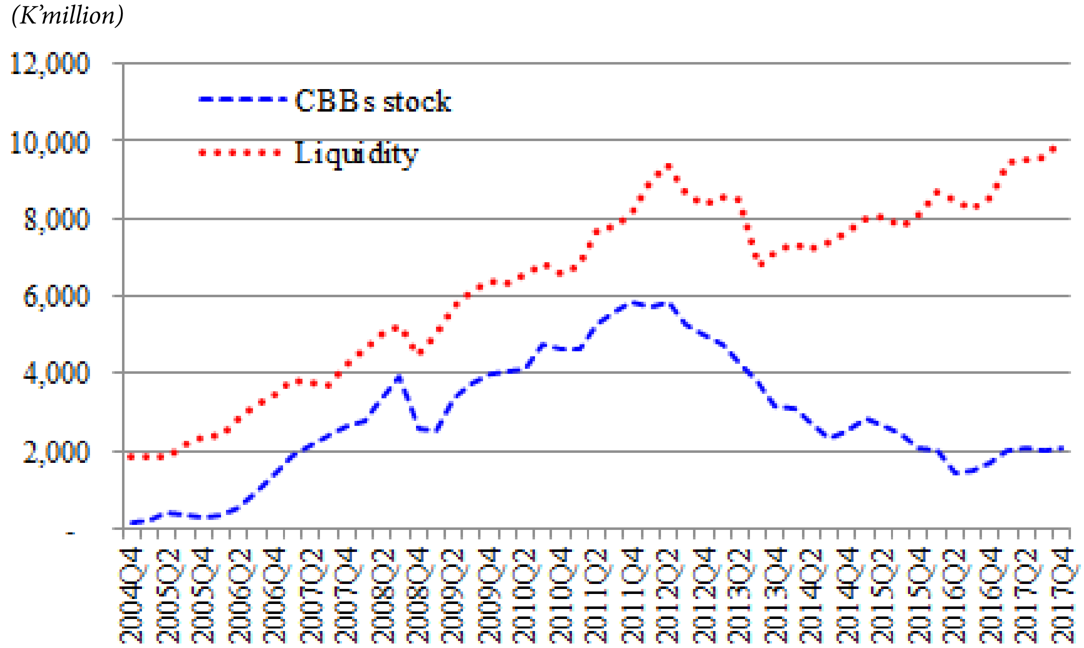
* Kina Facility rate (KFR) is a policy signalling rate. The KFR and CRR are adjusted monthly based on the assessment of macroeconomic condition by policymakers.

**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.

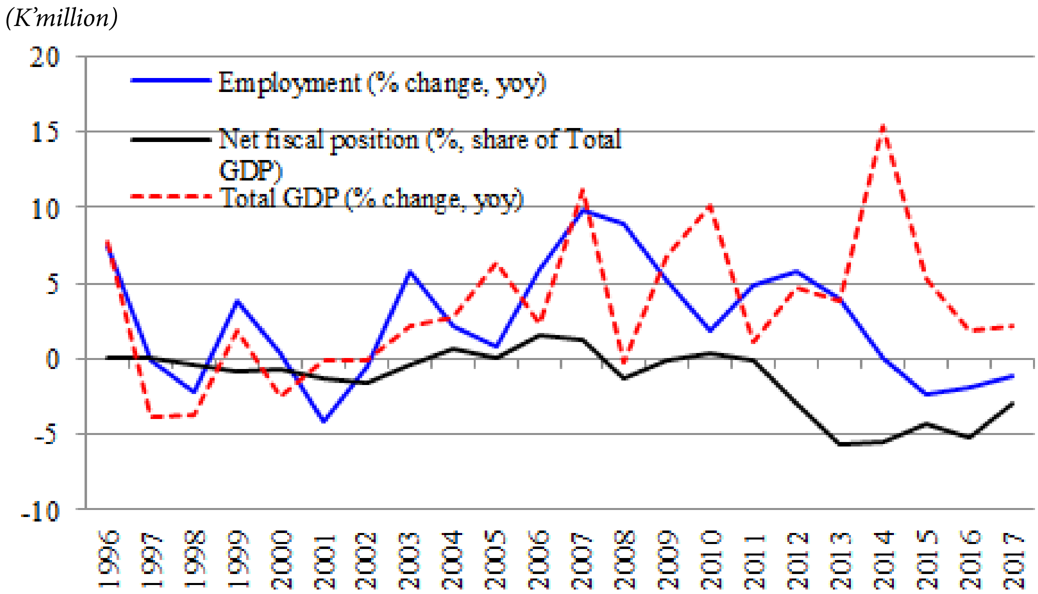
5. Government's use of external loans and funds drawdown from trust accounts held at the BPNG injected liquidity into the banking system.

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:

$$u_t^{oil} = \epsilon_t^{oil}, \quad (2)$$

$$u_t^{food} = \alpha_{21}\epsilon_t^{oil} + \epsilon_t^{food}, \quad (3)$$

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

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

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

$$u_t^{m} = \alpha_{61}\epsilon_t^{oil} + \alpha_{62}\epsilon_t^{food} + \alpha_{63}\epsilon_t^{y} + \alpha_{64}\epsilon_t^{e} + \alpha_{65}\epsilon_t^{\pi t} + \epsilon_t^{m}, \quad (7)$$

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

$VAR\ (p_t^{oil}, p_t^{food}, y_t, e_t, \pi_t^{headline}, m_t)$						
Lag	LogL**	LR	FPE	AIC	SC	HQ
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.

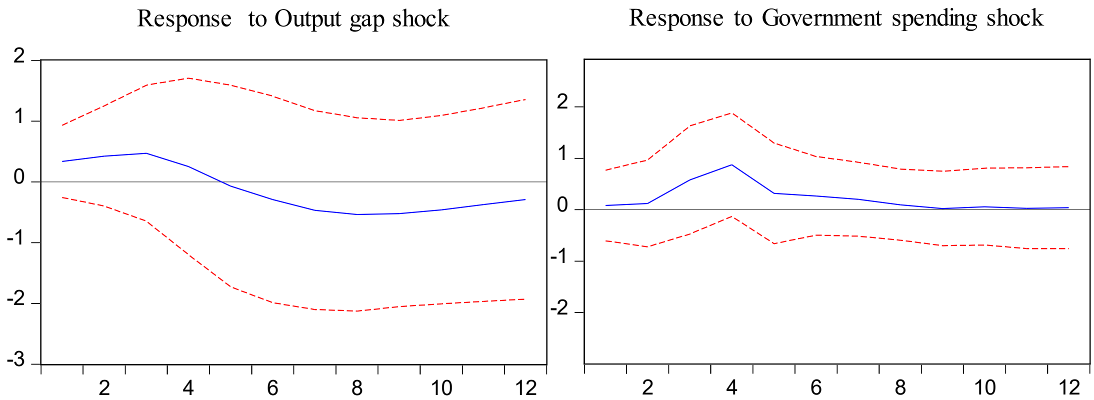
5.1 Impulse Responses

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

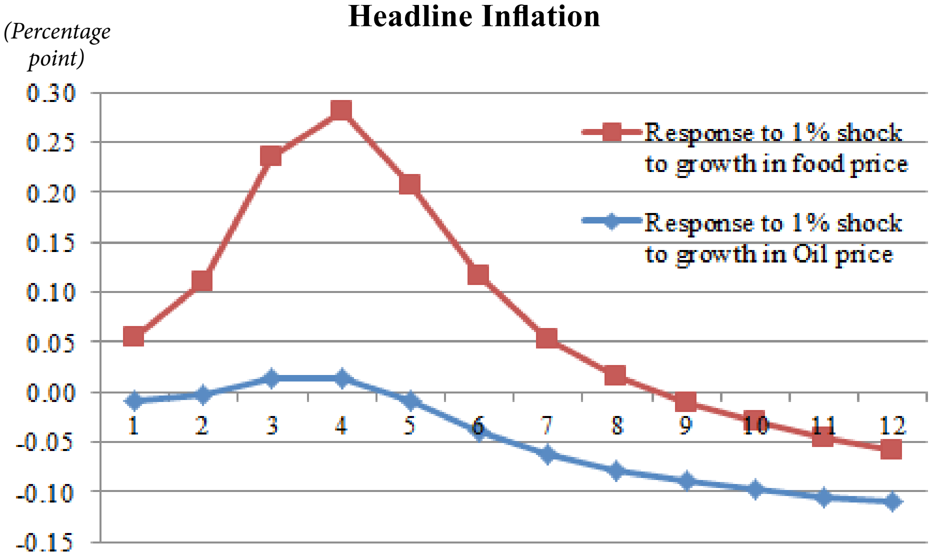
While we find that the direction and duration of the response in domestic inflation resulting from oil and food price shocks is as expected, it is equally important to understand the size of the cumulative impacts overtime[16]. Thus, the cumulative pass-through coefficient is interpreted as a percentage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



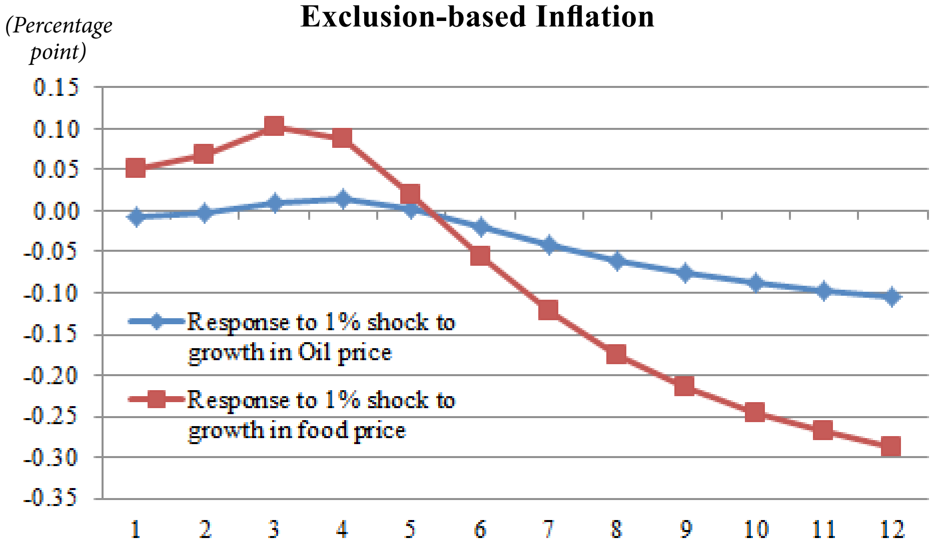
Source: Eviews output; Author’s calculation

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.

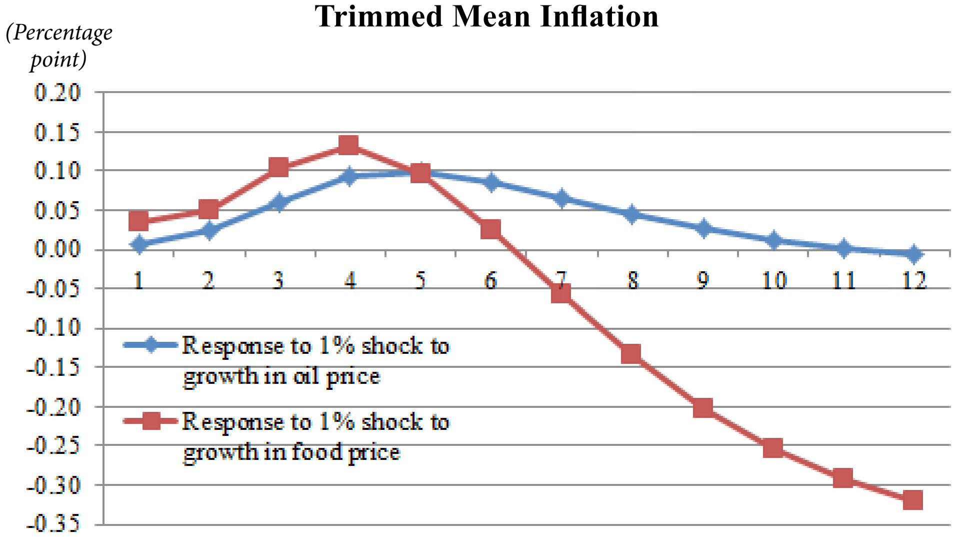
The analysis finds that the cumulative coefficients for the pass-through effect of global oil price shock to core inflation in the first year are higher than their impact on headline inflation. That could possibly suggest that the second-round effects of oil price shocks on domestic inflation might be 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)

Variance Decomposition of Headline Inflation							
Period	S.E.	p_t^{oil}	p_t^{food}	y_t	e_t	$\pi_t^{headline}$	m_t
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

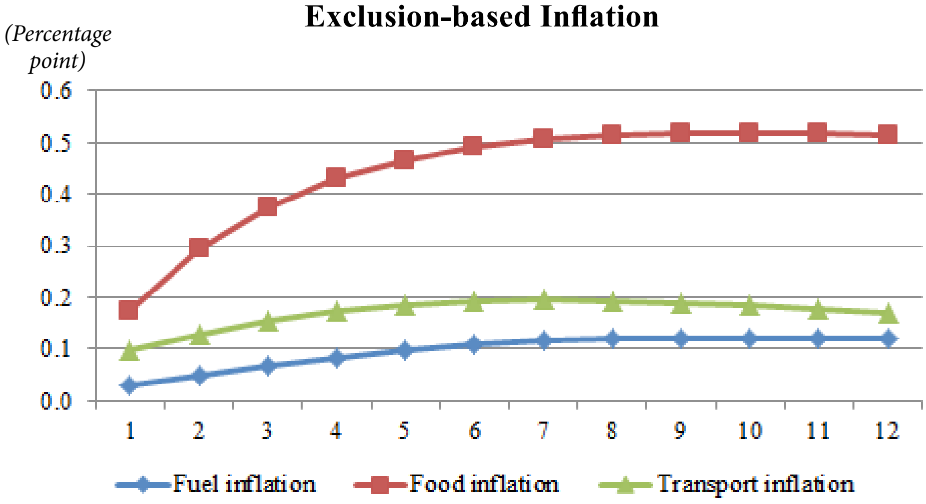
Mija, et al. (2013) argues that inclusion of the exchange rate and money supply in the baseline model limits the impact of world oil and food price shocks on domestic inflation. Note an alternative ordering of money supply in the baseline model has not altered the results very much. Therefore, this section 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.

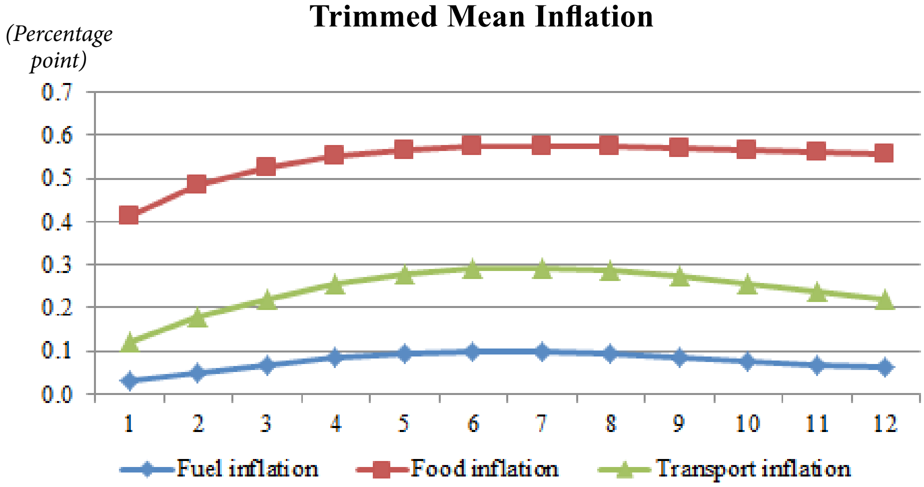
Figure 15
Cumulative Coefficients of Pass-through to Exclusion-based Inflation



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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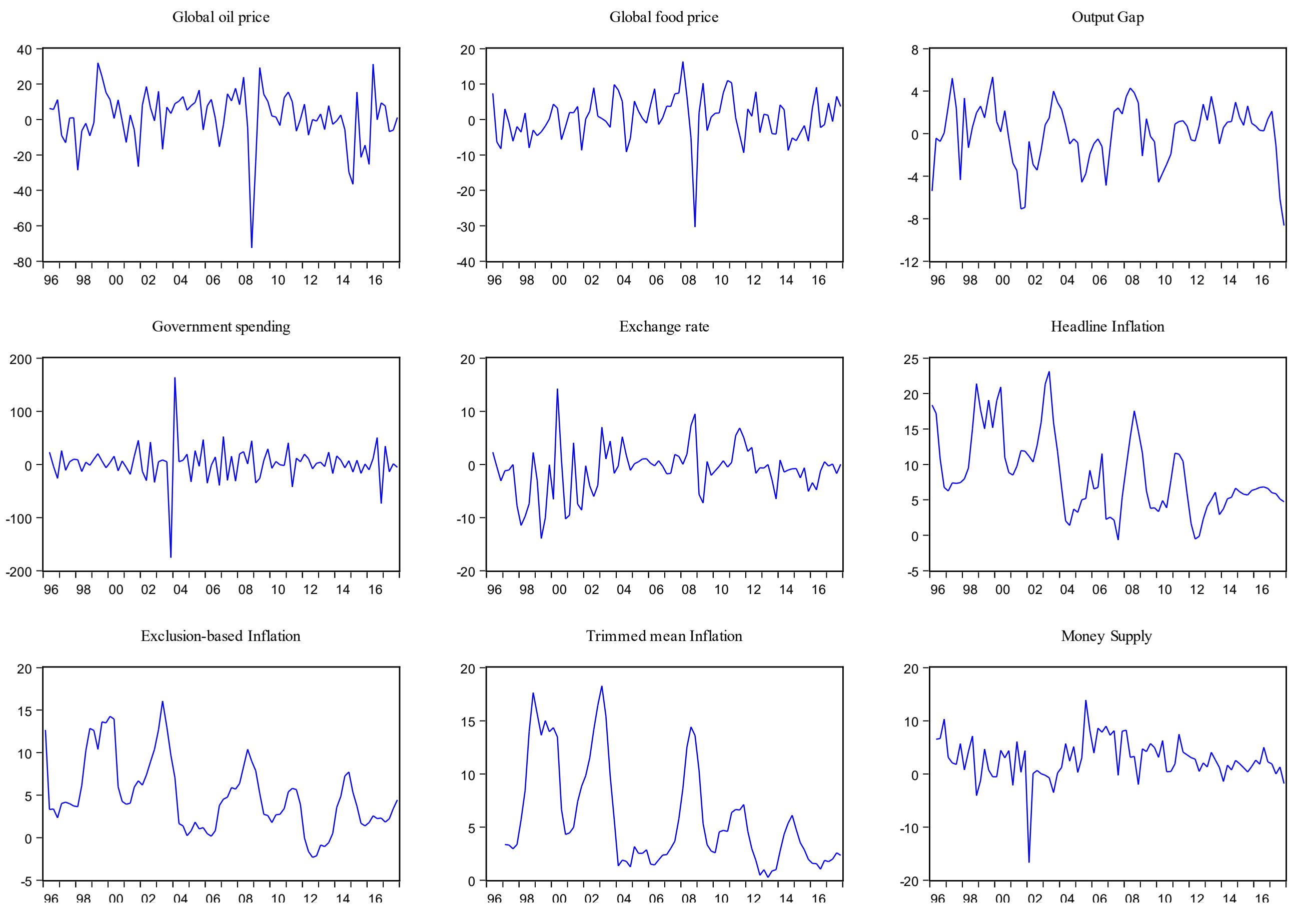
Appendix

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.

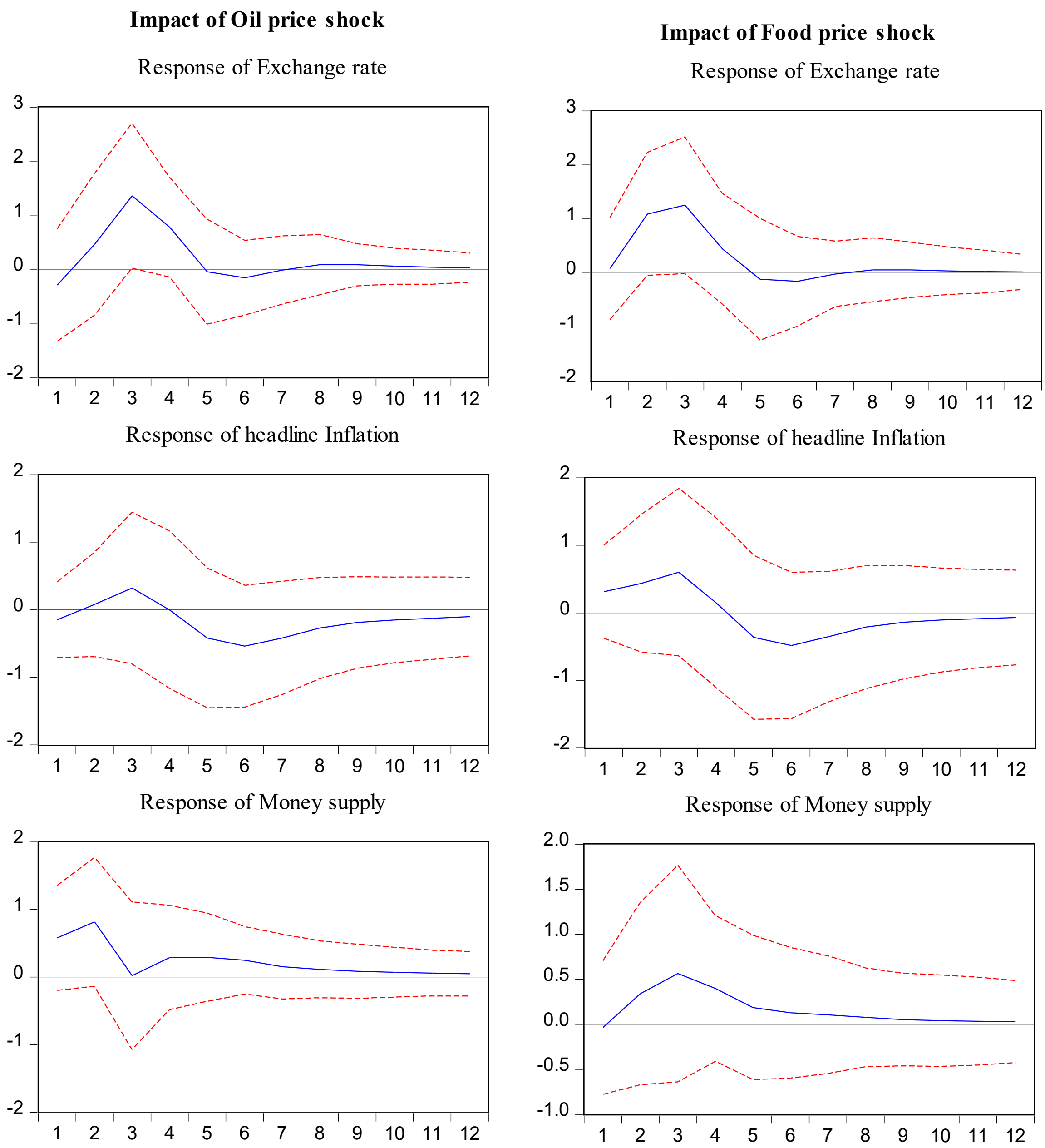
Note: The transport and food inflation are proxy for domestic food and transport services related prices due to absence of these data. The asterisks *** and * denote the 1% and 10% significance level of the tests at which, the null hypothesis is rejected for ADF and fails to reject for KPSS. Both tests 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]



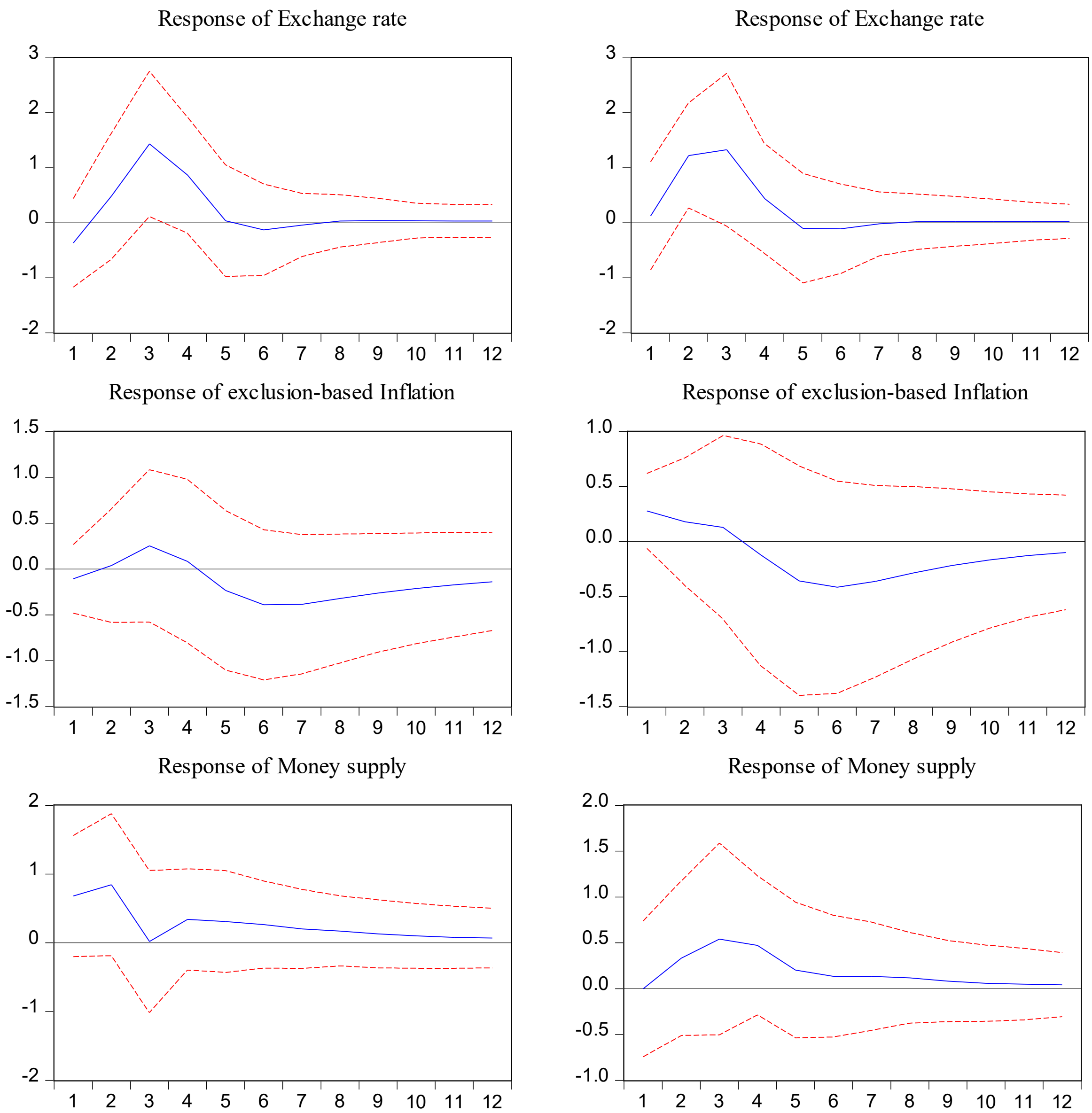
Note: The standard errors are generated through Monte Carlo simulation with 100 iteration levels. The red lines denote the ±2 Standard deviations. Per the object of the paper, impulse response of domestic demand is excluded.

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

Impact of Oil price shock | **Impact of Food price shock**

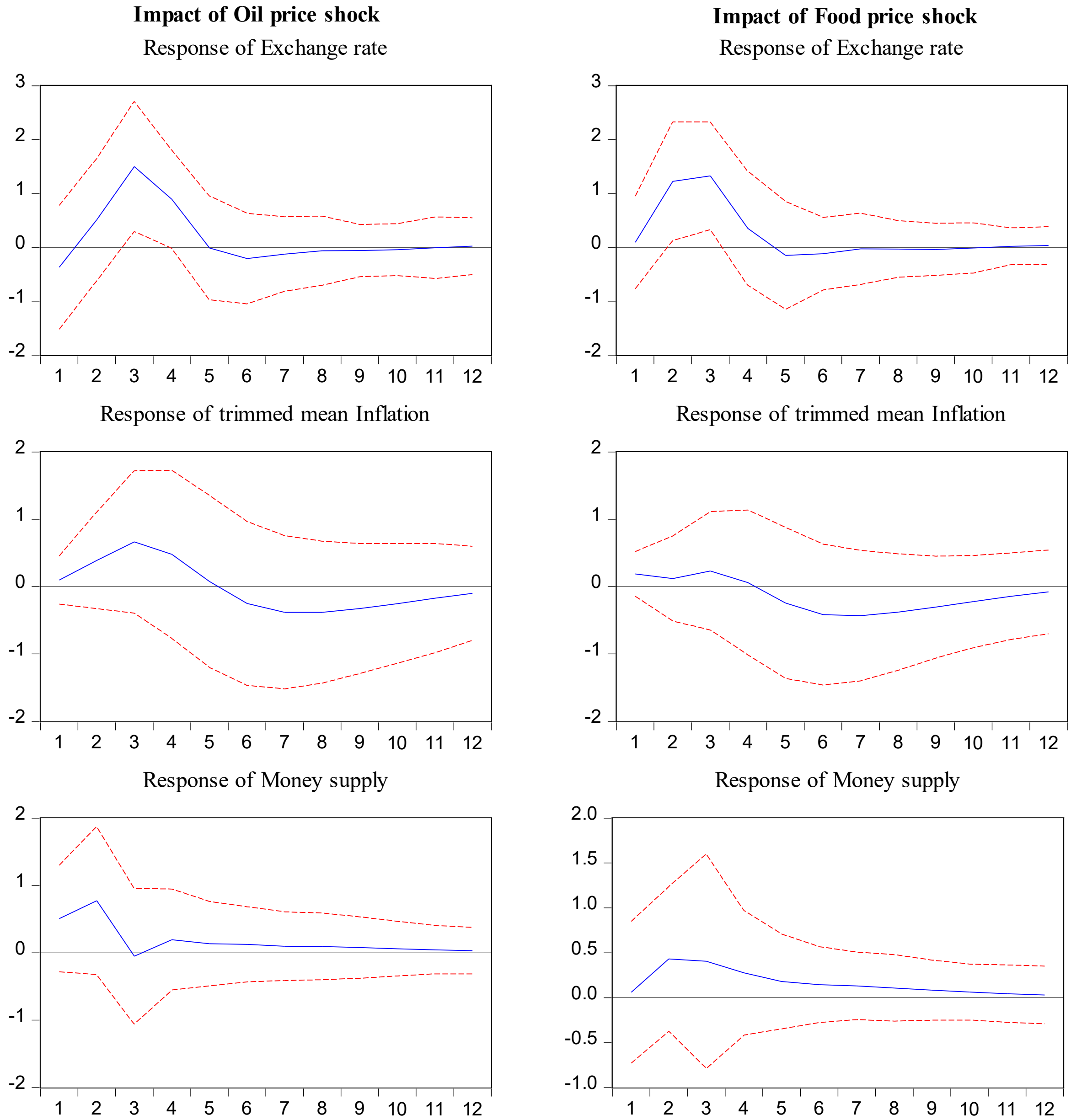


Note: The standard errors are generated through Monte Carlo simulation with 100 iteration levels. The red lines denote the ±2 Standard deviations.

Source: Eviews output; Author's calculation.

(End)

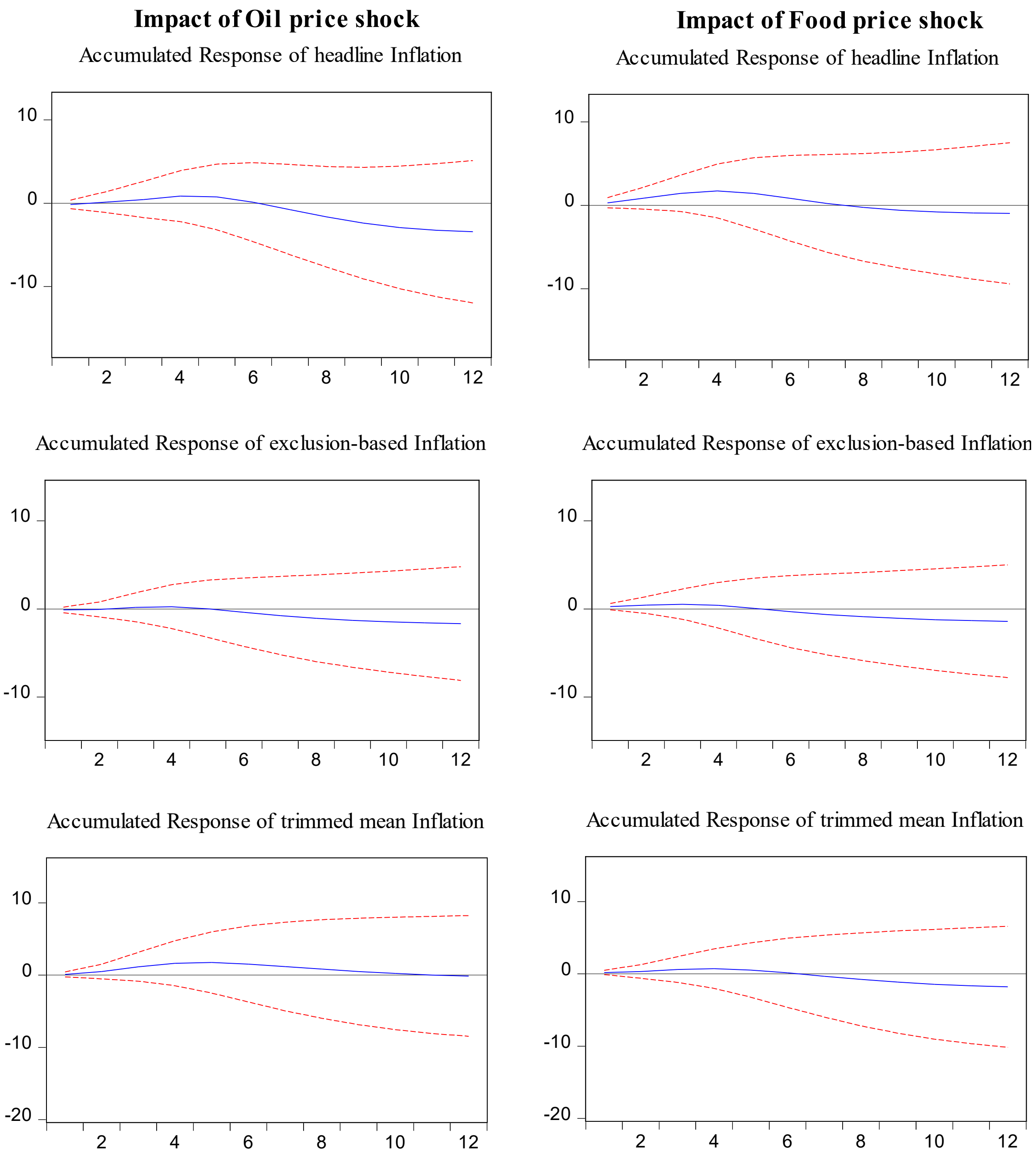
Impact of Trimmed Mean Inflation



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.

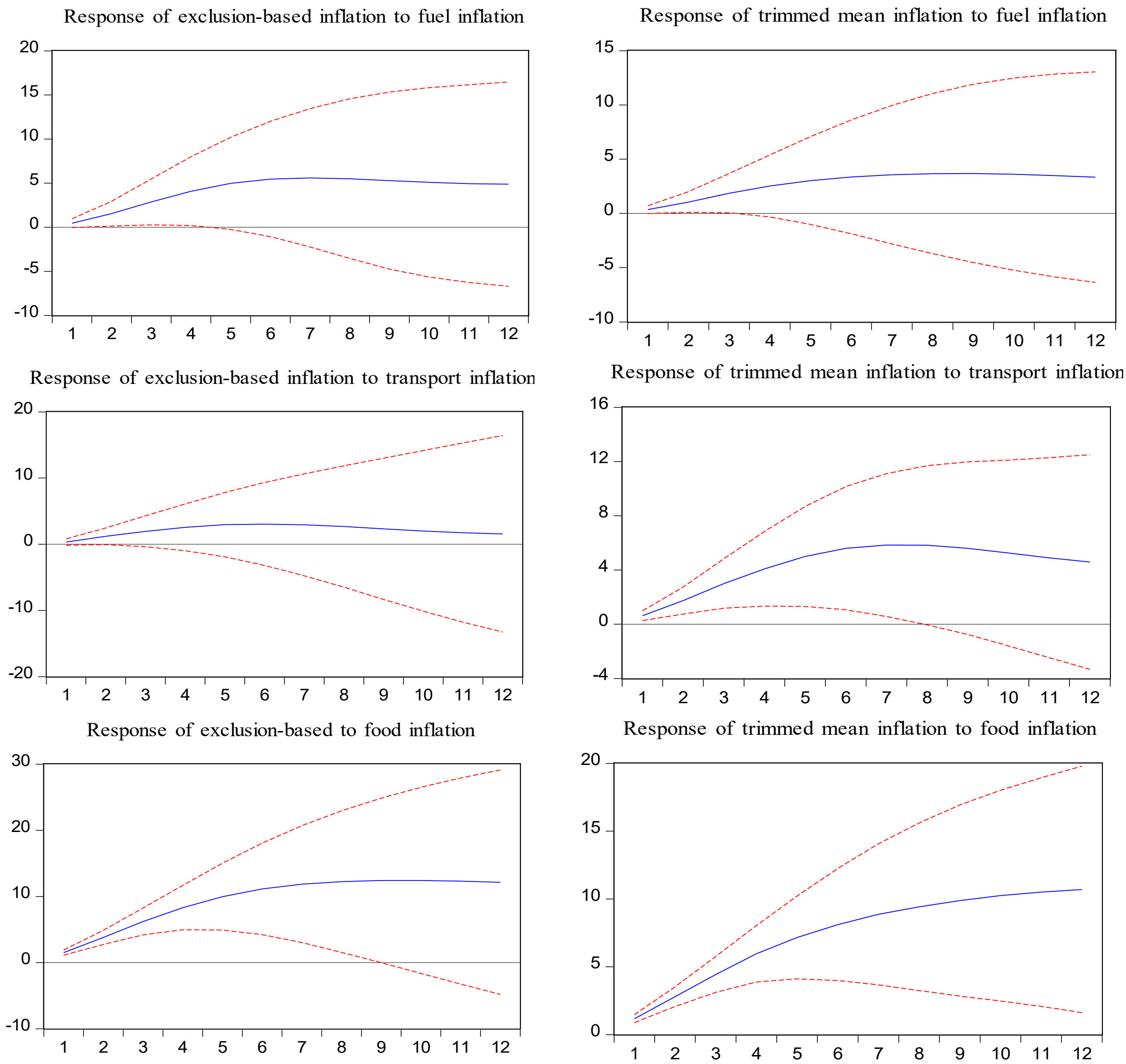
Figure 14
Cummulative Impluse Responses of Domestic Inflation to Shocks in Global Oil and Food Prices
[Response to Cholesky one S.D. (d.f. adjusted) Innovations ± S.E]



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.